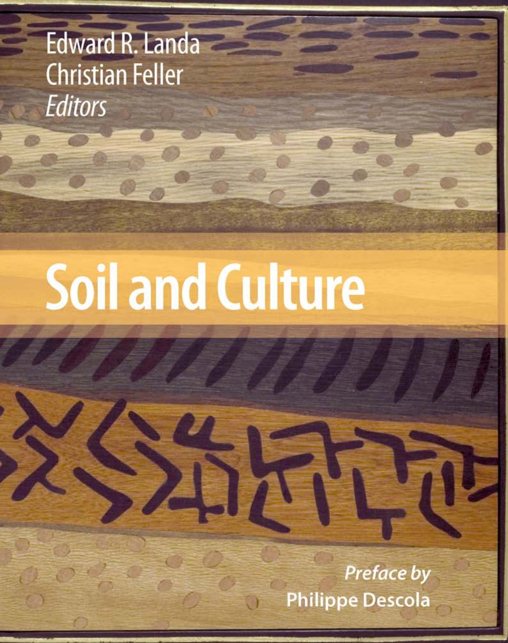
Edward R. Landa
Christian Feller
Editors

Soil and Culture

Preface by
Philippe Descola



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Soil and Culture

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with Preface by Philippe Descola

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Cover illustration: Artist, designer, and teacher Guy Pradel was born in France (Garches) in 1960. He specializes in marquetry (art made from pieces of wood veneer glued together to form a picture or pattern), and lives and works in Madagascar. Pradel studied art at "École du Louvre", and marquetry at the famous French "École Boule". His marquetry furniture is known worldwide, and he has been a consultant for institutions, such as the German Society for Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit; GTZ) and UNESCO, concerned with sustainable development.

The cover of this book is a photograph of a marquetry representing a soil profile that was done by Pradel in 2008. It is made from natural woods found in Madagascar, and is included in a leather binding made to cover a copy of Vasily Vasili'evich Dokuchaev's 1883 doctoral thesis "The Russian Chernozem", one of the founding books of soil science.

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Edward R. Landa holds an M.S. and Ph.D. in soil science from the University of Minnesota, and has been with the U.S. Geological Survey since 1978. His research focuses on radionuclide and metal mobility in soil and aquatic environments, and has included studies of uranium mill tailings, radium processing residues, oil field brines, and indoor radon. He participated in the International Atomic Energy Agency's International Chernobyl Project, and in studies of radioactive contamination in the Arctic regions. His interest and publication record in the history of science spans from the late 1970's, with an early focus on the history of the radium processing industry—a spin-off of his research on present-day soil contamination at these sites. This historical research resulted in a paper in *Scientific American* (1982) and a monograph published by the Colorado School of Mines (1987). Ed's more recent focus has been on the history of soil science; he has co-authored papers on soil physicists Lyman Briggs and Edgar Buckingham in the *Soil Science Society of America Journal* in 2003 and 2005. His co-authored paper on Albert Munsell appeared in *American Scientist* in 2005. He is the Chair (2006-2010) of the Commission on the History, Philosophy, and Sociology of Soil Science of the International Union of Soil Sciences.

Christian Feller

Christian Feller is an Emeritus Soil Scientist and the former Director of Research at the "Institut de Recherche pour le Développement" (IRD) in Montpellier, France. He earned his MS (1969) and PhD degrees in organic chemistry (1972) from the Sorbonne University (Faculty of Sciences) in Paris, and his Doctorate of Science (1994) in Soil Science from the Louis Pasteur University in Strasbourg. His research focuses on soil organic matter studies applied to soil fertility and environmental services—in particular, the impact of agroecological practices on soil-plant carbon sequestration in tropical and subtropical areas; he has worked extensively in Senegal, French West Indies (Martinique), Brazil, and most recently, Madagascar. Christian is a member of the French Academy of Agriculture, and was the first recipient of the Soil Science Society of America's Nyle C. Brady Frontiers of Soil Science Lectureship in 2006. He has published extensively on the history of soil science, including work on Charles Darwin's earthworm studies, Bernard Palissy's development of the soil auger, and the importance of French tropical research in the development of pedology. He serves as Vice Chair (2006-2010) of the Commission on the History, Philosophy, and Sociology of Soil Science of the International Union of Soil Sciences.

Prefacer Biography

Philippe Descola

Born in Paris in 1949, Philippe Descola obtained a master's degree in philosophy at the Ecole Normale Supérieure, before studying South-American anthropology under the supervision of Claude Lévi-Strauss. He received his doctorate in 1983 at the Ecole Pratique des Hautes Etudes. Most of his field-work was conducted among the Achuar Jivaro of the Ecuadorian Amazon with whom he spent three years (1976 to 1979) and where he has been returning ever since for shorter periods. Besides his field research, to which he has already devoted two books and many papers, Philippe Descola has published extensively on cultural ecology, contributing an original approach to the study of the social construction of nature. He holds the chair of anthropology at the Collège de France, where he heads the Laboratoire d'Anthropologie sociale, and he also teaches at the Ecole des Hautes Etudes en Sciences Sociales, Paris. He is the author of *Les idées de l'anthropologie* (Paris, 1988), *In the Society of Nature* (Cambridge, 1994), *The Spears of Twilight* (New York, 1996), *Par-delà nature et culture* (Paris, 2005) and the co-editor of *Dictionnaire de l'ethnologie et de l'anthropologie* (Paris, 1991), *Nature and Society* (London, 1996) and *La production du social* (Paris, 1999).

Preface

We tread upon the soil, and it feels unevenly dense, unevenly receptive to our steps, unevenly concerned with our balance; we lie upon it and, according to its compactness, to its texture and to the vegetation that covers it, it becomes more or less hospitable to our nonchalance; we dig it, and it meets our tearing with more or less open resistance. What goes for the soil also goes for all the other components of our life sphere. In other words, as with the wind that cools us or makes us shudder, as with the sun that scorches us or barely warms us, the soil is like an outer envelope of our body and an expansion of our muscles and senses. It is not within ourselves, obviously, but it is not entirely separate from us either; it is the accomplice of our body and that which anchors it to the world. This companionship is not really reflexive: even when the hardened clay resists our spade, even when the deep mud of a sodden path sucks in our steps, the soil does not for that become an external reality divorced from our actions, just a difficult partner which we have to contend with. The clod of earth that crumbles in our hand, the stony trail on which we stumble, the outcrop of rocks that break up the smoothness of a grassy patch, all of these acquires an autonomous existence only when, through a conscious decision, we convert them into objects worthy of reflection and susceptible to be subsumed under a generic category of phenomena. As a consequence, a notion of 'soil' emerges from the interface between our body and its setting, a domain federating a medley of ill-assorted facts that amalgamate impressions and degrees of resistance, specific kinds of knowledge and know-how, sensible qualities and types of genesis, facts that can be rearranged so as to render manifest the properties they share in common. The soil then becomes singularised as a particular kind of existent, endowed with specific qualities that are thus liable to be studied in themselves and for themselves.

The present book results from this movement of autonomisation. Dealing with the 'cultural' aspects of the soil, as the authors do, implies a dissociation between, on the one hand, an object—the plastic upper layer of the terrestrial crust—the limits and basic attributes of which would be universally perceived and, on the other hand, the myriads of ways in which this object is apprehended, represented, interpreted and partially objectified by humans according to their location in space and time and as a function of their social condition and personal dispositions. Such a dissociation between a natural object and the multiple cultural accounts given of it has emerged quite recently and it is associated with modernity as it blossomed in the West. It can be traced back to the rationalist revolution of the 17th century and to the distinction introduced by philosophers, notably Locke, between primary qualities and secondary qualities. The primary qualities of an object are its geometrical, mechanical and chemical properties that can be decomposed and measured (number, mass, speed, etc.), while secondary qualities are the fleeting or lasting impressions that these properties leave on our senses. Thanks to this subtle distinction, objective can be differentiated from subjective, natural from cultural, science from art; in short, all the categories by the means of which the Moderns conceptualize their engagement with the world become available. On the one side, we have the soil of pedology, this layer of matter resulting from the alteration of the parent rock material, that can be defined by its physical and chemical properties, on the other side we have the soil of the poet, of the visual artist working with a variety of media (the painter, the sculptor, the potter, etc.), of the gardener and, above all, of the multitude of non-Modern peoples, a bewildering array of variations, of points of view, of interpretations, dealing in their own ways with the solid mass of facts and processes, the mechanisms of which pedology has set as its goal to elucidate.

As a result one can even practice 'ethnopedology', as I did myself long ago among the Achuar Indians of the Upper Amazon. It means studying the soils of a region with the (much-needed) help of pedologists and geomorphologists, measuring their fertility and evaluating their fragility, prior to describing the uses that the local population make of them, the different types into which they divide them, the knowledge they have developed about them, the myths and narratives that relate to them. As if, by a miracle of universal reason, the subject matter of pedology (the word itself only dates from the end of the 19th century) had been universally apprehended as such since the dawn of times, as if all humans had an intuitive foreboding of the existence of the soil as a class of autonomous facts clearly demarcated within the perceptual flux by the means of which we continuously become aware of our environment. This is highly unlikely. A more plausible alternative is that, before the great Modern shift which instituted a separation between nature and culture, soil figured according to circumstances, and for such or such a person in particular, sometimes as a sensation under bare feet, sometimes as a potentiality to grow a specific kind of crop, sometimes as a mass to dig out when building an irrigation ditch, sometimes as a pigment for body painting, in short, as qualities referred to persons and their experiences, not as a material abstraction referred to a quantifiable abstraction.

This said, one does not escape easily from one's own cosmology. In that respect it has become quite difficult for us, Moderns, not to conceptualise the world as being distributed between natural objects and the multiple ways in which they are perceived, between the domain of plants, say, or the domain of animals, or the domain of soils, and the various ways in which they are apprehended, named, classified and used by peoples around the world. Seen in that constraining context which forces us to juxtapose a single nature to many cultures, the present book retains its originality. Although it is modernist in its inspiration, and perhaps inescapably so, it provides nevertheless a wealth of information on a topic that has been neglected and which can now be dealt with in a truly comparative manner. For, if the available literature on the history and ethnology of the representations of plants, of animals, of colours, of climates or of celestial bodies is vast, the study of the cultural perception of soils is still underdeveloped. Relating, as this book does, a non- human matter with human concerns thus helps remind the reader that the domains of inquiry carved out by the sciences in the texture of things do not exist as transcendental kingdoms but are the results of a long epistemological construction. After all, let's not forget that in Latin 'soil' (humus) and 'human' (homo) come from the same Indo-european root meaning 'earth'.

Philippe Descola

Introduction

SOIL —beneath our feet
—food and fiber
—ashes to ashes, dust to dust
—dirt

As reflected in a special issue of *Science* (2004), soil is the final frontier of environmental research. The critical role of soil in biogeochemical processes is linked to its properties and place—porous, structured, and spatially variable, it serves as a conduit, buffer, and transformer of water, solutes and gases. Yet what is complex, life-giving, and sacred to some, is ordinary, even ugly, to others. This is the enigma that is soil.

It has been said that "scientific advances do not truly become the possession of a culture until these discoveries are expressed through that culture's art and poetry" (Frodeman 2003). For soils, no such cultural history has been written—that is our goal here. The view of "culture" in our book is, however, more expansive, both temporally and topically, spanning to antiquity and beyond just art and poetry. As soil is a key consideration in the everyday life of many, rather than an abstract scientific concept to a few, *Soil and Culture* explores the perception of soil in ancient, traditional, and modern societies. It looks at the visual arts (painting, textiles, sculpture, architecture, film and comics), the written arts (prose, and poetry), religion, philosophy, anthropology, archaeology, stamp-design and wine production. Like soils, humans dwell in the dark, as well as the light. Thus we have extended the reach of topics to such as disease and warfare.

Soil and Culture explores high culture and popular culture—from the paintings of Hieronymus Bosch to the films of Steve McQueen. It looks at the work of ancient societies and contemporary artists. Our contributors delve into the mind of Carl Jung and the bellies of soil eaters. They examine Chinese paintings, African mud cloths, Mayan rituals, Japanese films, French comic strips, and Russian poetry. Like the biodiversity that characterizes soils, we have gathered a diverse pool of contributors— poets, studio artists, gallery owners, farmers, philosophers, historians, geographers, geologists, as well as soil scientists.

We are soil scientists, and between the two of us, our work has spanned from the geochemistry of radioactive waste disposal to the transformations of soil organic matter in tropical areas. Our profession has a big tent, and as well as our specialization, most of us have enjoyed exploring the territories within that tent that are less familiar, as well as the surrounding biological, physical and earth science-realms beyond those tent walls. With *Soil and Culture*, we are now going further from familiar grounds—not on a path of dilution, but rather one of enrichment and new perspectives—to see the realm that we study through other people's eyes.

We hope that our readership will include our professional kin and neighbors. But we also hope to attract others beyond the neighborhood, and to further the possibilities of dialog beyond those boundaries in the future—soil scientists talking with and working with sculptors, philosophers, painters and environmental historians. The list of human endeavors touched by the soil is immense, and such non-traditional linkages would seem to be fertile grounds indeed. The soil is truly a wondrous zone—it has been called "the earth's ecstatic skin" (Logan 1995), and we close with just a few examples to whet the appetite of those still testing the waters—not with an all-encompassing discussion of the mega-issues such as food production and biodiversity, but with a few snapshots of how soils function, how they interact with various components of the environment, how soils have been perceived in various cultures, and how soils help shape elements of our existence:

- A network of polygonal desiccation cracks is commonly seen in fine-textured soils when they dry. The eye-catching landscapes they create have long attracted the attention of photographers, and the processes governing these crack patterns have recently become a focus of study of physicists who are using mechanical forces and electrical fields as experimental variables to modify these patterns (*Physics Today* 2007).
- Leaf-cutting ants in Louisiana excavate soils for the construction of below-ground chambers in which they grow fungi on the harvested plant material. Ant activity is often high near roads, and this has resulted in sinkholes that have swallowed cars (Hooper-Bùi and Seymour 2007).
- "Mud pickles" are a traditional food in Japan's Hokuriku District. Eggplants kept in the wetted, reddish-brown acidic soils, known as "aka-beto", for nine days show a brilliant cobalt blue color (Tazaki and Kurashige 2000).
- Animal blood has been mixed with soil for centuries, with the practice being investigated into the 20th century as a way to produce weather-resistant building materials (Winkler 1956). In the 16th century, King Agokoli, in what is today Togo, was said to have put spikes in the ground to cut the feet of pedestrians and thereby produce blood-soaked mud for building walls (Zimmerman 2005).
- On Pentecost Island in the South Pacific, "land divers"—young men who today leap from platforms as high as 35 meters with vines attached to their bodies in a ceremony coinciding with the ripening of the yam crop—must touch the soil with their shoulders in a fifteen-century-old ritual that is said to fertilize the soil (*Glimpse Quarterly* 2008). At modern Catholic churches in central Africa, soil is brought to the church by local farmers at planting time for blessing by the priest to ensure freedom from thorns and other hazards, and for high crop yields (Aguilar 2002).

- At a Catholic shrine (El Santuario de Chimayó) in New Mexico dating from the early 19th century and now widely known as the "Lourdes of America", nearly 300,000 pilgrims a year come to collect soil that is said to have healing powers when mixed with water and then eaten or rubbed on the skin (Rossbacher and Rhodes 2007).
- During the 19th century, the ends of limbs of trees outside the homes of African Americans were sometimes capped with bottles containing soil from a grave. These "bottle trees" were said to ward off evil spirits. The practice is said to have come from the Bakongo people of west-central Africa (Old City Cemetery exhibit, Lynchburg, Virginia, 2006).

These examples show the complexity of physical-, chemical- and biological-processes operating in soils, and how soils touch people's lives on a variety of levels—from the intellectual, to the pragmatic, to the spiritual. While scientists investigating soils can measure water infiltration pathways and rates, and use gas chromatography to investigate the release of volatile organic compounds, there is also a human component of such processes:

> "To dig out the earth was to discover unusual treasures like pieces of colored glass, snail shells, and shard of pottery. To water the earth and see how it absorbs the water we provide is also a unique experience. To walk on the earth after a rainstorm is to be in touch with absolute fulfillment: the earth, satisfied, floods us with its well-being, while its many aromas saturate the air and fill us with life-creating impulses."
>
> Reinaldo Arenas
> *Before Night Falls*

It is this interface of soil science and soil underfoot that our authors explore in *Soil and Culture*.

This book was neither conceived nor developed in a vacuum. It grew from a rich seedbed of interest in the heritage of soil science and the cultural importance of soil to society initiated in Commission 4.5 (History, philosophy, and sociology of soil science) of the International Union of Soil Sciences (http://www.iuss.org) by Dan Yaalon and Benno Warkentin. Their books (Yaalon and Berkowicz 1997; Warkentin 2006) continue to provide us guidance, and are indeed, lasting footprints in the soil.

Edward R. Landa
Christian Feller

References

Aguilar M (2002) Postcolonial African theology in Kabasele Lumbala. Theological Studies 63: 302-323.

Arenas R (1993) Before Night Falls, Viking Penguin, New York, 317 p.

Frodeman R (2003) Geo-Logic: Breaking ground between philosophy and the earth sciences. State University of New York Press, Albany; 159 p.

Glimpse Quarterly (2007) v. 7, no. 1 (Spring 2007) p. 13

Hooper-Bùi LM, Seymour MA (2007) Leaf-cutting ants. Louisiana Agriculture 50 (4): 18-19.

Logan WB (1995) Dirt: The Ecstatic Skin of the Earth. Riverhead Books; East Rutherford, NJ; 202 p.

Physics Today (2007) Desiccation cracks; v. 60 (9): 116.

Rossbacher LA, Rhodes DD (2007) The magic in dirt. Geotimes 52 (7: July) 60.

Science (2004) v. 304 (5677) special issue: Soils—The Final Frontier.

Tazaki K, Kurashige K (2000) Characteristics of clays “Aka-beto” for making mud-pickles with traditional way. Earth Science (Chikyu Kagaku) 54: 287-297 (*Japanese with English abstract*).

Warkentin BP (ed) [2006] Footprints in the Soil: People and ideas in soil history. Elsevier; Amsterdam; 548p.

Winkler EM (1956) The effect of blood on clays. Soil Science 82: 157-164.

Yaalon DH, Berkowicz S (eds) [1997] History of Soil Science: International perspectives. *Advances in Geoecology 29*. Catena Verlag GMBH; Reiskirchen, Germany; 438p.

Zimmerman A (2005) A German Alabama in Africa: The Tuskegee expedition to German Togo and the transnational origin of West African cotton growers. The American Historical Review 110(5): 1362-1398; available at http://www.historycooperative.org/journals/ahr/110.5/zimmerman.html accessed 29 October 2008.

Part I
Soil and the Visual Arts

Chapter 1
The Representation of Soil in the Western Art: From Genesis to Pedogenesis

Christian Feller, Lydie Chapuis-Lardy, and Fiorenzo Ugolini

Preliminary remark on the word *soil*

Different people attach different significance to soil. Certainly this is the case for farmers as compared to typical city dwellers, and of course, for soil scientists compared to most other scientists and non-scientists. Consequently, the meanings and uses of the term *soil* are numerous. For the purpose of this chapter, *soil* when written with a lowercase letter, will be referred to the surface of the landscape. *Soil*, when capitalised, will refer to the Earth's surface layer—the pedological object—that if exposed in a vertical cut constitutes a pedological profile; a portion of that surface layer may include rock. A very large vocabulary is used for different Soils of the world and varies with the classifications. In this text the word "Lithosols" (French classification, Duchaufour 1982) is quoted, it refers to young Soils, mainly constituted from rocks debris by physical and chemical weathering of the initial rock; they are called Leptosols in the IUSS-WRB classification (1998).

1.1 Introduction

It is widely accepted that humans always have considered the natural environment a subject of great interest to art. Early pictorial examples include cave paintings done by Cro-Magnon man during the Upper Palaeolithic, about 30-40,000 years ago. However the vision of Soil, as an independent work of art, is recent and still extremely rare in the world of painting. For many years, artists have depicted

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actual or imaginary landscapes from which the trained eye of a pedologist, agronomist or geographer can recognise a schematic view of what is commonly called soil. The recognition of Soil must be restricted to surficial features, because deep cuts that exhibit the complete view of a Soil profile, as conceived by the pedologist, are rarely available. In fact, the three-dimensional view of Soil is not readily apparent on the landscape. What is commonly seen in the cultivated fields is what the soil specialist calls the "plough layer", the upper 30 cm of Soil. This is the part that muddies your shoes and it is the reason why in English "soil" is called "dirt"! This image can hardly inspire an artist, except for a few such as Brueghel the Elder. What a Soil specialist, or more specifically a pedologist, has in mind is the Soil profile, a vertical cut at the surface of the earth that may show vivid, brilliant and contrasting colors. This is the sight that has inspired the abstract artists, so that Soil or soil has entered into art. In the scarce literature exclusively dedicated to soil and art, the work of the well-known Swiss-American pedologist Hans Jenny published in 1968 can serve as a basic reference to witness the evolution of the concept of soil in the figurative arts. Two other online publications are by Wessolek (http://www.kunstundboden.de/) and Hartemink (http://www.alfredhartemink.nl/various.htm).

While the lack of enthusiasm of artists for Soil is somewhat understandable, earth scientists in general, and soil scientists in particular, deeply regret that the Soil, as a physical entity in nature, is not given greater consideration within the entire education sector—from primary school to the college and university level. It is also regrettable that national and international policies do not systematically consider the soil as a natural resource to be protected; recently, however, some progress has been made at the European Union level, with discussion in progress on the "European Directive on Soils". A good indicator of the current policy and of people's perception of Soil is the absence of representation of soil in art, at least as a major focus in most artwork. There is also a lack of writing and documentation in art history on soil. As far as we know, no work dealing specifically with soil and art has previously been published, while there is abundant literature related to others natural objects and features, such as plants, terrestrial and aquatic animals, water, rocks and landscapes (Carli 1980). Famous artists of the past even specialized in such themes, like Brueghel de Velours with flowers and animals, or Paulus Potter with cows.

However, even if the Soil is not the chief subject of independent artwork, it is perceived and included as a part of the landscape. The depiction of Soil or soil can have either a symbolic or a realistic aspect in the context of religion, history, science, and art for a given historical period. This chapter will: (i) show representations of Soil or soil in Western Art from the Palaeolithic to the modern era, and (ii) show some recent artworks where the Soil is considered as the main subject, and has as its goal to present Soil in art from Genesis (the Bible) to Pedogenesis (the scientific approach of the Soil formation, from the Greek word *Pedon* meaning soil).

1.2 When Soil is Depicted by Chance in the Landscape: The Soil as a Surface

1.2.1 Prehistory and The Bible

Cave paintings were produced by upper-Palaeolithic artists about 40,000 years ago. These paintings are linked to Nature only through hunting or fishing scenes, with drawings of wild animals and sometimes with parts of human body, usually the hands. Scarcely represented are other natural subjects, such as plants, and features of the landscapes; to a larger extent, soils are neglected. However, one exception is observed on the web site "Memo, le site de l'histoire", section "les cultures lithiques européennes" [http://www.memo.fr/Article.asp?ID=PRE_PAL_005 (in French)]. It concerns the Magdalenian and Hamburgian time periods (about 15,000 BP). Artistic representations from these periods, at Teyjat and Le Chaffaud in France, and Pekárna in Moravia, depicted herds moving on a landscape including a sketch of the soil surface. However, even if these depictions of hunting activities were extremely realistic, the specialists all agree that they were more symbolic than functional. In other words, except for the Lithosol of the pedologists which is the rock itself (!), no soil is represented in the caves.

In the biblical Genesis story of the World creation, the whole of humanity is "soil". In fact, Adam (meaning "soil" in Hebrew) was created from red dust and returned back to it. In addition, Chouraqui (1989), in his literary translation of the Bible, called the first man "Adam the Glebe" (Glebe in the archaic sense of soil or earth, or dirt, mud or clay), so that the depiction of Adam can be considered as a "soil" representation. But without going so far back in history, it should be mentioned that numerous past engravings and paintings depicted Adam coming out of the soil. As descendants of Adam and Eve, people are "doubly soil", since Eve (meaning "life" in Hebrew) was made from Adam, who in turn was made from soil. Thus, Adam and Eve were soil and life.

1.2.2 Antiquity

The few extremely schematic representations inherited from the Assyrian civilisation (11^{th} to 7^{th} BC) depict natural scenes in which the soil surface is represented by schematic rocks and hillocks, drawn as shaped curves (Parot 1961, p. 40). Such representations are also observed throughout the Middle Ages (see below). Although it is known that the Greeks made decorative paintings, very few traces have been found, except for frescoes of Aegean art coming from Santorini (also known as Thera), dating from the 5^{th} century BC (Carli 1980, p. 21). Later on, paintings on pottery remains have aided in deciphering the Greek perception of soil. Landscape was seldom represented on the ceramic objects, so no soil appeared. In the representations of agriculture and the goddess Demeter (Ceres in the Roman mythology), the only symbols displayed were those of the plough and the grain bundle.

Wall paintings were widespread in the Roman civilisation as decorative art designed in a truly realistic style that would never be seen again until the Early Renaissance. Beyond the pleasure of the flesh depicted at Pompeii, Nature was represented through flowers and birds, as well as other animals. However, relatively few representations of the landscape stood the test of time (Carli 1980, pp. 12 and 24). They were probably simply lost. It cannot be imagined that the Roman society with its large concern for agriculture (*e.g.*, agronomic writings of Cato the Elder, Pliny the Elder, Varro, Columella, Virgil and others) failed to have any pictorial representation of the landscape.

1.2.3 The Middle Ages

The Middle Ages period produced many representations of rural landscapes that included the soil surface. However, religious or mythological works presented in this section need to be distinguished from the secular ones, which could be considered rather as technical and pre-scientific representations. These latter illustrations came either from treatises on agriculture or the "Très Riches Heures", a famous illuminated manuscript of the 15th century that will be discussed later in the chapter.

From the Byzantine period of the Early Middle Ages (6th century), many mosaics depicted rocky landscapes. Thus, at Ravenna in "Moses Receiving the Tablets of the Law on the Mount Sinai", the schematic forms anticipated what would appear in the mosaics or paintings of the Late Middle Ages (Carli 1980, pp. 28 and 32), with soil represented only with a single line, and rocks and/or hillocks drawn as shaped curves. However, between the 5th and 12th century, the representations of soil surface or landscapes are very often strongly schematised with undulating lines or hillocks, as in religious miniatures (Fig. 1.1). During the Middle Ages, under the influence of Christian cosmology, the landscape painting styles inherited from the Romans and the Byzantines moved to an oversimplification, as the World vision of that period became more spiritual. Actually, Nature cannot be objectively represented unless is freed from its magical aspect; we have to wait until the Renaissance before this occurs (Lenoble 1969).

During the Roman period, rocky landscapes were drawn in a way that today would be described as either infantile or stark modern (Carli 1980, p.36: Nepi, Fresco, late 11th century, the three horsemen of the Apocalypse). An example is a detail of a miniature by Stephanus Garcia in "The Apocalypse of Saint-Sever", a French Romanesque illuminated manuscript from the 11th century. In "The Fall of Hail, Fire and Blood On The Earth" soil and roots were simply depicted with an undulated line on a large yellow colored area (Carli 1980, p.35: The Apocalypse of Saint-Sever, a miniature from the collection of "Bibliothèque Nationale de France"). Until the 14th century, there was almost no realistic design in soil representation. Artwork from that period was meant to be read as a group of

Fig. 1.1 « Tentation du Christ » *(Temptation of the Christ),* 12th century, Anonymous, Bibliothèque nationale de France (Manuscrits occidentaux, Copte 13, fol. 9v), Paris, France (see as color plate following *Index*)

symbols, even representations that seemed realistic, such as animals on the decorated Romanesque capital letters written on parchment. This tradition has continued until the 16th century. Famous painters continued to depict soil symbolically in their work related to religion and mythology as in "Adam and Eve" and Cranach (1472-1553) in "Venus in a landscape" (Fig. 1.2).

1.2.4 The 14th Century and the Renaissance: Realism in Landscape and Soil Representations?

The Florentine painter Giotto (1266-1337) made a decisive break with the static Byzantine style, introducing realism. His paintings of rocky landscapes were among the first that included some perspective. Other Italian painters from the contemporary Giotto's Sienese school developed a similar naturalistic style: Duccio di Buoninsegna (1260-1318), Simone Martini (1284-1344) and the Lorenzetti Brothers (1280/1285-1348). Duccio, and more than a hundred years later, Andrea Mantegna (1431-1506) were leaders realistic representation of rocky landscapes. For that period, Ambrogio Lorenzetti's fresco "Good Government, Bad Government"

Fig. 1.2 « Vénus debout dans un paysage » *(Venus standing in a landscape), circa* 1529, Cranach the Elder, Musée du Louvre (Inv. 1180), Réunion des Musées Nationaux (RMN), Paris, France. Photo J.G. Berizzi (see as color plate following *Index*)

(1338) was a pioneering landscape representation, with striking realism in the depiction woody hills and fields surrounded by cypress trees.

A century later, realism in landscape painting was more fully expressed in the "Miraculous Draught of Fishes" (1444), a memorable work by Konrad Witz (1400-1446). With the artist-rendered landscape perfectly depicting the surroundings of Geneva, the painting is considered a landmark in the history of Western landscape painting. The representation of natural sceneries was afterwards more realistic and the soil surface was depicted with numerous forms. The landscape watercolors by Albrecht Dürer (1471-1528) became famous for their modernity, as did the summer and winter landscapes painted by Peter Brueghel the Elder (1527/28-1569). Dürer's paintings were imbued with realism when depicting still life rather than religious or mythological subjects, but like Cranach, his soil representation was elementary, as for example in “Adam and Eve” (1507) (http://en.wikipedia.org/wiki/Adam_and_Eve).

During the Renaissance, the soil, as a surface, is generally represented in a highly realistic way, even for symbolic and/or imaginary landscapes. Such realism sometimes allows one to discern the Soil profile with different colours given to the surface soil and to deep horizons, as, for example, in the works by Hans Memling (1430-1494) of “The Last Judgment”, *circa* 1470) (http://en.wikipedia.org/wiki/The_Last_Judgment_(Memling)) and Hieronymus Bosch with his “St John the Baptist” (*circa* 1500) (see section 1.3.2).

1.3 When Soil is Depicted by Choice in the Landscape: the Soil as a Profile

Three reasons motivated the representation of a soil profile:

– to explain the resurrection of the dead,
– to display the roots,
– to show ploughing.

1.3.1 Soil Profile for the Resurrection of the Dead

In the “Last Judgment” by Rogier Van der Weyden (1432) [Fig. 1.3, detail (a)] the resurrection of dead required the artist to show the Soil profile. The complete painting exhibits numerous such soil profiles. A detail [shown in Fig. 1.4, detail (b)] is so true to reality that it might be titled “Birth of a Pedologist”, and can be compared to a photograph of a desiccated and polygonally cracked clayey soil surface (see photo in lower right corner, Fig. 1.4).

1.3.2 Soil Profile for Displaying the Roots

In the paintings of the Renaissance, the representation of a ditch or a soil cut in a painting served very often as an excuse to picture roots. In the “St John the Baptist” by Hieronymus Bosch (1450-1516) the figure of St John leans towards a sharp vertical exposure of soil which includes a strange large root. (http://en.wikipedia.org/wiki/St._John_the_Baptist_in_the_Wilderness).

A large root also appears in “The Tempest” painted by Giorgione (1477/78-1510) (http://en.wikipedia.org/wiki/The_Tempest_(painting) and in “The Fall of Icarus” (Fig. 1.5) by Peter Brueghel the Elder (1525-1569), just at right and behind the

Fig. 1.3 Detail (a) from « Le Jugement Dernier » *(The Last Jugement), circa* 1432, Van der Weyden R., Musée Hôtel-Dieu, Hospices Civils de Beaune, Beaune, France (see as color plate following *Index*)

ploughman. These works were just some examples of paintings in which large forked roots were made evident.

The representation of roots was not due to chance, but chosen for its symbolic value. The root presented in detail in the foreground of the "St John the Baptist" painted by Bosch or "The Fall of Icarus" by Brueghel (Fig. 1.5), could be from the mandragora as suggested by Marjnissen and Ruyffelaere (1987). The roots of *mandragora* genus (mandrake) were extensively used in magic rituals.

The famous French dictionary Le Robert (1966, p. 250) gave the following definition (translated from French):

> Mandragora- n., Bot. A dicotyledonous plant, of the *Solanaceae*, family with generally forked roots showing a basic similarity to a doll (Fig. 1.6); it produces yellowish fruits with an unpleasant smelling and taste. *Mandragora officinarum* has narcotic and purgative

Fig. 1.4 Detail (b) from « Le Jugement Dernier » *(The Last Jugement), circa* 1432, Van der Weyden R., Musée Hôtel-Dieu, Hospices Civils de Beaune, Beaune, France. The box in the lower right corner is a photograph of a desiccated and polygonally cracked clayey soil surface (see as color plate following *Index*)

Fig. 1.5 « La chute d'Icare » *(The Fall of Icarus), circa* 1568, Bruegel P.I., Musées Royaux des Beaux-Arts de Belgique, Brussels, Belgium (Inv. 4030). Photo : RoScan, J. Geleyns (see as color plate following *Index*)

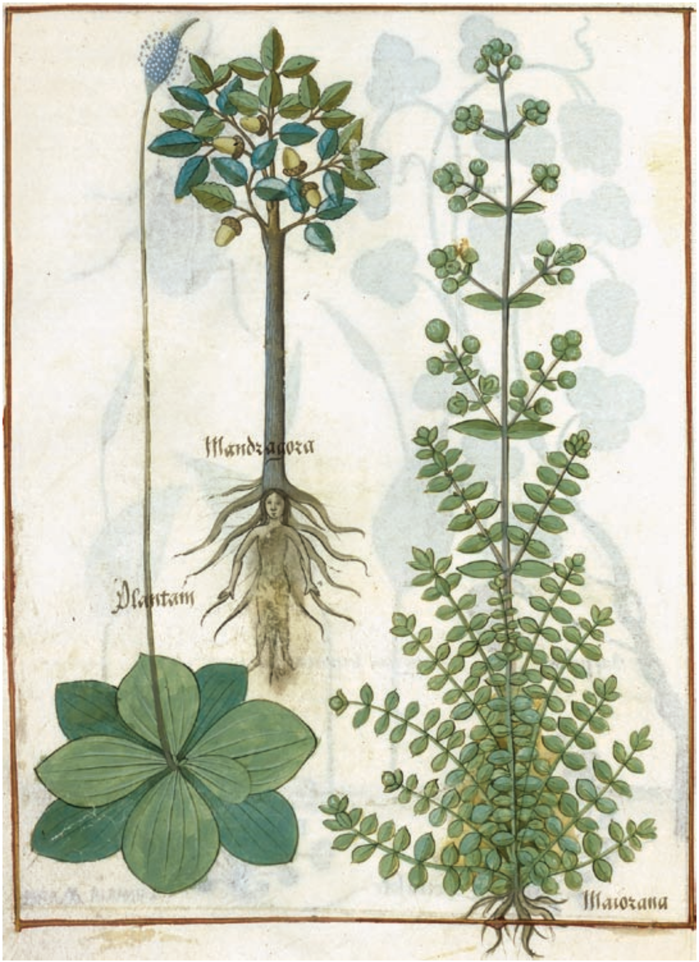

Fig. 1.6 « Flore Mandragore » *(Mandragora flora),* 15th century, Anonymous, Bibliothèque nationale de France (Manuscrits occidentaux français 12322, fol. 180v), Paris, France (see as color plate following *Index*)

> properties. Formerly used as a talisman when carved. (French) vernacular: Main-de-Gloire, aphrodisiac and fertility properties were assigned in past times to the mandragora…

"Transcendental Magic, its Doctrine and Ritual" is a treatise written in 1855 by French occultist Eliphas Levi; chapter 16 therein (Levi 1896; in English) is concerned with mandragora and can be consulted for more information on the subject.

The perception of mandragora as the subject of superstitions is presented in the "Encyclopédie des Symboles" (1996) through the following comments (translated from the French):

Mandragora is a plant with a high symbolic value, inspiring both fear and fascination. Its forked root which crudely resembles the human form has been credited since ancient times with a divine origin. It is considered as a universal medicine. The mandrake grows only at night, releasing some toxins (hyoscyamin, atropin, scolopolamin) with a narcotic effect. For this reason, the root was used by medieval witches to concoct potions, and it played a remarkable role in the occult practices. According to the legend, the root grew only beneath gallows trees as it was believed to be produced from the semen involuntarily ejaculated by a hanged man. It has to be gathered with high caution, and it was said that the mandrake gave forth an extremely piercing and fatal cry. It was uprooted, therefore, by a dog that died immediately after. During Antiquity, the mandrake was considered as one of the attributes of the sorceress Circe. The root was used by the Jews to overcome infertility. In general, mandrake was associated with black and supernatural forces that man would approach with many precautions.

The book by Jeanne Bourin (1990) on "The Rose and the Mandragora" provides additional information on the supernatural powers ascribed to mandragora. A history of the scientific properties and medical usage (pharmacology and anaesthetic effects) of mandrake was recently published by Hotton (2003).

The short book by Gustave Le Rouge (1912), one of the pioneers of science fiction, is a well-documented source, providing additional some useful information on beliefs about mandragora:

– The perfume of the mandragora's flowers can resulted to giddiness and a death-like sleep for anyone who inhaled it (p. 8), while the root has erotic and aphrodisiac virtues (p. 18).
– According to the alchemists and physicians of the Middle Ages, the first men were gigantic mandragores. In other words, humans originated from the mandragora that in an evolutionary sense, was a transition between the plant and animal (human) worlds.
– Snakes are especially loathed to mandragora, and its root can serve as an antidote for their bite; in fact, Eve could have used the mandragora as an antidote for the serpent (p. 22).
– Its root is thick, hairy and forked (p. 13), in a humanoid form;
– According to rabbinic traditions, the mandragora has grown in the Terrestrial Paradise in the shadow of the Tree of Knowledge of Good and Evil. Man has come from the silt of the Earth, so that he was probably molded at an early stage in a root.
– The fame of the mandragora reached its apogee during the Middle Ages. Just the mention of the *mandragora*'s name sent men trembling, and people avoided thinking of the "plant-human". When gathered, the root shrieked, and beads of blood squeezed out on its rootlets. But the one who got it became rich and happy forever…and stored it safely in a moneybox. Therefore, the mandragora became the source of a thriving trade. The mandrake could worth 2 to 3 times its weight in pure gold, especially if its form perfectly resembling the human body or attributes (p. 23-24).
– The mandragora was associated with Saturn (p. 29-30).
– It is associated with, or even mistaken for, other magical creatures such as "Teraphim", "Androids", "Golem", "Homunculus" (p. 35). The alchemists tried

to produce such viable creatures, and numerous narrations reported the production of an artificial humanoid in an alembic after mandrake distillation.

– Finally, many pages of Le Rouge's book (p. 117-144) described in detail the process of gathering the root beneath a gallows, either by the alchemist himself, or by a virgin. The young lady used her blond hairs to braid a rope that she tied to a dog's tail. She attached the other end to the plant stem, and then she scared the dog, so that in running away, it pulled out the sought-after root. The root was replanted in a red soil, and to maintain its vitality, it was doused with the blood of an animal whose sacrifice was dedicated to Saturn. Many details are presented above to underscore the importance of the symbolism surrounding the mandragora root, not just in the realm of magic and the hidden forces of nature, but also for the link to the Bible, and in particular to Genesis.

The mandragora was depicted in manuscript illustrations dating to the Middle Ages (Fig. 1.7). Inherent symbolism in paintings that pictured the mandrake is well established:

– It was associated with people closely related to the life of Jesus, such as in "The Worship of the Shepherds" by Peter Brueghel the Elder or in the "St John the

Fig. 1.7 « Récolte de la Mandragore » *(Mandragora harvesting),* 15th century, Anonymous, Bibliothèque nationale de France (Manuscrits occidentaux français 14969, fol. 61v), Paris, France (see as color plate following *Index*)

Baptist" by Hieronymus Bosch. In such cases, the mandrake might be the symbol of the fight against sin (antidote for the serpent). Moreover, the figures often wore red fabrics, the red being the colour referring to Adam and to Christ. For instance, during the mid 18th century, Johan Gottschalk Wallerius (1753) mentioned "Adamic Humus", meant to be refer to a reddish earth, in his "mineralogical" classification of "humus".

– The painted figures associated with mandrake are generally presented as having a melancholy temperament. Moreover, according to popular belief, "melancholia" is a disease affecting the artists. But the mandrake is also a symbol of Creation; its positive and negative aspects, as depicted in Bosch's "St John the Baptist", show that mandrake might be associated with both melancholia and the creation (in reference to Christ). As a last example, in his painting "The Magpie on the Gallows" (1568), Brueghel the Elder felt a need to depict a soil profile as well as a mandrake under the gallows (http://en.wikipedia.org/wiki/The_Magpie_on_the_Gallows).

In conclusion, the mandrake as an edaphic (and telluric) object is a significant symbol in the paintings of the Middle Ages and Early Renaissance. A more complete study of its symbolic importance in the arts is needed. That is also the case in literature; the mandrake is a central subject in the book "Vendredi et les limbes du Pacifique" by Michel Tournier (1972).

1.3.3 Soil Profile Displayed by the Ploughing

From the 14th and during the 15th century, especially in the "Très Riches Heures" and the "Calendriers" (calendars), we see representations of agricultural tasks and toils. Here, the soil is depicted with a clear concern of realism and technical specificity (Fig.1.8), including the tilling of the soil. Herein is an early artistic and technical representation of what agronomists and pedologists describe as an agricultural profile. In addition to this example, Peter Brueghel the Elder (1525/30-1569) might be newly cited for "The Fall of Icarus" (Fig. 1.5). Icarus is the tiny figure at the bottom on the right-hand corner, with only his legs visible, while in forefront of the canvas, attention is centered on the good Flemish ploughman tilling furrows. That was the triumph of daily working life over Utopia ("falling from the sky"). Beside the ploughman serving as a reference for agriculture, Brueghel the Elder did not fail to symbolize other of the world's riches—animal husbandry in the form of the sheepherder leaning on his staff, and the wealth of the sea shown in the form of a busy fisherman. It should be also noticed that forked roots are included in the agricultural profile—perhaps meant to be mandrake!

The symbolism associated with mandragora, in line with the heavenly utopia of Icarus, might be related to the earthly utopia that includes a desire for wealth and power. Nothing is better than a good ploughing to obtain resources from the Earth, rather than expecting those from Heaven. Icarus is seen flailing in the water, but is ignored. Other explanations were given, such as an illustration of an ancient Flemish proverb "No plough stands still because a man dies". Brueghel the Elder

Fig. 1.8 « Les Travailleurs » *(The Workers),* 1450, Maître de Talbot, Bibliothèque nationale de France (Manuscrits occidentaux français 126, fol. 61v), Paris, France (see as color plate following *Index*)

was surely not the first artist who depicted ploughing, but he probably was the first who did it in the non-technical context.

1.4 The soil by Hieronymus Bosch and his Disciples

The work of Hieronymus Bosch (*circa* 1450-1516) abounds in "earth" or "soil/Soil" representations. For instance in the triptych "The Temptation of St Anthony", bare soil represented a large proportion of the whole painting (Fig. 1.9). A detail of "The Temptation of St Anthony" shows a humanoid creature as a mixture of soil (a hill), man and plant (Fig. 1.10). The erotic symbolism of such a creature is quite evident. The soil in Bosch's work was not only represented as a surface, but often either as a Soil profile in a slope cut (see above), or in adobes that are associated with thatched roofs. Here he emphasized the decomposition and decay of the sides of huts, in the same way that plant debris is decomposing on the top of the soil (Fig.1.10). The whole of Bosch's work is influenced by "decomposition" and soil depiction contributes to this process. The work of Bosch would deserve an independent study of his "soil", or "Soil" vision.

Fig. 1.9 Central panel of « Tentações de St. Antão » *(The temptations of St Anthony), circa* 1500, Hieronymus Bosch (1505-1506), Museu Nacional de Arte Antigua, Divisão de Documentação Fotográfica - Instituto dos Museos e da Conservação, Madrid, Spain, (Inv. 1498 Pint), Photo José Pessoa (see as color plate following *Index*)

As Hieronymus Bosch is said to have been an inspiration for the surrealist movement of the twentieth century, some Surrealists might be considered as his disciples, not only by the "fantasy" genre they shared, but also throughout their vision of soil or earth's uses. For instance, in Salvador Dalí's work, in the "Soft Construction with Boiled Beans": Premonition of Civil War" (1936. Oil on canvas. Museum of Art, Philadelphia; (http://www.philamuseum.org/collections/permanent/51315.html), or in "The Spectre of Sex-Appeal" (1934. Oil on canvas. Gala-Salvador Dali Foundation, Figueras, Spain; (http://www.salvador-dali.org/eng/cat1104-2/finici.htm), or also in the "Metamorphosis_of_Narcissus" (http://upload.wikimedia.org/wikipedia/en/2/21/Metamorphosis_of_Narcissus.jpg).

Other examples are the "Extinction of Useless Lights" ("Extinction des lumières inutiles") by Yves Tanguy (1927. Oil on canvas) and "The Magician" by Jean Dubuffet (1954. Slag and roots, including slag base), both on view at The Museum of Modern Arts, New York (http://www.moma.org/collection).

Fig. 1.10 Detail of « Tentações de St. Antão » *(The temptations of St Anthony),* Hieronymus Bosch (1505-1506), Museu Nacional de Arte Antigua, Divisão de Documentação Fotográfica - Instituto dos Museos e da Conservação, Madrid, Spain(Inv. 1498 Pint), Photo José Pessoa (see as color plate following *Index*)

1.5 The Soil, Yesterday and Today

Paintings during the 16th, 17th and 18th centuries reached realistic excellence in representing the soil surface that could never be equaled. During this period and until the 20th century, artists have not considered the Soil as a chief subject, not even the Impressionists who have rendered it only as a landscape component.

During the 20th century, the soil surface was well represented in the Land Art movement [see chapters 4 (Toland and Wessolek) and 10 (Lafon), *this volume*].

The early scientific depiction of Soil in painting dated from the beginning of the 20th century, either prepared for educational exhibitions, generally as canvases representing different types of Soil, or as splendid illustrations in books on Soil. We explore here the interface between Science and Art. In a recent art exhibition on “The Earth” (2005, Uzès, France), C. Feller presented, without any technical explanation, two oil canvases (60 x100 cm) representing soil profiles; these canvases were previously published as illustrations in the Soil science book of

Demolon (1952) and were anonymously displayed in the 1940's for a Soil science course or exhibition. The 2005 exhibition visitors generally found these canvases splendid, and considered these paintings solely as contemporary art—never thinking of them as scientific illustrations.

Today, Soil is depicted as an object *per se* especially by some naturalists, agronomists, pedologists and others who have developed a substantial artistic talent besides their scientist's profession. Many works of contemporary artists - paintings, sculptures, performances, or art installations - centered on the Soil can be seen at http://www.kunstundboden.de/.

The World Soil Museum at the International Soil Reference Information Centre in Wageningen, the Nethererlands, displays many attractive renditions of pedological landscapes, unfortunately from anonymous artists. Among the works of our French scientific colleagues that can be cited: "Le Sol" (*The Soil*; Fig. 1.11) by Guy Paillotin, perpetual secretary of the French Academy of Agriculture, or "Tempête sur Jupiter" (*Tempest on Jupiter*; Fig. 1.12) by pedologist/mineralogist from INRA (the French National Institute for Agricultural Research) Folkert Van Oort who was able to create compositions with Soil collected in the forests of Orleans (or on Jupiter?). Before ending this chapter one must mention an "artist's book" by Martine Lafon called "Des taches et des concrétions…le sol est bourré de complexes" (*Stains and concretions… the soil is full of complexes*) (Lafon and Feller 2004; see illustrations in Lafon's chapter (10), *this volume*) that consisted of a transparent glass cylinder containing a rolled booklet made with Japanese paper. The artist engraved the glass cylinder (that represents a core) with an imaginary Soil profile, as well as creating etchings in the booklet that depict Soil features; the booklet's text was by C. Feller.

Of course, the representation of Soil in contemporary art cannot escape abstraction. In the near future, one can expect artists working with scientists will create computer-generated images of soil based on mathematical models aimed at depicting Soil processes. Hence, Science meets Contemporary Art. The abstraction of Nature is an old idea based on the ancient atomist philosophy of nature founded by Democritus (*circa* 460-370 BC). He highlighted the distinction between Reality and Appearance, because all reliable knowledge is based on this distinction (Lenoble 1969). To atomize Nature—this is what has been done for a century in Art as in Sciences, is it not so?

1.6 Conclusion

Our look at soil or Soil in art confirmed that in Western culture, most artists did not view soil as the complex and subtly beautiful medium that holds the interest of agronomists or pedologists. It was usually only considered as a surface. The below-ground layers were generally not represented, while rocks and other natural objects fascinated artists. However, as underlined by Jenny (1968) in his paper's conclusion: *"Whoever said that soils lack beauty is behind the times. Soil in art has arrived. It is an enrichment of art that is here to stay"*.

Fig. 1.11 « Le Sol » *(The Soil),* ca 1985. Oil on canvas. Guy Paillotin, Académie d'Agriculture de France. Private collection. With permission of the artist (see as color plate following *Index*)

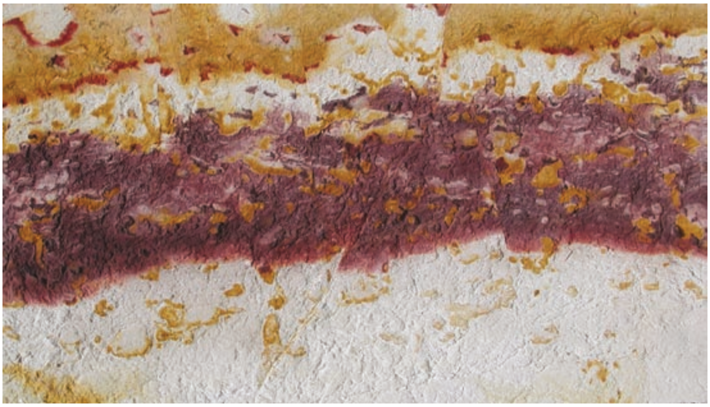

Fig. 1.12 « Tempête sur Jupiter » *(Tempest on Jupiter)), circa* 2000. Soil material attached to canvas,Van Oort F., INRA. Private collection. With permission of the artist (see as color plate following *Index*)

Finally, it is predicted that we will increasingly see more artists and Soil scientists interacting at the interface of their expertise and consciousness, to produce images and objects that will capture the attention of audiences. If a successful exhibition on "The Soil" could be hosted by the Grand Palais in Paris, or the Museum of Modern Art in New York, Soil science texts would surely become best-sellers the day after the opening reception!

Never stop dreaming…

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References

Bourin J (1990) La rose et la mandragore. Plantes et jardins médiévaux. Fr. Bourin ed., 166 p.

Carli E (1980) Le paysage dans l'art. Traduit de l'italien par M. Orcel. Nathan, Paris, 319 p.

Chouraqui A (1989) La Bible. 3ème édition. Desclée de Brouwer, Paris, 2430 p.

Demolon Ph (1952). Principes d'agronomie. Tome 1. Dynamique du sol, 5ème ed., Dunod, Paris, 520 p.

Duchaufour P (1982) Pedology. Transl. T.R. Paton. George Allen & Unwin, London, 448 p.

Encyclopédie des Symboles, 1996. Article « Mandragore », p. 392. traduit de l'allemand par F. Périgaut, G. Marie et A. Tondat. Edition française établie sous la direction de M. Cazenave. Librairie Générale Française, Pochothèque, Livre de Poche, 818 p.

Hotton J (2003) Histoire de l'Anesthésie. La mandragore magique. Cahiers Anesthesiologie 51 (4): 331-334.

IUSS Working Group WRB. 2006. World reference base for soil resources 2006. 2nd edition. World Soil Resources Reports No. 103. FAO, Rome.

Jenny H (1968) The image of soil in landscape art, old and new. *In* "Study Week on Organic Matter and Soil Fertility", Pontificiae Academiae Scientarium Scripta Varia 32, pp. 947-979, North Holland Publ. Co and Wiley Interscience Division, Amsterdam, New York.

Lafon M, Feller C (2004) Des taches et des concrétions. Le sol est bourré de complexes. Livre d'artiste. Impr. Simaco, Paris, Gravure Ateliet Post-Rodo, Uzès, 5 p.

Lenoble R (1969) Histoire de l'idée de nature. Albin Michel éd., Paris, 446 p.

Levi E (1896 and 1998) Transcendental Magic its Doctrine and Ritual by Eliphas Levi (translated by Arthur Edward Waite). Kessinger Publishing Co., Reprint edition (1 Feb 1998), Paperback: 448 p.

Le Rouge G (1912) La mandragore magique. Teraphim – Golem – Androides – Homoncules. H. Daragon ed., Paris, 171 p.

Marijnissen R H, Ruyfellaere P (1987) Jérome Bosch. Tout l'oeuvre peint et dessiné. Fonds Mercator. Albin Michel, Paris, Anvers, 513 p.

Parrot A (1961) ASSUR. Univers des Formes, coll. Dirigée par A. Malraux et G. Salles. NRF Gallimard, Paris, 380 p.

Robert Le (1966) Article « Mandragore », p. 250. Dictionnaire alphabétique et analogique de la Langue Française, Tome 4 (KLMNOParp). Société du Nouveau Littré, Le Robert, Paris.

Tournier M (1972) Vendredi ou les limbes du Pacifique. Postface de Gilles Deleuze. Edition revue et augmentée. Gallimard, Paris, 281 p.

Wallerius JG (1753) Minéralogie ou description générale des substances du règne minéral. Durand Pissot, Paris, 2 Tomes (569 p., 256 p.) et Suite (284 p.).

Chapter 2
Deforestation and Erosion Captured in Historical Art of the Pearl River Delta Region, China*

Walter E. Parham

2.1 Introduction

History tells us that South China and the Pearl River Delta region (Fig. 2.1) in particular began to suffer environmental damage about 1000 years ago when large numbers of people migrated from north to south (Marks 1998; Parham et al. 1993). As agriculture expanded, the loss of vegetation caused destruction of wildlife habitats for large animals like elephants, tigers, deer, and buffalo. Forest vegetation was removed for a variety of reasons: to provide firewood, building materials, and to make charcoal; to clear land for farming and settlements; to provide safety from fire, wild animals, snakes, and bandits (Grant 1960; Marks 1998; and Parham et al. 1993). Elephants disappeared from the region in about 1400 primarily because of forest destruction (Marks 1998; Elvin 2004). Tigers persisted until the early 19th century when their forest habitat became highly fragmented (Marks 1998) and the number of tigers has continued to decline since then.

Geologically, the region is composed largely of granite and volcanic rock, chemical weathering of the rocks reaches depths of 60 to 80 meters, soil fertility is poor, and grass fires and landslides are common. Once deforested, the land eroded easily under high rainfall (Parham 1969, 1975, 1997; Parham et al. 1993). Much of the land in the Pearl River Delta region is still in a damaged and degraded state.

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* **Note to reader:**

The original, longer version of this paper which contains considerably more relevant art work is entitled *"Art and the Pearl River Delta Environment"*. The paper was originally presented at the *International Symposium on Environment and Society in Chinese History*, Center for Chinese Social History, Nankai University, Tianjin, PRC, August 17–19, 2005; and can be viewed at http://**www.fas.org/blog/china**. Cited 7 Jan 2009. The reader may wish to look to the longer version for further evidence to support the arguments presented in the narrative form in this shorter version.

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Fig. 2.1 Map of the Pearl River Delta Region, China

It is likely that much of the land's appearance is a result of past, damaging land-use practices. Biological and physical scientists who study this region recognize clues that support the story of past, widespread, damage to the land, vegetation, and wildlife. Nevertheless, we can only imagine how the appearance of the land changed as human activities altered the land and its vegetation. It is evident from recent studies (Parham et al. 1993) that land abuse continued to have additional adverse affects over the last 50 years. World War II, China's Great Leap Forward and Cultural Revolution, coupled with the region's booming economic development, certainly are recognized as contributing factors to further environmental damage. Nationwide, natural ecosystems are degrading, habitat loss has accelerated, and the number of native species is decreasing (SEPA 2002).

Western and Chinese artists who frequented the Pearl River Delta region have recorded the damage in numerous paintings and drawings. These works of art are one way to look back into the past to examine how the landscape appeared some 200 years ago. Other researchers have tried similar techniques to link art and the environment. For example, one researcher, who was interested in whether or not cloud cover increased during the Little Ice Age of 1450 to 1850, examined thousands of art works painted during that period in European and American museums (Fagan 2000). He recorded the type and amount of cloud cover in each painting and showed statistically that cloud cover was significantly more common over Europe during the Little Ice Age than earlier. His results show how art and environmental change can be linked effectively.

Environmental damage is also documented in some of the earliest photographs taken in China. These only date back to 1844; a few daguerreotype photographs of Hong Kong (Hacker 1997) show deforestation and erosion damage in the 1860s. Many early photographs were taken in the vicinity of the "treaty ports", *i.e*., those ports established at the end of the Opium Wars for foreign trade. Finding non-inventoried China photographs today requires a massive amount of research time, a factor that discourages such an approach (Thiriez 2000).

2.2 Background

While visiting local Hong Kong art museums, I saw paintings of the Pearl River Delta region by Western and Chinese artists. Many showed that the artists paid careful attention to land-form detail. It seemed possible to extend our visual knowledge of the Delta region's land surface back in time using these early art works. The goal of this study is to answer these questions:

1. Did the Western and Chinese artists accurately represent the Chinese landscape in the 1700s and 1800s?
2. What does art tell us about the past condition of the land and wildlife habitats in the Pearl River Delta region?
3. What can we learn from historic art about the region's geology and geomorphology?

2.3 Source material

A recent publication (Sargent, and Palmer 1996) which combines much of the Asian Export Art (art produced in the Hong Kong region during the 1800s primarily for export) that is held by the Hong Kong Museum of Art, (http://www.lcsd.gov.hk/CE/Museum/Arts/english/e1_copyright.html; Cited 7 Jan 2009) as well as that of the Peabody Essex Museum (http://www.pem.org; Cited 7 Jan 2009) in Salem, Massachusetts, contains a number of examples in which geological and geomorphological features are well depicted, and where the general state of the land is recorded. The Wason Collection of East Asia at Cornell University Library (http:////www.explore.cornell.edu/; Cited 7 Jan 2009) also is a source for additional useful images. In addition, Asian Export Art dealers have Internet sites showing relevant Chinese and Western art.

Some of the first European artists who visited the Pearl River Delta on trading ships and naval vessels sketched and painted the local landscapes. These artists, in the process, passed some of their skills on to local Chinese artists who later incorporated their new skills in their subsequent artwork. The blending of Chinese art techniques with those from the West is evidenced in Asian Export Art, an important new business activity at the time (Sargent, and Palmer 1996). Many of the artists noted as "Anonymous" in the images of this paper probably were local Chinese artists.

Chinese art lacked perspective, a technique of geometry that local artists learned from Western artists starting about 1750 (Sargent, and Palmer 1996). "Truth" and "accuracy" in many Chinese paintings from the Pearl River delta region became established in drawings and paintings around 1788 (Sargent and Palmer (1996). Interestingly, Elvin (2004) notes that Chinese maps also improved their precision by 1850.

2.4 Method

I examined a large part of the 1200 image historical collection of the Hong Kong Museum of Art (HKMA) available to the public on the Internet. Some of these art works from the collection are referenced in this paper. In addition, I searched the literature for collections of old-photographs from Hong Kong and South China without a great deal of success. Numerous collections of Asian art also exist in American universities and museums, but only part of their collections are available today on the Internet.

2.5 Environmental assessment of historical art

2.5.1 Past condition of the land and wildlife habitats

Dinghushan (Fig. 2.2) is a UNESCO Man and the Biosphere Reserve situated 86 km west of Guangzhou (Kong et al. 1993). This 900 hectare remnant of original tropical evergreen, broad-leaf forest is at least 400 years old and is all that remains today of a forest that originally covered much of Guangdong Province and adjacent areas. The forest was the home of the elephant until 1400, and the South China tiger until the early 19th century. The picture of Dinghushan's forest cover (Fig. 2.2) stands in stark contrast to a 1793 sketch by a British naval officer which shows that in the Pearl River area grasslands prevailed, forest cover had been destroyed, and that large landslides were prominent.

Lan Tau Island, Hong Kong's largest island lying about 20 km further south, still exhibits an extensive grassland cover and an absence of its original forest. Fires commonly sweep across such grasslands in the fall requiring as much as 5–10 years for the vegetation to grow back to its pre-fire condition. These fires, mostly caused by man, continue to threaten wildlife habitats in the region today. About 20 km east of Lan Tau Island in eastern Hong Kong, Murdoch Bruce's painting of 1846 (Fig. 2.3) shows grasslands spreading far across the

Fig. 2.2 The moist, tropical, broad-leaf forest at Dinghushan is at least 400 years old, and once provided habitat for the South China Tiger *(Photo by W. Parham, 2003)* (see as color plate following *Index*)

Fig. 2.3 Eroded and deforested Hong Kong mainland, 1846 (Murdoch Bruce, Reproduced here by permission of the Hong Kong Museum of Art Collection) (see as color plate following *Index*)

land, as well as deep erosion scars. Two paintings (not shown here) of the north side of Hong Kong Island, probably by two different Chinese artists, are similar in that they show the deeply eroded mountain side, the general lack of forest cover, and the presence of some grass cover. Opposite Hong Kong Island on the mainland, the artist John Collins shows Kowloon, where Fort Victoria once existed. Arrows mark barren and treeless land in 1841 (Fig. 2.4). The view from

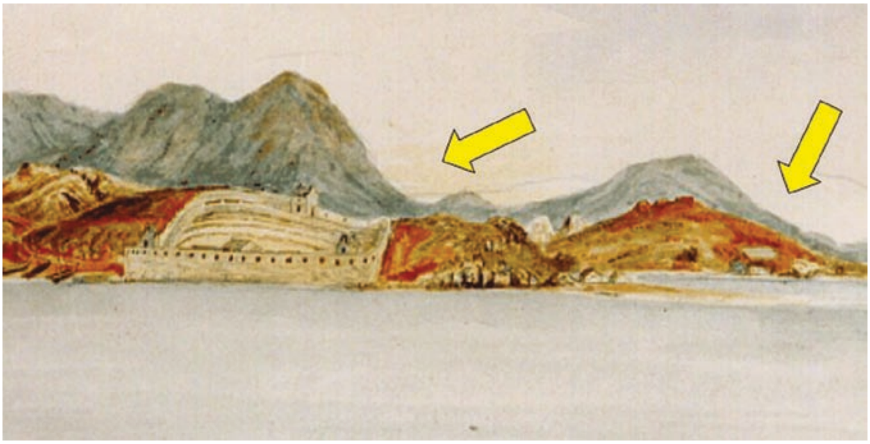

Fig. 2.4 Barren Kowloon, Hong Kong, 1841 (*John H. Collins, Reproduced here by permission of the Hong Kong Museum of Art Collection*) (see as color plate following *Index*)

Fig. 2.5 Deforested western Hong Kong and adjacent islands, 1860s (*Edward Hildebrandt, Reproduced here by permission of the Hong Kong Museum of Art Collection*) (see as color plate following *Index*)

western Hong Kong Island with its outlying islands (Fig. 2.5) painted by Edward Hildebrandt in the 1860s, also shows a badly damaged landscape with few trees anywhere.

Closer views of the land show severe damage. For example, the artist William Lodder in 1833–57 painted hill-side tombs which people dug by hand into Hong Kong's deeply weathered granite, surrounded by a scalped or denuded landscape with vegetation consisting of no more than a few bushes hidden in small depressions. Such sites composed of weathered granite are subject to severe erosion

Fig. 2.6 Eroded soil showing tree roots and surrounding barren land, 1838 (*Auguste Borget, Reproduced here by permission of the Hong Kong Museum of Art Collection*) (see as color plate following *Index*)

during the rainy season and, consequently, it is difficult for vegetation to reestablish itself. Similarly, an Auguste Borget 1838 painting shows the north side of Hong Kong Island, where either soil erosion has exposed a tree's root system or that the roots shown are natural for a banyan tree (Fig. 2.6). However, all of the tree's surrounding soil-surfaces are barren. The eroded south side of Hong Kong island shown in an 1840s Edward Hildebrandt, is deforested and deeply eroded exposing large, granite core-stones (see section below). He shows small patches of grass cover scattered over the eroded weathered granite. In another view of the island's south side, the artist William Lodder in 1833–57 shows some orderly replanting of trees near sea level which may be a plantation. Nevertheless, high on the hills, a barren landscape prevails.

2.5.2 *Geology and geomorphology*

Historical art depicting the Pearl River Delta region provides several geological and geomorphological applications such as determining the type of local bedrock, intensity of rock weathering, and the status of soil erosion. Certain landforms, such as *inselbergs*, core stones, and *beng-gang* erosion (a Chinese term roughly meaning *fallen hill*), can be identified readily from the art of the late 1700s and most of the 1800s. These geological features help to identify the composition of the underlying bedrock. The features that the artists depicted pre-date the first rudimentary geological description of Hong Kong in 1865 and Hong Kong Island's first geological map in 1880 (Davis, 1953). Nevertheless, it is clear that the art, in large part, is an accurate representation of what Hong Kong's modern geological maps show.

2.5.3 Pearl River inselberg island

Situated in the Pearl River near Humen, is a rounded, dome-shaped island that geologists refer to as an *inselberg*. This particular granite *inselberg* is formed from concentric layers of rock having an onion-like structure (Fig. 2.7). As layers of the granite exfoliate or fall away during the weathering process, the island continues to maintain its smooth, dome-like form (Fairbridge, 1968). The *inselberg* island is easily distinguished in several pieces of the historic art and is not likely to be confused with the more common island forms that are irregular, eroded rock remnants lacking such a structure.

The *inselberg* island is situated where the Pearl River narrows rapidly as one travels from Canton (Guangzhou) to the South China Sea, an area referred to as *Bocca Tigris*, the "tiger's mouth". The *Bocca Tigris* was the historical site of several old Chinese forts that were important during the Opium Wars, and was apparently a favorite place for artists to draw or paint pictures of the islands and of the *inselberg* island in particular. John Meares' sketch of the *inselberg* island in 1794 (Fig. 2.8) shows some vertical exaggeration but the island still is recognizable. Six other paintings of the Hong Kong Museum of Art's historical collection covering a 53-year time span also show the presence of the *inselberg*. In these paintings the artist's used the *inselberg* island as the focal point. All of the *inselberg* island images are recognizable and have common features. Other than some vertical exaggeration in a few works, the likenesses are reasonably similar. The artists

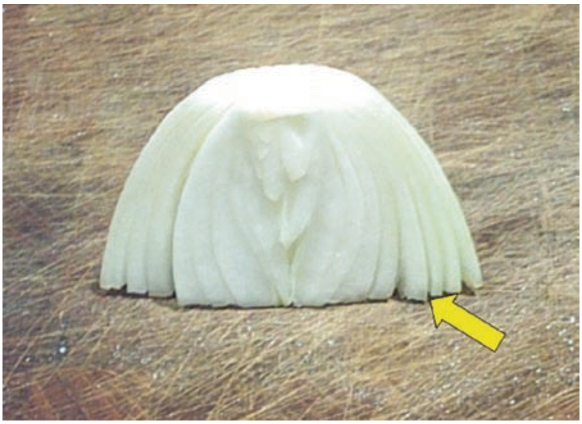

Fig. 2.7 Generalized layered-model of an *inselberg* island (*Photo by W. Parham*)

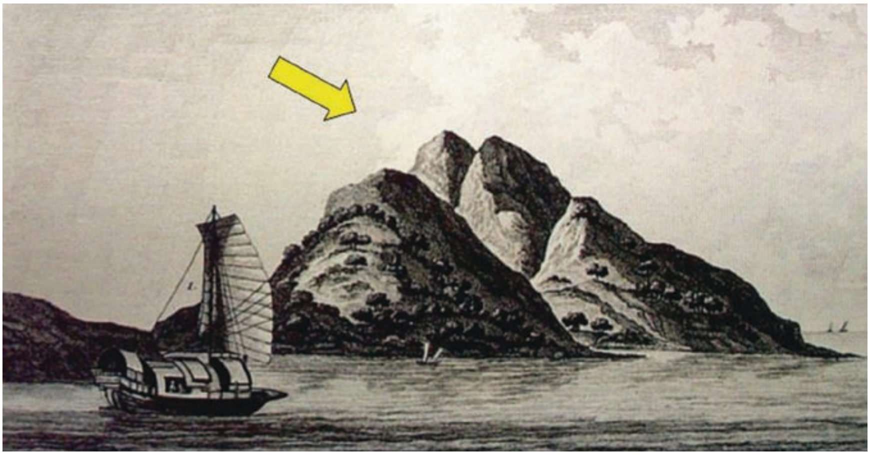

Fig. 2.8 Pearl River *inselberg* island, 1794 (John Meares, Reproduced here by permission of the *Hong Kong Museum of Art Collection*)

basically produced images of what they saw rather than what they imagined. Though they almost assuredly lacked geological training, the images they produced are useful to the geologist and geomorphologist in reconstructing the history of the landscapes' formation.

2.5.4 Core stones

Core-stone formation is common where granite is subjected to chemical weathering in the wet tropics. Weathering along joint planes in granite leaves adjacent rock unaltered. Once the vegetative cover is removed, erosion carries away the weathered material, leaving a collection of fresh core stones as a lag deposit on the land's surface resembling a pile of sugar cubes (Fig. 2.9). During periods of heavy rains, the core stones, some as large as automobiles, slide or roll down hills threatening people and man-made structures. Core stones are common in the Pearl River Delta region, and show up in many historical drawings and paintings from the region. A sketch of William Lodder's completed during 1833–57 of a section of a village shoreline shows an assemblage of large core stones along the shore as well as some smaller ones on the barren land of the hills above. One of the first daguerreotype photographs taken in Hong Kong in the 1860s (Fig. 2.10) shows the entire hillside behind a temple covered with core stones of various sizes.

Core stones form more readily in areas where granite is the bedrock and are less likely to form from volcanic rocks that have a different texture and structure. Modern geological maps indicate that this hill on which the temple is sited is

Fig. 2.9 Generalized model of core-stone formation *(Photo by W. Parham)*

Fig. 2.10 Daguerreotype of Hong Kong core stones, 1860s (*Reproduced here by permission of the Wattis Fine Arts Collection, Hong Kong*)

composed of granite (Allen and Stephens 1971). The Chinese artist Sunqua may have painted this picture of Hong Kong in 1854 (Fig. 2.11). The left half of the painting of Hong Kong Island shows a surface covered with numerous core stones. The right half, on the other hand, shows very few. Geological maps (Allen and Stephens 1971) show that the left half of the island is composed of

Fig. 2.11 Numerous core stones on granite area of Hong Kong Island, 1854 (*Sunqua (?), Reproduced here by permission of the Hong Kong Museum of Art Collection*)

granite as is the lower right-hand part, and the upper right half is composed of volcanic rocks.

2.5.5 Beng-gang gully erosion

Beng-gang is the Chinese name for the horseshoe-shaped gully erosion features common in deeply weathered granite areas of South China. Typically, the gully has a steep back wall and a narrow outlet. *Beng-gang* gully erosion can develop rapidly on hill slopes during heavy rains where vegetation is sparse or absent. Chinese researchers (*in* Parham et al., 1993) found that a combination of biological and engineering techniques works effectively to halt the *beng-gang* erosion process.

The artist Murdoch Bruce's 1846 Hong Kong painting shows well-developed *beng-gang* gully erosion in grass-covered, weathered-granite hills in his painting's background and core stones on some hill tops. Lt. Martin, a navy artist, shows in 1847 the advanced *beng-gang* erosion in grass-covered hills at Annunghoi, within a Chinese fort at *Bocca Tigris* (Fig. 2.12). William Lodder during 1833–57 sketched and painted two overlapping sea views of a particular locality. His sketch shows advanced *beng-gang* erosion cutting through a low hill. His painting of the same locality probably painted earlier or later than his sketch shows the same features. Both images show badly eroded hills, some core stones, and a devastated zone above the painting's shoreline. Lodder also sketched treeless Green Island in 1857 where evidence of *beng-gang* erosion is evident. Geologic maps verify that the island is at least half granite (Allen and Stephens 1971). Another 1857 Lodder sketch of a sampan at West Point, Hong

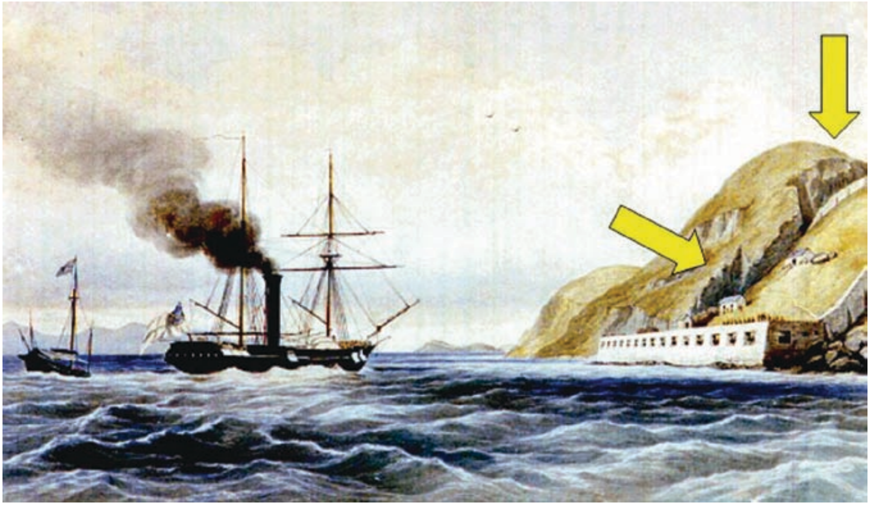

Fig. 2.12 *Beng-gang* gulley erosion, Annunghoi, Pearl River, 1847 (*Lt. Martin, Reproduced here by permission of the Hong Kong Museum of Art Collection*)

Kong shows barren, deeply weathered granitic land with *beng-gang* erosion and some scattered core stones.

2.6 Conclusions

- Much of the artwork produced by Western and Chinese artists about 150–200 years ago accurately represented the Chinese landscape.
- The land and the wildlife habitats were already severely damaged in the 1700s and 1800s.
- Geological information inadvertently recorded in historic art matches current geological knowledge.

Considerable agreement exists among historical art works produced by different artists over 200 years regarding the condition of the environment of the Pearl River Delta region. The artists painted what they saw even though they probably knew little of the scientific significance of the land features they recorded. The Western and Chinese artists show that the land was largely deforested and badly eroded 200 years ago. The condition of land then and now appears to be similar even though efforts have been made in some areas in recent years to restore tree cover. It is unlikely that there were extensive, undamaged wildlife habitats that remained in this region 200 years ago. Habitat destruction in the Pearl River Delta region depicted in the cited historical art works, combined with continued hunting and trapping of native prey species, may already have led to the extinction of the South China tiger.

The estimated tiger population in the wild was 4000 in 1949, 150–200 in 1981–82, and 30–50 in 1991, with about 50 more housed in zoos (Koehler, 1991). Recent, broad, field surveys of South China sites where the tiger should most likely live, show nothing but its absence (Tilson, 2004).

Even though the artists probably were not trained in geology, they demonstrated keen observations in their art works related to the nature of the land surface. Early geologists visiting the Pearl River Delta region could have benefited or perhaps even did from examining the local art of that time. Their assessment of the correctness of the artists' observations regarding the state of the land could have provided useful information early on about the bedrock geology, and the weathering and erosion history of the region. The presence of core stones, core-stone distributions, wide-spread *beng-gang* gully erosion, the presence of tombs dug by hand into deeply weathered bedrock, prominent exposure of tree roots, for example, are all important clues in reconstructing the region's geological history and geological processes affecting the region.

Using art to look back 200 years to determine the land's condition in the Pearl River Delta region may seem somewhat difficult. However, determining what the condition of the delta region's land will be in just the next 15 or 20 years may be equally difficult. Today, the Pearl River Delta economic zone accounts for about one-third of China's total trade and land development is booming here. Nevertheless, it is likely that today's artists will continue to record the rapidly moving land changes for us, and that within these images, they will record important information useful to future soil scientists, ecologists, geologists, and geographers.

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The Hong Kong Museum of Art, Historical Collection

Wattis Fine Art, Hong Kong

References

Allen PM, Stephens EA (1971) Report on the geological survey of Hong Kong, JR Lee, Government Printer at the Government Press, Hong Kong

Davis SG (1953) The geology of Hong Kong, The Government Printer, Hong Kong

Elvin M (2004) The retreat of the elephants, Yale Univ. Press, New Haven, CT

Fagan B (2000) The Little Ice Age, Basic Books, New York

Fairbridge RW (1968) The encyclopedia of geomorphology, Reinhold Book Corp., New York

Grant CJ (1960) Soils and agriculture of Hong Kong, Government Printer at the Government Press, Hong Kong

Hacker A (1997) Hong Kong: A rare photographic record of the 1860s, Printer's Circle Ltd., Hong Kong

Koehler GM (1991) Survey of remaining wild population of South China tiger, WWF Project 4512/China, Final Project Report

Kong G, Liang C, Wu H, Huang Z (1993) Dinghushan Biosphere Reserve: ecological research history and perspective, Science Press, Beijing

Marks R B (1998) Tigers, rice, silk, and silt, Cambridge University Press, New York

Parham WE (1969) Halloysite-rich tropical weathering products of Hong Kong, Proc. Internat. Clay Conf., Tokyo, *ed*. L. Heller, Israel Univ. Press, Jerusalem, 403–416

Parham WE (1975) Geological controls on environmental problems of developing countries of the humid tropics, World Population Society (Abst.), p. 35

Parham WE (1997) From Hong Kong geology to Chinese agroecology, Tropical Geography, 17:164–172

Parham W et al. (1993) Degraded tropical lands of China: problems and opportunities, *in* Improving degraded lands: Promising experiences from South China, eds. Parham W et al., Bishop Museum Bull. 3 in Botany, Bishop Museum Press, Honolulu, Hawaii

Sargent WR, Palmer M (1996) Views of the Pearl River Delta: Macau, Canton, and Hong Kong, Urban Council, Hong Kong, and the Peabody Essex Museum, Salem, MA, Fairmount Printing Factory Ltd., Hong Kong

State Environmental Protection Administration, 2002 Report on the state of the environment in China, Beijing, http://english.mep.gov.cn/SOE/soechina2002/index.htm. Cited 7 Jan 2009

Thiriez R (2000) Library collections and early photography in China, Internat. Assoc. Orientalist Librarians IAOL, Bull. http://wason.library.cornell.edu/iaol/Vol.44/thiriez_iaol44.html. Cited 7 Jan 2009

Tilson R et al. (2004) Dramatic decline of wild South China tigers *Panthera tigris amoyensis*: field survey of priority tiger reserves, Oryx, 38:40–47

Chapter 3
Transcendental Aspects of Soil in Contemporary Visual Arts

Nico van Breemen

An unlikely couple—soil and visual arts? Not on second thought. Many, if not most, essential basic materials used in the manufacture of art works are found in the earth's crust, including soils: various types of rock for sculpture, minerals for glass, clay for ceramics, ores for works made of metal and all mineral pigments used for paints and inks. Soil materials as such are also often used in painting. Many artists directly apply sand of different colors to create, often abstract, images. Material painters such as Jaap Wagemaker, Antoni Tàpies and Alberto Burri mixed paint with many different materials, including soil, to create their strongly physical object-like works. In this article I will discuss aspects of the relationship between soils and visual art that transcend the pure material aspects. These include the depiction of soils (*e.g.*, in landscape paintings), and physical/chemical/biological soil processes as a metaphor or as a (physical) force in creating works of art. My examples refer mainly to Dutch and European artists, which probably reflect my greater acquaintance with artists in those parts of the world, rather than anything else. Also, several of the artists I have come to know quite well since retiring from the Soils and Geology Department of Wageningen University in 2004, to become full-time involved in the contemporary art gallery Wit in Wageningen.

3.1 Soils in Landscape Paintings

Soils rarely feature as prime object in landscape paintings. Post-impressionists such as Van Gogh, Cézanne and Gauguin, however, did emphasize the strong colors of bare soil in some (Van Gogh) or of many (Cézanne, Gauguin) of their landscapes. They probably used the complementary red of Mediterranean or tropical soils vis-à-vis the greens in the vegetation to enliven their paintings, and not to depict 'soil' as such (see chapter 1, Feller et al., *this volume*).

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Fig. 3.1 Jan Hein van Rooy (2001) "Minas del Rio Tinto", casein tempera on paper on canvas, 75x105 cm. Reproduced by permission of the artist (see as color plate following *Index*)

Aspects of the approaches of both material painters and post-impressionists can be recognized in the landscapes of the Dutch artist Jan Hein van Rooy (born 1940). He concocts casein tempera with earth samples taken from the same Spanish landscapes that he depicts using that tempera (Fig. 3.1). His paintings also invoke the passage of time in the landscape at very long and very short time scales: centuries to millennia via effects of erosion and deposition, and the time of day via shadows cast by the relief in the landscape.

Another Dutch artist, Marinus van Dijke (born 1952) has left the traditional standpoint of the landscape painter behind the easel. He focuses on a small area of his beloved dunes on the island of Schouwen. Here he creates 'landscapes' by viewing the land from different angles and through time, by returning to the same spot in different parts of the year. In his paintings, photographs, videos, prints, artist books, wood reliefs and installations, he shows how water flows, wind blows, sands sift, plants grow, and man and animals move around. These activities leave traces in the soil and on the land surface, that he sees as memories to be stored by making them visible in his works.

3.2 The Subterranean Part of Life in the Arts

Soils represent the dark, but highly essential, subterranean part of life. They form the basement that is not only the final resting place for all of us, but that simultaneously provides the seedbed and most nutrients for new life. Such a potential treasure trove of metaphors would seem difficult to ignore by artists, e.g., those who deal with the concept of Vanitas. This important source of inspiration for artists in the Western world derives from Ecclesiastes 1:2–4 (New Revised Standard Version.): “Vanity of vanities, says the Teacher, vanity of vanities! All is vanity. What do people gain from all the toil at which they toil under the sun? A generation goes, and a generation comes, but the earth remains forever.”

The transitory nature of life is shown in the typical vanitas still lifes by 17th century Dutch painters through abundant flowers, overripe fruits, snuffed candles, skulls and sandglasses. Recently the vanitas concept has gained momentum again, as shown, e.g., by the works of 14 contemporary artists in the exhibition “Vanitas: Meditations on Life and Death in Contemporary Art” at the Virginia Museum of Fine Arts in 2000. In 2003, Anya Gallaccio (1963) was nominated for the prestigious British Turner award for her works made of perishable materials: flowers, fruit, and ice. None of these artists, however, has used ‘soil’ in vanitas works. Perhaps the subterranean part of life is as invisible to artists as it is to the great majority of our fellow citizens.

Few artists involve soil or soil-like material in works that refer to vanitas. One of them is the Dutchman herman de vries (born 1931) [he writes in lower case only], who collects and presents objects and images from nature: branches, flowers, fresh or fallen leaves, soil, ash, droppings of rabbits or goats, names of extant or extinct plant in a certain region, artifacts, photographs, sound tracks and video films. He lets the objects and images speak for themselves. They are presented ‘objectively’, as much as possible in their natural state or arranged regularly but in random order. herman de vries does not aestheticize his work in any way; he is, so to speak, absent in his work by trying to act as a neutral intermediate between objects taken from nature and the observer of his work. He invokes the transient nature of life, and aspects of biogeochemical cycles by rubbing ash and charcoal on paper (e.g., in a work entitled ‘in the wood stood an oak’), by pasting leafs as they come down on a sheet of paper placed underneath a tree in the fall, or by preserving a piece of forest floor partly covered e.g., by flattened dead grass stalks, or by feathers of the victim of a bird of prey (see, e.g., Gooding 2006). However, herman de vries rejects the aspect of vanitas that stresses the futility of wordly pleasure in the light of eternity. For de vries, organisms and the soil that supports them are the one and only basis for all of life, including humanity.

The importance he gives to ‘earth’ is reflected by his many rubbings of soil on paper. Soil scientists will immediately recognize a link between the familiar Munsell soil color charts and some of those works. Figure. 3.2 shows one of his latest, and his largest, representation of soils from all continents on a single sheet of paper.

Recently, de vries’ collection of over 7000 soil samples from all over the world has been acquired by Musée Gassendi in Digne-les-Bains, France, where they are placed as an installation on permanent display. Here soil is not the subject of art but it is the art object itself; soil has become art!

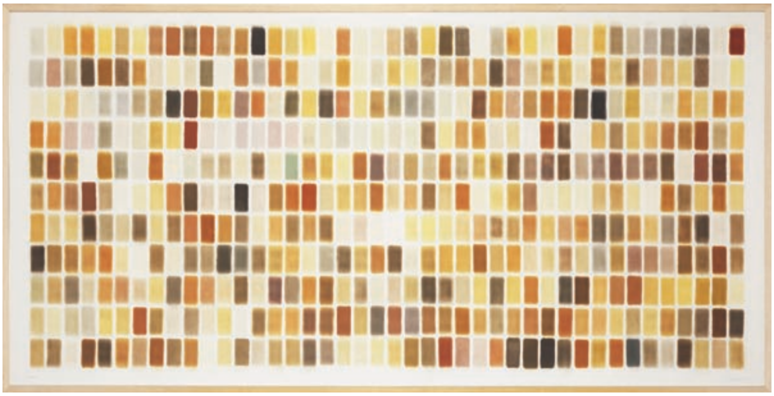

Fig. 3.2 herman de vries (2007)”from earth”, earth rubbing on paper, 102 x 204 cm.Collection Kröller Müller Museum, Otterloo, the Netherlands. Reproduced by permission of the artist (see as color plate following *Index*)

3.3 Soil and Sediment Processes in Creating Works of Art

The Belgian artist Anne Ausloos has become fascinated by, as she calls it, “the appearance of order from chaos” during sedimentation and drying processes of mineral suspensions. In several series of her works, soil materials with textures ranging from fine clay to medium sand are mixed in water to a completely homogenized suspension. Next the suspension is left until all particles are settled and the water is clear. After siphoning off the supernatant, she lets the resulting layers of sediment dry very slowly. The surprising color patters and beautifully curled layers due to sorting of grain sizes during sedimentation and ensuing differential shrinkage during drying are then fixed by firing the material in an oven. Ausloos carefully records the variations in her treatments and additions of different materials, as well as the resulting effects. By next manipulating those factors, she learns how to influence the final results in interesting directions. More recently, she has turned to study process on larger scales in the field, in north-central New Mexico (Ausloos et al. 2006). Examples of the results are shown in Figures 3.3 and 3.4.

In her use of objective and systematic observations, Anne Ausloos works at the interface of art and science. Mentally Anne Ausloos is related to the Arte Povera artists (Celant 1969) who used simple, elementary materials and processes to represent and show the magical world of nature. But Ausloos goes further; she not only presents natural processes, but she also directs them, thereby creating microcosms that reflect the macrocosm (Celant 1969).

Another artist who uses sedimentation processes as part of the creative action is Mario Reis (German, born 1953). Since the mid-1980’s he has used river water with suspended sediment as his paintbrush. By means of stones, he secures stretchers with canvas (usually 60 x 60 cm each) on the bottom of a stream, with their canvas-side down in order to catch the sediment on its “back side”, with the slats of the

Fig. 3.3 Sediment installations (2005) by Anne Ausloos in north-central New Mexico, Reproduced by permission of the artist (see as color plate following *Index*)

Fig. 3.4 Sediment installations (2005) by Anne Ausloos in north-central New Mexico, Reproduced by permission of the artist (see as color plate following *Index*)

canvass stretcher helping to slow down water movement and to increase sedimentation. He lets them sit there for a couple of hours or days, before retrieving them, drying them, and fixing the deposited materials, for presenting what would normally be the backside of a painted canvass. While the placement of the stones and their effect on water flow and sedimentation allow some control over the result of these so-called "nature water colors", natural processes dominate the outcome. Traveling with a kind of mobile studio through Europe, Africa, Japan, Iceland and North America along selected river sites along a projected route, he creates series of works that reveal patterns, colors, textures and residues that are typical of each site. Brought together as an ensemble of works, from numerous sites, they become a microcosmic study of the world's waterways (Boller 2004).

3.4 Land Art

Reis' nature water colors, started in the 1980's, as well as Ausloos' desert works from 2005, find their origin in the Land Art movement that emerged in America in the late 1960s and early 1970s. In land art, landscape and art are inseparable: the landscape is the very means of the creation of the art works. These frequently exist in the open, located well away from civilization, left to change and erosion under natural conditions. Many of the first works, created in the deserts of Nevada, New Mexico, Utah or Arizona were ephemeral in nature and now only exist as video recordings or photographic documents. The best-known example of land art is Robert Smithson's *Spiral Jetty* (1970), an arrangement of rock and earth to form a 500-meter long, spiral-shape jetty protruding into Great Salt Lake in Utah.

Not surprising, in response to wishes of collectors, curators, and museums, and perhaps of the artists themselves, land art creations eventually became dislodged from their original settings and were carried indoors. Placed inside, the installations of natural materials that so strongly contrasted with the typical architecture of museums and galleries often had amazingly strong visual impacts. One of the most successful artists who continues to combine and integrate outdoor activities (normally along walks taking weeks or longer) with the creation of stunning and moving works indoors is Richard Long (UK, born 1953). Examples of his aesthetic indoor testimonies of his inspirations outdoors are the circles, spirals, and craggy pathways imprinted by muddy feet, or made of rocks, feathers or sticks, as well as the geometric or chaotic hand-paintings or drippings of river muds on walls (Fig. 3. 5) or large sheets of paper. They reflect Long's experiences in the landscape, and form poetic evocations of the beauty and grandeur of the earth.

Fig. 3.5 Richard Long (1996) "Kyoto mud circle", river mud on wall, Kyoto Museum of Modern Art. Copyright Richard Long 2007, Courtesy Haunch of Venison, London (see as color plate following *Index*)

References

Ausloos A, van Westen J, Haak T, de Ruijter G (2006) Desert Passage (180 pp, limited edition, artist book, 300 copies). Printed by De Longte, Dordrecht, The Netherlands.

Boller G (2004) in Bulletin 69 of the Seedam Kulturzentrum, Pfaeffikon, Switzerland, p. 20–23.

Celant G (1969) Art Povera. Conceptual, actual or impossible art? Studio Vista, London.

Gooding M (2006) herman de vries chance and change, Thames and Hudson, London 144 pp.

Chapter 4
Merging Horizons—Soil Science and Soil Art

Alexandra Toland and Gerd Wessolek

A collection of canvases caked in colorful arrangements of browns and grays competes for space alongside an extensive accumulation of soil samples, old lab equipment, and remnants of assorted research projects in the basement of the Gorbatschow Building of the Berlin University of Technology. Remains of an artistic field experiment conducted last summer, the canvases mark the Soil Protection Department's attempts to integrate artistic dimensions into the soil science curriculum at the university. Such cross-disciplinary activities are gaining recognition elsewhere, as scientists, artists, educators, and environmentalists are developing a visual vernacular for the outermost skin of the earth.

Why, when and in what context did soil science and art merge horizons? While incidental depictions of soil and geologic forms may be identified in virtually all major artistic genres, artwork explicitly dealing with soil and soil conservation issues is uniquely characteristic to the more recent environmental arts movement spanning over the last 50 years. Regarding the art-historical developments from the Land Art monuments of the 60s and 70s to more recent interdisciplinary remediation projects, it is important to distinguish between artworks that favor a symbolic, conceptual use of the "earth," and those that more specifically make reference to "soil" as a geophysical, agronomic or ecological body. In this chapter, we introduce soil art as a subgenre of environmental art. We review the subject of soil throughout different historical developments of the environmental arts movement, look at several artists who have taken on soil as a fundamental focus of their artistic practice, and share some reflections on our own soil art experimentation at the TU-Berlin. Finally, we address the benefits and challenges of cross-disciplinary experimentation. It is our hope that a thoughtful combination of soil science and art will inspire new opportunities for collaborations within and beyond the soil science community.

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4.1 Historical Roots

4.1.1 Earthworks and Land Art

A plein-air extension of minimalism, Land Art, like happenings, interventions, installations and performance art, celebrated a distinct break from traditional forms of art making, art appreciation, and art theory. Unlike landscape painting, nature photography, and outdoor sculpture parks, Land Art incorporated the landscape not merely as subject or setting for the artwork but as an integral part of it. The Land Art movement is perhaps best known for "Earthworks," such as Robert Smithson's iconic *Spiral Jetty* in the Great Salt Lake in Utah (1970), Michael Heizer's *Double Negative,* cut into the Mormon Mesa in Nevada (1970), or Robert Morris' *Observatory* in the Netherlands (1977).

Many of the Land Artists also transported their perceptions of nature into museums and gallery spaces, isolating "earth" as an abstraction of the landscape. Prior to his herculean pursuits with bulldozers, Robert Smithson, for example, repeatedly framed simple arrangements of gravel, sand, salt and slate in mirrored corners of exhibition spaces and in wooden boxes on gallery floors. Smithson designated these minimalistic works with natural elements as "non-sites," as opposed to actual sites in natural settings. Alongside Smithson's *Non-Site* at the Dwan Gallery's "*Earthworks*" exhibition in 1968, Robert Morris similarly exhibited a pile of soil and rock installed as a sculpture.

In various exhibitions, Richard Long laid out arrangements of stones in museum settings, bringing attention to the raw materiality of natural elements, in juxtaposition with the contrived architectural context of the exhibition space. Artist Alan Sonfist similarly addressed the materiality of exhibition spaces in his *Atlanta Earth Wall* and *Macomb Wall of Earth* (1965). Here, the artist brought attention to the natural history architectural space by covering the outer walls with rippled sculptural facades made out of core samples taken from nearby sites.

Many are also familiar with Walter de Maria's *New York Earth Room* (1977). In this work, de Maria made reference to the lost natural history of New York by filling an entire gallery with 197 m^3 of peat rich soil. Probably the most massive A-Horizon (uppermost layer of organic enriched soil) on the whole island of Manhattan, the *New York Earth Room* allows the viewer to experience the raw, rich odor and texture of an isolated oasis in the middle of a concrete jungle, creating an eerie monument to pre-Columbian New York.

The definitive Land Art works were, however, embedded in the landscape. Far away from the white-walled safety of museums and gallery spaces, artists such as Michael Heizer, Richard Long, Robert Morris, Dennis Oppenheim, and Robert Smithson provoked new ways of interpreting art and experiencing the environment. Despite their groundbreaking contribution to art history, many of the monumental Land Art works often failed to acknowledge or protect the ecologies of the landscapes in which they were situated. When the state of California required artist team Christo and Jeanne-Claude to complete an environmental impact report for their 24 mile long *Running Fence* in 1976, attention shifted from the art world elite to a wider public discussion on the environment. While art critic Michael Auping (1983) commented on the negative ecological repercussions of Land Art in his essay "Earth Art: A Study in Ecological Politics," Allen Carlson (2002), professor of environmental aesthetics, even denounced some of the monumental earth works as being an "aesthetic affront to nature."

As cultural attitudes about environmental responsibility gradually shifted, artists adjusted their practice as well, ushering in a new canon of ephemeral, site-specific, ecologically conscious art that addressed nature for nature's sake, and not simply as a novelty of the art world. Appearing in the same year as the "*Earthworks*" Exhibition, Joseph Beuys' *Earth Telephone* (1968), consisting of a real telephone, earth, wire and straw, may thus be interpreted as a symbol of communication between artist and audience but also between humankind and nature. *Earth Telephone* (Fig. 4.1) represented a telepathic call for action, inviting other artists to follow a subtler, more sustainable path. Artists such as Charles Simonds and Ana Mendieta (among others) answered the call by creating ephemeral, allegorical works with soil that linked personal myths of creation with "the earth" as a fertile, celestial body. Works such as Alan Sonfist's *Time Landscape* (1965-1978), a recreation of a pre-colonial biotope in Manhattan, and

Fig. 4.1 Joseph Beuys, *Earth Telephone,* 1968. *Reproduced here by permission of the Artists Rights Society (ARS)* (see as color plate following *Index*)

Newton and Helen Mayer Harrison's installation of an endangered meadow on the roof of the national art museum in Bonn (1996-1998) marked a new direction for the Land Art movement.

4.1.2 Ecological Art

While Land Art can be traced back to a distinct period of postmodern artistic activity of the late 20th century, ecological art emerged as a critical response to Land Art around the same time period, and continues to thrive as a branch of contemporary art today. Ecological art addresses issues such as sustainable land use, natural processes, biodiversity, habitat conservation, and renewable resources. Two main approaches may be articulated here: artistic remediation that is primarily aesthetic and remediation that is also ecologically restorative. For example, Barbara Matilsky (1992 p. 56) makes a distinction between artists who have "proposed or created ecological artworks that provide solutions to the problems facing natural and urban ecosystems," and artists who hone their skills to attract attention or create awareness of environmental issues by "framing the problems through a variety of media…" Such a distinction becomes apparent with regard to artists working with soils.

In Robert Smithson's *Pour* series, the artist literally dumped truckloads of asphalt and glass and barrels full of glue and sulphur down the slopes of already contaminated strip mines for the pure aesthetic enjoyment of watching the clattering, gooey descent. In contrast, Alan Sonfist sought to ameliorate such conditions by pouring rings of humus rich soil onto industrial brownfields. The airborne seeds that landed within the *Pool of Virgin Earth* (1975) brought new life to industrial wastelands. In the *Grass Grows* and *Bowery Seeds* works by Hans Haacke (1970), the artist similarly placed mounds of fertile soil on rooftops and in gallery spaces to exhibit the physical and biological processes of change, renewal, and decay. In another example, artist-biologist Kathryn Miller developed a bold but humorous series of artistic recultivations by literally "bombing" brownfields with grenade-like sculptures of soil and seeds from native plants (Fig. 4.2). Miller's *Seed Bombs* (1992-2001) and *Subdivision* (1992-2001) soil mounds bring attention to the ecological potential of forgotten urban and industrial spaces.

Another example is Paolo Barrile's *Message Earth* (1961-2003). Well aware of the environmental art activities that had been going on in the United States, the Italian painter abandoned his formal painting career in the '60s to launch an ambitious, long-term series of performances, installations and public interventions. His mission was to collect and redistribute soil samples from all over the world as a symbolic gesture of environmental and social health. With the help of hundreds of artists, schoolchildren, and friends, Barrile scattered fertile soils on urban squares and brownfields, taking a passionate stance against soil sealing and environmental degradation.

Fig. 4.2 Kathryn Miller, *Seed Bombs,* 1992. Santa Barbara, California. Hand-packed soil and seeds of native plants. *Reproduced here by permission of the artist*

4.1.3 Artistic Remediation and Regional Transformation

Some ecological art goes beyond recultivating degraded sites to using more complex techniques of soil remediation. Mel Chin, for example, teamed up with agronomist Rufus Chaney in 1990 to test out bioreactors at the Pig's Eye Landfill in Saint Paul, Minnesota. *Revival Fields* consisted of a circular fenced-in area of geometric plantings of control species and "hyperaccumulators." These are plants with unique abilities to take up contaminants such as heavy metals from the soil. After several years of research and documentation, the unique phytoremediation (*i.e.*, remediation facilitated by plants) project generated interest for further collaboration, and was repeated in several locations in Germany and the United States. As different targeted pollutants required different treatments, new species were tested, bred and "installed" according to the conditions of each location.

The artist, Georg Dietzler, has similarly confronted soil contamination issues by instrumentalizing mycoremediation (*i.e.*, remediation facilitated by fungi) as art. (Fig. 4.3) In works such as *Self-Decomposing* Laboratory (1999) and *Moveable Oyster Mushroom Patch* (1996-1997), Dietzler makes use of oyster mushrooms (*Pleurotus ostreatus*) to break down organic pollutants such as PCBs (polychlorinated biphenyls). The oyster mushroom's unique ability to split chemical structures without absorbing toxins makes it an edible byproduct of waste management. Dietzler's work exposes the power and beauty of bioremediation in the filigree mycelium of prized gourmet mushrooms.

The reality of remediation is, however, often a complex and costly endeavor for artists as well as environmental engineers and soil scientists. When entire regions are at stake, scientists and artists must reach for solutions that are both ecologically and economically viable. For example, the coal mining regions of the Ruhr Valley in Germany, or mid-Appalachia in the United States, offer ample opportunity for experimental remediation projects. The scarred landscapes have attracted both aesthetic and ameliorative approaches that unfold like a barren canvas, spread out over many states on which to paint a new future.

One of the greatest post-mining success stories was initiated in 1994 in Vintondale, Pennsylvania by historian T. Alan Comp, and a group of artists, scientists, planners and members of the surrounding community. The success of *AMD&ART* lies in its

Fig. 4.3 Georg Dietzler, *Self Decomposing Laboratory,* 2002. Rauma, Finland. Straw bale, wood construction, clay plaster, PCB contaminated soil, oyster-mushroom cultures, moisture control unit, 152 x 152 x 122 cm. *Reproduced here by permission of the artist*

interdisciplinary commitment to nature. The group has fought abandoned mine drainage (AMD) with interdisciplinary art, engineering and community activism. They have restored habitats and ecosystem health through artfully designed passive water treatment systems. Initiated by the Carnegie Mellon Studio for Creative Inquiry, the *Nine Mile Run Greenway Project* represents a similar effort to restore and protect a watershed in nearby Pittsburg. The project has merged art and community involvement to confront environmental issues such as soil sealing, storm water management, habitat depletion, erosion and freshwater eutrophication.

4.2 Soil Art—Unearthing a Genre

It is not surprising that when we mention *soil art*, or talk about interdisciplinary collaborations between artists and soil scientists, a frequent response is an immediate association with "Earthworks." While most of the early Land Art and Earthworks were mainly concerned with various perceptions of space, artistic context, and historical meanings of landscape, soil art, in contrast, deals with the geophysical materiality and biochemical processes of the earth. It addresses the pluralistic roles and functions of soil as habitat, growth medium for plants, substrate for architectural structures, archeological archives, as a diverse natural filtration system, and as the basis of cultural identity. It explores the aesthetics of soil (see chapter 15, *this volume*) as a complex mineral and organic body, with infinite combinations of colors, textures, formations and interpretive meanings. In light of the historical frameworks described above, we define "soil art" as art consciously and specifically about, in, or with soil *as such* or soil conservation issues – created by artists, scientists, educators or collaborative efforts thereof. Furthermore, soil art comprises a wide range of artistic disciplines beyond painting and sculpture, to include installation, performance, photography, video and cinema, animation, landscape architecture, environmental remediation, and the Internet. As the field of soil science belongs to the environmental sciences, we identify soil art as a subfield of environmental art.

In addition to the artists and groups mentioned above, we will highlight the following four artists and their works as prominent examples in the advancement of soil art. These artists move beyond environmental art audiences and symbolic uses of "earth," to offer creative new insight on soil classification, documentation, and evaluation methods. Following the artists' profiles, we will go on to share two reflections of our experience at the TU-Berlin as practical examples for combining soil science and artistic practice. Partly supported by the German Soil Science Society and the Berlin University of Technology, the Department of Soil Protection has been investigating several approaches to "art-pedology" in recent years. Several student projects, field exercises and thesis papers have been carried out since 2002. Many other successful examples of soil science and art collaboration are documented on the soil arts website, www.soilarts.com (Toland and Wessolek 2006).

4.2.1 Marianne Greve—One Earth Altar

Upon entering the sun-drenched interior of the “One World Church,” the visitor’s gaze immediately falls on the imposing *One Earth Altar* (Fig. 4.4). Framed by tree-lined windows in the back, the glass and metal structure merges the crucifix as symbolic framework with an archive of earth-narratives. Hamburg-based environmental and conceptual artist, Marianne Greve, was invited to create the altar as the centerpiece for the “One World Church,” which was erected in Schneverdingen as part of the Expo 2000. Based on the artist’s earlier idea for an earth library, the Altar is designed as a set of massive folding metal bookshelves in the shape of a triptych cross behind a simple glass altar. The “earth books” that fill the shelves consist of soil samples collected from all over the world, poured into Plexiglas cases with reference numbers etched on the beveled bindings that sparkle in the afternoon sunlight. Seven years after its inauguration, the project includes over 5,000 earth books on its shelves, with room for a total 7,000.

Soil is the basis of all life on the planet and rich with symbolic meaning that can be traced to religions and cultures from the beginnings of human history. Marianne Greve (2001) describes the idea behind the work: “Earth from many places on the globe lets us realize our common dependence on this thin layer of weather-beaten stone, from which life takes its nutrition and in which it leaves its traces…. There are different worldviews but only one earth, which in its diversity and in conjunction with special places always proved fascinating to all people.”

Fig. 4.4 Marianne Greve*, Eine Erde Altar,* 2000. steel frame, etched acrylic book sleeves, soil samples; Photo: A. Toland *Reproduced here by the author and permission of the artist* (see as color plate following *Index*)

The *One Earth Altar* thus brings together people of all kinds, cultures and faiths, from every corner of the earth, to truly fulfill its name and purpose. Each earth book is documented in a local information terminal and on-line database (http://www.eine-erde-altar.net) according to origin, donor, key word and shelf location. The reference numbers of each book are generated randomly, so that the soil generously donated from Ambassadors and world leaders such as the Dalai Lama may be located next to those of local families. Each book is filled with about a half liter of soil and stones, and is accompanied by a reference sheet documenting geographic coordinates, locality and donor's name, geological, historical, political, spiritual, and emotional relevance, as well as soil color, texture, age, and other physical properties. The artist encourages personal stories to be delivered along with historical and geological information. Each soil sample carries a personal legacy of historical and cultural remembrance - family weddings, births and deaths, individual and collective milestones, memories and tragedies. As expansive and impressive as any collection of soil samples in a scientific institution, the *One Earth Altar* captures the natural and cultural diversity of the earth, offering real and virtual visitors alike a new perspective on experiencing and archiving soils. Readers are welcomed to go on-line and explore the international soil collection, or to donate their own personal sample to this unique soil classification project.

4.2.2 Daro Montag—Bioglyphs

Despite differences in established soil classification and mapping methods, soil profiles provide a common groundwork for identifying, analyzing and documenting the thousands of soil types of the earth. Soil profiles are for the most part similar in form – a simple vertical trench revealing the various soil horizons from the topmost layer of leaf litter, to the humus-rich topsoil and weathered subsoils, to the underlying parent material (a typical "A-B-C" profile). Similar to the binomial nomenclature (categorization of genus and species) of all living organisms, soil types may also be determined based on particular diagnostic characteristics such as horizon sequencing, color and aggregation. Accompanying standardized field analyses, soil profiles are often preserved for educational purposes with photographs, digital models, soil monoliths, and so-called lacquer profile "peels," a method invented by Ehrhard Voigt in 1930 and further developed by Prof. Reinhold Tüxen, in which a mirror image of the profile wall is preserved onto a cloth or board with multiple applications of an adhesive mixture.

Artist Daro Montag has developed a technique of profile preservation with film that transcends established soil documentation procedures. Montag's method exposes the essence of the pedogenetic microcosm in a biologically determined, artistic soil taxonomy. Rather than photographing the soil, Montag allows soil microorganisms to eat away, and in a sense develop exposed film buried vertically in the earth. Photographer Paul Kilsby (2001, p. 4) describes this as a process of creating "not images after nature but traces of nature – bioglyphs" (Fig. 4.5). As nematodes and a host of other soil organisms nibble their way along the gelatin-enriched surface of the film, swirling organic patterns of cyan, magenta and yellow are left in the infinitesimal wake of their sightless journeys. Montag's *Bioglyphs* portray decay as fine art, shedding colorful new light on the dark, unusual world of the detritivores (the diverse group of organisms that feed on decomposing matter). In the words of the artist, bioglyphs are "composition by decomposition," where "everything is in the process of becoming something else" (Montag 2001, p. 8).

Montag's use of film also encourages us to revisit Walter Benjamin's discussion on aura and authenticity in the developing process. In his essay, "The Work of Art in the Age of Mechanical Reproduction," cultural critic, Walter Benjamin (1936), describes the challenges photography and film present to traditional practices and interpretations of art. The reproducible nature of film complicates the "aura" of works of art, in their authenticity, creation, ownership and presentation, as the "original work" is no longer distinguishable from its copies. Montag seems to rekindle this

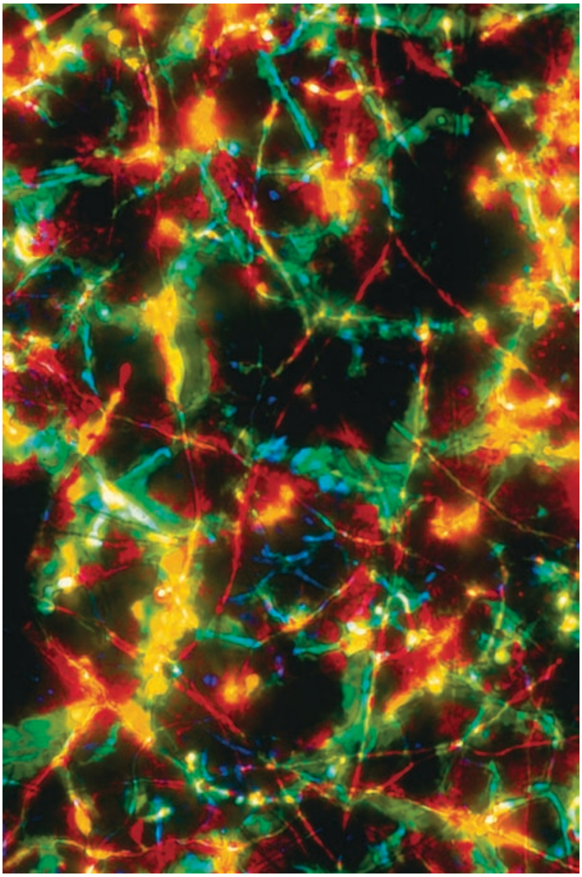

Fig. 4.5 Daro Montag, *Bioglyph: Radiance II*, 1994. Ilfochrome print from 35mm slide. *Reproduced here by permission of the artist* (see as color plate following *Index*)

discussion by inventing a new technique for "developing" film. Rejecting film as a merely replicative media, Montag rather uses film to set the stage for tiny miraculous performances of microbial activity. The originality and thus "aura" of the work lies in the method rather than an intended result. And in this case, the final product is not only dependent on the artist's ingenuity, but also on various biological processes in a given soil ecosystem. While the resulting "bioglyph" may be reproduced in print form, the phenomenological capturing of the image preserves both the aura of the medium as well as the unfolding of pedogenetic events. Montag's unusual use of film thus "does not portray objects or entities – it discloses events. It is not concerned with classification but with revelation" (Montag 2001, p. 8).

Soil is also to be seen here as *Prima Materia*, the primitive formless base of all matter (Montag 2007). It is a continuous cycling of mineral nutrients and biotic activity, an enigmatic universe that cannot be captured in a single photograph, monolith, lacquer peel or scientific field survey. Montag's unconventional soil profiles, or bioglyphs, are a collaborative art with microorganisms – a creative, cross-species experiment that compliments and challenges accepted concepts of soil documentation and classification as well as traditional photography.

4.2.3 Betty Beier—Erdschollen Archive (Earth Print Archive)

Urban soils do not merely provide sites for new construction and infrastructure, but also determine the quality of human health, local climate, water supply, safe waste storage, plant and animal habitats, and in some developing countries, even provide the source of nutrition and food production for the urban population. Soil is the fundamental substrate common to *all* terrestrial locations – natural or humanly altered. The shift in focus of environmental art from remote and rural locations to urban centers may be compared with the relatively recent increase in urban ecological research. For example, the SUITMA (**s**oils of **u**rban, **i**ndustrial, **t**raffic, **m**ining and military **a**reas) working group, initiated in 2000 by Prof. Wolfgang Burkhardt and others, examines not only the impacts of contamination but also the ecological potentials of anthropogenic soils. Despite SUITMA's progress, the classification and documentation of urban and industrial soils remains a major task. Although technosols (soils unnaturally brought to the surface, created, or substantially modified as part of an industrial or manufacturing process) have been just recently recognized in the World Reference Base for Soil Resources (Spaargaren 2005), the scope, heterogeneity and rapid growth of this urban soil group presents a significant need for future research.

In another soil-archiving project, artist Betty Beier has spent over ten years documenting technosols around the world. Concerned with the rising yearly loss of soil due to urban and industrial development, Beier explores the loss of landscape in the series *Erdschollen Archive* (*Earth Print Archive*). Although it is estimated that over 130 hectares of land are lost each year in Germany alone due to building and transportation projects, the German Federal Soil Protection Act (BBodSchG) does not even recognize soil sealing as an environmental impact (Wessolek 2008). Beier's *Erdschollen Archive* documents the vanishing surfaces of her own country and beyond as "landscape" is transformed into urban and industrial sites via soil sealing.

Using a method similar to Voigt's lacquer peel technique, described above, Beier's *Erdschollen* are neither paintings in a traditional sense, nor lacquer profiles, but something in between. Rather than digging a vertical trench to reveal the hidden composition of humanly created soil horizons, Beier makes earth casts with plaster molds and acrylic resins in square meter aluminum frames laid out horizontally on the surface. Reminiscent of Mark Dion's *A Yard of Jungle* (1992), in which the artist relocated one square yard of rainforest to the Museo de Arte Moderna during the Rio Earth Summit in 1992, Beier similarly extracts square meter samples of soil from various cultural and industrial landscapes. Here, as in Dion's *Yard of Jungle*, the square meter as artistic framing mechanism is used as an instrument of dislocation and a critical measurement of land use.

Working in such diverse places as the Xiaolangdi Dam in China, the Kárahnjúkar power plant in the Islandic highlands, and urban and mining areas in Germany, Beier's work explores rugged and degraded anthropogenic soils and the histories held within them. The growing archive of over 60 *Erdschollen*, is also accompanied by soil samples, photographs, and drawings of each site, as well as notes about the natural history, culture and politics of the regions. Art historian, Jörg Katerndahl (2006, p. 5) writes: "By analyzing the surface, (Beier's) work always reveals something from the underneath, the technical aspirations, the political background and the fates of the people affected."

Tire tracks, windblown footprints, trickles of surface runoff, and even the reflections cast in murky puddles are all frozen as moments in time. (Fig. 4.6) Excavated and abstracted from the landscape, the *Erdschollen* appear as memoirs of a vanishing resource – landscape sealed in symbolism and acrylic rather than asphalt. Beier's technolsolic portraits capture the rapidly changing face of the earth and challenge viewers to retrace the steps of industrial development, land allocation, and the importance and impermanence of site. In this sense, Beier develops Robert Smithson's earlier concept of "non-sites," by abstracting and isolating elements taken from the landscape and then using artistic methods to archive contemporary land use. The *Erdschollen* Archive and accompanying materials are documented on the website http://www.erdschollenarchiv.de

4.2.4 John Sturgeon—The "More Moor" Performances

Natural peats and bog soils are a result of organic matter accumulation under anaerobic conditions. The organic soil layers reveal the former conditions of plant communities and climate changes over relatively recent geological time. Organic soils were

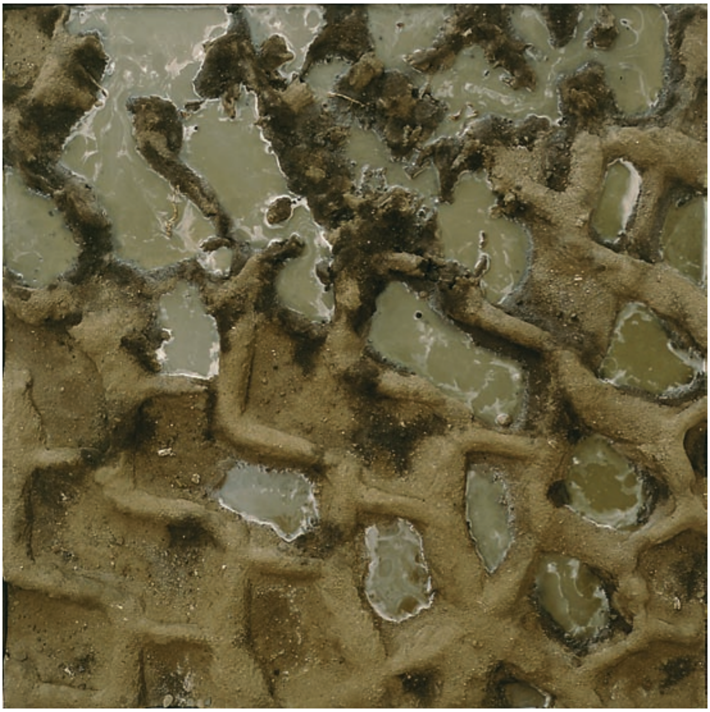

Fig. 4.6 Betty Beier, *Erdscholle* (Earth print) Ministergarten 100 x 100 x 7 cm, 1997. Photo B. Seeland *Reproduced here by permission of the artist* (see as color plate following *Index*)

formerly a sink for nutrients, humic substances, and water until humans started using these soils for food and fuel production about 250 years ago. The fate of these wetlands and their organic soils has become a major environmental concern. Having been drained for agricultural production, their role in the landscape changed from a sink to a source of CO_2 and N_2O. To successfully restore and conserve peat and bog soils, it is important to protect their natural soil water and nutrient regimes. This becomes more and more difficult in a state of rapid global climate change.

One special quality of organic soils is that they are spongy and seem to float over the underlying groundwater, which can easily be tested by jogging across the surface. In fact, to truly experience the resilience of ten thousand years of accumulated organic matter, one must jump up and down in a bog. This is how we introduce students to the drained landscapes of Brandenburg. And this is exactly what John Sturgeon did as a segue to other performances and installations at the "More Moor" Symposium in 1992 in the nature conservation area of "Holler and Wittemoor," near Oldenburg, Germany. Sturgeon's *Falling Moor* performance may be seen as a response to Joseph Beuys' *Bog Action* (*Eine Aktion im Moor*) of 1971, in which the artist ran, bathed and swam through a bog in southern Holland. Sturgeon similarly threw himself from different heights and positions into and onto multiple sites in the Wittemoor—a literal "getting to know you" phase between artist and bog. In another subtle reference to Beuys, this time reminiscent of the *Earth Telephone* (1968), Sturgeon, with both feet buried and temples wired to the landscape, seems to exchange messages with the earth in his performance piece *Moor Battery*.

Acclaimed digital media artist John Sturgeon is perhaps an unlikely protagonist of soil art. Yet his memorable multi-media performance and video works at the "More Moor" International Festival of performance, installation & site specific work provide inspiring new ways of looking at endangered wetland soils. In addition to *Falling Moor*, and *Moor Battery,* Sturgeon performed *Fishing Moor* with German performance artist Insa Winkler. The two artists dressed as anglers and traversed the conservation area with video-camera topped fishing poles. The resulting video portrayed various perspectives of the wetland ecosystem and the interactions of the performers.

The tone of Sturgeon's work becomes more serious in *Narkose*. (Fig. 4.7) This work touches on death as an inevitable aspect of soil. Here, Sturgeon appears buried horizontally "at a geological depth of about 2,000 years." (Sturgeon 1992). Accompanying the somber performance is a video loop on a monitor near the artist's head that flashes with images of environmental destruction cut with battle scenes from the Gulf War of 1991. As quickly as human life is obliterated, so are entire ecosystems. The motives may vary, but the irreversible effects carry a similar, unbearable weight. Additionally, an audio track of a text Sturgeon wrote emerges from small speakers in the ground. Dark echoes emanate from the depths of forgotten time and space as poetry to and from the earth. The foreboding content of the images and sounds, and the temporal nature of the digital media that convey them, create a melancholic, even threatening tension in the work. *Narkose* begs the

Fig. 4.7 John Sturgeon, *Narkose,* performance at Symposium Moor 1992. Photo: Insa Winkler *Reproduced here by permission of the artist*

question in dire metaphors—is this the fate of the earth, or a merely a passing phase of transformation?

4.2.5 Soil and Sculpture—TU-Berlin Students Retrace the History of Former Sewage Fields

Located on the northern periphery of Berlin, the *Rieselfelder*, or former wastewater disposal fields, are the site of acres of anthropogenic soils with a fascinating natural and cultural history. From 1890 to 1985, untreated sewage wastewater was applied to about 1,400 hectares of agricultural land outside the city. The disposal of more than 10,000 mm of wastewater in the 1970s rendered agricultural use no longer possible. Upon construction of the purification plant "Schönerlinde," intensive wastewater application finally came to a close in 1986. In 1987, in honor of the city of Berlin's 750th anniversary, the GDR attempted to reforest the site as a remediation effort. Unfortunately, this measure had virtually no effect on the site. Most of the trees died, mainly due to seasonal water shortage, nutrient deficiency, and heavy metal contamination. A complete change in soil moisture conditions, from very wet under the constant wastewater infiltration, to relatively dry, with only natural precipitation (ca. 570mm a year), caused the soil to become water repellent (Täumer et al. 2006), and a rapid turnover process of organic matter occurred, which induced increased leaching of heavy metals and nitrates (Hoffmann 2002). To protect the groundwater and reactivate weakened soil functions, a remediation program financed by the European Commission and the city of Berlin was initiated in 1997 under the leadership of the Department of Soil Protection of the Berlin University of Technology (TU-Berlin). For the long-term immobilization of heavy metals and improvement of soil fertility, 30 cm of calcareous lime excavated from a nearby tunnel construction project were applied to the surface and mixed with the contaminated soil up to 90 cm soil depth. As a result, a reforestation program was successfully carried out, and some locations are now used for an artificial groundwater recharge program for pre-purified water of the Schönerlinde facility.

Based on this complex history, TU-Berlin students developed artistic proposals to capture the history of the wastewater disposal fields and make the change of soil properties visible to the public. Inspired by the minimalist forms of the early Earthworks, landscape architecture student, Hardy Buhl, erected a giant soil "cake" in 2006 (Fig. 4.8). The 20 m diameter cake was divided by three intersecting mulch pathways, culminating in the center with a granite boulder, left behind by the last ice age, about 10,000 years ago. Several trenches were excavated in the area and the soil profile horizons were horizontally arranged in concentric circles. The uppermost layer of couch grass (*Elytrigia repens*) sod was placed at the outer perimeter, with deeper, subsoil materials towards the centre. In juxtaposition to the ancient rock at the center, the cake's striped slices revealed the stark anthropogenic signature of the former sewage-dumping site. Every other slice, however, was laid out with lime-enriched soil from remediated areas elsewhere on the site, exposing both the destructive and ameliorative effects of human activity on the soil.

Fig. 4.8 Hardy Buhl and Project Group "Bodenkunst auf Brachflächen" *Soil Cake Installation* at the Rieselfeld Sculpture Park, Berlin-Buch. Photo: Hardy Buhl, 2006. *Reproduced here by permission of the TU-Berlin, Dept. Of Soil Protection* (see as color plate following *Index*)

Today, the topography of the site shows little evidence of its former use to the untrained eye. Grassy meadows dotted with willows and poplars border hedge-lined dirt pathways leading up to a little lake on the eastern edge of the site. Managed by the Forestry Department of Berlin-Buch, the 2000-hectare large Rieselfelder are now used as a public park. Installed amidst the site's extensive outdoor sculpture park, the soil cake was both an artistic addition as well as an informative tribute to the Rieselfeld's hidden history. Sensitive to the surrounding ecology of the site, the work was allowed to be reclaimed by vegetation over the course of time and is now no longer visible, except for the top of the granite boulder that peeks out from a sea of couch grass.

4.2.6 Soil and Painting—A Springboard for Other Forms of Soil Art

Since the Upper Paleolithic time, humans have used soil-based pigments to adorn cultural artifacts, dwellings and their own bodies. "Earth paintings" also represent a by-product of the Land Art movement, including some lesser-known works of artists such as Richard Long, Robert Rauschenberg, and Alan Sonfist.

After an introduction to Land and Environmental Art, the TU Department for Soil Protection took the classroom outside. In the heat of the summer months, when the conditions for making lacquer profiles were just right, a series of creative field exercises was carried out in an overgrown urban lot near the TU campus (Fig. 4.9). Landscape planning- and environmental engineering-students, research fellows, technicians, and visiting scientists were invited to paint their impressions of the site with materials found on or buried in the soil. As participants scurried about collecting samples from different soil profiles, a discussion on urban soils, water

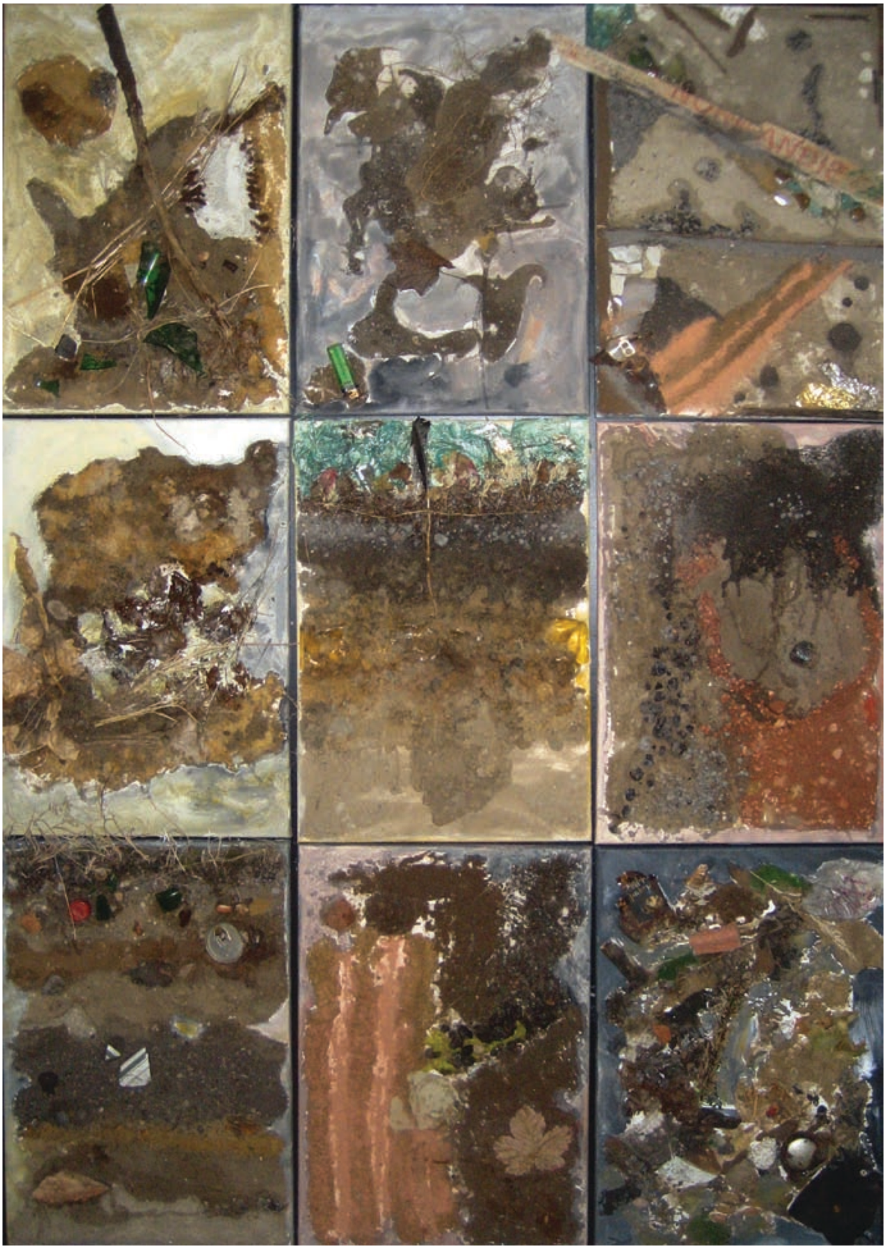

Fig. 4.9 Collective artwork of students and staff from the Dept. of Soil Protection, June 2006. Photo: Gerd Wessolek *Reproduced here by permission of the author* (see as color plate following *Index*)

and nutrient transport and surface sealing ensued. While waiting for the canvasses to dry, the site itself revealed its complex cultural and natural history. Everyone looked for clues that could be integrated into the artwork. There was an analysis of crumbling remnants of old building materials, the recycling of colorful, weather-beaten trash, the excitement of hitting ground water at the deepest point of the site, and the discovery of hidden fox holes beneath the new shoots of wild locust trees. Though the previous knowledge and experience of making art differed greatly among the participants, everyone was able to piece together their own unique interpretation of the site with paintbrush, stretched canvas, and soil.

While the active participation in the experiment was a great success, the lasting effect of such activities remains unclear. Stephen Wilson warns of the specialized blinders often donned by many in scientific fields: "Many scientific and technological researchers define the arts as alien territory… If they are personally interested, they hold stereotypical views of the arts that stops with classical museum and gallery forms such as painting and sculpture" (Wilson 2002*a*, p. 876). Such a warning is not without reason. Despite the collaborative efforts mentioned earlier, many scientists still view art as something decorative – to be hung on a wall or placed on a pedestal. Two important lessons may be learned, however, from the gritty brushstrokes of our artistic field exercises at the TU-Berlin:

1. Despite their stereotypical identity for the arts, painting and sculpture offer "easy access" to interdisciplinary educational models of combining soil science and art. To mould a figurative form out of a chunk of clay or to sprinkle medium-grained sand onto a canvas represents a creative, even cathartic, hands-on introduction to soil science and soil art. Artistic activities loosen institutional textbook soil science lectures to allow for other forms of knowing and experiencing soil.
2. Painting and sculpture with soil can be a springboard for other forms of artistic experimentation and collaborative research. While they represent an opportunity for combining different fields of interest, the experiment can still be developed further.

4.3 Interdisciplinary Opportunity and Challenge

In a beautiful a play on words, cultural researcher, Hildegard Kurt (2003, p. 5) compares science, (*Wissenschaft),* or literally "the making of knowledge" to art as "*Wissensform*", literally "the form of knowledge". Both are equal and necessary counterparts that, when used together, contribute to a holistic experience of understanding and appreciation. In a similar sense, Stephen Wilson (2002*b*) asserts that both art and science are carried out as *cultural acts*. Wilson (2002*b*, p. 18) compares the parallel roles of contemporary artistic and scientific practice:

> "Both value the careful observation of their environments to gather information through the senses. Both value creativity. Both propose to introduce change, innovation, or improvement over what exists. Both use abstract models to understand the world. Both aspire to create works that have universal relevance."

In an age of growing common interests and a collective sense of environmental responsibility, practitioners from both fields have become increasingly curious about the methods and research areas of the other. In addition to learning about various artistic activities with and about soils, we were also curious to find out how soil scientists felt about the field of *soil art.* At the German Soil Science Society's annual conference in 2007, we distributed a survey on soil science, aesthetics and art at a session on soil science, society and education. We asked members to share their opinions about the importance of this unusual aspect of soil science, and about their potential willingness to get involved. While 64% regarded the interdisciplinary direction of "soil art" as important, 85% answered that they would be personally interested in cooperating with an artist. These results suggest good potential for future soil science and art collaborations. But how?

Stephen Wilson's book, *Information Arts: Intersections of Art, Science, and Technology*, provides hundreds of examples of how artists have used and developed scientific research in their works, from fields such as atomic physics, robotics, microbiology and genetics. Conversely, we should ask how artists might be integrated into research projects – and more specifically, soil science research projects—not only with the goal of generating greater public understanding or promoting cultural values, but also by contributing their own creativity to finding solutions to problems such as *e.g.* soil erosion, contamination, or degradation. How can the field of soil science more openly incorporate aesthetic and artistic values that resonate with art audiences or a wider public? How can artists be paired with scientists in productive research partnerships? How can such pooling of creativity be further fostered in academic settings to influence conservation strategies?

To address these questions, it is worth mentioning a few organizations that document and support "best practice" examples of interdisciplinary projects. The following groups could inspire future collaboration between scientists and artists specializing in soils: the Leonardo and International Society for the Arts, Sciences and Technology (ISAST), greenmuseum.org online network for environmental arts, the Art and Science Collaborations Inc. (ASCI), the RSA Arts and Ecology Program, the Carnegie Mellon University Studio for Creative Inquiry, and the MIT Center for Advanced Visual Studies (CAVS). The following museums may also offer exciting new opportunities for soil science and art collaborations: the Underworld Exhibition in Osnabrück, Germany (Unterwelten Ausstellung des Natur und Umweltmuseums am Schölerberg), the ISRIC World Soil Museum in Wageningen, NL, the Underground Adventure at the Field Museum of Chicago, the Dig It! *The Secrets of the Soil* exhibition at the Smithsonian National Museum of Natural History in Washington D.C., and the Dokuchaev Central Soil Museum in St. Petersburg, Russia.

Interdisciplinary projects, such as some of those mentioned in this paper, and promoted by the organizations above, are unique in that they are either initiated by or include artists in solving local and regional environmental problems. The artistic element of involvement need not always result in an object or exhibition, but can rather be seen as a creative phase of guidance in restoration and conservation efforts. Verging on an "Is it Art?" aesthetic, the trend towards creative collaboration promises some interesting solutions to difficult environmental dilemmas, but also calls for a progressive cultural context that can support the new environmental avant-garde. Wilson (2002*c*, p. 131) warns of the inevitable challenges of interdisciplinary environmental and ecological art:

> Some analysts object that it is difficult to distinguish ecological art projects from political or scientific interventions. As art moves increasingly into actions in real-life settings with multiple non-art actors, the differentiation becomes difficult. How are these projects any different than if they were initiated by a political or scientific group? Other analysts suggest that definitions are changing and that new kinds of public art are emerging that do not resemble old forms. An even more radical suggestion is that the distinction between art and non-art is no longer visible.

In a Neo-Renaissance reconciliation of art and science, we must constantly examine what distinctions and parallels can be made between an ever converging critical art-world and a culturally literate scientific community. This is necessary for any attempt to combine soil science and art. Both fields must inform themselves of the other's developments if they are to take part in a constructive dialogue. Both must guide each other in achieving common goals of environmental change. Conscious cross-referencing and frequent communication is needed. This is not a theoretical observation, but a call for action. Professional artists should be invited more often to conferences, into laboratories, and to participate in engineering and agricultural experiments, while scientists might offer their expertise at environmental art symposiums, exhibitions and seminars. Creativity goes both ways. It must only be recognized and cultivated in settings that are home to both the arts and the sciences.

References

Auping M (1983) Earth Art: A Study in Ecological Politics. In: Sonfist (ed.), *ART IN THE LAND: A Critical Anthology of Environmental Art*, New York: E.P.Dutton, Inc., 92-103.

Benjamin W (1936) The Work of Art in the Age of Mechanical Reproduction. In: Benjamin, *ILLUMINATIONS: Essays and Reflections*, (ed.) Hannah Arendt, New York, Harcourt, Brace & World, 1968 / and Schocken Books, NY, 1969.

Carlson A (2002) Is environmental art an aesthetic affront to nature? In: Carlson, *Aesthetics and the Environment – The Appreciation of Nature, Art and Architecture*. Abingdon and New York: Routledge Taylor & Francis Group, 2007, 150-163.

Greve M (2001) Der Eine Erde Altar (One Earth Altar). Markus Kirchengemeinde Schneverdingen zur EXPO2000, *Eine Welt Kirche – Eine Erde Altar*. Greve, Marianne: http://www.eine-erde-altar.net/ Cited 11 October 2008.

Hoffmann C (2002) Schwermetallmobilität und Risikopotenziale der Rieselfeldböden Berlin Buch. Dissertation at the Technical University Berlin, published in: Bodenökologie und Bodengenese, Heft 35, 226 pp.

Katerndahl J. (2006) Documents of rapid change – Betty Beier's *Earth Prints Archive* – (*Erdschollen-Archiv*) – as a contribution to the art of preserving traces of our time. In: Beier, *Working on the Earth Prints Archive – The Kárahnjúkar Dam Project*. Exhibition documentation materials, Copyright Betty Beier.

Kilsby P (2001) Bioglyph: Infra et ultra. In: Montag, *Bioglyphs*. Cross Farm, Diptford, Totnes, DevonFesterman Press, 2001, 3-7.
Kurt H (2003) Introduction in: Agenda Transfer, *Die Kunst der Zukunftsfähigkeit – Ansätze, Beispiele, Hintergründe, Erfahrungen* Hg. v. Agenda Transfer, Bundesweite Servicestelle Lokale Agenda 21 , zusammengestellt von Hildegard Kurt, 82 Seiten, Bonn, 2003: Eigenverlag, ISSN 1439-1856.
Matilsky B (1992) Ecological Art: A Response to Environmental Issues. In: Matilsky, *Fragile Ecologies: Contemporary Artists' Interpretations and Solutions*. New York: Rizzoli International Publications, Inc., 56-60.
Montag D (2001) Artist's Statement. In: Montag, *Bioglyphs*. Cross Farm, Diptford, Totnes, and Devon: Festerman Press, 2001, p8. (originally published in Sci-Art catalogue, 1998).
Montag D (2007) Thinking Soil. In: Montag, *This Earth*. Cross Farm, Diptford, Totnes, and Devon: Festerman Press. 1-55. ISBN 978-0-9544187-4-8.
Spaargaren O (2005) Anthrosols and Technosols. Definition for the ISRIC –World Soil Information, Wageningen, The Netherlands.
Sturgeon J (1992) Performance Documentation of *Narkose*, performed at the *Symposium Moor 1992*, an international festival of performance & site specific work on the *Wittemoor.*
Täumer K, Stoffregen H, Wessolek G (2006) Seasonal dynamics of preferential flow in a water repellent soil. *Vadose Zone Journal*, special issue: "Scale transfers in the unsaturated zone", **5**, 406-411.
Wessolek G (2008) Sealing of Soils. In: Alberti et al. (eds.) *Urban Ecology*. Springer US, 161-179.
Wilson S (2002*a*) 8.2. Summary – The Future. In: Wilson, *Information Arts: Intersections of Art, Science, and Technology*. Cambridge, MA: MIT Press, Leonardo Series, 874-877.
Wilson S (2002*b*) Art and Science as Cultural Acts: *Similarities and Differences between Science and Art*. In: Wilson, *Information Arts: Intersections of Art, Science, and Technology*. Cambridge, MA: MIT Press, Leonardo Series, 18-20.
Wilson S (2002*c*) Ecological Art: *Questions Raised by Artistic Interest in Ecology*. In: Wilson, *Information Arts: Intersections of Art, Science, and Technology*. Cambridge, MA: MIT Press, Leonardo Series, 130-131.

Additional information on artists and organizations mentioned may be found online

Artists

Barrile, Paolo: http://www.paolobarrile.it
Beier, Betty: http://www.erdschollenarchiv.de/
Beuys, Joseph: http://www.beuys.org/
Chin, Mel: http://www.haussite.net/site.html
Christo and Jeanne-Claude: http://www.christojeanneclaude.net/
De Maria, Walter, New York Earth Room: http://www.earthroom.org/
Dietzler, Georg (in greenmuseum archive): http://greenmuseum.org/artist_index.php?artist_id=33
Dion, Mark (in pbs art21 archives): http://www.pbs.org/art21/artists/dion/index.html
Greve, Marianne: http://www.eine-erde-altar.net/
Haacke, Hans (in artnet archive): http://www.artnet.com/artist/674342/hans-haacke.html
Harrison, Newton and Helen Mayer: http://www.theharrisonstudio.net/endangered_meadows.html
Heizer, Michael: http://www.diacenter.org, and http://doublenegative.tarasen.net/
Long, Richard: http://www.richardlong.org/

Mendieta, Ana (in Guggenheim Online): http://www.guggenheim.org/artscurriculum/lessons/movpics_mendieta.php
Miller, Kathryn (in greenmuseum archive): http://greenmuseum.org/artist_index.php?artist_id=3
Montag, Daro: http://www.purdyhicks.com/dm_images_1.htm
Morris, Robert: http://www.guggenheimcollection.org/site/artist_bio_115.html
Oppenheim, Dennis: http://www.dennis-oppenheim.com/
Simonds, Charles (in Walker Art Center Resources): http://collections.walkerart.org/item/agent/509
Smithson, Robert: http://www.robertsmithson.com
Sonfist, Alan: http://www.alansonfist.com
Sturgeon, John: http://www.umbc.edu/sturgeon/

Organisations

AMD&ART: http://www.amdandart.info
Art and Science Collaborations Inc. (ASCI): http://www.asci.org/
Carnegie Mellon University Studio for Creative Inquiry: http://www.cmu.edu/studio/index.html
Dig It! The Secrets of the Soil Exhibition at the Smithsonian National Museum of Natural History: http://forces.si.edu/soils/
Dokuchaev Central Soil Museum in St. Petersburg: http://www.soilmuseum.narod.ru/english/index_en.htm
Greenmuseum.org network for environmental arts: http://www.greenmuseum.org/
ISRIC World Soil Museum in Wageningen, NL: http://www.isric.org/UK/About+Soils/World+Soil+Museum/
Leonardo and International Society for the Arts, Sciences and Technology (ISAST): http://www.leonardo.info/
MIT Center for Advanced Visual Studies (CAVS): http://cavs.mit.edu/
Nine Mile Run Watershed Association: http://www.ninemilerun.org/
RSA Arts and Ecology Programme: http://www.thersa.org/arts/
Soil and Art Online Platform of the TU-Berlin Dept. of Soil Protection: www.soilarts.com
Underground Adventure at the Field Museum of Chicago: http://www.fieldmuseum.org/undergroundadventure/index.shtml
Underworld Exhibition in Osnabrück, Germany (Unterwelten Ausstellung des Natur und Umweltmuseums am Schölerberg): www.osnabrueck.de/unterwelten/21037.htm

Chapter 5
Soil Colors, Pigments and Clays in Paintings

Fiorenzo Ugolini

5.1 Introduction

Pigments color our world—from the homes we live in, to the cloths we wear—and yes, to the food we eat. They are products of the Earth. Some are highly processed chemicals such as cobalt blue—derived, as the name implies, from cobalt-bearing ores mined from the underground. Some are biological materials, such as indigo—extracted from plants of the genus *Indigofera*. And some are geological materials, taken from the near-surface, weathering environment—the soil zone. These "earth pigments" are true reflections of the Earth around us. They are used industrially with minimal processing, and we begin to learn their exotic names, such as *burnt sienna*, as children, from our crayon boxes.

Traditionally, the natural earth pigments are called *Terres* or *Ochres*. The colors and mineral compositions of the most commonly used earth pigments are shown in Table 5.1. These natural pigments, especially the red ochres, were used by Paleolithic humans in burial ceremonies. Probably, symbolically, the pink color of the skin was associated with good health; on the contrary, a dead body was white. Coloring with red ochre was an attempt to bring them back to life or to wish them a good future life. These burial sites have been found in localities very far apart, such as Europe, North America and Japan. Paleolithic artists used also these earthy colors for cave paintings. They painted with red and yellow ochres, white clay, green celadonite and glauconite. The ancient Egyptians enriched these fundamental colors with other hues, such as purple obtained from the mollusks species *murex* and *nocella.* The Middle Age saw extensive use of natural colors with the addition of gold and crushed lapis-lazuli to obtain ultramarine blue, used to exalt the divine representations. A change in attitude in paintings came in the 18^{th}–19^{th} centuries, J.M.W. Turner, an English romantic landscape painters (1775–1851) known for his dynamic treatment of light was particularly attracted by brilliant coloring and

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Table 5.1 List of the most common Terre or Ochre including color, composition, and source. [Sources: Brunetti BG 2009; Crowley-Kiggins MA 2009]

Mineral name	Color	Composition and other information
Terre Gialle (Yellow Earth)	Yellow (with golden tonality)	Iron oxides mainly goethite and clay minerals. Goethite ranges from 15 to 70 %. The variable goethite content allows different tonalities sometimes with greenish shadowing. In oil painting this pigment needs 60% binder.
Terra di Siena or Sienna (Raw Siena)	Maroon (Yellow to brown)	Goethite (50–70%) with about 1% pyrolusite and clay minerals.
Terra di Siena Bruciata (Burnt Siena)	Red	Hematite 50–70% obtained by dehydration of goethite at 200–300° C. Both Raw and Burnt Siena Terre show excellent coating power and tinting strength.
Terra Verde di Verona (Green Earth)mined at Monte Baldo	Green, those with less prounanced green color are richer in celadonite	Celadonite and Glauconite.
Terra d'Ombra (Umbra ochre)	Dark brown	Hematite with 16% pyrolusite.
Terra d'Ombra di Cipro (Cipro's umbra ochre)	Dark brown	Hematite with high percent of pyrolusite this mineral produces dark tonality.
Ocra Bruna (Brown ochre)	Brown-Yellow	mixture of lepidocrocite and goethite, clay minerals also present.
Bolo Bianco (White)	White	Kaolinite

diffuse light. In fact, he was known as "the painter of light". Turner, together with Delacroix (1798–1863) who also made use of brilliant colors and refined chromaticity, especially after his experience in Morocco, opened the door to the early French Impressionists. By the mid 1800, however, the German chemical industry was producing synthetic, vivid colors placed conveniently into metallic tubes very suitable for outdoor paintings. Renoir made the observation that without the new colors in the small tubes there could not have been painters such as Cezanne, Monet, Sisley or Pissaro or no Impressionism! With the success of synthetic colors did the earthy pigments disappear? Recently, there has been a renewed interest in the use of pigments of the Renaissance masters. However, The newly mined *Terre* was not the same as the old ones; the ochre deposits of Siena, Corsica and Cyprus were exhausted while the substitutes produced ochre more opaque and less transparent. Nevertheless, new pigments have been developed, for example Mars colors consisting of synthetic iron oxides appear, in terms of light fastness, comparable to the natural ochre (Auneddu 2006; Encyclopedia Britannica 2007; Crowley and Kiggins 2009).

5.2 Soil Colors

Fundamentally, soil colors are due to the presence of humus that imparts a black color, to iron oxides for different shades of yellow and red, to calcium carbonates or other salts for white and, less commonly, bluish tones due to manganese oxides. Soils dominated by gray colors are found in the wide expanses of the arctic tundra and in the hot and cold deserts; also, the same colors are displayed by poorly drained soils and by soils forming on recent geological deposits. However, it was only with the advent of the Munsell Color Charts that a systematic scientific nomenclature for soil colors was established. Prior to this event, folksy expressions such as coffee brown, cinnamon, rusty brown, lemon yellow, ashy gray and others, were used to designate the colors of soils. Soil colors represent only one fifth, or about 322 color chips, of the possible complete coverage in the Munsell Book of Color (1976).

In the Munsell Color System the color notations include: the Hue, the Value and the Chroma. The Hue designates the major five wavelengths that comprise: Red, Yellow, Green, Blue and Purple. There are also five intermediate Hues that are the midpoint between each pair of the principal Hues: Yellow-Red, Green-Yellow, Blue-Green, Purple-Blue and Red-Purple. Color charts are available for submerged soils and full grayscale. The Value notation indicates the lightness or darkness of the color. It ranges from 0 black to 10. The Chroma reports the purity of the wavelength. It starts with 0 for neutral gray and increases for soil colors, to a maximum of 8. For achromatic colors such as gray, white and black, the Chroma is 0 and they have no Hue. In this case, the letter N (neutral) is used in lieu of the other letters. For the Value, the notation ranges from 0 black to 10 white. The Munsell notation for a yellowish brown soil is 10YR 5/4. Perfect matching between the color of the soil sample and the color chip in the book is less than one in one hundred (Soil Survey Division Staff 1993). Details for the procedure involved in determining soil colors are available in the Soil Survey Manual (Soil Survey Division Staff 1993) and in the Field Book for Describing and Sampling Soils (Schoeneberger et al. 2002).

In the natural world, soils display numerous colors; these colors are the results of the *soil forming processes* that in turn are conditioned by the *soil forming factors*— these factors include *climate, parent material or geological substratum, relief, biota and time* (Jenny 1941; 1980). The soil forming processes are responsible for imprinting the color to the soil, and for the formation of the pigments responsible for providing the earthy colors that are used in paints, building materials, and other applications. During soil formation or pedogenesis, the color of the parent material may be preserved or thoroughly changed depending on the impact of the other soil forming factors. Recent soils, such as those developed on freshly emplaced unconsolidated deposits *e.g.*, fluvial, glacial, and pyroclastic tend to retain the color of the geological material. In contrast, there are soils, *Ferralsols (Oxisols)* that have been exposed to pedogenesis for long time in a very aggressive tropical climate. Here, the chemical alteration, associated with loss of silica and cations, changed the original rock into clays, and iron and aluminum oxyhydroxides. Between these two

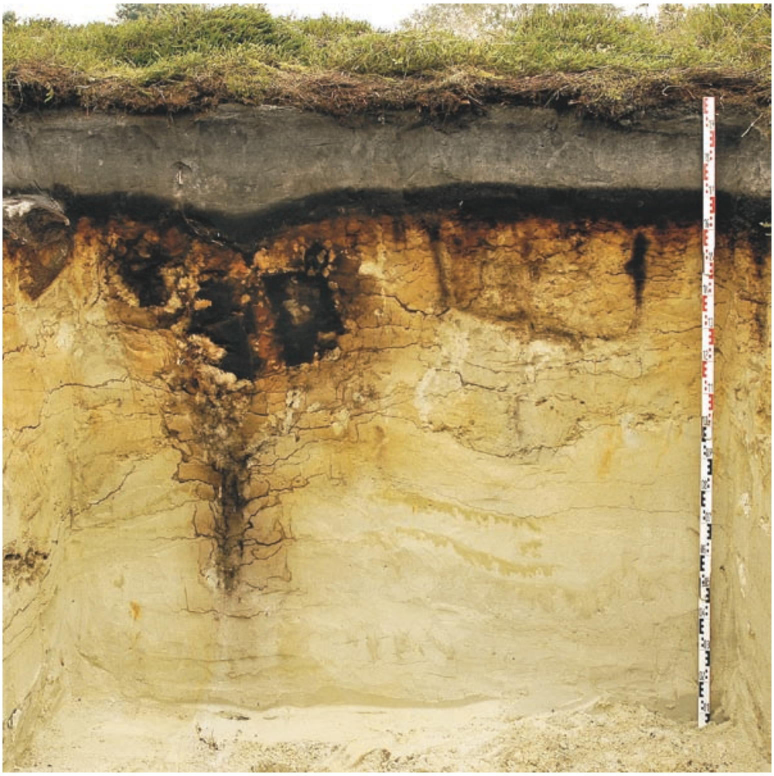

Fig. 5.1 Soil profile of a podzol [an *Albic Carbic Ortsteinic Podzol* (FAO/ISRIC/ISSS 2006)] from the heathlands of northern Germany. This image was used as part of an educational campaign by the German Soil Science Society for public recognition of soil as a diverse and precious resource; the podzol was recognized as the "Soil of the Year" for 2007. Photograph by Wolfgang Pietrzok (see as color plate following *Index*)

extremes, there are numerous examples of soils in the temperate regions that display intensively contrasting colors in the upper 1.5 meters of the profile.

One of the most photogenic soils is the Podzol or Spodosol (Fig. 5.1). *Podzols* are commonly found in the cool to cold forested regions of the Northern Hemisphere; but they are reported also in very humid subtropical and tropical areas (Tardy and Roquin, 1998). They show a black humus layer at the surface, O horizon, followed by a highly leached, ash-gray (N8) E horizon that rests on an intense dark red material (5YR), the Bhs horizon that in turns rests on a reddish yellow (10YR) Bs horizon. In the prairies or long-grass steppe regions of the world, the *Chernozems*, meaning black soils in Russian, are soils that have a thick, very dark brown (10YR 2/2) to black (10YR 2/1) A horizon rich in humus, well mixed by earthworm activity and with a neutral pH. Another example of soils affected by the process of surficial darkening, also known as *melanization*, from "melanin" meaning dark, but under acid conditions, are the *Andosols*—soils developed on volcanic material mainly ash and pumice (Fig. 5.2).

Fig. 5.2 Andosol (Andisol) Scale - shovel about 1m, Tohoku University Farm, Tamatsukuri, Japan. (Photo by the author) (see as color plate following *Index*)

They show a very dark brown (7.5YR2.5/2) to black (7.5YR 2.5/1) thick, humus-rich surficial A horizon followed, sometimes, by a multicolored stratified volcanic ash deposits. In some Andosols, fire, with the formation of charred material is partially responsible for the characteristic black A horizon (Ugolini and Schlichte 1973; Shindo et al. 2002).

Waterlogged soils, the *Gleysols*, show a greyish-colored matrix with orange-red and blue spots called *mottles*. Fluctuations of the water table may cause changes in the soil colors. Oxidation-reduction reactions affecting primarily the iron (Fe)- and manganese (Mn)- bearing soil minerals are responsible for mottle formation. Soils that show the most intense coloration are the *Ferralsols* (FAO/ISRIC/ISSS 2006) or Oxisols (Soil Survey Staff 2006), with dark red (10R) colors (Fig. 5.3). They are the products of an advanced alteration under hot and humid climate. Under these conditions, there is a concentration of iron, in form of the minerals hematite or goethite, and aluminum, in form of kaolinite, gibbsite or boehmite (Tardy and Roquin 1998). Some of these soils are paleosols, or soils of the past, as is the case for some

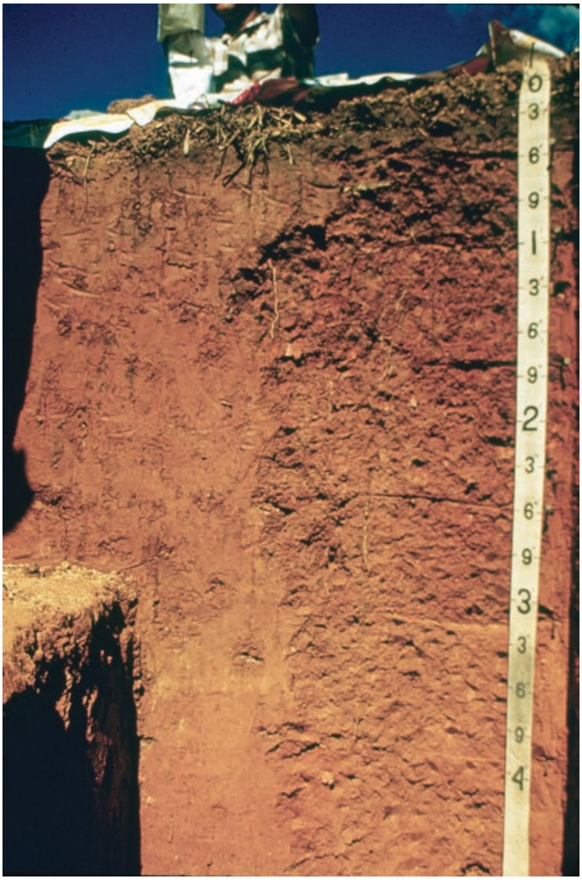

Fig. 5.3 Oxisol (Ferralsol) Scale in feet, Central Puerto Rico. ("The Marbut Memorial Slides" Soil Science Society of America, 1968. With permission (see as color plate following *Index*)

examples in Australia, where they were formed under different climatic conditions but retain the vivid red colors to the present. These paleosols developed in the Eocene, about 50 million years ago, under a tropical climate characterized by strongly contrasting seasons: hot and wet, and hot and dry. At that time, Australia was at about 65°S and because of the continental drift was moving northward toward the Equator. This paleoclimate was responsible for deep weathering and the formation of highly weathered soils, the Ferralsols, now exposed on sea cliffs near Sidney. They strongly contrast with moderately developed modern soils (Retallack 1990). Similar situations are also present in Africa, where climatic changes are associated with continental drift. Red lateritic crusts made of iron oxides, which could only have formed in tropical climate, are now present in desert and semi desert areas (Tardy and Roquin 1998). According to Retallack (1990), some of the soil Orders of the Soil Taxonomy have formed on the landscape since the Precambrian supereon that started about 4.55 billion years and ended approximately 542 million years before the present. Other soil Orders: Histosols, Alfisols, and Spodosols appeared approximately in the last 300,000 years (Retallack 1990). The continuous trend toward dryness in the last 50 million years (Parrish et al. 1982) has resulted in drying out of the soils to the extent that there has been a shift toward more arid soil Orders. The net result is less enrichment of organic matter at the surface and hence lighter soil colors.

Because of the association of colors with specific pedogenic processes, it is not surprising that many past and current soil classifications systems have used color as a major diagnostic factor and nomenclature term—for example, in the 1949 U.S. Soil Classification, the names of the Great Soil Groups were largely derived from the colors of the soils hence Red Desert soils, Brown soils, Chestnut, Chernozem, Podzols, Gray wooded, Brown Podzolic, Gray-Brown Podzolic, Red-Yellow Podzolic, and Reddish-Brown Lateritic soils, to name a few (Thorp and Smith 1949). In the different versions of the U.S. Soil Taxonomy (Soil Survey Staff 2006) the colors appeared only in three Orders out of twelve while, in the last edition of the World Reference Base, the names for eight out of thirty-two Soil Groups are based on soil colors (FAO/ISRIC/ISSS 2006). In the French Soil Classification, Duchaufour (1991) recognized twelve classes of which six are distinguished for their colors. In the Russian classification five orders are named according to prevailing soil colors (Shishov et al. 2001).

5.3 How Do Soil Colors Develop?

The process that transforms photosynthetically produced, green biomass into a black organic material is known as *humification* (Jenny 1980). Humus, the end product of a complex process involving biological and chemical reactions, tends to accumulate, especially in regions where the conditions for further decomposition are inhibited by temperature and other environmental conditions. This explains the large deposits of humus in form of peat in cold, wet environments. The mineral fraction of soils derived from igneous or sedimentary rocks contains, in addition to quartz and feldspars, also iron-bearing minerals such as olivine, pyroxenes, amphiboles, and biotite. In these minerals of igneous origin, iron and manganese are present in reduced forms. Under near-surface conditions, the minerals undergo alteration or *weathering*. Hydrogen ions attack the iron-silicate minerals and liberate iron and manganese ions. In well-aerated soils, there is sufficient oxygen to oxidize these metals in solution, leading to precipitation of new mineral species that are stable in the surficial environment (Schwertmann 1985; McKenzie 1989).

5.4 Iron and Manganese Oxides

Goethite (α FeOOH) is the common form of iron oxides in soils (Schwertmann and Taylor 1989). It occurs in most climatic regions and it imparts the yellowish-brown color to the soil matrix (7.5YR –2.5Y); it may accumulate in certain horizons, or form concretions and nodules. Hematite (α Fe_2O_3) bright red in color (5R to 2.5 YR) is the second most abundant iron oxide found in soil. Its occurrence is restricted to warm climate, consequently where hematite and goethite occur, the latter is present in wetter and cooler areas (Schwertmann and Taylor 1989). Warm and dry conditions help the decomposition of organic matter, thus favoring the formation of ferrihydrite, the necessary precursor of hematite. Humic substances and organic acids tend to react with metals ions such as iron, forming stable complexes and hence preventing the synthesis of iron oxides (Schnitzer and Kodama 1977). If hematite present in paleosols or sediments is exposed to a wetter and cooler climate than the one in which it formed, it may change into goethite (Schwertmann 1971).

There are also other secondary iron minerals with distinct colorations, such as lepidocrocite (γ FeOOH)–orange in color (5YR-7.5YR)–present in hydromorphic or wet soils that have been drained. In wet soils, the iron is in reduced form. Lepidocrocite appears when the soils are drained and the reduced iron is rapidly oxidized. Maghemite (γ Fe_2O_3)–reddish brown in color (2.5YR-5YR)–seems to be favored by an ample supply of ferrous iron and dryness. Ferrous iron derives from the weathering of basic igneous rocks, *e.g.*, basalt, while dehydration is expected in a warm climate (Schwertmann and Taylor 1989). Maghemite is found also in areas subjected to reoccurring fire; in these cases it is considered site specific. Ferrihydrite ($5Fe_2O_3{\bullet}9H_2O$) is reddish brown (5YR-7.5YR). It precipitates upon oxidation of the organic fraction to which it is chelated (combined). It may be present in the B horizons of Podzols; it will eventually crystallize into either goethite or hematite, depending on the climatic conditions at the site (Schwertmann and Taylor 1989).

There are also iron oxides minerals, the so called "green rust" group, that contain both reduced and oxidized iron and display a greenish color. Fougerite is a recently discovered mineral of the green rust group whose composition includes ferrous, ferric and magnesium ions $[(Fe^{2+}, Mg)_6 Fe_2^{3+} (OH)_{18} \cdot 4H_2O)]$. Fougerite is present in Gleysols or sediments; it has a bluish-green color under reducing conditions, but changes to red-yellow hues when exposed to the air (Trolard et al. 1996).

Numerous oxides and hydroxides of manganese are possible because the substitution of Mn^{2+} and Mn^{3+} for Mn^{4+} commonly occurs in the mineral structures (McKenzie 1989). Among the most frequently encountered Mn-minerals in soils are:

- pyrolusite, (MnO_2): steel gray to black, mostly concentrated into concretions;
- birnesite (black or brown): part of a group of oxides under the name of δ-MnO_2; the group includes vernadite (chocolate brown to black).
- lithiophorite $[(Al, Li) MnO_2 (OH)_2]$: commonly found in the soils of Australia (McKenzie 1989); bluish-black.

Biological oxidation can play an important role in the formation of these oxides. In a well-aerated soil with a high pH, manganese is readily oxidized, often by bacteria, from Mn^{2+} to Mn^{4+}. Reduction occurs in waterlogged soils where the O_2 is exhausted. Manganese oxides may be present in the soils as a dispersed phase in the soil matrix, and as nodules. Manganese nodules often show a color-banded, annular growth pattern and contain oxides of Fe, Mn and other metals. Conditions affecting the oxidation or reduction of Mn in soil can change within a few centimeters, leading to distinct color changes.

5.5 Clay Minerals

An important distinction is made in soil science between clay-size particles and clay minerals. Clay-size particles are those that have dimensions less than 0.002 mm or 2 μm. However, the clay minerals are those belonging to the phyllosilicate class—minerals having a distinct layered structure. The particles of these abundant soil minerals typically are "clay-size", hence the somewhat ambiguous terminology. Looking at the mineralogical composition of *Terre*, one finds that, in some instances, the main coloration is due to clay minerals. This is the case for *Bolo Bianco* (White bolo) made of kaolinite, and for *White Mica* or muscovite. There are also other two mica minerals: glauconite and celadonite responsible for providing a green color to *Terra Verde*. Celadonite was reported by Reid et al. (1988) in hydrothermally altered basalt. At Monte Baldo, Verona, the type location for *Terra Verde di Verona* celadonite collects in cavities as a coating in altered basaltic rocks.

5.6 Soil Coloration

It is apparent that soils display colors that to some extent are predictable on the basis of pedological processes that prevail. However, how could this earth-colored material be used as pigments for painting? With exception of iron and manganese concretions, soil material, even if colored, may not contain a substantial quantity of pigment. For example, in the case of iron oxides, a small amount can produce a high degree of pigmentation; this is especially the case in coarse textured soils that display low specific surface area. Coarse sand with 0.2% iron can acquire a yellowish red (5YR5/6) color; however, once the soil is ground, the apparently reddish soil may yield a dull color (Schwertmann and Taylor 1989; Nuhn 1987). The most abundant of the minerals in the soil matrix are quartz and feldspars, both whitish in color. Most of the iron oxides in soils occur as cryptocrystalline in a finely dispersed phase adsorbed at the surface of minerals, especially clay minerals, or concentrated in voids. Goethite in soils appears as small spherical particles of 5-10 nm in diameter; soil hematite shows particles less than 100 nm (Manasse and Mellini 2006). In soils, concentration of hematite and/or goethite, with the exception of highly weathered soils of the tropics or subtropics, is low hence, grinding tends to dilute the pigment and to reduce the coloration. Soil material from basalt or ultrabasic rocks may be more promising. A basaltic rock has on average between 5 to 15% iron oxides whereas granite contains about 3% (Encyclopedia Britannica, 2007). Terra di Siena contains between 54 and 70% iron oxides. Nanoparticles of goethite 2 to 10 nm in size are present in Raw Siena pigment; when heated at 400°C to produce Burnt Siena, goethite is changed into hematite. Nevertheless, there are rocks that in spite of being whitish in color, such as limestone, may contain an intensely colored, insoluble residue with high iron content (Mirabella and Carnicelli, 1992). Furthermore, when these calcareous parent materials are dissolved over geologic time by weathering agents such as carbonic acid, a red residue is left. Carbonic acid is produced by the reaction of carbon dioxide (CO_2) with water. Carbon dioxide is abundantly evolved in soil by the degradation of organic matter and autotrophic respiration. The dissolution of limestone leaves a residue of clay minerals, pyrite, iron oxides, bituminous matter and others insoluble materials (Pettijohn, 1957). Therefore, it should not come as a surprise to learn that at Lascaux, in southwestern France, one of the most famous caves containing Stone Age paintings, was formed on limestone. The dissolution of this limestone by meteoric waters enriched in CO_2 produced underground passages, caves, and sinkholes, and an insoluble, red residue. In northern Spain and southwestern France, such caves were occupied by Upper Paleolithic humans who covered the walls with paintings, mostly of animals. At Lascaux, 40 to 15,000 years ago Cro-Magnon men drew the outlines of animals in black, while the bodies were painted in light-red or reddish-brown colors (Bandi et al. 1961). The red ochre probably came from the dissolution of calcareous rocks, especially hard limestone containing hematite, while the yellow-brown could have come from earthy materials rich in goethite (Duchaufour, 1982). Soils of the Dordogne region, where the Lascaux caves are located, are now classified as Calcisols and Cambisols. However, within these Groups, vividly colored chromic Subgroups are present; these are the Chromic Cambisols, or the Rhodic Nitisols, or the Rhodic Luvisols.

Extensive areas in Spain, southern France, southern Italy, Greece, Lebanon, and Turkey are covered by soils, once called *Terra Rossa*, suggesting the intense red color (Soil Atlas of Europe, 2007) [Fig. 5.4]. Analyses conducted on over 85 samples from the red soils of the Mediterranean areas show a mean content of iron oxides of 3.5% (Durn 2003). On the other hand, the red coloration of soils is not restricted to substrata derived from limestone; the color is due to iron oxides, and many parent materials contain these minerals. Iron oxides are the most abundant of the metallic oxides in soils (Schwertmann and Taylor, 1989), with concentrations ranging from less than 1 to more than 10% (Torrent 2007). In the area where *Terra di Siena or Terra di Sienna* is extracted, the soils are called *Terra Rossa* betraying, hence, the intense red color. Presently, the term *Terra Rossa* has not been retained in modern soil classification systems; consequently, a number of other names have been used: Sol Rouge Fersiallitique Lessivé, Haploxeralfs and Rhodoxeralfs, or Chromic Cambisols and Luvisols, Chromic Vertisols, Vertic Luvisols, Eutric Nitisols. In the World Reference Base (FAO/ISRIC/ISSS, 2006), the Terra Rossa soils are called Chromic Cambisols or Luvisols or Rhodic Luvisols or Rhodic Nitisols. In the Siena district, Mirabella et al. (1992) have analyzed Terra Rossa soils developed on Triassic limestone and Triassic dolomite. They found that goethite and hematite were the dominant iron oxides and that the redness of the soils was statistically correlated with hematite content. Additional investigations of

Fig. 5.4 Terra Rossa. Profile about 30 cm. Carini, Sicily, Italy. (Photo by the author) (see as color plate following *Index*)

paleosols developed on the "Montagnola Senese" found that the red colors and hematite are the results of processes that have occurred in the past under different climatic and internal drainage conditions (Costantini et al. 2006).

Quarries for the original *Terra di Siena* were virtually exhausted by the mid-1900s; consequently other quarries were opened in the Mt. Amiata, not too distant from Siena. Bolar earths, meaning mineral pigments of *Yellow Raw Siena* and *Red Burned Siena* from the Amiata district have been studied to find their association with arsenic. Evidently, arsenate anions are strongly adsorbed to goethite surfaces forming very stable complexes presenting very limited risk for the arsenic release to the environment (Manasse and Viti 2007).

5.7 Desert Varnish

Another process of interest that occurs at near-surface conditions is the formation of *desert varnish*. When exposed to desert weathering conditions, the surfaces of pebbles and boulders acquire a shiny, black or brown coating consisting of a 50 to 100 μm thick layer of iron and manganese oxides. The chemical and mineralogical composition of the varnish does not coincide with that of the underlying rocks, and it is believed that the patina derives from wind-blown material deposited on the rocks (Perry and Adams 1978; Taylor-George et al. 1983; Perry and Kolb 2004; Ugolini et al. 2008). The origin of the staining is still under discussion, especially the role of microorganisms in the process. Desert varnish is found in both hot and cold deserts (Ugolini 1970; Dorn and Oberlander 1982; Perry and Kolb 2004). Native people in these desert lands have taken advantage of these stained surfaces for incising lines and making drawings of animals, hunting scenes, warriors, dances, and battles (Fig. 5.5). In the Hisma Basin southern Jordan, Borzatti von Lowenstern and Masseti (1995) reported about 15,000 examples of rock carving. Examples of these rock carving are often found in North Africa, in the mountain regions of the Sahara on the Tassili, Hoggar, Aïr and Tibesti massifs. Many engravings depict animals such as elephants, rhinoceroses, large buffalos, giraffes, large antelopes and ostriches no longer living at these sites, implying a climatic change. In Australia and the Hisma Basin, the creation of such rock carvings by native people has continued to present time (Bandi et al. 1961; Borzatti von Lowenstern 2005).

Fig. 5.5 Rock carving. Scale 15 cm. Hisma Basin, southern Jordan. (Photo by the author) (see as color plate following *Index*)

5.8 Summary and Conclusions

Colors in soils arise from both the organic and inorganic components. Humus is responsible for the black color, iron oxides for yellow to red, and carbonates for white, while less frequently, a bluish color is imparted by manganese oxides. Grayish colors are present in immature or poorly drained soils. Thanks to the introduction of the Munsell Color Charts, the nomenclature of soil colors has been placed on a numerical scale. Subjectivity, nevertheless, remains in color identification. The coloration displayed by the soils is the result of the soil forming processes that in turn are conditioned by the site-specific climate, biota, parent material, topography, and weathering time. In the wide expanses of the Tundra, the Cryosols acquire a grayish color because of reducing conditions. In the Boreal forest, and also in the Tropics, the Podzols have developed vivid contrasting colors; they show a whitish gray horizon at the surface and dark brown to yellowish red in the subsoil. In the long-grass steppes, the Chernozems are soils with a thick brown to black surficial horizon. The Andosols have a similar thick, dark A horizon because of their development on volcanic ashes under grassy vegetation. The Cambisols, soils with brown subsurface horizons, are present in the temperate forests; however, in the same region, one can find also the Luvisols soils with contrasting colors in the E and B horizons. In the Tropics and Subtropics, red colors prevail. Because of the association of colors with specific pedogenic processes, it is not surprising that classifications based on soil genesis principles used colors for segregating the soils into groups–the Soil Groups. This is the case for the 1949 U.S. Soil Classification and other European classifications. In the modern systems, criteria other than soil colors have been adopted.

In terms of the origin of the soil colors, black colorations result from the transformations, through biological and chemical processes, of the green biomass into black humus, in addition to charcoal produced by fires. Brown, reddish-brown, red and yellowish-red are due to the presence of iron oxides. Hematite is restricted to warm climate and imparts a bright red color, while goethite present in wetter and cooler environments produces a yellow-brown hue. Manganese oxides are responsible for blue and black colors. Among the clay minerals, kaolinite and muscovite produce a white coloration. Glauconite and celadonite are green. Limestone, in spite of its typical white color, can, in a Mediterranean climate, produce a strongly red colored weathering residue. Soils developed from this residue were called *Terre Rossa*. This red soil material was probably used as a pigment during the Upper Paleolithic by Cro-Magnon man for cave paintings. Other natural pigments derived from soils or soil materials are the *Ochres* or *Terres*. These earth-derived pigments dominated human usage prior to the Industrial Revolution when the chemical industry began manufacturing colored synthetic organic molecules. Finally, in cold or hot deserts, chemical processes occurring at the surface of exposed rocks produce a dark patina called a *desert varnish*. Indigenous populations have taken advantage of this black varnish for drawing animals, hunting scenes, warriors, dances and other events; in some regions such as Australia, and southern Jordan, such rock art has continued to the present day.

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References

Auneddu G (2006) Storia dei colori [History of colors] Quaderni di Storia dell'Arte di Giorgio Auneddu. G.A.M. Castle Torino, 6 pp. [in Italian]

Bandi H-G, Breuil H, Berger- Kirchner L, Lothe H, Holm E, Lommel A (1961) The art of the Stone Age. Holle and Co. Verlag, Baden-Baden, Germany, 249 pp.

Borzatti von Lowenstern E (2005) "Quadri di Pietra" 8000 anni d'arte nel deserto. ["Stone paintings" 8000 years of art in the desert] Casa Editrice Nuova SI, Bologna, 166 pp.

Borzatti von Lowenstern E, Masseti M (1995) Rock carvings of cattle in the Hisma Basin, Southern Jordan. Studi per l'Ecologia del Quaternario 17:10-19.

Brunetti BG Caratterizzazione di pigmenti a base di terre (Characterization of earthy pigments) http://becu.chm.unipg.it/corso/ChimicaAmbienteBC/lezione4-terre.pdf Accessed January 19, 2009 [in Italian]

Costantini E A C, Lessovaia S, Vodyanitskii Yu (2006) Using the analysis of iron and iron oxides in paleosols (TEM, geochemistry and iron forms) for the assessment of present and past pedogenesis. Quaternary International 156-157: 200-211.

Crowley-Kiggins, M. A History of Colors. Available at http://www.multimediaarts.com/watercolors/colrhist.htm. Accessed January 19, 2009.

Dorn RI, Oberlander TM (1982) Rock Varnish. Progress in Physical Geography 6:317-367.

Duchaufour Ph. (1982) Pedology. Translated by T.R. Paton George Allen and Unwin London, 448pp.

Duchaufour Ph. (1991) Pédologie [Pedology] Troisième ed. [Third ed.] E. Mason, Paris, 289 pp.

Durn G (2003) Terra Rossa in the Mediterranean Regions: parent materials, composition and origin. Geologia Croatica 56/1:83-100.

Encyclopedia Britannica (2007) Delux Ed. Chicago.

FAO/ISRIC/ISSS (2006) World Reference Base for Soil Resources. World Soil Resources, Report 103, Rome, 2006, 2nd Ed: Food and Agriculure Organization of the United Nations, International Soil Reference and Information Center, and International Society of Soil Science www.fao.org/ag/agl/agll/wrb/

Jenny H 1941. Factors of Soil Formation. A System of Quantitative Pedology. McGraw-Hill Book Company, Inc. New York, 281 pp.

Jenny H (1980) The soil resources: origin and behaviour. Springer – Verlag, New York, 377 pp.

Manasse A, Viti C (2007) Arsenic adsorption on nanocrystalline goethite, the natural example of bolar earths from Mt. Amiata (Central Italy). Environ. Geol. 52:1365-1374.

Manasse A, Mellini M (2006) Iron (hydr)oxide nanocrystals in raw and burnt sienna pigments. Europ. J. Mineralogy 18:845-853.

McKenzie RM (1989) Manganese oxides and hydroxides. In: Dixon SB and Weed JB (eds) Minerals in Soil Environment. 2nd ed. 9: 439-466. Soil Sc. Soc. Amer., Madison. WI, USA.

Mirabella A, Carnicelli S (1992) Iron oxides mineralogy in red and brown soils developed on calcareous rocks in central Italy. Geoderma 55:95-109.
Mirabella A, Costantini EAC, Carnicelli S (1992) Genesis of a polycyclic Terra Rossa (Chromic Cambisol on Rhodic Nitisol) at Poggio del Comune in Central Italy. Z. Pflanzenernahr. Bodenk. 155:407-413.
Munsell Book of Color (1976) Macbeth, a Division of Kollmorgen Corp., Baltimore, MD.
Nuhn WW (1987) Soil genesis in the 1980 pyroclastic flow of Mount St. Helens. MS, College of Forest Resources, University of Washington, Seattle WA.179 pp.
Parrish JT, Ziegler AM, Scotese CR (1982) Rainfallpatterns and the distribution of coals and evaporites in Mesozoic and Cenozoic. Paleogeography Paleoclimatology Paleoecology 40: 67-101.
Perry RS, Adams JB (1978) Desert varnish: evidence for cyclic deposition of manganese. Nature 276:489-491.
Perry RS, Kolb VM (2004) Biological and organic constituents of desert varnish: review and new hypotheses. Instruments, Methods, and Missions for Astrobiology VII, 5163, 202-217.
Pettijohn FJ (1957) Sedimentary Rocks. 2nd ed. Harper & Broder, NewYork 718 pp.
Retallack GJ (1990) Soils of the past. Unwin Hyman, London, 520 pp.
Reid DA, Grahm RC, Edinger SB, Bowen LH, Ervin JO (1988) Celadonite and its transformation to smectite in an Entisol of Red Rock Canyon, Kern County, California. Clays and Clay Minerals 36:425-431.
Shindo H, Honna T, Yamemoto S, Honna H (2002) Disrtibution of charred plant fragments in Japanese volcanic ash soils with reference to origins of black humic acids. In: Proceedings of the International Humic Substances Society, 20th Anniversary Conference, Northeastern Univ., Boston, MA., 2004, 466-468.
Shishov LL, Tonkonogov VD, Lebedeva II, Gerasimova MI (2001) Russian Soil Classification System (Translated by M. Gerasimova) V.V. Dokuchaev Soil Science Institute, Russian Academy of Agricultural Sciences, Moscow, 220 pp.
Schnitzer M, Kodama H (1977) Reactions of minerals with soil humic substances. In: Dixon JB, Weed SB (eds) Minerals in Soil Environments 21:741-770. Soil Sc. Soc. Am. Madison, WI, USA.
Schoeneberger PJ, Wysocki DA, Benham EC, Broderson WD (eds) (2002) Field Book for Describing and Sampling Soils. Version 2.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.
Schwertmann U (1985) The effect of pedogenic environments on iron oxide minerals. In: Advances in Soil Science. 1:171-200. Springer, New York
Schwertmann U, Taylor RM (1989) Iron oxides. In: Dixon J B and Weed S B (eds) Minerals in Soil Environments. 2nd ed. 8:380-438. Soil Sc. Soc. Amer., Madison. WI, USA.
Schwertmann U (1971) Transformation of hematite to goethite in soils. Nature (London) 232: 624-625.
Soil Atlas of Europe, European Soil Bureau Network European Commission (2005) 128 pp. Office for Official Publications of the European Communities, L-2995 Luxembourg.
Soil Survey Division Staff (1993) Soil Survey Manual. United States Department of Agriculture, Handbook N° 18. U.S. Government Printing Office, Washington, D.C. 437 pp.
Soil Survey Staff (2006) Keys to Soil Taxonomy. Tenth Edition. United States Department of Agriculture, Natural Conservation Service.U.S. Government Printing Office,Washington, DC.
Tardy Y, Roquin C (1998) Dérive des continents Paléoclimates et altérations tropicales (Continental drift Paleoclimates and Tropical Weathering) EÉditions Brgm, Orléans 473 pp.
Taylor–George S, Palmer FE, Staley JT, Born DJ, Curtiss B, Adams JB (1983) Fungi and bacteria involved in desert varnish formation. Microbial Ecology 9:227-245.
Thorp J, Smith GD (1949) Higher categories of soil classification: Order, suborder, and great soil groups. Soil Sci. 67:117-126.
Torrent J (2007) Soil iron oxides: origin, significance and application in environmental studies. Paper presented at the International Summer School on Forest Soils and Global Change, University of Molise, Campobasso (Italy), 9-23 September, 2007. Abstracts p.12.

Trolard F, Abdelmoula M, Bourrie G, Humbert B, Genin J (1996) Evidence of the occurrence of a "green rust" component in Hydromorphic soils. Proposed existence of a new mineral fougerite. CRAS, (Paris) serie II a, no. 232:1015-1022.
Ugolini FC (1970) Antarctic soils and their ecology. In: Holdgate MW (ed) Antarctic Ecology, 2: 673-692. Academic Press, London, UK.
Ugolini FC, Hillier S, Certini G, Wilson MJ (2008) The contribution of aeolian material to an Aridisol from southern Jordan as revealed by mineralogical analysis. Journal of Arid Environ. 72:1431-1447.
Ugolini FC, Schlichte KA (1973) Effects of Holocene environmental changes of selected western Washington soils. Soil Sci. 116:218-226.

Chapter 6
In a Supporting Role: Soil and the Cinema

Edward R. Landa

A screenwriter with a compelling story to tell.
A director with the vision to capture that story with the moving image.
An actor who can steal a scene with a glance.
These are what most of us think about when we consider the making and viewing of a film—indeed, they are some of its key human elements. And yet there are other elements embedded in the fabric of a film that give its characters and their stories uniqueness, reality, and a sense of place—soil is one such element. We will explore the depiction of soil in a variety of films and film formats—live action, documentary, and animated. We will look at film classics and films with limited distribution. And we will look at film and video as both an art form and as a tool being used by scientists to explore the dynamic properties of soil.

6.1 A Place to Work

For those of us who have made soil science our profession, probably no feature film title has so garnered our interest as *The Agronomist*. This 2003 documentary by director Jonathan Demme (best known as director of *The Silence of the Lambs*) is a look at the life of his friend, Haitian radio journalist and human rights activist Jean Dominique (1930-2000). In the opening of the film, during a 1993 interview with Demme, Dominique tells us:

> I am not a journalist.
> I became a journalist.
> I am an agronomist.

Indeed the thread woven from the title to the closing of the film is Dominique's attachment to the land and the people of Haiti. He was the son of a middle class

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Haitian nationalist who worked as a broker for the sale of coffee and other local crops. Accompanying his father on extended business trips, young Jean saw much of the countryside of Haiti and the Dominican Republic during the late 1930s. Jean went on to study at the Agricultural School of Haiti [Ecole Centrale d'Agriculture] in Damien (near Port-au-Prince) and later at L'Institut National Agronomique in Paris where he specialized in genetics and plant breeding. [Carrié Paultre (1924-1999) one of Haiti's leading novelists was also an Agricultural School graduate; before turning to literature, he served as agronomist in the Central Plateau and the Artibonite Valley (Freeman 1982).]

Jean returned to Haiti and worked for six years as an agronomist, working on improving production of cocoa, coffee and corn. These were troubled times in Haiti under the iron-handed rule of Papa Doc Duvalier, and during this time, Jean's boss and fellow agronomist Edner Ville was killed, apparently due to his efforts promoting agrarian reforms. This seems to have been a turning point in Jean's life, and he was later jailed for six months. During a subsequent period of exile, he went to Paris and experimented with filmmaking. He returned to Haiti and began "another season in my life"—his career as reporter and then owner of Radio Haiti. His political activism intensified over the years. He clashed with the central government on issues of censorship, corruption, and the economic status of small farmers—the latter including his support of their production of sugarcane and sorghum in the face of increasing imports of processed sugar from abroad. In April 2000 he was shot and killed at the radio station; an estimated 16,000 people attended the funeral.

Demme's cinematic approach to portraying his animated and charismatic subject is to return to Jean's quiet connection to the land at various points in the film. As Demme (ca 2002) describes it, this direction was guided largely by Jean's self-image:

> "Besides, Jean said, he was not a very interesting subject for a film, and even if he was, a portrait of Jean Dominique that focused on him as a journalist would be entirely missing the point of who he really was as a person. A man of the soil. A man of the countryside. An *agronomist*.
>
> Maybe someday when Radio Haiti–and Haiti itself–were up and running, then I could come back with my "little camera" and we would go into the heart of the country, to the Artibonite Valley where the rice and other crops are grown, and film Jean there, where the real Jean Dominique exists. And that film would be called "The Agronomist", because that is what he really is.
>
> I remember thinking at the time how poignant this self-image was: the mercurial man of the world, poet/genius analyst of the microphone, crusader for democracy in his beloved nation—and he likes to picture himself as the country mouse, never more true to himself than when he's shooting the shit about rainfall and the next mango crop with the other farm boys down in the boondocks."

Early in the film there is an enigmatic scene where we see a gourd with what appears to be a corn cob plug in the top being carried by a procession of peasants—its meaning becomes clear only at the end of the film—it is the funeral procession following the assassination--the dried gourd contains Jean's ashes— in the words of one of his mourners "to be joined with the waters and soil of the Artibonite River." The director notes in his closing remarks on the film:

> "And what emerged, to my amazement, delight and emotional wellbeing was the portrait of…*an agronomist*! Jean had labeled himself an agronomist, and I was bemused. But sure enough, as Jean's sister says in quoting their mom, Jean Dominique was an agronomist… "an agronomist without land…"
> It's incredibly moving for me that our film actually does wind up in the countryside as he said it must. Not just in the countryside, where Jean's ashes are scattered, but where we see his ashes floating in the currents of his beloved Artibonite River…the man of the soil, the country boy, literally becoming as one with the land."

Demme's recent work continues to document the lives of complex individuals. He released his second biographical documentary—*Jimmy Carter: Man from Plains*—in 2007.

Screenwriter Kobo Abe's (1924-1993) {based on his 1962 novel} and director Hiroshi Teshigahara's *Woman in the Dunes* (1964) was nominated for Academy Awards for best foreign language film and best director in 1965 and 1966, respectively. Stark sand dunes near the coast (shot in Tottori area of Japan; Gibeau 2007) provide the setting for a tale, told in black and white, of science and the surreal. {Such a harsh landscape was also the setting of the previous Teshigahara/Abe motion picture, *Pitfall* (1962), filmed on the tailings piles and the waste-pond mud flats of a coal mine.} Jumpei Niki is an amateur entomologist who comes to the dunes to look for tiger beetles. Seeking a place to spend the night, he is taken to a house at the bottom of a sand pit from which he later finds there is no escape. Now condemned to the life of a sand-digging slave, his interest gradually shifts to learning about subsurface water movement in the sand.

Images of dunes—their sharp crests and crisp shadows—are almost a cliché in nature photography. Teshigahara goes far beyond that in this film, and we have hints of this from the opening shots of contour maps and micrographs of sand grains, presented in documentary style. Film scholar Dan Harper (2003) observed that: "Teshigahara's wonderful abstract compositions of sand dunes constantly shifting bestow on geology an alarming *presence*."

Early in the film we hear a bit about soil moisture—the observation by the woman who lives in the house that the wood is suffering from wet rot, and that some dune houses have soil rich enough to grow cucumbers. Niki—the scientist, is skeptical, and once he comes to grips with his fate as a prisoner in the pit, his sole focus is survival and escape. Part of his escape plan is to catch a crow and tie a message to its leg. He devises a baited trap consisting of a wooden bucket buried in the sand at the bottom of the pit. It does not catch a bird, but it does fill with water. Niki is perplexed, as it has not rained in three weeks. He deduces that the driving force must be capillary action driven by evaporation at the dune surface. Learning about this natural pump that can provide the inhabitants of the dunes—first himself and the woman, and later the villagers at the surface who are his captors—with a reliable source of fresh water is now his prime focus.

This part of the film is rich with shots of Niki's conceptual sketches of the water flow process, and notebook tabulations of his twice-daily water depth measurements in the bucket. A sheet of newspaper baited with a fish over the mouth of the bucket (designed to catch a crow) has been replaced by a plastic sheet—the trap is now his experimental well.

Woman in the Dunes is not a science film per se. And the subsurface science it does depict in telling the larger story of a man coping with change is certainly not the type of science that most people would first think about for a visual medium. What made Abe think about dune hydrology is not clear. However, he had a degree in medicine and a strong interest in mathematics—the latter is apparent in the novel where he describes the Gaussian distribution of sand grain sizes in various desert and beach sands and the aerodynamics of wind transport of soil particles. As Abe did the script for the film, that perspective comes through on screen. Man's interaction with the natural world are recurring themes in his writings, and among his other novels and short stories are ones dealing with global warming and a man turning into a plant (Iles 2000). The earth science detail in *Woman in the Dunes* is impressive and unusual for a non-fiction novel or film, but not unusual for Abe. For example, in his book (later screenplay) *The Face of Another* the detail about manufacturing a life-like mask is painstaking and scientifically rigorous (Bolton 1998, p.149).

Writer Kobo Abe was a good match for director Hiroshi Teshigahara (1927-2001)—a gifted visual artist whose life in art included filmmaking, ceramics, calligraphy, experimental theater, and installation art. Teshigahara's art often focused on natural materials—earth (sand and mud) and its vegetation. We see hints of his later attraction to pottery in the mud flats where *Pitfall* was filmed, and he describes that attraction as innate and primal:

> "I was attracted by *earth*, not the art of pottery. I wanted the *feeling* of clay."
> (Ashton 1997, p. 14)

In the 1990s, Teshigahara created a series of large-scale installations using bamboo. Art critic Dore Ashton sees this as part of the continuum of Teshigahara's artistic vision, explored three decades earlier in *Woman in the Dunes*:

> "Teshigahara's characteristic material sensuousness is well served by Surrealist attitudes, in which all senses were honored in synthetic works. Throughout his career Teshigahara has worked with startling material juxtapositions and has characterized in his art the essential nature of each material: sand, its color and light, its granular character, its constant metamorphosis, its insistence on slipping out of form; bamboo, its spectacular growth, its pliable erectness, its supple jointed structure, its sound in the wind…."
> (Ashton 1997, p. 198)

6.2 Folklore

Seedlings sprouting from fertile soil—dead bodies laid to rest in a neighboring field. The linkage of the soil to the earth's life cycle is an enduring symbol in religion and folklore. Set in present-day Scotland, *The Wicker Man* is a film of haunting images, dialog and music, much of it strongly tied to Celtic and Druid folklore. The film was rescued from the oblivion of its initial 1973 release by the efforts of its creative team, including one of its lead actors, British horror icon Christopher Lee, and by American horror film producer/director Roger Corman. In the past three decades, it has acquired the status of cult film, and has been the subject of serious academic study—*e.g.*, a 2003 conference focused on the film was held at the University of Glasgow, attracting specialists in anthropology, archaeology, film studies, history, musicology and religious studies (Franks et al. 2006). The climactic burning of the large wicker figure at the end of the film is the apparent inspiration for the similar event at the end of the Burning Man Festival held each year in the Nevada desert.

The story revolves around a policeman from the mainland investigating the disappearance of a young girl on Summerisle, an isolated island community ruled by the Christopher Lee character. As the mystery unfolds, Lord Summerisle explains to Sergeant Howie that his grandfather, an agronomist, bought the island in 1868 because of its rich volcanic soil and warm Gulf Stream waters. He introduced new cultivars of fruits suited to local growing conditions and encouraged a return to pre-Christian agrarian religious rites and beliefs focused on the linkage of human sexuality and fertility with soil fertility and crop production (see chapters 13 and 16 by Patzel, *this volume*). The scene here with Howie and Lord Summerisle was apparently much longer during filming, but later was drastically edited down (much to Christopher Lee's dismay). The dialog removed described how the Christian ministers on the island opposed his grandfather's agronomic experiments, and threw tons of his artificial fertilizer into the sea. Lord Summerisle explains that his grandfather turned the islanders towards a belief in the old Celtic gods and goddess to separate them from these opponents of his work.

In developing the script, the director and writer relied heavily on the 1890-1915, twelve-volume treatise *The Golden Bough: A study in magic and religion* by Cambridge scholar Sir James George Frazer (the 1922 abridged edition is available in searchable form online at http://www.bartleby.com/196/). The religious practices depicted in the film, that tied the storyline to early Celtic cultures of the region, were in reality probably an amalgam derived from a variety of cultures worldwide. In one scene, Howie finds an umbilical cord ("navel string") in a young tree at the village graveyard. It is a Rowan tree, and the gravedigger/gardener [wonderfully played by Aubrey Morris; the character is called "Old Loam" in the film novelization of *The Wicker Man* by director Robin Hardy and writer Anthony Shaffer (Hardy and Shaffer 1978)] tells him that the cord belongs to the missing girl (Rowan Morrison). This represents the islander's view of the cycle of life—here from the girl to the tree. In a variety of cultures (*e.g.*, Native American, African, Caribbean, Polynesian, Maori) it was or is the custom to either hang the umbilical cord from a tree as a fertility symbol, or to bury the cord or placenta in the soil at a sacred place or birthplace.

Flesh & Blood (1985) is a film about medieval mercenaries in the early 16th century Europe. While not steeped in folklore like *The Wicker Man*, it does have an interesting scene where Rutger Hauer and Jennifer Jason Leigh view a man who had been hanged from a tree. In the soil below the body, she digs up a mandrake root (mandragore) and he tells her that it sprang up there as a result of semen from the man who had been hung. This is the type of unfamiliar reference that makes one grateful for pause buttons on DVD players and then for internet access. A quick search engine query reveals that the linkage of the mandrake with human fertility is ancient, and is reported in the Book of Genesis and writings on alchemy. The myth of mandrake growing abundantly in soil contaminated by human blood or semen seems to have surfaced in 16th century Europe (Carter 2003). The cultural significance of the mandrake and its depiction in western paintings is covered in detail in chapter 1 by Feller et al. (*this volume*).

Bram Stoker's 1897 novel *Dracula* has spun off a cottage industry, and there have been over 160 Dracula-titled films produced in the last 80 years, in addition to countless other vampire-themed films. These films are familiar to many of us, and our mental image of Count Dracula may be reflective of Max Schrek in the 1922 *Nosferatu*, or of one of his successors, who have included Bela Lugosi, Peter Cushing, Christopher Lee, Frank Langella, Klaus Kinski, Gary Oldman, and Willem Dafoe. Regardless of which actor comes to mind, an anchor for the plot of many of these films is Dracula's need to sleep during daylight hours in coffins filled with soil from Transylvania (in central-western Romania).

Stoker's book lays out the soil scenario. Preparing to go to England, Count Dracula has 50 wooden boxes of freshly dug Transylvanian earth. They are sent by ship, invoiced as "clay", to his new house at Carfax Abbey. Dracula then moves some of these coffin-homes, in order to have safe havens throughout London. His pursuers search for all of these boxes in order to consecrate the soil by laying a Communion wafer upon it, thus rendering it unfit for the Count. While the various films have slight variations on this storyline, the concept of unhallowed ground is central. Friedrich Murnau's 1922 *Nosferatu*, and John Badham's 1979 *Dracula* use rats to visually depict the unclean nature of the soil; Francis Ford Coppola's 1992 *Bram Stoker's Dracula* has white snakes in the soil.

In a literary analysis of Stoker's novel, Laura Sagolla Croley (2003) shows that 19^{th} century British literature often focused on the contiguity of social extremes—the rich and the poor. She sees soil as the vehicle for that message in *Dracula*:

> "These extremes meet in the Transylvanian soil Dracula totes through England, for he can be land-owner (with its attendant security and power) and vagrant (with its spatial mobility) at the same time. Like the vagrant, he sleeps in his own dirt—but it is dirt owned by him."

6.3 Reality and Unreality

Ask a soil scientist for the definition of a soil and the words "natural body" will likely be part of the answer. A soil is viewed as a three-dimensional landscape feature. The term "natural" denotes the fact that the terrains traditionally examined have been undisturbed except for agricultural utilization. This has been broadened in recent years as soil scientists have extended their view to include studies of anthropogenic soils in urban areas, landfills, mine overburden and other mine processing wastes, often referred to as "tailings". Some of these mine site soils have a cinematically captivating look, with features such as sparse vegetation due to chemical toxicity, unique colors due to ore components and weathering products, and striking depositional and erosional features. Abandoned gold mine tailings at Rodalquilar in southeastern Spain are fine textured and subject to wind transport and dune formation, finely bedded due to their intermittent wet deposition, and pink tinged due to the presence of hematite. Their surreal look has made the site a prime location for filmmakers (Moreno 2007).

While most non-soil scientists have a less well-defined view of the soil, there is an innate sense of where soil belongs and where it does not belong. Filmmakers have picked up on this instinctual boundary setting, and used it to help create on-screen environments where we are ill at ease. In an early scene in David Lynch's *Eraserhead* (1977), the lead character, Henry Spencer, emerges from a large, concrete box culvert into an industrial wasteland where there is an array of small, very smooth and uniform soil mounds—Henry purposefully walks over these and then continues on his way. We are next introduced to his one-room apartment. There is a conical pile of soil topped by a dead plant on his nightstand, and what appears to be pine-needle litter under his radiator and atop his dresser. This repeated imagery of soil and soil materials out-of-place effectively disturbs our sense of place and comfort. In another early, surreal film by Lynch, *The Grandmother* (1970), we see bucketfuls of soil deposited atop a bed by a young boy in an attempt to grow a nurturing family member from seed.

Interestingly, David Lynch probably had more exposure to the scientific study of soils in place than most people. His father, Donald W. Lynch, was a research forester with the U.S. Forest Service. His doctoral thesis dealing with tree growth in the Idaho-Washington-Montana region between the Cascade and Northern Rocky Mountains was titled "Effects of stocking on site measurement and yield of second-growth Ponderosa pine in the Inland Empire" (Lynch 1958). The study focuses on evaluation of "site", meaning an appraisal of all the environmental factors of an area influencing tree growth, and the second paragraph of the Introduction notes:

> "Site has been evaluated, for example, on the basis of the soil profile alone by correlating certain soil properties with the measured success of a tree species growing thereon. To the degree that soil characteristics reflect the combined influence of the many factors of the environment, they are valuable in delimiting divisions of productivity. The success of the edaphic approach has varied with locations and species."

It is also of note that *Inland Empire* is the enigmatic title of Lynch's 2006 feature film.

The out-of-place perspective is seen again in *The Man Who Wasn't There* (2001), a dark comedy directed by the Coen brothers, in which Billy Bob Thornton plays barber Ed Crane. The story is told from Ed's point of view, and we learn about his inner thoughts from extensive use of voice-over narration. Ed is an interesting character because, despite his lack of affect, he has flashes of reflection and introspection to which we are privy. Early in the movie, Ed has just finished giving a kid a crew cut. Staring at the top of the boy's head, he begins to tell the other barber his thoughts on hair—not its styling and grooming, but its very being— how it keeps on growing, how hair is part of us, how we cut it off and throw it away. Rather than just sweeping up and bagging the hair on the floor, Ed thinks it should be thrown outside, to mingle with the soil. The ideas are unsettling to Ed's partner in the shop, and the scene helps to introduce the audience to the complex character of Ed Crane. Late in the film, Ed has a near-fatal car crash. As his sedan leaves the roadway and his life flashes before him, time slows for Ed, and he shifts back to his earlier musings on the unlikely combination of hair and soil:

> "I thought about what an undertaker had told me once—that your hair keeps growing, for a while anyway, after you die—and then it stops.
> And I thought, what keeps it growing?
> Is it like a plant in soil?
> What goes out of the soil? The soul?
> And when does the hair realize that it's gone?"

In a case of life imitating art, there is quite a bit of chatter on organic gardening websites and forums about composting hair from barbershops and beauty salons. The consensus seems to be that human hair is high in nitrogen and that it decomposes slowly. Soil amendment and cropping investigations in Nova Scotia using human hair collected from barbershop shops without composting have shown it to act as a slow release fertilizer. While providing plant nutrients, the social acceptance and marketability of crops grown with hair waste was identified as a practical issue (Zheljazkov 2005).

6.4 Metaphor

Film has the ability to portray soil in a variety of ways—it can be a bland backdrop on which the action unfolds, or a scenic element whose color, aggregation, moisture content, or other physical properties create lasting images for an audience and help to tell the basic story. A third role also exists, in the subtext, where the on-screen images of soil are transformed in the mind of the viewer—where sand, silt and clay become the building blocks of the human experience. This is the realm of the metaphor, and its use is a tightrope act for the filmmaker—to effectively suggest, but not beat the audience over the head.

Woman in the Dunes uses sand as a metaphor. Writer Kobo Abe saw individual freedom as deriving from a lack of attachment to any single thing (such as national identity or social class), and from not being intellectually confined by the activities of daily life—what has been termed "existential nomadism". The constantly shifting dune sand is such a nomad; yet, as the micrographs of the film show, the sand grains possess an individual identity (Gibeau 2007). This unique identity and perspective on the world is the goal to which the protagonist Niki aspires after loosing his freedom at the bottom of the sand pit, and which he eventually finds in his dune hydrology studies. How one defines identity, and man's relation to society are continuing themes in Abe's work in print and in film. And indeed the use of scientific elements and scientific language are cornerstones of his work (Bolton 1998).

Geophagy is the practice of eating earthy substances such as soil (see chapter 23 by Abrahams, *this volume*). It is well known among ethnologists, but for the majority of moviegoers, it is seen as aberrant behavior. Thus, in *Ma Mere* (2005), the character played by Isabelle Huppert eats a handful of soil as a sign of her impurity and degrading life. The experimental film *The Family That Eats Soil* (2004) is indeed, on the surface, about just that; it is also about family members who, in the words of Filipino writer/director Khavn (De la Cruz) "raise the idea of dysfunction to strange new levels." Khavn sees soil as a metaphor for "essence and rootedness, a source of sustenance and spirit" in an agrarian society (Khavan 2004). In this satire, the eating of soil is emblematic of personal and societal dysfunction. We see a reverse spin on this in the *The Real Dirt on Farmer John* (2005). The film opens with farmer John Peterson tasting a handful of soil from his fields—"The soil tastes good today". So begins the tale of life-long love affair with the land, despite economic hardships and personal struggles. Always the free spirit, John can be seen atop a tractor in a flowing feather boa or spandex tights— but at the core of the film is a man whose life has been forged by the sweet smell of the soil of his northern Illinois family farm:

> Like a drug, the land can lure a person into destitution. It can overshadow ones love for others. The land can embolden, exhaust, ennoble. It can nurture, destroy, sustain.
> I don't know why I farm.
> I just farm
>
> (Peterson 1994).

Before Night Falls (2000) is the story of poet and novelist Reinaldo Arenas (1943-1990). The film is based on Arenas' autobiography, which opens in rural Cuba:

> "I was two. I was standing there, naked. I bent down and licked the earth. The first taste I remember is the taste of the earth. I used to eat dirt with my cousin Dulce María, who was also two. I was a skinny kid with a distended belly full of worms from eating so much dirt."
> (Arenas 1993)

He goes on to tell about his first crib, a waist-deep hole in the ground dug by his grandmother. It is this image that director Julian Schnabel uses to open the film.

Schnabel first established himself in the art world as a painter. And indeed the shot is like a brush stroke that then sweeps off the canvas. We see a naked boy in a flat-bottomed, vertical walled, rectangular pit. Is it a grave? Our minds race. The camera then rises out of the hole and runs close to the bare ground. The soil is revealed with speed yet clarity. Then the camera sweeps upward to reveal the small farm. It is a captivating image that sticks in the mind, and indeed foreshadows the future. In the end we see a terribly weakened Reinaldo in New York City, dying of AIDS. He eats soil from a flowerpot, and later commits suicide. The tale has come full circle—from Oriente Province to Manhattan, from birth to death—and the soil is the visual link, much in the way that Reinaldo portrayed it early in his memoir:

> "When we were born, the local midwife who cut the umbilical cord would rub dirt into it. Many children died of infection, but no doubt those who survived had accepted the earth and were ready to bear almost any future calamity. In the country we are attached to the earth in an ancestral way; we could not do without it. The earth was there when we were born, in our games, in our work, and of course, at the moment of our death. The corpse, in a wooden box, would be returned directly to the earth. The coffin would soon rot and the body had the privilege of dissolving in that earth and become a vital, enriching part of it. The body would be reborn as a tree, as a flower, or as a plant that one day, perhaps, someone like my grandmother would smell and be able to divine its medicinal properties."
> (Arenas 1993)

"Dirt" is a term that has multiple meanings. The ambiguity inherent in the word is used as a dramatic tool in the 1946 novel *All the King's Men* by Robert Penn Warren, and in the films of 1949 and 2006. The story of Willie Stark traces his path from a populist reformer to a cynical and corrupt governor of Louisiana. In a pivotal scene, Governor Stark (played in the 2006 film by Sean Penn) spars with a judge and political rival (played by Anthony Hopkins). This wonderful dialog (taken almost directly from the novel) has the two characters sparring with the term "dirt" meaning soil, and "dirt" meaning scandalous gossip or incriminating information. Stark tells the judge:

> "Well, dirt's a funny thing. Ain't nothin' but dirt on God's green Earth, 'cept what's under the water—and that's dirt too, come to think of it.
> Dirt makes the grass green—let's it breathe.
> The diamond on my wife's finger ain't nothin' but dirt (that) got awful hot.
> And what are we but dirt blowed off the hands of God Almighty—you and me and George Washington."

The concept of "native soil" as a part of national identity is ingrained in our speech and invokes an appeal to patriotism. We see it in *Blood Diamond* (2006) starring Leonardo DiCaprio as Danny Archer, a Rhodesian soldier of fortune. Early in the film, Danny visits a key player in the illegal diamond trade in Sierra Leone—his former commanding officer, Colonel Coetzee, at a South African vineyard. They squat like farmers between rows of grapevines, and Danny speaks of wanting to leave Africa and the diamond trade. The colonel takes a handful of soil, and lets it sift from his hand to Danny's:

> "That's red earth.
> It's in our blood.
> The Shana *{a tribe in Rhodesia}* say the color comes from all the blood that's been spilled fighting over the land.
> This is home.
> You'll never leave Africa."

In discussing this scene, director Edward Zwick noted that it sprang from the strong impression that the color of the soil made on him during his pre-production travels throughout Africa. While ascribing the blood linkage to the Shana was literary license on his part, Zwick later learned that this belief is indeed part of native culture in Zimbawe and other parts of the continent (Zwick 2006). This allusion to homeland comes full circle at the end of the film, as Danny, now fighting against Coetzee and his mercenary troops, lays mortally wounded on a hillside; blood drains down his arm, off his fingertips, and soaks into the red soil.

Much as in-place soil invokes a sense of place, belonging and wealth, blowing soil—dust—coveys a sense of lack of connection and lack of worth. The prolog to *The Beautiful Country* (2004) is a definition:

> "Bui Doi: "less than dust"
> Term used to describe Vietnamese children with American fathers"

The film follows such a Vietnamese young man, Binh, from his escape from Vietnam to the hardships of stateless life in America. Eventually, he finds the father he has never met (Nick Nolte) at a ranch in Texas, and they begin to tentatively learn about one another. In a pivotal scene, the two virtual strangers tend a vegetable garden. The father grasps a clod of soil, and begins to tell of his life in Vietnam:

> "It's a beautiful country."

Soil, as a metaphor for home, and the journey from a less-than-dust status, helps to portray the father-son bonding with subtlety and grace.

Undoubtedly the filmmaker most identified with dust is Akira Kurosawa. His epic *Seven Samurai* (1954) is the story of how a handful of warriors come together to defend a peasant village from marauding bandits in 16th century Japan. Images of wind and dust appear throughout the film. From a purely visual standpoint, the most striking of these scenes combine a static element with the dynamism of the dust. We see this early in the film where a kidnapper of a village child is overpowered and mortally wounded by one of the samurai. The kidnapper staggers from the house and then—as if captured by the dust swirling around his legs—falls, his hands stirring the powdery soil. And it is certainly a memorable element of the final graveyard scene, where the burial mounds and emplaced swords of four of the samurai are a stark counterpoint to the moving dust.

But the imagery also works at another level—in Kurosawa's own words:

> "I wanted to say that after everything, the peasants were the stronger, closely clinging to the earth. It is the samurai who are weak because they were being blown by the winds of time."
> (quoted in Mellen 2002, p. 65)

Indeed dust itself is the focus of a 2007 documentary by German director Hartmut Bitomsky. *Staub* (Dust) is a random walk through the world of particulate matter—from household dust to mining waste, from the World Trade Center to the cosmos, with some soil-specific stops along the way that include the Dust Bowl of the North American Great Plains, and experiments by Wolfgang Schimmack and Udo Gerstmann at the German Research Center for Environmental Health on the long-term corrosion and leaching of depleted-uranium munitions fragments in soil (Schimmack et al. 2007). In this documentary film, as well as in the non-documentary films noted earlier, the unsettling nature of dust is apparent in the narration:

> "Dust is unwanted matter,
> matter at the wrong place.
> It has no home of its own.
> It spreads everywhere.
> It leaves the trace of a fundamental denial.
> A battle is waged against dust,
> but the battle achieves nothing."

6.5 Animation

The Ant Bully (2006) is an animated film directed by John A. Davis and featuring the voices of Julia Roberts, Nicolas Cage, and Meryl Streep. The story focuses on a young boy {Lucas} who shrinks and enters the underground world of an ant colony. Using computer graphics, the film offers viewers a highly textured view of soils—both surface views and cross-sectional views in the ant nest—and detailed soil features—color, particle size, reflective minerals in a non-reflective matrix, desiccation cracks, root channels, and disruption of surface soil around emergent plants. I discussed the creative process and the mechanics of producing the soil images with Ryan Michero (Fig. 6.1), head of the production company's Texture and Shading Department:

Fig. 6.1 Ryan Michero

How did you choose to depict the soil?

One of Director John A. Davis' key ideas for defining the look of the movie was that Lucas when shrunk to ant size would discover a completely new and different world unlike the world he was used to. So to play up this contrast, the environs of the human world were designed by {Production Designer} Barry Jackson's team to be flat, rectilinear, and boxy, while the ant world was more organic, curvilinear, and rounded. This idea also drove the computer graphics production team to make the soil environments of the ant world more richly detailed, varied, and interesting.

Also, simply for the fact that nearly 2/3rds of the film takes place at ant scale and in any given shot a large percentage of the screen would be filled with magnified soil, we knew that making the dirt look good was a large part of making the movie look good.

What were your influences and reference materials (real soils? textbook or web images? documentaries? etc.)

We looked at a wide variety of reference materials, from photographs on the web and in books to documentaries on

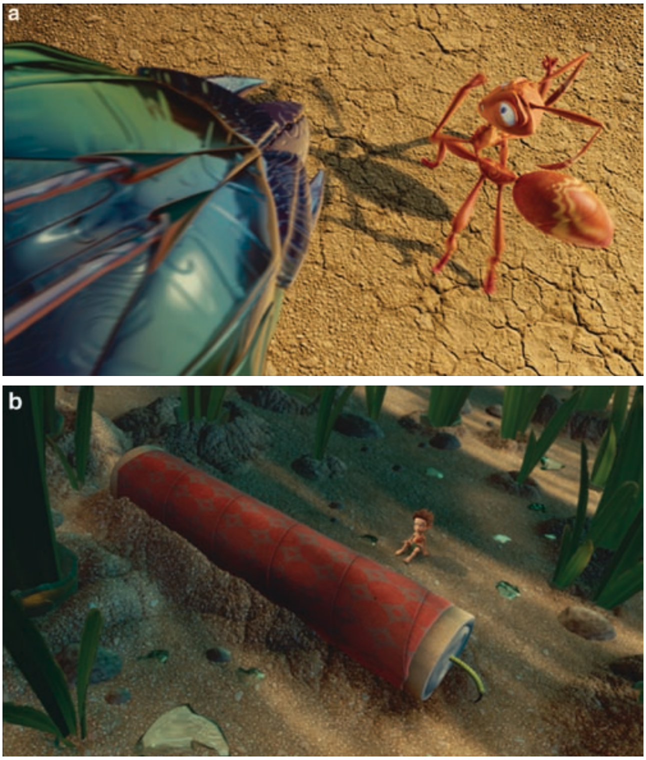

Fig. 6.2 a, b Two soil images from "The Ant Bully". By permission of Warner Bros. Entertainment Inc. [THE ANT BULLY © Warner Bros. Entertainment Inc. All Rights Reserved.] (see as color plate following *Index*)

insects that featured lots of close-up shots of soils. Probably the most important source of reference was the macro photography we took of our own lawns and different materials around us.

How does your view of soil, and the images that you created (Fig. 6.2a, b), compare with earlier animated films such as *Antz* (1998) and *A Bug's Life* (1998)?
Images of soil in *Antz and A Bug's Life* were sources of interest and inspiration for us (especially the interiors of the mound in *Antz*, and some of the elements of the exterior dirt shader in *A Bug's Life*), but we also strove to set the look of our film apart from theirs. I think we succeeded in making the soil in our film more organic and naturalistic than the soil in the previous films. For instance, for grass and plants growing out of the soil in our film, we made the soil immediately surrounding it appear as if it had been displaced up and out by the

growing flora instead of merely penetrating the plant into a flat surface. I also think we had more different looks and types of soil in our film than in theirs.

In general terms, how were the images created?
Since there were many different types of soil in the film, we used many techniques to achieve the different looks. But in general terms, the soil was made with polygonal surfaces manually constructed by modelers in our graphics software. These surfaces ranged from simple planes to the incredibly detailed, multi-leveled buildings in the interior of the ant mound. All of these surfaces had shaders assigned to them created by my team, the Texture and Shading Department. A shader is actually a small, simple program that describes to the renderer (image generation software, in our case Pixar's Photorealistic RenderMan) how a surface should appear in the final image. Shaders can use many techniques to describe a surface, from simple projections of a digital image to more mathematically complex noise functions that generate seemingly random patterns. My lead artist and Technical Director on the soil, Josh Smeltzer, tried many different techniques in creating the soil. We finally settled on a combination of texture maps and procedural noise patterns, mixed together to get the best of both techniques. Smeltzer himself took many different macro photographs of different materials, from soil and sand in his backyard to more exaggerated granular materials like pea pebbles and (believe it or not) cat litter, using those pictures for reference and for direct use in the shaders. Any given soil shader (and there were many of them) might use two or three of these modified images, mixed with procedural noise patterns, to give the final look. I should also mention some procedural modeling tools, developed primarily by Modeling Technical Director Walter Behrnes, that would allow Dressout artists to place individual sprouts of grass in the shot for composition, then modify and displace the polygons of the ground plane around the sprout depending on its placement. The ground tool would then pass information to our shaders, telling it that this was displaced soil, and the look of the shader would change to more broken and lumpy accordingly.

DEFINITIONS:

Dressout artist - "Dressout" was the "Final Layout" stage of our production pipeline. Typically, all extraneous set dressing pieces are stripped out of a scene by the Layout department before it is given to the Animation department, so that the scene runs as quickly and interactively as possible to give the Animators the feedback they need to do their jobs. Once the Animation is approved, the scene goes back to another group that is an offshoot of the Layout department, Dressout, in order for them to merge the animation and set data into a renderable scene file and add any set dressing elements not in the original layout of the scene to help composition and continuity. On The Ant Bully, much of what the Dressout artist did for the shots that took place in exterior environments was populate the backgrounds with grass using the tools developed for that purpose.

ground tool - A tool created by Walter Behrnes in our 3D software package (Houdini) that gave the Dressout artists an interface for creating the look of the ground in the film. The tool allowed the artists to load in the correct ground for the shot with its shaders attached. This was normally used in combination with a separate grass tool, which would populate the surface of the ground with instances of our many different kinds of grass geometry. Used together, the Dressout artist could populate clumps of grass and move them into place with the grass tool, then locally subdivide and displace the ground plane where clumps of grass were instanced with the ground tool.

How many different soil images were created by your teams, and how many were used in the final cut of the film?

There were many soil "looks" created by our production team, and I believe the majority of them are in the final film. They include human scale basic yard dirt, ant scale basic yard dirt, exterior mound dirt, interior mound natural dirt, interior mound structure dirt (ant building material), interior mound pathway dirt, wet mound dirt, wet interior mound dirt, wet sedimentary dirt, training course ground, wasp attack ground, frog attack ground, trial chamber dirt, eating chamber dirt, and wasp hideout ground. Some of these are similar, rooted in the same basic techniques, and some of these have a few subtle variations beyond its main purpose. So I would say we had from 15-20 distinct looks that could be extended and modified based on the shot.

How was the selection made to mate a given soil image with a given foreground?
This was determined mostly by the Director, who could be quite specific about what he wanted for the look of the soil in any particular scene in order to better communicate the story to the audience. For instance, when Lucas and Zoc {one of ant colony leaders} visit the wasps, Davis asked for a dry, parched, desert-like look to the soil, to underscore that the characters were entering a forbidding and dangerous area. And in the scene that takes place in the ants' eating chamber, where Lucas eats the "honeydew", the Director wanted the soil to be very richly detailed, lumpy, and somewhat damp, to imply that the ants had worked the soil, perhaps mixing it with their saliva, to build the environment. In this scene and others, this type of soil forms everything from giant cavernous walls to impressive organic structures, dotted with small, illuminated windows where ants presumably make their homes. In the eating chamber sequence, this communicates that the ants are revealing their impressive civilization to the human outsider. I don't think it's an exaggeration to say that in an animated film where every element of every image is painstakingly designed and built, even the dirt helps tell the story.

6.6 *DUNE*: The Vision of Frank Herbert

Following *Eraserhead* (1977) and *The Elephant Man* (1980), David Lynch would go on to direct *Dune* in 1984, based upon the 1965 science fiction novel by Frank Herbert. Lynch assembled an eclectic cast including British rock musician Sting, Jack Nance—the lead actor in "Eraserhead", and Max von Sydow as planetary ecologist Dr. Liet Kynes, to tell the tale of Arrakis, a planet where rain never falls and where giant segmented worms rule the arid sands. *Dune* is a complex weave of legends, political intrigues, expanded consciousness due to Arrakis' mined treasure ("spice"), and the mysterious relationship between the native people (the Fremens), the worms, and the planet's harsh environment, that is revealed as the story unfolds on screen.

The ecological underpinnings of *Dune* require considerable explanation. As such, they come through better in the novel than the film. Non-dialog mechanisms not available in film—such as an appendix on *The Ecology of Dune*, and an extensive glossary (*Terminology of the Imperium*) —work well to help tell the backstory, and allow Herbert to describe the history and life processes of this alien world of the 102nd century. We learn the cycle that links the worms and their castings to the "spice", to the infiltrating water, to the "spice blows"—details which the film only touches upon. Nevertheless, the film serves as excellent introduction to Arrakis and the *Dune* saga. As only cinema can, the film creates a sense of the desert, with shots from the Samalayuca Desert in the state of Chihuahua, Mexico (Herbert 2003), and provides unforgettable images of the worms and their sand riders.

Journalist Frank Herbert's path to *Dune* is tied directly to soil investigations on the dunes of the central Oregon coast. In 1957, he became interested in writing a magazine article about a soil conservation project to stabilize dunes by the planting of beach grasses (so called "poverty grasses", with below-ground, fine root systems that held the sand in place, and above-ground blades that slowed the wind and caused blowing sand to deposit). Herbert's proposal for the article noted (Herbert et al. 2005):

> "In 1948, several federal and state agencies centered on a study of dunes at Florence, Oregon, a town threatened by moving sand…. It took about ten years, but this group, under the direction of Thomas Flippin (work unit conservationist for the Siuslaw Soil Conservation District), has come up with the first enduring answer to shifting sands in all history…. sand could be controlled only by the use of one type of grass (European beach grass) and a system of follow-up plantings with other growth."

The magazine article, titled *They Stopped the Moving Sands*, was never published (Herbert et al. 2005). But Thomas Flippin (Fig. 6.3a), who had obtained his BS in farm mechanics from Oregon Agricultural College (now Oregon State University), and

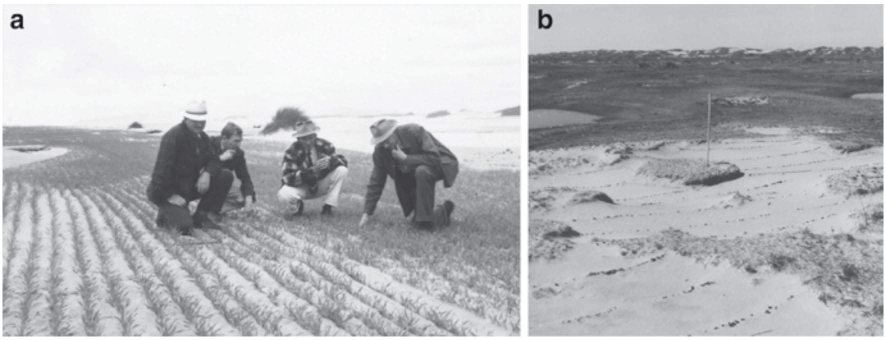

Fig. 6.3 **a** Thomas Flippin (seen on right) examining grass plantings used in 1958 dune stabilization trials by Siuslaw Soil Conservation District, Oregon [Oregon State Archives, Oregon Department of Agriculture, Photo from Soil & Water Conservation District Photographs, Dunes Folder, OAG0018-23]. **b** Coastal sand dunes in the Siuslaw Soil Conservation District. This 1959 photo shows an area of the dunes which was stabilized by mulching with rye grass straw and nearby "blow out" areas where erosion has started again. [Oregon State Archives, Oregon Department of Agriculture, photograph OAG0021].

began to work for the college in 1919 (personal communication, Karl McCreary, Oregon State University Archives, August 6, 2008), almost certainly became the character model for the planetary ecologist in *Dune*. In 1957 Flippin worked for the Siuslaw Soil Conservation District. He impressed upon Herbert the soil management issues associated with these nutrient-poor sands, and the value of introducing nitrogen-fixers such as Scotch broom (*Cytisus scoparius*), a leguminous shrub, after the grasses were established on the dunes (Herbert 1957?). The ecology appendix to *Dune* (Herbert 1965) clearly shows the tie to the research done by Flippin's group:

> "Downwind sides of old dunes provided the first plantation areas. The Fremen aimed first for a cycle of poverty grass with peatlike hair cilia to intertwine, mat and fix the dunes by depriving the wind of its big weapon: movable grains."

Indeed, Herbert introduces the reader to concepts of plant succession, nutrient cycling, nutrient availability—and even Liebig's Law of the Minimum! The testing of thousands of types of plantings by the Soil Conservation Service (SCS) and affiliated researchers that Flippin described to Frank Herbert is mirrored on Arrakis by a network of botanical testing stations.

The presence of ground water below the arid sands—as in *Woman in the Dunes*—is a compelling image and a key storyline in *Dune*; it too is a consequence of Herbert's time with Flippin on the Oregon dunes (Herbert 1957?), where he saw wet sand and rich vegetation in the deflation plains between the low foredunes and the high oblique dunes—a phenomenon resulting from wind removal of sand down to the water table. Indeed, the dune sand is the most productive aquifer in the Florence area (Hampton 1963). Other soil-plant-water processes such as fog drip on plants and sand blow-outs [areas of active erosion initiated where the protective vegetation is disturbed or destroyed (Fig. 6.3b) are reflected or morphed in *Dune*. (Herbert's notes on Flippin indicate "Talks of 'blows'….coast guard blow, long blow….etc.". The term undoubtedly stuck in his head, and in *Dune* we see the "spice blow"—an upwelling of buried material resulting from the reaction of water and sandworm excrement.] The sandworm castings are key to the question

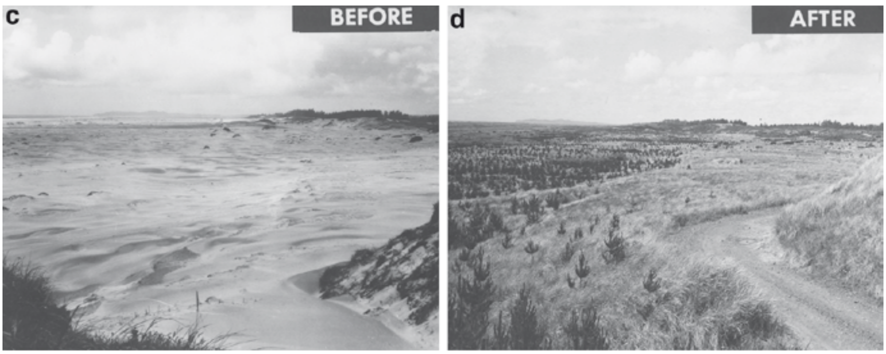

Fig. 6.3 **c**, **d** Before and after photographs of coastal sand dune stabilization with beach grass and pine trees, ca. 1959 [Oregon State Archives, Oregon Department of Agriculture, photographs OAG0026 and OAG0027].

repeatedly asked: What is the relation of the spice and the worms? And the sand on Arrakis itself is said to be mostly a product of worm digestion. Herbert's ecologically sophisticated and beneficial view of the sand worms is in accordance with the research of Charles Darwin (see Brown et al. 2003) and the observations of farmers in traditional cultures (see Rakotoson et al., chapter 18, *this volume*).

As final testimony to the esteem that Herbert held for Flippin and his fellow scientists, *Dune* is dedicated:

> " To the people whose labors go beyond ideas into the realm of 'real materials'—to the dry-land ecologists, wherever they may be, in whatever time they work, this effort at prediction is dedicated in humility and admiration."

It is testimony to Frank Herbert that more than 40 years after the publication of his novel, the real science of behind the story of Arrakis is still being discussed (Grazier 2000).

The early history of SCS activities associated with dune stabilization on the Oregon coast have been described by Reckendorf et al. (1985). Much like this unique landscape, the story of dune stabilization efforts here continues to evolve. European beach grass (*Ammophilia arenaria*) and other introduced species are now often viewed as undesirable, invasive species. Removal efforts are underway in Oregon and other coastal areas of the Pacific Northwest to promote the growth of native vegetation, and to create open dune areas conducive to the nesting of the snowy plover and other birds. The Oregon Dunes National Recreation Area (ODNRA) is part of the Siuslaw National Forest. Administered by the U.S. Department of Agriculture / Forest Service (USFS) and located south of Florence, Oregon, it is the very area that Flippin helped to plant with European beach grass 50 years ago. About half of the area that comprises the ODNRA is open now to dune buggies and other off-highway, motorized vehicles in an attempt by the USFS to help keep the European beach grass populations in check (Chapman 2008).

Recent work by microbiologist David Dalton and coworkers has shown that the success of European beach grass in growing on the nutrient-poor sands is due, in part, to the presence of nitrogen-fixing bacteria within the cell walls of its stems and rhizomes. Such "endophytic" nitrogen fixation, a process first identified in sugarcane in 1998, may help to explain the phenomenal success achieved by Flippin and others using this plant for dune stabilization (Dalton et al. 2004). Without that success story of stopping the moving sands (Figs. 6.3c, d), it is unlikely that Frank Herbert would have ever written *Dune*.

6.7 Briefly Noted

One cannot leave the subject of soil and film without noting a film where soil is the foreground player. Directed by first-time filmmaker Pare Lorentz, *The Plow that Broke the Plains* (1936) was the first film made by an agency of the U.S. government for commercial release (Horowitz 2007). Its written prologue begins: "This is a record of land… of soil, rather than people—". That latter role would await *The Grapes of Wrath* (1940) staring Henry Fonda. *The Plow that Broke the Plains* traces the impact of human and natural forces on the Great Plains—how sodbusting, wind and drought combined to strip away friable soils. While its narration style is dated, the images of "baked out, blown out, and broke" soils and people still have emotional impact today, and the film remains a subject for discussion by modern environmental historians (Lovely 1993; Dunaway 2007).

6.8 Scientific and Educational Use of Film and Video in Soil Science

Scientific visualization has made dramatic strides in the digital era. For example, in the 1970s, root distributions in soil were examined by excavation, stabilization of the roots with a grid of nails, and then the use of a stream of water to wash away adhering soil. Today we can use computed tomography (CT scans) to non-destructively achieve much finer detail and quantification on intact soil cores (Perret et al. 2007). The posting and viewing of videos is now an integral part of our personal lives, and new opportunities are opening up for using video and the web to communicate information on dynamic environmental processes.

Fig. 6.4 1928 yearbook photograph of faculty member Hans Jenny (approximately age 29) at the University of Missouri. [Savitar, 1928; Courtesy of University Archives, University of Missouri at Columbia].

The potential use of film as a vehicle to portray and explain soil processes was realized early in the life of the soil science profession. Hans Jenny (1899-1992) (Fig. 6.4) joined the soils faculty of the University of Missouri in 1927, shortly after earning his D.Sc. at the Swiss Federal Institute of Technology in Zurich. His thesis work and continued research focused on ion exchange reactions. Around 1931, he and two assistants produced *The Base Exchange Movie*, a 30-minute film on ion exchange reactions in soils to use as a teaching aid for students in his soil chemistry class; a detailed outline of the film is given in Jenny (1932). Unfortunately no copies of the film seem to have survived to the present. However, we see flashes of Jenny's wit in the title that opens Act IV:

> "What are the forces that attract and liberate the ions?
> Love? Hate?
> Answer: The forces are of electrostatic nature"

Jenny moved to the University of California at Berkeley in 1936 and published his classic volume, *Factors of Soil Formation*, in 1941. By papal invitation in 1968, he delivered a lecture *The image of soil in landscape art, Old and new* before the Vatican Academy of Sciences (see chapter 1 by Feller et al., *this volume*).

Today video technology is being used to depict dynamic soil processes such as organic matter transformations (http://www.kunstundboden.de/html/index.php?id=197), preferential water flow patterns (Wessolek 2006), root growth (Baker et al. 2001), and the development of cracking patterns in soil (Hallett and Newson 2001)—either through direct imaging or time-sequence display of data.

6.9 Fade to Black

An anonymous commenter on a movie website message board said of *The Agronomist:* "best movie about a soil and plant scientist ever". Probably true, but undoubtedly this will never be a large pool to draw from. Soil scientists and soil itself will likely be confined to the anonymity of the background of most films. Yet because of their scenic dimensions and their association with place and the cultures inhabiting these places, soils are conscious component of many films. The tie to soils may at times even transcend the landscape and be a subtle vehicle for characterization of people in the story—for example, in *All the King's Men*, the explicit selection by the director and costume designer of earth tones for the clothing of the poor rural folks was made to reflect their bond to the land (Allen 2006).

The use of video technology to document soil process shows great promise as an artistic, educational and research tool. And with greater awareness of Planet Earth and sustainability issues, soils may begin to step forward more often in the minds of movie makers and movie audiences, and on the screens of our theaters and home screens.

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References

Abe K (1964) The Woman in the Dunes. Alfred A. Knopf, New York, 244 p.

Allen M (2006) comments by costume designer Marit Allen in special feature: *The Making of "All the King's Men"*; on Sony Pictures Home Entertainment DVD.

Arenas R (1993) Before Night Falls, Viking Penguin, New York, 317 p.

Ashton, D. (1997) The Delicate Thread: Teshigahara's life in art. Kodansha International, Tokyo; 208 p.

Baker TT, Conner WH, Graeme Lockaby B, Stanturf JA, Burke MK (2001) Fine root productivity and dynamics on a forested floodplain in South Carolina. Soil Science Society of America Journal 65: 545-556.

Bolton CA (1998) Science and fiction in the work of Abe Kobo. Ph.D. dissertation, Stanford University (UMI no. 9908720).

Brown GG, Feller C, Blanchart E, Deleporte P, Chernyanskii SS (2003) With Darwin, earthworms turn intelligent and become human friends. Pedobiologia 47: 924-933.

Carter AJ (2003) Myths and mandrakes. Journal of the Royal Society of Medicine 96 (3): 144-147.

Chapman J (2008) Travels in geology: Roving Oregon's dunes. Geotimes (August 2008) p. 52-54.

Dalton DA, Kramer S, Azios N, Fusaro S, Cahill E, Kennedy C (2004) Endophytic nitrogen fixation in dune grasses (*Ammophilia arenaria* and *Elymus mollis*) from Oregon. FEMS Microbiology 49: 469-479.

Demme J (ca. 2002) {commentary on} The Agronomist at http://www.movienet.com/agronomist.html; accessed 8 August 2007.

Dunaway F (2007) New Deal jeremiads, *In* Special Forum: Films every environmental historian should see. Environmental History 12: 280-393; available at http://www.historycooperative.org/journals/eh/12.2/marson.html; accessed 24 Oct 2007.

Franks B, Harper S, Murray J, Stevenson L [eds.] (2006) The Quest for the Wicker Man. Luath Press, Edinburgh, 187 p.

Grazier KR (2008) The Science of Dune; Benbella Books, Dallas, 232 p.

Hallett PD, Newson TA (2001) A simple fracture mechanics approach for assessing ductile crack growth in soil. Soil Science Society of America Journal 65: 1083-1088.

Hampton ER (1963) Ground water in the coastal dune area near Florence, Oregon. U.S. Geological Survey Water-Supply Paper 1539-K.

Hardy R, Shaffer A (1978) The Wicker Man; Pan Books, London (2000 edition) 285 p.

Harper D. (2003) Hiroshi Teshigahara; in *Senses of Cinema* (online journal; University of Melbourne, Screen Studies Program); available at http://archive.sensesofcinema.com/contents/directors/03/teshigahara.html; accessed 2 December 2008.

Herbert B (2003) Dreamer of Dune; Tor Books, New York, 494 p.

Herbert F (1965) Dune; Ace Books, New York, 537 p.

Herbert F (1957?) Character outline of Thomas Flippin, typescript, 2 leaves; in Shifting Sand Dunes folder, in Frank Herbert Archives, Cal State Fullerton-Pollak Library (Special Collections); index available at http://library.fullerton.edu/content/AdministrationUnit/SpecialCollections/FrankHerbertArchives.doc; accessed 2 December 2008.

Herbert F, Herbert B, Anderson KJ (2005) The Road to Dune; Tor Books, New York, 489 p.
Horowitz J (2007) liner notes accompanying DVD *The Plow that Broke the Plains* and *The River*. Naxos.
Iles T (2000) Abe Kobo: an explanation of his prose, drama and theatre. European Press Academic Publishing; Fucecchio, Italy; 229 p.
Jenny H (1932) The base exchange movie. Report of the twelfth annual meeting of the American Soil Survey Association (Bulletin XIII), p. 151-156.
Gibeau M (2007) written communication, Mark Gibeau, Sapporo University, Faculty of Cultural Studies, 15 August 2007.
Khavan (2004) The Family That Eats Soil: Director's statement; available at http://www.kamiasroad.com/khavn/lupa.htm accessed 18 Jan 2007.
Lovely R (1993) Film review: The Plow that Broke the Plains. Isis 84: 768-769.
Lynch DW (1958) Effects of stocking on site measurement and yield of second-growth ponderosa pine. U.S. Department of Agriculture (Forest Service), Intermountain Forest & Range Experiment Station (Ogden, Utah), Research Paper no. 56.
Mellen J (2002) Seven Samurai, British Film Institute, London, 79 p.
Moreno T, Oldroyd A, McDonald I, Gibbons W (2007) Preferential fractionation of trace metals-metalloids into PM_{10} resuspended from contaminated gold mine tailings at Rodalquilar, Spain. Water, Air and Soil Pollution 179: 93-105.
Perret JS, Al-Belushi ME, Deadman M (2007) Non-destructive visualization and quantification of roots using computed tomography. Soil Biology & Biochemistry 39: 391-399.
Peterson J (1994) Why I farm; available at http://www.angelicorganics.com/Stories/storiescontent.php?contentfile=whyifarm accessed 1 Jan 2008.
Phillips S (2002) The various versions of The Wicker Man. Scenes filmed but never used; available at http://www.steve-p.org/wm/script.htm; accessed 3 February 2007.
Reckendorf F, Leach D., Baum R, Carlson J (1985) Stabilization of sand dunes in Oregon. Agricultural History 59: 260-268.
Sagolla-Croley L (2003) The rhetoric of reform in Stoker's *Dracula*. *In* Bloom, H. (ed.) Bloom's modern critical interpretations: Bram Stoker's Dracula; Chelsea House publishing, Philadelphia; p. 169-190.
Schimmack W, Gerstmann U, Schultz W, Geipel G (2007) Long-term corrosion and leaching of depleted uranium (DU) in soil. Radiation and Environmental Biophysics 46(3):221-227.
Stoker B (1897) Dracula. *In* Wolf, L. 1993. The Essential Dracula (includes the complete novel by Bram Stoker) Penguin Books, New York, 484 p.
Täumer K, Stoffregen H, Wessolek G (2006) Seasonal dynamics of preferential flow in a water repellent soil. Vadose Zone Journal 5: 405-411.
Zheljakov VD (2005) Assessment of wool waste and hair waste as soil amendment and nutrient source. Journal of Environmental Quality 34: 2310-2317.
Zwick E (2006) commentary track (DVD) *Blood Diamond*; Warner Bros. Pictures.

Part II
Under My Feet—Soil Presence and Perspectives in the Work of Four Contemporary Visual Artists

Chapter 7
Dig Deeper

Margaret Boozer

Trying to understand the physical world and to use it as a language is really a sign of the loving respect for the material we exist in and are made of.

Tony Cragg (in Cragg et al. 1997)

I make art about dirt. To be more specific, I make clay and ceramic compositions—landscapes—to be displayed on the wall and floor. Formally, these works exist somewhere between sculpture and painting. They are to be read frontally, but they are very physical, using the visceral language of materials. I've always implemented clay as a way to visually refer to earth in these works, but in recent years, I have begun to actually dig up a large portion of the clays and other ceramic materials I use.

Many ceramic artists object to calling clay "dirt", since clay is a more specific material and the terms are not technically synonymous. Not all dirt can be shaped into a pot and fired in a kiln. Scientifically speaking, you need a hydrated, layered-structure, aluminosilicate mineral for that. So not all dirt is clay, but all clay is dirt, especially at the point it is mined from the earth. I prefer the term "dirt" because to me it means clay that is earth and ground, as opposed to a refined, commercial clay.

Since I've begun using dug clays or dirt, my work has gained a more visual and innate connection to its geological origins. The rocks, imperfections and impurities that get processed out of commercial clays lend individual character to small batches of clay from particular sites. Clays have a history of geologic activity and travel before being deposited at their current sites. The pulverizing, weathering and sorting of particles as rocks decompose into clay imparts to some clays a finer texture, or gathers sand, aggregate and additional minerals into the mix for others. A unique geologic history distinguishes my local Mt. Rainier, Maryland clay from that of Arlington, Virginia, some 15 kilometers away. In the studio, this translates into different appearances and different behavior for the clays.

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My studio work now includes going outside to explore. I walk around construction sites and creek banks prospecting for materials. I carry my camera with me, taking pictures of dirt as I find it, showing evidence of erosion, the bite marks of excavator teeth, tire tracks and other human and geological forces. These instances of "clay in its natural habitat" have begun to inform my art. Commercial clay from a bag doesn't bring this information with it. I have thousands of photos, some of which get sent to my friends as "Dirt of the Day". I keep a collapsible shovel in the truck. I peer into road repair sites to see what's below the surface. I gather a chunk, a bucketful or a truckload and take my finds back to the studio. I have a storeroom filled with containers labeled "outside of Atlanta, Dec. 2004," "Calvert Cliffs, 2001" or "water main break, Perry Street, 2006."

As an abstract concept, dirt is a rich and complex metaphor to mine. It suggests fertility, growth and birth as well as death. It is old; it is deep. Dirt is common and base, yet vital to survival. As a physical material, dirt offers an inexhaustible palette. Using dirt has made me a better artist. It has taken me out of the studio and into the world, and it has given me a much more vocal material with which to converse.

Sometimes I find a cutaway bank of clay so beautiful that any artistic response I imagine seems trivial in comparison. But my job as an artist is not just to look closely at my environment, but to try and understand it, and then to communicate something about that understanding. And I can never resist taking some dirt back to the studio to see what I can make of it.

7.1 Eight Red Bowls

One crisp March day, I looked out the back door of my studio and saw the red bank leading up to the railroad tracks. After 10 years working as a ceramic artist, and 4 years looking out that particular door, I suddenly realized that I was looking at clay. I grabbed my shovel and began chipping away at the cold, hard surface. Deeper down, it was moist. My shovel began to stick. The consistency felt very tight and dense against the blade. I broke off a chunk. It had an intense red color that stained my hands. I tasted a little bit…a strong taste of iron, and a smooth texture with no sand at all. I went back for buckets. I dug four or five buckets full and lugged them back to the studio, where I just sat and admired my haul. What could be better for a ceramic artist than free material right out the back door of my studio?

I'm more of a sculptor than a potter, but this clay prompted me to unpack my wheel and throw some pots. Throwing a pot tells you about the plastic qualities of clay like nothing else. It's an intimate connection between artist and material as the spinning mound of clay takes shape in your hands.

I chose the kick wheel over the electric one. The manual power, quietness and slower speed seemed the right choice for this found clay. Centering the clay on the wheel head, I could feel its silky, smooth texture rise and fall under my hands. As I opened a bowl, I felt the clay's plasticity. The walls of the bowl stretched and thinned easily with the pressure of my fingers. Three pulls, raising the clay from base to lip, shaping the bowl just to its fullest form, the edge of collapse. The occasional rock meant I couldn't squeeze too tightly, and I couldn't spend too much time fussing over the form. This clay demanded a light touch: get in and get out. The resulting form was delicate, yet casual and gestural. Pretty nice. I worked through the small amount of clay I had and made a set of 8 bowls.

I then began to think about how to make this into a finished piece of art. I wanted to make a work that reflected back to me something about that red expanse of bank, something about digging, something about the ground. I got out the drill and mixed up a bucket of clay slip (think clay of milkshake consistency) poured out a puddle into a square frame on the floor, admiring the beautiful field of color. Then I dropped the bowls into it.

Over the next few days, I watched the clay. The slip puddle in the frame began to dry. The bowls began to break down and dissolve into the slip, and the slip, shrinking beyond the tension of its taught surface, began to crack into a pattern influenced by the bowls. The piece was becoming a sort of clay painting. It manifested two entirely different modes of clay work coming together in one piece. On one end of the spectrum was the articulated pot—conceived, executed, handled. On the other end was the untouched puddle of slip.

Looking back on this process, the making of ***Eight Red Bowls*** (Fig. 7.1) set into motion some methods of working that have become central to my studio practice.

Fig. 7.1 Margaret Boozer's ***Eight Red Bowls***, 2000, Mt. Rainier red clay, plywood, 80 x 69 x 14cm, collection Smithsonian American Art Museum (see as color plate following *Index*)

Instead of choosing clay for its particular attributes, I began to work in reverse. I'd find clay, then find out what it was good at, allowing the clay's behavior to suggest my approach in making the work. The experimenting became essential to the process, and I began to think of my work as part art and part science project.

This Mt. Rainier red clay, for instance, contains soluble salts. I discovered this upon firing it, when a white film appeared on the highest points, highlighting the ridges and textures. This was a result of salts dissolved in the water, migrating to the surface as the clay dries. The water evaporates, but the salt residue remains. At lower temperatures, this takes the form of chalky white highlights emerging from a bright orange background. At higher temperatures, the salts melt into a rich purple-black sheen against the dark red clay. Instead of applying a design, I could set in motion a "physical drawing" that was a direct result of form and natural processes. ***Eight Red Bowls*** taught me about the depth and richness that can come into my work when I find the critical balance between manipulating the clay into a composition, and letting it speak for itself.

The importance of the Mt. Rainier clay discovery felt so profound, I named my shop *Red Dirt Studio*. It marked a more personal philosophy, a more mature practice, and a whole new direction for my work.

7.2 Coming Home: A Journey In Clay

After finding the Mt. Rainier clay, I began to find clay everywhere. I couldn't pass a construction site without looking for tool bite marks, a telltale sign of clay. I scanned the roadside cut banks for colored strata. I talked with road repair workers—incredulous that anyone would want that stuff—but who helped me load the truck anyway. But my most exciting discovery revealed itself when I was introduced to Emlyn Whitin Stancill and the mine at Stancills, Inc. in Perryville, Maryland (Fig. 7.2).

Stancills, Inc. has been a family-owned mining and manufacturing business since 1934, mining sand, gravel and clay for industrial use, and making custom mixed materials that are used in sports field construction, the geotechnical industry, and horticulture. Over the years, the Stancill family has cultivated connections with ceramists enthralled with the beauty of the site and the quality of the clays. The mine is truly a ceramists' paradise, stunningly beautiful with at least five distinct types of high-fire clay.

Emlyn grew up at the mine. She played on the giant sand piles and went swimming in the slip pond. Now she's the vice president of the company. When the conference for National Council on Education for the Ceramic Arts came to Baltimore in 2005, Emlyn proposed an on-site exhibition of the ceramic artists who use Stancill clay. The show was titled ***Coming Home: A Journey In Clay***, and the work was exhibited in a gallery dug directly into the earth. The group show brought together artists from across the region and the country. We had all fallen in love with the clay and the mine, and we were all there bringing our work back to the earth, paying tribute to our primary material in its original setting.

Fig. 7.2 The mine at Stancills, Inc., Perryville, Maryland. Photo by Catherine White, reproduced here with her permission (see as color plate following *Index*)

Emlyn designed the exhibition space and the staff began to carve it into the earth in December. By February, the raw space was ready for nearly thirty artists to install their work. It was a labor-intensive installation…outdoors…in February. We put on our long johns, picked up our shovels and pick axes and started digging niches and pedestals out of the frozen ground. We shared tools, swapped labor and collectively exulted in the beauty of the site. Emlyn had specifically oriented the site to take advantage of the afternoon sun. We noticed the changing light on the banks of clay, the consistency of the clay as we dug through the cold, hard outside layers to the creamy, smooth softness of clay protected further in; we discovered surprising relationships between art and site. Tim Rowan built a clay igloo; Paul Chaleff and a crane installed a massive fired ceramic chunk on the crest of a bluff; Maggie Creshkoff wedged turquoise pots sideways into fissures (Fig. 7.3); Dan Ody camouflaged huge platters against the colors of a clay bank; Catherine White silhouetted her graceful vase against the backdrop of the pond. For my own work, I nestled my ***Channel Drawing*** in the path of an eroded trench on the side of a cliff, suggesting a continuation of the flow (Fig. 7.4).

Channel Drawing was about earth. Up until that point, I had thought that the best way for that earthiness to be seen was in contrast to the hard edge, the white, the "otherness" of a gallery space. I was afraid that the lack of contrast at Stancills would not serve my work well. But I was instead surprised to see a more subtle

Fig. 7.3 Maggie Creshkoff's installation, ***Something Borrowed, Something Blue***, 2005, as part of ***Coming Home: A Journey in Clay***, Stancills, Inc., Perryville, Maryland. Reproduced here with permission of Maggie Creshkoff (see as color plate following *Index*)

relationship. In the raw and semi-amorphous context of the mine, evidence of the hand, of craft and articulation, became much more pronounced. The piece stood out and became like a jewel in a setting.

The exhibition's opening reception was glorious. March 19 was the first warm and sunny day of the year. Ceramic educators, students, artists, geologists, curators, neighbors and even ceramic instrument musicians traveled to see this very beautiful and unusual show.

7.3 Dirt Drawings

I started making dirt drawings in the summer of 2006, after discovering some clay deposits at a construction site near my studio. On the side of a hill, the foundation cut revealed an enormous expanse of stratified colors: red, yellow, white, raspberry,

Fig. 7.4 Margaret Boozer's ***Channel Drawing***, 2005, Stancill stoneware, porcelain slip, glaze, 60 x 92 x 7cm, as part of ***Coming Home: A Journey in Clay***, Stancills, Inc., Perryville, Maryland (see as color plate following *Index*)

and at least two different purples. I felt compelled to respond. After collecting and testing however, I was disappointed to find that the fired results paled in comparison to the raw material…literally. I craved the simple beauty of color next to color. So, in the next experiment, I decided to use raw clay. Since I wasn't firing the clay, I had no size restrictions from the kiln. I began playing with the different clays, crushing them with the earth tamper, raking patterns, sorting particle sizes, organizing compositions spontaneously with colors activating each other, textures enhancing one another. In two hours I had a large scale, finished drawing that I loved. I took photos then swept it up to make another.

One of the things I love about ceramics is its suggestion of permanence. It is also one of the things I find daunting. In archaeological digs, ceramic works are what remain to tell the story hundreds and thousands of years after everything else has disintegrated. As an artist, I'm not sure I want everything I make to be committed to eternity. The raw, ephemeral dirt drawings became a counterpoint for me to the conceptual weight of fired ceramics.

The dirt drawings soon emigrated from my studio, and I began to create and exhibit them in public. One of my favorite dirt drawings was made at Herman

Fig. 7.5 Margaret Boozer's ***Purple Dirt Drawing (for Emlyn)***, 2007 Purple and gray Stancill clays, 244 x 244 x 16cm. This drawing was done at Herman Miller Design showroom in Washington, DC as part of an exhibition called ***Contemporary Art and Modern Design*** in June 2007. The clay is from the mine at Stancills, Inc (see as color plate following *Index*)

Miller Design showroom in downtown Washington, DC as part of an exhibition titled ***Contemporary Art and Modern Design*** (Fig. 7.5). I loved the transformation from quarry to showroom. The spare furnishings and the cool glass walls provided a compelling contrast with the dirt. And, there was something thrilling about dumping five million year-old clay on the showroom floor and asking for it to be seriously considered as art. In the context of the mid-century modern design showroom, my dirt drawing read like a designer rug, and the large clay chunks made an unexpected reference to Noguchi. I was reminded of Japanese American artist Isamu Noguchi's 1962 sculpture ***Lessons of Musokokushi***, which are giant rock-like mounds of clay translated into bronze, sited as if they were emerging from the gallery floor. (Interestingly, I learned that Noguchi, who is also known for his furniture design, worked for a brief period with Herman Miller, who continues to market Noguchi's famous coffee table.)

7.4 Basalt and Other Finds

Exploring clay sites, I've come across other interesting materials with ceramic application. For example shale and slate, which are essentially geologically compressed clay that has been exposed to heat, are commonly available materials. There is a massive cross-section of two-toned shale and slate on Rt. 15 in north-central

Pennsylvania, near the Tioga Reservoir. I brought some samples back from a road trip this summer, ground them up, and found they make beautiful iron rich slips and washes. At a construction site near my studio, I found iron and other metallic oxides, in the form of colored powders running in veins between the clays. I learn about my discoveries by firing them and comparing the results with what I already know about ceramic materials and ingredients.

Last summer, working on a new black wall piece, I wanted a deep and rich black glaze to use. My friends Catherine White and Warren Frederick suggested basalt from Vulcan Materials, a quarry near their home in Warrenton, Virginia. Catherine and Warren are artist potters and my compatriots in their fascination with clay geology. Warren showed me a beautiful satin black glaze he discovered after firing the fine particle sludge scooped out of the tire tracks at the quarry. The glaze is a deep satin black, deliciously buttery and smooth. The tire tracks collect water and encourage a self-sorting process in which the larger, coarse basalt particles sink to the bottom and the very finest ones to rise to the top. The tiny particles have enough surface area in proportion to their mass to completely melt at around 2175°F (1190°C). I found that the larger particles don't melt into a glaze, but rather retain their shape in the firing. So in addition to working with the basalt glaze, I began mixing basalt gravel into my clay to contribute texture and a dark speckled appearance.

Warren is an incredible resource for ceramic chemistry and is very generous with his research findings. I e-mailed him recently inquiring about the Vulcan basalt, and he responded by sharing some of his studies and speculation on the subject:

> I always called the Vulcan rock basalt, but it is actually a variant called "diabase." If I was guessing, there is probably 9-11 percent iron and 3-10 percent magnesium oxide (MgO) for the black/brown coloring. So like our black glaze formulas, there is 15 percent of colorant. At this level, they are also fluxes. The rock itself is mainly plagioclase feldspar along with pyroxene or olivine and other accessory materials like magnetite.

High school science was never this fun. I was lucky to become acquainted with another great earth science resource in the person of Ed Landa at the U.S. Geological Survey. Recognizing our common curiosity from different vantage points, we've struck up a friendship. Ed sends me geology books and articles on crack formation from scientific journals. I invite him to art exhibits that celebrate clay, rocks and dirt.

7.5 Earth Artists

Although my work responds to the dirt itself, I owe a debt to many artists whose ground-breaking work with dirt and earth paved the way for my own: Ana Mendieta, Robert Smithson, Richard Long, Andy Goldsworthy, and Michael Heizer, to name a few.

My dirt-art hero, though, is Walter de Maria, who in 1977 filled a SOHO apartment with 280,000 lbs. of dirt. The New York Earth Room, owned by the DIA Foundation, is open year round. The caretaker waters and rakes it weekly and picks the random mushroom. I love to think of this work as a response to Robert Smithson's 1964 comment, "The city gives the illusion that the earth does not exist." (*A Sedimentation of the Mind: Earth Projects*, Artforum, September 1968, p.44). Visitor Adam Varga describes his Earth Room experience on Yelp.com, "When I visit, I usually look at the dirt for about five minutes and then leave. Then I spend the rest of the day scratching my head and smiling." Critic Dana Turken wrote in the Village Voice *(Best of NY 2000)*: Viewers experience "a rich, pungent soil smell and may even leave with a sense of serenity." She goes on to say, "Reactions range from general befuddlement to angry, real-estate conscious New Yorkers exclaiming, 'A room full of dirt?! In Soho? I could be living here!' " The way I think about it, so little earth is accessible in New York that a room full of dirt just might make it possible to live there, as long you can go in and take a deep breath once in a while.

7.6 What Is Found There

In beginning ceramics classes, a lot of attention is devoted to controlling the clay. In making tiles, you learn to make them to be flat. In throwing a bowl, you slow the drying to get a round rim, not a warped oval. And most of all, you are on constant alert for cracks, learning strategies for avoiding them and repairing the ones you can't. After many years, I realized that I was more interested in letting the clay crack and warp than in preventing the occurrences. A tile warps because the top surface has more exposure to air than the bottom. As clay dries, it shrinks. So the top shrinks first, curling the clay upward. The cracks in drying clay reveal inherent stresses. All things being equal, clay will crack according to regular patterns, following the structure of the clay. If there is an anomaly in the surface, a discrepancy in thickness or a weak point in the construction, a crack will begin at that point. Cracking and warping are the clay's voice, an expression of its physicality, how it behaves in the world when it is not subject to the artist's control. Eventually, I learned to cast these flaws as the subject matter of the work itself rather than as intrusions in the pursuit of another artistic goal.

In 2003, I created a commissioned work using dug clays. The client and I had agreed on some parameters of what the piece should look like, but when I started digging the clay, the piece took on a whole new direction. When I broke ground, I uncovered a small treasure trove of artifacts about six inches down: an old medicine bottle, an iron ring, one of those old green glass Coke bottles and some broken bits of pottery. I was excited about my find and wanted to use the items in the work. Lucky for me, my client was receptive. The evolving art piece became about the childhood romance of buried treasure, and how a shift in perception can transform ordinary objects. I borrowed the title from a book by poet Adrienne Rich, titling the finished work "***What Is Found There***."

Digging clay has helped shape a philosophy of work for me, even if I use commercial materials. It reminds me to look, listen and pay attention to the voice of my materials. It has helped me realize that I work best when I respond to something that exists, to what is found there, as opposed to conceiving an idea and searching out materials to execute it.

And ultimately, I just feel so fortunate that my job, as an adult, is to go outside and dig in the dirt.

Reference

Cragg T, Gaensheimer S, Wilmes U, Friedel H [eds] (1997) Anthony Cragg: Material, Object, Form. Hatje Cantz Verlag; Ostfildern, Germany, 160 pp.

Chapter 8
Creating Fiber Art with Soil and Rust

Lisa L. Kriner

Artist Statement Stains from soil and water, cracks in rocks and the earth, peeling bark, and fault lines are marks in nature that draw our attention to the passage of time. With constant movement and change, is it possible to capture time? To think? To create? To remember? To be still? My fiber art is a visual exploration of these questions. I work with textiles and materials from nature to create patterns, textures, and lines that visually capture a moment. I layer fabrics and stitch on their surfaces as a metaphor for the way that time and experience layer memory. As the surfaces and layers of each piece are explored, the viewer is encouraged to intimately experience silence, reflection, and contemplation.

I never set out to be an artist. In fact as I took my first art classes, I could not have told you what an artist really did. They "make art" would have been my response, but what that was, I am sure I couldn't have defined. Because of this, finding my path within art has never been direct. I have tried and abandoned, and tried again. But what my art seems to come back to is the importance of place and visual evidence of the passage of time.

The point in my development as an artist when I stopped making school projects and started making art, began very keenly as frustration. Looking back at the incident, I now recognize it was a reaction to the chemical dyes and pigments I had spent so much time learning to use and control in my undergraduate education. It was easy for me to control the technical aspects of dyeing, but I wasn't sure how I could express my ideas. For my art, I was looking for the fleeting, the quiet. At the time, I had only a basic understanding of the history and use of natural dyes and pigments on cloth. What I did know was that at 23 years-old and in my fifth year of college, I would rather be outside in a park in the beautiful North Carolina spring weather, than with a severe mental block, sitting at my desk in the art

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studio. So with a juicy rationalization secure in my college-student mind, I grabbed my sketchbook, scissors, and a length of cotton print cloth and headed to the park to “work”.

After about 20 minutes of enjoying my freedom, the good Protestant work guilt kicked in. I could think of nothing to make for my last studio class, my last semester as an undergraduate. Nothing…. Nothing…. Nothing! Frustrated, I stood up from under the tree where I had been sitting, and began stomping on my cloth; cursing and jumping. After completely wearing myself out, I dropped to the ground and looked down at the cloth, which had so innocently been my target. And there it was. The “Ah-Ha!” moment all artists dream of. That North Carolina red soil had been pushed and dragged into the cloth. The faint and heavy concentration of soil on the surface of the cloth, made from contact between my feet and the ground, made light and dark patterns. I had found what I hadn’t known I was looking for, and my world of fiber art opened up.

After that, the work I produced sung to me. It had life! As I worked, ideas, processes, structure, and finishing flowed from my fingers. I listened to what the work told me and made decisions that expressed my thoughts, but that also respected the cloth and the soil that was coloring it. When I presented the work in critique, I was surprised. Had I really made that? It had seemed so natural and flowing as I worked, but now that I stepped back, I discovered new things in the art that I hadn’t seen before. The finished art was stronger than what I had envisioned myself making (Fig. 8.1).

While at the time I felt as if I had discovered something new, coloring cloth with various types of soil and its components was probably one of the earliest ways our human ancestors gave cloth meaning and value. Coloring cloth can make patterns, and these patterns can record information. Symbols can be stained, dyed, and

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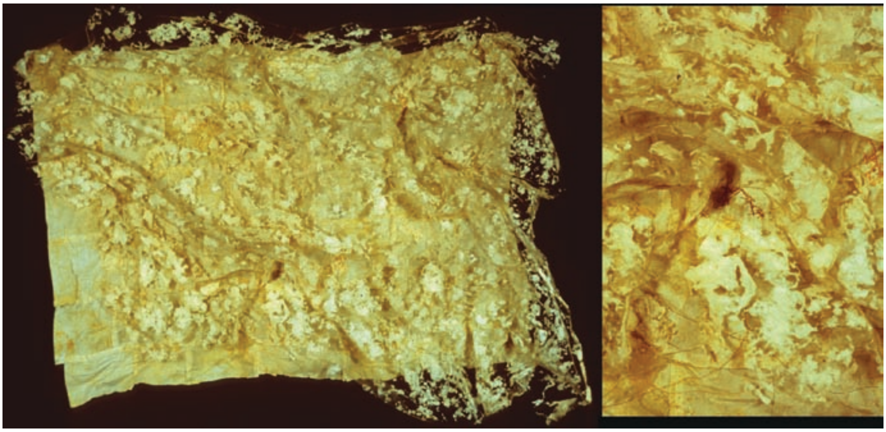

Fig. 8.1 *Alien to Myself*, 1993, inset: detail. Materials and process: cotton print cloth, nylon organdy with hand made cotton paper, embroidery, North Carolina soil stained, cut, and pieced. Height: 51 inches, Width: 39 inches. Reprinted with permission from the artist. Photographed by Lisa L. Kriner (see as color plate following *Index*)

bleached, making the finished cloth a storage place and reference tool for group memory. Depending on the source or what it is mixed with, soil can create a range of shades of black, brown, red, orange, yellow, and white. Wet or dry, it can be applied to cloth in a number of ways. Originally, soils were probably applied by hand, but brushes, sticks, and other tools led to the use of carved or relief stamps and screens. I imagine the woman who first discovered this phenomenon. I see her wiping her hands on her garments after digging for roots or tending to her children. And in her wisdom, instead of being frustrated by the new mess, she suddenly sees the possibilities. I dream that she and I are connected through time, as two women who discovered soil as a creative outlet.

Some of the most stunning examples of cloth colored by soil are made in Mali by the Bamana culture. These "bogolan" cloths (traditionally called "bogolanfini") are made using fermented (wet incubated) mud, thus earning their common name "mud cloths." The base cloth is made from long strips of woven cotton that are sewn together to create a wider cloth. The cloth is washed for shrinkage and soaked in a mordent solution of pounded tree leaves (*Anogeissus leiocarpus*, and *Combretum glutinosum*) that contain tannins (Rovine 1997). This turns the cloth yellow. Once dry, mud gathered from local riverbeds and fermented, is painted onto the cloth, outlining linear designs. The tannins react with the iron in the mud producing a background that can range from light brown to almost black, depending on the mud type and number of applications. For this process, it is the unpainted cloth that acts as the figure—the design—while the color created by the mud is the background. Depending on the intricacy of the design and the amount of outlining and applications, this can be a time-consuming process. Once the mud has dried, it is rinsed off, and the fabric again dried. To brighten the design, which is now off-white on a brown or black background, a caustic soda or bleach solution is applied. This causes the designs to visually pop against their dark backgrounds. Traditionally these cloths were woven by men, but designed and painted by women. Painting and understanding the designs was passed down between women through an apprenticeship process (Rovine 1997). Often used as garments, these cloths were used in rituals that marked transition. While this technique is still taught in the traditional manner, today it is also taught at the l'Institut National des Arts à Bamako, where both men and women design and paint these cloths. The mud-cloth style is used in a wide variety of contemporary applications including home furnishings, fashion, tourism, and contemporary art. Around the world the mud-cloth style designs and finished cloth, as well as the tradition of making them, are strongly identified with Malian culture and national identity.

After exploring the soil staining process in my last days of undergraduate education and continuing this exploration for two years after graduation, I needed more direction. I looked at several options, but decided to attend graduate school at the University of Kansas. Although I had traveled in the United States before, and been through the Midwest, this was the first time I was really away from home and my red soil. During the first months of graduate school, I had my mother mail me packages of soil from our backyard or some abandoned lot in the neighborhood. I worked it into fabric, but it didn't sing. It just sat there reminding me that I was in a new place. Shipping North Carolina soil out to Kansas felt artificial. I was mailing earth from one location to another, removing it from its place. Even the soil was homesick.

For me, studio life was stressful. I didn't have a Bachelor of Fine Art degree like everyone else in the program; I had a Bachelor of Science degree. I used scientific words to express myself, and others looked at me strangely. Competition ran high; I had no idea how to compete. My work started and stalled. I had no focus. I couldn't believe it. How had I made art that spoke to me as an undergraduate, then gotten to graduate school unable to make a thing? So I did what scientists and artists are good at—I observed.

One of my fellow students in the textile studio was working with vegetal disintegration— rotting vegetation that left marks on fabric recording the rotting process. The idea of using the marks created from soil to express passage of time began to roll around in my head. So I tried it with the soil sent by my mother. Nothing. Rubbing with direct connection to the ground worked best with the red soil. I simply could not reproduce the energy in the studio with imported soil. So I turned to the soil of Kansas. The earth around me was rich and brown. Farms were plentiful in the area, and I loved driving past them in the spring and fall watching the ploughed soil lines ripple past me. They reminded me of water and home. But this soil didn't take to the cloth. It reacted differently, or in some cases not at all. I needed to find another way, and started to examine what I knew. I explored why I was so focused on using this soil. I began to realize how important the connection to place was for me. I had to admit that my homesickness was not only for my family, but also for the familiarity of place. I began thinking about where I was from, and what I considered home.

While I spent most of my time as a child growing up in the central piedmont of North Carolina, we always spent some time during the summer on the North Carolina coast. I can remember driving to the beach as a child, the car piled with food, beach paraphernalia, and family. My sister and I would look out the windows to see when the hardwoods gave way to pine and the familiar red soil gave way to sandy soil. Once close enough, we could smell the salt air. The tangy wet air carried little bits of the sea right into our car. That tangy wet air slowly wore down the land and rusted away even the thickest metal.

My days at the beach were days of exploration. Since we were on an island, my parents were a little more liberal about us wandering off. At one end of the island there were no houses, just sandy piles of earth where little grew. I always think of dunes as having sea grass. These didn't, so I thought of them as big piles of sand. In this soil were old sun-bleached shells. I would sit and play amateur archeologist, finding shell after shell. These shells were not really different from what you found in the sand by the ocean, but something in the exploration and discovery made them more exciting. It was also the non-nature stuff that made this soil more exciting than the red soil in my backyard.

The man-made objects I found here were twisted and rusted beyond recognition. They had been tossed in the waves, rolled onto the beach, and buried in the sand. As I found them, I would imagine the great shipwrecks that they had come from. The precious objects they might have been and the knowledge of the past they might carry. Truthfully, they were probably extra boat parts and bottle caps from the local fishermen. But even today, when I find these things on the beach, it is the childhood fantasy that comes to mind first, not the frustration of finding litter in a place you love. I always kept these things—and sometimes still do. In the fall, when I went back to school, I would drop them in my coat pocket or my book bag, pulling them out on the playground or in class, telling myself a whole story about them.

My parents eventually bought a house at the beach, and gradually we spent longer and longer periods of time there. During these longer periods, I would walk farther in my explorations. I got to know the area more intimately, and during each visit, I returned to the same places on the island and dug in the same sandy soil. What always struck me then and still does, is how things change. Sand shifts, subtly moving the earth's surface. Solid objects disintegrated from the pounding surf—sand and salt slowly eating away at them. Harsh weather conditions leave scars from water and wind. The evidence of passage of time is recorded in nature. But time is also recorded in the man-made structures. These too are slowly consumed by the elements. Buildings lean, metal rusts, and paint-peeling wood succumbs to disintegration, joining and building the coastal soil. As I watch this slow, inevitable change, I always feel a kinship to it.

The graduate school experience too was about change. I was often unsure of the rules or if I wanted to play by them. I was constantly trying to navigate the waters and find my own direction. In my first year I almost always felt off balance and ungrounded. In this confusion, it was my observations about change that moved my art forward.

I was not interested in following in my studio-mates' steps of wrapping vegetables and vegetation in fabric and leaving it to rot; it was too stinky and there was too much mold. However I was interested in how the cloth captured patterns and stains from the rotting, evidence of what happened over time. For me, there was a similarity between this and what happened to materials on the coast, in the dune sand and salty air, and I became interested in documenting that slow deliberate change.

I began by pulling out pieces of metal I had found in the sand and collected over the years. They were portable touchstones of home, and while knowing it was a little crazy, I had taken them with me to Kansas. At first, I approached the cloth the way I had with the soil. I rubbed the rusted pieces on the cloth. This produced nothing of interest on the cloth, but pieces of the metal broke off. As I worked, this disintegrating metal would collect under my worktable, combining with other fallen bits making soil of its own. As this "studio soil" collected on the floor, it occasionally got wet, creating little circular stains of rust on the cement. When I noticed this, it became clear that the material had potential. It occurred to me that the natural elements of wind, water, and salt were missing. So I mixed salt water in a spray bottle and sprayed it on metal pieces I arranged on fabric. Clearly a bottle of salt water is missing much of the magic that makes up the ocean—but in Kansas, I did what I could, always remembering that there had once been a large ocean in this place, and that below the rich agricultural soil was ancient sand. The spray bottle didn't work very well, and neither did placing the objects on the cloth. The air, especially in the winter, was too dry. The magic that happens on the coast could not be duplicated in a studio in Kansas. However I did get some success when I wrapped the metal in the cloth rather than just laying it on the surface and was diligent about spraying the salt water. Wrapping the found objects helped embed the rust. The patterns that arose from the sprayed salt water had a fluidity that only comes from that process. I was encouraged and continued to experiment.

I cannot remember exactly how I moved from salt water to vinegar. It doesn't seem like a particularly logical move, and this makes me think that it must have come from a conversation, probably with one of my graduate faculty. Or perhaps it was a memory from one of my undergraduate chemistry classes; oxygen + acid = oxide. However, I like to think that it was closely related to the Kansas experience—the place again directing the materials I worked with. Either way, the idea was a good one. Metal wrapped in fabric, drenched in vinegar and then kept in a humid environment gave amazing results. With this discovery, I made the shift in how I colored cloth—from using iron oxides in the North Carolina soil to using iron oxides from pieces of metal. The patterned fabrics produced from this process were varied and rich. Patterns emerged depending on how the fabric had been folded around the metal, what kind of metal I used, and how much time it soaked. Not all metals worked; not all metals rust. I explored metal combinations— some gave a rich combination of browns, reds, and black. I tried copper, so desperately wanting that blue-green color. But it didn't work consistently and the patina, which was on the surface of the fabric rather than embedded, came off the fabric as I worked with it. I also tried to burn fabric so that I could use the ash, thinking that ash and soil were similar. That didn't work either. In fact, visually it was a disaster. There were other such failures, but these taught me about the process. And it was through developing this process of iron oxide printing that I learned to capture the evidence of passage of time through the disintegration of metal.

I practiced the iron oxide printing, making yards and yards of rusted cloth. I was at first experimenting, just making fabric to see what would happen—changing variables, getting results, and changing variables again. As I gained an understanding of what was happening in the process, I begin controlling the pattern. While this produced lots of fabric, it did not produce a lot of finished art. I had fallen in love with the rusted patterns and the rich colors and had to fight the urge to call the beautiful fabric that came directly out of the process "art". The cloth needed to be manipulated and directed before it earned that title. At first this was a scary leap for me, fearing that I might ruin the beauty of the cloth. I was afraid that by cutting the lengths of cloth or working back into the fabric, I would somehow diminish its beauty and its reference to passage of time. I needed to push both the visual aspect and the ideas to make the shift. To do this, I hung the fabric, rolled the fabric out on tables, folded it, tore it, sewed it together, stitched on top of it, and manipulated it in any way that came to mind. But to successfully manipulate cloth into art meant that I had to really look at what was happening with and on the cloth. I had to allow myself an open dialogue with the rusted cloth. I had to think about and respond to what I saw (Fig. 8.2).

Fig. 8.2 *Conclusive Evidence*, 1996, inset: detail. Materials and process: cotton print cloth iron oxide printed. Height: 42.5 inches, Width: 86 inches. Reprinted with permission from the artist. Photographed by Lisa L. Kriner (see as color plate following *Index*)

The first pieces that broke from the single length of patterned cloth were large sculptural and mural pieces. This scale was larger that I had worked with before, and the art moved from being flat to having dimension—taking up space, and creating a sense of place. Because of the size and the way that the pieces hung, they commanded a presence. They encompassed the viewer and occupied the full field of vision. The pieces hung with a tangible weight and they "breathed" with the movement of the air currents in the building. As they moved, small pieces of surface metal would fall to the floor below and collect. These small piles left evidence of decay and began to produce soil of its own—*new earth*. The process of making the pieces recorded the passage of time in pattern, color, and line, and these small piles of new soil were capturing time by showing the art's slow but inevitable disintegration. The best of this series both drew the viewer from across the room and rewarded that viewer with visually exciting and engaging details produced and accented through layering, repeating and embellishing. Here was a moment encapsulated and waiting for a viewer to contemplate. The art provided a space for the viewer to think and explore (Fig. 8.3).

During my second year of graduate school, I continued to rust fabric, extending my concept of place from the physical location on the earth we occupy and the soil where we feel rooted, to the physical body we inhabit. I began to think about the human body as a landscape— how the body shifts over time and how similar it is to the way soil and sand shift from water and wind. Here, like the body, change could be subtle & slow or radical & quick, leaving scars that act as reminders of an event. Like home, my physical body was a place I took for granted. A place I thought I knew: a landscape familiar enough that I stopped noticing it. But like a hurricane that brings winds and water strong enough to move and dissolve whole islands, change could be rapid and unexpected. To notice a difference meant to acknowledge my body's inevitable disintegration: "ashes to ashes and dust to dust".

For my thesis exhibition in my third year, I exhibited art that continued exploring patterns that could be formed in the process of making the cloth. The pieces drew

Fig. 8.3 *Necrosis*, 1996, inset: detail. Materials and process: cotton cheesecloth, steel wool, machine stitched, and iron oxide printed. Height: 100 inches, Width: 48 inches. Reprinted with permission from the artist. Photographed by Lisa L. Kriner (see as color plate following *Index*)

from the ideas of the passage of time and landscapes, and expanded on textures using processes that were tied to local weather conditions. In addition to rusted fabrics, I worked with sheets of rice paper that were layered and coated with varnish and left outside to dry overnight. The falling temperatures in the late Kansas autumn caused the water in the materials to freeze. The ice crystal patterns were then "captured" in the varnish creating a surface that recorded that specific night's freezing. The art had an overall feeling of landscape, but I wanted the viewing experience to be similar to the way one might closely examine a rock covered with lichen or the bark from a paper birch—seeing the overall first and then more closely examining and discovering the textures and spaces. Like the idea of captured time, these pieces were both delicate and fragile. Handling the finished art for exhibition, shipping, and storing was a trick. During exhibitions the art broke down and disintegrated, creating debris on the floor below similar to how the rusting metal created soil in my first year's work. The soil created by the collapsing varnish was different from the rust soil. On the floor of the gallery it was visually an icy mirroring of the materials and processes used to create it.

After teaching in Kansas for two additional years, I accepted a job at Berea College in Berea, Kentucky. In the decision to move, I knew the land on which I lived would profoundly influence the art I made. The move to a new place and the period of research that occurred while I was learning to teach in a new environment shifted and pushed my art. In Berea the idea of a community rooted in the soil took on added meaning. Berea College is located in the foothills of the Appalachian Mountains and this location greatly influences its mission. People from this area feel intimately tied to the "hollers" (valleys) and the mountains. Generations have lived on and worked the same soil where the idea of "Home" and "Homeland" is strong. It is also a place where the coal in the mountain rock and soil creates great controversy. In the stories of home, connection, and change, people talk of the coal companies as bringing employment and stability; yet in the same conversation, they often express regret over the loss and degradation of soil, and the cost to the land that these jobs extract. The love of the mountains and the removal of mountain's soil and rock create great conflict within individuals, families, and communities.

While I understood this conflict and have come to understand the connection people have to this place, my connection to the soil was much more suburban. In Berea, I rented a little house and was thrilled because it had some surrounding land and was tucked into woods. Having gardened in North Carolina and Kansas, I set about digging in this new soil, pulling weeds and planting pansies and lettuce—getting to know my new place through exploring the soil. Because it was autumn when I moved in, I was confronted with the black walnut. The trees dropped walnuts at all hours of the day and night, pelting the house and the yard without mercy. I took to picking up a bucket of walnuts each morning and dumping them in the woods. I would go out before breakfast and then back in the house, try to scrub the black from my hands. This daily ritual inspired the use of the walnuts in my art. I began picking up the soft, slightly rotten ones and wrapping them in cloth. This process was similar to what I had done with the metal for rusted cloth in Kansas, but because the place was different, the materials and the results were different. I tied the walnuts in the cloth and left the package in the soil in my back yard, open to the daily changes in weather. My hope was that the walnut hulls would break down and stain, and with the Kentucky soil, leave its mark on the fabric. In the studio, I cleaned the excess soil and walnut hulls off of the fabric. Like the rusted fabric before it, I responded to the stains and holes, making art that reflected passage of time and the uniqueness of a place.

This creative renewal was further encouraged by my increased opportunity to travel. During the summer after my first year in Berea, I was given the opportunity to travel in China and Thailand. As I traveled, I found myself drawn to explore the visual evidence created by the passage of time in these new places. Details—the slight changes, and the discarded parts—drew my attention. I photographed innumerable doors & windows—seeing them not only as literal passageways, but also as symbols of movement from an old to a new place and from private to public space. They were thresholds that framed views and entrances onto the world. To walk through these thresholds was to be able to change your mental and physical place.

I also documented the walls that surrounded these entrances. The walls were often constructed of earthen bricks made from soil or stone taken from the surrounding land. It was as if the buildings grew from the earth. They spoke of their specific place, revealing moments in time. The wall surfaces were layered with plaster, paint and paper, each peeling away to reveal the older one beneath. As I studied and photographed these rich, layered, and textural surfaces, I was often confronted with writing, images, and graffiti. The writing was beautiful in its formal structure, and in the lines and patterns that it created. I understood that the writing carried meaning but that meaning was lost to me. Now the writing symbolized and exposed the inner landscapes of thought and possessed the ability to both conceal and reveal. It felt similar to how I imagine objects and writing from the past carry partial meanings for an archeologist, while its context, use, and importance are mostly lost. It is the way layers of the earth carry history that is studied by geologists; but for most of us it reads simply as rocks, mountains, and soil.

To process these experiences, I kept detailed journal/sketchbooks of writing, collecting, and drawing. I was recording, layering my thoughts and ideas, layering my culture with the ones I was experiencing, and layering past experiences with present ones. Writing was another way for me to capture the passage of time. As I choose what to reveal and conceal, I recorded my mental landscape. I periodically reread and explore these journal/sketchbooks and I am always fascinated by what I thought was important enough to record and what wasn't. I recognize that I have left things out, assuming they were too obvious or mundane to mention, and they are now lost forever. What was left out seems as significant in recording changes in my mental landscape as what was included. Thinking about how I record my experiences exposes evidence of my complex mental layering and rifts, and changes in my thoughts and ideas.

When I returned to the studio, this way of thinking and the art that came out of these experiences combined the calm and contemplative color and structure of my previous art with new forms that referenced both energy and mental change. I combined the past and present: chemical dyeing from undergraduate work, rusting from graduate art, walnuts from my first experiences at Berea, and stitching and embellishing influenced by my time in Asia. The reference to doorways and passages became important symbols in the art, and the pieces took on their form. Circular and spiraling shapes and lines that appeared to be writing or thoughts began to appear in the art. These forms touched on my ideas of inner change by referencing journal writing, formal recording of important ideas, and the swirl of the imagination and thoughts. Visual evidence of passage of time in the weathering and stained fabrics were overlaid with evidence of a changing mental landscape in the form of journal writing and circles.

Recently the idea of boundaries has been rolling around in my head. I have begun to think about and explore the boundaries of change. What is the point, line, or space when something shifts from being one thing to becoming another? When is that minute, second, or millisecond when that the change occurs? Where does one thing stop and another begin? When a wave rolls in, where does the ocean stop and the land begin? As I breathe, when does my breath become the air? When do multiple thoughts coalesce to become an idea? And when a rock disintegrates, when does it cease to be a rock and become soil?

Reference

Rovine V (1997) Bogolanfini in Bamako: The Biography of a Malian Textile. *African Arts*, vol. 30, no. 1 (Winter, 1997), pp. 40-96.

Chapter 9
Soil, Subsoil, Priming and Architectural Design

Heinrich F. Jennes

Architects take little interest in the ground. They look more willingly into the distance, along the tops of skyscrapers, skywards and upwards to the heavens. This is where weightlessness captures the imagination and where heavy buildings seem to levitate above the horizon.

The ground hardly exites the imagination of most architects. It should do its duty to provide a building with a secure foundation, allowing simple integration into the subterranean utility conduits and surface connective arteries. That is all. Moreover the architect does not even carry out the unavoidable analysis of the construction site himself. He outsources that task to an engineer, who, in turn, is much less involved in the developmental design process.

Usually, the ground is secure enough that it does not require any massive, invasive soil improvement. Yet in all cases, it must be dug out and disposed of elsewhere. Additionally, the sealing above the ground and the piping below it may create damage. This occurs in particular when larger and deeper parts of the earth's crust are affected. The result is that the intrinsic functions of the ground—such as water infiltration, habitat for flora and fauna, humus formation—may become impaired.

It is exactly these functions that fulfill a different, important human dependancy on the soil: specifically, that the soil be as productive as possible. Should the architect, somehow, feel responsible for the soil in some manner, in a way that we would normally ascribe only to farmers? Why not? In the 18th century humans placed significant emphasis on the cultural, quasi-architectural practices of the farmer—not just to produce foodstuffs, but also to be an unassuming sculptor of a beautified landscape. And this dream today has its new supporters in the ecological movement— *e.g.*, the Social-Democratic German architect-politician Peter Conradi who speaks about the fact that a "building culture" also needs a "ground culture." Why should the urban architect of today not also function as an environmental planner, not merely concerned with any leftover adjacent grounds, but directly with the

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kernel of the building's design? In the past few decades this direction has changed, if only to a limited extent. Architectural competitions increasingly encourage participants to collaborate with environmental planners. In addition, "sustainability" concerning soil and landscape has been declared a major theme of UNESCO for the next 10 years. In its 57th meeting in December 2002, the United Nations General Assembly proclaimed the UN Decade of Education for Sustainable Development, 2005-2014, for which UNESCO is the lead agency. Its goal is to integrate the principles, values and practices of sustainable development into all aspects of education and learning.

Architecture doesn't necessarily need to be heavy and big. It works with what is found, with what it discovers, as its resonance body, to handle and arrange according to its own scale of use. It feeds on the geographic environment; it etches and shapes it. Subterranean qualities come into play, including indurated soil layers, stone seams, burrows, caves, hills and valleys, and riverbanks; in cities, old buildings and wasteland can be worked on and integrated. Under these conditions, the earth shows itself as an excellent apartment house.

Appreciation of the earth and seeking inspiration from it, as part of the art of architectural design, remains limited for many architects. It could be that the process of architectural practice needs to be reevaluated so that specific, related professions, which are usually pushed to the periphery—such as those concerned with soil, utility planning, geography, environmental and population planning, and archaeology—are brought to the center of the design process. The design process must be adapted, so that the adjacent grounds, accessibility, utility supply, foundation and construction of the building, and especially the roof, will be considered at the outset of the process, instead of half-heartedly at the end, following the determination of the ground plan, the walls, the ceilings, and the form. Even the initial sketches could be interpreted and incorporated differently in a "from the ground up" approach where the soil and landscape radiate their influence in the final building plans. Everything above the ground would act as a sounding board. The foundation would be the emanating source of all construction. And all of those fascinating utility systems, usually buried under the ground, would find their way above it, in order to contour the urban space.

9.1 Soil as a building material

As eagerly as the architect looks to the sky, he cannot ignore the ground. This is especially true when it comes to building materials. The earth provides clay as a building material for about one third of the world's population. Clay is used as a building material not only in warm, dry climates, but also in colder and wetter regions, where it usually appears together with a wooden skeleton in the form of half-timbered buildings. Usually clay is extracted directly from, or near to, the eventual construction site itself. Again, like all soils and rocks, it allows itself to be used with a double functionality, *i.e.*, both as building foundation and as building material. As a building material, it is mined, cleaned to remove stones, kneaded, and mixed with water and finely chopped straw. Building clay, like all other products, is prepared, and therefore predictable, while the foundation is always "a much more difficult material" (Széchy 1963).

"Clay" is above all the most important and most versatile material of our planet. It is versatile, in that it allows an abundance of plants and foodstuffs to grow, but it also allows humans to utilize it for their own designs. It provides for "creative impulse" in the form-giving artistic and architectural sense (Dethier 1982). In the wake of this creative impulse comes an enormous variety of societal, cultural, cosmic, sexual, and functional structure symbolism, which we today somehow happily admire and research, but which we only seldom desire as templates for our way to build. Since the Classical Modernity, we greatly prefer the technical, the moment of freedom and movement, as its model: the automobile, the airplane, and, in particular, the steamship. Collectively, it favors images that accept the ground only as a disturbing anchor or landing place. Its function is considered as a bearer of the foundation. Instead of a further cosmic search, instead of making modern metaphysical incantations, we should relate to that which is less removed—to the earth and the atmosphere.

The clay building, with its self-evident origin in the ground, could factor in this geocentric solution. Clay brings its territorial qualities into play. The clay building directs attention to the soil and models it. It can be changed to fit topographic movements. It can be attached as thin, elegant panels in front of the interior walls in order to keep the humidity of a room at a constant comfortable level. It does not discern between building and furnishing.

9.2 Archeological-geological priming

The capacity of clay building for reductability and horizontality is most apparent in the condition of its decay, when the building material is almost imperceptibly settled into the soil; when the roofs and walls have fallen, and with them the division between inside and out.

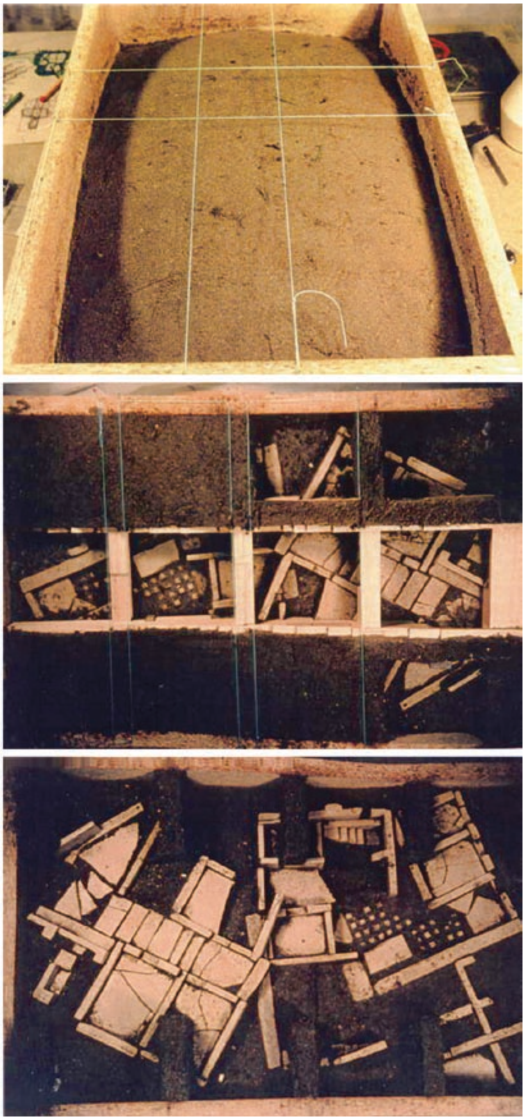
Clay cities in the Near-Eastern desert regions remain uninhabited for centuries or are destroyed through wars or by fire. They deteriorate, and are rebuilt many times over the millennia. Today, they ordinarily stand empty for long periods and build flat, artificial hills, which are easily confused with natural ones. These so-called "tells" are comprised of flat layers of whole settlement outlines, which are of particular interest to archaeologists. The excavation (Fig. 9.1) shows continuity of direction in space and appears to be connected though some form of flow. The archaeological outline reveals the wall as a flat, relatively broad footpath, as a dividing line between the neighboring, higher (later) or deeper (earlier) completed buildings. A definite affinity exists between the horizontal surface of the streets, grounds, walls, and rises.

Fig. 9.1 Habuba Kabira excavation area in Syria (from Strommenger 1980). Reproduced here by permission of photographer, Wolfgang Bitterle (see as color plate following *Index*)

The archaeologist sets excavation trenches, digs up layers, eventually opening up whole fields, takes out whatever is found there and reflects on its nature. The geocentric designer, by comparison, looks at the whole complex, at the archaeological “situation”. For him, the recyclability of clay becomes the recyclability of the whole given situation. Just as the construction material does not allow much differentiation from the soil that it came from, so does the designer not discern between the exposed walls and the levels of strata left as walkways, between archaeological and pedological ground sectors or markings. This view provides something of relevance to each and every concept, as a basic idea or rough draft: the simultaneous view of an architecturally pre-structuralized ground.

The view supposes that the ground is something structuralized, something to be conceived of and used, and that its qualities lie unfolded and unbridled for a “ground floor” to be built over. In contrast to this view, we propose with the project “Casatell” [H.F. Jennes 2001] (Fig. 9.2). It relates to “casa” = home and “tell” as described above. As an indication of its hidden inner life, the hill is stylized into the form of a single “swelling”, and the crosshair grid indicates the initial archaeological access (Fig. 9.2a). The mighty walls consist of soil-like layers in which artifacts/features remain. These walls represent an intersection through occasionally very thin layers and may easily be read as an historic barcode (Fig. 9.2b).

At least three “find layers” are simulated, each with a ground plan which is characterized by relatively well preserved floors and thresholds. The “find layers”

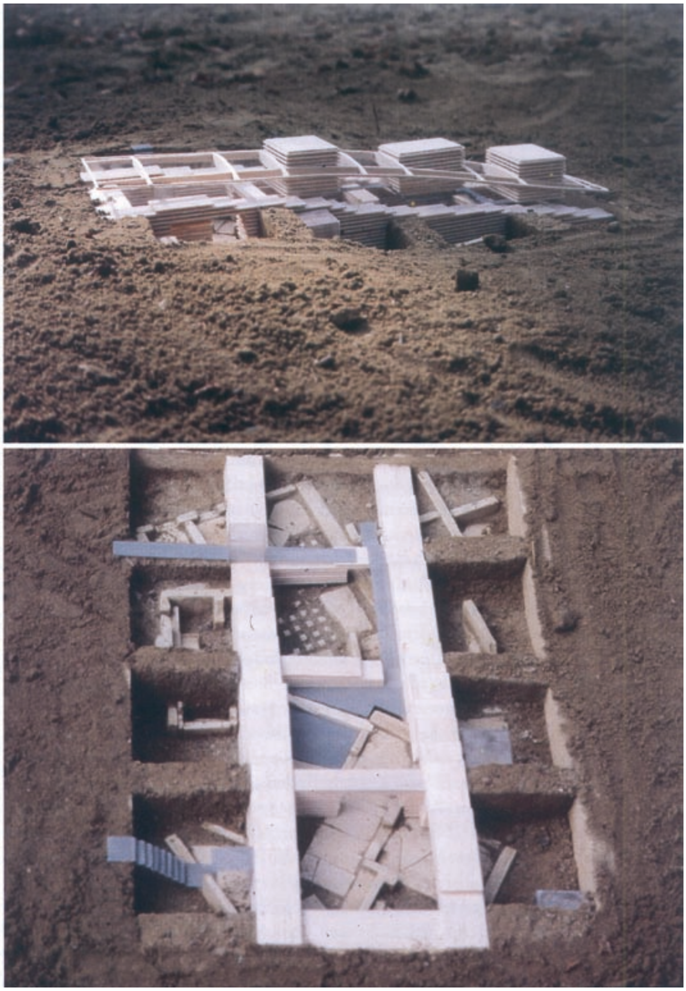


a b c

Fig. 9.2 "Casatell" Three stages, (model; 40 x 60 cm; sand, plaster, wood). H.F. Jennes in collaboration with Arne Böhm and Eckhard Drach (Jennes 2001) (see as color plate following *Index*)

overlap and are interlinked. They are themselves overlaid by the current matrix of archaeological walkway walls (Fig. 9.2c). The archaeological walkway matrix is partially opened by niches, which are then used to expand the internal functions. Three mostly closed living ashlars are hung from the roof, while the "find layer" remains throughout, according to the type of singular room. This experiment allows a breaking through of the taboo of (re)using discovered and researched sites of archaeological interest.

Figure 9.3 represents a further modelling of the Casatell concept (in a sandbox at a playground near the Technical University of Graz, Austria). The ground walls remain, as far as they make up the border of the field of excavation. In the interior area, however, they are architecturally composed, stabilized or successively exchanged, functionally and spatially translated in partition walls, shelves, kitchen walls or retaining walls for the overlying roof scaffolding (Fig. 9.3a). The group of the



a

b

Fig. 9.3 "Casatell" Three stages, (model; 40 x 60 cm; sand, plaster, wood). H.F. Jennes in collaboration with Arne Böhm and Eckhard Drach (Jennes 2001) (see as color plate following *Index*) former excavation “windows” are consolidated towards the top and made recognizable through the steel truss of the roof; slightly sunken, it contours the undulating land of the excavation mound. In the middle fields of the framework, residential cubicles will be hung (Fig. 9.3b).

9.3 Soil replaces architecture—Early English landscape art: Ground Movement as a critique of architectural design

The English landscape-gardens at the beginning of the 18th century arose from a critique of the geometrical style of French parks. In the name of freedom and change, the economic, intellectual and artistic elite of the time developed an aversion to regimentation, be it in the form of the poetry, the unruly beauty of country ballads, or ultimately in the landscape. They countered the noble gardens with axes, terraces, walls, pavilions, temples, fountains, sculptures, monuments and emblems. In order to improve the landscape, they sought to remove architectural forms, both in the form of geometrical designs and in the form of buildings. Only the manor house was allowed to continue in its role, albeit with less influence than before.

In order to provide an enjoyable experience of the landscape, it was sufficient to use meadows, hills, rocky outcrops, trees, shrubs, roads and areas of water whose organisation could hardly be differentiated from the surrounding landscape. The garden was not supposed to be a “world of its own”. Organized nature and unorganized nature were to be harmonised imperceptibly with each other. For this reason, a refined solution was developed to replace the traditional encircling wall that usually separated a garden from its surrounding (usually agricultural) landscape. In 1724, the poet Alexander Pope wrote of the garden of Stowe: “What adds to the bewty of the garden is, that it is not bounded by walls, but by a Hah-ha, which leaves you the sight of the bewtiful woody country, and makes you ignorant how far the high planted walks extend.” (Amherst 1896). The gardener Charles Bridgeman, who proposed the plan for Stowe, is recognised as the inventor of this new type of enclosure, which consisted of a trench along whose base a fence ran. Such an enclosure only becomes visible when the visitor is standing right in front of it, usually resulting in an “Ah-ha! ” of surprise. The exclamation uttered by misled wanderers eventually became the technical name of the device. Instead of the architectural wall, the ground now achieves this enclosing function in the form of its elevations and depressions.

All in all, the absence of architecture and architectural building material provides for the emancipation of what is naturally given. In particular, it is the soil that gains importance and the capacity to form itself, to influence the landscape and to make it appear as a unified entity. This capacity is exactly what Lancelot Brown (1716-1783), one of the planners of the Stowe Gardens, had in mind when he spoke about the “capability” of a garden; and it is exactly this term that became his nickname. How, then did “Capability Brown”, in the absence of architecture, bring the supporting function to expression? The terrain provided a wave-forming motion! “Provide”, in other words, meant that the motion was either naturally present, or was produced through the massive excavation of soil, by the demolition of existing buildings or, more extremely, by the destruction of the original vegetation.

Figure 9.4 shows the plan of the Gardens of Stowe at Buckinghamshire done by William Kent, and Lancelot Brown (Gothein 1926). The lithograph by Benard and Luis Philippe Alphonse Bichebois, and the previous drawing of Narcisse-Edmond Desmadryl, depicts the plasticity of the great meadowlands in an impressive manner. It is as if sculptors have given the ground surface a tension by the sculptor’s internal “Poussée ” (thrust). Meadows seem to be swollen or sunken in those places

Fig. 9.4 Kent-Brown plan of the Gardens of Stowe, ca.1830 (from Gothein 1926, vol, II, p. 374)

where groups of trees stand or where paths unfold. Lancelot Brown was brought to Stowe in 1742 by Lord Cobham in order to work as a young gardener with William Kent. Soon enough, he was not only entrusted with the execution of plans, but enjoyed a free hand to develop his own ideas. "At all events, the new 'natural' layout of the gardens was attributed to Brown by near contemporaries." (Hyams 1971). The ground illustrates its principal "capability", its presence in the form of supple meadow hills, which are curved at their deepest points by the "swinging" shape of the banks of ponds and creeks, and are contoured both by free-standing and arranged groups of trees. Lancelot Brown became the ultimate promoter of another attribute of the wave—the undulating line, which he introduced everywhere in his gardens. Terraces were banished as being completely unnatural, and footpaths followed the individual landscape elements. Brown's particular strength lay, however, in the composition of water; first, he gave it the curvatious movement, and by repeated curves, highlighted the interplay of the bends and the inlets of the banks.

In France, during the first year of the Revolution (1789/90), the English approach was criticized as just being a fragmentation of "the picturesque", caught in representations of the feudal. Still, this anti-architectural impulse was embraced, expanded and made the basis of a revolutionary collective way of dealing with earth. Soil became the epitome of a truthful, democratic public sphere/social space that could only be functional under an un-built sky.

Extensive preparations were necessary for the magnificent Fête de la Fédération (celebration of the Federation) on July 14, 1790, at the Parisian Champ de Mars. The famous historian Jules Michelet enthusiastically described the order of events 50 years later: "The Champ de Mars was at that time entirely flat and one wanted to give it the beautiful, grand form it has today…Everyone worked day and night: People of every class and every age, even children, citizens, soldiers, abbots, monks, actors, merciful sisters, beautiful women, market women. Everyone swung a hoe, pushed the wheelbarrows, loaded the wagons. Children walked ahead and carried the lights. Wandering bands of musicians fired the workers onward. These sang in turn, while they leveled the earth, the song of leveling: "Ah! Ca ira, ca ira, ca ira! Celui qui s'élève, on l'abaissera!" (Ah! It'll be fine, it'll be fine, it'll be fine. The one who is elevated shall be brought down)… This incredible task, that created a valley between two hills out of flat land, was completed – should one believe it? – in one week! It was begun on the 7th and completed on the 14th."

During the first years of the Revolution, there were many more 'soil productions' that competed with monumental architecture. 'Liberty Trees' were planted and steep mounds of soil were artificially heaped high in front of the city halls and churches as symbols of a "reconstruction of nature" or as the cult objects of a "religion naturelle." A few years later, after the sacred architecture for a cult of the "Goddess of Reason" again gained recognition, people went as far as to not only equip the interiors of churches with "parks", but also move the

Fig. 9.5 The holy mountain in the church of Sainte Maurice, Lille 1793. Lithograph from the 19th century. [appears in Harten and Harten (1989) p.132 , Fig 68] Reproduced here by permission of Bibliothèque Nationale, Paris, Département des Éstampes.

earthen mounds into these spaces (Fig. 9.5): "A lawn was laid out on the floor. In the side chapels, the saints had to give up their places to trees: ivy entwined elms, hawthorn shrubs and oaks. There was a mountain, over forty feet high, heaped up in the choir area, designed by an architect, a gardener and a watchmaker …" (Harten 1989, page 127). The mountain and its surrounding area acted as a theatrical set for the staging of processions and dramatic scenes. The record of the celebration further reports, "Mothers, the children nurse in the moss. Source for springs and reincarnation; next to that, a Hercules armed with a club against the despots that thronged out of the caves in the substructure of the mountain." This radical, partially anarchist movement in France ended in the year 1794/95 by decrees of the Revolutionary government. The trees and earthen mounds in the churches were forbidden and removed as being monuments of terror. What grew up instead was an architectural imagination that was mainly inspired by tombs.

9.4 "Sinking Site", Seven Reliefs on the Behavior of Architecture and Territory; 55cm x 43cm, polyester, steel, (H. F. Jennes, 2000)

These mixed media pieces (Fig. 9.6) by the author show the wave form as an imagined plastic reaction of weight and shape of an overlain structure quite similar to the early English landscape planning. The steel elements of the reliefs "Sinking-Site" are found metal objects that have been arranged in a matrix of modelling clay. The clay-form was moulded in plaster; the plaster was coated with polyester, and the polyester dusted with emery. The metal parts represent an architectural model, and the clay–polyester surface represents the surrounding ground. The reliefs allow experimentation on form-building architecture, with the plastic ground—the soil cover—either transecting the building element ("pinch"), or providing a natural element that orients the building ("pointer").

Openly, the mass aspires to avoid its own piecemeal reduction, so that all of its efforts go towards one end—namely, that of keeping its surface tension, its wholeness. The ground, as mass, is not cut into pieces by the superimposed stereometric bodies. Indeed, it is the collision of hard and soft —each with different viscosity— that focuses the concentration of the viewer on the fact that a simple geometrical element (*i.e.*, the rectangular pointer) exerts a special force on the soil that

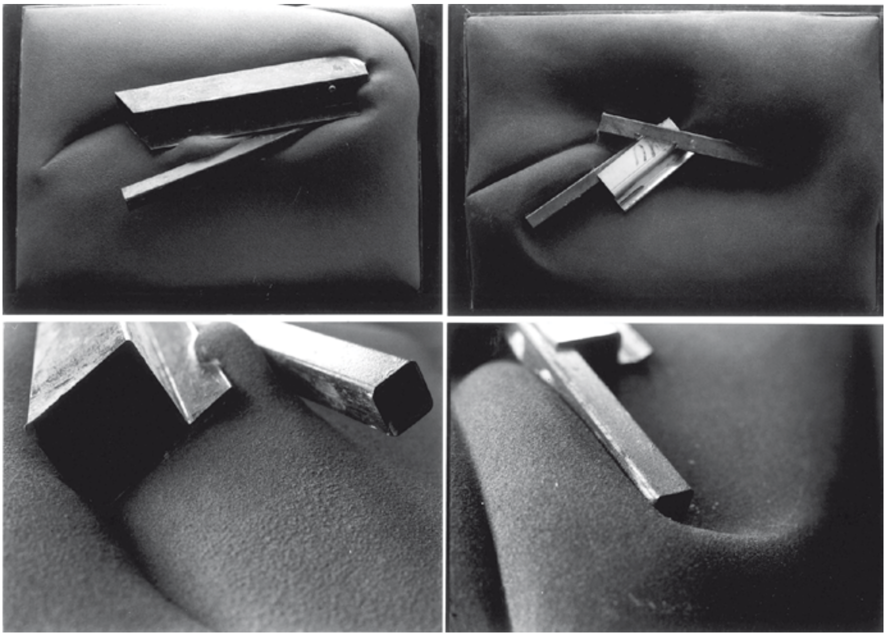


Fig. 9.6 "Pinch" and "Pointer"; from "Sinking Site". Seven reliefs on the behavior of architecture and territory, 45cm x 65cm, steel, polyester, emery (H.F. Jennes 2000).

surmounts the undulating line of Capability Brown. When the “elements” of landscaping artistry (ground, woods, water, rocks, and the architecture) strengthen one another, even almost to the point of interchangeability—when rows of trees simulate the cliffs, flat meadows mirror the water, and buildings comment on, contrast against, and simulate rocks—then the landscaping artistry offers conditions that are relevant to the future sustainability of the Sinking Site Conception: Ground segments enter the region of the solid body and, conversely, solid parts find themselves outside, as offshoots of the central body.

The idea is to dissolve the confrontation between object and environment. The “Sinking Site Series” does not allow any “building” to have the nature of a “bubble”, but rather turns the concept around. It provides the ground with the qualities of a bubble! It researches the elastic active and reactive abilities of the ground in relation to the relatively weak changeability of the constellation of solid bodies.

9.5 “The Topography of Terror” (H. F. Jennes, 2005) — Architecture as a contour of rubble and ground

In the center of Berlin is a three-hectare patch of land, adjacent to the cellar wall of the former museum for industrial arts (the “Gropius Building”). Stretching along a small strip at the northern edge is an open-air exhibition—“Topography of Terror”—concerned with the history of these particular grounds during the Nazi period. The SA (Sturmabteilung, “brownshirts”) and Gestapo set up their headquarters here, complete with prisons and torture cells. Near the end of the war, the buildings were mostly demolished and thereafter removed. Today one sees here a grove of locust trees next to elongated rubble heaps, which slope downward from heights of up to nearly 10 meters to the exhibition below. Little other evidence of the original buildings remains at the site. In 2005, a competition was announced for the construction of a large documentation center focused on this era. Aside from the current usage, the planned building might also be utilized for other purposes in the future. Thus, all participants had to accept, as an integral part of their concept, the fact that the organizing agency might at any time decide to remove the rubble piles.

In my view, it is precisely this condition that is unacceptable to the design. The rubble left on the site from the previous buildings is exactly the right material to use for presenting to the public the terrible history of the site. It is precisely rubble that mediates and helps to make the realities of the site tangible to visitors. My entry for the “Topography of Terror” competition (Fig. 9.7) is a composition of ground and building material, guided by the motif of “contour”. It illustrates the ground and construction as an elastic horizon, inside which the architecture appears primarily as something archaeologically buried, then uncovered. Only secondarily does the large, newly erected building take its place next to the uncovered architecture.

Fig. 9.7 Entry for competition "Topography of Terror", 80cm x 100cm, steel, aluminum, polyester, emery; Berlin (H.F. Jennes 2005) (see as color plate following *Index*)

It goes along with the linear rubble wall, so that it transforms into a massive fastener. With regard to the dump, the building undertakes nothing else but to reinforce the perimeter walls and to develop their height. The ground appears as a cobbled membrane, enclosing the whole of the site, and all its differentiations, be they botanic or archeological, are framed and animated by architecture.

References

Amherst AM (1896) History of Gardening, p. 251, 252

Dethier J (1982) "Lehmarchitektur" (Clay architecture); Munich, p. 104

Gothein M-L (1926) "Geschichte der Gartenkunst" (History of Gardening); Jena

Harten HC, Harten E (1989) "Die Versöhnung der Natur" (Reconciliation with Nature) Hamburg

Hyams E (1971) Capability Brown and Humphrey Repton, London, p. 15; p. 17

Jennes HF (2001) "Architektur des Horizonts - Bericht vom territorialen Entwurf",(Architecture of the Horizon – Report on Territorial Design) Berlin, p. 205–212

Michelet J (1847) History of the French Revolution, chapter 28 ("About the new Religion – The general Federation Feast 14th of July 1790")

Strommenger E (1980) "Habuba Kabira, eine Stadt vor 5000 Jahren" (Habuba Kabira Town 5000 Years Ago) 12. Sendschrift der Deutschen Orient-Gesellschaft, Mainz

Széchy K (1963) "Untersuchung und Festigkeitslehre des Baugrundes" (Analysis and Mechanics of Materials of the Subsoil) Wien, p. 42

Chapter 10
Art by the Ground

Martine Lafon

Walking is almost indistinguishable from the practice of artists preoccupied by the notion of the ground and the soil. To be close to the ground is to bend over it, to better understand it, to better grasp it, to better reproduce it—in short, to better live it. The physical and intellectual materials it provides require—if they are to be totally received—an attitude of humility, which, by its etymology, may mean to be close to the humus. Whether a reserve of pigments, a material linked to identity, a way of reading the landscape, or part of an imperiled planet, soil is, for the artist, a material for reflection:

> *"Beneath these stones, an area of sweet-smelling coal is slowly developing: black sponges with pores full of dirt, which dogs sniff and dig up, particularly in this cold season which matches the mining blackness. Little balls of coal are consumed not by heat, but by their fragrance, almost nauseating in intensity, which rises up as if from another world."*
> (Jaccottet 1970).

10.1 Walking on Color

Sites which are rich in iron oxides and which produce pigments constitute an immense palette that the painter need only dip into to gather color. Colored earth is found in numerous landscapes the world over, but for certain countries that have

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Translator's note:

Although this chapter is translated from French, many of the quotes and excerpts it contains were originally in English. In such cases every effort was made to locate and include the original English as opposed to re-translating, but at times this was not possible. Any instance where a quote appearing in this text was re-translated from French has been noted. Any other quotes are either translated from the original French, or left in the original English.

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totally integrated it into their culture through their rites and art, it has become the symbol of a specific identity. The Australian Aborigines use it to cover the ground and bark with rich ceremonial designs. Their ritual begins with the secrecy and intimacy of removing the natural pigments—a sacred material, continues with the creation of their earth-designs, and finishes ceremonially with chants and dances.

Even though the painter and ethnographer František Kupka—a missionary in the Arnhem Land, where the oldest traces of this activity linked to religious, ritual, and clan activities are found—and surrealist painter André Breton had already seriously examined Aborigine painting, we would not truly discover it in France until 1983, when the Paris Museum of Modern Art invited the Warlpiri to reveal their mysterious colored-earth designs to the public. Willing to bypass ancestral rules in order to save their culture, the knowledge and skill of which tend to decrease and disappear without leaving any trace since everything is erased at the end of the ritual, the Warlpiri urgently negotiated with the museum to assure that their paintings—usually produced for one individual ritual event—would be truly destroyed after they left.

Admittedly, the twelve square meter carpet of earth made on the floor of ARC (Animation Research and Creation) at the museum, by 12 Warlpiri men from the Aborigine community of Lajamam, never fell within the realm of artistic performance, but it was nevertheless comparable to a "necessity of the ephemeral," as the catalogue called it, and thus totally comparable to certain artistic movements of dematerialization.

They rejected the role of artist, insisting on the specificities of their system of representation:

> *"We, the Warlpiri, are not here in Paris to unveil a piece of artwork. We are not, and we do not want to become, professional painters. What we present to you is a glimpse of the way we venerate the Sacred Heroes who gave us our identity, so that Europeans can better understand what we are, and how strongly we feel the need to remain ourselves"*
> (Myers 1983) [Translated back into English from French. tr].

Their exhibits would multiply, notably in Paris at the "Musée en Herbe" and the "Musée National d'Arts Africains et Océaniens" (MNAAO), in 1988—the year of the Australian bicentennial—presenting the environment, the art and the culture of the Aborigines. These exhibits concerned the world of anthropology even more than the world of art, and relied in large part on scientific research, such as that of Claude Lévi-Strauss.

It was not until 1989, when France was celebrating the bicentennial of the Revolution, and when Paris became a European City of Culture (a label given by the European Union, created in 1985 and rechristened "European Capital of Culture" in 1999) that Jean-Hubert Martin's double exhibit "The Magicians of the Land" at the Great Hall of the Villette and at the Centre Georges Pompidou, allowed one to consider at once the status of international art and indigenous culture. Without any sense of hierarchy, a Warlpiri earth painting was shown beside a work by Richard Long, who uses mud in his pieces on the ground and on the wall. "Many anthropologists are starting to wonder why they've traditionally favored myth and language to the detriment of visual objects." (Jean-Hubert Martin 1989) The following year in Montpellier, at the exhibit "The Australian Summer," Aborigine artists mingled with contemporary artists. No anthropologists were invited, only art specialists and curators.

Without getting into the details of Aborigine art, these points demonstrate that the ritual or artistic use of a material like soil inevitably amounts to something original that falls somewhere between art and anthropology. The 1990 Venice Biennial confirmed the closeness of this relationship when two Australian painters, Queenie McKenzie and Rover Thomas, were invited to a ceremony in honor of dreamtime—the time when they cover their bodies, the ground, and rock walls with paintings, as part of a complex spiritual tradition.

If today, contemporary Australian artists, and in particular Aborigine artists, sometimes abandon natural ochre pigments for acrylics colours, they still work for the most part in strict reference to the traditional and ceremonial law that they perpetuate through a vocabulary of sacred signs, and a color gamut that is often close to the Earth's palette. In 1993, during the International Year of Indigenous Peoples, the MNAAO organised an exhibition on Aboriginal bark and acrylic painting. In the interest of promoting this art, in 2005 the architect Jean Nouvel selected eight artists—four men and four women—from different Aborigine communities to paint floors in the "Musée du Quai Branly", then under construction, noting that "Aboriginal art is the oldest culture in the world, that is still alive and inventive", beyond all primitivism.

10.2 Opening up the Ground and Discovering its Mysteries

To a lesser extent than Australia, the land in the different geographic zones of France is also rich in colored earth. The most famous site extends from Rustrel's "Little Colorado" to the ochre cliffs of Roussillon, where Samuel Beckett lived from 1943 to 1945:

> *"Le Vaucluse! Qui te parle du Vaucluse ?… Mais là-bas tout est rouge!… Je n'ai rien remarqué, je te dis!"*
> *"The Vaucluse! Who's talking to you about the Vaucluse?…But down there everything is red! I didn't notice anything, I tell you!"* (Beckett 1952).

Two locations in the Vaucluse department (city of Roussillon, Provence region) of southeastern France are particularly popular with tourists, artists, and photographers alike. A school where artists and painters learn to work with ochre and pigment now occupies the site of a former ochre factory ("Usine Mathieu", http://www.okhra.com). The Burgundian soil also has several quarries, one of which is named *Beaux-Art* (located at St Amand en Puisaye and Moutiers en Puisaye); its factory makes paint for artists (http://www.solargil.com; http://www.poterie-batisse.com).

In the past, the extraction of colored mud from these quarries primarily served potters and ceramicists. Today, it is in these places, both big and small, that artists rummage to experiment for themselves with the mother-material: the earth, thick and supple, that many like myself have cracked, beaten, sliced and molded in art schools—this earth which enriches our palette with its considerable range of colors from its oxides and roots. These ingredients with evocative names—clay or potter's clay, kaolin, sienna, yellow ochre, burnt sienna, madder lacquer, copper oxide, lead oxide, red lead—spoke discreetly of soil to me as a young student at L'École des Beaux-Arts.

In its structure and its material, soil constantly reminded me of the origin of painting, of the image, and of a form of expression, all hidden in the deepest history—in, shall we say, pre-history. But well beyond being just a material, soil provides the artist with a landscape vocabulary which becomes a pretext for particular reflection since, depending on its composition, soil has given varied offerings that have nourished the whole history of design and landscape painting. Vegetation varies, and the gullies in the marl—gray or colored by oxides—owes as much to soil as to time. In *"petit Colorado provençal"* (small Colorado of Provence) at Rustrel, I saw the so-called "fairy chimneys" standing tall on the soil. Soil scientists have told me that they are due to capillary phenomena, drawing mineral-rich water which hardens into mineral columns. The artist in me is overjoyed at this whole commotion going on before me. And when I look at the surface folds that the soil has sustained and compare them to drapes or other pleats treated with dexterity by the image tailors who have enriched the history of our architecture, I easily imagine that the slightest breeze will move the stone.

In the footsteps of André Gide, the French author who, as a child came to know the trails of Garrigue—a type of shrub and grass plant community found in Mediterranean areas on calcareous soils—I reread the gently dented landscape around Uzès. Thus was born:

"Un Petit Mamelon Calcaire"
[*"A Little Chalk Hillock"*]

a book I made (Lafon 2001) for the 50th anniversary of Gide's death (Fig. 10.1).
In:

"Non Loin de Là"
["*Not Far from There"*]

through photography and engraving, I reread the soil, relying on the René Pons text (Lafon and Pons 2005) that speaks of the "dry riverbed where pebbles in a layer of cracked silt striped with dusty grasses seemed like scattered skulls…" (Fig. 10.2).

With a text of Jean-Gabriel Cosculluela (Lafon and Cosculluela 1998):

"Sur le Sol Sec de la Figure"
["*On the Dry Ground of the Figure"*]

is the continuation of work led in the Lauragais region for the return to the uncultivated land and the fallow fields.

My work entitled:

"Le Partage des Terres"
["*Sharing the Land"*]

Fig. 10.1 "Un Petit Mamelon Calcaire" (from Lafon 2001). ["*A Little Chalk Hillock*"]

Fig. 10.2 "Non Loin de Là" (from Lafon and Pons 2005). ["*Not Far from There*"]

opened up a route in a field of phacelia, a honey-forming plant often sown to enrich agricultural land during the fallow year (Lafon and Cosculluela 1998).

And of course that colorful mystery—giant open air pigment reserves—has fascinated me like a number of artists. In 1982 I moved to the village of Saint Quentin-la-Poterie (Gard) with a hill that is a mound of colors. I catalogued about thirty varieties of ochre: yellow, red, pink, purple, green, white, and gray. The country that cuts through the hill is called the Potters' Hole. It was there that for several centuries, until the 19th century, a fine earth was extracted to make dinnerware. The soil all around the village is not only full of oxides but also the debris of terra cotta vessels, both of which very quickly interested me to the point where I stored and classified them (now in the collection of the Musée de la Terre, Saint Quentin-la-Poterie) in almost scientific, compartmentalized boxes in order to analyze the journey of this evolving and capricious ingredient from binding agent to its transformation into paints and glazes.

My 2004 book:

> Des Taches et des Concrétions, le Sol est Bourré de Complexes
> [*Marks and Concretions. The Ground is Full of Complexes*],

is the fruit of my encounter with pedologist Christian Feller, who created a text rich in the professional scientist's vocabulary, including expressions which took on a very literary sense for me (Lafon and Feller 2004). Reacting to the researcher's words with my graphical vocabulary, I carved images of soil profiles—real and imagined—into metal to print them. The images were then etched and transferred onto the surface of a glass tube which held the rolled-up book. And thus this forms a transparent vial, revealing the title and the *rotuli* [a parchment (later paper) roll whose text runs parallel to the direction in which it is rolled] showing the colored strata of the text (Fig. 10.3). An artistic interpretation of a plate of the Munsell soil color notation is presented using circular perforations and marks of ochres to accompany the reading of this little soil book (Fig. 10.4).

Researchers' expressions often seduce us with their unintentional poetry. Thus Paul-Armand Gette wrote that "art and science share a common bed" and dreamed of "Fluorine" and "Barytine", humanizing, as little girls (with fictitious names derived from the mineral names fluorite and barite), the salts and sulfates of the hydrothermal deposits in the place named "Le Filon du Rossignol" ("*The Nightingale's Vein"*) in central France.

The soil-root association is intimate, and for me, the *in-situ* root is a part of the living soil. Thus the colors derived from roots have a special fascination—in particular, the root of the madder plant (genus *Rubia*). There is a special and famous red dye derived from the madder root—the "Red of Andrinople". Andrinople is a Turkey city where madder was cultivated in the past; but the plant was also cultivated in Europe, especially in Wesseling Park in Alsace, where, in 2007, I undertook an installation (Figs. 10.5 and 10.6) called:

> "Débat de Cochenilles et Propos de Garance"
> ("*Debate of Cochineal and Subject of Madder"*)

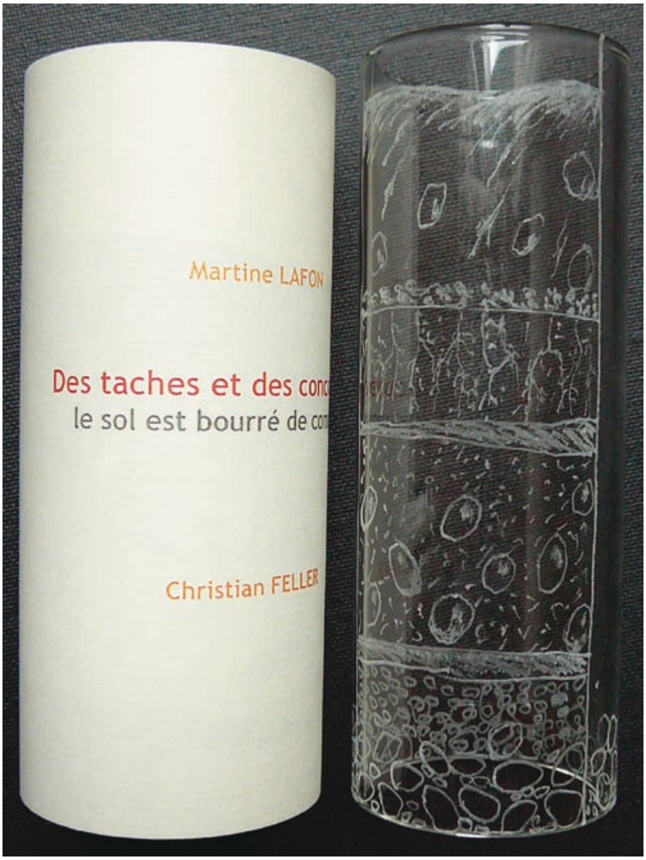

Fig. 10.3 "Des Taches et des Concrétions, le Sol est bourré de Complexes" (from Lafon and Feller 2004). ["*Marks and Concretions. The Ground is Full of Complexes*"]

Cochineal (*Dactylopius coccus*) is a parasitic insect living on cactus from which the crimson-colored dye "carmine" is derived.

10.3 Soil in the Landscape

> *"So vast is our country that it knows no boundaries. A mountainous zone of hard rocks and sudden drops, here is the dorsal fin that I imagine underlying this land. Nevertheless, the soil on which we live is covered in all parts by a thick layer of yellow lemon grass. It is a soil like a woman's womb; a fertile flesh, deep and generous, which year after year gives cereals and tirelessly nourishes the livestock, but whose bones are completely hidden from our senses"* (Kaikô 1959).

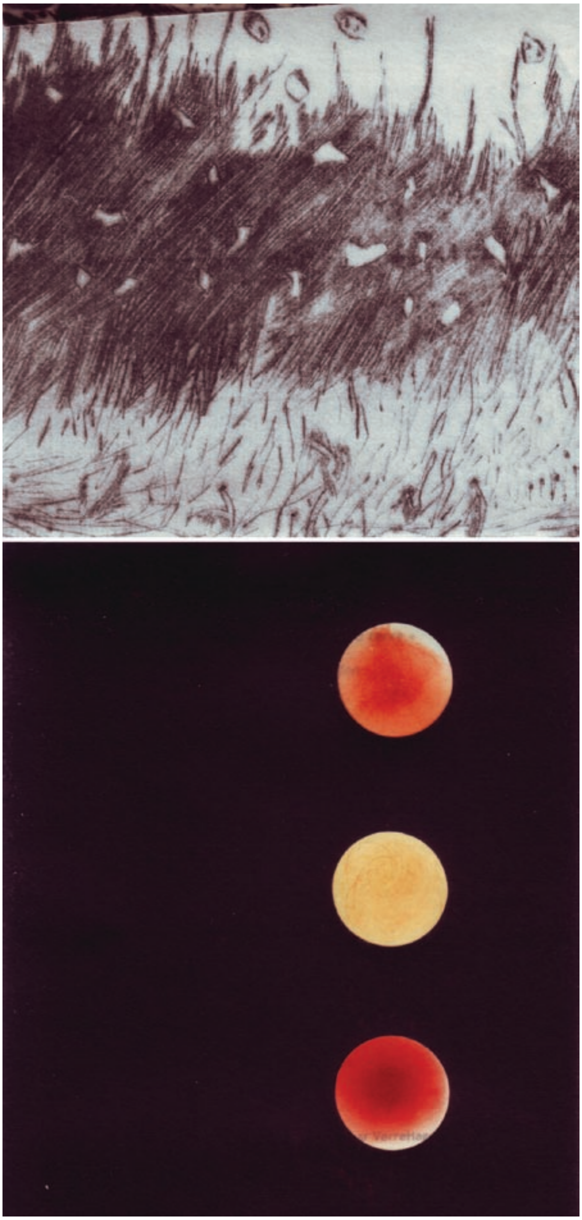

Fig. 10.4 "Des Taches et des Concrétions, le Sol est bourré de Complexes" (from Lafon and Feller 2004). ["*Marks and Concretions. The Ground is Full of Complexes*"]. Detail showing artistic interpretations of a soil profile and a plate of the Munsell soil color notation (see as color plate following *Index*)

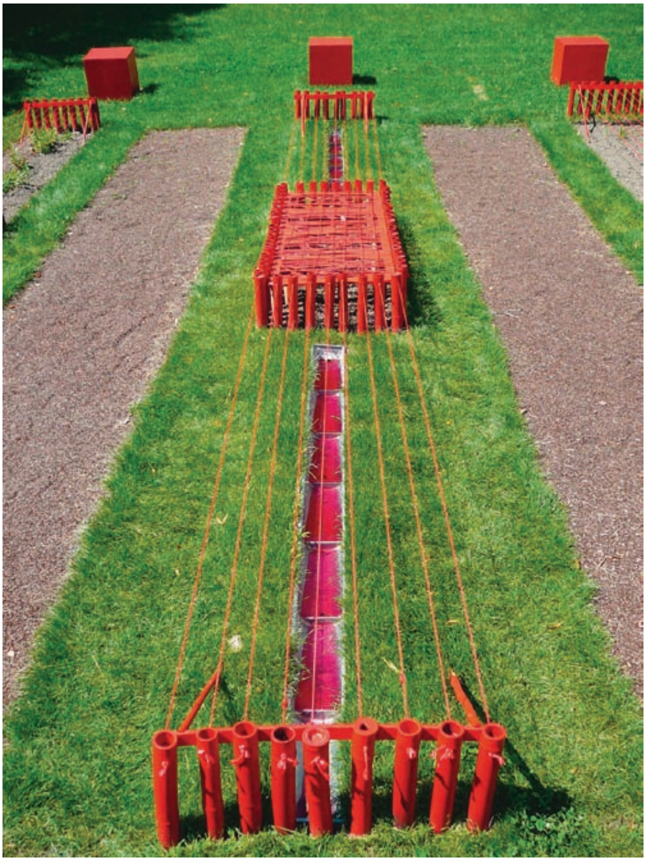

Fig. 10.5 General view of the installation of Wesserling Park (from Lafon 2007) "Débat de Cochenilles et Propos de Garance". [*Debate of Cochineal and Subject of Madder*]. The installation with red bamboo and red threads was undertaken in reference both to the red dye (Red of Andrinople), and the history of the factory associated with the textile industry (see as color plate following *Index*)

Direct contact with the soil has engendered, in several artists, a reflection on the physical and intellectual "body-soil" relationship. Walking is at the heart of the work of English artist Richard Long, who explores its artistic potential. He crosses the desert and mountains, charting his hikes. He records his walks, the number of steps, the distance, the time, the places he passes. The sculptures that this English artist realizes in nature, over the course of his walks in Europe, and in isolated areas of Nepal, Bolivia, or Australia, are lines or circles of stone or wood marked by the repeated passage of his steps. He gently moves things—stones, branches, cow or yak droppings—aligns them, places them in a circle, leaves, and comes back. To practice the elementary art of coming and going until a line is drawn—a mark in the grass, the sand, the snow—is to indicate that the topsoil records and imprints the passage of man—whether he wants it to or not—in a short period of time. The artist's traces are always respectful of the landscape in which they are inscribed;

Fig. 10.6 Detail of the installation with red bamboo and red threads of Wesserling Park (from Lafon 2007) "Débat de Cochenilles et Propos de Garance". [*Debate of Cochineal and Subject of Madder*] showing soil were Madder was cultivated and, in reference both to the red dye (Red of Andrinople) and the history of the factory which was involved into the textile industry (see as color plate following *Index*)

they share its characteristics and are on its scale. The artist memorializes them with a photo; on returning to the sites, he erases his passage, undoes what he has done, and leaves the landscape as he found it. When he works in these places, he uses nearby materials. But he also brings materials back: handfuls of muddy clay that he puts on the museum or gallery wall, to trace large circles or spirals that bring us back to the first pictorial gesture. (For an example of Long's work, see Fig. 3.5 in chapter by van Breemen, *this volume*).

With her 1994 installation *Earth Moving Pump Action*, Canadian artist Angela Bulloch conceived a sort of "painting machine". Art critic Yannik Miloux (http://www.frac-bourgogne.org) wrote about this machine, and saw in it, an ironic reference to the work of Richard Long: "… a machine which, by throwing mud onto the gallery walls, reflects the way Richard Long found his way back to the picture frames of museums after having tried to escape them with his solitary walks". However, in my view, it is incontestable that walking and hiking are essential components of Long's process and work.

In a way, a pebble that rolls under a hiker's foot helps modify the landscape. This allusion takes me back to writer Jorge Luis Borges who, building a pyramid of sand, said ironically that he was modifying the landscape. Isn't this simply what a mole does, hollowing out its chambers, leaving little mounds of dirt on the surface?

In 1987, Richard Long laid out a long line of anthracite coal on the ground of *Magasin*, the contemporary art center in Grenoble. Thirty tons of coal from a mine near the city formed a line that was 51 meters long and 5 meters wide. This combustible material formed a link between the region and its industrial past. Richard Long makes lines of flint, marble debris, and flagstone. Other alignments aren't mineral, but rather come from materials collected from the ground: branches or pieces of rock or bark. Some close in on themselves in a circle while others are arranged in sentences whose meanings relate directly to the ground, like "snow-flattened grass." This permanent contact with soil is also strongly linked to his interest in the vestiges of primitive civilizations, such as megalithic circles.

10.4 Soil as a Part of Identity

> *"I think he bent over first, then knelt, and only then did he sink his hand into the clay to coat his face. But it is not impossible that after kneeling he curled up to make himself as small as possible and that he immersed his face directly in the clay-rich soil…. I also don't know if he kissed the earth—he could have, since it was his native land of Bacska—but what I do know is that his art, whatever it was, surely had the same effect. Immersing oneself in the clay of one's native land is part of a purification ritual during which the intimacy which is created in the exchange between elements makes the two bodies inseparable, the man and the native land, the motherland. But at any rate, to cover one's face with clay one must bend down towards the soil, retreat from the sky, curve one's spine, in a word, be humble"*
> (Varszegi 2006, with regard to Nadj).

Josef Nadj, who comes from the Hungarian minority in Voivodine in the former Yugoslavia, has a cultural relationship with the earth— with that of the soil of the place where he was born, where his ancestors were born, and on which he grew up. In France, a country where disciplines must be compartmentalized, he is mostly known as a dancer-choreographer, the director of the Orléans *Centre Choréographique National*. Only when one more deeply explores his body of work, does one discover the plastics artist, the graphic artist, the photographer.

From *Last Landscape* to *Paso Doble*, Nadj deals with the deserted and clay-rich soil of virgin land close to the city of his birth. "So little by little, the actor is erased to the point of letting matter, color and energy freely draw another landscape" (Boisseau 2006). For several years Nadj regularly visited the studio of Spanish painter Miquel Barcelo, hoping to possibly collaborate. "In Miquel Barcelo's pictoral pieces, there is already work on relief, the depth of the surface, of that which is torn. What's more, the land that he uses, the clay is omnipresent in Kanizsa, my birth city. For a long time this material has incited me to do something with it, to use it in a deeper way. So I looked for a possible format, and performance seemed the best solution" (Varszegi 2006).

Miquel Barcelo and Josef Nadj collaborated at the "Festival d'Avignon" in 2006 (http://www.nytimes.com/2007/09/17/arts/dance/17paso.html?pagewanted=print) for a dance performance-installation *Paso Doble.* In clay on the ground and the wall, the two performers begin, in complicity as a duo, their assault on the earth, the original mud, that of the cave, of birth, of death. They plant their fists, their elbows, and their bodies in the clay. They claw at it with their hands. They dig at it with enormous gouges to extract wedges of earth that they plant into the surface.

Sculptors, dancers, or painters—it hardly matters. They are working between tragedy and ritual. "They exalt the notion of work at the heart of art, whatever it is…but they also know how to play, like kids with unquenchable dynamism splashing in the mud" (Boisseau 2006).

Standing before their joint realization, one senses that, just like with the Aborigines, something unidentifiable is happening that goes well beyond an artistic performance and that this moment, in which soil is an enduring part of one's identity, that doesn't need to be physically preserved.

Miquel Barcelo:

> *"In Paso Doble, we don't cook, we destroy."*

When asked "If your work disappears, this isn't a problem for you?", Barcelo replied:

> *"It would be if it were a work of a different kind, but in this case, the work is in fact a process. We don't even think about it. This destruction is even necessary. The goal is not to fabricate. What matters is what happens in that period of time: a performance that lasts only an hour"*
> (Filiberti 2007)

Jana Sterbak left Czechoslovakia in 1968 for Canada at the age of 13 following the Prague Spring. The influence of the events on her work is profound, and she makes reference to the Prague myth of the golem—the clay humanoid being with a Bible verse inscribed on its forehead, and which, in the Kabala, is the still raw material that, in the Talmud, attained the state preceding the creation of Adam. The principle of establishing a direct and striking link between idea and material, the land of origin, the land of a form of humanity, the land of the country one comes from, underscores the detachment that is unique to the immigrant artist.

The summer of 2005, in the context of commemorating the 30th anniversary of the fall of Saigon and of the end of the American conflict in Vietnam, saw a series of photographs entitled *Surface* by Liza Nguyen (born in France in 1979). With this series, she resisted forgetting a major historical drama, the Vietnam War. She brought 19 fistfuls of earth from 19 memorable sites on which French and American soldiers fought, from a 2004 trip to this familiar country—that of her father. The 19 fistfuls of earth that are recorded monumentally on the whiteness of photographic paper. *"Pieces of land which are index-linked to history, to bodies turned into dust"* says the artist (Nguyen 2005).

In several civilizations, the color that accompanies the body into the earth is red ochre:

> *"Which earth? Why, red earth naturally. That from which Adam took his name…"*
> *(Claudel, 1948)*

Thus it is the earth that gives life, but also which takes it away. I am reminded of the new, rammed earth Chapel of Reconciliation in Berlin, built on the ruins of the church of the same name, which the no man's land (East German security zone) had isolated until the church's destruction in 1985. The small new church built after the reunification is shaped like a heart, with walls made of mud brick from the earth of the former no man's land on which it stands, near Bernauerstrass—a forbidden land stained by the blood of those who attempted to cross the span of the wall that delineated it, the guards of the “corridor of death” atop their towers having had orders to fire.

I think again of Robert Filliou (born in Sauve, Gard; an artist of the Fluxus movement, with French and American dual citizenship), and of his death, as evoked by Pierre Tilman (2006): “Filliou’s body was taken to Bordeaux to be incinerated…. After the cremation, the ashes were gathered and mixed with dirt in about sixty little containers to form figures called *tsa-tsa*, which were painted different colors”. A Tibetan ritual, to be sure, but isn’t it also the prolonging of the artist’s work or, moreover, his final artistic gesture?

10.5 The Experience of the Cavity

“Alors fous-moi la paix avec tes paysages! Parle-moi du sous-sol!”
“You and your landscapes! Tell me about the worms!”
(Beckett 1952)
[The English sentence is from Beckett himself. The original French can be more literally translated “You and your landscapes! Tell me about the underground.”–tr.]

In 1979, American artist James Turrell bought a volcano, Roden Crater, in Arizona’s Painted Desert, not to make sculptures that would modify the landscape, but to observe the sky and the light. He is digging a network of underground halls and chambers at specific points of the crater, chambers he called “skyspaces” which look out onto day and night as seen from chosen parts of the sky. This is the continuation of the Hopi *kavis*, pits intended for the cosmic practices of the neighboring Hopi tribe with which Turell works in strict collaboration. He is transforming his volcano, little by little, into a gigantic astronomical observatory. He is architecturally adjusting its interior with materials he finds on-site: sand, glass, cinders, lava. This project, which he has never stopped pursuing, at once humble and pharaonic, is in fact the most extraordinary work of land art, a veritable homage to the beauty of the Earth whose almost 400,000-year-old volcanic rock is the primary material of his work. “Before human intervention, Roden Crater was just nature. Of course it was powerful and imposing, but it wasn’t a place yet. Hopi memory would be needed to give meaning to the slightest accident on the horizon, which would inform the desert’s remoteness, orient the colored fields of the earth and the sky. James Turell’s work of cutting up would be needed…” (Didi-Huberman 2001).

Isolation, the cave, the ditch, are for many artists an experimental necessity. The artistic experimentation of Marina Abramovic is essentially linked to the body, her own body, whose limits she exploits. Several of her actions associate the body with hollowed-out spaces in the earth or rock. Until 1988, her numerous experiments were carried out with her companion Ulay. In 1980 they came to the Australian desert to work amidst silence and emptiness. Their encounter with the Aborigines began in 1981 with a series of performances of *Nightsea Crossing* which examined the notion of quality of time and silence, and which they repeated in many parts of the world. The performance in Japan was the realization of Ulay's dream in the plane: to situate the performance in a space at once carved into the earth and outside it, not unlike those churches, carved down into rock, that emerge from the ground while still remaining attached to it in (most notably, the Church of St. George in Lalibela, Ethiopia). The piece consisted of a long silent face-to-face between the artists, seated as if petrified at either end of a table, without speaking or eating, for hours. Marina considered this work to be a still-life, and she applied the literal meaning of "still life" to it, making it a "silent-life". When they were invited to Japan they made their table and chairs out of earth from an excavation that they carried out in open air. Ulay noted that the principle interest in *Nightsea Crossing* was in the process of staying still. Their presence acquired the character of an object, which was already true of some of their other performances.

In 1991, Marina Abramovic went to Brazil. With about ten workers, she descended to the bottom of a mine in search of blocks of amethyst. The act of penetrating a place where she was the first woman to have ever gone brought an emotional and spiritual charge to her presence there. Her body was once again put to the test. With the help of the workers, she turned the amethyst blocks into a series of helmets and clogs that she transported, like a transfer of energy and a sort of ecological communion, to these exhibits, directing the spectator to become an actor, a user, by wearing the stone shoes, thereby offering a privileged, magical contact with her experience at the bottom of the mine. The weight of the shoes made moving impossible, and this immobility is reflected to the visitor in the performance of the artist, who remained seated for one day and lying for one day, without moving, in front of the crystals inside the mine. The same experience was replicated outside. Marina Abramovic is a Serb of Bosnian origin. Popular beliefs and Balkan rituals orient a large part of her work. In *Human Nest*, she arranged several nests in a rocky wall in Andalusia, which allowed one to relive the silence and solitude of the orthodox hermits of the Meteors of Mount Athos, a Greek mountain whose caves were occupied by hermit monks during the 10th century. These troglodytic nests were born of the idea of birds, and the solitude of nature. They were places for contemplation, just big enough for the human body. They completely enveloped and protected, at the same time as they endangered. You must concentrate, you must not fall! So the focus is on the here and now as long as a person occupied the nest.

When exploring the notion of the cavity, every artist is inevitably confronted with the phenomenon of the Lascaux caves. Why did prehistoric artists choose to go paint in the bowels of the Earth? Research, supposition, and controversy abound. Unlike James Turell's crater, these caves don't have zenithal openings. The painters therefore had to work by torchlight. But like the American artist, they used the materials they found on-site: burned wood, and ochre for their designs and paintings; bone stilettos and carved stone for their engravings.

Even though other painted caves have been discovered, Lascaux remains the reference point. Those rocky walls in the belly of the Earth remain, despite the many studies, an enigmatic "art lesson." Doubtless, it is these walls that drive us to that eternal restarting, to that tenacity that questions us again every day. Painter Gérard Gasiorowski struggled his whole life with painting, exploring all possible paths, one of which was to return pictorially to Lascaux, to rediscover Lascaux, for his idea was to start everything over, to pay a final homage to painting, for which there is perhaps no greater mecca in the world than Lascaux. This initiatory battle and this ritual with the animal are equivalent to the battle he fought with painting. He painted with anything came out of his gut and painting's gut, down to their excrement. That fecal matter which he kneaded, molded and baked is like that of the belly of the Earth—dirt, clay, a material for coating and covering. It is a matter of throwing out and resuscitating the art of painting.

10.6 The Land as a Pictorial Material

The materiality of painting, and that of the earth-material, was closely examined by Jean Dubuffet during the 1950s.

> *"Mud alone is enough, just a single monochromatic mud, if it is truly a matter of painting, not coloring scarves"*
> (Dubuffet 1967).

One would need to enumerate and look at all of his paintings from 1952's *Le Paysage Agité* [*The Agitated Landscape*] to 1960's *Terre Mère* [*Motherland*] to understand how much the surface of the ground and the landscape, which he calls "nature's tables," interest him: *Terre Mon Biscuit* [*Earth My Cookie*], *Terre Orange aux Trois Homes* [*Orange Earth with Three Men*], *Esplanade au Charreton* [*Flat car Esplanade*], *Histologie du Sol* [*Histology of the Soil*], *Topographie aux sept pierres* [*Topography with Seven Stones*], *les Texturologies [Texturologies*], *Topographie Miettes et Pavage* [*Topography, Crumbs, and Cobblestones*], *Mécanique du Sol* [*Soil Clockwork*], *Topographie Honneur au Sol* [*Topography Honor to the Soil*], *Topographie au Chemin Terreux* [*Topography and Muddy Road*], *Vie Minérale Ardente* [*Ardent Mineral Life*], *Surrection du Sol* [*Soil Upheaval*].

The soil of the path excited him so much that he cut up pieces of it with a pickaxe to hang framed on a wall. "This project scared me," he said, "it implied renouncing creation." In 1960 (two years after *Texturologies*) he launched the series *Matériologies* because when one walks, something is always omitted between the walker and his or her gaze, a no man's land he said, that he wanted to retain, to memorize (The words "matériologies" and "texturologies" were created by Jean Dubuffet). He mixed earth and applied it by hand like the Aborigines that André Breton would later lead him to discover.

Mark Tobey is an American abstract expressionist painter:

> *"My sources of inspiration have gone from those of my native Middle West to those of microscopic worlds. I have discovered many a universe on paving stones and tree barks"*
> (Tobbey 1966).

One could partly explain Mark Tobey's work simply through this quote:

> *"Look how children look at gutters and trash and find a thousand marvels"*

Tobey (1966) said:

> *"The Earth has been round for some time now, but not in man's relation to man nor in the understanding of the arts of each as a part of that roundness. As usual we have occupied ourselves too much with the outer, the objective, at the expense of the inner world wherein the true roundness lies".*

The browns and the grays of his paintings often evoke the natural world, and in particular, nature in close-up, seen through a microscope: a rocky surface furrowed by weather, or the grain of a tree's bark. He wanted all the richness of the universe to be contained in the smallest parcel of the real.

Emerging in 1967 in Italy, the *arte povera* movement led a political and critical battle, drawing attention to the risk of a possible gap between art and life, and warning mankind, which thought itself well armed against nature. Isn't it better to live than to reproduce life?—which is, after all, a continual living painting? As such, some *arte povera* artists trivialized the artist's toolkit, taking the mundane and elevating it to the height of art. In the mundane, there are those who recognized that the obvious material is given by the ground: cubes of earth and water, coal, pebbles, potatoes, leaves, rocks, branches, bark and trees—everyday nature. The ground was at once their workspace, and their productive flowerbed, on which they practiced the physicality of material and movement. Mario Merz stacked bundles of sticks, or put them in tepees. Kounellis used stones, Guiseppe Penome worked with potatoes, leaves, and pebbles. Penome also took nature for a partner, imposing his own laws on it by modeling new trees, by weaving and intertwining plants, so that time and nature joined forces in sculpture. It is an essential, physical, elementary relationship to which this artist lays claim. Guilio Paolini, another arte povera artist scrutinized the depth of soil and time.

10.7 The Heart-Art, Suffering Ground

> *"The basalt (at the shores) is black, the volcanoes purple, and their exposed interiors yellow and red. The beach is grey and the lake pink, topped with the icing of iceberg-like masses of salts."*
> (Aarons and Vita-Finzi 1994)

Artists point out the damage that mankind's machines do to the soil. All-terrain vehicles that mar the ground and upset the ecosystem, bulldozers that demolish and recontour at construction sites—these things provoke reactions in artists. Some, as is the case for Robert Smithson (http://www.robertsmithson.com/essays/crystal.htm), imitate these actions in order to denounce them, thereby shocking the visitor, and hoping to raise awareness. "There is no seamless way through the art of Robert Smithson; his work, like the geological formations to which he was drawn, is multi-faceted and multi-layered" (Gilchrist 1994).

Robert Smithson's work was molded by his reading of *Trap Rock Minerals of New Jersey*, a work by mineralogist Brian Mason on the rocks from his native state, and led to his fascination with the stratigraphy and glacial history of the region. He began to explore the American landscape, abandoned sites, fissured quarries, places ravaged by the acts of man, lands made sterile. His readings, excursions, writings, photos, maps and sketches all contributed to the creation of in-situ realizations, or echoed/reconstituted installations. These form the bulk of his work, in which science and fiction, creation and destruction mingle.

For example, one of his photographs, which he named *The Fountain Monument*, shows a scene of six factory pipes dumping chemicals into the Passaic River (in his birthplace of Passaic, New Jersey; transformed into a continual corridor like a shopping mall, whose earthy bank of the river was heavily polluted). For him, the site and the ground generate artistic propositions. He protested rectangular halls and Euclidian geometry, preferring to make a gallery or a museum out of nature. He played with the notion of the site and the non-site. It is the historic and geographic depths of the soils that allowed him to produce his body of work. His relationship to the earth, and the materials derived from it, engenders a multiplication of points of view on his work.

The photographs *Nonsites* he took in 1967 and 1969 in New Jersey of suffering ground—of that ambiance where everything degrades—present pieces of landscapes that he considered as "non sites," consisting of plant and mineral pieces taken from nature by the artist and placed into minimalistically aligned metallic structures, arranged in progressive and digressive patterns, or attached to mirrors aligned with the ground, where the paths of mirrors simulate the landscape. Earth, stone, gravel, salt from the mines of the Lake Cayuga region of New York, glass and mirrors were the recurring elements of his installations.

To denounce the long, wide bands of asphalt that unfold across the land and make it possible to cross it quickly, and thus to no longer appreciate it as would a walker, Smithson acted out in nature. He poured tubs of hot asphalt onto an embankment in an abandoned field in Rome. The images of this catastrophe remain terribly beautiful: the contents of real spills, glue, concrete, cement flowing down slopes and cliffs. Sometimes he triggered landslides, like crumbling land entombing a hut. He was concerned with recycling modern ruins, and with the abandoned and devastated areas of industrial civilization. He did not want to add himself to the space, but to reveal and awaken its energetic potential and its immanent configuration**.**

He explored the notion of the spiral and its derivatives, that is, the experience of historical and mystical times. Thus 1970 saw *Spiral Jetty* in Utah's Great Salt Lake. This undertaking acquired a mythical status for those who had only heard of it, for few ever saw it. Very remote, almost inaccessible to the artistic public except for a few dedicated pilgrims, the work was located by an old oil drill rig. The site itself engendered this shape because it afforded Smithson (1994)

"a sort of curvature to the horizon"

He rented four acres of the Great Salt Lake for its construction after having meticulously inspected the site, and said

"The mere sight of the trapped fragments of junk and waste transported one into a world of modern prehistory"
(Smithson 1994).

It was a monumental undertaking: Four and a half meters wide, 475 meters long. Today the rock spiral is covered or exposed by the rise and fall of the red waters that the artist loved. That same year, he constructed *Broken Circle* at Emmen, the Netherlands, in a quarry awaiting reintegration into the landscape. It was the realization of a dream, that of recycling a mining site into a work of art. Flying over his last work in progress, *Amarillo Ramp*, his plane crashed, killing him on July 20, 1973. He was 35 years old.

German artist Loïs Weinberger also observes the excesses of urbanization, of the invasion of asphalt that prevents the Earth from breathing. His process consists at once of cautioning and reassuring, with the knowledge that nature always ends up reclaiming its rights. So behind the Cassel train station in 1997, he broke apart the asphalt to expose the earth, and planted seeds that, by growing, would give the illusion that the plant itself had cracked the asphalt. He also likes working on abandoned, peripheral land. That same year at Cassel, for *Documenta X*, he planted "weeds," from Central and Eastern European countries between the rails of a disused platform at the train station, a platform from which trains once left for the concentration camps.

In conclusion, the relationship artists maintain with soil always has a certain ancestral and religious, social and cultural value. The marks left on it by civilizations—from the oldest to the most contemporary, and from surface scratches to enigmatic scars—can, in no case, make artists forget that they are bearers of messages as soon as they interrogate the Earth's crust. The circle forms a cosmic graphic link directly connecting Earth and Sun, the ground and the sky, and the North American Indians have always honored it. The symbol of eternity, it is the shape under which the ancients' councils were held, and which they adopted for their tepees. Similarly, on arriving at the Valley of Marvels (in the Parc national du Mercantour, about 80 km north of Nice, France), one finds an extraordinary collection of rock carvings (http://fun.chryzode.org/english/merveill.htm), a veritable sanctuary dedicated to Taurus and Earth, where the abundance of inscriptions raises many questions. An artist hunches over, humbly to trace with his or her thumb over the length of a miniscule labyrinth carved into a rock.

And who says artists only live in the clouds?

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References

Aarons J, and Vita-Finzi C. (1994) The Useless Land. Smithson Exhibit Catalogue. Musées de Marseille. Réunion des Musées Nationaux (RMN) 332 p.

Beckett S (1952). Waiting for Godot. Editions de Minuit, Paris.

Boisseau R (2006) Lumières d'Orléans sur Avignon. Le Monde 27 juillet 2006.
Claudel P (1948) Commentaire du Cantique des cantiques. Gallimard. Paris. 1954.
Didi-Huberman G (2001). L'Homme qui marchait dans la couleur. Editions de Minuit, Paris. 96 p.
Dubuffet J (1967) Prospectus et tous écrits suivants. Editions Gallimard. Collection Métamorphoses. Paris.
Gette P-A (2002) Fluorine et Barytine. Editions Tarabuste. St Benoît-sur-Sault. France. 48 p.
Gilchrist M (1994) Le Paysage Entropique 1960-1973. Smithson Exhibit Catalogue. Musées de Marseille. Réunion des Musées Nationaux (RMN) 332 p.
Lafon M (2001) Un petit mamelon calcaire. Ed Post-rodo. Uzès. 32 p.
Lafon M, Pons R (2005). Non loin de là. Ed Post-rodo. Uzès. 18 p.
Lafon M, Cosculluela JG. 1998. Sur le sol sec de la figure. Ed Post-rodo. Uzès. 20 p.
Lafon M, Feller C 2004 Des taches et des concrétions, le sol est bourré de complexes. Ed Post-rodo. Uzès. 16 p.
Martin J-H (1989) Catalogue exposition «Les Magiciens de la Terre ». Paris. La Villette. 271 pages.
Myers FR (1983). "Howard's Tampa-led recovery" 4 September 2001. Sydney.
Nguyen L (2005) Libération 09-08-2005 Supplément été p.IV (French newspaper).
Philippe Jaccottet Ph (1970) Paysages avec Figures Absentes. Editions Poésie Gallimard. 155 p.
Takeshi Kaikô T (1959) La Muraille de Chine. Récit d'un fugitif. Editions Picquier Poche. 2004. Arles. France. 109 p.
Tilman P (2006) Robert Filliou, Nationalité Poète. Les Presses du réel. Paris. 304 p.
Tobey M (1966) Tobey. Galerie Beyeler. Basel.
Varszegi T (2006) Josef Nadj, humilité incarnée. Alternatives théâtrales, Brussels, N° 89.

References used in translation

Mark Tobey quotes: http://yabaha.net/dahl/tobey.htm
Nguyen quote: http://www.gallery44.org/exhibitions/May07brochure.pdf
"Waiting for Godot" quotes: http://samuel-beckett.net/Waiting_for_Godot_Part1.html

Part III
Soil and Soul: Literature and Philosophy

Chapter 11
To Join the Real and the Mental Place: The Written Earth

Suzanne Mériaux

The word "verse", from "verso" (to turn) or "versus" (furrow), successively meant: to turn the plough at the end of the furrow, then the furrow itself and finally a line, a written line, a verse (Edwards 2003, p. 248). This evolution from a terrestrial object to a literary expression is a relevant image of my double perception and my double expression of the soil and more generally the earth.

The Earth with its various faces is a book for geographers: it is written through shapes, interpreting the action of Man and the environmental dynamics of the globe surface. It is also written with the words of men. The Earth is on the one hand a everyday place, a scientific object, and on the other hand the surreal place of the spirit, the dream place, celebrated by the Greek myths: Gaia the Earth Goddess, her daughter Rhea, her granddaughter Demeter.

11.1 The Three Faces of Earth

The Earth presents three faces to the inhabitants of its surface:

– *a volume with many scales*: from its totality as a planet in the cosmos, to a tiny water-filled pore in the soil tapped by a root hair,
– *a surface with many aspects represented by landscapes*: natural lands, and inhabited, humanized lands,
– *a physical presence*: rocks, sand, clay, decaying plants – that can be touched, smelled, probed.

The scientific object can be perceived and described, using our senses and technology to create a tangible image. But it is necessary to enter the object, to inhabit it, to understand it from the inside, to allow imagination to suggest new images, because, as the scientific philosopher Gaston Bachelard (1992, p. 185) said:

> "La réalité est faite pour 'fixer' nos rêves".
> *("Reality is made to 'fix' our dreams in place")*

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Science doesn't permit us to touch the surreal place. This is the realm of the artist – the sculptor, the painter, the writer. In the latter case, we must look for the best words to express the lost unity between the real and the mental places:

> "La terre est bleue comme une orange".
> *("Earth is blue like an orange")*
> (Eluard 1968, p. 232).

The painter can draw his palette from the soil colour. The sculptor can pull the clay from the Earth itself. The writer must extract words from his inner soil image to join the real and the mental place.

11.2 The Earth—My Search Object

Soil is the physical medium by which most of us connect to the earth during our lives, and indeed, after death. Adam was created from loam. Clay is for the French philosopher Gaston Bachelard, the only resistant element among the four fundamental ones. It can be mixed with water to get mud, a basic concept for creation. The meaning of Genesis is founded in modeling the original loam (Bachelard 1992). Modeling clay is the metaphor of modeling words to express one's own perception of the earth:

> "Tous les grands rêveurs aiment la terre. Ils vénèrent l'argile comme la matière de l'être".
> (*"All great dreamers love the earth. They venerate the clay as the material of the being")* (p. 131)
> "La terre n'est pas seulement cet objet qu'analyse la science : elle est un lieu sacré".
> (*"The earth isn't just an object that science analyzes; it is a sacred place."*)
> (Onimus 1991, p. 14).

The earth was my search object. As Bachelard (1978, p. 44) said:

> "On ne peut étudier que ce qu'on a d'abord rêvé".
> *("Only that which has first been dreamed can be studied.").*

I think that dreaming an object is necessary before investigating it. My childhood was spent in the country on familiar terms with the soil. In later life, I worked as a soil scientist, and tried to explain the characteristics and the functions of the soils. I joined this double perception—objective and subjective—in poems: (Mériaux 1997)

La terre
J'écris sur la glèbe
Une histoire héritée
Des sillons
Que des siècles d'ancêtres
Ont marqués de leur sceau

La terre d'ombre
Où s'abrite un poème exilé
Comme un secret message

Ouvrira-t-elle aux soleils nouveaux
Les profondeurs de son mystère ?

La terre aux couleurs des saisons
Psalmodie le temps
En longs versets
Que le silence entraine
Au vent des espaces

Elle est le sang
Elle est le sel
Elle étreint la vie et la mort
De son infatigable main
Qui trace au creux des jours
Le chemin des étoiles.

(The earth

I write upon the field / a story inherited / from the furrows / which centuries of ancestors / have marked with their seal.
Will the shadow land / where an exiled poem takes shelter / like a secret message / open the depths of its mystery / to new suns?
The land, colored by the seasons / chants time / in long verses / which are led by silence / to the wind of open space.
It is the blood. / It is the salt. / It leads life and death / by its tireless hand which, / nestled among the days, / traces the path of the stars.)

Soils are in danger. Unlike stones, soils are fragile when confronted by the actions of modern man. Roger Caillois (1996, p. 8) has written:

> "Je parle des pierres que rien n'altérera que la violence des sévices tectoniques et la lente usure qui commença avec le temps. Je parle des pierres plus âgées que la vie et qui demeurent après elle" (*"I speak of the stones that only the violence of tectonic processes and the slow wear and tear that began with time itself can alter. I speak of the stones which are older than life, and which will outlast it."*)

11.3 The Real and Mental Earth

The soils are our promise. They are glorifying our labour (Mériaux 2007):

Dure est la terre
Dure est la terre
Et lourde la racine
A l'ouvrir
A passer et repasser
Toujours
Dans son corps de silence

Un matin
La terre étend les mains
Et donne la fleur
L'arbre et le pain
La vie
L'éternité du monde

> ***(Hard is the land***
> *Hard is the land / and heavy is the root / to open / to pass by / always / in its body of silence*
> *One morning / the Earth stretches out it hands / and gives flowers / trees and bread / life / the eternity of the world*)

The mental earth starts from a real earth, "*a subjective-objective earth*". This earth is also a real one we may describe with our own sensibility, "*an objective-subjective earth*". The link between reason and sensibility was the aim of Caillois: the matter dreamed and the dreamer mineralized. This link may be termed "*a trans-earth" (*a crossover earth).

The relation between the real earth and the mental earth is included in the *Gaia hypothesis*: the earth is a regulator of the interactions between mankind and its environment (Lovelock 1979).

So the soil scientist standing in front of a soil profile feels its sensitive characters (Mériaux 2004):

> **Je sens dans la terre**
> Je sens dans la terre
> L'immense vérité du monde
> La terre aux mains de silence
> Qui entoure mon cœur
> Quand le soleil se lève doucement
> Sur les grands paysages
>
> Celle qui ouvre sa chair
> Au désir de l'eau
> Et coud des lumières
> A son éternité
> Pour que s'ouvre au soufflé du temps
> L'aube du commencement
>
> ***(I feel in the earth***
> *I feel in the earth / the world's immense truth / The Earth with hands of silence / that surround my heart / when the sun rises gently / over the great landscapes.*
> *The earth which opens its flesh / at the whim of the water / and sows light / to eternity / so that the dawn of commencement / will open to the breath of time.)*

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References

Bachelard G (1992) La terre et les rêveries de la volonté. José Corti 409 p. Paris, France.
Bachelard G (1978) La psychanalyse du feu. Gallimard. Collection Idées. Paris, France, 185 p.
Caillois R (1996) Pierres. Poésie / Gallimard, Paris, France (1[er] dépôt 1971), 164 p.
Edwards M (2003) Terre de poésie. Editions Espace, Montpellier, France, 285 p.
Eluard P (1968) Lámour la poésie. In Œuvres complètes T. 1 Pléiade NRF / Gallimard, Paris, France, 1662 p.
Lovelock J. E. (1979) Gaïa: a new look at life on earth. Oxford University Press.
Mériaux S. 1997 Mélanges. Soleil Natal, Chamarande, France, 44 p.
Mériaux S (2004) Des mots et au-delà. La Bartavelle, Charlieu, France, 63 p.
Mériaux S (2007) Et l'homme apparut. L'harmattan, Paris, France, 64 p.
Onimus J. (1991) Teilhard de Chardin et le mystère de la terre. Albin Michel, France, 212 p.

Chapter 12
"Pochveniks"—"The Poets of The Soil": The Geological School of 20th Century Poetry in Leningrad, USSR (St. Petersburg, Russia)

Paul Belasky

12.1 Introduction

Scientists have written poetry since the dawn of both science and literature. Aristotle in *Poetics* classified Homer as a poet and Empedocles as a "physiologist" rather than a true poet, even though both wrote poetry in a similar meter. There are numerous examples of scientists writing poetry, from Eratosthenes and Omar Khayyam to Newton, Goethe, Erasmus Darwin, Lewis Carroll, and Benjamin Franklin. In the 20th century, the list of scientist poets grows to include Vladimir Nabokov (who was a published butterfly specialist), William Carlos Williams (a physician), J. Robert Oppenheimer, and James Maxwell, just to name a few. In fact, so many scientists have written poetry that one almost wishes that more contemporary poets would reciprocate in kind (Cantor 2004).

In Russia, poetry has enjoyed an especially significant cultural and political influence, and the scientist-poet tradition is particularly strong—going back to the 18th century. Furthermore, it seems that nowhere has the poetry of scientists become so widely circulated, influential within literary circles, and immensely popular among all social strata than in Russia (and later the Soviet Union). It is also curious and significant that a disproportionate number of influential poets in Russia were earth scientists: geophysicists and paleontologists as well as mining and engineering geologists. It is those geologist-poets, specifically a group of students of the Leningrad Mining Institute in St. Petersburg (Fig. 12.1; commonly known as LGI which stands for Leningradsky Gorny Institut) who, in the 1950's, started a bona-fide movement in contemporary Russian poetry dubbed "the geological school" (Kuzminsky 1980; Losev 2006).

What makes the poets of the geological school different from most other poet scientists elsewhere in the world is that, despite continuing to work as professional geoscientists, many of them became best known as poets—a phenomenon possibly unique to Russia. Far from being branded dilettantes, some of them

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Fig. 12.1 The main facade of the Leningrad (now St. Petersburg) Mining Institute (LGI) located on the Neva River embankment, in the Basil Isle district. *[Photo by the Author]*

have become national literary celebrities. Although their poetry was not at all confined to earth-science themes and dealt with a wide variety of subjects, they made a wide use of the earth science metaphors. For example, Gleb Gorbovsky in a poem about his field sleeping bag described it as "my microcosm that inflates into a Cosmos…" (Gorbovsky 1975). The "soil" themes played an especially important role in the poetry of the geological school. This is all the more surprising in view of the fact that most founding members were geologists rather than soil scientists. The common preoccupation of geologist poets with soil as a metaphor for birth, life, death, motherland, and their own mortality, is largely why another contemporary group of poets have given them a sympathetic, mildly patronizing, though not derogatory, nickname: "pochveniks"—"poets of the soil", that also can be translated as "soil-heads" (Bitov 2003; Gorodnitskiy 1991; 2001). The latter, though, preferred to refer to themselves as "gornyaki"—"miners" in tribute to LGI, their alma mater.

The importance of their poems and songs for Russian cultural atmosphere of the liberalizing Soviet Union during the Khrushchev "thaw" of the late 1950's was enormous. Many of the pochveniks read their poetry to standing-room-only audiences in the scientific research institutes and palaces of culture and eventually reached millions with their geological "bard" songs—a genre they helped invent (Gorodnitskiy 1991). This is especially amazing because the work of these poets was largely unpublished due to censorship and was circulated in handwritten or typed copies, homemade recordings, or through word of mouth. Presently, their books of poetry have been published (along with numerous other volumes of poetry by earth scientists from all across Russia), and the influence of the founding group of pochvenik poets at LGI is still felt. In St. Petersburg alone, more than ten volumes of poetry by geologist poets have been published since 1990 (Tsaritsyn 2000), with such titles as "Explorations", "Gravity", "Placers", "Erratic Boulder", "The Geology of Life". In Moscow, the collection of geopoetry entitled "The flickering campfire: Earth explorers in poetry" contained poems of more than 250 geologist poets, mostly from Moscow (Vlasyuk 1998). Furthermore, most prestigious geological research institutes in Russia, from St. Petersburg to the Pacific coast, have officially published large collections of poetry of their resident poets (Tsaritsyn 2000).

How good was that poetry? Were these poets mere dabblers, as some skeptics have suggested, i.e., best poets among geologists and best geologists among poets? That, of course, is subjective, but to many careful readers the level of poetic craft in these poems, though uneven, is quite high (Tsaritsyn 2000; Gorodnitskiy 2001). Furthermore, some of the poetry, particularly the work of the pochvenik circle, is outstanding and represents an important movement in Russian poetry of the 20th century (Kuzminsky 1980; Korolyova 2003; Kushner 2003; Shteynberg 2003; Losev 2006). Yet despite their extraordinary, long-lived popularity in Russia, virtually nothing has been written or published about the poets of the geological school outside of Russia (Kuzminsky 1980 is an exception, but published in Russian) and, save for a few free-verse translations in Massie (1972), virtually none of their poetry on earth-science themes has been translated into English.

This article is aimed at filling this void. It includes my translations of twenty poems by the original "poets of the soil" and provides a cultural and biographical context to this remarkable phenomenon in the history of the earth science. An attempt is also made to understand the nature of the unusually strong connection between earth science and Russian poetry.

12.2 R-horizon (parent material)—The Foundation of Russian Geopoetry

The "poets of the soil" sprang from a storied, venerable institution, and it is difficult to imagine a more appropriate place of origin than LGI. There are several mining institutes and a large number of earth science departments at universities all across Russia, and for nearly 300 years they have produced, besides earth scientists, quite a few literati—poets, writers, historians, and journalists. In fact, earth science stood almost at the cradle of modern Russian literature: Mikhail Lomonosov, the great 18th century polymath, poet, and one of the founding fathers of modern Russian literary language was also a practicing mining geologist and engineer (Tsaritsyn 2000; Britanishsky 2003).

The Leningrad (now St. Petersburg) Mining Institute (http://www.spmi.ru/) was the foremost among other institutions with respect to the link between earth science and poetry. It was founded by Empress Catherine the Great in 1773 as a military cadet college of mining engineers. Its grand location on the Basil Isle in the center of St. Petersburg, right on the banks of the Neva River by the old port, figures prominently in the poems of its graduates. Accordingly, its faculty and students, including the "poets of the soil" wore quasi-military, Navy cadet-like uniforms with crossed geological hammers (a source of great student pride; Fig. 12.2). The literary tradition of this technical institution developed right from its inception. The first three directors of the institute were poets, well known by their contemporaries in the late 18th century. Several of its faculty and graduates also became notable poets in the 19th century, and one of them (A. Bestuzhev)—a leader of the anti-monarchist Decembrist rebellion of 1825 - was sentenced to 20 years of forced military officer's duty in the Caucasus Mountains and killed in action. One of the best Russian translations of Goethe's "Faust" was done by I. Shafranovsky (1907-1994), an eminent professor of crystallography at LGI (Tsaritsyn 2000). Shafranovsky also wrote his own poetry and a curious unpublished manuscript entitled "The crystals in poetry and the poetry of crystals", where he developed a mathematical model of symmetry in both crystallography and poetry (Kuklin 2003).

Even the architecture of the institute building reflected the connection between geology and poetry. There were two large statues on either side of the wide stairway leading to the institute (Fig. 12.1). One of them depicted Heracles lifting Antaeus, a giant who could only be defeated if he were lifted up from his mother Gaea-Earth (no wonder that the sympathy of LGI students was with the earth-bound Antaeus, not Heracles). The other statue showed the abduction of Proserpina (Roman version of the Greek Persephone) by Pluto (Hades). It also had geological connotations: Pluto, god of the underworld and geology, steals Proserpina, the goddess of vegetation, fertility, and poetry, whose name in Greek means "to emerge", for example, as a seedling from the soil (Britanishsky 2003).

Fig. 12.2 Geologist and poet V. Britanishsky in the LGI uniform, 1955. *[Photographer unknown; no traceable copyright holder]*

Much of the poetry written by LGI students and faculty during the 1930's and 40's was quite traditional in form, politically loyal in content, and strongly influenced by classic poets such as Alexander Pushkin (1799-1837) and published contemporary Soviet poets. Before providing an example of such a poem, it is necessary to comment on the vagaries of translation of Russian poetry into English. In contrast to the poetry written in English, much of the 20th century Russian poetry (and virtually all of the work by pochveniks) was rhymed and had a meter. This is, in part, due to the fact that Russian language has six cases and other grammatical complexities that allow for countless ways to modify words and provide an almost inexhaustible supply of diverse rhymes that hadn't yet become trite after three centuries of poetry writing. Much of the contemporary English-language poetry, on the other hand, is written in free verse. Herein lies a dilemma for the translator: to use free verse in the contemporary poetic style and try to preserve the precise narrative and meaning of each line of a poem (as was done in Massie [1972] and many other translations of Russian poetry) but lose its structure and rhythm, or to preserve the rhythmic structure and music of the poem by using meter and rhyme at the risk of producing doggerel or sounding trite to a discriminating reader of contemporary English-language poetry? After some consultations with published poets and comparative literature faculty (P. Barskova, pers. and written comm., 2005; I. Kaminsky, pers. and written comm., 2005; L. Golburt, pers. and written comm., 2006), I chose the latter approach. In doing so, I followed the advice of Joseph Brodsky (1940-1996), the 1987 Nobel laureate in literature and a great 20th century Russian poet, to stay as close as possible to the original Russian text and preserve, where appropriate, meter and rhyme, even at the risk of an occasional banality (Polukhina 1997; Brodsky 2000; 2002). I therefore have retained in many cases the original meter of the poems and even the number of syllables in a line and used rhyme (and approximate rhyme) sparingly. I would also like to emphasize that I am an earth scientist and professional translator, but not a literary critic. The poems were selected by me thematically and subjectively and translated with permission of the authors or their surviving family members (one exception is the poem below for which there are no traceable copyright holders). They do not necessarily represent the authors' best work, nor do they reflect the great breadth of themes in pochvenik's poetry. I leave the resulting verses to readers' judgment with the understanding that, inevitably, much is lost in translation.

Novaya Zemlya
by N. Zagorskaya

The flakes of inky thunderclouds
Above the convex whiteness of the glacier.
A lifeless river dressed in yellow till
And sun rays, glistening like spears at daybreak,
Pierce through the silent, silver sky
"Awake, oh Earth, awake!" - I cry
"Break free from this eternal coldness!

Transform your till and gravel into soil
And let the frigid puddles of the tundra
Be overgrown by reeds, green and unspoiled!"
The Earth is silent, and the pearly slabs of glaciers
Lie far beneath the icy sun, as in a trance.
Indeed, no human measure ever
Can wrap around this ancient, vast expanse.

It is ironic that this poem (published in Tsaritsin, 2000), in addition to extolling the formation of soil and imitating the grandiose style of the late 18th century Russian poets, glorifies the warming of the Arctic half a century before it was duly noticed to everyone's alarm. One must be careful of what one yearns for…

Some geologist poets continued writing officially sanctioned, politically orthodox poetry well into the 1950's and beyond. It was aimed at propagandizing the Soviet science in general, and earth science, in particular. "Hang tough, geologist! Be strong, geologist!" was the hook line to a popular song of that time "The March of Geologists". A Soviet poet Lev Kuklin (1931-2004) graduated from LGI as a geologist but did not join the pochveniks' circle. Instead, he went on to publish numerous books of poetry and write popular song lyrics glorifying the Soviet way of life, the geological profession, youth, and the romanticism of the road (usually leading to a government construction project of the day). Kuklin meticulously described geological field equipment in poems, whose titles speak for themselves: "Ode to the Oil Drillers", "Geological Boots", "What's in Your Backpacks, Boys?" There was much political conformism and sloganeering in this type of poetry, perhaps, well exemplified by Kuklin's (2003) use of a jaw-breaking Soviet acronym (which stands for a name of the geological oil-and-gas organization of the Yenisey region of Siberia) in a poem:

"YENISEYNEFTEGAZGEOLOGIYA"—here's a line that belongs in a verse!"

The pathos was deliberate, not tongue-in-cheek, and there was virtually no social criticism in the published Soviet poetry of the time. However, this was about to change with the formation of the Literary Union (LITO) at LGI.

12.3 C-horizon—The Transformation of a Poetry Club into a Movement

The LGI's Literary Union (thereafter referred to as LITO) had humble beginnings. It was a poetry club started by students in 1953 (the year of Stalin's death) and, on the surface, much like countless other such clubs at universities and factories all across the Soviet Union. It met once a week in a small room and published an in-house literary newspaper called "Gornyatskaya Pravda" or "The Miner's Truth". The difference, however, was that this poetry club was destined for big time (fame, albeit not fortune). They invited a professional, published poet Gleb Semyonov (1918-1982) to be their leader and advisor (Fig. 12.3). This proved to be a wise decision. Not only was Semyonov a respected poet with a discriminating poetic

Fig. 12.3 Poet G. Semyonov, the charismatic literary mentor of the LITO at LGI, 1950's. *[Photographer unknown; no traceable copyright holder]*

taste, he was a natural as mentor of young poets - demanding and critical yet open-minded, fair, and kind. His resume was tainted by the fact that the communist party officials relieved him of several similar jobs for "liberalism" and "ideological mistakes".

But who were these young "poets of the soil" and why did they choose a technical college for their education and earth science as a profession? After all, the salary of geologists in those days was quite low (about 80 rubles a month), less than that of engineers and, ironically, much less than that of many published Soviet poets. The LITO members whose poetry is featured in this article were Leningrad teenagers, who came into geology for a great variety of reasons. Some became fascinated with the earth science as children after reading a popular book on minerals (Vladimir Britanishsky [b. 1933]; Fig. 12.2), some were children of geologists (Yelena Koumpan [b. 1935]; Fig. 12.4), while others were drawn to geology in their teens by the romantic spirit of adventure and exploration (Alexander Gorodnitskiy [b. 1933], Leonid Ageyev [1935-1991], Oleg Tarutin [1935-2000]; Figs. 12.5-12.7, respectively), or sometimes even by accident (Gleb Gorbovsky [b. 1931]; Fig. 12.8).

Field geology had an amazing aura in those years. The mid-50's was the time when Khruschev's political liberalization (the so-called "thaw") following the death of Stalin brought a renewed energy and optimism to some segments of the Soviet society. At the same time, the new-found freedom and the half-hearted denunciation of Stalin's tyranny by the government led some to question the Soviet reality for the first time. While many social science and humanities departments at universities were still mired in the Stalin-era dogmatism, political orthodoxy, and inertia (Britanishsky 2003), it is technical colleges, in general, and earth science

Fig. 12.4 Geologist and poet Y. Koumpan, 1958. [*Photographer unknown; no traceable copyright holder*]

Fig. 12.5 Geophysicist, poet, and songwriter A. Gorodnitskiy with a magnetometer in the field in Central Asia, 1954. *[Permission granted by A. Gorodnitskiy]*

departments, in particular, that seemed to offer an alternative to idealistic youths – a way to escape from bureaucracy, official propaganda, and constraints of the city life into the vast expanses of the still largely unexplored Soviet Union, one sixth of the world's dry land. It was still impossible and even inconceivable then to travel to the

Fig. 12.6 Geologist and poet L. Ageyev, 1950's. *[Photographer unknown; no traceable copyright holder]*

Fig. 12.7 LITO poets G. Gorbovsky (left) and O. Tarutin (right), 1958. *[Permission granted by A. Gorodnitskiy]*

Fig. 12.8 G. Gorbovsky, 1956. *[Photographer unknown; no traceable copyright holder]*

west, so traveling east into the wild forests or Siberian tundra with your best friends in search of uranium, diamonds, oil, or whatever else seemed like a great adventure. It was the first act of non-conformism for the post-Stalin generation, a sort of self-imposed exile or internal emigration, where a huge physical distance was placed between the poet-geologist and the system. Although several women were among geologists and members of the LGI poetic circle, there was a certain "macho" aspect to this phenomenon. Many of the future "soil-heads" were undernourished, war-time city kids (some Jewish) who were bullied in school and strove to become self-reliant "real men" in the field (Gorodnitskiy 1991; 2001).

The romantic "wanderlust" and the search for freedom, variously defined, was one of the main reasons for getting into the earth science and writing poetry at LGI and elsewhere (Losev 2006). However, there were other reasons—that special positivist ethics that united the young geologists of those years—the love of unvarnished truth, loyalty, camaraderie, independence, and a disdain for duplicity, careerism, and whitewashing of reality. It is that proclivity for earthy realism, the desire to dig out the hard truth, and the preoccupation with landscape, soil, and earth themes that earned the "pochveniks" or "soil heads" their moniker. Although their early poems had some of the enthusiasm and pathos of the official Soviet poetry, a move away from propaganda and towards personal experience, contemplation, sincerity, non-conformism, and political conscience was already underway. Here are some early examples (published in Gorodnitskiy 1999, and Tsaritsyn 2003a):

Rocks

by V. Britanishsky [permission granted by V. Britanishsky]

Indeed, a mineral’s alive. Once as a brine or gas
it boiled as raging magma in the earth interior.
But carbon turned to diamond as the centuries passed,
and now it is before me, safe under my stare.

So don’t you tell me that the stone has no soul,
that most of them aren’t interesting to ponder,
I won’t believe you, rocks and stones are swell,
and I will write dozens of songs about them.

And don’t you tell me that the mineral’s got no life,
and to be cold and dead is in the mineral’s nature.
I won’t believe you, and my words will be upheld
by the example of the Urals Range.

I’ll gaze at jasper or a cubic pyrite crystal,
the reddish limonite or garnet, breathing fire,
and wonder how much was really witnessed
by stones that here before me lie.

Old Campsites

by A. Gorodnitskiy [permission granted by A. Gorodnitskiy]

I can’t stand to pass by my old campsites,
Where rotting wood posts stick out of the ground,
And tin cans I opened last season
Are covered by rust.

I hate to return to
Where birches were flayed with the knife,
And mud marks the spot
Where the fire once was.

The smell of old ash terrifies me,
A voyeur, I spy on my fate,
And stand in the midst of a graveyard.
Alone with the last cigarette.

So I race past my old campsites,
I holler and pick up the pace
My reindeer are walking in silence,
Their silence - nothing can faze.

Mosquitoes, as always, are humming above me,
My rifle pulls at my side.
We’re surging ahead, forward
We’re leaving the past behind.

Although the last two lines of the poem may sound on the surface like a slogan of a young Communist, they more likely refer to the introspection, contemplation of fate, and even fear of death by a lone geologist in the middle of the tundra.

12.4 B-horizon—The Romance of Field Seasons: Searching under the Subsoil

The pochveniks spent quite a bit of time partying with other poets and geologists in the field and in the city. However, they were not bohemians in the typical sense, because none of them were planning to give up their main profession, the earth science, for the life of mostly unpublished and underemployed denizens of other Leningrad poetry circles (Kushner 2003). Nevertheless, some of the "soil-heads" did wear black berets, even in the field! (Fig. 12.9). In fact, much of their energy and inspiration was centered on summer field work – those famously long Russian geological field seasons, when small parties trekked across the taiga or tundra and camped in leaky tents for up to four months with poor provisions and minimal supplies (Gorodnitskiy 2001; Belasky 2003). Their maps and much of the work on finding natural resources, such as uranium, was considered top secret by the government and resulted in additional responsibility and stress (Gorodnitskiy 1991). Despite these challenges, field geology was a romantic passion and a labor of love for multitudes of young people in the 1950's and 60's. One didn't have to be a geologist to join a field expedition as a technician or a sample collector. Thousands of students and hundreds of young poets, including the future Nobel laureate in

Fig. 12.9 Geologist, poet, and abstract artist Y. Vinkovetsky in the field, undated. *[Photographer unknown; no traceable copyright holder]*

literature Joseph Brodsky, spent their summers in the field and began writing poetry there (Brodsky, 2002). "Blessed are the field seasons!" is a line from Brodsky's early, unpublished poem and reflects the mood of the time (Kuzminsky 1980). The poems below (published in Gorbovsky 1975, Kuzminsky 1980, and Koumpan 2003b) are the testament to the hardships, pleasures, and dangers of work in the field. Some of the pochvenik poets wrote about it with romantic pathos (A. Gorodnitskiy), some with humor (O. Tarutin, G. Gorbovsky), but nearly all—with warmth, lyricism, and nostalgia (Koumpan 2003a; 2005).

In the Taiga Forest

by Y. Koumpan [permission granted by Y. Koumpan]

My forest beckons me like home.
Taiga - ahead, taiga - behind me.
What could there be behind its wall?
Or is it really never-ending?

Are there still cities in this world?
Or am I merely dreaming of them?
And have I lived in them at all?
It seems as though we never met.

Who loved me? - they are strangers now.
Who gave me life? - they are not there.
How many springs have I survived?
How many children did I bear?

No birthmarks on my weathered skin,
No pungent memory of home,
It's like I've risen from the bottom,
When I looked down into the pond.

A Path At Night

by G. Gorbovsky [permission granted by G. Gorbovsky]

A path at night. A moon on fire.
Branches rub against my face.
Forest creatures have retired,
And the grasses slumped to rest.

In the stream the future fish cans
Closed their fisheyes once again,
They ignore the King of Nature,
No one seems to give a damn.

In my high boots an old blister
Gnaws and rubs against the sole

Earth, I'm not your high commissioner,
Nor your navel, nor your salt.

Silently I make my journey
Past the boulders, through the strife
Bouncing like a beat-up clunker
On the potholes of my life.

A Ballad of Two Geologists

by G. Gorbovsky [permission granted by G. Gorbovsky]

In memory of N. Tereshenkov

A tent in the mountains…Twilight…
A greedy and empty stomach.
A comrade lies nearby,
Dead for the second day.

The short wave radio wails,
The sky is drizzling with Morse code.
They didn't hear us. We'll wait.
They don't know a damn thing yet.

His ragged jacket is patched
On the elbow with mother's stitches,
Inside, he quietly lies
Dead for the third day.

It was only a lowly pebble,
That slipped underneath his sole,
And he plummeted down as if
abandoned at once by all.

Another man slowly places
forget-me-nots on his chest.
There are two of us now. And one is
dead for the fourth day…

Gleb Gorbovsky (Fig. 12.8) was one of the most famous "poets of the soil" and a leading member of their circle. In a sense he was truly a folk poet, charismatic, daring, and hard-living. His poems were so popular with the ordinary folk that even militiamen, who occasionally arrested "soil-heads" for public drunkenness, knew some verses by heart and upon learning the poet's identity were happy to let him and his friends go (Kuzminsky, 1980). Although his readings were major events in Leningrad's unofficial literary circles and attended by hundreds of eager fans, he was rarely published prior to 1960's, frequently penniless, and employed for decades as a geological field technician all across the Soviet Union. As the last poem attests, the geological fieldwork could be deadly, especially for geophysicists, who had to carry heavy magnetometers into the high mountains and, unlike their geologist field partners, couldn't help themselves up steep cliffs with rock hammers (Fig. 12.5). Several "poets of the soil" dedicated poems to friends who died tragically in the field (Gorodnitskiy, 1991).

Another common theme of the field poems was that of man vs. nature and the price of human survival. Environmentalist mindset was quite a rarity in the 1960's in a culture that glorified the "taming" of nature, industrialization, and an all-out exploitation of natural resources. In fact, the LGI official logo reflected this by showing a superhuman figure of a geologist literally tear the Earth open to reveal crystals deep inside. Nevertheless, some pochveniks, notably Ageyev, Gorbovsky, and Tarutin (Figs. 12.6 and 12.7), began to question this Soviet strategy from a humanist and spiritual perspective. Here are two examples (published in Gorbovsky 1975; Ageyev 2002):

The Funeral Feast

by G. Gorbovsky [permission granted by G. Gorbovsky]

The other day a mountain goat was killed,
It took him long to tumble down the cliff,
The red star of his forehead wound replaced
A little furry white star underneath.

His horns snapped off against the jagged rocks,
And landed by the stream below.
The gray old mountains stayed awake till dawn,
Lamenting, mourning their creature.

They roared with giant waterfalls,
And then, sequestered by a cloud layer,
Gazed down at all of us from far aloft
With their severe and terrifying stare.

We greedily, with gurgle in our throats,
Were biting the goat's body to the bone…
And those gray-haired ones upon the summit thrones,
They judged us, humans, all night long.

A Logging Tale

by L. Ageyev [permission granted by Y. Ageyeva]

Into the fresh scent of bark
axes thrust and fell silent…
While above the white stumps,
the uprooted trunks
a sound hung in the air,
a terrified holler: – "Bear!"
…And he came out – tall and thick-boned
Scared of nobody, waddling about,
not in blood – in wildberry nectar
was his kind, rusty-colored snout.

He came out of the Russian fables,
Or the circus – to beg for laughs
With a sly and half-squinting glare
he was smiling at us, perhaps…
Surprised by the first bullet,
he sat down – not a growl or sound.
Three shotguns aimed at his gullet
blasted off a six-barreled round.
At close range, one after another,
pale-faced men, washing in sweat,
put more shots into him on the ground
And his paws – crossed at the head.
The paws with a few golden birch leaves
impaled at the tips of his claws…
Evening falls. People 'round the fire
are clutching their steaming bowls,
and the cunning ways of the bear
they hash over throughout the night..
Life is brutal. Old rules - still there.
Younger brother is never right.

In contrast to L. Ageyev's seriousness and tragic realism, the poems of O. Tarutin (Fig. 12.7) represent the lyrical and humorous aspect of the pochveniks' poetry. In a way, many of them, including the one below (published in Tarutin, 1976), are letters from the field to loved ones in the far-away Leningrad.

Yana River

by O. Tarutin [permission granted by N. Tarutina]

Finally, a respite for my spine,
there's no need to walk or move my camp -
Finally, I reached the Yana River…
Hope today you'll think of me again.

All that lingered - tapered to an end.
The first snow has fallen on the swamp.
And the final errand in my camp -
Is my fire that I will have to keep
till the morning on this empty shore,
near the water purring like a lynx -
for at dawn the chopper will descend
just to vanish upward in the mist…

Yana, Yana! River of black hue,
Won't you splash into my cup and say goodbye.
You'll go north, into the cold of northern lights,
as for me, I will not follow you.

So I sit, and slowly sip my tea,
while the river's forging far ahead,
and the leaky dipper, still unclaimed,
once again is hanging over me.

A fascinating cultural phenomenon swept across the Soviet Union in the 1960’s - the so-called “bard” songs. In a sense, it was reminiscent of the American folk music movement of the early 60’s. These “bard” songs were set to poetry and sung *a cappella* or, more often, with a simple guitar accompaniment. They were quite distinct from the mainstream Soviet songs of the day, which were written by professional, state-licensed composers and lyricists. The authors of the “bard” songs wrote both lyrics and music, and were people of various trades (geologists, physicists, engineers, athletic coaches, theater actors, outdoorsmen). Their songs were officially denounced or ridiculed, and no bona fide records of them were made for decades. Nevertheless, the “bard” songs became increasingly popular and spread all across the country in reel-to-reel tape recordings. They were played or sung live in communal apartments, scientific research institutes, prisons, and campfires across the entire country. Although the movement reached its peak in Moscow in the mid 1960’s, the origins of the “bard” song genre can once again be traced to the geology students at LGI (Gorodnitskiy 1991; Tsaritsyn 2003b). As early as the mid 1950’s, a decade before the “bard” songs boom, the now familiar pochveniks of the LITO circle developed a genre of “geological” songs. Originally, these songs were written for annual student plays and later acquired a life of their own. Some songs by Gorbovsky and Gorodnitskiy became so well known that they were considered by many listeners and performers to be “folk songs”, and the authors were nearly beaten up by new acquaintances in the field for daring to suggest that they (and not the “folk”) actually wrote them (Gorodnitskiy 2001; Gorbovsky 2003a). Here is one famous example of a geological song (published in Gorodnitskiy, 1999):

Tundra Shadows

by A. Gorodnitskiy [permission granted by A. Gorodnitskiy]

The grass and moss and lichens of the tundra,
Where summer’s seconds slowly tick away,
Where boulders are like giant cushions,
Where it is hard to walk on the first day.
The shadow of a cloud, drifting above the tundra,
The shadow of a bird, soaring above the tundra,
The shadow of a deer, running across the tundra,
They pass a traveler on his way.

And if one morning you awoke and once
Forgot about your mirror and eye shadow,
And asked me for a memory of the tundra,
I’ll try to find a single paper scrap,
The shadow of a cloud, drifting above the tundra,
The shadow of a bird, soaring above the tundra,
The shadow of a deer, running across the tundra,
That’s what my pencil would unwrap.

And then to finish my uneasy task,
I'd leave some spaces white for daisies,
The rest of this landscape I'd boldly paint
With green, so pleasant for the eyes.
Then I would choose a brush, the finest in possession,
And carefully dip its bristly tip in paint,
I'd color a bellflower, just one - in navy blue,
And having done so I will end my story.

I can repeat on end despite all hardship
The world to me is festive and profound,
Indeed, the world is festive and profound,
As long as I can witness when I want,
The shadow of a cloud, drifting above the tundra,
The shadow of a bird, soaring above the tundra,
The shadow of a deer, running across the tundra,
And right along with them – my own.

Although the genre of geological songs has declined in popularity, the "bard" phenomenon that geological songs helped initiate has reached its zenith of political significance in the early 1970's and, eventually, became part of the mainstream culture. To this day thousands of fans gather at outdoor festivals in Russia (Fig. 12.10) and other countries with a significant Russian community (notably USA, Canada, Israel, and Germany) to listen to "bards" from all walks of life, and sing together with them around campfires in marathon, vodka-drenched sessions that last several days and nights. A. Gorodnitskiy, one of the original "poets of the soil" of the LITO circle, is a co-founder and star of this genre. He still writes new songs (http://gorodnit.bard.ru/) and participates in "bard" festivals across the world (Fig. 12.11).

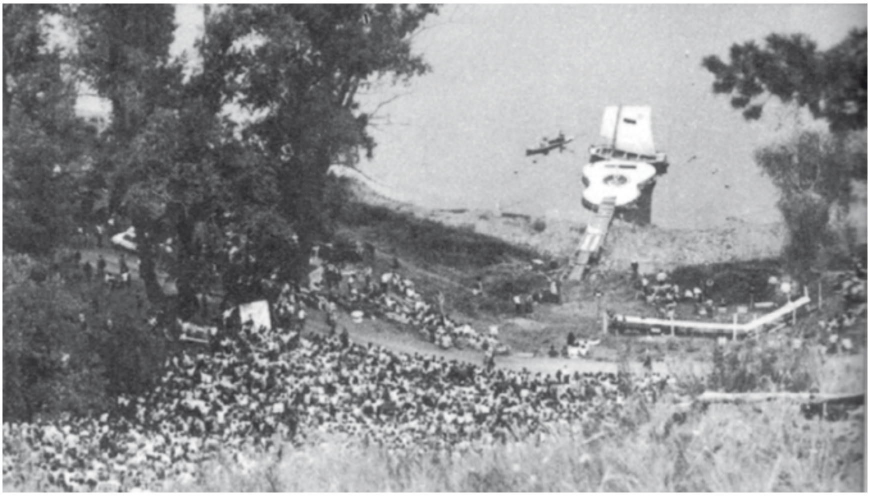

Fig. 12.10 The annual festival of "bard songs" brought tens of thousands of fans from all over the Soviet Union to a riverside village and a guitar-shaped pier/stage, 1976. *[Permission granted by A. Gorodnitskiy]*

Fig. 12.11 A. Gorodnitskiy signs autographs for fans at a “bard song” festival, 1973. *[Permission granted by A. Gorodnitskiy]*

12.5 A-horizon—The True Soil Connection

Although most of the pochveniks were geologists rather than soil scientists, one reason for their nickname “soil-heads” was the desire to “dig out” the unvarnished truth from under the cover of lies and propaganda. In addition, the soil theme is present in many of their poems (Kupchik 2005), particularly the work of female members of the circle - Yelena Koumpan and Lydia Gladkaya (Figs. 12.4 and 12.12, respectively). In some poems, the soil is used as a metaphor for the entire human life cycle - from birth or emergence from Mother Earth (earth being a womb or a cradle) to the ultimate return to the soil (earth being a grave). There was also a common theme of mingling or merging with the earth during a poet’s life, complicated by that fact that in Russian, as in English, the word “earth” (“zemlya”) can mean both, the “planet” and the “soil”. Secondly, unlike “earth” in English, “zemlya” in Russian also means “land”. For centuries Russian culture was predominantly agrarian. The soil was held as sacred, and in difficult times the peasants implored “Mother Moist Earth” to come to their aid. The historical Mother Russia and mythological Mother Earth thus co-mingled to produce the creative power attributable to the land itself (Hubbs 1988). Similarly, the soil and earth was used as a metaphor for the Russian motherland and motherhood by some pochveniks, particularly Gorbovsky and Gladkaya, whose Russian patriotism and religious beliefs became increasingly prominent in their later work. Lidiya Gladkaya’s poem “To My Son” (Gladkaya, 2003; permission granted by L. Gladkaya), is filled with soil metaphors:

“If I turn into soil, don’t be anguished, my darling…”
or
“I’ll be the firm ground for his confident stride,

I'll nourish my son with a breast of the bountiful earth…"
and
"In times of trouble, don't ask anyone for consolation:
Instead come down to the ground - your mother's breast."

Fig. 12.12 Petroleum geologist and poet L. Gladkaya, 1956. *[Photographer unknown; no traceable copyright holder]*

At the end of this poem, the mother waits for her son to return to earth—her womb—posthumously. Gladkaya uses another soil metaphor in her poem "To Poet Sergey Makarov" (Gladkaya 2003):

"One day we'll be as one with Russian soil…
But until then we'll be as one with Russian land!"

It is important to note that, with the exception of later Gorbovsky, this type of declarative and, occasionally, strident patriotism was not typical of other "poets of the soil". Yet similar metaphors of becoming or co-mingling with the earth/soil can be found in the lyric poems of Koumpan, another female pochvenik of the LITO circle (published in Tsaritsyn 2000; Koumpan 2003b):

The Campfire

by Y. Koumpan [permission granted by Y. Koumpan]

I am on the ground beside the fire,
and slumber grabs my arm.
My shoulder tingles, falls asleep
completely numb.

The ringing in my ears subsides,
My heart is full of yearning.
And little cinders of my soul
burn out before the morning.

My palm is sticky from the sap,
The rain pours down my shirt.
I'm apt to be the soil, the earth,
I'm cozy in the dirt.

Boulders

by Y. Koumpan [permission granted by Y. Koumpan]

A boulder with a snowcap
stands like an empty house.
And whispers to me slowly:
"Please wait before you pass.

I'm of an ancient lineage
Like mammoths and their kin.
There's an entire village
of boulders just like me.

Your eyes are not familiar,
but gray, my favorite hue.
Become a boulder, traveler!
We'll stay here - me and you.

I'll cover you with snow -
And make a proper home.
And with the last year's lichen,
so soft, so warm."

I listen terrified to
his gentle monotone,
As if I'm petrified
Next to a giant stone.

Perhaps, soil metaphors are especially common in the work of female pochveniks because of the traditional association of soil and earth with motherhood, fertility, and rejuvenation. After all, soil is of female gender in many ancient epic narratives including Egyptian, Greco-Roman, and Russian. One should also reemphasize that, despite active participation of several women in the pochvenik circle, a certain "machismo" mindset could be discerned in the poetry of some of its members, especially Gorodnitskiy. This, however, was typical of the contemporary Soviet society, in general, and the geological profession, in particular. Jack London and Ernest Hemingway were translated and widely read in Russia in the 1950's. They were heroes to many poet-geologists (Gorodnitskiy 1991; Kuklin 2003), which along with the rough-riding culture of the field may have played a role in their common poetic exaltation of the "masculine" virtues. And despite the professed desire of pochveniks for poetic clarity and sincerity, it is their personal life and relationships that seem to receive a rather sketchy, reserved treatment in their work. The female geologist poets, on the other hand, faced a balancing act of having to be as tough as men in the field and at the same time feminine, as defined by the traditional Russian gender roles. Nevertheless, the soil metaphors can be found in the poems of male pochveniks, too. Here are some examples (published in Ageyev 1989; Gorodnitskiy 1999):

Caves

by L. Ageyev [permission granted by Y. Ageyeva]

We crawled into the ground – into gray stones,
toward the caves – into the sleepy realm.
But those were no caves at all,
instead they were a magic ballroom hall.

The multitude of icicles,
and flowery meadows on the ceiling…
Who sculpts them? Paints them?
Animates them? Who?!

There is no ordinary soil here
to squeeze between your palms and roll,
but here you find the clearest water
that just appears beneath your sole.

No, you can't see it, eyes are useless
(the lights shine on the rocky floor),
And only with my own reflection
the water comes alive once more…

Yes, I have flown **above** the earth.
Like all the rest I live **on** earth.
I now stand **beneath** the earth
And I drink water from **within** it.

What more can possibly occur?
There's only one thing left to try,
I will **become** the earth once more,
When it's my time.

The Uzon Crater

by A. Gorodnitskiy [permission granted by A. Gorodnitskiy]

The Martian colors of the Uzon's cone,
Where mud's alive with spit and bubbles,
Where light is motionless and shadows long,
And sky's a bowl filled to the rim with crimson.

I try not to surprise a flock of geese,

That found a home on the hot scoria
Here cinnabar is born, deep in the murk,
And soil is bloody from the deadly mercury.

The newborn Earth sports a severe face,
Pockmarked by vesicles and lingering boils,
Here geysers spout and fountains spray the sky
Out of the blowholes of the subterranean whales.

Here I see clearly that my time is short,
And firmament is anything but firm,
Since continents, like ice floes, screech and float,
Only to fold and melt under the overload.

While we live here, undaunted, as we must
Claim from the Earth our 15-minute glory,
On an unsteady, thin as a paper, crust,
Over the slowly churning, glowing slurry.

The poem by Ageyev contains the already familiar metaphor of merging with the earth in life and after death. The poem by Gorodnitskiy, however, contains another metaphor that, in my view, provides a clue to the importance of the soil theme in pochveniks's poetry. It is the metaphor of soil as time. Joseph Brodsky believed that expressing or describing the passage of time in a poem is one of the highest pursuits in poetry, and that he often works to reduce a poem to the "swinging of a pendulum" when he writes it (Brodsky 1981; Polukhina 1997). For a geologist or a soil scientist, as well as a geologist poet, time can be equivalent to and, perhaps, best expressed by the formation of rock or soil. Who but the earth scientist could better grasp the profundity of their equivalence? Thus, it is not surprising that soil is one of the major themes in the poetry of pochveniks. It is their way to poetically express time, describe its passage, and contemplate their own grandeur or mortality. Rocks and soil also represent memories of the past. As Ageyev (2003) wrote in his poem "Geology of Life", it is "the sand's memory of the granite" that keeps his stone quarry's foremen awake at night.

12.6 The Plow of Politics

The influence of the pochveniks on Russian poetry and contemporary culture is so significant that it is remarkable that their poetry circle, LITO at LGI, existed for only 4 years, from 1953 to 1957. Its brief history provides a key insight into the unprecedented and complex relationship between art, science, and politics in the post-war Soviet Union.

The times were changing under the leadership of Khrushchev. Stalin was dead and partially denounced, and it became possible to say and, some thought, even print things thereto unthinkable. But as G. Semyonov and LITO found out, there were limits to this liberalization. Initially, the common identity of members of the circle was ideological opposition to officialdom (”the system") and a maxim of "never to lie in verse" (Kushner 2003). Semyonov, at considerable risk to his career and even freedom, introduced pochveniks to the work of poets banned and/or even imprisoned under Stalin (Gorodnitskiy 1991). As a result, LITO became one of the most free-thinking and non-conformist poetry circles in all of Russia in the 1950's (Gorbovsky 2003a; 2003b). Here is one example subsequently published in Tsaritsyn (2003a):

On the Train

by Y. Koumpan [permission granted by Y. Koumpan]

I watch the slow procession of the forests.
Three days behind the window of the train
someone is chasing, chasing, chasing them…
And with a face half-hidden by the fog,
they slowly rise, they lean against the hills,
and circle round the lakes and bogs.
For them there is no orphanage or prison,
No degradation deeper than their snows.
They march without sleep for countless nights
and face their endless transfer without protest.

But then, so suddenly, a single, scrawny pine
Runs towards me out of the tangled forest.

On the surface, this poem is not political, and a casual reader might conclude that it is simply about a geologist on a long train ride contemplating nature. But a careful and politically astute contemporary reader would realize that the subtext of this poem is Stalin's labor camps. Although this is not explicit, the use of code words "prison", "degradation", and especially "transfer" in the Soviet context was deliberate and had definite political connotations. For example, "transfer" is a prison term referring to the dreaded transfers of prisoners on foot between distant Siberian prison camps during Stalin's regime. Although many labor camps were being closed and political prisoners released during the mid-1950's, the subject was still controversial. The last two lines of the poem are especially poignant, with "a single, scrawny pine" being a metaphor for one of the countless prisoners on a deadly march in a long column under guard who desperately dashed toward the train, perhaps, to ask for a piece of bread or simply wave goodbye. It was the geologists who were often the first to revisit the abandoned Siberian labor camps in the 1950's (Belasky 2003). In fact, when a KGB agent threatened to send Brodsky in 1959 to places no human foot ever trod, he wasn't terribly impressed because he had already been to many of the places they were talking about as a geological technician (Brodsky, 2002). When they finally sent him to one such place, he had no problem adjusting to it and wrote some of his best poetry there.

Some of the pochveniks' poetry was originally published in the official LGI newspaper, "The Miner's Truth". The poets were frequently invited to poetry readings at various scientific institutes or worker's palaces of culture in Leningrad, where they showed up on stage wearing the LGI uniforms. The halls were often filled to standing-room capacity (Glebova 2003), and the popularity of pochveniks led to the semi-official publication of the first collection of their poetry (Semyonov, 1956). This book, all 300 copies of it, literally flew off the shelves and is now a collector's item.

But the clouds were gathering. Some of the poems by pochveniks were becoming increasingly political. L. Gladkaya (Fig. 12.12) wrote an especially brave and controversial poem entitled "November 26, 1956" (Gladkaya 2003; permission granted by L. Gladkaya) in the aftermath of the Hungarian crisis, when Soviet tanks invaded Hungary and crushed the independence movement. It contained lines that could have easily landed the poet in prison:

Where blood is spilled onto the black asphalt
The Russian "Freeze!" sounds like a Nazi "Halt!"

The poem also implied that Russian soldiers were killing their brothers in Hungary ("our flesh and blood dies on our bayonets"), while nobody in Russia gave a damn. It is amazing that this poem was actually read aloud by Gladkaya at an official young communists' meeting, and this did not result in the poet's immediate sanction and punishment. Perhaps, the reason was that the poem wasn't published at the time and therefore not on the record.

The situation was different when the second collection of the LITO poetry was about to be published in 1957. Although it did not contain any explicitly anti-Soviet material, the party authorities in Moscow were especially vigilant in view of the recent Hungarian crisis and the international youth festival held in Moscow that year (Gorodnitskiy 1991). As a result, the order went out to destroy all copies of the book and punish the authors. Thus, KGB agents burned (!) the remaining copies of that student poetry book in the LGI backyard. Only several copies survived, because some geology students had taken them along with them to the field in Siberia just a few hours prior to burning (Koumpan 2005). Furthermore, the mentor of the pochveniks and the volume's editor, G. Semyonov (Fig. 12.3), was fired and the LITO soon fell apart. But though the poetry circle at LGI was finished, this was not the end of the geological school of poetry. Mostly unpublished, poems of its members continued to find their readers, and songs —listeners all across the Soviet Union. Nevertheless, the book burning had a profound effect on the lives and work of the "poets of the soil". A poem published in Gorodnitskiy (1999) and written 35 years after the event, recreates the atmosphere of those days.

The Mining Institute

by A. Gorodnitskiy [permission granted by A. Gorodnitskiy]

The books with our poems were burned in the institute yard,
Near an antediluvian boiler, in line with the Party's decision,
The meat of our rhymes ended up as a cup of gray ashes,
The Hungarian crisis, it hung in the air at that gray autumn dawn.

The swampy land's end of the low Basil Isle,
Where we all went to school as geologists and poets,

Ships were creaking against the embankment of stone,
And the whispering Neva below was our muddy, inscrutable Lethe.

We took time to decide who the enemy was, or the friend,
But we heard those crows as they gathered around us
We laid open our souls for they told us "Don't LIE",
Those letters of brass that were pinned to our uniformed shoulders.

And our rough rhymes were whispered to us by the fresh Baltic wind,
We were beckoned by ores and the cold Arctic Circle,
For it isn't by chance that the name of our student brigades,
Had this tempting and beckoning word "exploration."

The ephemeral guard of the doors to our old alma mater,
We held tight to each other and we were no rivals,
They did not teach us style, but our style was the motto:
"Poems must tell the truth, damn it – only the truth!"

Can't forget how we deftly escaped from the lectures and dates,
To the foot of the Sphinx by the black drifting ice of the Neva,
And drank vodka right out of an apple carved out with a knife
As if from a shot, then we sniffed at the core of that apple.

What else can my memory bring from those long, bygone days?
The portraits of "leaders"? The ruins of churches? Razed temples?
Our own early poems were burned in the institute yard,
And ashes were scattered – I know of no higher appraisal.

And when I remember the time when we stood at the start,
The time when our conscience developed and strengthened
It isn't the campfires of our expeditions that knock at my heart,
But that sticky smell of those cold, dear, scattering ashes.

The Hungarian crisis and the book burning led to the increasing disillusionment with Khrushchev's reforms among the "soil-heads" and other liberal Leningrad intellectuals. They continued to meet with Semyonov at his home, write poetry, and spend summer months in the geological field. But the slow ideological crackdown continued into the 60's and 70's, especially after the ouster of Khrushchev. A first part to the well-known song (published in Gorodnitskiy 1999) expresses the defiant mood of the time and makes yet another reference to the 1957 book burning.

Antigalileo

by A. Gorodnitskiy [permission granted by A. Gorodnitskiy]

I wonder who sings these days,
The air is filled with ashes,
They tear at my lips with irons,
Poke cigarettes at my soul.
The hangmen have slashed my hide
To frighten the crowd around me
They tell me: "Come on now, cry!"
But all I say is: "No way!"

12.7 O-horizon—A Fertile Ground for Nostalgia

It has now been fifty years since the dissolution of the poetry circle at the Leningrad Mining Institute. What happened to the “the poets of the soil”? Where are they now? The surviving “soil-heads” are all in their seventies, and their lives and fates are as diverse as one could imagine, considering how tight-knit they were in their youth. But even though their circumstances and politics may now be different, many of them still maintain contacts with each other, even across continents. And one of them, Gorbovsky (2003), is convinced that “all are still good people… dreamers… lovers of life…”.

Yelena Koumpan (Fig. 12.4) married Gleb Semyonov (her former mentor at LITO who died in 1982; Fig. 12.3), moved to Moscow, and is now a literary critic. Vladimir Britanishsky also moved to Moscow and became an award-winning literary translator and critic, and he still writes poetry (Fig. 12.2). His late poem (published in Tsaritsyn 2003a) is filled with yearning for his years as a field geologist.

Letter From a Friend

by V. Britanishsky [permission granted by V. Britanishsky]

“I’m sorry, time is short, the chopper’s taking off…”
a letter from a friend. Date: 1960.
Still our young blood is pumping in our veins.
Still God - that pediatrician (the old-fashioned kind)
is gazing at us from the drifting clouds
with the all-knowing, helpless, melancholy smile.
And with the downwash, our Finno-Ugric Russian giant
subcontinent just floats, floats, floats away…
The helicopter rises like a small mosquito.
While we, throughout our endless Arctic day,
are juggling symbols – iron, copper, nickel –
like children’s blocks with letters on the sides.
A distant lightning – like a sparking rectifier -
would blind us for a moment with an UV flash.
And then it’s daylight once again, the Arctic day is dragging,
it feels like immortality to which one is forever doomed…

Yes, it’s been twenty years! And how I, ungrateful,
was so unhappy then!.. Just think about it: Twenty years!

Oleg Tarutin (Fig. 12.7) worked as a field geologist in Siberia, Iran, and Antarctica. He published several books of poetry as well as novels, science fiction, and children books before his death of cancer in 2000. Leonid Ageyev (Fig. 12.6) also worked as a geologist for many years and published several poetry volumes. Some of his best work remained unpublished in his lifetime, or appeared decades later in an edited, sanitized form. He had problems with drinking and died in St. Petersburg in 1991. To end this sad list I will mention Yakov Vinkovetsky, another geologist-poet, abstract painter, and a popular member of the LITO (Fig. 12.9). He left the Soviet Union in 1975, immigrated to Houston, USA, worked as an oil company geologist, and committed suicide in 1984 under tragic, apparently job-related circumstances. The loss of these talented poets and dear friends was mourned greatly by other pochveniks. Here is a powerful epitaph dedicated to one of them (published in Tsaritsyn, 2003):

In Memory of Poet Leonid Ageyev

by G. Gorbovsky [permission granted by G. Gorbovsky]

Friends are dying - the trees are cut down…
So you, too, are now one with the sky and the ground,
You are scorched, you have darkened, your face - like the earth…
And the ground wind picks up when it blows from the north…
Trees are cut, and between them the widening gaps
Make it harder to stand and to wait for the ax…
And the fewer the friends, and the louder the bells,
The more fierce the wind of the coming farewells.

The life of Gorbovsky (Fig. 12.8) took several dramatic turns. Widely considered to be one of the most talented poets and the most charismatic personality of the pochvenik circle, he married Gladkaya (Fig. 12.12), and both of them moved to the Sakhalin Island in the Russian Far East to work as field geologists. They continued to write poetry but soon got divorced. Gorbovsky continued to work in geological expeditions for many years and, despite having periodic problems with alcohol, has become a more or less regularly published poet with more than 30 books of poetry (some of them in obscure publications with a tiny circulation). Much of his best work, though, was unpublished for decades, and he has had great difficulty making a living as a poet, despite his popularity. Furthermore, some have criticized his later work for becoming increasingly conventional and even politically incorrect for its earnest patriotism (Kuzminsky 1980; Brodsky 2000; Gorodnitskiy 2001). Presently, Gorbovsky is in reasonable health and good spirits, living modestly in St. Petersburg and writing poetry every day, much of it masterful and still unpublished. Nevertheless, he received the Pushkin Prize, a top presidential award in 2008, and is (perhaps, along with Gorodnitskiy) the most prolific and famous of the "poets of the soil". After forty years of separation, Gorbovsky and Gladkaya have reconciled. She is now the editor and co-publisher of his work (Gorbovsky 2003b).

It is Alexander Gorodnitskiy, however, who has had a consistently successful career both as an earth scientist and a poet/songwriter (Figs. 12.5 and 12.11). After his graduation from LGI he moved to Moscow and completed a doctoral dissertation on plate tectonics and paleomagnetism. He worked as a marine geophysicist onboard several Soviet submersibles and research vessels and traversed the globe several times in the 1960's through 1980's. Nevertheless, he continued to write poetry and songs that have soon made him a national celebrity among fans of the "bard songs". An indefatigable traveler in his mid-seventies, he performs live in Russia and abroad, in addition to working on a variety of film projects. Whereas his early poetry at LITO was characterized by youthful romantic pathos of a field geologist (Koumpan, 2005), his later poetry is more wide-ranging and erudite in subject matter, skillful in poetic craft, and emotionally powerful (Kupchick, 2005). But despite personal success, his more recent poems (Gorodnitskiy, 1999) are filled with a sense of profound sadness and nostalgia - for youth, geology, his “dear Leningrad”, and friends who passed away. If there were a hymn dedicated to the vanishing generation of poet geologists, the “poets of the soil”, I think the poem below would be most appropriate.

Nostalgia

by A. Gorodnitskiy [permission granted by A. Gorodnitskiy]

In the grip of latter-day nostalgia’s fever,
When I reminisce, and once again
I recall the Gorbiachin River,
And its tributary - Kulumbei,

Where we once sat all together,
With our field gear, practicing our trade,
As a tin can turned, ever so slowly,
Yielding to a rusty blade.

The mosquitoes sang in high soprano,
And the rapids hummed the lower note,
As the spam was melting, made in China,
In the dangling, grimy firepot.

That old knife is hanging on my wall now,
With my rifle belt of worn-out hide,
Of the three young men around that fire,
I’m the only one who’s left behind.

Never will I melt some snow and mix it,
In my cup with pure alcohol,
Never will I once again return here,
To that year, so unforgettable,

When in torn-up, standard-issue clothes,
Still together, through the swarms of flies,
We again walked towards the horizon,
Perched between the mountains and the sky.

12.8 Conclusion – Bumper Crop or Famine?

There are far fewer earth scientists in Russia today compared to the 1960’s and even fewer young geologist poets. Part of it has to do with the unraveling of the Soviet geological infrastructure and the current economic climate. Earth science was never very lucrative in Russia (petroleum geology—a significant exception) and is no longer viewed as a romantic profession by most young people. “I am going to where there is mist, dreams, and the smell of the taiga” was the chorus to a popular “bard” song of the 1960's. Later, cynics changed the words to "I am going to where there's money, only fools go to where there's mist". Now is indeed the twilight of the romantic age of Russian geology, though the last few years saw an upsurge in the number of students and working earth scientists, driven by the oil boom. But the main legacy of pochveniks appears to be in the realm of Russian poetry. It is their poems, songs, and stories that inspired me and other members of my generation who came of age in the 1970's and 80's to become wanderers and geologists (Belasky, 2003; Day, 2007) and for some to write geologically-themed poetry (e.g., Belasky 1987; Vlasyuk, 1998). But the key question is: what is it about earth science that makes it produce a disproportionately large number of serious poets? Surely, geology can be thought of as a romantic profession, like poetry, but there are other sciences, no less romantic. Has wildlife biology produced as many important (Russian) poets or its own poetry movement? According to Brodsky (2002), most young poets yearn to travel, so do most young geologists: they both want to see all the different landscapes that exist on earth, human and rock, and that is what unites them.

One other epiphany has emerged from translating and writing about the "poets of the soil". The interchangeable nature of rock, soil, and time in the earth sciences, and the fundamental importance of time, that "swinging pendulum" in poetry (Brodsky, 2002), provide the unique link between these two seemingly unrelated fields and give rise to profound poetic metaphors for the human condition. Perhaps, the "poets of the soil" will be back.

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References

Ageyev, LM (2002) Geologiya zhizni. Izbrannyye stikhotvoreniya [The geology of life. Selected short poems]. St. Petersburg, Neva, 207 pp.

Ageyev LM (1983) Okruga [The Surroundings]. Leningrad, Sovetsky Pisatel', 86 pp.

Ageyev LM (1989) Sorok sorokov [The Multitude]. Leningrad, Sovetsky Pisatel', 304 pp.

Belasky P (1987) Geologicheskaya elegiya [Geological elegy]. Stalker Almanac, Los Angeles: 2:40.

Belasky P (2003) The romance of geology in Russia: A tribute to Alexander Ainemer. Geotimes 11:56.

Bitov A (2003) My byli prozvany «pochvenikami» [we were nicknamed «poets of the soil»]. In: Tsaritsyn VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin's vaults. Poems and memoirs]. St. Petersburg, Neva, 414-416.

Britanishsky VL (2003) Pokhischeniye Prozerpiny Plutonom [The abduction of Persephone by Pluto]. In: Tsaritsin VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 13-44.

Brodsky J (1981) Virgil: Older than Christianity. A poet for the New Age. Vogue: 10:178.

Brodsky J (2000) Bolshaya kniga intervyu [The big book of interviews]. Moscow, Zakharov, 703 pp.

Brodsky J (2002) Conversations. Jackson, University Press of Mississippi, 191 pp.

Cantor PA (2004) The scientist and the poet. The New Atlantis 4:75-85.

Day D (2007) A tribute to Russia’s «poets of the soil». Northern California Geological Society Newsletter 9: 2-4.

Gladkaya L (2003) Stikhi [Poems]. In: Tsaritsin VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 147-165.

Glebova, L (2003) Iz dnevnika [From the diary]. In: Tsaritsin VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 448-452.

Gorbovsky GY (1975) Stikhotvoreniya [Short poems]. Leningrad, Lenizdat, 238 pp.

Gorbovsky GY (2003a) Otkuda est’ poshla [Where I come from]. In: Tsaritsyn VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 454-460.

Gorbovsky GY (2003b) Sobraniye sochinenii. Stikhotvoreniya i poemy, 1953-1963 [Collected works. Volume 1. Poems and verses, 1953-1963]. Volume 1, St. Petersburg, Istoricheskaya Illyustratsiya, 440 pp.

Gorodnitskiy AM (1991) I vblizi, i vdali [Near and far]. Moscow, Poligran, 495 pp.

Gorodnitskiy AM (1999) Stikhi i pesni. Izbrannoye [Selected poems and songs]. St. Petersburg, Limbus Press, 624 pp.

Gorodnitskiy AM (2001) I zhit’ escho nadezhde… [And hope is yet alive…]. Moscow, Vagrius, 635 pp.

Hubbs, J (1988) Mother Russia: The feminine myth in Russian Culture. Indiana University Press, Bloomington and Indianapolis, 302 pp.

Koumpan, YA (2003a) Autodafe vo dvore Gornogo Instituta [Burned at the stake in the yard of the Mining Institute]. In: Tsaritsyn VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 492-496.

Koumpan, YA (2003b) Stikhi [Poems] In: Tsaritsyn VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 492-496.

Koumpan, YA (2005) Blizhnii podstup k legende [The close-up view of a legend]. St. Petersburg, Zvezda, 367 pp.

Korolyova NV (2003) O leningradskoi poezii 1960-h godov [Leningrad poetry of the 1960’s]. In: Tsaritsyn VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 481-483.

Kuklin (2003) Stikhi [Poems]. In: Tsaritsin VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 240-258.

Kupchik, YV (2005) Aleksandr Gorodnitskiy: Obraz mira i mir obrazov [Alexander Gorodnitskiy: The image of the world and the world of images]. Tyumen, Mandr and Co., 159 pp.

Kushner A (2003) Sorok let spustya [Forty years since]. In: Tsaritsin VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin’s vaults. Poems and memoirs]. St. Petersburg, Neva, 500-504.

Kuzminsky KK (1980) Geologicheskaya shkola [Geological school]. In: Kuzminsky KK, Kovalyov GL (eds) The Blue Lagoon anthology of modern Russian poetry. Newtonville, Oriental Research Partners and the Institute of Modern Russian Culture at Blue Lagoon, Texas, 385-483.

Losev LV (2006) Iosif Brodsky: Opyt literaturnoy biografii [Joseph Brodsky: A literary biography]. Moscow, Molodaya Gvardiya, 447 pp.
Massie S (1972) The living mirror: Five young poets from Leningrad. New York, Doubleday, 344 pp.
Polukhina V (1997) Brodsky glazami sovremennikov [Brodsky through the eyes of his contemporaries]. St. Petersburg, Zvezda, 334 pp.
Semyonov GS (ed) (1956) LITO Leningradskogo Gornogo Instituta. Stikhi [Literary union of the Leningrad Mining Institute. Poems]. Leningrad, LGI, 82 pp.
Shteinberg A (2003) Ia vsegda budu vas lyubit' [I will always love you]. In: Tsaritsin VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin's vaults. Poems and memoirs]. St. Petersburg, Neva, 552-558.
Tarutin OA (1976) Tranzitnaya vstrecha [A meeting while in transit]. Leningrad, Sovietsky Pisatel', 96 pp.
Tsaritsyn VA (2000) Rossypi. Stikhi i pesni peterburgskikh poetov-geologov [Placers. Poems and songs of St. Petersburg poet-geologists]. St. Petersburg, WELCOME Publishers, 288 pp.
Tsaritsyn, VA (ed) (2003a) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin's vaults. Poems and memoirs]. St. Petersburg, Neva, 575 pp.
Tsaritsyn, VA (2003b) O geologicheskikh pesnyakh serediny 50-h [Geological songs of the mid-50's]. In: Tsaritsyn VA (ed) Pod voronikhinskimi svodami. Stikhi i vospominaniya [Under the Voronikhin's vaults. Poems and memoirs]. St. Petersburg, Neva, 536-538.
Vlasyuk, VI (ed) (1998) Negasnushchy koster: Razvedchiki nedr v poezii [The flickering campfire: Earth explorers in poetry]. Moscow, Geoinformmark, 559 pp.

Chapter 13
The Soil Scientist's Hidden Beloved: Archetypal Images and Emotions in the Scientist's Relationship with Soil

Nikola Patzel

13.1 Introduction

From the outset, the practice of modern soil science has been a *double-grounded process*, being simultaneously in touch with outer observations and inner images. Scientists have studied soils with their senses and their means of consciousness, while also being fascinated, driven and guided by other factors of their inner life. These internal factors are emotional inner images and ideas, and they act often unconsciously. Some keywords of emotional inner images, expressed by pioneers and leaders of soil science, are: *Mother Earth*, *vital force,* the *Stone of the Sages,* the *encompassing whole*, and *total control*. They can be found in the writings of Liebig, Sprengel, Fallou, Dokuchaev, and Jenny, as well as contemporary soil scientists, and I call them their *inner soil*.

To qualify these internal factors forming the inner soil of soil science, we can name them 'archetypal' (following the psychologist Carl Jung), because their general structures are not individual achievements, but common to all humans. The work presented here has been done relying on a hypothesis (central to depth psychology) which is not common sense in present Western societies, albeit there is much empirical evidence for it: That we humans think, judge and act not only out of conscious rational decisions, but also out of unconscious motivations with their own kind of rationality or non-rationality. The unconscious is not just 'feelings' or 'emotionality'; it is a whole world supporting and surrounding our conscious lives. For those readers, who want to have an idea about the author's concept of the unconscious before reading the whole text, I offer the following three indented paragraphs:

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What about the unconscious?

1) When our consciousness is asleep (or in some other 'absent states'), clinical measurements show our brains to be periodically highly active, especially during the REM (rapid eye movement) periods of sleep. The inner perspective of this state of activity is a world of dreams—from unconscious wishes seeking for their place in our life to the deepest religious visions; from a chaotic whirlpool of emerging strange images to experiences of order and harmony unlike any we have ever had when awake.
2) With the methods of scientific psychology or comparative religion, we can observe some common patterns of dreams and visions all over humanity (research pioneers have been Carl Jung, Mircea Eliade, Erich Neumann and others). And from an inner perspective, countless dreamers and visionaries have reported the impression that there is something spiritual that transcends the borders of their own subjectivity and individuality. To highlight the commonness of groups of similar inner images, they have been named by Jung "archetypal images", emerging in individuals out of common layers of the unconscious, which can be characterised therefore as "collective unconscious" (Jung 1969). The term 'archetype' comes from Greek *archétypon* = 'original form'.
3) Here we work with the hypothesis that the unconscious is not only effective and relevant in the dream or vision state of a human, but also in our life in the normal daily mode, for example, when writing a scientific publication about the soil. But then, in general we don't notice its presence and its effects. But its traces can sometimes be followed, as has been done in this paper, which is mainly about emotion-rich archetypal images and ideas expressed by soil scientists.

The aim of this chapter is to give some preliminary answers to the questions:

What are the main features of the 'inner soil' found with pioneers and leaders of modern soil science?
Which modes of the scientist's relation to the inner soil are traceable?
And what could be a fair and fertile way of dealing with it?

13.2 Mother Earth

F.A. Fallou (1794–1877), one of the founders of modern soil science and the one who coined the term 'pedology', admired the *Earth Mother*, whose general devaluation made him suffer. In the introduction to his "Pedology", Fallou (1862, p. 3, translation by author) wrote: "*Everything ugly and miserable, useless and worthless, man can imagine, he names by the summarising words: dust, dirt, dung and mud. These are the honorary titles he has assigned to his Mother Earth in past and present. No word is breathed that he owes his existence to this cursed dirt and dung. Everybody is pleased to see good old Mother Earth rejuvenating, donning her flowery spring garment. However, nobody remembers the dirt and* *dung concealed underneath the beautiful clothes, which he avoids touching with hands, and even prefers not to set foot on it. Everybody wishes to walk on flowers, nobody wants to know anything about the soil, without which no flower could emerge*."

And further, Fallou stated (1862, p. 46): "*Our culture and civilisation, everything we have, we owe solely to the bond, which man had entered with his Mother Earth. Because it was agriculture, which made man become himself*." Fallou called the earth (1857, p. 2) "*mother of all*", and the "*teachers and followers of natural studies and agronomy*" were called by him "*priests of Isis and of Ceres*". These are the Egyptian goddess of life, matter and related magical knowledge, and the Roman goddess of Earth and agriculture.

When the ideas of *organic farming* emerged in the minds of its pioneers, Mother Earth was evocated, too. For Rudolf Steiner (1861–1925), one of the founders of organic farming, every spring, the "*divine creativity sprouts from Mother Earth*" [Steiner (1998, p. 262, translation by author)]. In Steiner's worldview, Mother Earth was a conscious spiritual being with "*an 'I' in her centre*". Steiner (1993, p. 122, translation by author) repeated the old mythological phrase: "*The earth is the flora's mother, the heaven its father. That is really, literally the case*." In 1932, his followers patented the name of 'Demeter' (Greek Mother Earth goddess; sister of Zeus) for the products of bio-dynamic agriculture (von Wistinghausen 1982, p. 46), a label which is still in use today.

Hans-Peter Rusch (1906–1977), another of the founders of continental European organic farming, evoked the "*holy Mother Earth*", which could not be reduced to simple nutrient elements (Rusch 1955, p. 22; 1968, p. 71). And Sir Albert Howard (1873–1947), the British pioneer of organic farming who had strong ties to India, wrote that agriculture should be done following to the principles of nature, invoking the name of "*Mother Earth*" (1940, p. 4): "*Mother earth never attempts to farm without live stock; she always raises mixed crops; great pains are taken to preserve the soil and prevent erosion; the mixed vegetable and animal wastes are converted into humus; there is no waste; the processes of growth and the processes of decay balance one another; ample provision is made to maintain large reserves of fertility; the greatest care is taken to store the rainfall; both plants and animals are left to protect themselves from disease*."

Howard (1940) showed his feelings towards Mother Earth/Nature with the quotations that he placed at the beginning of his "Agricultural Testament": Shakespeare ("Romeo and Juliet"): "*The Earth, that's Nature's Mother, is her tomb / What is her burying grave, that is her womb.*"; and Longfellow ("The Fiftieth Birthday of Agassiz"): "*And Nature, the old nurse, took / The child upon her knee, / Saying: 'Here is a story-book / Thy Father has written for thee.' / 'Come, wander with me,' she said, 'Into regions yet untrod; / And read what is still unread / In the manuscript of God'*."

In contrast to academic soil science, which was completely male-dominated at its beginnings, organic agriculture had at least four women among its pioneers: Gabrielle Howard (1876–1930) and Maria Müller (1894–1969) as background researchers and developers (with their husbands being in the limelight), and Lady Eve Balfour (1899–1990) and Mina Hofstetter (1883–1967) working on their own behalf. {Maria Müller's husband Hans Müller (1891–1988), a today rather-unknown organic farming pioneer, was the key promoter and social leader of the non-biodynamic branch of organic farming in continental Europe at its inception. His role was comparable to that of Jerome Rodale (1898–1971) in the United States.} It is notable that Lady Balfour started a magazine with the title "Mother Earth" (present title: "The Living Soil"); and Mina Hofstetter, founder of the first organic farming school in Switzerland, showed an approach to Mother Earth that can, in retrospect, be called 'spiritually feminist'. Hofstetter wrote in 1941 (p. 14, translation by author): "*We want to throw a light on paths we consider as wrong, which were thought up and dictated by men in a commercialistic way, instead of being empathically sensed and fulfilled by mothers. From mothers, to which the same law belongs, as to the earth.*" Hofstetter claimed the importance of a spiritually receptive attitude towards Mother Earth: "*Then, suddenly, she starts talking and becomes understandable*" (1941, p. 14f). Schmitt (2006, p. 56) wrote on Hofstetter: "*… whereas Lady Eve Balfour embarked on a series of world lecture tours, others, like Mina Hofstetter, drew people from all over the world to the sites of their efforts*."

The classical idea of Mother Nature being the female master and teacher of scientists—formerly strongly held by many alchemists—was expressed by the soil scientist Karl Senft. In his textbook from 1888 (p. v, translation by author), he introduced his results with the statement, "*to use only Mother Nature as master craftswoman*" and announced his wish to covey what she teaches, as far as he could understand it, "*truly and honestly*" (p. vi). The aspect of Mother Nature, which is highlighted by Senft here, is a guiding *feminine wisdom*, as we saw it also with Howard above, being the 'know-how of life'. Earlier, the feminine wisdom of Earth-Nature was evoked, for example, by addressing the Egyptian goddess Isis, and the spiritual master craftswomen of Arabic and Western alchemists.

As a side remark, it should be mentioned that the teachings of nature were seen by a most influential philosopher of science, Francis Bacon (1561–1626), as answers under compulsion (Bacon 1863, p. 48), "*… under constraint and vexed; that is to say, when by art and the hand of man she* [Nature] *is forced out of her natural state, and squeezed and moulded*." And p. 134: "*For even as in the business of life a man's disposition and the secret workings of his mind and affections are better discovered when he is in trouble than at other times, so likewise the secrets of nature reveal themselves more readily under the vexations of art than when they go their own way.*" Statements like these lead the ecofeminist Carolyn Merchant to draw the conclusion (1982, p. 169): "*Through vivid metaphor, he transformed the magus* [sorcerer, here: scientific adept] *from nature's servant to its exploiter, and nature from teacher to a slave*."

In the late 20th century, the symbol of Mother Earth remained in only a few traces in the soil science literature. One of these is the "skin of the earth" for the soil—alluding to a living body having a skin. This term was used, for example, as motto for the 2005 annual conference of the German Soil Science Society (DBG). A stronger return to the archetypal images of Mother Earth was employed by soil scientist Daniel Hillel [(1991b, p. 404); for more, see Hillel (1991a)]: "*The* *adjective 'human' means 'of humus'—of the soil.*" He called then to a "*returning*" and "*reawakening*" to this basis, by quoting Friedrich Nietzsche (1844–1900): "*'Let your gift-giving love and your knowledge serve the meaning of the earth.' Perhaps that most common matter underfoot that many among us scarcely notice and take for granted is our most vital resource, the mother-lode of terrestrial life and the source of its productivity. 'For out of the earth thou art, and unto earth shalt thou return,' in spirit as well as body.*"

Interpretation

What was meant by 'Mother Earth' by those speaking about her? The spectrum of archetypal meanings is sketched by the Encyclopædia Britannica (15th ed., 1992): "*Earth Mother, in ancient and modern non-literate religions, an eternally fruitful*

Fig. 13.1 "Venus à la Corne" from Laussel, about 25.000 years old. One hand possibly holding a cornucopia which has 13 notches, the other hand on her belly. © Musée d'Aquitaine, Bordeaux. Photo L. Gauthier; reproduced here by permision.

source of everything. Unlike the variety of female fertility deities called mother goddesses … the Earth Mother is not a specific source of vitality who must undergo sexual intercourse. … The most archaic form of the Earth Mother transcends all specificity and sexuality. She simply produces everything inexhaustibly, from herself. … In other mythological systems she becomes the feminine Earth, consort to the masculine sky; she is fertilized by the sky in the beginning and brings forth terrestrial creation. Even more limited reflections of the Earth Mother occur in those agricultural traditions in which she is simply the Earth and its fertility."

Some important aspects of this description of Mother Earth are: She is, in the basic meaning, the primal ground and origin of the living creature. Second, being part of a primal polarity of being (like Chinese Yin and Yang), Mother Earth is the archetype of femininity, to which the masculinity (*e.g.*, God in Heaven, or: Her Son) is seen as the complement. Third, as fertile earth and soil, she becomes more identified with the just creative living matter. {A much more encompassing and differentiated analysis of Mother Earth as one aspect of the "Great Mother" has been given by Neumann (1972).} All of these are qualities which may be activated in the soul of a soil scientist, who is touched, moved, and motivated by *Mother Earth*.

13.3 The Vital Forces or Spirits

In western history of ideas, Aristotle's concept of *entelechy*, meaning *life having its purpose in itself,* founded an important tradition. (For primary sources, see in the *Corpus aristotelicum:* De anima II 1, 412a, Metaphys. VII.13, 1038b 1-6, IX.8, 1050a 9-16, Phys. III, 1.) Part of this tradition is the co-called 'vitalism', the philosophy of vital forces or spirits. Before its appearance with soil and agricultural science will be discussed, the following paragraph provides some more background to the historical vitalism vs. materialism/determinism debate.

With Aristotle's renaissance in the modern period, some philosophers of the special qualities and forces of life emerged (*e.g.*, Jan Baptist van Helmont 1577–1644, Georg Ernst Stahl 1660–1734, Albrecht von Haller 1708–1777, Paul-Joseph Barthez 1734–1806, Marie François Xavier Bichat 1771–1801). These authors were opposed to mechanistic and deterministic views of living beings, which were fundamental to modern 'life sciences': First the Cartesian dictum *"animalia sunt automata" / animals are machines*, compare Descartes (1637, p. 185; 1649); second the Baconian dictum *"nam causarum finalum inquisitio sterilis est" / thus, the investigation of final causes [finality] is sterile* (Bacon 1623, vol. I, part 5). As René Descartes negated all soul and spirit, except in human consciousness and within a rather abstract God image, Francis Bacon aborted the idea of purposeful development and intentional processes (do something "for the sake of …") by reducing them to deterministic effects of determined causes. To these fundamental ideas of 'enlightened' science, vitalism formed a countermovement.

During 19th century, this movement was called 'vitalism'—first by its adversaries (Engelhardt 1997, p. 160f; Duchesneau 1997, p.297), and then by the 'vitalists' themselves. Within the early 19th century soil science community, Albrecht Daniel Thaer (1821, vol. 2, p. 85, § 109; translated by author) called humus "*a creation of the organic force, a compound out of carbon, hydrogen, nitrogen and oxygen, as the inorganic powers of nature cannot bring it forth*". {For more context to this quotation in the development of the *humus* concept, see Feller (1997).}

Carl Sprengel (1787–1859), the German chemist who first formulated the so-called "law of the minimum" (relating plant growth to a set of essential nutritional chemical elements) wrote in the same publication where he published the chemical "law of the minimum" [Sprengel (1830, p. 176f, translated by author)]: "*A highly organized body is therefore composed of many life atoms and many chemical atoms. … The inner nature of the life atoms is as little explainable as that of the chemical atoms*." These life atoms, being also the "*life principle*", would stay with the residual products of decaying organisms. The growing of a plant would also depend on the availability of life atoms (Sprengel 1930, p. 176f). Thus, it can be stated that Sprengel's "law of the minimum" was in reality a pairing: the chemical and life 'atoms' would only together form the necessary and sufficient conditions for plant growth.

Justus von Liebig (1803–1873), the important developer and promoter of agricultural chemistry, also kept "*vital forces*" within his image and feeling of nature. In his "Familiar Letters on Chemistry", he wrote (von Liebig 1851, p. 18; see also von Liebig 1878, p. 14): "*Let us, however, carefully distinguish those effects which belong to the chemical, from those which depend peculiarly upon the vital force, and we shall then be in the right channel for obtaining an insight into the latter. Chemical action will never be able to produce an eye, a hair, or a leaf.*" However [von Liebig (1878, p. 144, translated by author)], *"The vital forces are not disposable to our will in the same way as are heat, light, gravitation etc*.". As examination of different editions of his works (beginning in the late 1850s) show, Liebig was somewhat torn between materialistic and vitalist ideas, but tried to reconcile them [von Liebig (1878, p. 213, translated by author)]: "*Exact science has shown, that all the powers of matter really play a part in the organic process. Now, the extreme reactionary forces pretend, per contra to the former opinion, that only chemical and physical forces would determine the phenomenon of life, and that no other force would be acting in the body. However, in the same way as former philosophers of nature were not able to prove that their vital force makes everything, yesterday's materialists cannot show a proof, that it is done by inorganic forces, that they are sufficient to bring forth organisms, even the mind. … Truth lies in the middle, which transcends the one-sidedness, acknowledging a formative principle, a ruling idea for organic life, within and together with chemical and physical forces*."

The most effective disciple of Liebig in Germany, Adolph Stöckhardt (1809–1886), wrote in his most popular book entitled "Chemical Field Sermons" (1851, pp. 14, 16, translated by author): Whereas chemical forces would act unhindered in the soil, they would stay within plants under the "*tutelage of a mysterious higher power*", which could be called "*vital force*" or "*God's breath*", on which the chemist would have no power.

At the beginning of 20th century, the 'vitalism' discussion of the 19th century was summed up, for example, by Bütschli (1901), Wolff (1905) and Braeuning (1907), and culminated with the bio-philosophical vitalism of Driesch (1922). Its next cycle started with the modern-era organic farming movement. Vitalist ideas were crucial for some important founders of organic agriculture. For Hans-Peter Rusch, the keyword was "*living substance*". First, he identified the 'living substance' with cell organelles and macromolecules (Rusch 1953, p. 15; 1960, p. 53), which he considered to become part of the humus, the latter being considered as the primeval appearance of "*living tissue*" on earth (Rusch 1955, p. 155). Under the pressure of contradictory scientific evidence, Rusch retired this biological hypothesis and went back to the core statements of the vitalist tradition, interpreting living matter as the appearance and materialization of a "*really spiritual principle*" (Rusch 1968, p. 33). For biodynamic farming, Rudolf Steiner worked out a sophisticated model of psychic and spiritual forces and 'beings', which would form and inhabit plants, animals, and humans. In his view, the "*farm organism*" (compare Steiner 1984, p. 202; Raupp 2000) would be the organisational level where the unifying transformation of the different kinds of forces would take place.

The "*living principle*" was also important for the co-founder of organic agriculture in Great Britain, Lady Eve Balfour (1943, p. 18): "*In our modern world, which is largely ruled by chemistry, we have tended to overlook this continuity of the living principle in nature*"; that is, the "*organic circle … This ever recurring cycle of birth, growth, reproduction, death, decay, decay passing once more into birth, is often called the Wheel of Life*." Balfour might have been inspired in this by Sir Albert Howard, who stated (1940, p. 22f) that one must look at the "*wheel of life as one great subject … made up by two processes—growth and decay*".

Interpretation

From the quoted sources above, we see the traces of the following cultural and mental development: After the blow stroke on the image of enchanted nature by the 'Enlightenment' (Bacon, Descartes and others as spearheads), the (re-)emerging vitalism offered a new framework for some of the old beliefs.

The tension between vitalism and materialism, which coexisted in the mind of distinguished 19th century scientists, lead then to a segregation of worldviews into 'mainstream science' and 'undercurrent science', the latter forming some of the important roots of European organic agriculture. One may say that the idea of special organizing 'vital forces' and life capacities emphasizes the qualitative difference of life from its 'abiotic' environment. This has connections with the ideas that the soul steers the body, and God makes the plants grow. More generally, there are links to the ideas that there are non-material factors acting in the plants, whose expressions in folk beliefs have been labelled with the term *vegetational spirit* (Mannhardt 1875-77, Frazer 1914-18, and others).

13.4 The Stone of the Sages

From late antiquity on, the *Stone of the Sages* (*lapis philosophorum*) was a well-known name for the highest value that Arab and European alchemists strived to achieve with all their efforts. One of its properties, in popular belief, was the potential of this most precious stone to give immortality—to transcend the limits of material existence. Within this context stands the following idea of the agricultural chemist Adolph Stöckhardt. In his "Chemical Field Sermons", which was one of the most popular books of agricultural chemistry in Germany for decades (Henning and Suntheim 1997), Stöckhardt wrote (1851, p. 1) under the chapter heading "Chemistry as the farmer's concubine" ("Die Chemie als Hausfreundin des Landwirthes"):

"*Since all times up to present, man had the following two big wishes: He would like to be everlasting young and healthy, and in addition to be quite rich. Following a dim legend, somewhere in nature should be a wonderful jewel hidden or to be distilled out, which would be able to fulfil these two wishes; it was called Stone of the Sages. … During a millennium, this treasure was sought-after, but not found. … To a certain degree, chemistry really owns these powers, one had attributed to the stone of the sages …*"

{Note the similar title of the extremely successful textbook (written in question and answer format) of J.J.F. Weir (1844): *Catechism of Agricultural Chemistry and Geology*; a book that had about 50 editions and reprints within 50 years.}

Interpretation

Here we see very clearly, how Stöckhardt transferred the symbolism of alchemy, which meant ultimately (at least in spiritual alchemy) the transformation of human soul and spirit and its union with God, in a very concrete way, to chemistry. This is in line with one of the main tendencies of the western cultural mainstream since the Enlightenment: *to consider knowledge of the outer world and mastering of matter as the highest value, effectively replacing spiritual values.* To make the hypothetical link from Stöckhardt's chemistry to the "Stone of the Sages" clearer, the argument is drawn again step by step:

1. The Stone of the Sages was, throughout the centuries, an alchemical symbol for the highest value and goal of human life.
2. In Stöckhardt's time, the spiritual dimension of alchemy (and with it also, of matter and its elements) was more and more dismissed as 'mystic' and 'superstition', as opposed to emerging 'modern' chemistry.
3. The new chemistry did not loose the whole psychic and religious energy, linked before (in Alchemy) with a *highest value* as the Stone of the Sages, but became itself a most promising realm of human striving.
4. As a part of this value shift, Stöckhardt transferred the fascination with the highest value of human striving from the Stone of the Sages to chemistry.

For material showing that Stöckhardt was not a single case, compare Carl Jung's work about "Psychology and Alchemy", with a special focus on his conclusion about the psychological dimension of the transformation process alchemy-chemistry (Jung 1968, par. 432).

13.5 The Whole—and Its Control?

13.5.1 The Classical Four Elements

When dealing with soil fertility, the classical four elements—water, fire, air, and earth—sometimes appear to the mind. The outstanding 19th century soil scientist Karl Senft (1888) used the idea of the four elements for structuring his model of soil processes: He stated that the soil, being a "*laboratory*", prepares the food for plants mainly "*in the way, that it absorbs atmospheric air, humidity and warmth*" in the proportion and distribution which is needed to transform mineral and organic residues (Senft 1888, p. 95). This corresponds to the alchemical idea of the stepwise union of the four elements: water, air, and fire being united with each other and with the fourth one, namely the earth (soil), which is vitalized and renewed by this union of opposite factors.

A new canon of four elements was proposed by Adolph Stöckhardt (1850, p. 574, translated by author): "*Carbon, oxygen, hydrogen and nitrogen: these four elements are, what God's almightiness fixed as elementary pillars for the whole construction of the organic creation*." A recurrence of the classical four elements took place in the 20th century with the organic-farming pioneer Mina Hofstetter (1941, p. 16), who believed that God created life out of the four elements "*fire (sun/light), air, water and earth …. And the synthesis* [in alchemical language: the "quintessence"] *of those is the plant, which nourishes beast and men!*"

Interpretation

The number four often serves to give complete conscious orientation on earth (Abt 2005, p. 127-130); for example, by means of the four cardinal points, the four seasons, the classical four elements (worked out by Empedocles, Aristotle, Plato, Hippocrates, Paracelsus and others), or, in science, as the Cartesian cross or as four-dimensional space-time. In agriculture, you find the four corners of the field, and symbolic fourfold structures like the Christian cross brought into or near the fields, or Indian cross-ploughing (Högger 2000). The number four has the archetypal quality of orientation and ordered totality. This archetype of orientation was also attractive for structuring the complex phenomenon of soil fertility. In addition, it led to the symbolism of life (plants, etc.) as the central fifth element, seen symbolically in the centre of the cross or as offspring from the union of the four elements.

13.5.2 The Primeval Factors and the Whole

The first scientist to speak of the soil as an "*organised whole*" was the Danish researcher P.E. Müller (1840–1926). Within that whole, he saw a complicated interplay of "*factors*" such as fungal mycelium, soil animals, water percolation, and climate [Müller (1887, notably p. 3, 87f and 176f); see also Feller (2005)]. But then it was Vasilii Vasil'evich Dokuchaev (1846–1903), the Russian pioneer of modern soil science, who made the term 'pedology' popular, and who established a more complete, multifactor approach to understand soil genesis. One of Dokuchaev's main new points was that he criticised the purely analytic approach in soil science, which only looked at separate parts and pieces, and called instead for a holistic soil science. The following quotations illustrate Dokuchaev's new approach [Dokuchaev (1949-50, pp. 399 and 397), as quoted by Dobrovol'skii (1996, p. 107-108)]: … *link that exists between forces, bodies, and phenomena; between dead and living nature; between the vegetative, animal and mineral kingdoms on one hand, and between man, his everyday life, and even mental world on the other. It is this relationship, this natural interaction, that makes up the essence of nature cognition …—the best and supreme fascination of natural science*." And further: "… *in the study of these factors and particularly in mastering (if there is such a wish) them, the entire, single, integral, and indivisible nature must be, by all means, reckoned with as far as possible, and not its fragmentary parts; all its principal elements must be revered and studied alike; otherwise, we shall never be able to control them, and we shall never learn what belongs to one factor and what to another*." We see that Dokuchaev's highest value was an all-encompassing picture of nature, including its humanistic dimension, and the relation patterns of all of its elements, with the soil and its forming factors at the centre of interest. This approach made Dokuchaev an ecological pioneer within soil science.

Building upon the foundation established by Dokuchaev, the Swiss-American soil scientist Hans Jenny (1899–1992) worked out his famous "*factors of soil formation*" model (Jenny 1941). In addition to their description, Jenny tried to grasp the primeval factors of soil genesis as state variables which could be described by mathematical means (Jenny 1984): "*I enjoyed seeing field data aligned by equations and derived aesthetic pleasure from the shapes of the curves. … I could solve the equation. That was the new approach.*" Jenny showed some similarities to Fallou, who, in a certain way, was drawn to both Mother Earth (quoted above), and simultaneously to clear, man-made, rational order (Fallou 1865, p. 158f): "*Formerly, nature lay before us like a dismembered clockwork*." But then, "*after having lined the chaotic army of beings one by one [German: allgemach] in formation, and thus having finally ordered and classified everything according to a well reasoned plan",* he exclaimed: "*The whole nature has become [like] a big state*." With "*state"*, Fallou had probably the Prussian State ideal of his time in mind: a rational world order, established and ruled by a hierarchy of 'enlightened powers'.

But as Jenny shared with Fallou the pleasure of seeing soils and soil data aligned in rational order, he also shared with him the strong emotional attachment to the soil : "… *if you are used to thinking of soil as dirt, which is customary in our society, you are not keyed to find beauty in it.*" The soil "*speaks to us through the colors and sculptures of its profile, thereby revealing its personality; we acknowledge it by giving soil a name, albeit in a foreign tongue, but we don't mention our emotional involvements. In fact, our soil language is lifeless*." And further: "*I am intrigued by the thought that good soils make good people, but that notion seems untenable. Well, not wholly so. … Observing soils, studying them, and reflecting on them induces respect, if not wonder. All of us relate unconsciously in our daily nourishments that make us participants in the continuous flow of nutrient atoms that originate the soil. And in the final act our bodies are returned to the soil. Over the years I have acquired a kind of reverence for the soil, for the creature-world inside it, and for its character expressed in the profile features. … My attitude may be a quirk, or a result of lifelong interest in soil.*" [Jenny (1984); compare with the quotes of Hillel above in this chapter].

You see with Fallou and Jenny the polarity between the emotional and feeling approach on the one hand, and the fascination with rational order on the other hand. This points to a very important problem that still confronts scientists: How to deal with the separation between the "lifeless language" of scientific discourse on one side, and the "personal quirk" of feelings, fantasies and emotional bonds with the object of their study on the other side? For example, in terms of scientific development and human society's relationship with soil: what can happen when Fallou's feeling that earth has aspects of a Goddess ("Isis and Ceres"), or Jenny's "respect", "wonder" and "reverence for the soil" get suppressed or lost? In fact, this had been widely the case, and one might argue that this contributes to the accelerated and ongoing soil deterioration and destruction in large parts of the world.

13.5.3 Holism in Organic Agriculture

'Holism'—the attitude and philosophy working with the assumption that everything is a part of a single whole, with every part being interconnected with others—played a fundamental role for the founding of organic agriculture. Steiner wrote (1984, pp. 169 and 103, translated by author): "… *nature is a whole, from everywhere are powers acting*." Therefore, "*It is thought* [in his approach] *out of the whole*." Subsequently, the so-called "*farm organism*" has become a central image of the bio-dynamic branch of organic farming (*e.g.*, Raupp 2000). On the non-biodynamic side, Rusch wrote (1968, p. 30, translated by author): "*Soil fertility is the basis of all life, its origin and the place of its continuous renewal; its reflection/contemplation [German: Betrachtung] compels us to see things as a whole, otherwise it* [soil fertility] *is unfathomable*." Rusch argued (1955, p. 39) that for a holistic approach to be fully realized, not only logic would be needed, but also the whole human nature: "… *also our spiritual, psychic* [German: *seelisches*] *and bodily being, our character as well as instinct and intuition*."

In the Anglo-Saxon roots of organic agriculture, Sir Albert Howard (1940, p. 23) stressed that, as "*the wheel of life is uninterrupted throughout, … it must therefore be studied as a working whole*." And Lady Eve Balfour (1978, p. 5) wrote about her "*wholeness approach*", that "*… the biota is a whole, of which we are a part,*" every part having its own right to exist. And: "*If I am right, this means that we cannot escape from the ethical and spiritual values of life for they are part of wholeness*."

Interpretation

According to Scofield (1986), the word 'organic' in 'organic farming' went back to the 1940 book "Looking at the Land" by Lord Northbourne [Walter Ernest Christopher James (1896–1982)], a bio-dynamic practitioner in England. He used the term not in the chemical sense (*i.e.*, as opposed to 'mineral'), but in the sense of the 'organic whole' of a farm or of a society. Indeed, the holism of organic agriculture shows features of an organismic worldview. The idea of also comparing human societies with organisms has deep roots in the West [see, for example, Plato's "Republic" as a utopian state, and the physiocratism of Modern Age: *e.g.*, Quesnay (1694–1774)]. A new dimension has more recently been added to the concept: the idea of the whole earth being like one (super-)organism. Heckman (2006) pointed out the similarities of the *Gaia* Hypothesis with agricultural holism: "*This concept of organic is similar in many respects to the holistic ideas more recently expressed by James Lovelock in the 'Gaia Hypothesis'* [*i.e.*, (Lovelock 1979)] *and Lynn Margulis in her book 'Symbiotic Planet'* [1998]*, but on the smaller scale of a whole farm as a symbiotic unit*."

13.5.4 The Wish to Control

The approaches of Dokuchaev and of Jenny have led to the ever more sophisticated mathematical modeling efforts. The possibility to which Dokuchaev hinted at—*i.e.*, of "*mastering (if there is such a wish) them* [the factors/elements]" [Dokuchaev 1949-50, p. 399 as quoted by (Dobrovol'skii 1996, p. 108)]—has become one of the major purposes of research of modern pedology and agricultural science. Of course, discoveries and knowledge bring the human power drive into the arena: the wish appears to control all relevant factors of the soil. That was clearly stated by the US National Research Council, Board on Agriculture (1997, p. 1): "*Precision agriculture is a phrase that captures the imagination of many concerned with the production of food, feed and fiber. … Precision agriculture conjures up images of farmers overcoming the elements with computerized machinery that is precisely controlled via satellites and local sensors and using planning software that accurately predicts crop development. This image has been called the future of agriculture.*" The phrase "overcoming the elements with computerized machinery" means to have dominion over the soil and nature's elements; and the word "overcoming" indicates an attitude, as if they have to be defeated. Will that attitude towards nature be the "future of agriculture"? What feelings and emotions go with this image?

In the heyday of communism, formulations were found which carried the negation of soil dignity and autonomy as a living natural body to extremes [Rosenkranz (1963. p. 196, translated by author)]: "*When detaching forceful from such folksy but scientifically untenable ideas: the soil would be something special, full of life, life-bringing, fertile, maybe even mysterious and unfathomable in its coherence and action, and when replacing these ideas by a dialectic materialistic perspective* [*i.e.*, the world interpreted by relying on its 'objective' material features; compare Stalin (1938)]*, then the soil will become a carrier system, one of many means for work, like others, who allow humans, when used by them, to produce plants out of water, sun energy and elements for plant nutrition. Solely man is producing; neither plants nor animals, nor the soil is 'capable' to bring forth a harvest*." This quotation has been chosen because of its radical and ruthless formulation of a certain devaluation of natural life and autonomy concerning soil and agriculture ("*I* produce wheat, milk and meat …"); similar views have also surfaced in the capitalist world.

Interpretation

For many centuries, the Christian cultural tradition has included the image of 'God's Eye' in a triangular frame, viewing the whole world from above, and at the same time seeing the tiniest events on earth. Even today, we see an image of 'God's Eye', for example, on the U.S. one-dollar bill, and in different shapes on amulets in various cultures. We now have man-made satellites orbiting the earth. They enable humans to see their planet as a whole globe for the first time in history—this is an innovation whose cultural impact cannot be underestimated. So, one may comment that the place of 'God's eye' in heaven had been imitated by man-made 'machine eyes' in the sky. In addition, the human capacity to perform the most detailed measurements of what goes on in the soil, to create complex environmental-process databases and models, and to calculate future scenarios, has increased enormously (compare Psalm 139 from the Old Testament). In this cultural frame, new techniques such as remote sensing and continuous in-situ measurement of soil properties and processes give new tools to the human power drive and to the related self-understanding of being the controller and steerer of nature—that is, to our hubris.

13.6 Conclusions

13.6.1 Outer and Inner Soil

When working with the soil, as scientists or as farmers, humans encounter more than the outer soil. {Concerning farmers' attitudes in the 'pre-enlightened' European agrarian culture, see chapter 16 of this book: *European Religious Cultivation of the*

Soil.} One may also encounter emotions, feelings, intuitions and 'just-so' convictions, which are associated with one or more guiding ideas and inner images. These archetypal inner images and ideas arising from the unconscious have often proved to be attractive or irritating, motivating or possessive—and to be fertile. Where do they come from? These mental phenomena cannot be deduced from the outer observations. They are typical expressions of the human's internal system and the world's 'inner space' and 'beyond', traditionally called *soul* and *spirit*. Therefore, when working with the soil, one is also confronted with elements of his/her own soul and with all the spirits appearing from there to 'me' (the empirical 'I').

When dealing with outer nature and its phenomena, one is also dealing with phenomena from inner nature. Inner nature is understood here as the unconscious, appearing to us from or through the psyche. When working with the soil, a human 'I' with its ego-consciousness enters a relationship with two aspects of nature: Its material appearance (the *outer soil*, perceived by the senses and through measurement data) and its mental appearance (the *inner soil*, affecting consciousness from the unconscious and by its symbols). The four topics which were discussed above: *Mother Earth, vital forces, Stone of the Sages* and the idea of the *whole*, are examples of structures of the inner soil, that is, of the unconscious, which act by archetypal images and emotions in the mental framework of the scientist.

13.6.2 Factors of the Inner Soil

Where archetypal images of *Mother Earth* are effective in the scientist's soul, his or her 'I' (ego) may react with a worshipping attitude in relation to earth and soil. The 'I' may also react with an emancipation program: to become independent from the 'mother', or by activating the power complex: wanting to have dominion over the big nourishing being. Below this polarity of attitudes we see, in most cases, a certain scientific baseline—*i.e.*, scientists wanting to understand how Mother Earth 'functions', and what are her 'principles' or 'laws'. A more spiritual approach, where the earth is perceived and treated as a Goddess, was taken by the pioneers of organic agriculture, and was sometimes perceivable within soil scientists of the past and present.

The ideas of *vitalism*, that *matter is not mere matter* (in the sense of materialism), were quite strong at the beginning of modern scientific soil analysis. Perhaps vitalism was a conceptual vessel for the *feeling* of enlightened thinkers and matter analysts—a sense that there is something other, which they cannot grasp?. But, suspected to be just a custodian concept for phenomena that are not *yet* explainable, vitalism generally disappeared in later soil science—except within the continental European branches of organic agriculture. There, vitalist concepts were developed further, subsequently forming a new scientific subculture.

The explicit identification of chemistry with the *Stone of the Sages* (Adolph Stöckhardt) can be seen as a symbol in a general psychic undercurrent in Western enlightenment: to transfer psychic energy from spiritual values to material values, and to strive for scientific knowledge concerning to this as a central aim of human cultural work. Carl Jung (1968: par. 432) has shown how alchemists projected even the highest value, namely the ideas of the immortal soul and of God, into matter. This has been, following Jung, the starting point for both modern chemistry and of philosophical materialism. The similar formulations "*chemical catechism*" (Weir 1844), "*chemical gospel*" (Liebig [Henning and Suntheim 1997]) and "*chemical field sermons*" (Stöckhardt 1851) are also indicators of that transference process.

The image and idea of the *whole* is very present in current sciences. A symbol for that is the image of the whole earth seen from the space, which is present on the covers of many scientific and popular books, and on the television news programmes. Because of the fascination with the image and idea of the 'whole', it is more difficult for present scientists to reflect critically about it than it is with images and ideas that are not so active in their own souls. I will confine myself here to the obvious polar aspects of the *whole* and of *holism*: Do we, seeing the soil *and ourselves* as parts of a greater whole, have an attitude of adaptation, cooperation, and reverence—or rather an attitude of control, domination, and utilitarianism? Both attitudes being profoundly human, their *real* balance is most important for which scientific questions we pose and what we do with the results of our investigations.

Modern soil science has not been in complete opposition to traditional belief systems concerning the soil, as it should have been in the naïve view of the Enlightenment as a new rising consciousness which emancipated all in its path from tradition and from the unconscious psyche. Modern soil scientists also had 'inner children' from archetypal ideas and emotions, known from cultural history and able to appear in the individual soul.

13.6.3 The Soil Scientist's Concubine?

How can the factors from the inner soil be integrated into the life of a scientist who is concerned with the outer soil? Is the inner soil split off from the official life and work of the scientist, or is it well integrated into it? Is there an unequivocal relationship, like with a concubine or fancier? Or is it the inner beloved, which is acknowledged in her/his full autonomy and meaning as a partner of consciousness—is there a respectful and fair partnership? Is a scientist sometimes possessed by an inner concubine/fancier who has, so to say, married his/her dark side (which the scientist does not know about), for example his/her power drive or vanity—or is he/she aware of these pitfalls and avoiding them carefully? These problems are not specific for scientists in general, or soil scientists in particular, but are of special interest, as these individuals serve as 'experts' on the 'management' of a natural 'body', 'system' or 'resource' essential to the survival of human society.

To present a simple and straight hypothesis: *The 'inner soil' is of equal importance as the 'outer soil'; more general: the 'inner world' is of equal*

Fig. 13.2 "Dux Natura tibi …" (nature be thy guide …). Picture by the alchemist Michael Maier (1618, emblem no. 42), showing the guiding aspect of the unconscious in relation to consciousness.

importance as the 'outer world'. This assumption given, the need becomes clear: to give to the relation with the inner soil (and the knowledge from that) the same attention as to the relation to the outer soil (and the knowledge from that). Then, the unconscious driving forces and images will no longer be treated like a 'concubine' or act like an unconsciously possessive 'demon', but will come into relationships with human consciousness that are appropriate to their nature. I know that this sounds strange to extrovert people in an extrovert culture like the present Western one. One may ask: what is the author speaking about? In this case, please look back to the examples of inner soil given in the text above; if there is something that you react to emotionally, be the emotion positive or negative, you have found an entrance to your inner soil.

13.6.4 Perspectives

A renowned soil scientist once confided to me: "*Basically, the soil is my girlfriend*." Another told me, after I gave a talk on "the soil scientist's hidden beloved" at a scientific conference: "*With me, too, there is, of what you gave examples in your presentation—but I feel it's better, not to speak about it*." Not everything which comes from inside can or should be announced and neatly laid out for examination—it is unlike a raw data collection which comes from outside. It has a different power, quality, and meaning.

The inspiring and guiding role of the unconscious psyche, not only in art and religion but also for the scientific quests of humans, has in some cases been documented. For example, the periodic table of the elements [Mendeleyev (Strathern 2000)], the benzene ring [Kekulé (Wotiz 1993)], the function of the acetylcholine in the body (Loewi 1960), the discovery of the automorphic functions (Poincaré 1912: 51-62) and of the Law of Quadratic Reciprocity (Gauss 1805) have been acknowledged by the authors as having involved the collaboration of the unconscious. But the help from the unconscious cannot be forced, the possibilities to 'tap' its knowledge are limited and the risk of being overwhelmed and possessed by it is always present. For the outer object of science, the ideal has been established that the relationship of scientists to it should be serious and honest. What, if this same ethical rule would be applied to the living mental beings of the inner soil?

Thus, the individual *relation* to the inner soil (instead of any 'mastering' approach) is so important—but delicate to (re-)establish, and even more delicate to talk about. For this purpose, we would have to dedicate more attention to the *language of living symbols* in science, too. Symbols can tie individual links with the non-graspable. This is why symbolic pictures and expressions are so important in arts and religions. The effects of living symbols on consciousness can complement the necessary attempts at conceptual understanding. It would go beyond the scope of this chapter to analyse the linkage of creativity to the interplay with the unconscious in more detail. But the documented evidence shows that the unconscious influences not only, what we *do with* what we find in science, but also what we *find* in science—and of course, what questions we pose. As a personal experiment with this hypothesis, the author (Patzel 2003) has systematically documented his own process of integrating dreams and respective interpretation work into the research process concerning soil fertility and soil science over some years.

In closing, let me introduce, for further reflection, another of the factors that may be important for the kind of relationship to the inner soil. It has to do with the kind of relation between the male and the female. The fertile earth is often compared by humans with their own feminine aspect, and therefore female qualities are perceived for the soil; so, the relation to the soil is also a relationship to the feminine. Considering further, that most authoritative scientists of modern soil science since 1800 were men, then, the relation to the soil is also a relation to the feminine, from a male-dominated human standpoint. For an individual or a culture which is dominated by male properties and ideals, the task to have an equal, fruitful and sustainable *relationship* with the feminine, is a difficult one, which requires personal and cultural change and engagement by women and man involved with the soil.

So, again, the question is posed: How could we personally and scientifically relate in an appropriate, fruitful, and sustainable way to our 'inner soil', so that it does not lead us to ideological one-sidedness and dogmatism, but may bestow on us just the right idea at the right moment, the energy and guiding symbols to follow our path to what our culture needs next?

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References

Abt Th (2005) Introduction to Picture Interpretation According to C.G. Jung. Living Human Heritage Publications, Zurich

Aristotle (no date) Corpus aristotelicum. Therein: De anima [about the soul] II 1, 412a, Metaphys. [beyond physics] VII.13, 1038b 1-6, IX.8, 1050a 9-16, Phys. [physics] III, 1

Bacon F (1623) De Dignitate et Augmentis Scientarum [On dignity and increase of science], caput III, London

Bacon F (1863) The Works of Francis Bacon, Baron of Verulam, Viscount St. Albans and Lord High Chancellor of England. Collected and edited by Spedding J, Ellis RL and Heath DD. Vol. VIII, being translations of the philosophical works, vol. I. Taggard and Thompson, Boston

Balfour Lady E (1943) The Living Soil. Evidence of the importance to human health of soil vitality, with special reference to post-war planning. Faber, London

Balfour Lady E (1978) Towards a Sustainable Agriculture. The Living Soil. The Soil Association Quarterly Review 4(2):1-5

Bütschli O (1901) Mechanismus und Vitalismus[Mechanism and vitalism]. Engelmann, Leipzig

Braeuning K. (1907) Mechanismus und Vitalismus in der Biologie des neunzehnten Jahrhunderts. Ein geschichtlicher Versuch [Mechanism and vitalism in 19th century biology. A historical draft]. Engelmann, Leipzig

Descartes R (1637) Discours de la méthode pour bien conduire sa raison, & chercher la verité dans les sciences [Treatise on the method of good self-conduction of the intellect and looking for the truth in science]. Imprimerie Ian Maire, Leyde

Descartes R (1649) Lettre à Morus, 5 février 1649 (extrait) [Letter to Morus, Feb. 5th, 1649 (exzerpt)]. Published on http://www.caute.lautre.net/article.php3?id_article=1431, 12th Sept 2005. Cited 1st March 2009

Dokuchaev VV (1949-51) Sochineniya [Works], vol. 6. Akad. Nauk SSSR, Moscow. Quoted from Dobrovol'skii (1996)

Dobrovol'skii (1996) Dokuchaev and Present-Day Natural Science. Eurasian Soil Science ["Official English Translation of Pochvovedenie"] 29(2):105-110. Translation from Pochvovedenie 1996(2):117-123

Driesch H (1922) Geschichte des Vitalismus [History of vitalism]. 2. verb. u. erw. Aufl. [2nd revised and enlarged ed.] (1. ed. 1905). Barth, Leipzig

Duchesneau F (1997) Territoires et frontières du vitalisme [Domains and frontiers of vitalism] (1750–1850). In: Cimino G and Duchesneau F: Vitalisms from Haller to the cell theory. Proceedings of the Zaragoza Symposium, XIXth Int. Congr. of Hist. of Sc., 22-29 Aug. 1993. Olschki, Firenze, 297-357

Engelhardt D von (1997) Vitalism Between Science and Philosophy in Germany Around 1800. In: Cimino G and Duchesneau F: Vitalisms from Haller to the Cell Theory. Proceedings of the Zaragoza Symposium, XIXth Int. Congr. of Hist. of Sc., 22-29 Aug. 1993. Olschki, Firenze, 157-174

Fallou FA (1857) Anfangsgründe der Bodenkunde [Founding of pedology]. G. Schönfeld's Buchhandlung, Dresden
Fallou FA (1862) Pedologie oder allgemeine und besondere Bodenkunde [Pedology or general and particular soil science]. G. Schönfeld's Buchhandlung, Dresden
Feller Ch (1997) The Concept of Soil Humus in the Past Three Centuries. Advances in GeoEcology 29:15-46
Feller Ch (2005) Quand l'humus est à l'origine de la pédologie. 1. Les traveaux du forestier danois P.E. Müller (1840–1926). [As humus stands at the beginning of pedology. 1. The works of the Danish forester P.E. Müller.] Étude et Gestion des Sols, Vol. 12(2):101–122
Frazer, JC (1914-18) The Golden Bough. A study in magic and religion (in twelve volumes). London, Macmillan
Gauss, CF (1805) Brief an Heinrich Olbers vom 2. Sept. 1805 [Letter to Heinrich Olbers from 3rd Sept. 1805]. Published on p. 268 in C. Schilling (1900): Carl Friedrich Gauss und Heinrich Wilhelm Matthias Olbers: Briefwechsel [correspondence]. Springer, Berlin
Heckman J (2006) A History of Organic Farming—Transitions from Sir Albert Howard's War in the Soil to the USDA National Organic Program. Renewable Agriculture and Food Systems, pp. 143–150. Electronic version published at http://www.westonaprice.org/farming/history-organic-farming.html. Cited 1st March 2009
Henning HL and Suntheim (1997) 1847 Erster Lehrstuhl für Agrikulturchemie in Deutschland [1847, first chair of agricultural chemistry in Germany]. VDLUFA-Kongressband 1997, VDLUFA Schrift Nr. 46
Hillel D (1991a) Out of the Earth. Aurum Press, London
Hillel D (1991b) In so many words: language in relation to soil. Soil Science 152(6):403-404
Hofstetter M (1941) Mutter, gib mir Brot! [Mother, give me bread!] In: Zimmermann W, Hofstetter M, Krebs G, Häusle P, Bertholet E: Mutter Erde – Weckruf und praktische Anleitung zum biologischen Landbau [Mother Earth—wake-up call and practical guide to organic agriculture]. Fankhauser, Zielbrücke-Thielle
Högger R (2000) The Cross-Ploughed Field [preprint]. Published later in: In Search of Sustainable Livelihood Systems. Managing Resources and Change. Edited by Ruedi Baumgartner and Ruedi Högger; Sage Publications India Pvt Ltd, New Delhi 2004, chapter 7:166-186
Howard Sir A (1940) An Agricultural Testament. Oxford University Press, London
Jenny H (1941) Factors of Soil Formation: A System of Quantitative Pedology. Reprint 1994, Dover Publications, Mineola, New York
Jenny H (1984) My Friend, the Soil. (Interview by K. Stuart.) Journal of Soil and Water Conservation 1984 (May-June):158-161
Jung CG (1968) Psychology and Alchemy. In Adler G and Hull RFC (series eds.), The Collected Works of C.G. Jung (vol. 12). Princeton University Press, Princeton (NJ). (Original work published 1952, 1st ed. 1944.)
Jung CG (1969) Archetypes and the Collective Unconscious. In Adler G and Hull RFC (series eds.), The Collected Works of C.G. Jung (vol. 9 part 1). Princeton University Press, Princeton (NJ). (The original works to this volume were published 1934–1955.)
Liebig J von (1851) Familiar Letters on Chemistry. London, Taylor, Walton & Maberly
Liebig J von (1878) Chemische Briefe. 6. Auflage. Neuer unveränderter Abdruck der Ausgabe letzter Hand [Familiar Letters on Chemistry, 6th ed. Reprint of the last edition by Liebig]. Winter'sche Verlagshandlung, Leipzig und Heidelberg
Loewi O (1960) An Autobiographical Sketch. Perspectives in Biology and Medicine 4(1). Reprint in Lambeck F and Giere W (1968): Otto Loewi. Ein Lebensbild in Dokumenten [Documents of a life]. Springer-Verlag, Berlin, 168-190
Lovelock JE (1979) Gaia: A New Look on Life on Earth. Oxford University Press
Maier M (1618) Atalanta fugiens, hoc est emblemata nova de secretis naturae chymica, … [The fleeing huntress, that is, the new chymical emblems of the secrets of nature …] Johann Theodor de Bry Publisher, Oppenheim

Mannhardt W (1875-77) Wald- und Feldkulte [Cults from woodlands and fields] (2 vol.). Reprint by Wissenschaftliche Buchgesellschaft, Darmstadt, 1963

Margulis L (1998) Symbiotic Planet. Basic Books, New York

Merchant C (1980) The Death of Nature: Women, Ecology, and the Scientific Revolution. Harper & Row, San Francisco

Müller PE (1887) Studien über die natürlichen Humusformen und deren Einwirkung auf Vegetation und Boden. Mit analytischen Belegen von C.F.A. Tuxen [Studies on natural humus forms and their effects on vegetation and soil. With analytical evidence from CFA Tuxen]. Springer, Berlin. (This book resulted from the translation of two Danish publications from 1879 und 1884.)

Neumann E (1972) The Great Mother: An Analysis of an Archetype. Transl. from German by Ralph Manheim. Princeton Univ. Press, Princeton

Northbourne Lord [James, WECh] (1940) Look to the Land. Supplementary title: We have tried to conquer nature by force and by intellect. It now remains for us to try the way of love. Dent, London

Patzel NF (2003) Bodenwissenschaften und das Unbewusste. Ein Beitrag zur Tiefenpsychologie der Naturwissenschaften. [Soil science and the unconscious. A contribution to depth psychology of natural science.] Ökom, München [Munic]

Poincaré H (1912) Science et méthode [Science and method]. Flammarion, Paris

Raupp J (2000) The well-proportioned farm organism. Just a pleasing image of a mixed farming system or rather a basic requirement for functioning organic husbandry? Proceedings of the 12th International IFOAM Conference, August 2000, vdf Hochschulverlag, Basel, 700-703

Rosenkranz O (1963) Zur Ökonomik der Bodenfruchtbarkeit [Concerning the economics of soil fertility. (the unusual term "Ökonomik" instead of "Ökonomie" is theory-loaded in the sense of "economic determinism")]. Zeitschrift für Agrarökonomik 6:195-200

Rusch H-P (1968) Bodenfruchtbarkeit. Eine Studie biologischen Denkens [Soil fertility. A study of biologic thinking]. Haug Verlag, Heidelberg

Rusch H-P (1953) Das Verfahren der biologischen Boden-Untersuchung [Method for biologic soil survey]. Kultur und Politik 8(1):13-18

Rusch H-P (1955) Naturwissenschaft von Morgen. Vorlesungen über Erhaltung und Kreislauf lebendiger Substanz [Science from tomorrow. Lectures on maintenance and cycling of living substance]. Emil Hartmann, Küsnacht

Rusch H-P (1960) Über Erhaltung und Kreislauf lebendiger Substanz [On maintenance and cycling of living substance]. Zeitschrift für Ganzheitsforschung 4:50-63

Schmitt M (2006) Fertile Minds and Friendly Pens: Early Women Pioneers. In G. Holt and M. Reed: Sociological Perspectives on Organic Agriculture. From Pioneer to Policy:56-69

Scofield AM (1986) Organic farming–the origin of the name. Biological Agriculture and Horticulture 4:1-5

Senft K (1888) Der Erdboden nach Entstehung, Eigenschaften und Verhalten zur Pflanzenwelt. Ein Lehrbuch für alle Freunde des Pflanzenreiches, namentlich aber für Forst- und Landwirthe [Origin and properties of the soil, and its relation to the flora. A textbook for all friends of the plant kingdom, but especially for forest engineers and farmers]. Hahn'sche Buchhandlung, Hannover

Sprengel C (1830) XIII. Ueber Rindviehharn. Schluss einer mehrteiligen Abhandlung [XIII. on cattle urine. Final part of a multi-part treatise]. Journal fuer technische und oeconomische Chemie von O. L. Erdmann 3(7):171-195

Stalin IW (1938) Dialectical and Historical Materialism. In: Stalin: Problems of Leninism, Foreign Language Press, Peking 1976:835-73

Steiner R (1984) Geisteswissenschaftliche Grundlagen zum Gedeihen der Landwirtschaft. Landwirtschaftlicher Kursus [Spiritual-scientific foundations for success in farming. The agricultural course]. 7th edition, Rudolf Steiner Verlag, Dornach. [Equivalent to Gesamtausgabe (complete works) vol. 327, 8th ed. 1999.]

Steiner R (1993) Der Mensch als Zusammenklang des schaffenden, bildenden und gestaltenden Weltenwortes [The human being as harmony of the creative, up-building, and formative world-word], 7th edition. Gesamtausgabe [complete works] vol. 230. Rudolf Steiner Verlag, Dornach

Steiner R (1998) Das christliche Mysterium [The Christian mystery], 3rd edition. Gesamtausgabe [complete works] vol. 97. Rudolf Steiner Verlag, Dornach

Stöckhardt A (1850) Schule der Chemie, oder erster Unterricht in der Chemie, versinnlicht durch einfache Experimente. Zum Schulgebrauch und zur Selbstbelehrung, insbesondere für angehende Apotheker, Landwirthe, Gewerbetreibende etc. Fünfte verbesserte Auflage [Chemistry school, or first instruction in chemistry, made evident by simple experiments. For teaching and autodidactic use, especially for becoming pharmacists, farmers, manufacturers etc. Fifth rev. ed.]. Vieweg, Braunschweig

Stöckhardt A (1851) Chemische Feldpredigten für deutsche Landwirthe [Chemical field sermons for German farmers]. Georg Wigands Verlag, Leipzig

Strathern P (2000) Mendeleyev's Dream. The Quest for the Elements. Hamish Hamilton, London

Thaer AD von (1821) Grundsätze der rationellen Landwirthschaft. 2. Bde. in einem [Principles of rational agriculture. 2 vols, in one]. Reimer, Berlin

US National Research Council, Board on Agriculture (1997) Precision Agriculture in the 21st Century. Geospatial and Information Technologies in Crop Management. National Academic Press, Washington D.C.

Weir JJF (1844) Catechism of Agricultural Chemistry and Geology. Blackwood, Edinburgh, and other publishers

Wistinghausen A von (1982) Erinnerungen an den Anfang der biologisch-dynamischen Wirtschaftsweise [Memories from the beginnings of biologic-dynamic farming practice]. Verlag Lebendige Erde, Darmstadt

Wolff G (1905) Mechanismus und Vitalismus [Mechanism and vitalism]. 2. ed. (1. ed. 1902). Thieme, Leipzig

Wotiz JH (1993, ed.) The Kekulé Riddle. A Challenge for Chemists and Psychologists. Cache River Press, Clearwater

Chapter 14
Comprehending Soil within the Context of the Land Community

Frederick Kirschenmann

> *We must look at our present civilization as a whole and realize once and for all the great principle that the activities of homosapiens, which have created the machine age in which we are now living, are based on a very insecure basis---the surplus food made available by the plunder of the stores of soil fertility which are not ours but the property of generations yet to come.*
>
> Sir Albert Howard, *The Soil and Health (1947)*

The foundation of modern science has deep roots in Western culture, reaching back to the 16th and 17th centuries. The central dogma underlying this science is rooted in the mathematics-based science of Rene Descartes. As he articulated in his *Meditations* published in 1641, Descartes believed that one could and must separate the thinking mind (or subject) from the material world (or object). By doing so, he believed one could establish objective certainty, wholly determinable, and free of any subjective bias. It was on this basis that Descartes reduced material reality to mechanical functions. This perspective formed the basis of the "disinterested" sciences and eventually yielded the knowledge, technologies and culture that spawned the industrial revolution and ultimately industrial agriculture. This philosophy of science also shaped our perceptions of soil within modern agriculture.

Descartes' view of the world as a collection of mechanistic fragments was part of an emerging school of thought at the time. Francis Bacon, a contemporary who espoused this same philosophy, promoted the idea that nature must be controlled and manipulated for the exclusive benefit of humans. He asserted that we needed to "bend nature to our will." Descartes, in turn, was convinced that with his new science we would become the "masters and possessors of nature." This scientific dogma perpetuated a form of human arrogance which led us to believe that we were what Aldo Leopold warned us not to be: the "conquerors" of the land community.

Together Descartes and Bacon led the way in developing a culture that viewed nature, including soil, as a collection of mechanistic fragments to be manipulated for our own benefit. Perceiving nature as a collection of objects separate from us

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and promoting the belief that nature could be controlled and dominated for our benefit made it inevitable that most soil scientists would view soil as a thing to be manipulated rather than a web of relationships to be appreciated. Sir Albert Howard, Aldo Leopold, Hans Jenny and a few others were the exception to the rule.

Influenced by Cartesian science, Justus von Liebig published his *Chemistry in the Application to Agriculture and Physiology* in 1840. While Von Liebig still adhered to some ecological principles, he believed that we could simplify agricultural production and increase crop yields without the laborious task of enhancing humus in the soil. By inserting chemical fertilizers into the soil he contended that we could significantly increase crop yields. In 1843 John Bennett Lawes and J. H. Gilbert manufactured and patented superphosphates, built the first fertilizer factory and proceeded to demonstrate the validity of Liebig's thesis. Eventually the ability to substitute chemical fertilizers for nutrient cycling practices encouraged farmers to specialize, focus on a few high-value crops grown in monocultures, and abandon integrated crop/livestock systems which incorporated livestock manure and green manure into the soil to an extent that Liebig probably could not have imagined.

Sir Albert Howard and a few other agriculturalists at the time took strong exception to this approach to soil management. Howard complained that given what he called Liebig's "NPK mentality,"

> . . . the soil in general and the humus in it were looked on as mere collections of material without organic growth of their own; there was no conception of their living nature and no knowledge whatever of fungous or bacterial organisms, of which humus is the habitat. Liebig had no difficulty in disproving the role of humus when presented in this faulty way as dead matter almost insoluble in water. He substituted for it a correct appreciation of the chemical and mineral contents of the soil and of the part these constituents play in plant nourishment.
>
> This was a great advance, but it was not noticed at the time that only a fraction of the facts had been dealt with. To a certain extent this narrowness was corrected when Darwin in 1882 published *The Formation of Vegetable Mould Through the Action ofWorms, with Observations of Their Habitat*, a book founded on prolonged and acute observation of natural life. The effect of this study was to draw attention to the extraordinary cumulative result of a physical turnover of soil particles by natural agents, particularly earthworms. It was a salutary return to the observation of the life of the soil and has the supreme merit of grasping the gearing together of the soil itself and of the creatures who inhabit it (Howard 2006).

Other agriculturalists of his day shared Howard's dismay at this "machine age" approach to managing the soil. But the powerful allure of the simple, effective, almost majestic way in which the soil seemed to respond to the need to increase productivity proved too seductive for most agriculturalists to ignore. As Aldo Leopold observed in 1945,

> It was inevitable and no doubt desirable that the tremendous momentum of industrialization should have spread to farm life.

However, like Howard, Leopold (1999) also recognized the vulnerabilities of this industrial approach.

It is clear to me, however, that it has overshot the mark, in the sense that it is generating new insecurities, economic and ecological, in place of those it was meant to abolish. In its extreme form, it is humanly desolate and economically unstable. These extremes will some day die of their own too-much, not because they are bad for wildlife, but because they are bad for the farmers.

14.1 The Role of Soil in the Future of Agriculture

As we enter the 21st century, the insecurities perceived by Leopold are beginning to manifest themselves, and there are urgent reasons to reevaluate the way we have come to think about soil. There are at least three natural resources essential to the successful management of the NPK method, and each of them now face steep declines.

The first of these essential resources is *energy.* The industrial input/output system, the foundation of our modern industrial agriculture production system, depends almost entirely on fossil fuels. The nitrogen used for fertilizer is derived from natural gas. Phosphorus and potash are mined, processed and transported to farms with petroleum energy. Pesticides are manufactured from petroleum resources. Farm equipment is manufactured and operated using petroleum-based energy.

As long as fossil fuels were abundantly available, they provided a cheap source of energy for this energy-intensive input/output soil management system, making it difficult for Howard's self-renewing, recycling system to compete. Most independent scholars agree, however, that we now have either reached peak oil production or will do so shortly (Heinberg 2004, Roberts 2004). The era of cheap energy is over and, more than any other natural resource, the lack of cheap energy may force us to rethink the way we manage soil and begin considering how we can restore the soil's natural vitality.

Of course alternatives to fossil fuel energy are available—wind, solar, biofuels, etc.—so theoretically, one could contemplate replacing oil and natural gas with alternative sources of energy to keep industrial agriculture viable. But the reality that we must face is that our industrial economy was created on a platform of *stored, concentrated energy* which produced a very favorable energy *profit ratio*—the amount of energy yield less the amount of energy expended to make it available. Alternative energy sources are based on *current, dispersed* energy, which has a far lower energy profit ratio.

The primary sources of stored, concentrated energy are coal, oil and natural gas. So far as anyone knows, there are no other sources of stored, concentrated energy available on the planet. Consequently, economies based on industrial production systems fueled by cheap energy are not likely to fare well in the future. That is why the depletion of our fossil fuel resources not only will require that we transition to *alternative* fuels to produce our food, but also that we adopt a new energy *system.*

The real energy transition that we must contemplate is converting from an energy *input* system to an energy *exchange* system, a system that potentially could employ some of Howard's principles of soil management. Soil management will have to be incorporated into systems based on biological diversity, organized so that each organism exchanges energy with other organisms in the land community, forming a web of synchronous relationships, instead of relying on energy-intensive inputs.

A relatively *stable climate* is the second natural resource that has been essential to the success of the highly specialized production, industrial input/output soil management paradigm. We often mistakenly attribute the yield-producing success of the industrial soil management system entirely to the development of the new production technologies that were developed in the last century. In fact those robust yields were at least as much due to unusually favorable climate conditions as they were to technology. Such advantageous climates are atypical for planet earth so as more unstable climates return it will pose additional challenges for highly specialized production systems.

A National Academy of Sciences (NAS) Panel on Climate Variations reported in 1975 that "our present [stable] climate is in fact highly *abnormal*," and that "the earth's climates have always been changing, and the magnitude of . . . the changes can be catastrophic." The report went on to suggest that "the global patterns of food production and population that have evolved are *implicitly dependent* on the climate of the present century." It further suggested that climate change might be further exacerbated by "our own activities." (NAS 1975) According to NAS, this *combination* of "normal" climate variation *plus* the changes stemming from our own industrial economies (greenhouse gas emissions) could have a significant impact on our future agricultural productivity.

Given our current soil management paradigm, the impact of such climate change on production agriculture could be especially severe. While it is impossible to predict exactly how climate change will affect agricultural production in the near term (Rosenzweig and Hillel 1995), most climatologists agree that we can anticipate greater climate fluctuations—"extremes of precipitation, both droughts and floods" (Rosenzweig et al. 2001). Such instability can be especially devastating for the highly specialized, genetically uniform, monoculture systems so characteristic of industrial agriculture.

A third natural resource that may challenge our current soil management system is *water*. Lester Brown points out that while we each require only four liters of water to meet our daily liquid needs, our current industrial agriculture system consumes 2,000 liters per day to produce each of our daily food requirements. A significant amount of that water is used by production agriculture under our current soil management system. Agricultural irrigation alone consumes more than 70 percent of our global fresh water resources (Brown 2006). We use twice the amount of water for agricultural irrigation today as we did in the 1960s. We are drawing down our fresh water resources at an unsustainable rate.

Water tables in the Ogallala Aquifer, which supplies water for one of every five irrigated acres in the United States, are being overdrawn at the rate of 3.1 trillion gallons per year (BBC 2000), and according to some reports, this fossil water bank is now half depleted (Soule and Piper 1992).

Reduced snow packs in mountainous regions due to climate change will decrease spring run off (a primary source of irrigation water in many parts of the world), further stressing our water shortages.

14.2 Back to the Future

We know both from research and on-farm experience that when soils are managed in accord with the “law of return,” the soil’s capacity to absorb and retain moisture is significantly enhanced, reducing the need for irrigation. We also know from on-farm experience (as well as from nature’s own elasticity) that diverse systems are more resilient than monocultures and therefore perform better under adverse climate conditions. On-farm experience also tells us that energy inputs can be dramatically reduced when input/output systems are replaced by recycling systems. This has been especially pertinent on our own farm in North Dakota (which we operate by organic standards) now that fertilizer costs are spiraling upward. The increased cost of applying compost and managing green manure cover crops has been modest compared with the three-fold increase in the cost of anhydrous ammonia and phosphorus.

All of these factors give renewed credence to Howard’s soil management vision. It might be prudent to seek new ways to adopt his principles on the landscape as we face our challenging, post-industrial future.

Exploring new insights developed by modern ecology and evolutionary biology and applying them to modern nutrient recycling and humus-based farming could provide us with additional critically needed intellectual capital. Such knowledge could assist us in developing concrete models of humus-building soil management and ecologically based farming systems appropriate to farms within specific ecosystems.

Soil is, of course, a very dynamic system, with its own local characteristics and patterns of accumulation and erosion for millennia (Charman and Murray 2000). Soil erosion due to human activity has for centuries been a major contributing factor to humankind’s failure to sustain civilized societies (Lowdermilk 1953), and there is no good reason to believe that our current civilization is exempt from a similar fate.

Yet, while soil loss due to wind and water erosion contributes significantly to diminished soil quality, a more troubling aspect of soil loss as we enter a world devoid of cheap energy, surplus water and stable climates, is the drawdown of much of the remaining soil’s “stored fertility,” as Howard (2006) described humus-rich soil.

As we navigate our way toward a program of soil management that addresses our future challenges it becomes especially important to remember that soil is “not a thing” but “a web of relationships”, always unique to its time and place (Logan 1995). Soil, as Hans Jenny noted, is “part of a much larger system that is composed of the upper part of the lithosphere, the lower part of the atmosphere, and a considerable part of the biosphere” (Jenny 1941). The living organisms in the soil then become part of soil formation in relationship to all the other factors like climate, topography, parent material, time, nitrogen content, etc. Life in the soil adapts to its place as do other life forms. As a dynamic system, soil can be managed to dramatically reduce energy and water consumption, and produce a more resilient, diverse landscape that can sustain productivity in the face of unstable climates.

We now know from considerable research that soil which is managed as a complex set of relationships, including the use of green manure and livestock manure, can solve many of the production problems which our industrial farming systems now solve with costly inputs that seldom address the root of the problem and require excessive energy inputs (Mador et al. 2002). The Land Institute in Salina, Kansas has also demonstrated that perennials can play a key role in improving soil health, increasing water absorption and reducing energy inputs.

Unfortunately, cheap fossil fuel energy enabled us to use artificial inputs to increase food production without attending to intrinsic soil quality (Russelle et al. 2007). Embracing the "NPK mentality," we ignored the law of return, and now we are left with soils essentially depleted of vigor. Recent research has reconfirmed that soil health is not likely to be restored without the return of organic inputs in the form of cover crops, manure and other waste materials (Teasdale et al. 2007). Therefore, managing our soil to restore and enhance its self-renewing and self-regulating capacity will be critical to maintaining productivity in our post-industrial world.

As Leopold (1949) observed, "The art of land doctoring is being practiced with vigor, but the science of land health is yet to be born."

14.3 Establishing a New Land Community on the Farm

So how can we proceed to make this paradigm shift in managing soil? Since farmers have been indoctrinated to believe that yields can only be maximized by inserting a few artificial nutrients (the NPK mentality), that no-till (notwithstanding all its benefits) is the silver bullet solution to soil depletion, and that crop residues are "waste materials," it may be challenging to sell them on managing soil as a web of relationships.

While clearly not welcomed by farmers, rising energy costs, restricted water use and more unstable climates, have combined with the growing awareness that the industrial system is rife with its own failures. These new conditions could well cause farmers to seek alternatives faster than we can currently imagine.

Some contemporary researchers already have begun to point out the deficiencies of the industrial farming system. Joe Lewis of the US Department of Agriculture's Agricultural Research Service (ARS) and his colleagues from Wageningen Agricultural University, the University of Georgia Agricultural Experiment Station, and ARS (Lewis et al. 1997), for example, clearly articulate the failure of the industrial "single tactic" "therapeutic intervention" strategy (while ignoring the web of relationships in ecosystems management) as applied to pest management. They call attention to the opportunities inherent in alternative ecosystem management tactics that in some ways echo Howard's soil management principles. They point out that while it may "seem that an optimal corrective action for an undesired entity is to apply a direct external counter force against it," in fact "such interventionist actions never produce sustainable desired effects. Rather, the attempted solution becomes the problem." The alternative, they propose is "an understanding and shoring up of the full composite of inherent plant defenses, plant mixtures, soil, natural enemies, and other components of the system. These natural 'built in' regulators are linked in a web of feedback loops and are renewable and sustainable." (Lewis at al. 1997)

Approaching pest management or weed control from this ecological perspective always involves a web of relationships that include the way soil is managed. "For example, problems with soil erosion have resulted in major thrusts in use of winter cover corps and conservation tillage. Preliminary studies indicate that cover crops also serve as a bridge/refugia to stabilize natural enemy/pest balances and relay these balances into the crop season." (Lewis at al. 1997). In short, such natural systems management can revitalize soil health, reduce weed and other pest pressures, get farmers off the pesticide treadmill, and begin the transition from an energy-intensive industrial farming operation to a self-regulating, self-renewing one.

Another example of this new web-of-relationships thinking is evident in Rattan Lal's warning about using crop residues as a source of renewable energy. He perceives this is

> . . . a dangerous trend because crop residue is not a waste. It is a precious commodity and essential to preserving soil quality. In addition to controlling erosion and conserving soil water in the root zone, retaining crop residues on the soil is also necessary for recycling nutrients, improving activity and species diversity of soil micro- and macro-fauna, maintaining soil structure and tilth, reducing nonpoint source pollution and decreasing the risks of hypoxia in the coastal regions, increasing use efficiency of fertilizers and other inputs, sustaining biomass/agronomic yield, and improving/maintaining soil organic matter content (Lal 2007).

Other benefits, such as greater water conservation, flow from improved soil health. As research conducted by John Reganold (1987) and his colleagues has demonstrated, soil managed in accordance with the "law of return" develops richer topsoil, more than twice the organic matter, added biological activity, and far greater moisture absorption and holding capacity.

Such soil management serves as an example of how we can begin to move to an energy system that operates on the basis of energy *exchange* instead of energy *input*. But more innovation is needed. Nature is a highly efficient energy manager. All of its energy comes from sunlight, which is processed into carbon through photosynthesis and becomes available to various organisms, which exchange energy through a web of relationships. Bison on the prairie obtain their energy from the grass, which absorbs energy from the soil. The bison deposit their excrement back onto the grass, which provides energy for insects and other organisms which, in turn, convert it to energy that enriches the soil to produce more grass. These sorts of energy exchange systems could restore and renew our post-industrial farming systems, but currently, very little research is devoted to exploring such energy exchanges on a farm scale.

Fortunately a few farmers already have developed such energy exchange systems and appear to be quite successful in managing their operations with reduced fossil fuel input (Kirschenmann 2007). Converting farms to this new energy model involves a major transformation. Highly specialized, energy-intensive monocultures will need to be converted to complex, highly diversified operations that function on energy exchange. The practicality and multiple benefits of such integrated crop-livestock operations have been established through research (Russelle et al. 2007), but further study will be needed to adapt this new model of farming to various climates, watersheds and ecosystems. And, of course, markets, food industry infrastructures, and public policies will have to be redesigned to support the new food and farming systems.

14.4 A New Science for a New Agriculture

Since Cartesian science informed the industrial agriculture of the last century, it might be well to consider a new science for the more ecologically based agriculture needed in the next century.

In his creative book, David Abram (1996) succinctly describes the core issue.

> Ecologically considered, it is not primarily our verbal statements that are 'true' or 'false,' but rather the kind of relations that we sustain with the rest of nature . . . A civilization that relentlessly destroys the living land it inhabits is not well acquainted with *truth*, regardless of how many supposed facts it has amassed regarding the calculable properties of its world.

In other words the proof is in the pudding, not the recipe. Establishing scientific "truth" that addresses the issue of sustainability in an ecological rather than an ideological sense is perhaps one of our most important pending scientific challenges. Our future as a species on the planet may depend on it. But how do we *know* what it means to find the truth in an ecological sense? How can science help us?

In this regard, some of the insights provided by Michael Polanyi (1946, 1958, 1967, 1969), a 20th century Hungarian physicist/philosopher, offer tools for rethinking the epistemological scientific paradigm for science for the 21st century. Four key components of Polanyi's vision of science are, I think, extremely helpful for understanding our world, including soil, from an ecological perspective.

Indwelling. Polanyi reminds us that we can never totally separate ourselves from the phenomenon we are trying to understand. Contrary to the objectivist science of Descartes, Polanyi argues that it is never possible to separate the knower from the known. We always dwell *in* what we know or seek to understand. Such indwelling is not to be confused with subjectivism, however. Subjectivism and objectivism are both victims of the same fallacy. Objectivism assumes the knower can separate himself from what he experiences *externally* and therefore can establish certitude, while subjectivism assumes that the knower can separate himself from what he experiences *internally* and therefore can establish certitude. Both ignore the fact that no knowledge exists apart from the participation of the knowing person in the knowing process. The only way we can know anything is by dwelling in the clues that point to a meaning we are struggling to understand. We know soils best when we dwell in them the way Darwin did when he dwelt in the world of earthworms while writing *The Formation of Mould Through the Action of Worms, with Observations of Their Habitat*.

All Knowledge Contains Three Poles. All knowledge is an activity that contains three poles: the knower, our subsidiary awareness (a multitude of our experiences, beliefs, memories and sensory operations), and our focal awareness (the focus of our attention–that which we are striving to understand). All knowledge therefore exists in a from-to relationship. Given the three-fold nature of the knowing process, knowledge can never consist of precise information. Knowledge is always a skillful act performed by the knower, who perpetually relies on that which he tacitly holds to be true in order to attend to that which he is struggling to understand. Understanding the complex web of relationships that make up the dynamic soil ecology is a constant, ongoing process.

Discovery. We are in a continual state of discovery. All sentient beings struggle to discern more coherent and comprehensive integrations of meaning. Accordingly, we are continually driven to uncover more satisfying interpretations of reality. The knowing process, therefore, is not a mechanical accumulation of exact, precise findings, but a heuristic enterprise that includes many false starts and numerous surprises along the way. For Polanyi, this means there is no such thing as dispassionate, value-free inquiry. Our inclination to constantly find new integrations of meaning is driven by passion, and to some extent passion is always shaped by our tacit awareness. We probably know soils best when we are personally engaged in the process of ongoing discovery, as Howard was, and remain fascinated by how much we still expect to discover in the future.

Commitment and Risk. The knowing process, according to Polanyi, always begins as an act of faith. Since truth can never be established independent of the knower, the knower always has to begin with certain assumptions; that words have meaning, the scientific method is reliable, and the truth we seek to discover actually exists. This means that all knowledge carries a risk and "an inevitable tension between our conviction that we know something, and the realization that we may conceivably be mistaken." Given this tension, there is no way to escape personal vulnerability or the need to constantly verify our perceptions with those of others similarly engaged. There is no way that an outside observer can "compare another person's knowledge of the truth with the truth itself. He can only compare the observed person's knowledge of the truth with his own knowledge of it." (Polanyi 1958)

It is our dependence on the perceptions of others to validate our own conclusions that mandates the need for a scientific community, or what Polanyi liked to call "the society of explorers." There is no way that we can verify the "truth" of our perceptions of soil without subjecting them to the perceptions of others who are similarly focused on an understanding of soil. This makes a "community" of soil ecologists indispensable to our ongoing exploration of soil science. It also mandates that humility be an essential component of the scientific enterprise.

14.5 Soil Science as Conversation

Harvard University geneticist Richard Lewontin reminds us that the environment in which we live exists only by virtue of millions of organisms modifying and reshaping their environment out of the bits and pieces available to them. In the course of this activity, they create challenges and opportunities for all the other species that share their space in an ecosystem (Lewontin 2000). This suggests a picture of the earth that is dynamic, constantly changing and emerging, and highly interdependent. The earth is a vibrant biotic community. Soil is simply a part of that dynamic land community as Leopold recognized more than a half century ago.

This description of our world suggests that the most appropriate science is not one that leads us to detach ourselves from the land community in the interest of some kind of supposed objectivity, nor one that attempts to oversimplify the complexity of that community, nor one that presumes we can know all we need to know about that community to implement technological innovations with impunity. The most appropriate science would be one that invites us into conversation with that biotic community and engaging that community with a reasonable amount of humility.

In an enlightening essay entitled "Ecological Conversations," Stephen Talbott (2002) suggests some guidelines we might use for such conversations with the soil. First he suggests that every technique we use, every industrial process we initiate, and every technology we introduce should be "a question put to nature." With each of our innovations we are trying to remedy some ignorance, and for precisely that reason we should act with caution and humility. We should never introduce a technology as an answer to a problem; rather it should be introduced as a question put to nature.

Such an approach is consistent with the observation by Joe Lewis and his colleagues that in pest management we should always begin with the question, "Why is the pest a pest?" rather than "How do I get rid of the pest?" The first question engages us in dialogue with the problem, while the second presumes we know all we need to know to introduce a solution. Managing soil appropriately might best begin by having a conversation with the soil we intend to manage.

Second, Talbott points out that in a conversation, we are always, to some extent, "compensating for past inadequacies." So part of any conversation with the soil involves an attempt to heal what we have harmed in prior conversations. It is always better to admit this at the outset. Ignoring the harm we have done in the past likely will lead to similar or even worse errors in the future. Part of the scientific task is to learn how to continually enhance the health of the land community as we converse with it. And, as Aldo Leopold (1949) prompted us, health, in this context, is the capacity of the biotic community to renew itself. Our task is not to "save" the environment, nor to preserve things as they are, (neither of which is possible in a web of dynamic relationships) but to engage the biotic community in ways that enhance its capacity for self-renewal.

Third, in a conversation with the soil, there is never any single right or wrong response. This is where creativity comes in. The alternatives that exist depend in large part on the alternatives we encourage. Good science is inventive. Declaring that there is but one universal way to manage soil is to mismanage it.

Fourth, conversation always takes place in the particular. We cannot have a conversation with an abstraction. We can only have conversations with particular individuals. We cannot reasonably save a species, we can only engage in the work of restoring a particular habitat of a particular species. We cannot reasonably feed the world, we can only engage in activities that improve the food sovereignty of particular villages or communities. We cannot reasonably devise a program to manage all soils properly, we can only engage farmers in a process that involves them in conversation with their own soils.

Conversation is a useful metaphor for describing good science and good soil management. Unfortunately much of the science of the industrial world has been a monologue rather than dialogue. We *(homo sapiens)* decide what technological innovations to introduce based on what *we* believe will enrich *us* without any regard for the impact such innovations will have on the larger biotic community. At the same time, we insist that we are operating in concert with "sound science" and that all of our decisions are "science-based." We behave as if the biotic community belongs to *us*, rather than entertaining the possibility that, as Leopold (1949) put it, we are simply "plain members and citizens" of that land community.

Accordingly it would seem that soil science in the future should spend more of its resources mapping the intricate web of relationships found in the soil, and less time and energy treating soil like a thing to be manipulated. It should spend more time ensuring the future productivity of agriculture by learning to understand the self-renewing and self-regulating dynamics of healthy soil, and less inventing new technologies to make certain components of the soil perform to our expectations, or to target singular pest problems.

And since (as Hans Jenny told us) soil always adapts to its place, good soil science also is local. As David Abram (1996) reminds us, "We can know the needs of any particular region only by participating in its specificity---by becoming familiar with its cycles and styles, awake and attentive to its other inhabitants." That suggests that good soil science is more likely to be conducted in the context of local cultures and local ecologies, rather than in some abstract, universal global economy.

References

Abram D (1996) The Spell of the Sensuous. Random House, New York, NY, p. 264, 268

BBC. http:/news.bbc.co.uk/hi/english/static/in_depth/world/2000/world_water-crisis/default.htm. (Cited 8 Feb 2007)

Brown LR (2006) Plan B 2.0. W.W. Norton and Company, New York, NY, p. 42-44

Charman PEV, Murphy BW (eds) (2000) Soils: Their Properties and Management. Second Edition. Oxford University Press, New York, NY, p. 14-15

Grene M (ed) (1969) Knowing and Being: Essays by Michael Polanyi. University of Chicago Press, Chicago, IL

Heinberg R (2004) Power Down. New Society Publishers, Gabriola Island, BC, Canada
Howard A (2006) The Soil and Health. (New Edition) University of Kentucky Press, Lexington, p. 59, 70
Jenny H (1941) Factors of Soil Formation. McGraw-Hill Book Company, Inc., New York, NY, p. 8, 198
Kirschenmann FK (2007) Potential for a new generation of biodiversity in agroecosystems of the future. Agronomy Journal March-April 99:2
Lal, R (2007) There is no such thing as a free biofuel from crop residues. Crop, Soils, Agronomy News May 52:5
Leopold A (1999) The outlook for farm wildlife. In: Callicott JB, Freyfogle ET (eds) Aldo Leopold: For the Health of the Land. Island Press, Washington, D.C.
Leopold A (1949) A Sand County Almanac. Oxford University Press, New York, NY, p. 196, 204, 221
Lewis WJ, Lenteren JC, Phatak SC, Tumlinson JH III. (1997) A total system approach to sustainable pest management. Proceedings, National Academy of Sciences 94 12243-8
Lewontin R (2000) The Triple Helix. Harvard University Press, Cambridge, MA
Logan WB (1995) Dirt: The Ecstatic Skin of the Earth. W.W. Norton and Company, New York, NY 63. *(Logan here reflects what Hans Jenny has been saying about soil his "whole life.")*
Lowdermilk WC (1953) Conquest of the Land through 7,000 Years. U.S. Department of Agriculture, Soil Conservation Service, Agriculture Information Bulletin 99. GPO,Washington, D.C.
Mador P et al. (2002) Soil fertility and biodiversity in organic farming. *Science* 296. 31 May
National Academy of Sciences. (1975) Report of the Panel on Climate Variations. Understanding Climate Change. Washington, D.C. (*emphasis mine*)
M. Polanyi M (1958) Personal Knowledge: Towards a Post-Critical Philosophy. Chicago: University of Chicago Press, Chicago, IL
(1964) Science, Faith and Society. Phoenix Books, Chicago, IL
(1967) The Tacit Dimension. Doubleday, New York, NY
(1969) Knowing and Being: Essays by Michael Polanyi. Grene M (ed) University of Chicago Press, Chicago, IL
Reganold JP, Elliott LF, Unger YL (1987) Long-term effects of organic and conventional farming on soil erosion. Nature, 330:370-2
Reganold JP, Glover JD, Andrews PK, Hinman HR (2001) Sustainability of three apple production systems. Nature 410 926-30
Roberts P (2004) The End of Oil. Houghton Mifflin Company, Boston, MA
Rosenzweig C, Hillel D (1995) Potential impacts of climate change on agriculture and food supply. Consequences. 1:2 Summer
Rosenzweig C, Iglesias A, Yang XB, Epstein PR, Chivian E (2001) Climate change and extreme weather events: implications for food production, plant diseases and pests. Global Change and Human Health 2:2 December
Russelle MP, Entz MH, Franzluebbers AJ (2007) Reconsidering integrated crop-livestock systems in North America. Agronomy Journal March/April. 99:2
Soule, JD, Piper JK (1992) Farming in Nature's Image: An Ecological Approach to Agriculture. Island Press, Washington, D.C.
Talbott SL (2002) Ecological conversations. *Netfuture*. #127. http://www.netfuture.org/ (Cited 18 April 2004)
Teasdale JR, Coffman CB, Mangum RB (2007) Potential long-term benefits of no-tillage and organic cropping systems for grain production and soil improvement. Agronomy Journal September/October 99:5 1304

Chapter 15
Core Samples of the Sublime—On the Aesthetics of Dirt

Alexandra Toland and Gerd Wessolek

15.1 Digging for Beauty

Is it possible to marvel at grains of sand as we would fine brushstrokes, to listen to infiltrating rainwater as we would a symphony, or to read geologic processes as we would an epic novel? While art may communicate environmental concepts differently than soil science, it does not necessarily guarantee an aesthetic appreciation for subterraneous environments *as such*. Art may serve to "offer soil a new, more up-to-date image in addition to its undisputed ecological significance" (Wessolek 2002), but should not exclude the aesthetic appreciation of soils in the absence of artistic intention. What aesthetic features or experiences do soils have to offer, and how do these correlate with or differ from other aesthetic experiences in nature? Do soil scientists consider different aesthetic criteria compared to artists or the general public? (See thought sketch, Fig. 15.1) In light of a recent survey on the aesthetic and artistic prospects of soil science, carried out at the German Soil Science Society's annual conference in 2007, we will consider several models of appreciation in the establishment of an "aesthetic of dirt," and in so doing, make a conscious distinction between the appreciation of soil *as such,* and photographs, preserved monoliths, scientific models, artworks, and other representations thereof.

To begin our task, we must first considerably readjust our guidelines for accepted beauty. After all, it is admittedly difficult for most people to sympathize or identify with a resource generally regarded as dirt. Appreciation of seascapes or mountain vistas seems entirely natural, but what about the underworld realms of loam, sand, and clay—environments which are not always visible for us to focus our gaze upon, let alone judge as breathtakingly beautiful? We cannot watch the silent, seeping,

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Fig 15.1 *"Soil Criteria"* painted by Gerd Wessolek, 2007. *Reproduced here by permission of the author* (see as color plate following *Index*)

leaching processes of one horizon melting into the next, in the same way that we can watch the setting sun in a spectacular rose colored sky. We cannot physically experience the slow-motion weathering of bedrock in the same way that we experience the pelting force of falling rain, even when it is that very force that helps transform rock into soil. Long-term processes, such as the development of new soil minerals or the displacement of calcium, iron, or other elements in the soil profile, are not usually observable within the short lifetime of a human being. While we are awed by the thundering roar of a waterfall, we do not usually register the silent power of groundwater. Few are aware of the life-giving upward soil water flux (capillary rise) from the groundwater table to the root zone, and few realize the effects of sinking groundwater levels, or the loss of peat soils due to over-drainage of the pore system. We do not usually appreciate annual changes in river discharge and its load of suspended, fertile sediment—though many live in fear of catastrophic floods. Our spatial-temporal frame of reference is that of another scale. We must accordingly dig a bit deeper if we are to formulate arguments for the aesthetic appreciation of soil.

15.2 Applied Models for the Aesthetic Appreciation of Soil

Although aesthetics has historically been equated with the philosophy of art, aesthetic experience, especially in the appreciation of nature, quite often takes place in the absence of artists and their artistic endeavors. Nature however, reaching back to the traditions of Kant and Hegel, has long been perceived and aesthetically judged as if it were art: landscape vistas judged on the same basis as landscape paintings, natural objects as sculptural objects, and so on. Yet nature's infinite scope and lack of authorship puts it into a completely different category of aesthetic appreciation that should be handled in its own right.

Inspired by Ronald Hepburn's essay, "Contemporary Aesthetics and the Neglect of Natural Beauty" (1966), a thriving discussion on environmental aesthetics has evolved, distinguishing appropriate attitudes towards nature, from those dealing with art. In the "Aesthetic Appreciation of Nature," Malcolm Budd (2002*a*, p. 110) summarizes Hepburn's original argument as follows:

> First, there is the idea that, through being both in and a part of nature, our aesthetic involvement with nature is typically both as actors and spectators. Second… in contrast to works of art, natural things are not set apart from their environment as objects of aesthetic interest… they are "frameless." Third… aesthetic experience of nature should not be restricted to the contemplation of uninterrupted shapes, colors, patterns, and movements. Finally… the imaginative realization of the forces or processes that are responsible for a natural thing's appearance or that are active in a natural phenomenon is a principal activity in the aesthetic experience of nature."

These initial ideas, especially the aspects of involvement and imagination, are interesting to consider with regard to the appreciation of soil. Indeed, it is nearly impossible to experience the earth under our feet without involving ourselves to some extent in the immediate environment, or at least getting our boots a bit muddy. Involvement, however, usually requires attention on many levels, making it improbable that our focus is always and only on the soil under our feet, and not also on the larger environment. Reflecting the tenets of ecology as the study of endless interactions between organisms and their environments, environmental aesthetics is similarly concerned with creating models of appreciation for whole ecosystems, rather than parts thereof.[i] How then, are we to establish an "aesthetics of dirt," without in so doing, separating soil from the rest of the environment?

Soil is regarded here as an integrated part of an environmental whole, seen aesthetically as a fundamental part of "the larger picture." Without attempting to fully decipher the theoretical models presented below, we intend to provide a set of ideas adapted from the field of environmental aesthetics, which will hopefully offer new ways of appreciating, understanding and protecting soil as a natural resource. While the proposed aesthetic framework does not necessarily reflect traditional land evaluation methods, it may offer new perspectives for conservation and educational strategies, and makes a case for pedogenetic beauty, independent of artistic intervention.

15.2.1 Rousing Scientific Imagination—Models of Cognitivism and Creativity

Of the major contributions to environmental aesthetics, Allen Carlson's body of work, and in particular his natural environmental model, are of significance for us here. Carlson's basic premise is that as we turn towards art historians, curators and museum directors to guide us in our understanding and appreciation of art, we must similarly turn towards scientific experts to clarify and enhance our experience of nature. As one's experience of contemporary art is enriched by catalogue guides, exhibition tours or other expert publications, a walk through the woods may be enriched by field guides, educational trails and tours led by naturalists. Carlson (2000*a*, p. 6) outlines the science-based approach to the aesthetic appreciation of nature:

> "First… as in our appreciation of works of art, we must appreciate nature for what it is, that is as natural and as an environment. Second… we must appreciate nature in light of our knowledge of what it is, that is, in light of knowledge provided by the natural sciences, especially the environmental sciences such as geology, biology and ecology."

This contention seems particularly applicable with regard to the complex world below the earth's surface. To begin with, while many physical properties of soils may be considered aesthetically interesting, when exposed to the uninformed eye these features may also appear visually confusing. For instance, while most everyone understands what a sunset is and can therefore enjoy the colorful display at dusk, an accumulation of black flecks in a sandy profile could be taken as oxidized manganese deposits, the rotting remains of decomposed roots, or buried evidence of industrial contamination. Questions of how the black flecks came to be there, why they are arranged at a particular depth in the B horizon, and how they might change over time, appear as mysterious dark striations to the uninformed eye. Formally, but also ethically, in the possibility that the blackness does represent some kind of contamination, our observation is directly affected by the *knowledge* of what we are seeing. Thus, if we are digging for beauty in the moist soils of a hardwood forest, our expert guides to the subtle textures, often indistinguishable transitions in color and granulation, and teeming microbiotic universe of the epipedon, are soil scientists, agronomists, or other professionals who work with soil. With the help of such knowledgeable experts, the mysterious dark flecks in our theoretical B horizon then poignantly appear as the faded signature of a long-since departed oak, its quietly vanishing roots the only reminder of its former magnificence.

At the outset of this paper, we were curious to see if scientists could be active and willing partners in an aesthetic dialogue on soils, and how science-based appreciation[ii] plays a role in the daily aspects of soil scientists' work. As we see in the section of this volume "Under my feet—Soil presence and perspectives in the work of four contemporary artists", and in our companion chapter 4, "Merging Horizons—Soil Science and Soil Art" (Toland and Wessolek, *this volume*), artists have contributed a great deal to an aesthetic discussion on soils. As a counterpoint, we were also interested in the aesthetic perspective of soil scientists. For, if they are to act as our specialized aesthetic guides to the enigmatic subterranean landscape, it would seem beneficial if they too approached the object of their research with a sense of beauty and awe. Who are these guides, and how are they equipped to direct and frame our aesthetic experience? Do they have aesthetic inclinations in their lab experiments, fieldwork and journal articles? Does such an underlying aesthetic attitude matter in their work? Soil ecologist David Wolfe, for example, seems to approach his work with a heightened sense of aesthetic appreciation. In the introduction to his book, "Tales from the Underground," Wolfe (2001, p. 4) writes:

> "knowledge of the incredible beauty, diversity, and activity of the subterranean world completely alters one's perception of the landscape. Gazing out over a barren plain becomes an experience similar to that of gazing out at a wide expanse of turquoise sea… I hope to serve as a subterranean "dive guide" of sorts… into a mysterious world we are just beginning to comprehend".

In our search for other "subterranean dive guides," we distributed a ten-question survey on the topic of soil, aesthetics and art at the German Soil Science Society's 2007 annual conference in Dresden. The survey was completed by all 60 members of the audience during the session on "soil science in society and education." The results were compelling, and provide us with incentive to continue the study within further academic circles.[iii] We were first interested in finding out which major disciplines (environmental science, social science, or aesthetics or combinations thereof), were most relevant for soil scientists. As expected, environmental science still plays the major role for soil scientists, but aesthetics was ranked in second place, and the combination of both natural science and aesthetics received slightly more votes, for example, than the combination of natural science and social science. (Table 15.1, Question 1)

Furthermore, although 36% answered that their work included no aesthetic aspects (with 49% answering *sometimes* and 16% *yes*), more than 80% admitted to personally collecting soil and mineral samples for aesthetic reasons. Which experiences or activities can be deemed as having aesthetic value? Nearly 50% shared the opinion that fieldwork is the central occasion for aesthetically experiencing soil. This was followed by viewing images of soil and encounters on nature walks or hikes, while 8% even identified laboratory activities as having aesthetic value. (Table 15.1, Question 2)

With our subterranean "dive guides" then seemingly in place to take part in an aesthetic dialogue on soils, we introduce our first challenge to the argument of scientific cognitivism. Although knowledge significantly enhances, and is sometimes necessary for the proper appreciation of soil, some have argued that it fails to provide sufficient criteria for *aesthetic* judgment. Emily Brady (1998, p. 158), for example, argues that scientific knowledge is "a good starting point," but unnecessary for aesthetic appreciation:

> "I can appreciate the perfect curve of a wave combined with the rushing white foam of the wave crashing on to sand without knowing how waves are caused. My judgment of the

Table 15.1 Selected questions from a survey on the aesthetic and artistic prospects of soil science, carried out at the German Soil Science Society's annual conference in Dresden, 2007

Questions	Answers (%)				
1. Which allied disciplines are relevant for soil science?	Natural Science (41%)	Aesthetics (28%)	Social science (24%)	Combinations of above (7%)	
2. When do you notice aesthetic values of soils?	Field work (51%)	Viewing pictures (32%)	On walks (24%)	Lab work (10%)	Discussions (3%)
3. Which soil properties have high aesthetic values?	Colors (52%)	Horizons (46%)	Structures (26%)	Textures (19%)	Smells (9%)
4. Which soil type do you find aesthetic and which one not?	Gley 50% Positive 50% Negative	Podzol 100% positive	Anthrosols 12% Positive 88% Negative	Chernozem 65% positive 35% negative	Marsh 21% positive 89 % negative
5. Do anthropogenic factors change a soil aesthetic value?	Anthr. factors *decrease* aesthetic value. (54%)	Anthr. factors *increase* aesthetic value. (31%)	Yes, but it depends on the situation. (15%)		

> wave as spectacular and exhilarating can be dependent solely on an appreciation of perceptual qualities and any associations or feelings that give meaning to these qualities."

Brady goes on to present the imagination-based model as an alternative to scientific cognitivism, arguing that an individual's scientific knowledge can be extremely limited by educational opportunity and experience, while imagination is only limited by the mind of the observer. When scientific knowledge is unavailable, the observer must depend on her sensory perceptions and imagination to guide experience.

With regard to soils, however, we believe that a broader knowledge base equips the imagination with more possibilities for interpretation and appreciation. The more we know about geologic and pedogenetic processes and underlying factors such as climate, parent material and vegetation cover, the better we can imagine and thus appreciate the development of unique soil types. Indeed, the complexity of soil seems to demand at least some background knowledge for a richer aesthetic experience. A checklist of facts and features can guide our perceptual experience with cues to easily overlooked details, allowing us to arrive at judgments of beauty that we might have otherwise missed. The "ah-ha" moment in the aesthetic appreciation of soils is often more subtle than aesthetic experiences of other natural environments, objects or events, such as in the wave example given above. In the continuation of the beach metaphor, Brady (1998, p. 163) does acknowledge how background information may enhance imagination to some extent:

> "In contemplating the smoothness of a sea pebble, I visualize the relentless surging of the ocean as it has shaped the pebble into its worn form. I might also imagine how it looked before it became so smooth, this image contributing to my wonder and delight in the object. Merely thinking about the pebble is not sufficient for appreciating the silky smoothness, which is emphasized by contrasting its feel with an image of its pre-worn state."

For the aesthetic appreciation of soil, we propose a combination of the imagination-based model with the argument for scientific cognitivism. While background information can aid imagination, imagination can conversely enhance scientific cognitivism. Indeed, imagination is sometimes necessary for the extension of sentience towards soils and their alien-like microscopic inhabitants. It is relatively easy to appreciate and thus protect rare flowers, songbirds, or other non-human beings that have features we can relate to and inhabit environments that are common to our own experience. Imagination can help stretch perceptions of the complex populations underground, and begins to dissolve what David Wolfe (2001, p. 3) has called "surface chauvinism."

The capacity for imagination also involves the power of narrative. Soils unfold as a series of field stories, unearthed horizon for horizon, revealing the dramas of past ice ages, wars, settlements, global warming and drought. Educators should be encouraged to approach their curricula more creatively, and to tap the imagination by using narrative in their work to inform and inspire others. In addition to using abstract numerical models, by using descriptive language that triggers the imagination, multiple neurological pathways are opened and the educational effect is strengthened. The work of Daniel Hillel immediately comes to mind here, not because of his extensive contribution to soil physics, but for the way he has shared his knowledge with the world in books such as "The Natural History of the Bible"

(Hillel 2006), and his integrated approach of mixing textbook soil science with historical and cultural anecdotes in "Environmental Soil Physics" (Hillel 1998).

15.2.2 Squishy, Gritty, Chocolate Brown—Arguments For and Against Aesthetic Formalism

What facts and features make soils beautiful or less beautiful and on which qualities do soil scientists base their aesthetic judgments? We were subsequently interested in learning what characteristics are relevant for the aesthetic appreciation of soils, and how these correspond to those described in other environmental aesthetic theories. To address these questions, we turn to another familiar discussion in environmental aesthetics—the debate over formalism.

> "Concerning aesthetic appreciation, formalism holds that such appreciation is to be directed toward those aspects – textures, lines, colors and resultant shapes, patterns, and designs – that constitute the form of the object. Concerning aesthetic value, formalism holds that the formal qualities of an object, which it has in virtue of these aspects, are the only qualities relevant to the aesthetic value of that object. An object is aesthetically good in virtue of having formal qualities such as unity and balance… and aesthetically bad in virtue of having formal qualities such as disharmony or lack of integration" (Carlson 2000*b*, p. 28-29).

After briefly outlining the argument for environmental aesthetic formalism, Carlson goes on to brand this position the "scenery cult." He first rejects formalism based on Hepburn's original account of the frameless and interactive nature of experiencing the environment. Furthermore, by restricting our attention to the formal qualities of nature, we end up falsely interpreting environments as we would sculptural objects or landscape paintings, judging nature not for what it is, but only for how it appears, devoid of meaning, normal experience, or deeper understanding. Natural beauty is reduced to humanly perceived colors, textures and shapes, without consideration of the delicate interactions, complex biological and geological processes, and rich natural history embodied in every natural form or group of forms. Such appreciation is sometimes appropriate, as we cannot deny our senses the occasional indulgence of intense color and contrasting forms, but it is not sufficient. Carlson (2001, p. 96) warns that: "in landscape appreciation we cannot appreciate form without considering content."

At first, Carlson's claim seems legitimate with regard to the appreciation of soil. For one thing, soil features (such as color, texture, aggregate structure, and horizon boundaries) that are not usually visible are certainly difficult to judge. On the other hand, appreciation of formal features, when visible, seems completely natural. The stark glowing forms of shifting dunes or the cathartic texture of a crumbly humus enriched topsoil certainly provide opportunity for aesthetic appreciation. Are there any aspects of formalism that could support an "aesthetic of dirt?" In his argument for moderate formalism, Nick Zangwill (2001, p. 223), for example, criticizes the static position of Carlson's "scenic cult," asserting that an active involvement or engagement with the environment does not cancel out aesthetic formalism in the appreciation of nature: "Being active and immersed in nature might be the best way to appreciate its three-dimensional formal aesthetic properties, just as the best way to appreciate such properties of works of sculpture or architecture might be to walk around such works." Indeed, aesthetic experience of soils usually requires active participation to simply reveal the object of appreciation. We must often dig, scrape or hammer to first uncover the object of perception, which is usually followed by a hands-on examination of *e.g.*, texture between the fingers, color based on Munsell color charts and density based on probing the soil with a knife blade at different depths. While such characteristics are used for scientific surveys, they may simultaneously be regarded as an examination of formal aesthetic features, discerned by an active and involved observer.

In our questionnaire, we were curious to find out which formal properties intrigued soil scientists, and if such aesthetic preferences confirmed a formalist approach. More than 50% regarded color as the most significant feature, with horizon sequencing close behind, followed by soil structure, texture and smell. (Table 15.1, Question 3) Interestingly, soil structure received a higher aesthetic value than soil texture. The perceived differences between the sand, silt, and clay fractions of a soil paled in comparison to the highly organized and complex architecture[iv] of structural soil aggregates. While soil monoliths may be seen as analogous to paintings in a formalist sense, the appreciation of soil in sculptural terms is also possible on many scales of observation, from microscopic aggregates to the hoodoos of Bryce Canyon. Our survey suggests that although the formalist model is perhaps superficial and inadequate for some, it is nevertheless a highly regarded form of aesthetic appreciation for others, especially those professionally close to the earth.

Furthermore, when asked to rate several typical northern European soil types, formal beauty dominated over scientific knowledge in aesthetic judgments. Despite being one of the poorest, nutrient-depleted soil types, the amazing color composition and beautiful horizon sequence of a podzol (see Fig. 5.1 in chapter by Fio Ugolini, "Soil Colors, Pigments and Clays in Paintings", *this volume*) rendered it without a doubt the most attractive soil type, with not a single negative evaluation. In all other cases we found both positive and negative reactions to each soil type. A chernozem, for example, was rated by about 15% as an attractive soil type while 10% did not agree. Gley soils had nearly the same amount of positive and negative reactions. In general, wet soils received more negative reactions than drier soils. (Table 15.1, Question 4)

These findings, from professionals who are supposedly equipped to guide our aesthetic experience with their knowledge, at first seem to conflict with the scientific cognitivist view described above. Shouldn't the knowledge of a chernozem's fertility or the ecological significance of wetland soils sway our aesthetic reactions? Does framing the question in aesthetic terms change our overall judgment of a soil's worth? It would be interesting to see if the same relative proportion of laypeople would arrive at similar opinions, or to reformulate the question for scientists: "*Based on your knowledge* of the following soils, rate their aesthetic worth." On the other hand, formal appreciation of nature need not replace or detract from our knowledge of ecological interactions and the aesthetic values we attribute to them. We can find a salt marsh soil, for example, formally boring but simultaneously beautiful on account of our knowledge of its unique role in a wetland ecosystem.

Such formal judgments can also serve to offer a new set of values, in addition to those determined by existing ecological assessments of soils. Even Carlson (2002*b*, p. 29), who seems to maintain that all formalist models of appreciation are inadequate, alludes to proponents of geography, forest management, recreation planning and landscape architecture, who employ the tenets of formalism in attempts to quantify scenic values for the sake of environmental protection. In this sense, the value of scenic beauty and classic “Photo-Op” moments has led to consequential legal protection of vast areas of national forests and coastlines. And while soil is generally hidden from sight, and thus devoid of the same kind of “scenic beauty” so integral to the appreciation and protection of other environments, we have seen that formal features do play a role for soil scientists, and may thus be used as additional values in conservation efforts.

Carlson (2002*b*, p. 28) also notes that “there is a marked emphasis on formal qualities in much of the current non-theoretical research in environmental aesthetics,” citing the U.S. Forest Service in their efforts to preserve the “character of the landscape.” Comparable to representatives from the Forest Service, most soil scientists could also be associated with Carlson’s “non-theoretical branch of environmental aesthetic research.” On the other hand, many soil scientists do spend a significant amount of time in the field probing for characteristic and unique formal features in diverse landscapes. Core samples of the sublime? Soil profiles are indeed used as ideal framing mechanisms in the identification and categorization of dominant soil types (or groups), while the process of excavation is also an act of decisive aesthetic execution, carried out with regard to the scale and dimensions of the trench and the formal composition of the profile wall. In this sense, scientific reference standards are partially based on formal aesthetic properties such as color, texture, density, shape, contrast, pattern and uniformity. If soil types may be internationally identified, categorized, and mapped out on account of formal aesthetic features, then perhaps the use of aesthetic formalism as an argument for soil protection is not far behind. If spectacular sand dunes or fossil beds may be listed as natural monuments and given certain environmental protection status, then why not specific soil groups on account of their aesthetic uniformity or uniqueness?

Although formalism plays a significant role in aesthetic judgment and sometimes conservation, it is nevertheless problematic in the appreciation of both art and the environment. There are a couple classical examples in art history that illustrate the weakness of aesthetic formalism. For example, the intricacy and attention to detail in Richard Dadd’s Victorian masterpiece, *The Fairy Feller’s Master-Stroke* (1855-1864), becomes complicated when the viewer discovers that that the painter was actually a murderous madman. Similarly, Leni Riefenstahl’s Nazi era films, documenting the rise of the Third Reich and the 1936 Olympics, are usually met with moral criticism despite the groundbreaking cinematic accomplishments of the filmmaker. With regard to environmental art, formalism is also a double-edged sword. Whereas the elegance of Andy Goldsworthy's fleeting compositions with leaves, icicles and stones demonstrates a harmonious interdependence of natural beauty and human design, the raw aesthetic formalism of many of the earlier land art works is immediately compromised when knowledge of environmental degradation arises. The initial awe of such monumental earth works as Michael Heizer's 'Double Negative' (1969-70), Christo and Jean Claude's 'Wrapped Islands' (1980-1983), or Robert Smithson's 'Spiral Jetty' (1970) is challenged by the knowledge of negative consequences to the local ecosystems in which the works were executed.

Nature, though free from the burden of artistic intention, is also inevitably subject to moral judgment. Just as the overall beauty of a work of art may be diminished by aspects of ambiguous moral, ethical or ecological integrity, the beauty of a landscape may also be diminished by evidence of pollution, degradation, disproportionate development, or discordant features such as mobile phone towers or nuclear power plants. A fascinating result of our survey is the fact that anthropogenic soils were overwhelmingly rated as aesthetically negative (Table 15.1, Question 5). To the question, "*Do anthropogenic factors change a soil aesthetic value?*" more than 50% answered that human alteration of soils *decreases* aesthetic value. Here, we again encounter the dilemma of aesthetic formalism. Though some anthrosols and technosols[v] have wildly varying horizon sequences and fabulous coloration, our judgment, like the vision laid bare before us, is polluted by our knowledge of ecological degradation.

Beyond the moral dilemma of aesthetic judgment, which we will address in the following section, lies a more obvious objection to formalism. While aesthetic formalism is mainly concerned with visual perception, the appreciation of soil is often more than just visual. Emily Brady's wonderful essay on "the aesthetics of smells and tastes" may shed new light on the appreciation of soil. Brady (2005, p. 177) writes, "Sniffing and savoring constitute not only a fundamental route to sensory awareness of our environment, but they also contribute to defining the quality and character of people, places and events… despite their significance in our lives, however, smells and tastes are a neglected part of aesthetics…" Brady goes on to attribute this deficiency to the "predominance of the visual in aesthetics and more widely in human experience."

Despite the fact that smell was rated last on our scale of aesthetic properties (Table 15.1, Question 3), the incredible potential of smell and taste in the appreciation of soils should not go unmentioned. Aside from those who are lucky enough to witness the "scenic beauty" of an excavated soil profile, an exposed relief, or a freshly eroded outcropping on the side of a mountain road, most are left unaware of the visual magnificence hidden below ground. With no immediate view to fix our vision on, we are forced to experience the beauty of soils with other sense organs, to rely on smell, taste, touch and intuition to guide our aesthetic experience. It is no surprise that the "perfume of the earth" has been the subject of recent investigation. A group of chemists at Brown University recently identified the enzyme responsible for geosmin, the substance responsible for the unmistakable smell of fresh soil (see Jiaoyang et al. 2006). It turns out that the presence of geosmin, literally "the smell of the earth," is also a criterion of soil quality checklists, such as those created by the Illinois Soil Quality Initiative (ISQI) for farmer-based soil screening tests. In this sense, the common human experience of smell links aesthetic judgments such as a soil's sweet, putrid, pleasant or unpleasant, musty, acrid, or comforting odor with established scientific methods for soil quality assessments.

The appreciation of soil is also similarly linked to our experience of food and drink, and our non-formal aesthetic judgments thereof. This is the essence of the terroir concept (see chapter by van Leeuwen, *this volume*). Indeed, all epicurean delights stem from the earth. The savored taste of yellow Boletus mushrooms in late August, for example, or the comforting flavor of a hearty beet soup, or the delicate flavors of a good Bordeaux, clearly point to hidden qualities of soil that escape the capacity of sight and transcend the bounds of formal appreciation.

Beyond taste and smell, the feel of soil represents another important aspect of appreciation. Soil texture and structure, for example, are determined by touch. Handling soil is an important step in soil quality assessments and represents a first aesthetic encounter with soil. While the sand, silt, and clay content of a soil sample can be estimated by trying to form a thimble-sized amount into a ball or pencil-thick roll with the fingers, the quality of soil aggregation is easily seen and felt as blocky, platy, granular, or prismatic chunks in a handful of soil. Such determinations are also aesthetic in nature, surely relevant to potters, sculptors and other artists and builders who use earth materials. Certainly the soft velvety squish of fine sediment between the toes at low tide, or the cool, moist soil of a wheat field on a hot summer day can also be aesthetically appealing, so much so that this experience is abstracted and commodified in the form of peat-baths at health spas or the sale of mud-masks, sand-scrubbles, or other earth-based body products. Subsequently, the grit of windblown silt or fine sand on the skin, mouth or eyes, denotes a decidedly negative aesthetic experience.

For the purposes of our discussion here, we neither fully endorse aesthetic formalism, nor completely reject it as Carlson and Hepburn do. We accept particular aspects of formalism, especially as they are embraced by those who use them for scientific inquiry, agricultural productivity, or environmental protection. However, we adopt a more comprehensive approach in the search for criteria in the aesthetic appreciation of soils. In addition to formal visual qualities such as color, texture, tilth, and horizon sequencing, other sensory perceptions such as touch, taste, and smell are to be included in aesthetic judgment.

15.2.3 The Good Earth—A Sliding Scale in Positive Aesthetics

A further tenet promoted by Carlson, among others, is that of positive aesthetics, or the notion that nature, or at least pristine nature, is inherently good: "All virgin nature… is essentially aesthetically good. The appropriate or correct aesthetic appreciation of the natural world is basically positive and negative aesthetic judgments have little or no place." (Carlson 2000*c*, p. 72)

Fig 15.2 L'Hiver (The Winter), Arcimboldo Giuseppe (ca. 1527–1593) Paris, musée du Louvre, RF1964-33 (C) RMN/Jean-Gilles Berizzi (see as color plate following *Index*)

As scientific progress gave credibility to attitudes of aesthetic distance, what was previously regarded as gruesome was magically transformed into the sublime. Once abhorred as black, infernal matter by the god-fearing communities of pre-enlightened western culture, soil came to be eventually celebrated as the womb of life. Regarding the changing perceptions of the pedosphere, this is perhaps most memorably captured in Darwin's final and controversial book, "The Formation of the Vegetable Mould Through the Action of Worms," (1881) and the waves of mixed reaction that followed. Renaissance painter Giuseppe Arcimboldo's depiction of *The Four Seasons* (1573) represents an early intimation with nature as subject, in a time where religious themes dominated artistic content. In *Winter*, (Fig. 15.2) a human figure is represented with tree roots, mushrooms and dead leaves. As scientific progress justified aesthetic attitudes towards nature, what was previously regarded as gruesome was over time transformed into something sublime.

Carlson goes on to trace aesthetic positivism back to the eighteenth century concept of the sublime, and later to the nineteenth century naturalist movement, which was critical of the negative effects inflicted on nature by industrial and technological progress. As expected, Carlson (2000c, p. 90) also links positive aesthetics to scientific cognitivism: "the natural world must appear aesthetically good when it is perceived in its correct categories, those given and informed by natural science."

We extract the following simple wisdom from Carlson's argument - scientific progress reflects and supports advancements in environmental aesthetics, and thus also in environmental protection. In other words, what we can understand we can appreciate, what we appreciate must also be good, and what is good is worth protecting. But how can literally everything in nature be aesthetically good (regardless of our scientific understanding of it)? Heavy sand storms, resulting in the desertification of agricultural land, mudslides, and flash floods may be all considered sublime under the guise of aesthetic distance,[vi] but are not usually positively appreciated by those who have suffered personally under the arbitrary force of nature. Pathogens, parasites and disease can hardly be regarded as sublime from any account of aesthetic distance. Maggots and mold cannot possibly compete for the same affection as birds and butterflies. And even in this day and age, many people are still revolted by earthworms and their multi-legged, invertebrate cohorts. Budd (2002*b*, p. 104), however, argues that such "negative" aspects must be seen as necessary parts of a more beautiful whole:

> "Although an ecosystem will contain objects and events that, in themselves, possess a negative aesthetic value, when these are seen in the context of the recycling of resources intrinsic to the system, which issues in the perceptual re-creation of life (much of which is beautiful)… the system, considered as the temporal unfolding of those processes, is itself beautiful (or sublime)."

Soil could be considered the poster child for Budd's point here. While erosion, to some extent, is immediately accounted for, so too is the rather unsavory process of decomposition. With its uncanny ability to immobilize toxic particles before they enter the ground water system, soil recycles or safely stores the rotting refuse of the earth, turning the ugliness of decay into a symphony of necessity. Like the human body, with its kidneys, lungs, intestines and skin, soil also possesses a unique ability to dutifully cleanse itself of the world's filth and transform incoming (organic) substances into vital nutrients. The beauty of the soil carbon cycle is that despite the death and disease welcomed into the upper horizons of the underworld, the transformative nature of soil creates new humic substances out of fallen ghosts, feeding once primary producers (generally plants) and consumers (generally animals) to hungry swarms of decomposers (macrofauna such as earthworms and isopods, and microorganisms such as bacteria and fungi) (Toland 2007). While decay is not usually considered formally beautiful, it finds unbiased acceptance within the arguments of aesthetic positivism.

Other critiques of aesthetic positivism, however, claim that such quality judgments are not aesthetic but ecological, or even *ethical* in character. Robert Elliot (1982), for example, argues that because nature has no author, judgments of goodness associated with positive aesthetics are inappropriate for nature, and best reserved for human activity, behavior, and creations (such as art). While we have already touched on the fact that moral or ethical judgments inevitably affect aesthetic experience with regard to formalism, the dilemma of human influence is still not easily resolved. Aesthetic positivism seems to preclude the appreciation of humanly altered or artificial environments. "Pristine nature" seems to set a standard of goodness and beauty unattainable by most landscapes.

Let us take another look at the question of whether human alteration changes the aesthetic quality of a soil. In our survey, anthrosols were predominantly rated as negative. Despite their unique formal beauty, they may also sometimes be seen to demonstrate great human ingenuity or archival value. Aesthetic appreciation of anthropogenic soils must also take remediation of past degradation into account. And while remediation would not be necessary in cases where human activity had not damaged natural soils in the first place, the visible and chemical effects of such measures may still be seen as aesthetically positive, if not (ethically) heroic. Environmental artist Mel Chin's "Revival Fields" and regional remediation projects such as "AMD&ART" celebrate this kind of human reversal of fortune, rendering their art examples of "reclamation aesthetics." (Spaid 2002, p. 109) This concept could be similarly attributed to such remediation projects as the efforts to restore wetlands off the Gulf Coast of the United States or the recultivation of former mining areas or other highly disturbed terranes—e.g., the slag-heaps around mining sites in Germany's Ruhr Valley, or the artificial mountains of rubble created after World War II in Europe.[vii] Such artificial structures may sometimes be positively regarded, as they create new topographies, outlook vistas, ecological niches and recreational opportunities in otherwise geologically flat landscapes.

The overwhelmingly negative aesthetic reaction to anthrosols, however, suggests that aesthetic positivism is in most cases an appropriate attitude in the appreciation of soil. Natural soils, regardless of their positive or "negative" formal aesthetic characteristics, are usually judged as inherently good, whereas humanly altered soils are not (Table 15.1, Question 5). Despite this overwhelmingly negative aesthetic reaction to anthropogenic soils, agreement was not unanimous. A handful of people still rated anthrosols positively. More than 30% found human influence on soils to actually *increase* its aesthetic value, and 15% concluded that "it depends on the situation." This discrepancy clearly points to a sliding scale in positivism. Stephanie Ross (2006), for example, argues that human influence is not the only factor for negative judgment, and that such judgment is relative. Human alteration of nature must be seen in degrees of positive or negative influence:

> "Let us grant, then, that nature and culture interpenetrate and that naturalness comes in degrees. We can and do make judgments about the degree of naturalness of particular cases. A human walking across a pristine beach and leaving footprints is quite different from a developer constructing condos all along that same beach" (Ross 2006, section 3).

A weaker version of aesthetic positivism can thus be applied to the appreciation of soil. Certainly problems associated with urban sprawl, contamination, deforestation, acidification, salinization and non-sustainable forms of agriculture are to be negatively judged from an ecological, ethical and aesthetic perspective. But human influence is also to be judged in degrees, so that the positive appreciation of archeologically or culturally significant soils, as well as cases of soil remediation, recultivation, sustainable agriculture, and other examples of "best practice" may be included in our aesthetic evaluations.

15.3 A Shift in Values

As of 2008, more than half of the earth's population lives in cities. Increasingly fewer individuals in industrialized countries depend on soil for their own personal subsistence, while many families in developing nations cultivate small plots of urban soil for their food supply, regardless of potential contamination. In a time of on-line supermarkets, genetic patenting and questionable agroindustrial standards for nutrition, agricultural policy has become all but obscured from conventional wisdom and far removed from the daily undertakings of most citizens. With the bounty of Wal-Mart and other mega-stores at our disposal, centuries of rural folk knowledge have been consigned to the yellowing pages of farmers' almanacs. New valuation systems are needed if conservation efforts and sustainable food production strategies are to succeed on a wider scale, particularly in heavily populated areas.

How can aesthetics contribute to a much-needed shift in values? Following the wisdom of Aldo Leopold's "Conservation Esthetic" (1949), some have suggested the integration of aesthetics into environmental education. Arnold Berleant (2005, p. 57), for example, writes:

> "Experiencing environments aesthetically is, in fact, an embodied argument for the importance of environmental values. Furthermore, an aesthetic encounter is a way to approach environmental education by helping to cultivate feelings of care and responsibility for the earth. Each environment provides an opportunity for a distinctive aesthetic experience."

In his essay "What is the Correct Curriculum for Landscape," Allen Carlson (2001) compares the landscape to a text, which we may study and learn from, and out of which interpret multiple different readings, depending on our cultural and historical backgrounds. This position allows for multiple layers of meaning and educational value, such as "form, common knowledge, science, history, contemporary use, myth, symbol and art." (Carlson 2001, p. 105) In this sense, "aesthetic encounters" with soils are certainly not exclusive to soil scientists, farmers, gardeners, surveyors, environmental engineers or miners, but are available to virtually all who care to turn their gaze earthward. Carlson's curriculum for environmental appreciation and the kind of aesthetic awareness of environments that Arnold Berleant suggests above is applicable to an "aesthetic of dirt," generally—for the communication of soil aesthetic values to a wider public, and specifically—for soil scientists in various educational and conservation efforts. This kind of awareness is strengthened by the introduction of models of appreciation such as those described in this chapter: scientific cognitivism, moderate aesthetic formalism, imagination, positivism, and the qualitative use of touch, taste and smell in soil assessment.[viii]

But what does this imply for the field of soil science? The combined results of our survey indicate that although aesthetic interest seems to be an important aspect of the field, the obvious questions must be asked: *Why don't soil science societies and their members talk more about the aesthetics of soil? How can aesthetic judgment be employed as a tool for examining alternative meaning, understanding, and experience of soil?* While more than half of those interviewed confirmed enjoying moments of aesthetic experience during fieldwork, less than 5% of aesthetic experience could be attributed to engaged discussion with colleagues or friends (even less than in the lab!) (Table 15.1, Question 2) If aesthetics is a relevant concern to soil scientists, why isn't it discussed more openly and more often?

Furthermore, if soil scientists are to act as specialized guides in the aesthetic appreciation of soils (in addition to their many other pursuits), then aestheticians should perhaps be prepared to "guide the guides" through the epistemological labyrinth of environmental aesthetics. Interdisciplinary dialogue is strongly needed, if an "aesthetics of dirt" is to be developed further. While soil scientists could do much to inform aestheticians of their progress in ecological research, professors of environmental aesthetics could be invited to contribute to soil science journals or conferences. Without active participation on both ends of the dialogue, scientists will remain on what Carlson (2000*b*, p. 28) describes as the "non-theoretical side of environmental aesthetic research," uninformed of how their knowledge could benefit other academic fields, and how knowledge of aesthetics could strengthen soil protection efforts. Only in collaboration can a comprehensive curriculum for environmental appreciation be established, or the "aesthetics of dirt" developed further. Finally, we advocate the integration of aesthetic values into already existing soil evaluation and protection contexts in order to better serve conservation and land use strategies. Where scientific assessments are not sufficiently adequate to address aspects of the picturesque, sublime, or other emotionally moving experiences in nature, especially regarding soils, objective aesthetic arguments could be used instead. In a new era of sustainability, we might ask—*how* can beauty help save the earth?

References

Berleant A (2005) The World from the Water. In: Berleant, *Aesthetics and Environment – Variations on a Theme*. Burlington VT: Ashgate Publishing Company, 57-67.

Brady E (2005) Sniffing and Savoring – The Aesthetics of Smells and Tastes. In: A. Light and J.M. Smith (eds.), *The Aesthetics of Everyday Life*. New York: Columbia University Press, 177-193.

Brady E (1998) Imagination and the Aesthetic Appreciation of Nature. J. of Aesthetics and Art Criticism, 56: 2, 139-147.

Budd M (2002*a*) The Aesthetics of Nature: A Survey. In: Budd, *The Aesthetic Appreciation of Nature*. Oxford and New York: Oxford University Press, 2005, 110-148.

Budd M (2002*b*) Nature, Art, Aesthetic Properties, and Aesthetic Value. In: Budd, *The Aesthetic Appreciation of Nature*. Oxford University Press, 2005, 90-109.

Carlson A (2000*a*) The Aesthetics of Nature. In: Carlson, *Aesthetics and the Environment – The Appreciation of Nature, Art and Architecture*. Abingdon and New York: Routledge Taylor & Francis Group, 2007, 3-15.

Carlson A (2000*b*) Formal Qualities in the Natural Environment. In: Carlson, *Aesthetics and the Environment - The Appreciation of Nature, Art and Architecture*. Abingdon and New York: Routledge Taylor & Francis Group, 2007, 72-101.

Carlson A (2000*c*) Nature and Positive Aesthetics. In: Carlson, *Aesthetics and the Environment – The Appreciation of Nature, Art and Architecture*. Abingdon and New York: Routledge Taylor & Francis Group, 2007, 72-101.

Carlson A (2001) What is the Correct Curriculum for Landscape? In: A. Light and J.M. Smith (eds.) 2005, *The Aesthetics of Everyday Life*. Columbia University Press, 92-107.
Darwin C R (1881) The Formation of Vegetable Mould, Through the Action of Worms. London: John Murray. Reprinted in 2007 by Echo Library, p. 1.108.
Elliot R (1982) Faking Nature. In: R. Elliot (ed.), *Environmental Ethics*. Oxford University Press, 1995, 76-88.
Jiaoyang J, Xiaofei H, Cane DE (2006) Geosmin biosynthesis. *Streptomyces coelicolor* germacradienol/germacrene D synthase converts farnesyl diphosphate to geosmin. J. Am. Chem. Soc. 128:8128-8129.
Hasegawa S, Warkentin B (2006) The Changing Understanding of Physical Properties of Soils: Water Flow and Soil Architecture. In: Footprints in the Soil: People and Ideas in Soil History, B. Warkentin (ed.), Elsevier.
Hepburn R (1966) Contemporary Aesthetics and the Neglect of Natural Beauty. In: B Williams and A. Montefiori (eds.), British Analytical Philosophy. London: Routledge and Kegan Paul, 285-310.
Hettinger N (2008) Objectivity in Environmental Aesthetics and Environmental Protection. In: Carlson A, Lintott S (eds) Nature, Aesthetics, and Environmentalism: From Beauty to Duty. Columbia University Press.
Hillel D (1998) Environmental Soil Physics. San Diego, CA: Academic Press, 771pp.
Hillel D (2006) The Natural History of the Bible – An Environmental Exploration of the Hebrew Scriptures. New York: Columbia University Press, 376 pp.
Leopold A(1949) Conservation Esthetic. In: Leopold, *A Sand County Almanac and Sketches Here and There*. London, Oxford, New York: Oxford University Press. 65-177.
Parsons G (2007) The Aesthetics of Nature. Philosophy Compass 2/3 (2007): 358-372.
Rossiter DG (2005) Proposal for a new reference group for the World Reference Base for Soil Resources (WRB): the Technosols. 2nd revised draft, Enschede, The Netherlands.
Rolston H *III* (1998) Aesthetic experience in forests. Journal of Aesthetics and Art Criticism 52 (no. 2):157-166.
Ross S (2006) Paradoxes and Puzzles: Appreciating Gardens and Urban Nature. Contemporary Aesthetics. http://www.contempaesthetics.org/newvolume/pages/article.php?articleID=400. Cited October 2007.
Spaargaren O (2005) Anthrosols and Technosols. Definition for the ISRIC –World Soil Information, Wageningen, The Netherlands.
Spaid S (2002) Reclamation and Restoration Aesthetics. In: Spaid, *Ecovention – Current Art to Transform Ecologies*. Cincinnati, OH: The Contemporary Arts Center, Ecoartspace (also available at http://greenmuseum.org/c/ecovention/)109-130.
Toland A (2007) Art, Physiology, and the Soil-Body Interface. Landscape & Arts Network Journal No. 40. p. 26-36; available at http://www.landartnet.org/Journal.htm.
Wessolek G (2002) Art and soil. Newsletter of the Committee on the History, Philosophy, and Sociology of Soil Science of (International Union of Soil Sciences) no. 10, p. 14-16; available at http://www.iuss.org/.
Wolfe D (2001) Introduction. In: Wolfe, *Tales from the Underground*. Cambridge, MA: Perseus Publishing, 1-14.
Zangwill, N (2001) Formal Natural Beauty. Proceedings of the Aristotelian Society (Hardback) 101(1):209-224.

Notes

i Resource-specific contributions include, for example, Arnold Berleant's (2005) "The World from the Water," Yuriko Saito's (2005) "The Aesthetics of Weather," Holmes Rolston's (1998) "Aesthetic Experience in Forests," and most recently Arnold Berleant's "The Soft Side of Stone: Notes for a Phenomenology of

Stone," presented at the 6th International Conference on Environmental Aesthetics, in June 2007 in Finland.

ii Glenn Parsons (2007) also refers to science-based appreciation as "scientific cognitivism," in "The Aesthetics of Nature."

iii Since the writing of this paper, our survey was subsequently carried at the SUITMA Conference in China, where about 150 replied, and at colloquiums in Sidney and Palmeston North, New Zealand. These results have not been included here as the follow-up study is still in progress.

iv 'Soil architecture' is the wonderful term introduced by Benno Warkentin (2006) in "The Changing Understanding of Physical Properties of Soils: Water Flow and Soil Architecture."

v Anthrosols are soils that have been formed or profoundly modified through long-term human activities, such as addition of organic materials or household wastes, irrigation or cultivation. Technosols are soils whose properties and formation circumstances are dominated by their technical origin or other profound human influence such as transportation. They are proposed to better accommodate urban, industrial, traffic-impacted, and military soils (referred to collectively as 'urban soils') [definitions here modified slightly from those given by Spargen (2005) for the ISRIC – World Soil Information] A comprehensive discussion, definition, and classification of technosols within the WRB is also found in the "Proposal for a new reference group for the World Reference Base for Soil Resources (WRB) 2006: the Technosols," 2nd revised draft (Rossiter, December 2, 2005).

vi "Distance" as a psychological condition for properly appreciating art or other objects of aesthetic judgement was most notably argued by Edward Bullough in the article "'Psychical Distance' as a Factor in Art and as an Aesthetic Principle," published in 1912 by the British Journal of Psychology, followed by multiple works by Jerome Stolnitz.

vii A typical example for such an urban geotope is the Teufelsberg (Devil's Mountain) in Berlin, with a height of 114.7 m. It boasts one of Berlin's best lookout points and its parent material is rubble from World War II. Today it is used for bikers, and even sometimes for international skiing events.

viii Ned Hettinger's (2008) concept of "aesthetic protectionism" should also be mentioned here as an acceptable guideline for the "aesthetics of dirt."

Part IV
Perspectives on Soil by Indigenous and Ancient Cultures

Chapter 16
European Religious Cultivation of the Soil

Nikola Patzel

16.1 Introduction

16.1.1 'Enlightenment' of the Land Versus European Agrarian Culture

One of the battle cries during the cultural change called European Enlightenment was: "Our foes are superstition and dullness, our heroes are enlightenment and reason." What happened in Europe, especially with its agrarian culture, during its biggest change, after the transition from the pre-Christian religious age towards Christianity?

With the development of modern chemistry, analytical and physiological experimentation with plants and soil samples began. Additionally economic analysis was made part of the management of some estates. Thus began the 'enlightenment' of the soil and agriculture. The rural-population enlightenment campaigners included liberal politicians, teachers, writers/journalists, estate owners, and priests. They spread their message by means of speeches, pamphlets, newspapers, and reformist farmer's almanacs. This activity began in the second half of the 18th century and intensified during the whole of the 19th century. The object of cautious undermining or ambivalent criticism, as well as of aggressive attack, by this movement for cultural change, was the agricultural tradition, in part or as a whole. It was considered to be full of false and misleading beliefs concerning soil and agricultural techniques, and was seen by many scientists and campaigners as a dull bar or a hideous opposition against the oncoming new time.

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16.1.2 An Early 21st Century View of this Cultural Change in Europe

Now we see that the European Enlightenment was a complex cultural struggle for hearts and minds. The visible drivers of change were new economic principles and trade relationships, new scientific discoveries and related technological inventions, and a whole process of social and political change. *Psychologically understood, it was a new consciousness of matter and a new consciousness of individuality, breaking its way to become the new mainstream in the course of about 150 years (1800-1950).* This mental framework proved to be decisive for the development of a new attitude towards soils and plants.

While the old cultural battles are not yet completely finished, new conflicts are now more prominent. In the current state of Western culture, the classical enlightenment, its emphasis on what is called ‘rationality’, and its protagonists are criticised or under attack in a different way, other than by the well-known conservative reaction. This has happened mainly out of the ecological movement, including organic farming, as well as from old churches and new esoteric and religious cultural movements. One general aim of these movements is to establish a new relationship with Nature, with a new *agri-culture* as important element. We will come back to this point at the end of this chapter. But what was it—‘yesterday’s yesterday’—the religious cultivation of the soil in Europe?

16.1.3 Some Core Mental Characteristics of European Agrarian Culture and this Paper’s Source Material

How can the mental characteristics of the ‘pre-enlightened’ and pre-industrial agrarian culture of Europe be described? From the modern perspective of European and American culture, the first impression is that there was an enormous and confusing variety of customs, religious beliefs and magical-religious practices around land cultivation and crops.

Some examples:

- God was evoked to be the good master of the field instead of the devil. (The mental background is that in any case, spiritual forces were able to dominate the field—and not the farmer himself.)
- Special rituals with objects like the Christian cross, holy water, fire, or green boughs were considered effective in helping to insure successful agricultural work.
- Agricultural omens and oracles were generally acknowledged as predictors.

Because it would be impossible to offer, within the framework of this book chapter, a detailed exploration of the mental world of European agrarian culture, the material is presented in the form of examples that illustrate the following main descriptive axes:

1. The Christian notion of God and divine involvement in agriculture.
2. Unorthodox spirits of the fields and soil.
3. Effective magical symbols.
4. Clues about the future, and the right time for action.

The main source used here is a collection of manuscripts from the 1860s from Central Europe, which is for the most part yet unpublished. These manuscripts were gathered by Wilhelm Mannhardt (1831–1880), a pupil of the famous, fairy tale-collecting Brothers Grimm. Mannhardt attained most of his material as result of a huge survey: he distributed hundreds of thousands of detailed questionnaires within central Europe with the help of journals and regional distributors. His supporters in this effort were mostly sixth-form students (*Primaner*) from grammar/high schools and members of teacher training colleges, but also included folklorists, pastors, and estate owners. Their actual informants had been mainly farmers and estate owners.

Out of the huge Mannhardian collection [about 10,000 manuscript pages in the Mannhardt estate (Berlin State University), used by Mannhardt for his 1875/77 publication], mainly the small part coming from Switzerland is used here [published in Patzel (2009)], complemented by some material from the German and Austrian collections. Some additional information is taken from folkloristic literature of the 19th and early 20th century; only specific quotations from this literature are cited.

16.2 The Christian Notion of God and Divine Involvement in Agriculture

The soil where men worked was seen in 'pre-enlightened' European societies as a highly contested place. Like *Adam* or *Homo*, the human made out of soil, agricultural soil was seen as a part of nature influenced by different forces, following the Christian notion of the *powers that be*. The strongest of these competing forces was God himself. Therefore, evocations of God had played a central part in successful soil cultivation. God was evoked as the master of the fields. Therefore, set phrases like "Beginning in the Name of God" were used to express that whatever was done, was done on behalf of the Lord and with the hope to get his His support. Another of these phrases, which were very important when starting to sow or to harvest, was the liturgical sentence: "In the name of the Father, the Son, and the Holy Spirit" (that is the Holy Trinity of the Christian God image). Here, and also when starting an action with longer prayers, the work with soil and crops was obviously a holy action—an invitation to the divine to be effectively present here and now on earth. But this presence and action of God on earth was not always taken as a given. Therefore, an appeal to God's *faithfulness* was often an important element of the invocation: "Oh God, act truly."

Fig. 16.1 Bell with God's Eye on its neck strap. Reproduced by courtesy of Christof Hirthler

A very important Christian symbol in the religious cultivation of the soil was the *holy water*. In most Catholic areas, it was custom (and in some places, up to the present) to sprinkle the earth in spring with blessed, holy water. In processions of the Catholic confession, the most powerful symbols, such as the crucifix, figures of Holy Mary or the saints, and the monstrance [latin *monstrare* = 'to show': a vessel with the Host (consecrated wafer) with God's presence] encircled the fields, together with the community. During this circumambulation, the priest mediated God's spirit to the encircled soil by means of the holy water, or in a slightly different interpretation, the priest marked God's realm so that no unholy spirits may dare to touch this place. Also, the *Cross* was brought to the fields: The first handful of seeds was sown forming the pattern of a cross, small wooden crosses were buried in the soil, and large crosses or crucifixes were erected on the way to the fields or on a hilltop where the risk of hail was high. This can be seen as a magic-religious protective action, or as an action of centring and ordering all relevant forces into a structure, where nothing, not even the Evil One, was able to dominate the scene.

The latter interpretation can be given, because the cross is—not only in Christianity—a well-documented symbol of an ordered world, where the crucial centre is present, and *everything* important has its place. In India, for example, the cross-ploughing of the fields symbolises the fertile union of heaven and earth, where the earth is symbolically reinforced in its structure and linked with the heavenly order (Högger 2000).

But the God of the fields was not only seen as the God of Love who is predominant in the New Testament. The *fearsome notion of God*, manifest prominently in the Old Testament, was very present too. Therefore, for the farmers, a question of highest practical value was: Are the disappointing yields and evil that I perceive in my fields the work of witches or sorcerers, with the Satan's power behind it—or is it a sign of the furious God, showing those who are withdrawn from him who is the master of everything? In the first case, it was important to appeal to God's love and power to see what happens on earth. This was done by praying, and by inviting him to the fields by bringing his symbols close to them. In the second case (misfortune caused by God), it was important to reconcile with God by the way of prayer and/or repentance. For example, the case was reported, that farmers in southern Germany vowed, after several years with heavy hail, no longer to put manure on the fields on Saturday, in order to respect better the holiness of Sunday (Eberhard 1907, p. 1).

Another very important part of the Christian notion of God, involved with the soil, was the *Holy Mary*. Maybe it was in or through Mary that God—after Christ's assumption to heaven—was felt closest to the earth. Mary was sometimes depicted bearing a cloth with painted ears (spikelets) of grains, or grain was given in homage to statutes of Mary. The ears of grain were seen as symbols for Christ, appearing as the fruit of a human, after having conceived God's spirit. Or conversely, as an appeal to Christ—who was born out of the earthly body of Mary and who resurrected after his burial in the dark earth—as a role model for the new life-bringing plants, emerging at the soil's surface after the burying of the seeds.

Mary was not only important as a symbol for the living soil. She was also a bridge from the farmers and their soils to "God Father in Heaven". That means—as Heaven was often imagined being above the sky—to an aspect of God felt to be very distinct and, in some moments, distressingly far away from earthly and human reality. For example, in a special Austrian Church bell (of St. Margarethen in Vorarlberg) there was incorporated "a hair of the Mother of God". This bell was exclusively rung, when the fields were threatened by a thunderstorm. On the bell's surface was engraved, as on many bells of this type: "*O rex glorie Christi veni cum pace*" ("Oh Christ, glorious King, come with thy peace"). Having the hair of Mary inside, this "hail-bell" can be seen as symbol of the spirit and tone of Mary. Her sound, as *voice of the earth,* appealed on ringing to God in heaven to prevent the destruction of the fruitful land which he gave to Adam and Eve for cultivation. The ringing of bells and the making of other sounds (*e.g.*, shouting) for similar purposes can be found in many different cultures. Thus, as for most of the magical-religious actions mentioned here, the consideration of more comparative material could show a symbolic layer, which is not specifically Christian, but common to humans of all religions.

16.3 Unorthodox Spirits of the Fields and Soil

Given the dominance of the Christian notion of God and the Devil in ‘pre-enlightened’ Europe, it is of interest to examine how people addressed those ‘spirits’ one felt existed within and around the soil, whose existence was *not* part of the religious dogma. One of the most commonly reported earthly spirits were *dwarfs*. In the Mannhardt sources, the dwarfs appear directly from the soil and enter into a relationship with the humans working with the soil. One of the reported actions of dwarfs was that they nourished the fieldworkers. For example, humans smelled baking breads or cakes when ploughing, and sometimes they perceived “bread from those living below”. The fragrance was said to come from the dwarfs’ subsurface bakeries. The legend was handed down that farmers taking a mid-day nap in the field would awake to a nourishing meal served on silver dishes. After eating this meal, they fell asleep again for a short time; the dishes were then taken back by those who lived in the earth.

The reverse action was reported in legends in which humans (mostly women) gave nourishment or other help to the dwarfs. A common tale here involved human women going to a cavern of the dwarfs, and there, helping a woman from below give birth to a new being. On the other hand, it was often part of dwarf tales that the blessing from below disappeared at the moment when some human transgressed the limits of fair behaviour towards the dwarfs, *e.g.*, stole their precious dinnerware. All of these stories seem to be commenting on the proper relationship with Nature and the sustenance coming out of the earth. People in Central Europe found ways to integrate the dwarf legends into a Christian worldview. The following legend was reported in the Alp Mountains: When God expelled Satan and angels adhering to him from Heaven after the appearance of Christ on earth (see Luke 10:18), not all of angels fell as deep as Hell. People—in some tales, not the worst ones—who were stopped by the trees and by the earth’s surface became the dwarfs, living in the soils, rocks and woodlands—that is, just between Heaven and Hell.

A second important group of ‘unorthodox spirits’ involved with soil and crops was built around the “Corn Mother” (‘corn’ meant in the broad sense as ‘grain’) and similar figures, imagined to live in the fields and woodlands. Some of the harvest was *left* in the field, or *given back* to her after taking it, so that she would not have to give all of her bounty and fertility to humans. She was also represented as a figure made out of sheaves, which had similar proportions to the many figures of the Earth Goddesses found in all places throughout history.

But the European corn mother could also become dangerous to humans, especially to their children when going into the fields: “If you go to the fields, the Corn Mother may take you!” Out of the many such stories, two interpretative approaches seem to be meaningful. First, there seems to have been a fear among humans that somebody, who is naturally ruling the fields, may practice revenge. As humans have taken her children, she may steal the children (symbolically, also the future) of humans. The second approach to this motif suggests itself out of stories, which put forward behavioural rules, *e.g*., “don’t go into the fields before harvest, children”, or “don’t pluck unripe hazelnuts”. The functional hypothesis is well known—that ghost-like figures are used as a threatening means to assert social rules. But the *numinous* quality [a mysterious, majestic presence inspiring dread and fascination; from *lat.*: *numen* = Spirit] of the legendary figures, and especially tales where *they* tell the behavioural rule to a man or a woman, suggests the following hypothesis: There may also have been the feeling that *the other side* (a spiritual side *within* Nature) wants certain behavioural rules to be respected by those humans who profit from the crops.

The spirits of the fields did not appear only in the shape of a Corn Mother or other feminine beings. There were also a multitude of male figures in the fields and in the soil. These were figures like the “Hook-Man”, who is able to pull children down into the earth with his hook. The multiple male figures were generally reported as being harmful, except the central one: the “Old One” (*der Alte*). He was mainly documented in northern and (former) eastern Germany. The Old One was also represented as a figure made out of a sheaf, with a remarkable phallus. Like the Egyptian phallic Earth God named Geb, the Old One can be considered a symbol for the creative powers out of matter—in this case, a symbol of soil fertility.

Numinous field-beings in the shape of animals have been described by Mannhardt as almost always being positive. They were called, for example, the “sow”, the “billy goat” or the “rabbit”. There were harvest customs, where the fieldworkers “catch the sow” or they shouted-out “the rabbit escaped”. Also, the last sheaf was given such a name and carried home, often in an adorned form. And finally, it was a common harvest custom to call the man who cut the last ears with a name similar to that given to the last sheaf. He then, being for example the “sow”, was on one hand honoured, and on the other hand laughed at, and had to play a special role at the harvest festival.

Within the interwoven magic-religious elements of ‘pre-enlightened’ agriculture, the link between the numinous harvest beings and the new sowings have been especially tight. The rituals and ideas which are documented, hint at the following meaning: There are numinous beings, living in the soil or the field, often also having a relation to the woodlands, who are involved with soil fertility and plant growth. These beings appear in an ancestor aspect (Corn Mother and Old One), in an aspect closer to humans (Corn Maid, Corn Child, Hook-Man …), or in an animal aspect (Wolf, Sow, Billy Goat, Hare …). The latter two aspects can be considered, in mythological logic, to be children of the first one. In some way, these beings were believed to incorporate into the harvest plants or to *be* them; and these had to be partly left in the field or returned to it (“don’t take them all”) in order to prevent anger and revenge of the numinous mother and the end of the blessings. Because the, basically religious, paradox of taking and non-taking the *other side* had to be respected. Complementary, but less prominent, was the idea of the death and resurrection of the ‘corn spirits’, showing some structural similarities with religious ideas in the Greek myth of Demeter and Persephone, or the Christian belief of Jesus’ death and resurrection.

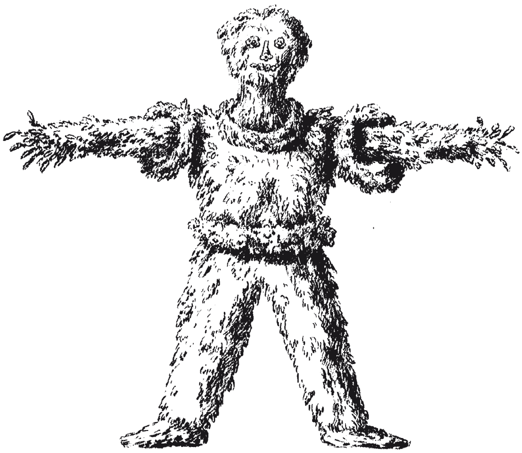

Fig. 16.2 Man of Corn and Flowers. Reproduced by courtesy of Berlin State Library from the Mannhardt estate, K. 4, folder "Abbildungen"

16.4 Effective Magical Symbols

Magic is, from the viewpoint of contemporary Westerners, always an especially irritating and sometimes fascinating part of ancient, 'archaic' or 'primitive' cultures. The use of Christian and other symbols in agriculture had a magical-religious aspect. The term 'magical-religious' is used here because there is so much overlap between 'magic' and 'religious' practices and ideas, that their conceptual distinction appears to be more of a normative valuation (however important in theology) than an empirically suitable classification. (A more differentiated discussion of this topic is given in Patzel 2009.) It was important that the symbols came *physically* close to the soil and crops, or that they stand *physically* in the way of a thunderstorm.

Water, from the moment that it was blessed by a priest, was no longer considered to be normal water. *Holy Water* was considered to be capable of causing or provoking more effects than satisfying the thirst of humans, animals or plants. It was seen as a carrier or mediator of divine forces. But not all magic objects had to be blessed or made a 'carrier' in order to have special effects. For example, "Agatha bread", baked in the form of female breasts, was thrown out of the window to protect against thunderstorms. Saint Agatha (3rd cent. AC) was a Christian martyr from Catania, near Mount Etna in Sicily. Part of her martyrdom was that her torturers cut off her breasts. After her death, it was said that Agatha made a threatening lava stream deviate from its way to Catania. Agatha then became patroness of Catania and the patron saint against fire, thunderstorms and some other perils. We see here that the Agatha bread had been created as a (magically used) symbol, carrying an ultimately invincible feminine power that is able to provide protective borders against the most destructive actions, and therefore also may shield against disastrous scourges like fire or hail. This story of the Agatha bread also gives a general idea of how the magical-religious involvement of "Saint souls" (other cultures would say: "great ancestor spirits") was introduced into agricultural folklore and practice.

Palm branches represent another class of important magical-religious objects—the forceful plants. These green boughs from various plants were erected at the corners of a field to protect it against pests and other hazards. They might be the blessed palm branches from the church. Alternatively, they could be taken during the night, and under special ritual conditions, from a tree or bush. The magic power of those special branches came, in most cases, out of their quality of being evergreen or greening anew. The boughs probably symbolised the eternal forces of life, being the source of protection or enhanced vitality.

Another popular principle was to use an object or action for *property transference* or analogy magic. A very simple example: "Jump high on the fields, then the flax will grow high." Or it was said: "Cabbage, become as thick as my legs!" These actions and the associated evocations were meant to attract a property to an object by means of something that already has this property. There is no physical causality. Instead, they draw on a relation and on non-causal 'effects' of the magic-religious ritual. Talking to the crops or making contact with them by shaking or other palpable actions was also seen as beneficial. These were often combined with the aim of property transference. For example: fruit trees were beaten with sticks during wintertime (often on the night between the 24th and the 25th of December, the 'Holy Night' when Christ was born), in order to "wake them up", so that they may prepare for bearing many fruits in the season to come. These customs show that the plants were considered to be receptive to the expressions and intentions of humans.

Swiss psychologist Marie-Louise von Franz, who devoted much of her attention to a new Western understanding of magical-religious practices of ancient cultures, wrote (von Franz 2006, p. 30): "*What we scornfully call magic is, however, nothing else but a more archaic form of religion which is characterized by treating matter as containing a divine and psychic element. Magic relates to matter instead of only manipulating it. It tries to influence matter, not by technological means, but by psychological means. In other words, the goddess of matter has to be propitiated and devotedly worshipped. Even the stupidest magical recipe presupposes this a 'religious' handling of the materials. It also belongs to the traditional form of magical systems, which believe that man has to put himself in the right attitude in order to be able to influence matter positively. His soul then communicates with the soul of matter.*" Magic can be interpreted as a kind of religious treatment of *matter*, the latter being considered to have mental or spiritual qualities. Therefore, magical-religious practices are of special interest for the analysis of the old European agrarian cultures and non-Western modes of soil (fertile matter) cultivation.

16.5 Clues About the Future and the Right Time for Action

Hints or predictions about future events and the right time for specific actions have forever been of greatest interest. In the religious European agrarian culture, three main approaches to the future existed. The first one was built up on correlation rules, the second given by signs and oracles (divination), and the third resided with people possessing special knowledge and/or abilities (*e.g.*, weather prophets). The first two approaches are represented in our source material from Wilhelm Mannhardt.

16.5.1 Correlation Rules and Other Calendar Rules

Correlation rules concerning the future had been mainly transmitted in the form of country sayings such as weather proverbs. These were often rhymed short sentences, describing a relationship of different events in time. The majority of weather proverbs showed a direct predictive value for the harvest. For example: “Dry March, wet April, airy May with some of either side, fills the sacks with corn and the casks with wine”, or “Rain on Good Friday—this year will be blessed with fruits”. Some weather proverbs refer to correlation patterns between different weather periods; others refer to the quality of spiritually intense moments of time, like Christmas, Easter or Whitsun (Pentecost), the latter ones being seasonably quite variable. Where weather rules are linked to saint’s days, it is sometimes hard to distinguish if they concern natural patterns or spiritual time qualities. In the rituals and ideas connected with the crucial times of the spiritual year, it was as if the divine drama was to be lived through the whole of creation at these observances, the dangers (demons threatening the crops) as well as the beneficial and salutary events. In this perspective, calendar rules sought to bring the farmer’s action into harmony with the spiritual rhythm of the year.

16.5.2 Signs and Oracles (Divination)

The so-called “interpretation of *signs*” was popular among the people, particularly concerning the future. For example, based upon the numbers of “eggs” found in the small cup of the “Bird’s Nest Fungus” mushroom [*Cyathus striatus*, called “lucky cup” (Swiss German: Glückshäfeli) or “dear one” (German: Teuerling)] conclusions were made on the future price of the corn still in the field. The birdcall of the quail was also interpreted with regard to the future harvest. Among the agricultural *oracles*, the “onion oracle” was the most popular in 19th century Switzerland and Germany. An onion was cut in two pieces. The cup-like layers were laid side by side, up to the number of twelve, and some salt was put on all of them. After a night had passed (often the Holy Night) people looked at the water content of the onion layers, every layer representing a month of the coming year, in order to get ideas about the abundance of rain in these forthcoming months. Other oracles were done with the behaviour of tree branches, either being planted on the field for a certain period of time, or put in a vase in the house.

The implicit assumption with these signs and oracles might have been that there is an 'objective knowledge' which can be brought in touch with human consciousness by signs or symbols. Oracles exist all over the world, but most of them are much more sophisticated, with more variables to be interpreted, than those of 19th century Europe. This may suggest that the European agricultural oracles and sign interpretation rules were expressions of the psychic need to have hunches about the future, but with lesser cultural development and without the sophistication seen in African, East Asian and other cultures.

16.5.3 Rules Referring to the Situation of the Changing Moon

The most important celestial advisor of farmers was the *moon*. Which phase of its changing appearance is actually there? Is it ascending or declining with respect to the ecliptic (going up or down towards a lunar node?), and referring to the horizon from night to night? With which signs of the zodiac is it actually associated? Is it close to or far from the earth (perigee or apogee)? These questions were traded orally and presented and answered in many popular farmer's almanacs, combined with detailed suggestions for actions in tune with the moon. Sowing of plants with above-earth fruits was preferentially done when the moon was growing and/or ascending, and sometimes also, when it was full and close to the earth. Sowing of plants whose edible parts were underground was preferentially done with a descending moon. Manure was applied to the soil when the moon was close to the earth (perigee sign) and/or descending. These practices led to sayings like: "Bring dung out when the moon goes down. Otherwise, it will not stick to the earth." Of all the luminaries in the night sky, the moon was considered to be in an especially close relation to the earth, with the plants and water-holding matter (like manure) being strongly influenced by its times.

The *zodiac signs* in relation with the moon were mainly acknowledged following their symbolic properties, for example, "bitter" (scorpion; *Scorpio*), "watery" (fishes; *Pisces*), "not coming up" (*Cancer*), "buckled" (like the capricorn horns; C*apricornus*), "bearing a lot" or "being well-adjusted" (like the balance; *Libra*). Thus, in addition to the primary time qualities coming from the moon's phase and orbit, there were secondary qualities, mediated by the moon from the twelve zodiac signs, which were considered to represent fundamental time qualities. From this perspective came sayings like: "Sow beans in the [moon-]sign of the virgin, then they will flourish again and again."

16.5.4 Hints for Action Received from Dwarfs or Other Unusual Phenomena

The dwarfs, as important ‘spirits of the underground’, were already addressed above in this chapter. Legends from the Alps tell of additional attributes that have not been mentioned by the Mannhardt-sources: Dwarfs, as well as woodland fairies and other figures, may tell a farmer the right time for action. In such legends, for example, a farmer was urged to sow at a time when it was not typically done following common practice. The others laughed at him, but then afterwards, the weather conditions showed that he did right. We may interpret such legends as symbolic expression for ‘irrational’ intuitions, coming to a single farmer’s consciousness from a part of the unconscious close to Nature, telling him to break the rule in order to do the right thing at the right time.

16.6 A Brief Glance at ‘Cultic Cultivation’ Today

Some of the former beliefs and practices of magic-religious cultivation of the soil are still alive within regional and cultural minorities of European farmers—in traces in many places, more intense in some cultural ‘island positions’. In 1997, for example, a farmer near the city of Schaffhausen (Switzerland) told me that he would always start sowing in a field by sowing a cross. In explanation, he said that it “would not be the same to get 40 or 70 quintals of wheat per hectare”. Accordingly, it is his belief that he would risk to get low yield if not doing the cross. Some regional case studies in form of PhD studies are interesting to quote here: In 1992, the rural sociology investigation done by Reinhard (1992), showed that in the Swiss Emme valley (Emmental), 60% of the farmers at times still observed the zodiac signs; one third believed in folk tales, inexplicable events, and abilities of special individuals. And for Austria, Burger-Scheidlin (2007) and Christanell (2007) found in two regions (Western Styria and Great Walser Valley/Vorarlberg), similar customs and beliefs that Mannhardt had reported 140 years before. Some of them abundant: *e.g.*, the observance of moon times and weather proverbs, rituals with palm branches, weather blessings, and processions; others rather rare: *e.g.*, rituals with holy water, with Good Friday eggs, or outside praying.

In addition to the continuation of older customs, there are new individual ideas or social movements springing up, where traditional and/or new religious ideas are considered important for soil and land cultivation. The most important social movement is the bio-dynamic branch of organic farming, where some acknowledgement of “elementary beings” (*e.g.*, dwarfs) can be observed. In this context, I have been told in 2006 in southern Germany of the private ritual of feeding such beings porridge and considering them to take “the essential” out of it. In 2009, from the same region, I learned of a newly introduced ritual in which the farm community invited the beings to thanking rituals on Sunday by walking around with bells. The current observations of religious cultivation of the soil can be interpreted as traditional remnants—and/or as an indication of the new emergence of these psychic-spiritual patterns in present-day people.

16.7 Dealing with the Unconscious when Cultivating Nature

16.7.1 The Typical Split and the Longing for Connection

It is a recurrent phenomenon of Western societies that people are fascinated by foreign cultures that they perceive as ‘primitive’, ‘archaic’ or ‘indigenous’. One of the motivations has been to find an inspiring contrast to its own present cultural state, and perhaps a glimpse at one’s own psychic and spiritual roots, and cultural history. Examples of individuals who have undertaken this quest are Paul Gaugin (1897) as an artist, Sir Laurens van der Post (1952) as a diplomat and writer, and Frank Speck (1935) as an ethnologist. Another aspect of the search for orientation, or the longing for reconnection with one’s own roots, is to look for traces of our own ancestors and their cultural space. This was the motivation for the Grimm brothers to collect the German fairy tales, and also the motivation for Wilhelm Mannhardt to document the religious cultivation of the soil in many European countries—something that was fading away, but, against expectation, did not disappear, since the rational enlightenment had reached the minds of rural people.

Such looking back and looking abroad can also have another effect—*finding these irritating and fascinating strange things living with one’s own soul!* At this moment, the personal relationship to them acquires a new quality. Then, a new task may be faced: to achieve new insights by the effective connection of that which found us from our inner world (emerged from our soul and/or gotten as inspiration) with that which became conscious to us from the outer world. Something of the inner human view of the world is manifest in traditional or new folk-religious belief-knowledge, and some of the outer human view of the world is condensed in current scientific pedological knowledge-belief. Each refers to aspects of reality, which are perhaps complementary but which belong together.

An *unconscious* coalescence of inner and outer world perception, when appearing in the present Western culture, can show serious problems as well as does the usual inner split between ‘rationality’ and the soul-and-spirit realm. To deal with these issues is a very personal venture and at the same time a major scientific research and cultural renewal undertaking.

Now, how is one to deal mentally with the attempts at religious cultivation of the soil described above, and the conflicts that arise from them within a modern ‘rational’ consciousness? Stepping back to a former cultural and mental state is always possible, and is indeed observed in some esoteric and fundamentalist religious movements of Western and other cultures. But this looks very much like cultural regression instead of renewal, and cannot bridge the gap between the aboriginal experiences and all of the religious traditions of humankind on one side, and the cultural achievements of a new consciousness of matter and individuality—often labelled with terms such as ‘enlightenment’, ‘scientific worldview’ or ‘modern freedom’—on the other side.

16.7.2 Concepts of C.G. Jung's Psychology may be Useful for Bridging the Gap

The Swiss psychologist C.G. Jung introduced an interesting new notion of *symbols* into psychology and cultural sciences. He definitely did not understand living symbols as 'signs' or 'codes' for something intelligible. Instead, he worked with the hypothesis that symbols were tentative bridges between a given human consciousness and the realm of the "unconscious" (*e.g.,* Jung 1968). The term 'unconscious' is used here, to name what is not part of our consciousness, but appears, when touching it, mentally. For example, what is called "the beyond", appears in a way that it can also be perceived as part of the unconscious.

Some contents of the unconscious can be integrated into consciousness, *i.e.*, made conscious themselves. That is the objective of Freudian psychoanalysis and similar approaches. Other contents of the unconscious resist being integrated to consciousness. These traditionally are referred to with terms such as 'spirit', 'demon', 'Devil' or 'God'. It has to be disclaimed again, that no 'psychologisation' of God is intended, as if He were nothing but a mental construction. But it is assumed here that the phenomenon of God should not be confused with human consciousness, and is not part of it. Therefore, the empirically perceivable appearances or intrusions of what is named 'God' into human consciousness can be said to come out of the 'unconscious'. Following this viewpoint, *living religious symbols are interface phenomena* between human consciousness, with its structures and knowledge on one hand—and the *numinosum tremendum et fascinans* (Otto 1917), the irritating, fascinating (or repelling) and overwhelming 'other', perceived to come as from 'outside', on the other.

16.7.3 Some Hypotheses

Our main hypothesis here is that the elements of the religious cultivation of the soil ('religious' in the broad sense of the word), presented above, are full of symbols. One may say, that by means of these symbols, people tried to link themselves to the unconscious, including the spiritual and divine dimension within themselves and within the outer world. But more than that, the aim of magic-religious cultivation was to achieve direct, material effects on the fields, not only an effect on one's own mental condition and personality. So, the more precise conclusion could be: *People tried to stimulate processes within Nature, where spiritual factors are seen to be inherent, involved or introducible, by addressing these factors and thereby connecting themselves to them.*

A look from the perspective of comparative religion at the factors or *powers that be*, which were acknowledged in European agriculture, shows that: 1) some are fully in tune with the Christian notion of God, as represented by the churches, *e.g.*, symbols of Christ; 2) some are in close relation with underground or 'folk' currents of the Christian spirit, *e.g.*, some feminine symbols; 3) some are close to religious patterns of pre-Christian Europe, and of other cultural spaces, *e.g.*, the spirits of soil and vegetation. The use of symbols of Christian origin can be seen as the human attempt of bringing the soil (like Mary) and the Holy Trinity closer to each other, with the good hope to receive meaning and bounty out of that mutual devotion. In particular, the customs where Mary is involved show her with more traits than are canonically attributed the Mother of God. For example, the "hair of Mary" in the ringing Austrian bell, whose sound may symbolically mean the voice of the earth (see above). Other symbols do not show any strong connections to the Christian notion of God. Their mental embedding can rather be found in pre-Christian European religions and religions of other regions. The spirits of the soil and the lands, the magic-religious acts with plants, and some of the divination and premonition complex, contribute supplemental layers and branches to the religious practice of soil cultivation.

The proposition by Marie-Louise von Franz (2006) quoted above, that 'magic' means basically, to address the divine within matter and to try to relate to it, might be a good conceptual framework for understanding material symbols in agriculture. And if one looks at these symbols not with a theological, but with a psychological, anthropological or comparative ethnological perspective, the general, archetypal structures of religious cultivation of the soil, which cannot be fully reduced to or explained by specific religious traditions, become more visible.

Some basic patterns of religious cultivation of the soil seem to occur all over the world (see for example Frazer 1914-18); and apparently they are able to occur in the soul of everyone, coming out of the unconscious, and enabling symbolic bridges to the *inner soil* (see also chapter 13 in this volume by author, "The Soil Scientist's Hidden Beloved").

16.8 Perspectives

Religious cultivation of the soil means, that more than the outer soil is cultivated. In Europe, attention and care to inner factors of soil cultivation and successful crop growth was an important part of *agri-culture*. It was full of inner tensions and tentativeness, but was trying to have a relation to and to deal with 'the beyond' and the *powers that be*—the unconscious—when cultivating the earth. Maybe a new soil culture is needed: one which is anew in touch with more than what we can grasp, but without loosing its foothold on concrete soil. This development will need a major effort. {A remarkable pioneering work in this direction was done by Abt (1989)}. Then, effective symbols which link our consciousness to the unconscious nature may provide good service to us as individuals and to the concerned societies as a whole.

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References

Abt Th (1989) Progress Without Loss of Soul. Toward a Wholistic Approach to Modernization Planning. Chiron Publications, Wilmette (Illinois)

Burger-Scheidlin H (2007) Wetter- und Klimakonzepte von Landwirten. Wahrnehmung und Wissen zwischen Praxis und Theorie. Eine sozialanthropologisch-ethnoklimatologische Studie im Großen Walsertal, Österreich. [Farmer's concepts on weather and climate. Perception and knowledge between theory and practice. A social-anthropological and ethno-climatological investigation in the Great Walser Valley, Austria.] PhD, Univ. of Nat. Resources and Applied Life Sci., Vienna

Christanell A (2007) Lokale Perspektiven zur Wetter, Klima und Klimawandel. Eine sozialanthropologische und ethnoklimatologische Untersuchung in der Weststeiermark, Österreich. [Local perspectives on weather, climate and climate change. A social-anthropological and ethno-climatological investigation in Western Styria, Austria.] PhD, Univ. of Nat. Resources and Applied Life Sci., Vienna

Eberhardt A (1907) Mitteilungen über volkstümliche Überlieferungen in Württemberg [Notes on popular customs in Wurttemberg], Nr. 3. Sonderabdruck aus dem Württembergischen Jahrbüchern für Statistik und Landeskunde, Jahrgang 1907. Kohlhammer, Stuttgart

Frazer JG (1914–18) The Golden Bough. A study in magic and religion in twelve volumes. Macmillan, London

Gaugin P (1897) „Where do we come from? What are we? Where are we going?" [Painting title]

Högger R (2000) The Cross-Ploughed Field [preprint]. Published later in: In Search of Sustainable Livelihood Systems. Managing Resources and Change. Edited by Ruedi Baumgartner and Ruedi Högger; Sage Publications India Pvt Ltd, New Delhi 2004, chapter 7:166–186

Jung CG (1968) Introduction to "Man an His Symbols". In Adler G and Hull RFC (series eds.), The Collected Works of C.G. Jung (vol. 18): The Symbolic Life. Princeton University Press, Princeton (NJ). (Original work written 1961, after Jung's death first published 1964 as a reworked version in Jung GC and von Franz M-L: Man and His Symbols.)

Mannhardt W (1875/77) Wald- und Feldkulte (2 Bände) [Cults from woodlands and fields (2 vols.)]. Reprint by Wissenschaftliche Buchgesellschaft, Darmstadt, 1963

Otto R (1917) Über das Heilige in der Idee des Göttlichen und sein Verhältnis zum Rationalen. Trewendt & Granier, Breslau [English 1923: Idea of the Holy; Oxford]

Patzel NF (2009) Symbole im Landbau. Auswertung der Mannhardt-Umfrage in der Schweiz [Symbols in agriculture. The Mannhardt survey in Switzerland]. Ökom, München [Munic]

Reinhard J (1992) Zwischen Gespür und Planung – zwischen Gefühl und Berechnung. Ein Beitrag zum Umgang mit Unerklärlichem im bäuerlichen Alltag unter besonderer Berücksichtigung einer praxisbezogenen landwirtschaftlichen Ausbildung [Between intuition and planning—between feeling and calculation. A contribution for the dealing with the unexplicable in rural everyday's life; with special regard to an agricultural formation which is close to practice]. PhD, Swiss Federal Institute of Technology, Zurich

Speck FG (1935) Nascapi: The Savage Hunters of the Labrador Peninsula. Repr. Universtity of Oklahoma Press, Norman, 1977

Van der Post L (1952) Venture to the Interior. Hogarth Press, Richmond

Von Franz M-L (2006) Psychological Commentary. In: Abt Th and Madelung W (eds.): Book of the Explanation of the Symbols. Kitab Hall ar-Rumuz. By Muhammad Ibn Umail. Living Human Heritage Publications, Zurich

Chapter 17
"Rock – Stone" and "Soil – Earth": Indigenous Views of Soil Formation and Soil Fertility in the West Indies

Christian Feller and Eric Blanchart

17.1 Introduction

Scientific investigations are conducted without blinders on. While the goals of our investigations tend to lead us from point A to point B in targeted data collection, sometimes information that is tangential, yet undeniably fascinating, falls into our laps. Such was the case for us during the course of botanical, agronomic and pedological investigations conducted in the West Indies during 1981-1986. This paper is based on information collected during informal interviews with local, family farmers from the islands of Martinique and Saint Lucia.

Two sorts of farming system coexist all over the Lesser Antilles (see Peeters 1976):

– large (private or public) plantations represented by intensive monocultures (sugarcane, bananas, pineapple, coconut or fruit orchards), close to the food processing industry, and characterized by agricultural practices defined by scientific knowledge;
– small family farms, "the Creole garden", where subsistence and cash crops are closely interlinked. The level of chemical inputs is still low despite efforts aimed at introducing modern technology. Farm management practices focus on rotation with traditional (bush) fallow crops, and recycling of organic residues (burying of fallow vegetation, use of crop residues and manures). The rationalization for crop rotations as well as other agricultural practices is based on a traditional view, but also integrating some technical elements, such as mineral fertilization provided by rural extension services.

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The small farmers working on the hilly terrains caught our interest. The most interesting interview was with a farmer designated “X”, living in the region of Saint-Marie, in the northeastern part of Martinique. This interview was used in the present work as a comparative reference, particularly with regard to interview data gathered during a meeting with a group of six farmers (called the SL group) from Choiseul on Saint Lucia Island. Our discussions focused on the origin of soils and rocks, and what emerged was a remarkable contrasting view from these tillers of the soil as compared to the general scientific view of the rock weathering cycle.

17.2 Relationships between soils and rocks

17.2.1 The Scientific View of Soil Formation

The collision of the Caribbean and Atlantic tectonic plates contributed to the emergence of the West Indies arc, with its string of volcanic islands such as Martinique and Saint Lucia (Westercamp and Tazieff 1980). These islands are mainly made-up of volcanic rocks ranging from dacite to basalt, and appearing as different lava flows or aerial fallouts. Volcanic activity continues to recent times, and the 1902 and 1929 Mountain Pelée eruptions, with emission of ash and pumice, are still relevant events in minds of Martinique inhabitants.

Through alteration, these volcanic rocks give rise to soils whose characteristics (Fig. 17.1) depend largely on the age of the deposits and the amount of rainfall (Cabidoche et al. 2004; Feller et al. 2006). Following the terrain along a path of increasing rainfall, one can distinguish:

– soils that are more and more clayey when increasing age (older than 10,000 years), with a dominance of kaolinitic clays under high rainfall (Ferrallitic soils and tropical Brown-red soils with red, grey, yellow and multicoloured horizons) and with dominance of smectitic (swelling) clays in lower rainfall regions (Vertisols with black horizons);
– on very recent deposits of ash and pumice (between 50 and 10,000 years) and under high rainfall, sandy-silty and sandy-clayey soils (young Andosols) with a dominance of allophanic minerals (amorphous, non crystallized clay) develop.

The regions, with an average rainfall above 2.5 metre, of “X” and of the SL group show similarities in soil distribution due to the existence of a stacking of young materials (pumice or tuff) on old weathered one (dacite or andesite lava): Ferrallitic paleosols or paleo-weathered horizons are often covered by younger soils, such as Andosol or Brown soils.Variations can be observed at the scale of the farm (Fig. 17.2). Colluvial or alluvial soils occupy only very small parts of these areas.

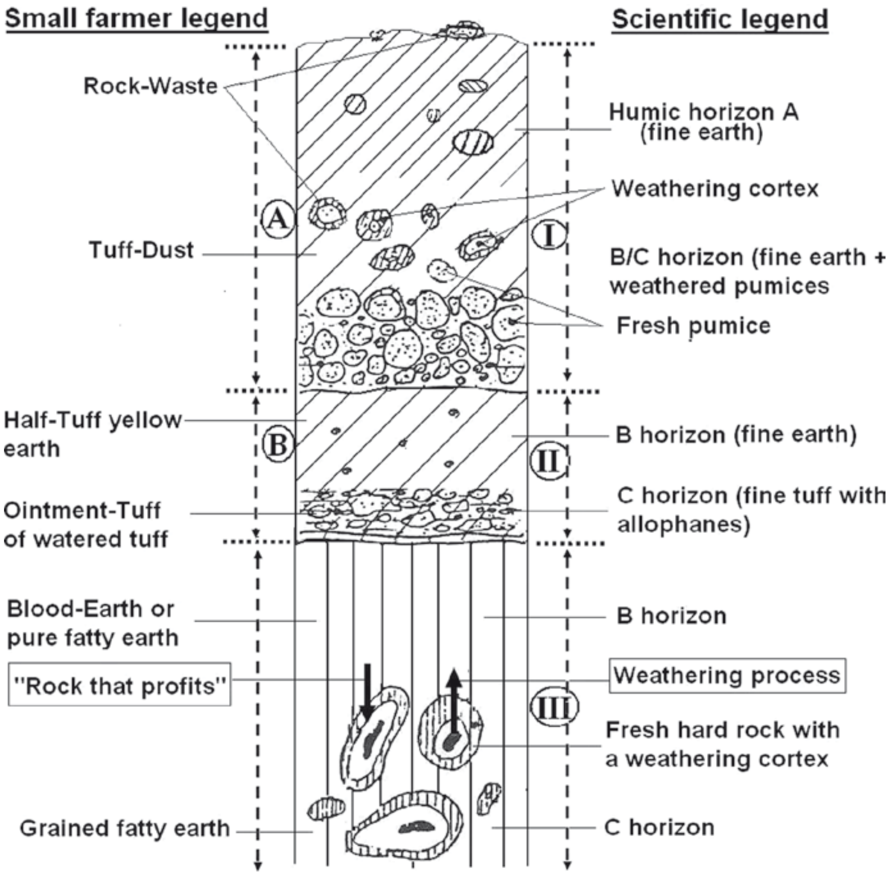

Fig. 17.1 Example of horizon profile likely to be found in Northern Martinique or Choiseul region of Saint Lucia with farmer nomenclature on the left and scientific legend on the right. Note the succession of present soil (A and I) and paleosols (B, II and III)

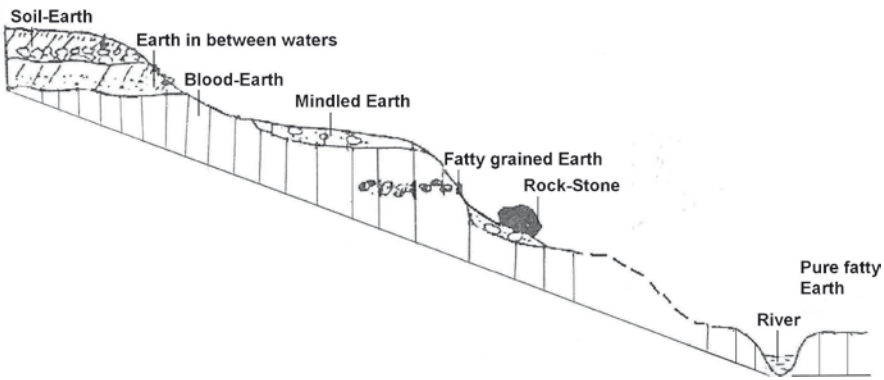

Fig. 17.2 Schematic soil distribution in the farm of X. Note in particular that the "pure fatty earth" (ferrallitic weathered B horizon) close or not to a river and devoid of rocks (because completely weathered) is said to be a "substance-free soil", inappropriate for the growth of "rocks-stones"

17.2.2 The Local Farmer's View of Soil Formation

Below is a synthesis of the view of soil formation uncovered by our interviews. Words or terms in quotation marks are from the interviewed people and translated from Creole (given in bold); the French equivalent term is given in parentheses and quotation marks.

In the beginning, God created the Sky, the Earth (planet), seas, rivers, mountains, rocks and "earth" (soil materials in the pedologic sense), humans, animals, and plants. X and the SL group agree that the "earth" has always existed, but their views diverge concerning soil-rocks relationship. Some (X and the SL1 subgroup) developed a theory attributing the formation and growth of rocks from "earth" (**woch ka profité, laté ka nouri wôchla**), while others (SL2 subgroup) rejected this theory. None of them related the presence of rocks to volcanic phenomena, and none subscribed to the scientific view of soil formation, that is "earth" from rocks (alteration and pedogenesis).

The concept of the "benefiting rock" (noted below) seems to be well anchored in the West Indian farmers' perception of soil and rock, though some of them reject it. The same Creole term is used both in Martinique and Saint-Lucia, suggesting its appearance many years ago. We focus below on the statements of X whose father was a "quimboiseur" (local French word for a traditional medicine-man; a kind of shaman) and whose views demonstrated a synthesis of field observations and traditional knowledge.

17.2.2.1 Views of X

The "earth" which has always existed (established soil), and which was neither recovered nor mixed with recent inputs, is the "soil-earth." Additionally, "earth" can also be brought by rivers or landslides. Different deposits are then observed: "earth in between waters" or a mixture of materials ("many-coloured earth"). Although rocks can be deposited by rivers, they generally can "grow in/from the earth and benefit of it". This assumption is confirmed by:

- the nature of some rocks—the "waste-rocks"—whose external covering (the altered layer according to scientific view) is formed by moist soft materials having an earth aspect but already acquiring the structure of rocks (Fig. 1). In some cases, the origin of the "waste-rocks" would be the **filibo-la-rivière** (filibo of the river). The filibo-la-rivière is described as "an earth rolled by rivers and transformed into pebbles". In fact, it is a fragment of highly weathered rocks (the example of a filibo waste-rock shown to us was a totally altered, brown andesite fragment). The Creole term "filibo" (or "pilibo") when used alone refers to a multicolored, pyramid-shaped candy. It is a specific traditional candy from Martinique that does not exist in other Caribbean islands. The small pebble **filibo-la-rivière** looks like a filibo candy;
- the fact that some "earths," though they are set close to a river, do not contain any rock (all "earths" are not capable of rock growth), and conversely, other "earths" distant from the river contain hard and large rocks, the "stone-rocks" (Fig. 2);

Many factors regulate the growth of rocks:

- "earths" contain some "substance" that is needed for rock formation. This substance is found in the water of the earth and moves from earth towards the rock's heart (Fig. 1). A rock grows at its periphery, the outer cortex being always moister than its heart and still looking like "earth" (rock in formation). Thus all "earths" do not have the same capacity for rock growth;
- "earth" or "earth substance" works all the better when the moon rises or a river is nearer; like some plants, "earth and rocks swell as the moon rises". Although opinions differ between X, SL1 and SL2 groups about the "swelling of rocks", a unanimous agreement is however reached about the "swelling of earth". A small farmer from Saint Lucia describes the following observation: the amount of earth extracted from a hole would not be enough to refill it when the moon withdraws, but would spill over when the moon rises;
- "all pebbles don't change to rocks". Pebbles must first reach a certain "maturity." An example of a well-matured pebble is the "waste-rock" [slightly altered dacite or andesite gravel (Fig. 1) which could develop into "stone-rock" (hard large rock, like a non-altered andesite). Consequently, the bigger the "stone-rock", the older it is. Some strongly altered, blackish gravels will never form rocks. Moderately altered "tuff" (coarse pumice stone) fragments (these are "soft rocks") will only form "small tuff gravels" instead of "stone-rocks". Finally, "male rocks" (hard rock, see below) seem also to be incapable of growing;
- rocks can be "wounded" (broken). This term "wounded rock" was also used by the SL2 subgroup. These rocks lose their "vitamin", "their substance" through the wound. Consequently, they give back "earth". Only the healthy part of them will be able to grow;
- wet seasons facilitate the growth of rocks, unlike dry seasons. Indeed during the dry season, the typical pattern can reverse, and the transformation of a rock into "earth" can occur (X described this process on a slightly altered pumice with a dusty, crumbly outer rind).

In summary "rock grows from earth", but growth capability depends on the kind of earth, gravel or rock, on the climate, on the moon position, and on the history of the rock (a wound, for example). Thus, growth regulation is possible. "Pebbles are like seeds" and have a life history: birth, life and death. The "substance" (sometimes called "the rock genius") is the active principle and comes from the "earth." Each "earth" has its own "substance" but can also lack it. What is then this "substance"?

This substance seems to be the growing factor for everything related to the "earth" such as rocks and plants as well. Effectively, the more "creamed" (containing some humus and/or fertilizer) is an "earth", the more "substance" it has to nourish plants: the "cream feeds plants" (**la krem ka nouri plant**) [this fundamental notion of "cream" is very common in the Lesser Antilles]. It is still difficult for us to understand the relationship between "cream" and "substance", but probably it must be strong, since X described interactions between plants and rocks. Thus, bad plant growth is attributable, in some cases, to a competition between plants and rocks (to the advantage of the latter) in the use of the "earth substance".

This justifies why gravels should be removed from arable land, and why uncultivated fields will be soon loaded with rocks. In other cases, a “wounded” rock can throw out in the “earth” some “substances” that can be either toxic for plants, or can inhibit the effects of fertilizers or manure.

Each “earth” has its own properties, its own “powers” towards rocks, plants, animals or humans. “Each country has its own earth”. The earth “emits vapours”, especially at night; at dawn, there is dew, evidence that “the earth sweats”. These vapours may poison some plants (essentially “foreign plants”); hence, the non-adaptation of some exotic plants. Those vapours may also be harmful to humans. “Earth should not be worked before 7 or 8 in the morning, for it is bad for the lungs” unless “some rum or absinth liquor has been drunk in the morning” to act as an antidote. “A cemetery earth” poisons any other “earth”.

Some “earths” or gravels are used as a component of some medicine, or required for a given “work” done by the “quimboiseur” (shaman). X refused to speak about this last subject “avoiding evil to come to us”; nevertheless, he quoted some traditional pharmacopoeias as examples:

– the **filibo-la-rivière** (a weathered stone, see explanation above 17.2.2.1.) “crushed and mixed with vinegar and bicarbonate taken at 2- and 8-day intervals when the moon withdraws, followed with a purge, is a good medicine against cancer;
– “violent pleurisies” can be cured with ”firm earth” preparation;
– a powder made of “female tuff” can fight against acne.

17.2.2.2 Nomenclature of Rocks and Earths

Statements of X are richer than those of the SL group; nevertheless no major contradiction has been noticed between them. Terms only used by X will be emphasized below.

The classifications of “rocks” and “earths” as presented hereafter come from us.

Different kind of rocks

a) The “male” and “female” rocks

X and the SL group agree that in nature, everything is either male or female—rocks, plants, animals, and humans. While the SL group can not distinguish between these two kind of rocks, X stated that “male” rocks are very hard and can be scarcely broken, such as “apricot-rocks”, “stone-rocks”, and some “tuffs”, while “female” rocks can easily be broken; they are either a weakened hard rock due to their flat shape (“porcelain-rocks”), or soft rocks known as “female tuffs” [With some humour, one member of the SL group seems convinced of this sex difference between rocks, as it is not rare (he says) to observe rocks atop one another… No comment!].

b) Rock classification according to their hardness, structure, or alteration level

"Apricot-rock": small to medium-sized hard rock (dacite and andesite);

- "Iron-rock": very hard rock;
- "Stone-rock": hard rock. "They smell of sulphur when rubbed against each other". They can reach a large size;
- "Waste-rock": hard and slightly altered rock;
- "Tuff": coarse pumice stone;
- "Grained rock": slightly altered tuff with coarse grains;
- "Ointment-tuff": fine textured tuff, often with allophane;
- "Female tuff": fine and altered tuff spreading "dust in sunlight". It gives back to "earth";
- "Ordinary sand": fragments of sandy pumice stone;
- "Cement sand" or "sand-earth" or "hollow earth": volcanic-ash derived sand, rich in magnetite, and currently used in earthquake-resistant building materials;
- Finally, for a particular case, the filibo-la-rivière which is "an earth rolled by rivers and transformed into pebbles" (see section 17.2.2.1.).

Different kind of earths

Many criteria are considered when characterizing earths:

a) Coarse element content

- "Dust for tuff": a soil with allophane (showing little development), rich in pumice fragments, developed on slightly altered pumice stone;
- "Half-tuff yellow earth": a soil with allophane in which the proportion of fine elements increases;
- " Mixed-earth" or "mingled-earth" (**tè mélé**): a mixture of fine and coarse elements;
- "Grained fatty earth": Clayey ferrallitic (rich in iron oxides) horizon (B or C) commonly red or multi-coloured, still containing highly altered clayey lithorelics (rock debris with important mineralogical transformations);
- "Fatty-earth", "firm earth", "blood earth", "Carafe-earth": clay materials, commonly red and without particles larger than 2 mm.

b) Fine element content and degree of moisture

According to all the farmers interviewed, "earths" are distinguished as:

- "light earths" (**tè légé**), "firm earths" (**tè fim**), "half-fatty earths", "fatty earths", and "heavy earths" according to sand or clay content;
- "Cold earths", "warm earths", or "hot earths" according to moisture, colour and period of sunshine. "Cold earths" correspond to the wettest Andosols (with allophane), characterized by a yellow colour; "hot earths" correspond to halloysite-rich soils (Nitisols) or smectitic soils (Vertisols), characterized by a dark reddish or black colour respectively.

Some other typical West Indies terms can also be used:

- “the mangrove tree earth” (“terres mangle-coulisse”): an unconsolidated clay mud located near edges of rivers and ponds. “Mangrove tree earths” (“terres-mangles”) or “mango tree earths” (“terres-mangues”) (**tè mang**). It is difficult for us to distinguish between those two terms although the Creole term refers to wet, peaty, muddy soils found in the mangrove zones (with mangrove trees such as *Rhizophora mangle*). In old books (Anonyme ATB 1841; Descourtilz 1835, vol. 1, plate 10, p. 45) mangrove trees are also called “mangliers” (in French). Descourtilz (1835, vol. 6, p. 72) indicated also that the Indian mangrove trees *Rhizophora* or *Bruguiera* can also be called *Mangium celsum* and **Mangé-mangi**. To conclude, let us say that the Creole pronunciation would be “terres-mangue” in Martinique and “terres-mangle” in Saint Lucia;
- “dried mangrove tree earth”: when cultivated;
- “Yellow ointment earths”: soil with hydrated allophane with thixotropic effect (soapy touch; sliding of material when pressed between fingers). This diagnostic field test used by X is the same as that used by professional soil surveyors. These “earths” are generally localized above a “watered-tuff” (a sedimentary volcanic layer below the water table).

c) Stackings of clay horizons or material mixtures

These are “earths in between waters” or “many-coloured earths” (see section 17.2.2.1).

d) The richness of “earth”

The richness of an “earth” depends on the “substance” or the “cream”. “Creamed earths” are good soils and “have much power”. “Earths” can be “creamed” with organic inputs, manures, animal dungs, etc. X also described a “double fatty earth”—a clayey earth not having abundant organic matter but not requiring the use of fertilizers.

In summary, the quality of observation and the language accuracy, often picturesque, from the farmer’s statements are noteworthy. Rocks are distinguished according to their hardness, (“iron rock”, “apricot-rock”, “stone-rock”), structure (“grained” or not), level of transformation (“waste-rock”, “mature rock”, “stone-rock”), water-holding capacity (“tuff”, “ointment tuff”, “watered-tuff”). “Earths” are also classified according to their colour, coarse-element content, texture, humus content and fertility.

17.3 Discussion and Conclusions

Differences in the respective views of X, and the SL1- and SL2-subgroups have been specified above; henceforth, the farmers’ views discussed will refer mainly to X and the SL1 group.

The farmers’ discourse is clearly based on the assumption of the *nourishing Earth*, but in a more extended meaning than its usual consideration, since “earth” provides a source of life, not only for plants (hence for animals and humans), but also for rocks.

Would "earth" then, in that view, be the fundamental matter of reproduction and renewal? It would be very interesting to see if parallels can effectively be drawn up between soil fertility and human fertility across a variety of traditional cultures.

This assumption of parallelism would seem to explain:

– *the genesis of rocks*: its birth with "rolled earth" (as in the case of filibo-la-rivière), growth into "waste-rocks" and "mature rocks", and death with "wounded rocks" and "old rocks" to give back "earth". "Earth" is therefore the owner of the growth factor, since "waste-rock" or "mature-rock" show on their surface a rind which "is not anymore an earth, but not yet a rock". This factor is the "substance" sometimes called "the genius of the rock". Devoid of this "substance", an "earth" contains few or no rocks.

– *plant growth:* essential role of the "substance" and including:

  * Competitive phenomena between rocks and plants based on either the use of the nutrient factor ("the substance"), or toxicity and inhibition;
  * Mechanisms of regulation, particularly by the Moon or the Sun. There is a generalized integration of the Earth's physical milieu with the cosmos. "Swelling" of "earths", rocks, or plants is a moon-regulated process. The Moon is probably the uppermost factor of regulation. The role of the Sun is less clear; it can however change rocks into "earth".

Hence, one can understand through the farmers' discourse, that the local volcanoes, despite recent eruptions, are not perceived as the source of "rock" or "earth". The farmers' statements concerning the earth–plant relationship bring to mind a general agronomic theory of the late 18th century (Thaer 1811)—the Humus theory—giving a major importance to soil organic matter in plant nutrition (Feller et al. 2003).

Beyond local traditional construction, the farmers' perceptions of earth-rock relationships and rock genesis from soil may also come from scientific discourses conveyed by colonizers two or three centuries ago. J. Barrau from the French National Museum of Natural History told us (pers. comm.) that a scientific theory very close to that of farmers was common in the 18th century concerning mines that were "left for rest" so that they will "build up again". Up to the end of the 18th century, scientific discourses are not really clear about the formation and origin of rocks and earth. For instance, at the end of 16th century, Bernard Palissy, one of the founders of modern geology and of the mineral theory of plant nutrition (Feller 2007) clearly attributed the formation of rocks from earth through some special water—the "generative water (Palissy 1880 edition, pp. 357, 405-406, 420). One can find some Palissy-like ideas in the discourse of X: stone formation is easier along the river (pp. 359, 360). One century later, in the book "Nouvelle Maison Rustique" (Liger 1721, p. 483), it is written that "tuff is a dry earth that begins to petrify". This idea was largely accepted up to the end of the 18th century. Where modern soil scientists would see alteration, scientists from the 18th century (in line with the present-day view of X) saw the first steps of rock formation.

In conclusion, let us compare the scientific view [based on pedogenesis (from rock to soil)] with the farmers' view [based on lithogenesis (from "earth" to rock)]:

Scientific view (pedogenesis)	Local farmer's view (lithogenesis)
Rock existed first.	"Earth" existed first.
Rock gives birth to soil.	"Earth" gives birth to rock.
Rock is older than soil.	"Earth" is older than rock.
Soil development depends on time:	Rock development depends on time:
- young, thin soils: little developed	- small pebbles: young
- old and thick soils: highly developed	- large rocks: old
There is alteration.	There is aggregation.
Water is the main alteration factor.	Water is the main growth factor.
Competition (for plant nutrition) exists between soil and plant—*e.g.,* in fertilizer use: immobilization in soil or root absorption.	Competition (for plant nutrition) exists between rock and plant.
Rock (the mineral) means death.	Rock means life.

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References

Anonyme ATB (1841) Notices sur l'île de Sainte-Lucie par un planteur de l'île. Rapport, p. 62.

Cabidoche YM, Blanchart E, Arrouays D, Grolleaux E, Lehmann S, Colmet-Daage F (2004) Les Petites Antilles : des climats variés, des sols de natures contrastées et de fertilités inégales sur des espaces restreints. Cahiers du PRAM 4: 21-25.

Descourtilz J Th (1835) Flore pittoresque et médicale des Antilles. Paris, 6 vol.

Feller C (2007) Une fausse rupture ou de l'intérêt du retour aux sources en histoire de l'agronomie : l'exemple de la nutrition minérale des plantes et du « génial » Palissy. In: Robin P, Aeschlimann JP, Feller C (ed), Histoire et Agronomie : entre ruptures et durée. Coll. Colloques et Séminaires, IRD, Paris: 181-202.

Feller C, Thuriès L, Manlay R, Robin P, Frossard E (2003) The principles of rational agriculture by A.D. Thaer (1752-1828). An approach of the sustainability of cropping systems at the beginning of the 19th Century. Journal of Plant Nutrition and Soil Science, 166: 687-698.

Feller C, Clermont-Dauphin C, Venkatapen C, Albrecht A, Arrouays D, Bernoux M, Blanchart E, Cabidoche YM, Cerri CEP, Chevallier T, Larré-Larrouy MC (2006). Soil organic carbon sequestration in the Caribbean biome. In: Lal R, Cerri CC, Bernoux M, Etchevers J (eds) Soil Carbon Sequestration and Global Climate Change: Mitigation Potential of Soils of Latin America. The Harworth Press Inc., Binghamton, New York, USA: 187-211.

Liger L (1721) La nouvelle maison rustique ou économie générale de tous les biens de campagne. 2 tomes : tome 1, 3e édition, Paris, Prudhomme 782 p.

Palissy B (1880) Oeuvres complètes. P. Charavay Ed., Paris, 499 p.

Peeters A (1976) Le petit paysannat martiniquais et son environnement végétal. Recherches en cours. Journal d'Agriculture Tropicale et de Botanique Appliquée, 23 (1, 2, 3), 47-56.

Thaer A (1811) Principes raisonnés d'agriculture. Paschoud Imp., 4 tomes.

Westercamp D, Tazieff H (1980) Martinique, Guadeloupe, Saint-Martin, La Désirade. Guides géologiques régionaux. Masson Ed., Paris, 135 p.

Chapter 18
Mobilizing Farmers' Knowledge of the Soil

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One way in which a culture can be read is through the way its people control their material environment, and through the knowledge that accompanies it. Such knowledge is part and parcel of social representations, which are ways of imagining daily life and the world, as developed, shared and transmitted within a community. They set up a consensual reality, and orientate the behaviour of a group, with the view of controlling the social, material, and ideological environment (Lévy and Lussault 2003).

In rural communities, control and use of land is one arena where "local" or "indigenous" knowledge is one of the main determinants. We will focus on such "local land knowledge". While there is a purely anthropological interest in these folk representations and classifications (Friedberg 1992; Holman 2005), there is also a practical interest in how this rural knowledge interfaces with the external stakeholders' ideas that are often derived from popularized scientific knowledge. In every project concerning rural areas, indigenous knowledge (particularly among the farmers) must be recognized and taken into account in order to bring about consensus between various stakeholders on actions to be carried out (Dupré 1991; Roose, 1994).

An example from Madagascar will show how the mobilization of rural knowledge about the soil, and close observations of cultivated soils and indigenous agricultural practices, are particularly important components of projects aimed at achieving sustainable agriculture.

Separated with South-East Africa by the Mozambique Channel, Madagascar is the fourth largest island in the world, and contains a wide variety of landscapes and ecosystems. Its ancient isolation has permitted an exceptional evolution of life. As a result, Madagascar is classified as a "biodiversity hotspot"—a region where a large concentration of endemic species are threatened by loss of habitat (Myers et al. 2000). Nevertheless, for centuries, it has faced a high loss of habitat and species due

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to deforestation and conversion of primary vegetation. Most of the Malagasy people (people of Indonesian, Arabian and African origin who inhabit Madagascar) depend to a high degree on natural resources, with about three quarters of this population living as subsistence farmers. The East of Madagascar is a warm-, rainy-, formerly forested- and moderately populated-lowland. The Highlands, the grassy elevated center of the island, is drier and more highly populated. A prominent forested escarpment forms the boundary between the eastern lowlands and the central Highlands.

The agricultural practices in the Highlands, with their Indonesian-looking landscapes of impeccably terraced rice fields, contrasts with the basic slash-and-burn prevailing practices (called *tavy* in the native language) of the Eastern people, often considered as "forest people" (Le Bourdiec 1974, Rabearimanana 1988). The wealth of knowledge that the Highlands farmers have about their soils and erosion control had been studied earlier (Rakoto-Ramiarantsoa 1995; Blanc-Pamard and Rakoto-Ramiarantsoa 2006). In contrast, little is known about the Eastern populations. This chapter will focus on them.

The repetitive *tavy* practices are the principal causes of the deforestation in this area (Coulaud 1973; Rakotovololona 1987; Green and Sussman 1990). But deforestation is not Madagascar's only environmental problem. Soil erosion is another process with major sustainability impacts (Ravel 1989). From the first experimental studies carried out in the rainy Betsimisaraka region [along the National Road 2 (RN2)], the zones of *tavy* have generally been described as zones of high erosion (Bailly et al. 1976; Ratovoson 1979; Rossi 1979; Raunet 1997). The lack of agricultural land in the narrow valleys, combined with strong population growth, is pushing farmers to farm steep slopes with agricultural practices which do not always seem to take the risk of erosion into account. Under the highly erosive climate of the East, the long and steep slopes have the highest risk of erosion (Malvos et al. 1976). Recently Brand and Rakotovao (1997) found, on a plot cropped in upland rice, a loss of soil to be 14.6t/ha/year, confirming high diffuse erosion potential of tavy. Landslides are another important source of erosion in this region subjected to hurricanes (Brand 1997). Yet erosion must be put into perspective with other risks (floods in bottoms during storms) and soil degradation processes (compaction, nutrient depletion) that are worse problems (Brand and Rakotovao 1997).

Nevertheless, in one area in the South-East inhabited by the Tanala ("the forest people"), several geographers have long been astonished that they could not observe signs of erosion in the landscapes, despite the systematic practice of *tavy* in geographical conditions typical of the East (Le Bourdiec 1974; Battistini 1965 cited by Le Bourdiec). This region, thus, seems to be an exception, departing from the proposition "*tavy* induces erosion". The aim of GEREM, our research program (2004-2007) was to contribute knowledge to support rural development compatible with forest conservation projects. The projects managers asked us questions concerning erosion risk management in order to protect the railway line Fianarantsoa-East Coast (FCE) that passes through Tanala region, and is essential to its economic life. The surrounding cultivated land and the *tavy* practiced by the

Tanala were particularly suspected of promoting erosion. An anti-*tavy* policy and a more-or-less forced adoption of alternatives to slash-and-burn have been considered. We therefore undertook a multidisciplinary reconnaissance study of land bordering the FCE railway in Tanala country, near the towns of Tolongoina, and Manampatrana.

Episodes of mass erosion (landslides) and rill erosion are observed locally, in particular along the railway, but these are neither invasive nor generalized as one would expect to observe considering the geographical conditions [marked relief, 2500 mm of rain, frequent hurricanes], the practices of *tavy*, and what the literature tells about the effects of *tavy*. These first observations confirmed the earlier geographers' observations of limited signs of erosion in this region when compared with Betsimisaraka RN2 sites further north, and other less rainy, less mountainous and *tavy*-free regions (such as the Alaotra region) that are devastated by *lavaka* erosion, the well-known type of Malagasy erosion. In the Alaotra region, grassy hills made of ferralitic alteration materials are literally open-ripped by deep ravines called *lavaka* (Tassin 1995, Wells and Andriamihaja 1997). The railway problems appeared to be due to the susceptibility (in the east-Malagasy climate) of badly maintained railway embankments and trenches, especially following two sequential, huge hurricanes in 2000. Tanala farming systems were not directly implicated. Insidious erosive processes (sheet erosion, landslides hidden by the rapid return of vegetation) were looked for in the Tanala *tavy* landscapes on several village territories, but no massive erosion symptoms were found on the studied area (Rakotonirina 2005; Rakotoson 2006). Still, farmers did not practice any "anti-erosive installations" that are strongly advised by the engineering departments to fight erosion in agricultural land subjected to an erosive climate.

As a hypothesis, the rare occurrence of erosion in the Tanala region may be explained by a good adaptation of the typical Tanala *tavy* to climatic-high erosivity, topographic-high erosion susceptibility and variable soil's erosion susceptibility. Beneath these adapted practices may exist specific knowledge of the soils. We thus sought to explain the limited erosion in the Tanala agricultural lands by applying scientific survey methods of soil science, agronomy and human geography: the study of the soils in their human, ecological, and climatic environment; the study of farming practices at plot and landscape levels, and the collection of rural knowledge (Milleville 1987; Blanc-Pamard 1986; Soulard 2005).

18.1 The Tanala of Tolongoina

The Tanala region is a narrow band between the Central Highlands and the coastal areas in the East of Madagascar, along a forested escarpment running North-South and commonly called the "Tanala cliff" (Fig. 18.1). It presents many similarities with the RN2 Betsimisaraka region. To the West of the forested bordering escarpment, an herbaceous plateau at an altitude of 800-1300 m comprises the territory of the Betsileo people, with rice fields in hollows and on terraces, and

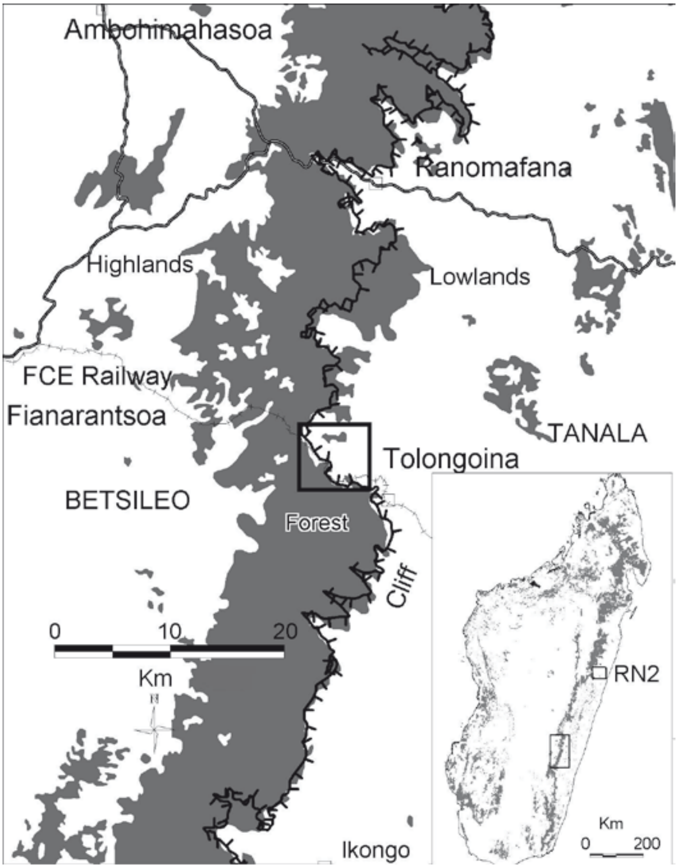

Fig. 18.1 Tanala land in its regional environment; location of RN2 Betsimisaraka region to north also shown on index map of Madagascar. (sources G. Serpantié, FTM)

cattle farming. The Tolongoina zone at the foot of the cliff (300–800 m) consists of hills with steep slopes and narrow valleys. On the cliff sides and the hills, where the villages and the main agricultural lands are established, one finds patches of an evergreen forest, mostly on the tops. The shrubby and herbaceous secondary vegetations, respectively called *kapoka* and *roranga*, extend each year a little further up the hillsides. With more than 2500 mm of annual rain and frequent hurricanes (about one every three years), the climate is one of the most erosive of Madagascar, similar to the RN2 Betsimisaraka region.

According to available 1/500,000 geomorphologic maps (Riquier 1968; Delenne et al. 1980), the Tolongoina zone presents the same types of landscapes and soils as the Betsimisakara region that has been the subject of considerable experimental research on erosion. Situated at the foot of an escarpment, these two regions contain gneissic bedrock, and have deeply dissected relief, in the form of hills with steep slopes with ferralitic soils, or Ferralsols (FAO 2006). The soils of the sandy river terraces are Fluvisols, and the soils of marshy places are Eutric Cambisols (Brand and Rakotondranaly 1997).

Surrounded by the coastal people and those of the Highlands, the Tanala have maintained their ethnic identity. People of Ikongo, not far from Tolongoina, have effectively resisted the domination of the Central Highlands people, the Merina (Ardant du Picq, 1912; Beaujard 1983).

Tavy is the main Tanala cropping system, applied to the forested hillsides or more generally formerly forested slopes. Its record goes back to the most ancient sources of Tanala history—from the first population called "Vazimba" (Beaujard 1983), to the second population coming from the eastern coast in the 12th century (Solondraibe 1986). This temporary cultivation belongs to the class of the shifting cultivation systems or to the fallow system, depending on the crop and fallow durations (Ruthenberg 1971). Successively, the vegetation is cleared; the cut vegetation lies drying then is burned. Rice or beans are then sown into seed holes. Manual weeding and protecting against birds take place while the crops grow. After the harvest, cassava cuttings are planted with a worn spade without tillage, after some clearing without fire. Growing cassava is hoed with a spade. Once the cassava is harvested, the land lies fallow until future use. Linton (1933) noted in the Ikongo zone a fallow duration of 5 to 10 years.

Apart from the rice-cassava *tavy* on the hillsides, the farmers also grow banana and sugar cane (which they transform into local rum) on the bottom lands, rice in drained marshland (*horaka* rice), and irrigated rice on terraced bottoms. Rice and cassava constitute staple foods, whereas banana and sugar cane play a commercial role, having now largely replaced coffee as the dominant cash crops of the region. The formerly forested Tanala land has been, in large part, converted little by little to a shrubby cover (*kapoka),* and then to an herbaceous cover *(roranga*) by repeated *tavy* and induced bush fires (Linton, 1933; Serpantié et al. 2007).

18.2 Methods

Two tracts of Tanala land at the foot of a cliff, bordering the railway, were selected in separate villages in the commune of Tolongoina. The choice of these villages depended on criteria deemed relevant for the study of erosion, as impacted by *tavy* and the degree of deforestation. The agricultural territory of Ambalavero still has 31% forest cover, whereas the more ancient Ambodivanana has only 10% remaining. These forest patches are mainly situated on the hilltops. The well-covered and *roranga*-free Ambalavero territory (Fig. 18.2) had experienced very little exploitation at the beginning of the 20th century according to an early reconnaissance survey of the region (Delpy 1903). In contrast, Ambodivanana, with more *roranga* and less forest suggests that deforestation had taken place long before (Fig. 18.3). It is confirmed by Delpy's map.

Both territories include the forested top of the cliff (over 1100 m), the side of the cliff (30° to 60° slopes), and the hill zones (dissected relief with an average altitude

Fig. 18.2 Ambalavero landscape (source IRD-G. Serpantié) (see as color plate following *Index*)

Fig. 18.3 Ambodivanana landscape: view of a Betsileo immigrant collapsed rice field terrace on *foringa* medium steep slope (source IRD-G. Serpantié) (see as color plate following *Index*)

of 550 m and 20° to 40° slopes). The Ambalavero and Ambodivanana agricultural territories have population densities of 27 and 43 inhabitants per km^2 respectively.

Studying the Tanala soils, landscapes and agricultural practices were the first fieldwork in 2005, allowing a progressive integration in the community. Then we managed to collect (through semi-directed surveys) various discourses about the soil, the *tavy*, erosion, and the way these underlie (or justify) their practices. Formal inquiries on agricultural and socio-economic issues were carried out on a sample of 15 farms in each village. The information obtained here was confirmed in 2007 by the inhabitants of a third village, Tolongoina.

The study of the soils in their landscape followed the methodology described by Randriamboavonjy (1995). A variety of soil profiles with differing vegetation histories on both the cliff zone and the hills zone were examined. Field and laboratory tests were done to characterize water infiltration rates and other parameters assessing sensitivity to erosion. Soil results will be presented first, before moving to a description of the main cropping system, *tavy*, and then to the farmers' views on soils, erosion, and farming practices. Finally, these results will be examined in context to make it possible to evaluate the real risk of erosion and describe the way this potential problem is currently managed. After discussing the nature of this management and the limits of local and current scientific knowledge, we will conclude with recommendations for sustainable management, within a framework recognizing increasing population density and the necessity of forest conservation.

18.3 Results

18.3.1 Observed Hillside Soils

The soil surface generally has an aggregated structure, and does not show physical or biological surface crusts. Only the forests have an organic A_0 layer that can be up to 10 cm deep. The A-horizon shows a variable thickness (10-40 cm; 20 cm mean), independent of the present vegetation or topographic position. Clay content (20% mean) is significantly lower on the tops, and under *roranga* vegetation or cultivation (10%), testifying to the phenomena of impoverishment in these positions and under this vegetation. More or less strong colouring indicated the clay content and not organic matter content, with the impoverished soils being the darkest.

The A-horizon under *kapoka* and *roranga*, (50-55% porosity) are significantly less permeable (water infiltration rates of 100-1000 mm/h) than the soils under forests and crop cultivation, which have an aggregated and friable structure (>60% porosity, >1000 mm/h). But the *roranga* soil's lower permeability still allow for infiltration of most of the rainfall events, as intensities rarely exceed 100 mm/h. Being rich in decomposing organic matter and iron, soil aggregates in surface horizons are, in most cases, quite stable and well-protected from erosion by rain splashing.

The deeper soil layers often have massive structure and higher clay contents than the surface layers. Soils at the top and bottoms of toposequences tend to have thick, clay-rich B-horizons that limit water infiltration—thus these are at high risk of water saturation and runoff under heavy rainfall conditions such as typical of a hurricane. In these cases, first components being eroded after clearing and burning are light and detached particles such as plant debris, charcoal fragments, loose sand, and disrupted soil aggregates (in the case of trampling or tillage). In contrast to these more erosion-susceptible soils, soils on the middle of hillsides, because of deep layers with lower clay contents, are at lower risk.

Current vegetation creates or reveals variations in erosion-susceptibility. The observed loss of clay of soils under degraded *roranga* vegetation indicates that these badly protected soils have been subjected to fine particle-selective erosion by rainwater. Their lighter texture leads them to be more susceptible to rill erosion by runoff. On the hilltops, the impoverished surface layer is erosion-susceptible too, if not covered by dense forest cover, where tree roots facilitate rainfall infiltration through the B-horizon.

Another major erosion process exists in soils with light cohesiveness—mass erosion. If tested with the penetrometer, Ferralsols of the Tanala region have a significantly lower cohesion than the Highlands savanna Ferralsols under another climate. But sometimes they have compact, deep layers, locally present as discontinuous ironpans. On very steep slopes (40° and more), when rainfalls in hurricane weather exceed deep infiltration capacity, soils with high infiltration rates are favourable to landslides after liquefying intermediate layers. Soil disturbance by human activities such as tillage, terracing and excavation may favour landslides on less sloping land. Such landslides may start under forest cover, or after soil crumbling around the wind-shaken isolated tree trunks. Some red soils under forest testify to such natural truncations of the brown A- and yellow B-horizon.

18.3.2 Current Practices of *Tavy* in a Forestless Society and Impacts

Tavy is applied widely in the forested or formerly forested hillsides. *Tavy* has resisted the migration of Betsileo people coming from the Highlands and renowned for being the best farmers in Madagascar, with their terraces and their skills at handling the *angady* (a ploughing spade) and developing rice irrigation in the bottoms around the marshes already cropped by Tanala (*horaka* rice field). The Tanala farmers, however, are famous for their handling of the *goro* (machete), the main tool for *tavy* in shrub vegetation. An examination of current *tavy* practices highlights multiple dimensions: the positioning of fields in the landscape, the soil preparation method, and the features of the cultivation-fallow cycle. These essential points will be dealt with in the section on the Tanala representations of their own practices.

An objective indicator of land fertility status in *tavy* regions has to take into account the main historical crop in *tavy* systems—upland rice. The percentage of farmers in Ambalavero growing upland rice was 44% in 2006, compared to only 9% in Ambodivanana. The controlling factor limiting rice production in Ambodivanana is soil fertility. The impact of temporary cultivation on soil fertility depends on many features, most importantly, fallow duration and reserve of forested land. Both population growth and scarcity of available forests under favourable climate (less than 800 m on this escarpment, Serpantié et al. 2007) have contributed to reducing the fallow period. The Madagascar government's Contractualised Forest Management system, set up in 1999, promoted conservation rules and gave the community responsibility for the management of their forests. In exchange for this new right, the community was obliged to commit itself to limit *tavy* to the four year-old shrubby or herbaceous fallows. Today, farmers clear no more forests or five years-old *kapoka*, and no longer let their land lie fallow more than two years. They are torn by these new regulations that reduce both fallow duration (traditional duration is five years and more) and available agricultural land.

In Ambalavero, whereas much of the land is still not degraded, the current farming system has reduced its sustainability with such short fallows. Locally new *roranga* are observed.

With a higher current population density, Ambodivanana, which has been exploited for a longer period than Ambalavero, shows a much more degraded environment, with the presence of large *roranga* spaces (about 25%). An important feature to take into account is the number of shrub tavy on a same place: each re-growth is slower than previous one (Pfund 2000). Furthermore, vegetation has a species composition that is pushed toward fire-favourable species (ferns and grasses) producing *roranga* vegetation. In Ambodivanana, there are more signs of rill erosion; surface soils contain less clay. Following the *tavy* carried out on immature shrubby fallows or on degraded *roranga*, rice yields were too low and many farmers gave up on attempts at upland rice production, keeping cassava cropping. Even though a degradation of soil is admitted by most of the farmers, their other production techniques have not changed. As in all Tanala villages, they use no chemical products or manure. The degraded land is the principal problem of this village. The excessive number of repeated shrub clearings, or the shorter fallow periods, or the frequent burning of shrubs may lead to the same problems.

Another factor impacting vegetation regeneration (Randriamalala et al. 2007) and erosive risk (Brand and Rakotovao 1997) is the level of physical disturbance of the soil. In Tanala land, the *tavy* remains fortunately without tillage. Weeds are removed by hand or cautiously with a worn spade. The only places where the Tanala farmers plough or irrigate are rice fields on Fluvisols and terraces on gently sloping bottomlands. This tricky work is mostly done by their Betsileo workers.

Due to food constraints and the necessity of a cash income, agriculturally less-and-less efficient lands are, paradoxically, destined to be more intensively farmed. Technical options of new varieties and intensive cropping systems are very limited or unsuitable due to additional risks or investment costs (Serpantié et al. 2007). Development projects for other income-generating activities are still rare in this region, or neglected by people suffering at a more elementary level from difficult access to basic services (hospitals, schools, irrigation dams, roads). Tolongoina, the largest village, with a market and health care facilities, is three hours away on foot, and neither Ambodivanana nor Ambalavero have their own schools. And according to the Tanala farmer, recommended changes might paradoxically entail the loss of his only wealth—his land.

18.3.3 Tanala representations of the land

The Tanala express their representations of the land in various dimensions: physiographic, economic, dynamic, and most certainly symbolic, the latter requiring further studies in order to be understood. The terms land and soil are both called "*tany*".

18.3.3.1 Land quality references

The Tanala represent their environment and land by reference to the physical geographic settings and current or former biologic configuration. *An'ala*, the forest area, refers to forest- covered areas even if most of these lands have shifted to a predominantly herbaceous vegetative cover, as in Ambodivanana village. The villagers implicitly refer to the past. The Tanala also use specific vocabulary to describe the location of their land in the landscape, their fields, and the abruptness of the slopes (Table 18.1).

Table 18.1 Tanala vocabulary for description of land

	Vocabulary	
Subject	*Malagasian*	English or *Latin name*
Geomorphology	*an-tety*	forest peaks and plateau
	amboditety	foot of the cliff
	vohitra	steep sloped hills
Slope	*harana*	very steep slopes
	foringa	medium steep slopes
	harenana	shelves
Valleys	*gebona*	small valleys on the hillside and bottoms
	farihy	hollows
	horaka	marshes
Plot orientation	*mianatsimo loha*	northern exposition (good) « heads turn to the South »
Vegetation and fields	*tavy*	slash and burn action, and all temporary field following it
	kapoka	shrubby fallow
	roranga	herbaceous cover after many *tavy* and bushfires
	ala (Tanala)	forest (Forest People)
	tavy ala	field derived from clearing a forest
	tavy jinja	field derived from clearing a shrubby fallow *(jinja* = to mow)
Plant species as indicators of good soil	*longoza*	*Aframomum angustifolium*
	harongana	*Harungana madagascariensis*
	dingana vavy	*Psiadia altissima*
Indicators of bad soil	*ringotra*	*Dicranopteris linearis*
	ampanga	*Pteridium aquilinum*
	anjavidy	*Erica spp.*
	radriaka	*Lantana camara*
	tenina	*Imperata cylindrica*
Agricultural tools	*angady*	spade
	goro	machete
	fitomboaka	seeding stick

Table 18.1 (continued)

Subject	Vocabulary *Malagasian*	English or *Latin name*
Soil description	*tany*	soil, earth, land of ancestors
	tany mainty	"A_0" horizon, organic layer (only under forest)
	tany roaka	"A" horizon after slash and burn
	volondohan-tany	"A" horizon of a cultivated soil ("hair on the head of the soil")
	tany mena mavo	"red yellow soil" ("B" red yellow horizon)
	tany mena voalohany	"first red soil" ("B" red horizon)
	andrin tany	"soil pillar" ("C" red horizon)
	tain kenkana	worm casts
	tany menaka	"fatty soil"
	tsiron-tany	"soil taste" (nutrients, fertility, organic matter)
Soil properties	*malemy*	loose, kind
	tsara	good
	mainty	black
	mahery	hard or strong
	am-patrana	where it is hard
	ratsy	bad
	mena	Red
	mafana	Warm
	manara	Cold
	maditra	tired, exhausted. Generally associated to *roranga* vegetation
	masiaka	harsh, nasty. Used about interdictions (*fady*)
Erosion and runoff	*tany toha*	landslides
	tany miambaka	rectilinear cracks
	longeona	underground channels
	abilema	mudslide in FCE railway trenches and embankments
	ranovohitra	very important runoff events

For the same position in the landscape, vegetation (density and species) is considered as the first indicator of land quality; secondary forests and shrubby fallow *kapoka* lands are preferred. The dominance of ferns, *Ericaceae*, and *Imperata cylindrica,* in herbaceous *roranga*, is evidence of bad land quality.

Soil is the second ecosystem compartment to be taken into consideration for agricultural activity, endowed with various properties linked with the success or the challenges of crop production. The forest soils contain four distinct horizons:

– The organic layer, called *tany mainty* ("black soil") is said to be made up of decomposing leaves, branches, and small underground animals that contribute to this decomposition. This soil is therefore charact erized by constant moisture content, and contains the element that bestows fertility on the soil (*tsiron-tany,* "soil taste"). It roughly corresponds to the top of the A-horizon (also noted A_0).
– When the forest disappears, the surface soil is called *tany roaka*, equivalent to the base of the A-horizon, after the high organic matter, and low density A_0-layer has been burnt-up or scattered. An aggregated structure, dark brown color, and the presence of worm castings are characteristics of this layer.

- Underneath is an intermediary zone, the *tany mena-mavo* (red-yellow soil). This more compact layer contains roots, and can be seen as equivalent to the B-horizon or the CB- horizon of rejuvenated soils.
- Red soil underlies the red-yellow layer. It is called *andrin-tany* ("soil pillar"). It is very deep, and characterized by its remarkable uniformity. It can be seen as equivalent to the C-horizon.

The adjectives used to describe soil's agricultural properties refer first to **colour**. The black soils, as opposed to red ones, are the best for agricultural activity, and they are typical of Tanala land. According to the Tanala farmers, the reason for good black soils on Tanala lands is the presence of forests; in contrast, the bad red soils on Betsileo lands are associated with deforestation. **Biology** is another indicator in land agricultural quality. Earthworms are a good indicator for soil fertility of the *tany roaka* layer. Furthermore, **exposure** is an essential property determining land quality. In this very humid zone with steep terrain, the best lands are those that receive enough sunshine. This allows for more rapid evaporation, and makes soil dryer and "warmer". Good exposures are those from the North and the East. Land parcels with bad exposures, South and West, remain wet and *manara* ("cold"). These wet soils are too plastic, becoming compacted and poorly aerated when trampled by cattle.

The various names for soil components indicate a lexicon that is not only metaphorical, but is also frequently inspired by the human body and human characters. The "head" of the field is the part situated at a higher altitude, and the "head" of the soil is the A-horizon. The land is *masiaka* (literally: harsh, nasty) when prohibitions (*fady*) enforced by religious or magical sanctions (taboos), whose violation may cause the person's death, are associated with it. The *masiaka* character of the *tany* is said to be linked to the character of the former inhabitants who instituted the taboo. The *tany* can also be *maditra* (indomitable; a term commonly used to describe a stubborn person or child), and *mahery* (strong) when it requires a lot of work, namely ploughing, in order to produce, as in Betsileo country. However, with the expansion of herbaceous *roranga*, there are more-and-more *tany maditra* and *mahery* on the Tanala lands. According to the farmers, the successive bushfires and *tavy* burning in these places are the main reasons for the soils becoming *maditra* or *mahery*. Repeated fire (*tavy* and bushfires) is seen as a threat to soil fertility because the fires burn the soil fauna that contribute to the production of *tsiron-tany*.

18.3.3.2 Soil evolution and erosion

The farmer thinks that a cultivated soil evolves differently according to its topographic position:

- The soils that get most rapidly impoverished are the summit soils. They do not allow a faster return to shrubby vegetation.

- The summit soils are linked to the slope soils. Indeed, the forest presence on the peaks maintains soil water on the slopes, whose soils then remain loose and favourably suited for agriculture, thanks to the moisture transfer from the summit.
- The mid-slope zone of medium slopes is known as the most resistant to erosion and runoff. Temporary cropping has less impact on soil at this topographic level, which therefore seems the most sustainable one.
- The small valleys on the hillside and bottoms are considered the most fragile zones, but are also the most fertile, because of the presence of more *tsiron-tany*.

According to the farmers, the main erosion process is landslide. The main factor stems from the loose *malemy* characteristic of Tanala soil. Landslides take place especially on steep slopes in the cyclonic season. Rainwater and infiltrating runoff make the soil very loose by penetrating through cracks near the roots or underground channels *(longeona)*. In addition, the wind causes the trees to sway, thus increasing the cracks nears the roots, and may even uproot them. The runoff then finds an "entry" that will provoke the landslide. Slopes bottoms are the wettest parts, and that is why bank landslides are frequent there. However, in their view, landslides on railways represent another erosion process, caused by the daily roaring of trains, and by the fact that the soils of the artificial embankments and trenches are less resistant.

During the first *tavys*, little surface erosion is observed, thanks to a permanent vegetation cover on the soil. The exceptions typically involve recently cleared and burned or weeded plots, and cyclonic rains where extreme runoff episodes wash away plant litter, charcoal and ashes. But these runoff events do not lead to loss of either soil fertility or soil itself. In contrast, repetitive *tavy* with short fallows progressively causes the disappearance of the first layers (*tany mainty* and *tany roaka*) and the uncovering of the deeper, less fertile layers, such as the ironpans. But shorter fallows and frequent bushfires change the character of the vegetation (more herbaceous, less covering *roranga*), and transform the soil. Such an evolution is understood as inevitable.

From their point of view, the dominant, visible mass erosion phenomena are not seen as having, in themselves, significant impacts on agricultural productivity. A landslide does not prevent them from planting either cassava or rice on the same place the following year. The only inconvenience they mention is the destruction of crops in the heap of fallen earth and landing zones. Swamp rice fields at the base of the landslide are thought to indeed thrive due to improved soil fertility —the belief being that marsh soils are too high in organic matter and too low in mineral content. Erosion by landslides therefore seems to be unpredictable, and of little net economic impact. As a consequence, the issue of risk management does not arise.

Despite the discrete but well-known processes of erosion, the Tanala do not directly express the notion of fighting against it; erosion is either seen as slow and inevitable (long term erosion in the case of short fallow periods), or as without consequences (local landslides).

18.3.4 *Tanala representations of their own practices*

We are now going to examine more closely whether the Tanala link their actions to their knowledge about soil and erosion. We will then examine their practices in light of agronomy and soil science knowledge. In the general view of farmers, *tavy* in itself does not have a negative impact, but the sustainability of soil fertility depends most importantly on factors such as fallow duration, fallow management, and the cumulative number of burnings. A minimum fallow duration of five years without bushfire is necessary for the soils to recover the required qualities for rice growing. But due to external forces such as population growth and forest management regulations, it is becoming more difficult to make a five-year fallow. Farmers have to return more often to the same parcel. On the whole, no immediate and general link has therefore been found between *tavy* and erosion in the collected rural Tanala knowledge. But as we will see, most of their practices are done in order to provide against soil losses, and to provide for the maintenance of fertility.

18.3.4.1 An adapted crop location

Farmers dislike the quality of summit soils, and this leads to those being the last to be cleared. The loss of earnings is the primary cause that keeps them from deforesting the summits. Since those soils become rapidly impoverished, and since the fallow lands do not regenerate well, the initial clearing of a summit forest is less profitable than that of a slope when it comes to establishing an agricultural domain. They also think that maintaining forests on the crests is useful to the slope soils and springs. The mid-slope zone of medium slopes is known as the topographic zone that best resists damage from temporary crops. It is also the one that is most often cultivated by *tavy*, and the zone where the farmer's hut is typically built, either on a shelf or on a constructed terrace, surrounded by perennial crops.

The slope bottoms and small hollows are recognized as fragile but fertile. It is the zone of permanent crops: coffee, sugar cane, banana, and fruit trees. This strategy makes it possible to avoid ploughing the soil, or to leave it bare while making good use of the fertilizing elements that are deposited on it by the wash off of ashes and organic matter on the slope under the effect of local runoff after heavy rains. The marshes and small valley bottomlands are highly prized spaces because of their high fertility, despite their narrowness and the risks of cyclonic floods. They represent the domain of *horaka* rice planting. With irrigated rice fields on the alluvial margins of marshes and on small terraces in the most stable places, they are permanent rice cultivation systems. When cyclones flood the rice, the farmer's rely on *tavy* production for subsistence.

By practicing *tavy* almost exclusively at the mid-slope level on *foringa* (medium steep), and by avoiding all the other locations, the Tanala therefore avoid more runoff-prone areas or areas with high risks of landslides. By leaving parts of forests on the peaks, they avoid worsening the production of runoff from up-slope zones.

18.3.4.2 A minimum soil structure modification

In the Tanala region, the soil is *malemy* (loose). This generalized representation affects their technical choices; it limits any inclination towards deep tilling of the soil, and guides the type of clearing methods chosen. In order to prepare the soils before cultivation, the Tanala farmers do not take out the stumps, for fear of leaving big holes in the ground. Heavy rains might wash some soil away and cause a serious landslide. On the other hand, progressive rotting of these stumps gives natural soil fertilization. Rice is planted in seed holes dug with a stick. Cassava is planted by lightly pushing a worn spade into the ground diagonally, parallel to the slope, so as to create a little opening where the cutting will be placed. Permanent crops are planted by cutting and seedlings. The base and roots of the weeds are left in place, and provide some protection against direct effects of rain and runoff on soils.

When asked about the effects of soil tillage like ploughing, the farmers mention multiple disadvantages, as well as useless and tiring work. Ploughing a loose soil would inevitably provoke the erosive loss of fertile soil, and the less-productive red layers will rapidly appear at the surface. Ploughing also requires additional operations, such as stump removal. Furthermore, ploughing must be done every year, as the soil hardens more quickly. Finally, turning the soil over every year does not allow fallow regeneration, which should create a humus-bearing horizon. Regular fertilizer input would be needed, which is an extra expenditure. According to the farmers, ploughing is justified only when the soil begins to be hard and unproductive. All these techniques address the concern of not excessively loosening the earth; the weather and fallow maintain it naturally loose, rendering it useless and risky to loosen it more. But farmers in the old villages are now hesitating; in order to deal with the low fertility status of their soils, Ambodivanana farmers are thinking they might have to plough, despite the risks, in an attempt to improve the crop yields.

18.3.4.3 Temporary crops and long-duration fallowing

In the view of the Tanala farmers, in order to maintain their loose and soft quality, the soils need a periodic return to native vegetation status without fire for a minimum period of five years and a limited cultivation period, generally one year of rice or bean followed by one or two of cassava. Yet, an impoverished soil will take more time to regain its *kapoka* status, and will increase the necessary fallow period.

The positive effects of the fallow on the soil are attributed to the restoration of the *tsiron-tany* due to vegetation regeneration, the work of underground animals, and the final burning. Fallow is favourable not only on the following rice crop, but also on the cultivated plots down-slope, since the fallow reduces runoff from uphill. Therefore, the length of the farming-fallow cycle is very important in order to enable the soils of the region to be productive in the long term.

Permanent crops (coffee, banana, sugar cane) constitute a complementary strategy for the management of the land. Historically, permanent crops have generally taken up about a third of the land; another third is devoted to temporary crops, and the last third lies fallow. However, temporary crops have tended to increase in importance over the years, and this generally has been to the detriment of the fallow land and sometimes to the oldest permanent crops.

In summary, a link does indeed exist between *tavy* practices and knowledge expressed on erosion. The management of this risk, however, is not given as the only justification for these practices.

18.4 Discussion and conclusion

The issue that was raised earlier concerned the search for an underlying [and largely unspoken (outside of this community)] Tanala land-management system that would explain the low occurrence of demonstrable erosion features on Tanala land, where erosion due to a rainy climate and slope steepness is typically a serious risk. Because signs of erosion are often masked by vegetation or otherwise not readily apparent, it is more difficult to comprehend than in other regions. Farmers, the forest department, scientists and railway managers each have a major role to play in erosion control, and reconciliation between their different perspectives and sources of knowledge is needed.

18.4.1 New data

According to our observations often confirmed by rural Tanala knowledge, erosion may occur in *tavy* fields, but rarely and differently according to a variety of ecosystem and management conditions. First, *tavy* leads to an erosion of only the organic surface layer (A_0) that may have been partially destroyed by burning of biomass. The erodibility of most soils of the middle hillsides remains low, as vegetation is not degraded by multiple *tavy*, short fallows, or bushfires. It is the best place for annual crops without tillage. Bourgeat et al. (1973) had similar findings for Highlands' Ferralsols. But degradation of vegetation after repeated *tavy* practices, short fallows and frequent bush fires, increase erosion and clay-impoverishment; this loss of clay results from insidious selective diffuse erosion under poor vegetative cover. The number of tavy and bush fires, position of remaining cover in the landscape, fallow duration, cropping practices, degree of slope, local soil type, and texture of the subsoil are the many sources of variation of local erosion risk.

So the scientific knowledge, systematically relating *tavy* to severe erosion may have been distorted by hasty generalization of the results of first experiments in the 1960's (Serpantié et al. 2006). Experiments of 1990's gave some new perspectives but the sampling was also very limited (one plot, one year). In 1995, in Beforona, a 144 t/ha/year loss of soil from ploughed fields planted to ginger was measured, whereas *tavy* upland rice lost 14.6 t/ha/year, young fallow 5.5 t/ha/year, and the *kapoka* only 0.37 t/ha/year (Brand and Rakotovao 1997). These data suggest much higher erosive losses with the ploughing system. It should be pointed out that the average annual amount of soil loss for the overall *tavy* system is a composite of the measured cropped and fallow values ("only" 4.4 to 5 t/ha/year).

The type of vegetal cover and the level of soil disturbance are generally the only two factors studied by experimentation on "erosion plots." Our field studies of the soils show that many other factors need to be taken into account in the management of erosive risk; first, the position in the landscape, and this is precisely taken into account by the farmers. Thus, the real yearly erosion average in young *tavy* landscapes is probably less than 5 t/ha/year; but it will increase with time. The addition of new scientific knowledge is helping us to recognize the importance of local practices and the relevance of local knowledge.

18.4.2 Understanding the underlying rationale of tavy

Although their tools are rudimentary, Tanala practices can be interpreted as comprising multiple precautions to prevent soil loss. The Tanala manner of conducting *tavy* and its implicit rules (the essential characteristics of which are summarized below) are key to these erosion-vulnerability reduction practices:

Principle 1: Use of a passive space management system—as much as possible, avoiding practicing *tavy* in areas that entail high risks of runoff or of mass-erosion starting points: *gebona* dips, *harana* steep slopes, hillside bottoms. Permanent crops are grown on risky areas. Degraded and impoverished *roranga*, are avoided. Summits are avoided because fallow soils do not regenerate well (refer to principle 3). Additional erosive risk reduction practices include conservation of summit forests and of fallow lands upstream from a *tavy*.

Principle 2: Soil structure is not to be disrupted, or if so, then as little as possible and for the shortest period possible. This minimizes the risk of loosened soils being washed away by runoff, and leads to fallow lands regenerating better (refer to principle 3).

Principle 3: Temporary farming and long fallow: let the slope ecosystem heal for as long as possible after disruption. The soil structure will remain stable to allow cropping on non-ploughed soils (refer to principle 2).

A fourth principle was gathered by Le Bourdiec (1974): Clearing forests (primary or secondary) preferably to *kapoka* fallows, the Tanala telling that erosion develops more after a shrubby fallow. This principle implied mobility. Currently, this principle cannot be gathered nor followed, since forest remnants are now largely protected as reserves, and since villages are definitely sedentary.

These linked technical principles can be qualified as "passive," given that they are not actions as such, but are rather passive acts: abandoning fields, not working the soil, avoiding certain areas. However, these are definitely management principles. Only forests are not spared, as these so-called "forest people" are in fact, pioneers and farmers. This rudimentary technical approach is due not to agricultural ignorance, but rather is a form of environmental economy, in harmony with other aspects of temporary farming such as ecosystem management (weed control, nutrient availability), labor economy, and social organization economy. Therefore, a management system for erosion risk does indeed exist, and explains some *tavy* features.

Although often demonized in the scientific and technical realm, *tavy*, as conducted by the Tanala, seems particularly adapted to this topographically varied and very humid zone. Such a cultural adaptation was already noted by Kottak (1971). However, adapted does not mean sustainable. Denying the erosive risk would be as fallacious as denouncing *tavy*. Reality is complex, and requires a combination of various angles of approach, several levels of observation and care in generalization. Our GEREM study seems to reconcile mono-disciplinary scientific knowledge that appeared contradictory. Perhaps early science conclusions have to be blamed for not sufficiently referring to experimental conditions and for inappropriate generalization. Erosive manifestations truly increase in formerly deforested villages, like Ambodivanana. The proposition that "*tavy* induces erosion" on Ferralsols has been confirmed in the long term only in the case of high population density and non-mobile settlements. This is precisely the case in the highly populated Betsimisaraka zones of RN2, where erosion has been studied through experimentation. Furthermore, not all *tavy* systems are equal in soil losses. In villages that have been deforested for less than a century, and where deforestation has not yet reached the crests, local practices and knowledge make risk mitigation still possible. The resident population density, the time elapsed since deforestation began, and less careful practices due to land scarcity might constitute aggravating risk factors, and might not be addressed by local knowledge. However, borrowing from other bodies of knowledge with the view of adapting to current population density requires prudence. Adopting the agricultural management system of the Betsileo region, renown for its sophisticated farmers, would lead to even worse catastrophes. This is illustrated by the example of a Betsileo migrant in Ambodivanana who, despite being in a highly erosive environment, attempted to construct terraced rice fields on ordinary *foringa* slopes; the failure is seen in Fig. 18.3.

18.4.3 Fortuitous or Intentional Management?

The link between the detailed practices and the farmers' knowledge of their environment has been confirmed and shows that this management is reasoned and so, intentional. For the soil scientist and the agronomist, it is reasonable from the point of view of a sustainable production if minimum fallow duration without bushfires is respected. Thanks to it, erosion has minor economic consequences. Managing erosive risk is not the only aim of the Tanala way of temporary cropping.

Their very old system of practices is an integral part of their identity, and has enabled them to build their territory and their society. Thus, the Tanala have not developed concepts or theories (in their representations or in their language) to view the management of potential erosion. Their theory is the Tanala practice itself. Under these conditions, changing practices would endanger a tried and shared system. But general conditions are shifting and population pressure is growing. The question of current concern becomes: have Tanala local knowledge and practices been able to adapt to current conditions?

18.4.4 Limits to Tanala knowledge and scientific knowledge

Both the scope and the limits of the indigenous knowledge that underlies rural practices, as well as the scope and the limits of scientific knowledge that underlies technical advice, have to be examined in an integrated manner in order to identify correspondences and divergences. In terms of limitations, Tanala concepts place too much emphasis on the forest and on soil colour. Despite a high deforestation rate, their region remains *an'ala* (in the forest). When they refer to the Betsileo region as "deforested", they do not mention the climatic and relief conditions that are different from those in their region. Black soil *"mainty"* is highly valued by the farmers, but as far as the soil scientist is concerned, this color, in the soils of this region, often indicates low clay content (a phenomenon of impoverishment) rather than good soil condition and erosion resistance. The disappearing of the dark A-horizon may have happened under forest cover, before the first tavy, but organic matter may have a sufficient level in such "red soils". This makes it hard to say that soils with red or yellow-coloured surface horizons are systematically "degraded" soils. When the farmers refer to the degraded *roranga* soils as *mahery* (hard), they seem to reflect the soil's impoverished nature due to its low fertility and diffuse erosion rather than its massive structure**.** Granted, forest and kapoka soils are the loosest, but it has not been established that the impoverished *roranga* soils are so excessively indurated or massive that they need to be ploughed. Ploughing them may help to improve mineralization first. They know the erosive risk that awaits them when they begin to plough or irrigate slopes, but do not have enough knowledge to replace their practices. The farmers' body of knowledge is only compatible with conditions of low population.

In many other domains, there is a high degree of convergence between local bodies of knowledge and scientific expertise about the soils and their use, although the superposition of the arguments is certainly not perfect. For example, some aspects of Tanala knowledge about the relationship between peak and slope soils and the effect of the crest forest on infiltration do converge. But the superposition of the discourses also makes it possible to measure the superiority of some aspects of Tanala knowledge in relation to scientific knowledge, which is necessarily limited by investigation costs or excess of specialization. The farmers' knowledge sometimes anticipates science. The negative effect of ploughing on fallow regeneration that was mentioned by the farmers was recently confirmed by Randriamalala et al. (2007) on fallows of the Betsileo forest. Therefore, the farmers' practices of minimum disturbance of the soil match the most recent agro-ecological knowledge. The farmers also bring us information on the role of exposure on soil features. Malagasy people attach major importance to cardinal directions in their symbolic view of the world. But verifiable microclimatic information is probably at work here.

According to the farmers, summit forests maintain the moist state of cultivated-slope soils. That relates back not only to topsoil's water-holding capacity and runoff control, but also perhaps to other unknown local forest properties and ecosystem relationships, such as microclimate, and sources of seeds and fauna for fallow.

18.4.5 Enriching the search for consensual solutions

Our ultimate goal was to help develop a new, "consensual" action plan consistent with both forest conservation and sustainable production. Studying the details of soil representations has made it possible to understand why the prohibition to clear remaining peak forests was respected and even encouraged by the farmers of Ambalavero. Indeed, this global injunction does not contradict local knowledge on forests functions (protection of slopes and springs, conservation of nearby wood resources), and does not cost much socially (since summits fields are the least sought-after parcels). On the other hand, the conservation of all the five-year fallows remaining on hill slopes recommended to the community by the Forest Service, is contradictory to the Tanala's third and fourth principles of land management, and reduces the available land.

New practices that are viewed as compatible with local knowledge will have the best chance of adoption, but new knowledge is also needed. Demographic growth, poverty, and forest conservation restrictions might, for lack of knowledge on alternatives, lead the farmers to practice techniques they know to be environmentally damaging. In Ambodivanana in particular, attempts are being made to extend rice fields by building terraces with irrigation canals on hill slopes; subsidence has been common here. On the hills, ploughing and terrace construction to increase farmable acreage can be expected to result in massive erosion.

Despite reaching their ecological limits at a period when population densities are crossing thresholds never experienced by the Tanala population, the knowledge of farmers gives a pathway to managers and agricultural research. The Tanala principles and practices—emphasizing minimal soil disruption, covering by withered weeds, a fallow system, and taking soil types and their plant communities into account—are principles that are compatible with the agro-ecological techniques studied at the Madagascar agronomic center (FOFIFA), such as no tillage systems (Rasimalala 2004) and integrated agro-forestry systems (Nambena 2003, Nambena 2004). The challenge that remains is to find ways to work together with the Tanala people on these techniques in order that they might be adapted to the Tanala context—its culture, lifestyle, and economic realities.

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References

Ardant du Picq Ltnt (1912) La forêt et la vie Tanala [Forest and Tanala life]. Bulletin de l'Académie de Madagascar 10: 257–261

Bailly C, de Cognac B, Malvos C, Ningre JM, Sarrailh JM (1976) Etude de l'influence du couvert naturel et de ses modifications à Madagascar. Expérimentation en bassins versants élémentaires [Study of natural cover influence and its modifications in Madagascar. Experimentation on elementary catch basins]. Cahiers Scientifiques de la revue Bois et Forêts des Tropiques, n°4, Nogent sur Marne

Battistini R (1965) Notes de reconnaissance sur quelques types de paysages agraires traditionnels du Sud et du Sud-Est de Madagascar. In Madagascar, Revue de Géographie, 6, jan-juin 1965: 115

Beaujard P (1983) Princes et paysans Tanala: les Tanala de l'Ikongo [Tanala Princes and farmers: Tanala of Ikongo]. L'Harmattan, Paris

Blanc-Pamard C (1986) Dialoguer avec le paysage ou comment l'espace écologique est vu et pratiqué par les communautés rurales des Hautes Terres Malgaches [Talking with the landscape or how ecological space is seen and practised by rural communities in the Malagasy Highlands]. In: Chatelin Y, Riou G. (ed) Milieux et Paysages, Masson, Paris: 17–35

Blanc-Pamard C, Rakoto-Ramiarantsoa H (2006) Les pratiques paysannes de gestion de l'érosion sur les Hautes Terres Centrales (Farmers' practices to manage erosion in the Central Highlands). In: Actes des journées scientifiques régionales du réseau "Erosion et GCES", AUF, Antananarivo:168– 178

Bourgeat F, Van Nhan H, Vicariot F, Zebrowski C (1973) Relations entre le relief, les types de sols et leurs aptitudes culturales sur les Hautes Terres malgaches [Relations between relief, soils types and their agricultural aptitudes in the Malagasy Highlands]. Cahiers Orstom série Biol. 19: 23–41

Brand J (1997) Impact des cyclones [Impacts of cyclones]. Cahiers Terre Tany 6: 27-33, Fofifa Antananarivo

Brand J, Rakotondranaly N (1997) Les caractéristiques et la fertilité des sols [Soil characteristics and fertility]. Cahiers Terre Tany 6: 34–48. Fofifa Antananarivo

Brand J, Rakotovao W (1997) Dégradation des sols [Soil degradation]. Cahiers Terre Tany 6: 19–26 Fofifa Antananarivo

Coulaud D (1973) Les Zafimaniry, un groupe ethnique à la poursuite de la forêt [The Zafimaniry, an ethnic group in pursuit of the forest]. FMB, Antananarivo

Delenne M, Pelletier F, Bied-Charreton M, Bonvallot J, Dandoy G, Hugot B, Peltre P, Pomart E, Portais M, Raison JP, Randrianarisoa J, Galice P (1980) Conditions géographiques de la mise en valeur agricole de Madagascar: thème 1: potentiel des unités physiques: feuille Sud [Geographical conditions of agriculture in Madagascar, theme 1: potential of the physical units]. ORSTOM. Paris

Delpy Ltnt (1903) Levé de reconnaissance de la région Sud-Ouest d'Ifanadiana au 1/80000. [Reconnaissance survey of the southwestern area of Ifanadiana]. Archives Nationales Malagasy

Dupré G (ed) (1991) Savoirs paysans et développement [Farmers' knowledge and development]. Karthala et Orstom, Paris

FAO (2006) Word reference base for soil resources 2006. World soil resources reports 103
Friedberg C (1992) Représentations, classifications: comment l'homme pense ses rapports au milieu naturel [Representations, classifications: how Man thinks about his relationships with the natural environment]. In: Jollivet M (ed.) Sciences de la nature, sciences de la société. Les passeurs de frontières: 357–391
Green GM, Sussman RW (1990) Deforestation history of the eastern rainforest of Madagascar from satellite images. Science 248: 212–215
Holman EW (2005) Domain specific and general properties of folk classification. Journal of Ethnobiology: 71–91
Kottak CP (1971) Cultural adaptation, kinship, and descent in Madagascar. Southwestern Journal of Anthropology 27, 2:129–147
Le Bourdiec F (1974) Hommes et paysage du riz à Madagascar [Man and rice landscapes in Madagascar]. FTM, Antananarivo
Lévy J, Lussault M (eds.) (2003) Dictionnaire de la géographie [Dictionary of Geography]. Belin, Paris
Linton R (1933) The Tanala, a hill tribe of Madagascar. Field Museum of Natural History, bull 317, Anthrop. Series, vol. 22, Chicago
Malvos C, Sarrailh JM, Bailly C, Rakotomanana JL (1976) Etude de la susceptibilité à l'érosion des sols de Madagascar. Expérimentations en parcelles élémentaires [Study of erosion susceptibility of Madagascar's soils. Experimentation on elementary plots]. CTFT
Milleville P (1987) Recherches sur les pratiques des agriculteurs [Research on farmers' practices]. In Les Cahiers de la Recherche-Développement 16: 3–6
Myers N, Mittermeier R, Mittermeier CG, da Fonseca GAA & Kent J (2000) Biodiversity hotspots for conservation priorities. Nature, 403: 853–858
Nambena J (2004) Analyse de la subsistance paysanne dans un système de production en crise et identification participative de stratégies durables d'adaptation. Cas de Beforona, versant oriental de Madagascar [Analysis of farmers' subsistence in a system of production in crisis, and participative identification of sustainable adaptive strategies]. PhD. Heidelberg University
Nambena SM (2003) Using information systems to assess possibilities of expanding traditional agroforestery in slash and burn zones in Madagascar. In: Mountain Research and Development 23, 4: 329–333
Pfund JL (2000) Culture sur brûlis et gestion des ressources naturelles: Evolution et perspectives de 3 terroirs ruraux du versant Est de Madagascar [Slash and burn agriculture and managing natural resources]. PhD, Ecole Polytechnique de Zurich et de Lausanne
Rabearimanana L (1988) Le paysan de l'Est de Madagascar. Du *tavy* à la riziculture irriguée, une mutation tardive [Farmers of Eastern Madagascar. From *tavy* to irrigated rice, a late mutation]. Omaly sy Anio 27: 75–91
Rakoto-Ramiarantsoa H (1995) Chair de la terre, oeil de l'eau. Paysanneries et recompositions de campagne en Imerina (Madagascar). [Flesh of land, eye of water. Farming communities and changes in the Imerina countryside, Madagascar] IRD, Coll. A travers champs. Paris
Rakotonirina A (2006) Diagnostic du risque érosif en pays Tanala: Cas des villages d'Ambalavero et d'Ambodivanana (Commune rurale de Tolongoina - Fianarantsoa) [Erosive risk diagnosis in Tanala land: case of Ambalavero and Ambodivanana]. Masters thesis. Université Antananarivo, Madagascar
Rakotoson D (2006) Gestion paysanne des contraintes du milieu: cas de l'érosion en zone péri-forestière (Pays Tanala) [Farmer management of environmental constraints: case of erosion in peri-forestry area (Tanala Land)]. Masters thesis, Université d'Antananarivo, Madagascar
Rakotovololona S (1987) La pratique du *tavy*, l'autosuffisance alimentaire et la déforestation (Firaisana de Ranomafana) [Practise of *tavy*: food self-sufficiency and deforestation District of Ranomafana]. In: "Le Tanala, la Foret et le *Tavy*". Musée d'art et d'archéologie, Madagascar
Randriamalala RJ, Serpantié G, Carriere SM (2007) Influence des pratiques culturales et du milieu sur la diversité des jachères d'origine forestière (Hautes Terres, Madagascar) [Influence of

cultural practices and environment of diversity of forest-origin fallows, Highlands, Madagascar]. Revue d'Ecologie (Terre Vie), LXXII: 169–189

Randriamboavonjy JC (1995) Etude des pédopaysages dans quatre zones - test de Madagascar [Study of pedo-landscapes in four test-areas in Madagascar]. PhD, Université d'Antananarivo, Madagascar

Rasimalala A (2004) Contribution à la résolution des problèmes de dégradation du sol par l'érosion hydrique pour la mise en valeur des tanety: cas des systèmes sous couverture végétale sur le riz pluvial dans la région du Vakinankaratra [Contribution to problem-solving of soil degraded by water erosion of hillsides: case of vegetal cover system of rain-fed rice in Vakinankaratra region] Masters thesis, Université Antananarivo, Madagascar

Ratovoson C (1979) Les problèmes du *tavy* sur la côte Est malgache [*Tavy* problems on Eastern Malagasy coast]. In: Madagascar, Revue de Géographie, 35: 141–165

Raunet M (1997) Bilan et évaluation des travaux et réalisations en matière de conservation des sols à Madagascar: solutions techniques de lutte contre l'érosion [Works and progress on assessments in soil conservation in Madagascar]. Vol III. Antananarivo, CIRAD-FOFIFA

Ravel G (1989) Madagascar: record mondial de l'érosion [Madagascar: world record of erosion], In: Marchés Tropicaux et Méditerranéens: 1224–1225

Riquier J (1968) Carte Pedologique de Madagascar au 1/1,000,000. [Pedological map at 1/1,000,000]. Orstom, Madagascar

Roose E (1994) Introduction à la gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols (GCES) [Introduction to conservation management of water, biomass and soil fertility]. FAO. Bulletin Pédologique de la FAO 70, Roma

Rossi G (1979) L'érosion à Madagascar: l'importance des facteurs humains [Erosion in Madagascar: importance of human factors]. Cahiers d'Outre Mer 128: 355–370

Ruthenberg H (1971) Farming Systems in the Tropics. Oxford Science Publications

Serpantié G, Coadou Le Brozec E, Rakotoson D, Rakotonirina A, Toillier A (2006) Diagnostic régional de la gestion du risque érosif, étude autour du corridor forestier de Fianarantsoa (Madagascar) [Regional diagnosis of erosion risk, a study around Fianarantsoa forestry corridor Madagascar]. In: Actes des journées scientifiques régionales du réseau "Erosion et GCES" AUF:179–185

Serpantié G, Rasolofoharinoro, Carrière S 2007 Transitions agraires, Dynamique écologique et Conservation. Le « corridor » Ranomafana-Andringitra [Agrarian transitions, ecological trends and conservation]. CITE-IRD, Antananarivo, Paris, 278p

Solondraibe T (1986) La tradition orale et histoire: la région de Ranomafana -Ifanadiana [Oral and historical tradition: Ranomafana - Ifanadiana region]. Omaly sy Anio, 23–24: 149–167

Soulard CT (2005) Les agriculteurs et la pollution des eaux. Proposition d'une géographie des pratiques [Farmers and water pollution. Proposition for a geography of practises]. In Nature Sciences Sociétés 13: 154–164

Tassin J (1995) La protection des bassins versants à Madagascar: bilan des actions conduites dans la région du Lac Alaotra [Protection of catch basin in Madagascar: assessment of actions in Alaotra Lake]. Bois et Forêts des Tropiques, 246: 7–22

Wells NA, Andriamihaja BR (1997) Extreme gully erosion in Madagascar and its natural and anthropogenic causes, In: Goodman SM & Patterson BD (eds) Natural change and human impact in Madagascar, Smithsonian Institution Press, Washington, London: 44–74

Chapter 19
Ancient Maya Perceptions of Soil, Land, and Earth

E. Christian Wells and Lorena D. Mihok

19.1 Introduction

The worldviews and religious beliefs of many agrarian societies of prehispanic Mesoamerica, including the Maya who occupied parts of present-day southern Mexico and upper Central America, emphasized soil concepts, especially soil fertility. Cosmic beliefs about how the world operates were materialized through cults of gods and spirits associated with agriculture and the earth. Soil was understood, not as the product of biogeochemical processes involving erosion and weathering, but as a gift from the ancestors that must be reciprocated with human blood.

In this chapter, we examine ancient Maya perceptions of soil, land, and earth from the perspective of indigenous and early Spanish documents, including prehispanic pictorial manuscripts (native screenfolds made from bark paper), creation mytho-histories recorded at or near the time of Spanish contact, early Spanish chronicles, and Colonial era Mayan/Spanish dictionaries. These diverse accounts provide unique insights into how the Maya perceived soil evolution and how they used this understanding to model their relationship with tropical soil resources prior to the arrival of Europeans in the 16th century. Our study reveals that environmental worldview (*i.e.*, one's understanding of how the world works or should work and what the appropriate ways are to interact with the biophysical environment; Wells and Davis-Salazar 2008, p. 191) and ecological knowledge are important factors that shape how the Maya interacted—and continue to interact—with soils, past and present.

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19.2 Folk Soil Taxonomies among the Contemporary Maya

In many cultures, knowledge about how to care for the environment is transmitted through oral traditions including stories, parables, and songs. Historically, in some cultures, such as those occupying the Maya region, formal writing and symbolic systems transferred information about soils and land use. However, since most prehispanic Maya manuscripts were destroyed by the Spanish in the 16th century, we know very little about the ways and extent to which soils and their attributes were remembered and shared prior to Spanish contact. In contrast, we have detailed information about contemporary Maya indigenous soil knowledge. Barbara Williams and Carlos Ortiz-Solorio (1981) provide an extensive review and discussion of these and other Mesoamerican cases. More recently, Antoinette WinklerPrins and Narciso Barrera-Basso's (2004) review has extended this survey to include several new studies, especially in the Maya region.

It is clear from recent work that we know a good deal about soil management in agroforestry, home-gardening, and cultivation practices among the Maya of today (*e.g.*, Faust 1998; Graefe 2003; Terán and Rasmussen 1994), but very little about their local soil taxonomies. This could be the case because many such taxonomies appear to be based on macroscopically observable morphological attributes of surface appearances, without reference to subsurface variability. As a result, compared to other Mesoamerican groups, soil taxonomies in the Maya region tend to be restricted to a small number of primary classes (*e.g.*, Williams 2006). For example, Christopher Jensen and colleagues (2007) report five soil types in use among the Itzá Maya of the southern lowlands around Lake Petén Itzá in Guatemala. These include *ek luum* ("black soil"), *saknis* ("white earth"), *ek luk* ("black clay"), *chachak luum* ("red/colored soil"), and *kan luum* ("yellow soil"). A sixth class, *tierra mezclada* ("mixed earth"), is sometimes used to refer to mixed soil classes. Similar soil types have been identified by Peter Ewell and Deborah Merrill-Sands (1987), who report four primary soil types, derived from locally perceived differences in color, inclusions, and texture, for swidden cultivation systems (use of temporary agricultural plots produced by cutting back and burning off vegetative cover) among the Yucatec Maya of the northern lowlands in Mexico. One possible exception to the apparent abbreviated nature of Maya soil taxa is that reported by William Carter (1969), who documented 24 distinct categories for soils used by the K'ekchi Maya of highland Guatemala. However, many of these "categories" are probably informal descriptive phrases (see Wilk 1981, pp. 138-141) that attempt to account for intra-pedon variability.

In contrast to these taxonomies, Narciso Barrera-Bassols and Víctor Toledo (2005) have identified 12 main soil types currently in use in northern Yucatan. Most of these are consistent with those reported by Nicholas Dunning (1992a, pp. 36-45; see also Dunning 1992b; Dunning and Beach 2004, p. 9) in his study of contemporary knowledge of Puuk soils in western Yucatan. The types are based on a wide range of topsoil attributes, including color, relief, position, depth, stoniness, drainage, moisture retention, consistence, texture, fertility, and workability. In addition to the main soil types, Barrera-Bassols and Toledo (2005, p. 18) found that the Yucatec Maya have more than 80 descriptive terms referring to soil characteristics—more than any other Mesoamerican group surveyed to date (Barrera-Bassols and Zinck 2000; Williams and Ortiz-Solorio 1981; Wilshusen and Stone 1990). Variation in local soil taxonomies reflects the diversity in ecology and soil-forming factors, even though most of the Maya lowlands are underlaid by the same parent material, limestone (Dunning and Beach 2000, p. 183).

The observation that many Maya farmers recognize a great deal of variation *within* but not *between* primary soil classes suggests that Maya taxonomies may hold significance beyond their utilitarian function. Barrera-Bassols and Toledo (2005, pp. 26-28), for instance, suggest that Yucatec Maya soils have strong symbolic significance in local worldview (or the "kosmos sphere"), wherein soil colors have associations with the cardinal directions and thus are linked to cosmic structure and organization. They also propose that subsurface soil is seen as a womb, since it gives rise to humans and other forms of life. As Nicholas Dunning and Timothy Beach (2004, p. 10) point out, for many traditional Yucatec farmers, soil is believed to impart *itz*, "the holy substance of life" for growing plants. Such associations are intriguing, but surely represent a synthesis of information and attitudes from prehispanic, Colonial, and modern knowledge sources. To what extent, then, do these kinds of symbolic associations and metaphors have prehispanic roots? To answer this question, we need to examine first the soil resources of the prehispanic Maya and then consider how the Maya described these resources and represented them in their worldview.

19.3 The Ancient Maya and their Soil Resources

The ancient Maya world, encompassing southern Mexico, Guatemala, Belize, and parts of Honduras and El Salvador, is one of the most physiographically, biologically, and culturally diverse places on Earth (Fig. 19.1). The region encompasses a varied landscape, generally divided into three zones. The Maya highlands, dominated by both extinct and active volcanoes (some reaching up to 13,000 feet in altitude), include all of the elevated terrain in southern Guatemala and the Chiapas highlands of southern Mexico. Highland soils, derived from Pleistocene and Holocene volcanic activity, are rich and fertile, though divided between steep hillslopes and a few broad valleys, including those of Guatemala City, Quetzaltenango, and Comitán.

The lowlands consist of a vast limestone plateau that rises slightly toward the south, ending where the mountainous highlands zone interrupts the plain. The southern lowlands lie just north of the highlands and incorporate the Petén rainforest of northern Guatemala, Belize, and the southern portions of the Mexican states of Campeche and Quintana Roo. Soils in the south tend to be deep and varied in texture and consistence. The northern lowlands cover the remainder of the Yucatan Peninsula, including the Puuk hills. Soils in the north tend to be shallow, well drained, and calcareous, but

Fig. 19.1 The ancient Maya world, encompassing the modern nation states of southern Mexico, Guatemala, Belize, and parts of Honduras and El Salvador

also more leached than those in the south. Geologic structure varies throughout the lowlands, producing variation in many soil-forming factors and leading to the development of a range of soil types, including Rendolls, Vertisols, Histosols, Mollisols, and Oxisols (see Furley 1974). Timothy Beach and colleagues (2006) provide a detailed picture of the soil history of this and adjacent regions.

The peoples who occupied this region can be traced back at least 5000 years before the arrival of the Spanish in the 1500s, though it is unclear when exactly linguistic and cultural patterns that can be recognized as "Maya" were first established and from where they emerged. Villages and communities seem to have been settled by about 1800 BC, soon followed by the massing of large cities, such as El Mirador in the southern lowlands, with populations on the order of tens of thousands. Equally complex societies flourished in the highlands, such as at Kaminaljuyú, which underlies present-day Guatemala City. New findings over the past decade, such as those at San Bartolo near El Mirador, show that, by the turn of the millennium, the Maya had a fully developed pantheon of gods (emphasizing the Maize God), which was integrated into a complex and probably pan-Maya creation story.

The period from about AD 250-900, generally referred to as the "classic" era of Maya society, represents the time when the Maya reached intellectual and artistic heights, as well as large populations, a flourishing economy, and complex adaptive agrosystems that incorporated swidden cultivation with raised and drained-field agriculture, terracing, and other intensive farming technologies (*e.g.*, Fedick 1996; Flannery 1982; Harrison and Turner 1978). Nicholas Dunning and colleagues (1998) provide a thorough overview of lowland agricultural systems, showing how Maya farmers adapted their strategies to different environments and how these strategies changed over time in relation to environmental fluxes as well as regional political and economic shifts. The variety and complexity of agricultural systems demonstrate that the ancient Maya held a deep understanding of soils and their properties, management, and care.

Unlike other societies that flourished throughout the Americas before the arrival of the Spanish, the Maya left us richly detailed written accounts about many aspects of their lives, which were recorded in hieroglyphic inscriptions on monuments, architecture, artifacts, and bark-paper books. These historical sources of information, as well as those created just after the arrival of the Spanish in the early 16th century, provide us with unique particulars about a wide range of social and political matters, religious rites and rituals, and even the names of specific individuals and some of their activities along with the dates when such actions and events took place. Nancy Farriss (1984) has documented how, and to what extent, the Yucatec Maya cosmos survived Colonial Spanish intrusion, arguing that the transformation of Maya gods into Catholic saints helped to preserve the core of the Yucatec Maya worldview. It is to these and other early sources that we now turn to examine what the Maya had to say about soil, what they thought was important to record, and what has survived and changed over the past 500 years of colonial and economic intrusions.

19.4 Maya Creation Stories and the Origins of Soil

The most notable source of information on ancient Maya beliefs is the *Popol Vuh*, the so-called "council book" of the Quiché Maya of the Guatemalan highlands. The book, written by members of the lordly lineages of the Quiché in the mid-16th century, is a transcription of a complex oral history that stretches back hundreds, if not thousands, of years. The book begins with an account of activities that took place "before the first sunrise," and record how the universe, including the *cahuleu*, or "sky-earth" ("world"), and everything in it came into existence. This account is followed by the story of the Hero Twins, Hunahpu and Xbalanque, who move back and forth between the surface of the earth and the underworld to play the ancient Maya ball game with the Lords of the Underworld. These activities are steeped in metaphor and symbolism of the movements of the sun, moon, planets, and stars.

According to the *Popol Vuh* (as translated by Tedlock 1996), in the beginning there only existed an empty sky and a calm sea below. Out of this, the gods of the primordial sea (Maker, Modeler, Bearer, Begetter, Heart of the Lake, Heart of the Sea, and Sovereign Plumed Serpent) join those of the primordial sky (Heart of Sky, Heart of Earth, Newborn Thunderbolt, Raw Thunderbolt, and Hurricane) to envision and conceive of the earth:

> For the forming of the earth they said "Earth." It arose suddenly, just like a cloud, like a mist, now forming, unfolding. Then the mountains were separated from the water, all at once the great mountains came forth. By their genius alone, by their cutting edge alone they carried out the conception of the mountain-plain, whose face grew instant groves of cypress and pine…Such was the formation of the earth when it was brought forth by the Heart of Sky, Heart of Earth, as they are called, since they were the first to think of it. (Tedlock 1996, pp. 65-66)

According to Dennis Tedlock's (1996, pp. 31-32) analysis, the gods set in motion a process they sometimes refer to as "sowing" and "dawning," which includes "the sowing of seeds in the earth whose sprouting will be their dawning," the sowing of human beings in the womb whose birth will be their dawning, and finally the sowing of humans in the earth at death that is followed by "dawning when their souls become sparks of light in the darkness." Thus, human beings are as old as the earth itself and the existence of the two is intimately related.

The gods' attempts to make humans are fraught with failure, however, especially when they tried to create humans from soil:

> So then comes the building and working with earth and mud. They made a body, but it didn't look good to them. It was just separating, just crumbling, just loosening, just softening, just disintegrating, and just dissolving. Its head wouldn't turn, either. Its face was just lopsided, its face was just twisted. It couldn't look around. It talked at first, but senselessly. It was quick dissolving in the water. (Tedlock 1996, pp. 68-69)

Although this being talks, its words make no sense. Since its body is poorly made, it could not reproduce. Eventually, it dissolves into nothing.

After several attempts, humans are finally fashioned from cornmeal that is mixed with water when Xmucane, a mystic diviner (and mother/grandmother of the Hero Twins) who the gods consult for help, washes her hands after grinding maize. The resulting humans (the Quiché Maya in this account) represent apical ancestors ("mother-fathers") to everyone in the Quiché lineages. Here again, there is an inextricable connection between people and the earth, this time mediated through people's manipulation of soils—with the help of gods and ancestors—to produce maize, which is perceived as both the flesh and sustenance of humans.

From the very beginning, humans have needed help making corn. Because the first humans were modeled from corn dough, the gods must be consulted before planting or harvesting, for only they know the propitious times in which to do so. This knowledge is encoded in the *Popol Vuh* in the story of the Hero Twins, ball players who travel to the Underworld, called *Xibalba* or "Place of Fear." The principal mission of the Hero Twins is to bring maize through the soil to the surface of the earth. In scenes depicted on Late Classic (ca. AD 600-800) pottery vessels from the southern lowlands, Hun Hunahpu (the Maize God) is shown being resurrected by his Hero Twin sons, Hunahpu and Xbalanque, or by Chaak beings (rain gods), who brandish lightening weapons to help him emerge from the earth, which is represented as a giant tortoise carapace (*e.g.*, Coe 2005, p. 219; Taube 1993, p. 66). In this and other prehispanic imagery, the Hero Twins are shown receiving help from gods in their efforts to grow maize.

Apart from the *Popol Vuh*, which explains the creation of the earth and humans and the relationship between them, the handful of prehispanic documents still in existence (primarily historical-genealogical manuscripts and ritual-calendrical documents) offer very few insights into Maya perceptions of soil genesis. There are, however, frequent mentions in these sources of the general concept of "earth" or "land" in reference to both cosmology and agrarian ritual; no entries specifically mention "soil." The principal prehispanic pictorial manuscript to mention "earth/land" is the Madrid Codex (also known as the Trocortesiano Codex), which contains approximately 250 almanacs of scheduled rituals grouped thematically into sections explaining ceremonies for rain and the ritual calendar, planting and harvesting, deer hunting, beekeeping, and other topics. The codex is a compilation of pictures and hieroglyphic texts written in a script that was used throughout the Maya lowlands from the 2nd to 15th centuries AD in a region occupied by Yucatec and Ch'olan speaking populations.

The Madrid Codex (Villacorta and Villacorta 1976) shows four primary deities associated with the manipulation of the earth to produce crops: K'awil (god of sustenance), Chaak (god of rain), Nal (god of maize), and Itzamnaaj (god of earth). The deities associated with sustenance, maize, and earth are depicted in succession on Folio 24a (Fig. 19.2a), each grasping a plant sprouting out of a *kab'* glyph, representing the earth or soil (Villacorta and Villacorta 1976, p. 272). The hieroglyphic text accompanying each of these figures reads, in part, *nah?/na?-nik-na/li?*, "first?/honored? flower" (question marks indicate uncertainty in the translation; Vail and Hernández 2005), giving each god the title of "first" or "honored" "flower." This could be an honorary title or perhaps a metaphorical reference to the season's first harvest.

The principal god is Itzamnaaj, who has several aspects or guises. One of these is a caiman (*itzam*), which is called Itzam Kab Ain, the great earth caiman, by the Colonial Yucatec Maya (Craine and Reindorp 1979, p. 118; Thompson 1970, p. 216). In the Madrid Codex, Itzamnaaj is shown seated or lying on the earth, represented by the *kab'* glyph or with *kab'* markings, conducting a variety of rituals (folios 24a, 62b, 79b, 88b, 91b, 99b, 100b, 109b, 110b). In one scene (Fig. 19.2b), he is shown patting the earth, represented by a strip filled with *kab'* markings, below which is a god mask or figurine (Villacorta and Villacorta 1976, p. 442). The hieroglyphic text records, *mu-ku-u//k'uh//itzamna-na//nah?/na?-nik-li*, "Itzamnaaj, first?/honored? flower, is burying [the] idols" (Vail and Hernández 2005). A similar scene on Folio 99b shows God M, god of merchants and warriors, holding a maize seed or tortilla while seated on or behind the buried idol (Villacorta and Villacorta 1976, p. 422). Here, the gods (or humans impersonating them) are apparently participating in a deity renewal ceremony honoring Chaak. Bishop Diego de Landa (Tozzer 1941, p. 161) describes this ceremony (*Oc Na*) in some detail, noting that, "they celebrated this festival every year, and besides this, they renewed the idols of clay and their braziers…"

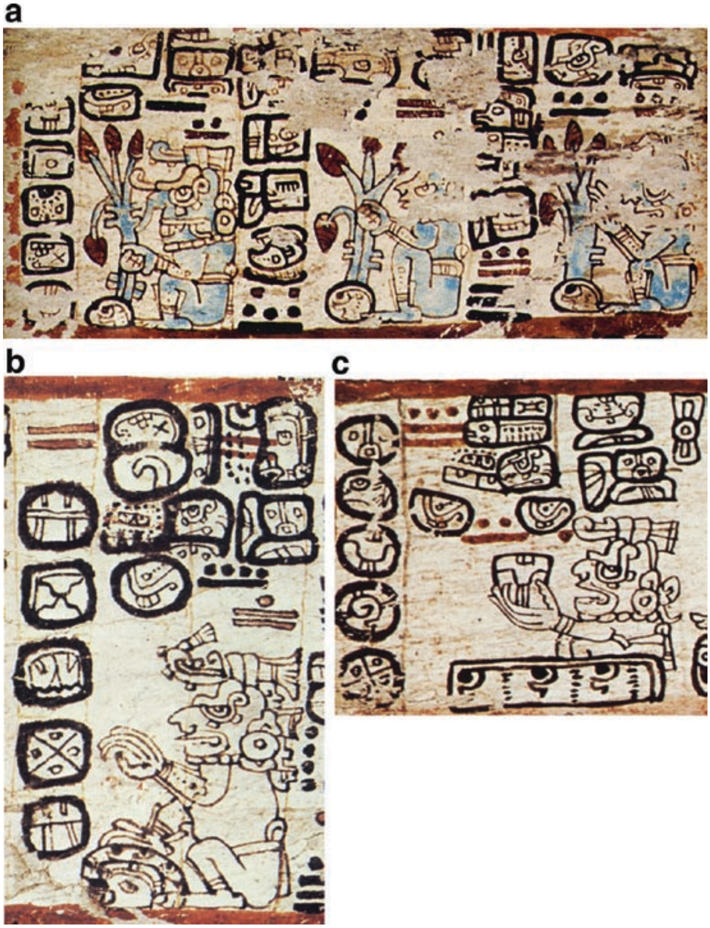


Fig. 19.2 (a). Folio 24a from the Madrid Codex, showing (from left to right) Chaak (or K'awil), Nal, and Itzamnaaj, each grasping a plant sprouting out of a *kab'* glyph (*Codex Trocortesiano; illustration courtesy of Museo de América, Madrid, Spain*). (**b).** Folio 109b from the Madrid Codex, showing Itzamnaaj burying a god mask or figurine in the earth, probably during a deity renewal ceremony honoring Chaak (*Codex Trocortesiano; illustration courtesy of Museo de América, Madrid, Spain*). (**c).** Folio 91b from the Madrid Codex, showing Itzamnaaj seated on the earth possibly holding a maize seed (*Codex Trocortesiano; illustration courtesy of Museo de América, Madrid, Spain*) (see as color plate following *Index*)

The ceremony was in honor of the Chaaks, "whom they regarded as the gods of the cornfields" (Tozzer 1941, p. 161).

In another scene (Fig. 19.2c), Itzamnaaj is seated on the earth and appears to be holding a maize seed, possibly with the intention of planting it (Villacorta and Villacorta 1976, p. 406). The accompanying hieroglyphic text reads, *ahaw-le// tzi-li-yu//itzamna//nah?/na?-nik-li*, "[in] rulership; Itzamnaaj, first?/honored?

flower's goodness" (Vail and Hernández 2005). He is also shown in some frames (Folios 65-72, 73b), along with other deities, holding a sprouting maize plant. Gabrielle Vail and Victoria Bricker (2004, pp. 186-187, 192-193) have interpreted these scenes as representing the same seasonal event in the month of Kumk'u over many years in the Maya's 260-day ritual calendar.

Other deities are depicted relative to *kab'* (earth) markings. For instance, an image of the sun god (K'inich Ahaw) emerges from the mouth of a serpent, which ascends from a *kab'* glyph (Folios 65-72, Frame 20; Villacorta and Villacorta 1976, p. 356). In most cases, however, the glyph is used to identify the location of a ritual or other activity as taking place in relation to the earth. For example, the Underworld God (Folio 50a; Villacorta and Villacorta 1976, p. 324), and the Maize God (Folio 51b; Villacorta and Villacorta 1976, p. 326) are shown standing on an earthen platform inside of a thatched building. In another folio depicting the Underworld God (Folio 87c; Villacorta and Villacorta 1976, p. 398), the *kab'* glyph is pictured above the thatched structure, indicating that the scene takes place inside the earth.

While the prehispanic Maya did not place the Western notion of "soil" at center stage in their creation story or in their almanacs, it is evident that they had a clear concept of soil, whether in the context of the Hero Twins' search for maize in the Underworld or as represented in the use of *kab'* markings for situating the actions of deities. Moreover, Maya ideas of creation, growth, and reproduction (physical and social) as attested in the *Popol Vuh* and the Madrid Codex interlink the creation of humans with the creation of the earth and with the underlying belief that humans are made from maize. Since maize is a product of the earth, and the earth is owned by the gods and operated by the ancestors, humans must seek permission and approval to interact with the biophysical environment, including soil.

19.5 Early Colonial Perspectives on Maya Soil Perceptions

Much of what we know about the activities and beliefs of the early Colonial Maya come from the account of Fray Diego de Landa, a Spanish clergyman based at the monastery of Izamal in the northern Yucatan Peninsula during the mid-16th century and who served as the Bishop of Yucatan from 1571 to 1579. His *Relación de las cosas de Yucatan* ("Relation of the things of Yucatan") is a socio-historical ethnography largely devoted to the religious rituals of the protohistoric Maya, although he reports on other, more secular, aspects of their lives as well. According to Landa,

> Yucatan is the country with least earth that I have seen, since all of it is one living rock and has wonderfully little earth, so that there are few places where one can dig down an *estado* [depth of five feet, seven inches] without striking great layers of very large rocks…It is very good for lime of which there is a great deal, and it is marvelous that the fertility of this land is so great on top of and between the stones, so that everything that there is and that grows in it grows better and more abundantly amongst the rocks than in the earth, because on the earth which happens to be in some parts, neither do trees grow nor are there any, nor

> do the Indians sow their seeds in it, nor is there anything except grass, And among the stones and over them they sow and all their seeds spring up and all the trees grow and some so large and beautiful that they are marvelous to see. The cause of this is, I believe, that there is more moisture and it is preserved more in the rocks than in the earth. (Tozzer 1941, p. 186)

This curious description of Yucatan's "earth" (or soils) suggests that the Maya had their work cut out for them. To deal with low soil moisture and fertility, the early Colonial Maya pursued a number of measures that we might find practical today, such as the use of rock mulch mentioned in the quotation above and adding ash to plant roots to increase the soil's fertility: "the Indians grow [wormwoods] for their sweet smells and their pleasure, and I have seen them made more beautiful when the Indian women put ashes at their roots" (Tozzer 1941, p. 194). But by far, most effort was given to conducting agrarian rituals—for planting, harvesting, sufficient rain, and bountiful harvests—designed to attract the attention and beneficence of the ancestors (*e.g.*, Tozzer 1941, pp. 28, 54, 97, 111-112, 116, 154, 161-162, 180-181, 184). The most notable of these is the Ch'a-Chaak "rain" ceremony, which is still actively practiced today (Freidel et al. 1993, pp. 29-33). In addition, the Yucatec Maya also practice(d) the *hetz lu'um* ritual for "feeding the land" and the *loh* ritual for "curing the land" (Barrera-Bassols and Toledo 2005, pp. 30-31; Redfield and Rojas 1934, p. 175). The first is practiced as a petition when a farmer wants to clear a forest plot for agriculture—an activity that is thought may drastically disturb the "world balance" and thus offend certain deities (such as Chaak) who would then punish the farmer. The second aims to restore a field if an agricultural plot is not performing well. For prehispanic times, Patricia McAnany and colleagues (2003, pp. 75-78) have unearthed 9th and 10th century ritual deposits from cenotes and caves in the Sibun Valley of central Belize, which may refer to these kinds of agrarian rites.

Maya environmental worldview is clearly embedded in agricultural ritual (see McAnany 1995, pp. 64-110; see also Taube 2003). The underlying premise is that landscapes are animated by ancestral spirits who must be consulted or placated to produce crops, just as the Hero Twins had done. For the contemporary highland Maya of Chiapas, Mexico, Evon Vogt (1976, p. 56) writes that agricultural field rituals represent reciprocal transactions between the Maya and the Earth Lord, Yahval Balamil, or "owner of the earth," who must be compensated "for incursions into and utilization of materials from his domain." In agrarian rituals, "compensation has concrete meaning: only with appropriate offerings will the Earth Lord permit sufficient rain to fall on the crops and control destructive winds" (Vogt 1976, p. 57). Robert Redfield (1932, pp. 304-306) argued for a similar relationship between the Maya and the earth in northern Yucatan, noting that humans must appease the *aluxes*, or spirits of the fields, with offerings of food and drink, or else the sprits might bring harm to the crops or community.

If human interactions with soils were mediated by deities and ancestors, then we might expect to find that the ways in which the Maya conceived of soil were linked to broader themes in their belief system. For example, several of the contemporary folk soil taxonomies discussed earlier classify soils according to color, principally yellow, red, white, and black. According to Landa (Tozzer 1941, p. 137), these specific colors have directional associations, which are probably associated with the path of the rising and setting sun and zenith and nadir (Vogt 1992, p. 118); yellow (*kan*) is associated with the south (*kimi*), red (*chac*) with east (*chuwen*), white (*sac*) with north (*kib'*), and black (*ek*) with west (*imix*). Each color is also associated with a deity in Maya religion: *kan* (yellow), *chaak* (red), *sacal* (white), and *hosan-ek* (black). These links are not always clear and appear to vary somewhat from region to region. Still, from the perspective of the early Colonial sources, soil was understood and classified in the same terms as other nonmaterial phenomena.

Of these soil/color associations, Landa (Tozzer 1941, pp. 18, 171) only specifically mentions "*sac cab*," which he describes as "white earth, excellent for buildings." However, he notes that soil and clay were used for certain religious ceremonies:

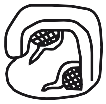
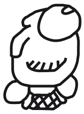
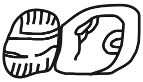
> The priest gave incense prepared beforehand for the host, who burned it in the brazier, and so they say the evil spirit fled away. This done, with their accustomed devotion they appointed the first step of the heap of stones with mud from the well, and the other steps with a blue paste, and they scattered smoke from the incense many times, and invoked the Chacs and Itzamna… (Tozzer 1941, p. 164)

Beyond Landa's report, early Colonial Mayan/Spanish dictionaries provide entries for "soil" and related concepts in the Yucatec Mayan language. Two Yucatec Mayan vocabularies mention "soil," namely the *Calepino Maya de Motul* (referred to as the "Motul dictionary," authored in *ca.* 1580-1614) and the *Bocabulario de Maya Than* (also known as the "Vienna dictionary," written in *ca.* 1570s). In addition to the "white earth" described by Landa (appearing in the dictionaries as *zahcab*, *zac cab*, *zacab*, *zah cab*, and *zazcab*), the Vienna Spanish/Mayan dictionary (Acuña 1993) lists *puz kan luum*, which can be translated as "dry yellow earth." The Motul Mayan/Spanish dictionary (Acuña 1984) similarly lists *puz luum*, but without the color referent: "tierra seca sin piedras" (dry earth without rocks). This soil type contrasts with *yax-cab* ("green earth" or "fresh earth"), mentioned in the *Popol Vuh* (as *rax ulew*, "green [or raw] earth; Tedlock 1996, pp. 116, 272) and the late 18th-century manuscript, *Ritual of the Bacabs* (Roys 1965, p. 127), a Yucatec Maya book of incantations. Comparisons between soils and colors most likely represent continuations of these ideas and observations from prehispanic times, as such associations were explicitly made in the Madrid Codex (Folios 24c-25c, 27c-28c, 35, 36, 58c-62c) and the Dresden Codex (Folios 65b-69b, 74) (Vail and Hernández 2005).

Other entries provide descriptions for soils rather than formal soil types. For instance, the Motul dictionary lists *akacnac luum* as "moist earth" (Bolles 2001, p. 30v), and the *Ritual of the Bacabs* describes *yax-kax* as "a certain soil between red and black" (Roys 1965, p. 127). The Motul dictionary additionally lists the phrase *ah took chuk kab*, transcribed as "he of the burnt charcoal earth" (Clark and Houston 1998, p. 44), which probably refers to an individual who makes lime for plaster. Contemporary Itza Maya also use the phrase *lu'um ma'lo*, or "good land," (Hofling 1991, p. 201) as it is used in the following: *a' 'ek=lu'um-ej, jach ma'lo' ti'ij päk'-aJ-al*, "The black earth is good for planting" (Hofling 1997, p. 237).

While there are various ways of describing soil using color and other properties, the Maya appear to have been careful in distinguishing soils based on attributes of cohesion and adhesion, or consistency. Table 19.1 shows the hieroglyphs used to

Table 19.1 Examples of Classic Maya Hieroglyphs Denoting Soil Concepts

Glyph[1]	Transcription[2]	Meaning	Reference
	**KAB'** (*kab'*)	earth	Stuart 2005
	**lu-mi** (*lum*)	soil	Lacadena and Wichmann 2004, Houston et al. 1998
	**lu-k'u** (*luk'*)	mud	Lacadena and Wichmann 2004, Houston et al. 1998
	**tz'i-ku** (*tz'iik*)	clay	Houston et al. 1998

[1]adapted from entries in Montgomery (2002) and Boot (2005)
[2]typeface in bold indicates hieroglyphic spellings, typeface in italics represents transcriptions

note the general concept of earth or land (*kab'*), compared to the more specific ideas of soil (*lum*), mud (*luk'*), and clay (*tz'iik*). These differences suggest that the amount of moisture, or perhaps more specifically of stickiness and plasticity, was of signal importance to the Maya for distinguishing soils and their utility.

The specific ways in which soils are discussed, both by Landa and by the Maya themselves, suggest that the Maya drew on their worldview (manifest in creation stories and other parables of existence) to understand and describe the physical universe around them and to help make decisions about how to use their environment. This is perhaps most evident in the blending of colors, directions, and gods for classifying soils. Given that the early Colonial sources also attest to certain soils or sediments being used in particular ceremonial practices suggests that earth materials played a role in activating and expressing—and possibly altering—that worldview. This would seem to indicate that, in certain instances, soils had as much agency as humans.

19.6 Toward a Holistic Approach for Understanding Maya Soils

In this chapter we have considered some of the ways that aspects of Maya worldview intersected with soil knowledge, complementing the work of Nicholas Saunders (2004) who has considered the relationship between minerals and the cosmos among various groups throughout the Americas. Our approach has been partly as an extension of, and partly as a reaction to, the insightful essay by Verena Winiwarter and Winifred Blum in *Footprints in the Soil* (2006). Winiwarter and Blum consider the role of soils in belief systems through an historical and cross-cultural survey of worldviews in small-scale and pre-industrial societies. They observe that, in such societies, soils are often conceptualized as part of a world that is controlled by invisible beings representing ancestors, spirits, and other “higher, unseen powers” (Winiwarter and Blum 2006, p. 108). While soils have “immaterial qualities, they were—to some extent—objects of religious reverence and corresponding ritual practices to ensure their sustained fertility existed” (Winiwarter and Blum 2006, p. 108).

Here we have pursued this idea—of “souls and soils,” as Winiwarter and Blum phrase it—among the ancient Maya of southern Mesoamerica. However, we have departed from the notion that premodern societies perceived soils as “objects” and instead have shown how soils were often viewed as active cultural agents that contributed to fashioning and fixing worldview, values, and beliefs. The contemporary Maya, like many of the cultures discussed by Winiwarter and Blum, hold pantheistic beliefs about the biophysical environment (Vogt 1969, pp. 297-306). Such beliefs perceive cultivated soils as animate—inhabited by ancestors that demand supplication and recompense (Vogt 1969, pp. 455-461). This notion, which situates humans as a part of (not apart from) nature, encourages a high degree of mutualism between people and their environments. Decisions that impact the landscape thus represent consensus between terrestrial and celestial beings, both of which have legitimate environmental agency (*e.g.*, Wells and Davis-Salazar 2008). In this way, people and soil interact in highly complex ways that draw on worldview to make sense of these relations and to guide future actions, which, in turn, may change worldview.

The holistic approach we have taken leads us to consider soils as active participants in human processes of meaning making. Such a perspective suggests that a broader concept for soils is needed for understanding both the material and spiritual aspects of soil use and management. The concept of “cultural soilscape” which can be defined most broadly as “a given area of the earth’s surface that is the result of spatially and temporally variable geomorphic, pedogenic, and *cultural* processes” (Wells 2006, p. 125, emphasis ours) is useful because it views soil as a physical embodiment of human-environmental interactions. The cultural soilscape is an analytical domain that reveals for study the “complex and multilayered dialectic between human behavior and soil bodies over long periods” (Wells 2006, p. 125) and emphasizes the social and historical frameworks that have shaped soil bodies. For instance, Jonathan Sandor (1987, 1992; Sandor and Gersper 1988; Sandor et al. 1986) has studied cultural alterations to soilscapes in the form of agricultural terraces. Sandor (2006, p. 521) argues that “the placement, construction, and soil characteristics of agricultural terraces are the physical manifestations of what cultures have learned in working with their environments.” Thus, agricultural terraces are cultural soilscapes because they manifest worldview and belief and also structure and organize the built environment in which human societies operate.

Because of the close connection between people and their environments, environmental worldview and local knowledge are central to investigating cultural soilscapes (see Sandor et al. 2006). For the ancient Maya, reciprocity between humans and ancestors was a fundamental principle guiding human/soil interactions. Reciprocal relations informed by a worldview that placed soil partially in the domain of gods and partially in the domain of humans conditioned the possibilities for soil use and change over time.

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References

Acuña R (ed) (1993) *Bocabulario de Maya Than* [*Vocabulary of Than Maya*]. Universidad Nacional Autónoma de México, Mexico, DF.

Acuña R (ed) (1984) *Calepino Maya de Motul [Maya dictionary of Motul]*. Universidad Nacional Autónoma de México, Mexico, DF.

Barrera-Bassols N, Toledo VM (2005) Ethnoecology of the Yucatec Maya: Symbolism, knowledge and management of natural resources. *Journal of Latin American Geograph*y 4:9–41.

Barrera-Bassols N, Zinck JA (2000) *Ethnopedology in a worldwide perspective: An annotated bibliography*. International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands.

Beach T, Luzzadder-Beach S, Dunning NP (2006) A soils history of Mesoamerica and the Caribbean Islands. In: McNeill JR, Winiwarter V (eds) *Soils and societies: Perspectives from environmental history*. White Horse Press, Isle of Harris, UK, pp. 51–90.

Bolles D (2001) Combined Dictionary–Concordance of the Yucatecan Mayan Language. Foundation for the Advancement of Mesoamerican Studies, Crystal River, Florida. http://www.famsi.org/reports/96072. Cited 10 Sep 2008.

Boot E (2005) A preliminary overview of common and uncommon Classic Maya vessel type collections in the primary standard sequence. http://www.mayavase.com. Cited 10 Sep 2008.

Carter WE (1969) *New lands and old traditions: Kekchi cultivators in the Guatemalan lowlands*. University Press of Florida, Gainesville.

Clark JE, Houston SD (1998) Craft specialization, gender, and personhood among the post-conquest Maya of Yucatan, Mexico. In: Costin CL, Wright RP (eds) *Craft and social identity*. American Anthropological Association, Arlington, Virginia, pp. 31-46.

Coe MD (2005) *The Maya*. Seventh edition. Thames and Hudson, New York.

Craine ER, Reindorp RC (1979) *The Codex Pérez and the Book of Chilam Balam of Maní. University of Oklahoma Press, Norman*.

Dunning NP (1992a) *Lords of the hills: Ancient Maya settlement in the Puuc region, Yucatán, Mexico.* Prehistory Press, Madison, Wisconsin.

Dunning NP (1992b) The implications of soil folk taxonomies for agricultural change in Middle America. *Yearbook, Conference of Latin American Geographers* 17/18:243–247.

Dunning NP, Beach T (2000) Stability and instability in prehispanic Maya landscapes. In: Lentz DL (ed) *Imperfect balance: Landscape transformations in the Precolumbian Americas*. Columbia University Press, New York, pp. 179–202.

Dunning NP, Beach T (2004) Fruit of the *lu'um*: Lowland Maya soil knowledge and agricultural practices. *Mono y Conejo* 2:1–25.

Dunning NP, Beach T, Farrell P, Luzzadder-Beach S (1998) Prehispanic agrosystems and adaptive regions in the Maya lowlands. *Culture and Agriculture* 20:87–101.

Ewell PT, Merrill-Sands D (1987) Milpa in Yucatan: A long-fallow maize system and its alternatives in the Maya peasant economy. In: Turner BL, Brush S (eds) *Comparative farming systems*. Guilford, New York, pp. 95–129.

Farriss NM (1984) *Maya society under Colonial rule*. Princeton University Press, Princeton, New Jersey.

Faust BB (1998) *Mexican rural development and the plumed serpent: Technology and Maya cosmology in the tropical forest of Campeche, Mexico*. Bergin and Garvey, Westport, Connecticut.

Fedick SL (ed) (1996) *The managed mosaic: Ancient Maya agricultural and resource use.* University of Utah Press, Salt Lake City.

Flannery KV (ed) (1982) *Maya subsistence: Studies in memory of Dennis R. Puleston*. Academic Press, New York.

Freidel D, Schele L, Parker J (1993) *Maya cosmos: Three thousand years on the shaman's path*. William Morrow and Company, New York.

Furley PA (1974) Soil-slope-plant relationships in the northern Maya Mountains, Belize, Central America: I. The sequence over metamorphic sandstones and shales. II. The sequence over phyllites and granites. III. Variations in the properties of soil profiles. *Journal of Biogeography* 1:171-186, 1:263-279, 3:303-319.

Graefe S (2003) Crop and soil variability in traditional and modern Mayan maize cultivation of Yucatan, Mexico. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*. Beiheft No. 75. Kassel University Press, Kassel, Germany.

Harrison PD, Turner BL (eds) (1978) *Pre-Hispanic Maya agriculture*. University of New Mexico Press, Albuquerque.

Hofling CA (1991) *Itzá Maya texts*. University of Utah Press, Salt Lake City.

Hofling CA (1997) *Itzaj Maya-Spanish-English Dictionary*. University of Utah Press, Salt Lake City.

Houston S, Stuart D, Robertson J (1998) Disharmony in Maya hieroglyphic writing: Linguistic change and continuity in Classic society. In: Ciudad Ruiz A, Fernández Marquínez Y, García Campillo JM, Iglesias Ponce de León MJ, Lacadena García-Gallo A, Sanz Castro LT (eds) *Anatomía de una civilización: Aproximaciones interdisciplinarias a la cultura maya [Anatomy of a civilization: interdisciplinary approaches to Maya culture]*. Sociedad Española de Estudios Mayas, Madrid, Spain, pp. 275–296.

Jensen CT, Moriarty MD, Johnson KD, Terry RE, Emery KF, Nelson SD (2007) Soil resources of the Motul de San José Maya: Correlating soil taxonomy and modern Itzá Maya soil classification within a Classic Maya archaeological zone. In: Wells EC, Terry RE (eds) *Advances in geoarchaeological approaches to anthrosol chemistry, part I: Agriculture. Geoarchaeology: An International Journal* 22:337–357.

Lacadena A, Wichmann S (2004) On the representation of the glottal stop in Maya writing. In: Wichmann S (ed) *The linguistics of Maya writing*. University of Utah Press, Salt Lake City, pp. 100–164.

McAnany PA (1995) *Living with the ancestors: Kinship and kingship in ancient Maya society*. University of Texas Press, Austin.

McAnany PA, Berry KA, Thomas BS (2003) Wetlands, rivers, and caves: Agricultural and ritual practice in two lowland Maya landscapes. In: Iannone G, Connell SV (eds) *Perspectives on ancient Maya rural complexity*. Cotsen Institute of Archaeology, University of California, Los Angeles, pp. 71–81.

Montgomery J (2002) *Dictionary of Maya hieroglyphs*. Hippocrene Books, New York.

Redfield R (1932) Maya archaeology as the Mayas see it. *Sociologus* 8:299–309.

Redfield R, Villa-Rojas A (1934) *Chan Kom: A Maya village*. Publication 448. Carnegie Institution, Washington, DC.

Roys RL (1965) *Ritual of the bacabs: A book of Maya incantations*. University of Oklahoma Press, Norman.
Sandor JA (1987) Initial investigation of soils in agricultural terraces in the Colca Valley, Peru. In: Denevan WM, Mathewson K, Knapp G (eds) *Pre-Hispanic agricultural terraces in the Andean region*. British Archaeological Reports, International Series 359(1):163–192.
Sandor JA (1992) Long-term effects of prehistoric agriculture on soils: Examples from New Mexico and Peru. In: Holliday VT (ed) *Soils in archaeology: Landscapes evolution and human occupation*. Smithsonian Institution Press, Washington, DC, pp. 217–245.
Sandor JA (2006) Ancient agricultural terraces and soils. In: Warkentin BP (ed) *Footprints in the soil: People and ideas in soil history*. Elsevier, Amsterdam, The Netherlands, pp. 505–534.
Sandor JA, Gersper PL (1988) Evaluation of soil fertility in some prehistoric agricultural terraces in New Mexico. *Agronomy Journal* 80:846–850.
Sandor JA, Gersper PL, Hawley JW (1986) Soils at prehistoric agricultural terracing sites in New Mexico: I. Site placement, soil morphology, and classification. II. Organic matter and bulk density changes. III. Phosphorus, selected micronutrients, and pH. *Soil Science Society of America Journal* 50:166–180.
Sandor JA, WinklerPrins AMGA, Barrera-Bassols N, Zinck JA (2006) The heritage of soil knowledge among the world's cultures. In: Warkentin BP (ed) *Footprints in the soil: People and ideas in soil history*. Elsevier, Amsterdam, The Netherlands, pp. 43–84.
Saunders, NJ (2004) The cosmic Earth: Materiality and mineralogy in the Americas. In: Boivan N, Owoc MA (eds) *Soils, stones and symbols: Cultural perceptions of the mineral world*. University College London Press, London, pp. 123–141.
Stuart D (2005) *Sourcebook for the 29th Maya hieroglyph forum*, March 11-16, 2005. Department of Art and Art History, University of Texas, Austin.
Taube K (1993) *Aztec and Maya myths*. British Museum Press, London.
Taube K (2003) Ancient and contemporary Maya conceptions about field and forest. In: Gómez-Pompa A, Allen MF, Fedick SE, Jiménez-Osornio JJ (eds) *The lowland Maya area: Three millennia at the human-wildland interface*. Ford Products Press, New York, pp. 461–492.
Tedlock D (1996) *Popol Vuh: The Mayan book of the dawn of life*. Simon and Schuster, New York.
Terán S, Rasmussen C (1994) *La milpa de los mayas: La agricultura de los mayas prehispánicos y actuales en el noroeste de Yucatán [The milpa of the Maya: Agriculture of the prehispanic and modern Maya of northwest Yucatán]*. Daanish International Development Agency, Mérida, Yucatán, México.
Thompson JES (1970) *Maya history and religion*. University of Oklahoma Press, Norman.
Tozzer AM (1941) *Landa's Relación de las cosas de Yucatan: A translation*. Peabody Museum of American Archaeology and Ethnology, Harvard University, Cambridge, Massachusetts.
Vail G, Bricker VR (2004) Haab dates in the Madrid Codex. In: Vail G, Aveni A (eds) *The Madrid Codex: New approaches to understanding an ancient Maya manuscript*. University Press of Colorado, Boulder, pp. 171–214.
Vail G, Hernández C (2005) The Maya Hieroglyphic Codices, Version 2.0. http://www.mayacodices.org. Cited 10 Sep 2008.
Villacorta JA, Villacorta CA (1976 [1930]) *Códices mayas [Maya codices]*. Tipografía Nacional, Guatemala.
Vogt EZ (1969) *Zinacantan: A Maya community in the highlands of Chiapas*. Harvard University Press, Cambridge, Massachusetts.
Vogt EZ (1976) *Tortillas for the gods*. Harvard University Press, Cambridge, Massachusetts.
Vogt EZ (1992) Cardinal directions in Mayan and Southwestern Indian cosmology. In: Esponda Jimeno VM, Pincemin Deliberos S, Rosas Kifuri M (eds) *Antropología Mesoamericana: Homenaje a Alfonso Villa Rojas [Mesoamerican anthropology: Homage to Alfonso Villa Rojas]*. Consejo Estatal de fomento a la Investigación y Difusión de la Cultura, Chiapas, Mexico, pp. 105–127.
Wells EC (2006) Cultural soilscapes. In: Frossard E, Blum WEH, Warkentin BP (eds) *Function of soils for human societies and the environment*. Geological Society, London, pp. 125–132.

Wells EC, Davis-Salazar KL (2008) Environmental worldview and ritual economy among the Lenca of Honduras. In: Wells EC, McAnany PA (eds) *Dimensions of ritual economy*. Research in Economic Anthropology, Vol. 27. Emerald Group Publishing Limited, Bingley, UK, pp. 189–217.

Wilk RR (1981) *Agriculture, ecology, and domestic organization among the Kekchi Maya.* Doctoral dissertation, Department of Anthropology, University of Arizona, Tucson. University microfilms, Ann Arbor, Michigan.

Williams BJ (2006) Aztec soil knowledge: Classes, management, and ecology. In: Warkentin BP (ed) *Footprints in the soil: People and ideas in soil history*. Elsevier, Amsterdam, The Netherlands, pp. 17–41.

Williams BJ, Ortiz-Solorio CA (1981) Middle American folk soil taxonomy. *Annals of the Association of American Geographers* 71:335–358.

Wilshusen RH, Stone GD (1990) An ethnoarchaeological perspective on soils. *World Archaeology* 22:104–114.

Winiwarter V, Blum WEH (2006) Souls and soils: A survey of worldviews. In: Warkentin BP (ed) *Footprints in the soil: People and ideas in soil history*. Elsevier, Amsterdam, The Netherlands, pp. 107–122.

WinklerPrins AMGA, Barrera-Bassols N (2004) Latin American ethnopedology: A vision of its past, present, and future. *Agriculture and Human Values* 21:139–156.

Chapter 20
The Soil Memory: Case Study of a Protohistoric Archaeological Site in Senegal

Bruno Chavane and Christian Feller

20.1 Introduction and Site Description

Historians investigating lost civilizations of Sub-Saharan Africa face more challenges than their fellow workers in other regions of the world. Written testimonies are scarce; old Arabic texts from the 9th century consist of second hand narratives from Caravan conveyors of trans-Saharan trade (Cuoq 1975). Oral tradition has only retained a limited number of names and legends from old empires and kingdoms: Ghana or Wagadou, Tékrour, Galam, or Gadiga. Apart from the Nile Valley, the archeologist in this region has no architectural monuments as points of reference. A few circular and sporadic megalithic sites and earthen burial or anthropogenic mounds (tumulus) are found in areas of Western Africa, such as Gambia, Senegal, and Mali. While each site is rich in information, none reveal enough to recreate the lifestyle, activities, or exchanges of the former populations (Clerisse 1931; Niane 1957).

As mentioned by Fedoroff and Courty (2005), past civilizations can drastically change soil properties and soil functioning. Soils can keep the memory of past human activities at tumuli sites. In the study of such sites, the soil scientist can inform the archaeologist about the origin of the soil material, its nature, and the degree of transformation by human activity. On the other hand, the archaeologist can enlighten the soil scientist on some aspects of landscape formation and morphology associated with past human activities: *Soilscapes have a cultural dimension* (see chapter 19, Wells and Mihok, *this volume*). This paper takes such a cross-disciplinary approach with pedology and archaeology at a Protohistoric (metal age) site in Senegal.

Archaeological excavation of former habitations is the best way to determine the history of black Africa going back to the first millennium. Excavations conducted in

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the valleys of the Senegal River (Thilmans and Ravisé 1983) and Niger River (Niane 1957) have slowly revealed a former powerful civilization—the “Niger Valley” civilization. It is now recognized that an institutional entity known for its metallurgical techniques, exchanges, and cultural influences, had existed in both river valleys, midway between the source and the mouth (Kaké 1974; Devisse 1982).

These narrow strips of land adjacent to the rivers lay within large, arid territories, areas subject to drought since the fifth millennium. The intense technological and cultural activity in these alluvial lands was a direct result of the available water and food supply. Massive populations of black farmers settled along the northern part of those rivers (near the mouth), but soil aridity and the slave trade, pushed the populations back towards the more humid lands of the south. For example, the Soninké population from the oldest Sahelian Empire (the Ghana Empire) lived in the current area of Mauritania. Its capital city, Koumbi Saleh was probably located along the northern bank of the Niger River, a barren and desert-like area today (Bonel de Mézière 1920).

The migration of sub-Saharan people towards more fertile lands led them to the fluvial valley bordering the Sahara desert. Along with easy lines of communication, this valley was suitable for habitation and provided abundant water supply and fishery reserves, fertile soils for alluvial farming, and a raised bank for dwellings. These populations brought their skills, traditions, and techniques, and established a permanent settlement. The “Niger Valley” civilization emerged from intercultural and interethnic interactions along those riverbanks.

In order to uncover the different aspects of West African ancient history, an explorer in this terrane, devoid of written accounts and “solid” monuments, must use those archeological methods generally reserved for older civilizations. At the same time, new tools of research must be applied and adapted to the remains of the Protohistoric period. The first step of this adapted archeological process requires the detection of old habitation sites. A detailed examination of the soil surface can reveal the existence of former villages and their hidden vestiges. Martin and Becker (1974) completed surveys of numerous Protohistoric sites along the Senegal River, including Ogo. The Ogo site (13°17’W, 15°34’N) was located 2.4 km west of the present Ogo village, not very far from the city of Matam in the middle valley of Senegal (Figs. 20.1 and 20.2).

The site has an elliptic shape that is 350 m long and 110 m wide. This eroded mound stands 3 m high above the surrounding fields. The surface of the site has a very compact soil, and is virtually devoid of any vegetation except for some acacia plants and a few occasional, small, scattered grasses. A large number of small pottery fragments, pieces of whitened animal bone, fish vertebra, a variety of pearls, several pieces of charcoal debris, and iron metallurgy slag have been discovered on the surface of the mound, revealing the former settlement at the site. The site, dated to ca. 1000 AD, had, at that time, important activity in iron metallurgy (Chavane, 1980). Slags and large metal fragments strewn across the site surface in the archaeological pits testify to the high amounts of metallurgy-related activities of the former population. Blacksmiths had practiced their art of iron forging since the beginning of this village.

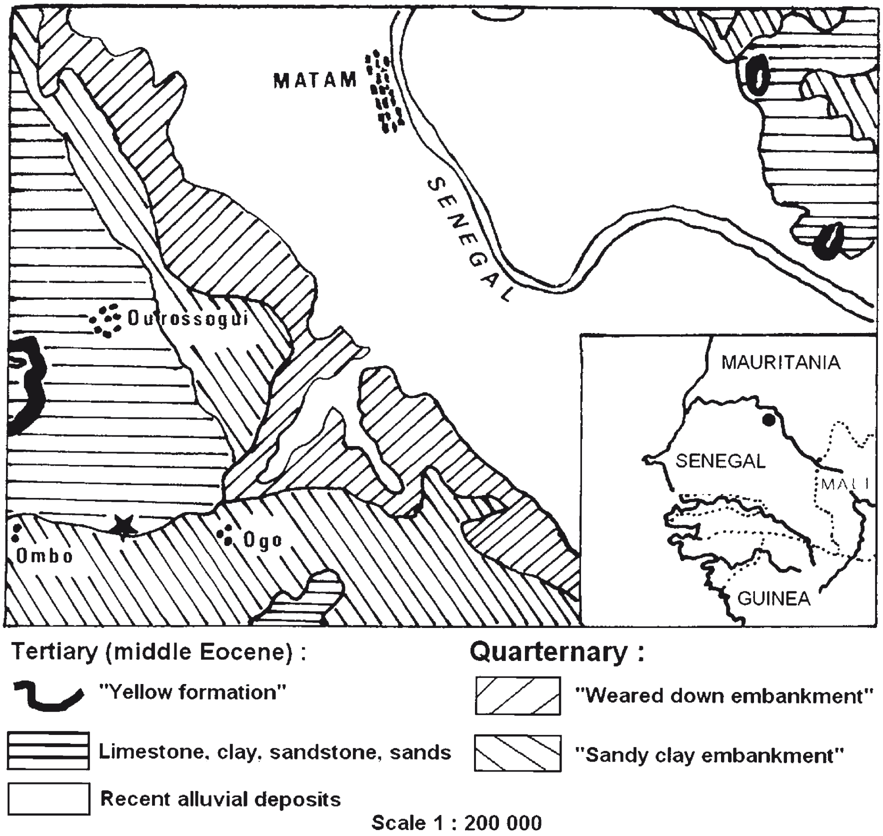

Fig. 20.1 Location of the Ogo village in the Senegal Valley (redrawn from Chavane and Feller 1986)

Besides anthropogenic vestiges, the site mound has a large amount of coarse natural elements, including pebbles and grits arranged along the slope and concentrated along the periphery. Limestone pebbles (10-20 cm diameter) that are typically round and white (slightly reddened due to fire) are present.

When the pedological study of the site began, the soil scientist questioned the following points:

- Where did the coarse natural elements at the surface of the site originate?
- What was the accumulation process (of the soil material) that built up the mound?
- How did human activity transform the environment and the landscape of the region?

The detailed results of that study were published in Feller et al. (1981) and Chavane and Feller (1986); it is also a part of Chavane's thesis (1980) and Chavane's book (1985).

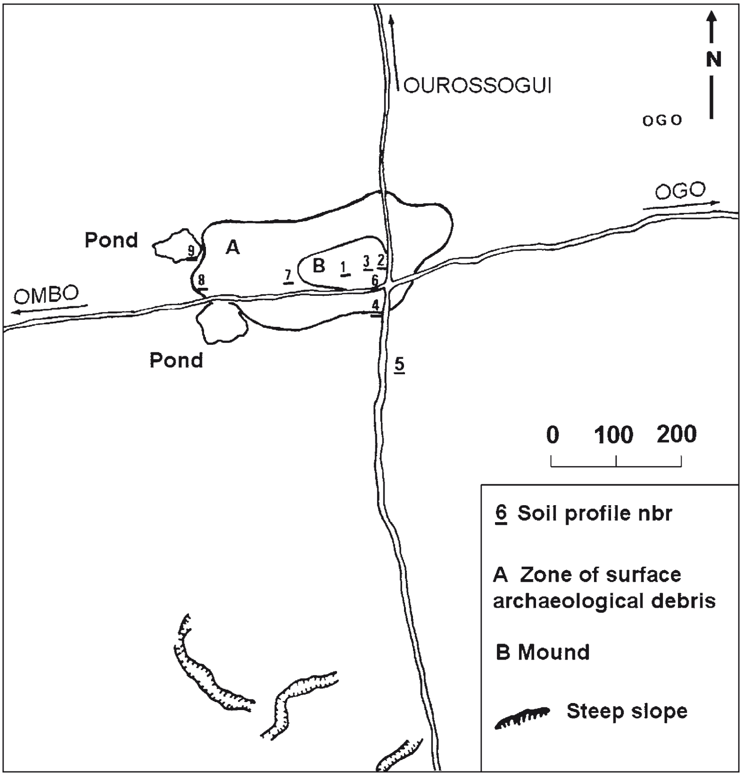

Fig. 20.2 Locations of the studied soil and archaeological profiles of the Ogo site (redrawn from Chavane and Feller 1986)

20.2 Where did the Coarse Natural Elements at the Surface of the Site Originate?

All coarse elements originated from a local geological formation located about 10 km away. The zoogenic limestone was taken from a Middle Eocene formation and was used by the former population for making iron. Limestone was used by the blacksmiths as a smelting agent to facilitate the reduction of iron ore. The rounded, red-brown to yellowish ferruginous gravels (3-8 cm), intact or broken, came from an iron pan level at the summit of the geological formation named "Continental Terminal," and were the source of iron for the metallurgy. Total iron content from the archaeological site's ferruginous gravel, and from the geological formation or colluvial residues in different locations were compared (Chavane and Feller, 1986). Gravels, from the site and off-site, exhibited the same range of variation in total iron content—from 20 to 55 %, with a mean value of about 40 %. Thus, all coarse materials found on the site as pebbles and gravels were selected and transported intentionally to the site by the former population.

20.3 What was the Accumulation Process of the Soil Material to Build Up the Mound?

The answer to that question requires an examination of the morphology of the soil profiles and analysis of the soil materials.

20.3.1 Morphology of Soil Profiles

Nine soil profiles (2 to 4 m depth) were excavated for archeological and/or pedological examination (Fig. 20.3). Profiles OS1, 2, 3, 4, 6, 7, and 8 were located along the axis of the mound. Profile OS5 was excavated at a location away from the mound (80 m south of the previous profile) to unearth a natural soil reference, and to compare it with the profile of anthropogenic soils. Profiles OS9 and OS10 were located at the northeastern exterior limit of the site, in a temporary pond that filled at the end of each rainy season (see Fig. 20.3). Detailed descriptions of the different profiles were given in Feller et al. (1981) and summarized hereafter. As an example, soil morphology for the OS2 profile is represented in Fig. 20.4.

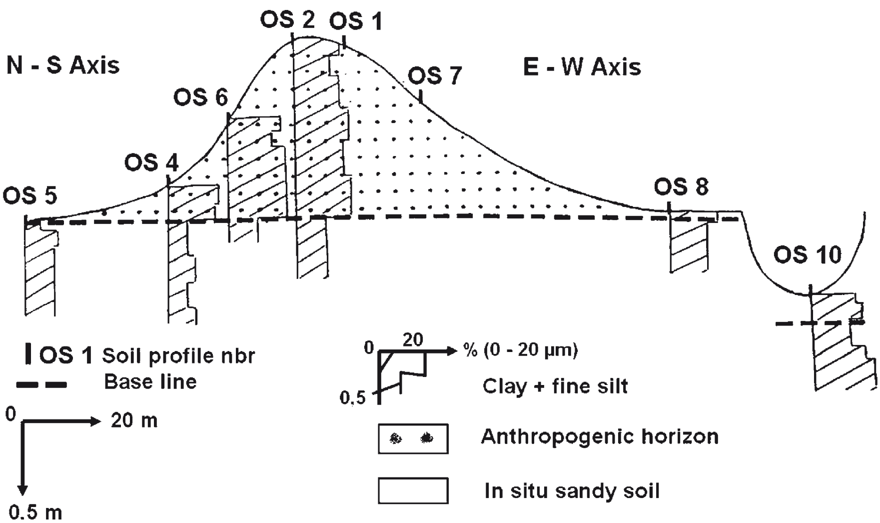

Fig. 20.3 Longitudinal view of the Ogo's site with clay + fine silt contents of soils (redrawn from Chavane and Feller 1986)

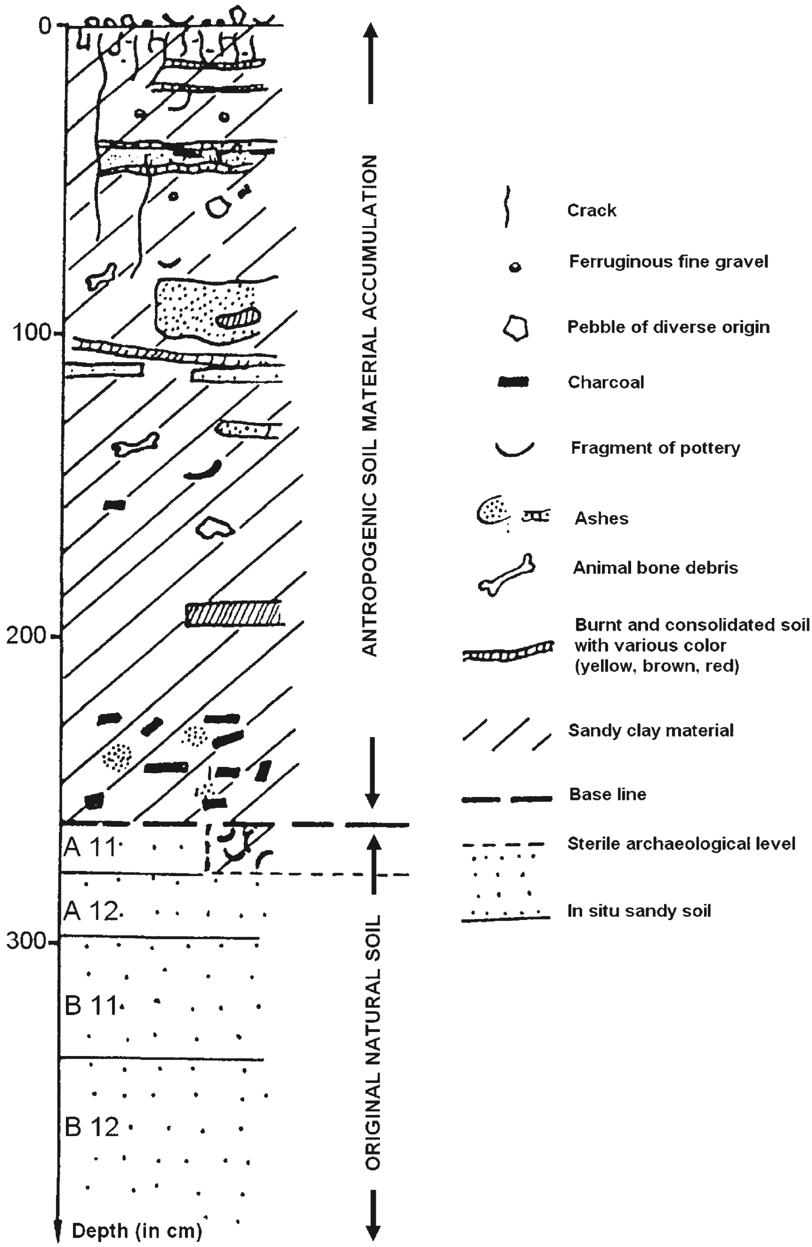

Fig. 20.4 Soil morphology of the OS2 profile (redrawn from Chavane and Feller 1986)

From observations of profiles OS1 to OS8 (including the reference OS5), it is possible to summarize the soil at the archeological site:

i) Two series of horizons can be distinguished: the soil layers largely modified by human activities with archaeological characteristics, and the *in situ* soil horizons identical to soil profile OS5;
ii) The anthropogenic soil profile can be divided into four main soil layers from top to bottom:
   - at the surface: many coarse elements such as pebbles, fine gravels, fragments of pottery, and slag from iron metallurgy;
   - one or two well-structured layers (prismatic to cubic), 10-20 cm thick, that are poorly enriched with coarse elements;
   - a series of soil layers with a clayey-sand to sandy-clay texture, a massive structure, and discontinuous and horizontal lines with burnt earth, ashes and charcoal debris. Soil material is enriched in many coarse elements and exhibit effervescence in the presence of hydrochloric acid (HCl);
   - a lower layer, similar to the previous horizons, but richer in charcoal debris, testifies to a high level of fire-related human activity at the beginning of settlement. This layer exhibits a transition from the *in situ* soil, the morphology of which is similar to the reference soil profile OS5, with the absence of coarse elements, no effervescent reaction with HCl, less compaction, and a coarser texture.
iii) The intermediate layer with the *in situ* soil (called the “base level”) is the level of first human occupation, between the paleosol (OS5 type) and anthropogenic horizons. Generally, it clearly appears in different profiles, sometimes inside of the *in situ* profile itself because of local burying activities such as hearths or inhumations. The transition (baseline) with the *in situ* soil is always very sharp. Finally, the maximum thicknesses of the archaeological layers were 2.6 m. The shape of the baseline is more or less horizontal (see Fig. 20.3), which indicates quite a flat soil surface at the beginning of the human settlement. From the profile features, there was no evidence that the accumulated soil material at the site could have originated from an alluvial, colluvial, or eolian process. It originated only from human activity and transportation. So, where did the soil material come from? Some soil analyses are necessary to answer the question.

20.3.2 Analysis of the Soil Material

Soil analyses were given in detail in Feller et al. (1981) and Chavane and Feller (1986). Here we only focus on granulometry, the particle-size content of the less than 2 mm fraction of the soil. Clay + fine silt (c+fs, 0-20 μm) contents were determined for the different soil layers of the studied soil profiles and are presented in Fig. 20.3. It appears that c+fs contents are about 30 g/100 g soil for the anthropogenic layers, but only 15-20 g/100 g soil for *in situ* soils and OS5 soil profile. Thus, the soil material of the site is definitely enriched in fine materials (0-20 μm). The c+fs contents typically varied from about 20 to 40 g/100 g soil, for soil material originating from the pond near the site, and from ponds at other neighboring villages where "banco", the soil material used to make air-dried bricks and build up the traditional habitations (huts) was extracted

The original soil material, the banco, was drastically transformed by human activity as shown by other soil chemical characteristics such as:

- presence of calcium carbonate in the anthropogenic layers due to burning activity (under semiarid conditions) and inputs of rock carbonates, as contrasted with its absence in the *in situ* soil;
- pH higher than 7.8 in the anthropogenic layers (due to carbonates) and lower than 7.5 in the *in situ* soil;
- higher carbon (mainly due to ashes) and phosphorus content in the anthropogenic layers.

These data corroborate the findings and synthesis of Wells (2004), Wells and Moreno-Cortés (in preparation), and Wells et al. (2000, 2007) on the same subject for a Mesoamerican sites.

At this stage of analysis, the following conclusions can be made. The former human occupation existed on flat land. That occupation presumably began by burning the tree savannah (see section 4.1). Holes intended for cooking, forging, or burials were excavated within the first horizon of *in situ* soil. Chemical analysis demonstrates that the characteristics of the anthropogenic layers resulted from fire-related human activities and left mainly ashes. The new population settled and built durable structures such as huts with banco. The selected materials had an adequate fine texture. When the village grew and gradually took the shape of a mound, old structures fell into ruin and new ones were built up from the banco extracted near the village, leaving artificial ponds at the periphery of the village. The banco soil material, plus ashes, food waste, and other debris from human activities, accumulated and the mound grew. After the abandonment of the site, erosion reduced the height of the mound, and allowed a concentration of human and natural coarse elements located at the surface to fill the ponds that resulted from the original human domestic activities.

20.4 How did Human Activity Transform the Environment and the Landscape of the Region?

20.4.1 Vegetation Changes

Analysis of pollen (palynology) residing at various depths in the soil allows scientists to reconstruct the natural and human-induced vegetation changes which occurred over time at the site. Such analyses were applied to the Ogo's site (Feller et al. 1981). In terms of vegetation changes, three events are most important:

– at the base of the soil profiles (2.8 m depth), pollen indicates a landscape then covered by a tree savannah [dominated by *Lannea* sp. (from Anacardium tree family)] and provides evidence of a more humid climate than the present one.
– at the beginning of the site occupation by humans, an almost complete disappearance of trees is revealed (probably due to deforestation for the increasing iron metallurgy activity), along with an increase in grasses from herbaceous fallows.
– more recently, corresponding to 1.2 m depth in the soil profile, another vegetation clearing appears jointly with the presence of cotton cultivation, confirmed by the presence of tools for cotton spinning, and presence of weeds.

20.4.2 Soil Changes

At the village scale, the environment was drastically changed by slash and burn activities, changes in soil characteristics, and the appearance of pits dug for banco extraction. In addition to deforestation, the expansion of this iron metallurgy civilization a millennium ago led to important environmental changes still noticeable today. The following three examples come from the work of one of the co-authors while he conducted the soil survey of the region and established the soil map at the 1:200,000 scale (Feller 1975):

– Some soils, naturally without carbonates, had some carbonates in the surface horizons. It was only after this pedo-archaeological study that the explanation was found: a past effect of the human activity during the Niger Valley civilization;
– Generally, the slopes of the "Continental Terminal" hills are partly covered by gravels and pebbles resulting from destruction of the iron-pan covering the hills. In some places, iron gravels and pebbles disappeared completely. This was the case for the slopes near the Ogo site; but, when existing in other places, it probably also represents evidence of an ancient "metallurgy village";
– Many small ponds in the region did not belong to the natural hydrographic network. The hypothesis to explain them is that humans built them in the process of habitation construction for the Ogo site.

In conclusion, it is important to focus on the benefits of a cross-disciplinary perspective by pedologists and archaeologists on the soil material. On one hand, the pedologist makes the "inert" soil material of the archaeologist "speak" On the other hand, the lessons from the archaeological site explain the landscape and soilscape of the present time. Therefore, we can arrive at the conclusion that soils keep the historical memories of former human settlements.

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References

Bathily A (1969) La légende du Wagadou *(The legend of Wagadu)*, IFAN Bulletin, Série B (1), Dakar, Senegal.

Bonnel de Mézière A (1920) Recherches de l'emplacement du Ghana (Fouilles à Koumbi et Settah) et sur le site de Tekrour *(Researches of Ghana place and the Tekrour site)*. Imprimerie nationale, Paris, 49 p.

Chavane B (1985) Villages de l'ancien Tekrour *(Villages of the ancient Tekrour)*, Editions Karthala, Paris, 188 p.

Chavane B (1980) Recherches archéologiques sur la moyenne vallée du Sénégal *(Archaeological research on on the middle valley of Senegal river)*. Mémoire de Thèse de 3ème cycle, Université de Provence (LAPMO), 277 p.

Chavane B, Feller C (1986) Construction de l'habitat et activité métallurgique dans un site protohistorique de la moyenne vallée du Sénégal. Effets sur l'environnement actuel *(Habitat building and metallurgy activity in a protohistoric site of the middle valley of Senegal river)*. Cahiers ORSTOM, série Sciences Humaines, 22(1):49–56.

Clerisse H (1931) Les gisements de Tondidiaro (Soudan français) et les tumuli échelonnés le long du Niger de Niafunké au lac Débo *(Tondidiaro's deposits and tumuli along the Niger river from Niafunké to Débo's lake)*. IVème Session internationale d'anthropologie et d'archéologie préhistorique. Paris, pp. 273–278.

Cuoq J (1975) Recueil des sources arabes concernant l'Afrique occidentale *(Collection of Arabian sources concerning West Africa)*. CNRS, Paris, 490 p.

Devisse J (1982) L'apport de l'archéologie à l'histoire de l'Afrique occidentale entre le Vème et le XIIème siècle *(Contribution of archaeology to the West Africa history between the 5th and 7th centuries)*. Comptes rendus des séances de l'Académie des Inscriptions et des Belles Lettres. Janvier 1982, Paris.

Fedoroff N, Courty MA (2005) Les Paléosols et sols archéologiques: mémoire des climats et des hommes *(Paleosols and archaeological soils : memory of climate and mandkind)*. *In* MC Girard, C Walter, JC Remy, J Berthelin, JL Morel (eds.) "Sols et Environnement ». Chap. 7: 151-186. Dunod, Paris.

Feller C (1975) Étude des pâturages naturels du Ferlo Boundou. Étude pédologique *(Study of natural pastures of the Ferlo Boundou. Pedological study)*. ORSTOM , Dakar, 122 p.

Feller C, Medus J, Paycheng C, & Chavane B (1981) Étude pédologique et palynologique d'un site protohistorique de la moyenne vallée du fleuve Sénégal *(Pedological and palynological study of a protohistorical site of the middle valley of Senegal river)*. pp. 235-248. *In* EM Kan Zinderan Bakker, J.A. Coetzee. (eds.) "Palaeœcology of Africa". Vol. 13. Balkema, Rotterdam.

Kaké IB (1974) La civilisation de la boucle du Niger, du XI au XVème siècle *(The Niger valley civilization from 11th to 15th century)*. Revue d'histoire africaine 2: 23–54.

Martin V, Becker C (1974) Répertoire des sites protohistoriques du Senégal et de la Gambie. Doc. ronéo., 93 p., Kaolack (Sénégal).

Miege J Assemien (1966) Bibliographie sur la palynologie. Pollens actuels et fossiles et problèmes paléo botaniques sur en Afrique occidentale et au Sahara *(Bibliograhy on palynology. Modern and fossils pollens and paleobotanical problems in the West Africa and Sahara)*. Bulletin de l'IFAN, série A, 28(1): 401–403.

Niane DT (1957) Recherche sur l'empire du Mali au Moyen *Age (Research on the Mali empire at Middle Age)*. Présence Africaine, Paris, 112 p.

Raimbault M, Sanogo K (1991) Recherches archéologiques au Mali *(Archaeological research in Mali)*. Editions Karthala ed., Paris.

Siré Abbas Sow, Delafosse M, Gaden H (1913) Chronique du Fouta Sénégalais.Column of the Senegalese Fouta. Larose ed., Paris, 328 p.

Thilmans G, Ravisé A (1983) Protohistoire du Sénégal. Recherches archéologiques. Tome 2 : Sintiou-Bara et les sites du fleuve *(Senegal's protohistory. Issue 2: Sintiou-Bara and river sites)*. Mémoire IFAN 91 bis, Dalar, 185 p.

Vuillet Y (1920) L'introduction de la culture du cotonnier en Afrique occidentale (The introduction of cotton cultivation in West Africa). Paris, Larose, Bulletin du Comité d' Études Historiques et Scientifiques de l'Afrique Occidentale Française (B.C.E.H.S.AOF): 52–59.

Wells EC (2004) Investigating Activity Patterns in Prehispanic Plazas: Weak Acid-extraction ICP/AES Analysis of Anthrosols at Classic Period El Coyote, Northwest Honduras. Archaeometry 46(1):67–84.

Wells EC, Moreno-Cortés JE Chimie du sol et archéologie : exemple du Mexique et de l'Amérique Centrale. *(Chemistry and archaeology. Example of Mexico and Central America)*. Étude et Gestion des Sols. *In preparation*.

Wells EC, Novotny C, Hawken JR (2007) Quantitative Modeling of Soil Chemical Data from Inductively Coupled Plasma—Optical Emission Spectroscopy Reveals Evidence for Cooking and Eating in Ancient Mesoamerican Plazas. In Archaeological Chemistry: Analytical Techniques and Archaeological Interpretation, edited by Glascock MD, Speakman RJ, Popelka-Filcoff RS, pp. 210-230. American Chemical Society, Washington, DC.

Wells EC, RE, Hardin PJ, Parnell JJ, Houston SD, Jackson WJ (2000) Chemical Analyses of Ancient Anthrosols in Residential Areas at Piedras Negras, Guatemala. Journal of Archaeological Science 27(5):449–462.

Part V
Soil and Health

Chapter 21
Soils and Geomedicine: Trace Elements

Eiliv Steinnes

Soils can affect human health in various ways. The most obvious influence is through supply of nutrients to plants and further transfer through the food chain to man. However, soils can also adversely affect human health in several ways. The organism can be affected directly by soil ingestion or inhalation of soil particles, or by contact through wounds. Moreover the soils may contain chemical elements and substances, either naturally or through pollution, that are toxic to humans and animals by excessive intake. On the other hand many soils may contain too small quantities of essential elements in plant-available form to provide adequate supply to plants, animals, and in the end, man.

Aspects of soil ingestion are covered in the chapter on geophagy in this volume elsewhere (Abrahams; chapter 23, *this volume*) and will not be discussed here. Also the health effects of soil-borne human pathogens (Bultman et al. 2005; Handschumacher and Schwartz; chapter 22, *this volume*) and inhalation of natural aerosolic mineral dusts (Derbyshire 2005) are considered to be outside the scope of this chapter. Furthermore the chapter does not consider the adverse health effects of soil *pollution* but concentrates on *natural* conditions and processes may affect health through the soil.

21.1 Definition of Geomedicine

Geomedicine is defined as the "influence on ordinary natural processes on the health of humans and animals" (Låg 1990). In addition to influence from geological processes this definition also encompasses the influence on health of factors such as incoming radiation from the sun and interstellar space, climatic conditions, and atmospheric transport of chemical substances. In this chapter such factors will be

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discussed only to the extent that they may affect health by impact on the composition of the soils. Recently interest in the connections between the natural environment and human health has been strongly stimulated through activities in "medical geology" (Selinus et al. 2005). Medical geology deals with essentially the same problems as those covered by the term geomedicine, and this book can be recommended for a more extensive treatise of some of the problems discussed in this chapter. Other reviews dealing with soils and geomedicine are papers by Oliver (1997, 2004) and Deckers and Steinnes (2004).

21.2 Geomedicine in a Historical Context

Ancient Greeks noticed that some human diseases were related to particular geographical areas (Låg 1990). Chinese medical texts dating back to the third century BC also contain several references to relationships between environment and health (Davies et al. 2005). Marco Polo, in his travels in central Asia in the 13th century, described goiter in a local population that he ascribed to a peculiarity of the local water (Davies et al. 2005). The first examples of geomedicine in the modern sense are apparently the health problems in humans and livestock in Iceland due to fluorine emissions from several eruptions from the Hekla volcano during the period 1693-1845 (Låg 1990). Still the influence of these events was mainly of temporary character and probably affected the population and their animals primarily through inhalation of volcanic dust and ingestion of surface deposits on vegetation. The first example of geomedical problems related to more permanent soil conditions was presumably the linking of goitre with iodine deficiency, first proposed in France around 1750 (Låg 1990).

In spite of these historical facts it is surprising to note the limited attention that has been paid to the relation between soils and human health by soil scientists as well as medical professionals (Deckers and Steinnes 2004). In fact the veterinary profession has been much more aware of this kind of relationship. An extensive literature exists on the problems on deficiency and excess of trace elements in animal nutrition (Lewis and Anderson 1983; Mills 1983; Frøslie 1990), and balancing of micronutrient intake according to known requirement has for a long time been a very important aspect in feeding of domestic animals.

21.3 Importance of Soil Factors on Nutrient Uptake in Crops

Although nutrient uptake in plants is not a topic for this chapter *per se* it is discussed briefly here because micronutrient deficiency in plants may limit agriculture production and either directly or indirectly, affect human nutrition (Andersen 2007; Alloway 2005). There are seven recognized essential plant micronutrients: boron, chlorine, manganese, iron, copper, zinc, and molybdenum (Gupta and Gupta 2005).

With the exception of boron these elements are also essential to humans and higher animals.

The plant uptake of these essential elements as well as other elements discussed in this chapter depends on their chemical form in the soil. Moreover it depends on a number factors related to the chemistry, biology, mineralogy, and texture of the soil. The soil pH is particularly important in this respect. Elements such as molybdenum and selenium may be strongly bound in the intermediate pH range (5.5-7.5) but readily plant available in more alkaline soils. On the other hand iron, aluminium, manganese, and very toxic metals such as cadmium and lead are more available in acidic soils. Under reducing conditions iron and manganese oxides may dissolve following reduction of iron (III) and manganese (IV) respectively, and trace elements bound to the oxide minerals may be released.

Sometimes competition between different metals may prevent optimal uptake of a particular nutrient, such as the decreased zinc availability induced by the presence of other metals such as copper, iron, and calcium (Kiekens 1995). Under identical conditions different plant species may take up the same metal from the soil at very different rates (Alloway 2005). Davis and Carlton-Smith (1980) showed that lettuce, spinach, celery, and cabbage tended to accumulate large amounts of cadmium, whereas potato tubers, maize, beans, and peas accumulated only small amounts.

21.4 Microelements and Health

The basic elements in biochemical compounds (carbon, oxygen, hydrogen, nitrogen, phosphorus, sulphur) and the other macro-elements in humans and animals (sodium, magnesium, chlorine, potassium, calcium) are not considered in this chapter. Most of the 90 elements present on earth however occur in the human body at concentrations of 100 mg kg^{-1} or less. A few of these elements are known to have essential functions in the body. For some other elements clinical symptoms have been observed on deficient supply but the exact biochemical function is not known.

A majority of elements however are not known to possess any specific biological function. Most if not all elements are toxic to the human organism if they occur in the food in specific chemical forms and above certain concentrations. This means that for essential elements there exists a certain concentration range representing a safe and adequate intake. Concentrations above or below this range may cause health problems due to deficiency or toxicity. For elements not possessing any biological function there is probably no such range, but just a concentration threshold above which the element becomes toxic. Fig. 21.1 shows the elements that are either main constituents of the human body: macronutrients, essential micronutrients, and suspected (but not yet proven) as essential micronutrients. The rest of the elements are just classified as non-essential, but some of them may be proven essential at some future stage. Data for mean concentrations of the elements in the upper continental crust (Wedepohl 1995) and median levels in surface soils

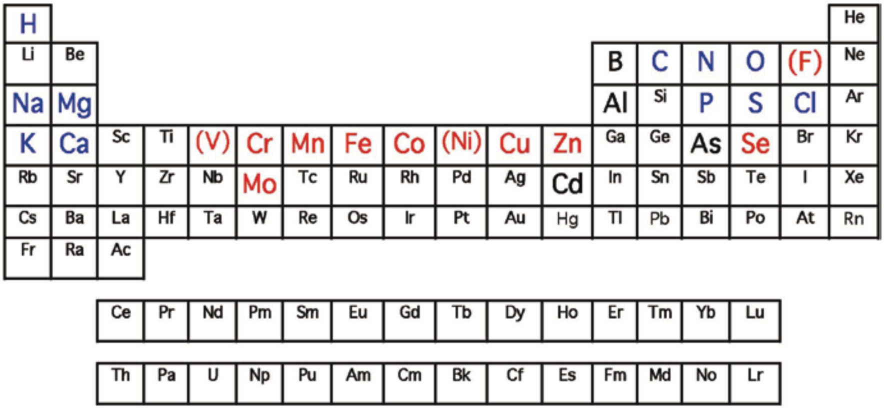

Fig. 21.1 Elements relevant to the present paper: Blue: Major elements in humans and animals, Red: Essential nutrient elements for humans and animals, Red in parentheses: Elements suspected but not proven to be essential, Black bold: Elements discussed in this paper for other reasons (see as color plate following *Index*)

(Bowen 1979) are available in the literature. In most cases the median level in soil is rather similar to the crustal mean.

Some metals are more mobile than others and may be depleted in the surface soil by leaching to deeper layers. On the other hand root uptake in plants and return to the soil surface by decaying plant material may serve to concentrate some elements in the surface soil relative to deeper layers (Goldschmidt 1937, Steinnes and Njåstad 1995), known as “plant pumping”. This is particularly evident for plant nutrients such as potassium, calcium, manganese, and zinc, but may also explain surface enrichment of other elements readily absorbed by some plants such as rubidium, cesium, barium, and cadmium. In some cases supply from the marine environment in the form of sea salt aerosols or volatile organic compounds, or from volcanic activity, may significantly affect the concentrations of elements in the surface soil; the atmospheric supply of iodine and selenium to coastal areas from processes in the ocean (Låg and Steinnes 1974, 1976) and the contamination of agricultural land in Iceland by fluoride from eruptions of the Hekla volcano (Låg 1990) are examples.

In the following text some selected examples of geomedical problems related to trace elements will be briefly discussed. For a more extensive treatment of this subject the reader is referred to Deckers and Steinnes (2004).

21.4.1 Boron

Boron is essential for plant growth but no known function is known in humans. Excessive boron intake may cause symptoms of boron poisoning such as: gastrointestinal disturbances, erythematous skin eruptions, and signs of central nervous system stimulation followed by depression (WHO 1996). Boron is an issue for concern in irrigated agriculture, as high boron levels in irrigation water may cause boron levels in the soil rising to such an extent that crop levels become too high.

21.4.2 Cobalt

Cobalt deficiency is frequently observed in sheep, and also sometimes in cattle. Cobalt deficiency is widespread in New Zealand, Australia, and Great Britain, and also occurs frequently in parts of Scandinavia (Frøslie 1990). Endemic problems in humans related to cobalt are not known, with the exception of a proposed relationship between the cobalt status in the environment and incidence of goiter in Russia, which deserves to be further examined (Smith 1987).

21.4.3 Copper / Molybdenum

In animals both copper deficiency and copper poisoning problems related to natural pastures are quite common, in particular in sheep (Frøslie 1990). In both cases the condition may be influenced by the antagonistic effect on copper exerted by molybdenum. Thus the copper/ molybdenum ratio in the feed is important, in particular with ruminants. Excess of molybdenum can cause copper deficiency at otherwise sufficient copper levels (molybdenosis), whereas poisoning may occur at relatively moderate copper levels if the molybdenum intake is too low.

Interestingly, copper deficiency and/or molybdenosis may have been the reason for a complex disease observed in moose in a region of Sweden affected by acidic precipitation (Frank 1998). The clinical signs of this disease were multiple, including sudden heart failure and osteoporosis, and the reason was thought to be increased pH in soil and water in the moose environment and corresponding changes in plant availability of Cu and Mo. In humans copper deficiency is relatively rare in adults but is involved in several diseases in children, particularly in situations of malnutrition. Geo-medical correlations with copper in human medicine however remain inconclusive so far.

21.4.4 Fluorine

The natural fluorine content shows large geographical variations (Havell et al. 1989), which has a great impact on human and animal health. Deficiency in fluorine has long been linked to dental caries, and fluoride addition to drinking water to augment naturally low fluoride concentrations has been undertaken in some countries (Edmunds and Smedley 2005). The range of safe and adequate intake of fluoride however appears to be very narrow. The WHO (2004) guideline for fluoride in drinking water is 1.5 mgL^{-1}. More than 200 million people worldwide are thought to be drinking water with fluoride in excess of this value, including about 70 million in India and 45 million in China (Edmunds and Smedley 2005). Experience from Sri Lanka, where the incidence of dental fluorosis among children is high, shows that the fluoride exposure may depend not only on the natural fluoride content of the bedrock but also on the climate (Dissanayake, 1991). In spite of the fact that rocks containing fluoride-rich minerals are underlying most of the country, areas in the west with mean annual precipitation above 2000 mm experience few fluoride problems, whereas they are abundant in the eastern and north central regions of the country where the climate is dryer. This difference is apparently due to more extensive leaching of fluoride in the areas of high rainfall.

21.4.5 Iodine

Iodine has long been known as an essential element for humans and mammals, where it is a component of the thyroid hormone thyroxene. Insufficient supply of iodine results in a series of iodine deficiency disorders (IDD), the most common of which is endemic goiter. Iodine deficiency during pre-natal development and the first year of life can result in endemic creatinism, a disease which causes stunted growth and general development along with brain damage. This brain damage may occur when there is no obvious physical effect, and probably represents the most widespread current geomedical problem on Earth with as much as 1.6 billion people at risk (Dissanayake 2005). The areas of the world currently most affected by IDD are largely located in developing countries (Fuge 2005), with large, continuous territories in continental parts of Africa, Asia, and Latin America. Even in some affluent countries of western Europe however it has been suggested that as much as 50-100 million people may be at risk (Delange 1994).

21.4.6 Manganese

There are some epidemiological studies linking manganese deficiency to human health problems. Marjanen and Soini (1972) found a strong negative linear relationship between soil manganese content and cancer incidence (all types of cancer included) in a study comparing 179 parishes in Finland. Several studies in South Africa and Iran seem to link the incidence of oesophagus cancer with manganese deficiency (Deckers and Steinnes 2004). Another health problem located to South Africa, the Mseleni joint disease, has also been associated with manganese deficiency (Fincham et al. 1981). Presumably much work still needs to be done to elucidate the geomedical role of manganese.

21.4.7 Selenium

Selenium concentrations in soils show extreme geographical variations. This along with the narrow range of safe and adequate intake means that geomedical problems have been identified in humans and livestock both in relation to selenium deficiency and excess. In USA, for instance, there are large areas in the Great Plains where selenium-rich soils are present and some plants may reach levels toxic to livestock. Wheat from these areas has for a long time been the main source of flour for bread baking in Norway, which is assumed to be a main reason for the good selenium status in the Norwegian population (Meltzer et al. 1993). On the other hand the selenium-deficiency related disorder white muscle disease in animals has been commonly observed in several states of the northeast as well as the northwest USA (Muth and Allaway 1963). China is another country where soils show extremely variable selenium contents geographically (Fordyce 2005), and where significant geomedical problems are evident both in low-selenium and high-selenium districts.

The selenium status varies considerably among different populations in the developed world, depending on the composition of the diet. Finland was among the countries with low selenium status in the population around 1970. At the same time the incidence of cardiovascular disease in Finland was among the highest in the world, and it was hypothesized that low selenium might be one of the reasons. A large-scale experiment adding selenium to fertilizer was therefore initiated. This led to increased selenium content in the bread grain, and eventually almost a doubling of serum selenium concentration in the population (Hartikainen, 2005).

In developing countries where many people live from locally produced food, some very serious health problems due to selenium deficiency have been described. In China geographically widespread endemic diseases such as the Kashin-Beck disease, an endemic osteoarthropathy resulting in chronic arthritis and deformity of the joints, and the Keshan disease, a cardiomyopathy whereby the heart muscle is damaged, have both been shown to be associated with selenium deficiency (Tan and Hou, 1989). The Keshan disease was most prevalent in eroded hills where regosols and leptosols dominated the soil landscape. Rice seemed to concentrate Se more efficiently from the soil than other local food crops, and people on a rich rice diet showed less selenium deficiency symptoms that people with other eating habits. Selenium supplementation to the affected populations has now reduced these health problems substantially.

There are similarities between the Kashin-Beck disease and the iodine-deficiency disorder creatinism (Fordyce 2005). In addition the recent establishment of the role of a selenium-containing enzyme, iodothyronine deiodonase, in thyroid function means that selenium deficiency is now being examined in relation to iodine deficiency disorders in a more general sense. Concordant selenium and iodine deficiency has been suggested to account for the high incidence of creatinism in some countries of Central Africa (Kohrle 1999) and selenium deficiency has been demonstrated in populations suffering from iodine deficiency disorders in Sri Lanka (Fordyce et al. 2000).

Låg and Steinnes (1974, 1978) found that selenium in forest soils of Norway decreased regularly with distance from the coast from around 1.0 mg kg^{-1} near the coast to <0.2 mg kg^{-1} in areas shielded from marine influence, suggesting that the ocean may be a significant source of selenium to coastal terrestrial areas. This seemed surprising considering the extremely low content of selenium in seawater (0.1 μg L^{-1}). Cutter and Bruland (1984) however showed that organic selenide made up around 80 % of total dissolved selenium in ocean surface waters. Mosher et al. (1987) observed anomalous enrichment of selenium in marine aerosols, and found that the concentration was related to primary productivity in the sea. Cooke and Bruland (1987) studied the speciation of dissolved selenium in surface water, and observed the formation of volatile organo-selenium compounds, mainly dimethyl selenide, $(CH_3)_2Se$. On that basis they hypothesized that out-gassing of dimethyl selenide may be an important removal mechanism for dissolved selenium from aquatic systems. Thus it seems that biologically driven transport from the ocean to continental areas naturally low in selenium may be a significant geomedical factor.

21.4.8 Zinc

Zinc is one of the most important essential trace elements in human nutrition, being essential for the functioning of a great number of enzymes. Examples of the essential role of zinc are (a) its utmost importance during pregnancy, pregnant women requiring much more zinc in their diet than otherwise (Jameson 1982), (b) its importance for brain growth in infants (Prohaska 1982), and (c) its extreme importance in immunocompetence (Nauss and Newberne 1982). Red meat is a particularly good source of zinc nutrition, and whole grains, pulses and unpolished rice are also important sources of daily zinc intake (Oliver 1997).

Large areas of the world have soils that are unable to supply staple crops, such as rice, maize, and wheat with sufficient zinc. According to Alloway (2005) zinc deficiency is the most widespread essential trace element deficiency in the world. In several countries large proportions of the arable soils are affected by zinc deficiency, such as in India where around 45% of soils are deficient in zinc (Singh 2001). Zinc deficiency was first observed and reported among rural inhabitants of the Middle East in the early 1960’s (Nauss and Newberne 1982). During the mid-1960’s zinc deficiencies became such a big problem in the maize growing areas of South Africa that zinc was included in commercial NPK fertilizers and super phosphate, a practice which is still being followed (Deckers and Steinnes 2004). Dietary zinc deficiencies are also found in industrialized countries such as USA (Nauss and Newberne 1982) and Sweden (Abdulla et al. 1982). Moderate zinc deficiency has been cited as a major etiological factor in the adolescent nutritional dwarfism syndrome in the Middle East, the cardinal features of which are severe delay of sexual maturation and dwarfism (Hambidge et al. 1987). Phytate intake is assumed to adversely affect zinc metabolism, and consumption of phytate-rich bread has been suggested as a reason for the above problem (Reinhold et al. 1973).

Other studies however have failed to demonstrate a significant inhibitory effect of phytate on zinc uptake (Hambidge et al. 1987).

21.5 Need for Future Geomedical Studies

At the most recent international conference on biogeochemistry of trace elements (Zhu et al. 2007) more than 400 papers were presented, a large part of which related to soils. An overwhelming part of the papers however dealt with toxic trace elements of pollution origin and measures to prevent human exposure to these elements. The papers at this conference dealing with geomedical issues can probably be counted on one hand. This may seem rather disappointing considering the great need for further research related to the natural occurrence of trace elements. Research on soil pollution may be important *per se*, but the problems in the world related to imbalances in the supply of naturally occurring elements to humans and livestock are probably much greater than those related to soil pollution.

Because of their greater reliance on locally grown foodstuffs, many studies linking human health and the status of essential elements in soil have been done in less developed nations. However, geomedical problems do exist also in developed countries, in spite of the more balanced diet available in these countries. One particular development that may be followed closely in this respect is the rapid development of organic farming (Steinnes 2004). Organic farming aims at self-sufficiency of nutrients both with respect to forage for animals and fertilizers, and in its most extreme form neither synthetic fertilizers nor commercial feeding stuffs are accepted. Recycling of organic material in combination with the natural composition of the soil is supposed to provide sufficient amounts of nutrients to plants and animals. However, results from comparative studies (Öborn 2004) indicate that negative balances may develop in organic farming systems both with respect to macronutrients (*e.g.* K, P) and essential trace elements (*e.g.* Zn, Se). If the farmers and their advisers have insufficient knowledge about the local geochemical conditions and the demands for micronutrients in plants and animals, they may face deficiency-related diseases in crops and animals, reduced agricultural production, and inferior product quality. The practices accepted for use in organic farming should be able to account for these problems by allowing some supplement of trace elements in feed and application *e.g.* of K fertilizer in cases where the natural supply is shown to be insufficient.

References

Abdulla M, Svensson S, Nordén A, Öckerman PA (1982) The dietary intake of trace elements in Sweden. In: Gawthorne JM, Howell, JM, White CL (eds) Trace element metabolism in man and animals, Springer, Berlin, Germany, 14–17.

Abrahams PW (2009) "Earth eaters": ancient and modern perspectives on human geophagy. In: Landa E, Feller C (eds) Soil and Culture; Springer, ISBN: 978-90-481-2959-1.

Alloway BJ (2005) Bioavailability of elements in soil. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P (eds) Essentials of medical geology - Impacts of the natural environment on public health, Elsevier - Academic Press, London, UK, 347-372.

Andersen P (2007) A review of micronutrient problems in the cultivated soil of Nepal. Mountain Research and Development 27: 331–335.

Bowen HJM (1979) Environmental chemistry of the elements. Academic Press, London, UK.

Bultman MW, Fisher FS, Pappagianis D (2005) The ecology of soil-borne human pathogens. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P (eds) Essentials of medical geology - Impacts of the natural environment on public health, Elsevier - Academic Press, London, UK, 481–511.

Cooke TD, Bruland KW (1987) Aquatic chemistry of selenium: Evidence of biomethylation. Environmental Science and Technology 21: 1214–1219.

Cutter GA, Bruland KW (1984) The marine biogeochemistry of selenium: A re-evaluation. Limnology and Oceanography 29: 1179–1192.

Davies BE, Bowman C, Davies TC, Selinus O (2005) Medical geology: Perspectives and prospects. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P (eds) Essentials of medical geology - Impacts of the natural environment on public health, Elsevier - Academic Press, London, UK, 459–480.

Davis RD, Carlton-Smith C (1980) Crops as indicators of the significance of contamination of soils by heavy metals. Technical Report No 140, Water Research Centre, Stevenage, UK.

Deckers J, Steinnes E (2004) State of the art on soil-related geo-medical issues in the world. In: Sparks DJ (ed) Advances in Agronomy 84: 1-35. Elsevier, Doordrecht, The Netherlands.

Delange F (1994) The disorders induced by iodine deficiency. Thyroid 4: 107–128.

Dissanayake CB (1991) The fluoride problem in the groundwater of Sri Lanka - environmental management and health. International Journal of Environmental Studies 38: 137–156.

Dissanayake C (2005) Of stones and health: medical geology in Sri Lanka. Science 309: 883–885.

Edmunds M, Smedley, P (2005) Fluoride in natural waters. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P (eds) Essentials of medical geology - Impacts of the natural environment on public health, Elsevier - Academic Press, London, UK, 301-329.

Fincham JE, Van Rensburg SJ, Marasas, WFO (1981) Mseleni joint disease - A manganese deficiency? South African Medical Journal 60: 445–447.

Fordyce FM, Johnson CC, Navaratne URB, Appleton JD, Dissanayake CB (2000) Selenium and iodine in soil, rice and drinking water in relation to endemic goiter in Sri Lanka. Science of The Total Environment 263: 127–142.

Fordyce F (2005) Selenium deficiency and toxicity in the environment. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P (eds) Essentials of medical geology - Impacts of the natural environment on public health, Elsevier - Academic Press, London, UK, 373–415.

Frank A (1998) “Mysterious” moose disease in Sweden. Similarities to copper deficiency and/or molybdenosis in cattle and sheep. Biochemical background of clinical signs and organ lesions. Science of The Total Environment 209: 17-26.

Frøslie A (1990) Problems on deficiency and excess of minerals in animal nutrition. In: Låg J (ed) Geomedicine, CRC Press, Boca Raton, Florida, 37–60.

Fuge R (2005) Soils and iodine deficiency. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P (eds) Essentials of medical geology - Impacts of the natural environment on public health, Elsevier - Academic Press, London, UK, 417–433.

Goldschmidt VM (1937) The principles of distributions of elements in minerals and rocks. Journal of the Chemical Society, London: 655–673.

Gupta UC, Gupta SC (2005) Future trends and requirements in micronutrient research. Communications in Soil Science and Plant Analysis 36: 33–45.

Hambidge KM, Casey CE, Krebs NF (1987) Zinc. In: In: Mertz W (ed) Trace elements in human and animal nutrition - Fifth edition, Volume 2. Academic Press, San Diego, USA, 1–137.

Handschumacher P, Schwartz D (2009) Do pedo-epidemiological systems exist? . In: Landa E, Feller C (eds) Soil and Culture; Springer, ISBN: 978-90-481-2959-1.

Hartikainen H (2005) Biogeochemistry of selenium and its impact on food chain quality and human health. Journal of Trace Elements in Medicine and Biology 18: 309–318.

Havell RJ, Calloway DH, Gussow JD, Mertz W, Nesheim MC (1989) Recommended Dietary Allowances, 10th Edition. National Academic Press, Washington D.C., USA, p. 285.

Jameson S (1982) Zinc nutrition and pregnancy in humans. In: Gawthorne JM, Howell, JM, White CL (eds) Trace element metabolism in man and animals, Springer, Berlin, Germany, 243–248.

Karim MR, Ahmad SA, Shahidullah M (2007) Nutritional status of children aged 5-14 years in selected arsenic exposed and non-exposed areas in Bangladesh. In: Zhu Y, Kiekens L (1995) Zinc. In: Alloway BJ (ed) Heavy metals in soils, 2nd ed, Blackie Academic and Professional, Glasgow, UK, 284–305.

Kohrle J (1999) The trace element selenium and the thyroid gland. Biochimie 81: 527–533.

Låg J, ed (1990) Geomedicine. CRC Press, Boca Raton, Florida.

Låg J, Steinnes E (1974) Soil selenium in relation to precipitation. Ambio 3: 237–238.

Låg J, Steinnes E (1976) Regional distribution of halogens in Norwegian forest soils. Geoderma 16: 317–325.

Låg J, Steinnes E (1978) Regional distribution of selenium and arsenic in humus layers of Norwegian forest soils. Geoderma 20: 3–14.

Lepp N, Naidu R, eds (2007) Biogeochemistry of trace elements: Environmental protection, remediation and human health. Tsinghua University Press, Beijing.

Lewis G, Anderson PH (1983). The nature of trace element problems: delineating the field problem. In: Suttle NF, Gunn RG, Allen WM, Linklater KA, Wiener G (eds) Trace Elements in Animal Production and Veterinary Practice, Chapter 1.2. British Society of Animal Production, Edinburgh, UK.

Marjanen H, Soini S (1972) Possible relationship between nutrient imbalances, especially manganese deficiency, and susceptibility to cancer in Finland. Annales Agricultura Fennica 11: 391–406.

Meltzer HM, Bibow K, Paulsen IT, Mundal HH, Norheim G, Holm H (1993) Different bioavailability in humans of wheat and fish selenium as measured by blood-platelet response to increased dietary Se. Biological Trace Element Research 36: 229–241.

Mills CF (1983) The physiological and pathological basis of trace element deficiency disease. In: Suttle NF, Gunn RG, Allen WM, Linklater KA, Wiener G (eds) Trace Elements in Animal Production and Veterinary Practice, Chapter 1.1. British Society of Animal Production, Edinburgh, UK.

Mosher BW, Duce RA, Prospero JM, Savoie DL (1987) Atmospheric selenium: Geographical distribution and ocean to atmosphere flux in the Pacific. Journal of Geophysical Research 92: 13277–13287.

Muth OH, Allaway WH (1963) The relationship of white muscle disease to the distribution of naturally occurring selenium. Journal of The American Veterinary Medicine Association 142: 1379–1384.

Nauss KM, Newberne PM (1982) Trace elements and immunocompetence. In: Gawthorne JM, Howell, JM, White CL (eds) Trace element metabolism in man and animals, Springer, Berlin, Germany, 603-612.

Öborn I (2004) Do we risk nutrient imbalances in organic dairy production? In: Steinnes E (ed) Geomedical aspects of organic farming, The Norwegian Academy of Science and Letters, Oslo, Norway, 71–82.

Oliver MA (1997) Soil and human health: a review. European Journal of Soil Science 48: 573-592.

Oliver MA (2004) Soil and human health: Geomedical aspects in relation to agriculture. In: Steinnes E (ed) Geomedical aspects of organic farming, The Norwegian Academy of Science and Letters, Oslo, Norway, 16–32.

Prohaska JR (1982) Changes in brain enzymes accompanying deficiencies of the trace elements, copper, selenium, or zinc. In: Gawthorne JM, Howell, JM, White CL (eds) Trace element metabolism in man and animals, Springer, Berlin, Germany, 275–282.

Reinhold JG, Lahimgarzadeh A, Nasr K, Hedayati H (1973) Effects of purified phytate-rich bread upon metabolism of zinc, calcium, phosphorus, and nitrogen in man. Lancet 1 (7798): 283–288.

Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P, eds (2005) Essentials of medical geology - Impacts of the natural environment on public health. Elsevier - Academic Press, London, UK.

Singh MV (2001) Evaluation of current micronutrient stocks in different agro-ecological zones of India for sustainable crop production. Fertilizer News (Dehli) 46(2): 25–42.

Smedley PM, Kinniburgh DG (2005) Arsenic in groundwater and the environment. In: Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lundh U, Smedley P, (eds) Essentials of medical geology - Impacts of the natural environment on public health. Elsevier - Academic Press, London, UK, 263–299.

Steinnes E, ed (2004) Geomedical aspects of organic farming. The Norwegian Academy of Science and Letters, Oslo, Norway.

Steinnes E, Njåstad O (1995) Enrichment of metals in the organic surface layer of natural soils: identification of contributions from different sources. The Analyst 120: 1479–1483.

Tan J, Hou S (1989) Environmental selenium and health problems in China. In: Tan J et al. (eds) Environmental selenium and health, People Health Press, Beijing, 219–234.

Wedepohl KH (1995) The composition of the continental crust. Geochimica et Cosmochimica Acta 59: 1217–1232.

WHO (1996) Trace Elements in Human Nutrition and Health. World Health Organization, Geneva.

WHO (2004) Guidelines for Drinking-Water Quality, 3rd edition. World Health Organization, Geneva.

Yoshida S, Muramatsu Y (1995) Determination of organic, inorganic, and particulate iodine in the coastal atmosphere of Japan. Journal of Radioanalytical and Nuclear Chemistry - Articles 196: 295–302.

Zhu Y, Lepp N, Naidu R, eds (2007) Biogeochemistry of trace elements: Environmental protection, remediation and human health. Tsinghua University Press, Beijing, China.

Chapter 22
Do Pedo-Epidemiological Systems Exist?

Pascal Handschumacher and Dominique Schwartz

22.1 Introduction

Human health is a field for specialists but also a universal concern. The increase in information and analysis in the various kinds of media make it possible for every one to form an opinion, right or wrong, on the health hazards that we will incur. In parallel, progress on experimental and investigative techniques, and dramatic increases in the masses of knowledge in the biological and medical disciplines has lead to an increasing splitting of research, to the detriment of the understanding on the overall pathogenic systems. This double situation very often leads to a division of simple relations between risk factors and medical impact, largely subdivided by disciplinary approaches The reality is that the emergence and/or the space-time variability of health hazards can be seldom expressed in simple relations of cause and effect.

In France, during the period 1970–1980, H. Picheral, health geography Professor at the Montpellier University forged a new concept—the pathogenic system. For him, disease is the result of multiple interactions and reveals the physical and social structure of space (Picheral 1983). The initial object of research in health geography is thus the spatial, social and temporal variability of the disease and its factors—something that it has in common with epidemiology. But the final objective is to understand how the spatial heterogeneity of disease risk came into being, and how pathogenic systems function. Picheral distinguished four principal pathogenic systems:

- the eco-pathogenic system (where the environment plays an important role; *e.g.*, African Human Trypanosomiasis and vegetation),
- the techno-pathogenic system (where technical and industrial development dominates in the explanation of the risk; *e.g.*, cancer and dioxins),

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- the socio-pathogenic system (dominated by behaviour; e.g., alcoholism), and
- the genetical pathogenic system (*e.g.*, haemophilia).

The questions forming the framework of this article are thus:

- Within the large pathogenic system groups, can one identify pedo-epidemiologic systems dominated by the role of the soils in the explanation of health hazard variability, or at least in which the soils have a considerable role?
- Do pedo-epidemiologic systems exist whose impact can be reduced or thwarted by a preventive or curative action on the soils?

22.2 Soils and Exposure to the Health Hazards: a Brief Survey

Many publications have surveyed the relation between soils and health (Oliver 1997; Abrahams 2002; Sanchez 2002; De Silva 2003; Brooker 2006; Lal 2007).

Thus, the soil can be perceived as a mixture of components some of whose elements are potentially toxic for the man by inhalation, ingestion, or direct contact. Radon, lead, chromium, aluminum, arsenic, cadmium, and mercury are frequently evoked. Although the potential toxicity of the elements mentioned is not questioned, a sharp debate exists between experts to determine the thresholds and the acceptable concentrations in human and animal health (Glorennec 2005) (see Chapter 21 by Steinnes, *this volume*). In such discussion, these thresholds should be based on pedological conditions. The acidity of the soils, for example, is a crucial factor of insolubilization or availability of trace elements and aluminum (*e.g.*, Cambier 1994). In this case, the soil plays an active role in the relation between man and health.

In other cases, its role is passive. The soil is then a simple material support. It can be the medium in which parasites live; the pathway of exposure may be ingestion of soil adhering to food in the case of many intestinal parasitic diseases (Oliver 1997), or direct contact between the skin and the contaminated soil, as in the case of myiasis (Zumpt 1965). Myiasis is a class of diseases related to the parasitic development of dipterous larvae in living tissues (or in some cases, on the wounds of animals). Others are parasites of natural openings such as the nostrils, or of digestive tract. In the case of the Cayor worm (*Cordylobia anthropophaga)*, the fly lays eggs on wet ground or wet clothing, and the larva passes to the skin that comes into contact with this substrate. The larva develop in the skin before transformation into the adult fly. Myiasis is frequent in the tropical zone ("Cayor" is the name of a Senegalese district along the Atlantic coast) and affects the humans as well as other animals (Devienne 2004)). Most often, it needs wet, sandy soils.

The larbish or creeping disease is another example of risk related to a direct contact between the skin and contaminated ground. It can also be the medium of transmission of the bacteria causing tetanus (*Clostridium tetani*) that can invade the body when soil is introduced with puncture wounds (Sutter 1998)—introduction here by soil adhering to the larva.

Larbish (Chabasse 1995) is a “cutaneous larva migrans” syndrome (also called “creeping eruption”), caused by the active penetration of human skin by the larval stage of a parasitic organism shed by a lower-order animal. Most often, the species involved in this syndrome are larva of nematodes (*Ancylostoma braziliense* or *Ancylostom braziliense* in most tropical and sub-tropical countries, *A. ceylanicum* in south-east Asia, and *Uncinaria stenocephala* in temperate climate regions). These parasites are common in the digestive system of cats and dogs. The parasite eggs will be released in the environment with the stools of these animals. If they encounter sandy and shaded soils, and if temperature and humidity are high, eggs will then hatch out and contamination will be possible. Human contamination will appear with a simple direct contact between skin and soil contaminated with animal stools. But it is a specific animal disease and in the case of human beings, the parasite can’t develop for a complete cycle. So the larva cannot leave the skin and will cause the symptoms of larbish—a red, raised network of tunnels on the surface of the skin caused by the burrowing of larva. Hands, feet and buttocks are most commonly affected, and severe itching is symptomatic of the condition. The area of distribution of this disease is mainly the tropical subtropical area, and in particular, the coastal regions because of higher degree of humidity. One of the authors was infected by larbish while studying podzols on the coastal region of the Republic of the Congo (Congo Brazzaville).

Soil can also serve as a reservoir for other bacteria waiting for a receiving host that will be at the origin of a cycle of transmission. Thus is evoked the possibility of the inter-epidemic maintenance of plague (“black death”) thanks to the survival of the causative bacterium *Yersinia pestis* in certain soils (Karimi 1963; Drancourt et al. 2006). Rats and mice, the natural hosts of the plague, are susceptible to the disease and their populations are decimated by it at the time of the epidemic events. So one of the crucial questions for public health specialists is how the bacillus population is maintained in the environment, apart from any reintroduction. Laboratory studies suggest that the bacillus can survive in the soil for long periods, but this has yet to be demonstrated in the environment. A digging animal, such as a rodent, could then exhume the bacillus and contaminate itself. In another digging scenario, soil particles can be dispersed as an aerosol, causing a plague outbreak.

Soils can also play important roles in other vector-transmitted diseases. Thus, *Glossina palpalis*, the TseTse fly responsible for the transmission of the African human trypanosomiasis in West Africa, develops starting from an egg deposited by an adult in the soil. The soil is the essential medium to the maintenance of the epidemiologic chain (Laveissiére et al. 2000). In the forest, the favourable soils for TseTse larvae are typically black soils, high in organic matter. High clay content and very wet conditions are unfavorable environmental conditions for the larva because they permit development of predators such as termites (clay soils) or fungi (wet conditions).

In Western Africa, the causative agent of sleeping sickness is *Trypanosoma brucei gambiense (T. rhodesiense in East Africa)*, a protozoan reproducing in the blood of the human host. The introduction of only one parasite into a man can lead to death in a few years, even a few months. Humans can be infected with this protozoan by the bite of the TseTse fly (*Glossina* spp.). In West Africa, only *Glossina palpalis* and *Glossina tuchinoïdes* are vectors of sleeping sickness. The TseTse fly is exclusively African, occurring between the 15° northern degree of latitude and the 20° parallel south. These insects need a shady and wet environment to live, and not too high temperature (forests, cocoa or coffee crops in Sudanese areas; all botanical types in forest areas, with a preference for the skirts of forest and villages, as well as shady water spots). The only recognized reservoir of the parasite is man.

At another level, mechanical properties of soils can also be important. Windborne soil particles can play an important role in the processes leading to infectious diseases in humans. In West Africa, the incidence of meningitis, caused by the bacterium *Neisseria meningitides* (Lapeyssonie 1963), and ocular affections such as keratitis and trachoma (Schemann 2007; Reinhards J 1970) are linked to the Harmattan, the dry and dusty West African trade wind that blows from the Sahara south to the Gulf of Guinea from December to March. The geographical location (a Sahelian and Sudanian belt) of these diseases can be explained by the role of the wind and the sandy soils, whose combined effect causes physical damage to mucous tissues, facilitating infection with these pathogenic agents. Sandy soils play here only a mechanical role, causing microscopic wounds. But the main risk factors are not linked to soils characteristics, but to social conditions, in particular water availability and hygiene practices.

Trachoma is the leading avoidable cause of blindness in the world. It is a *keratoconjunctivitis* (inflammation of the cornea and conjunctiva) due to an infection by *Chlamydia trachomatis*. The infection and irritation associated with it can evolve to *trichiasis* (ingrown eyelashes) in the second stage of this disease, causing corneal wounds that lead to blindness. The disease affects an estimated 84 million people worldwide; 6 to 7 million are at the ultimate stage, and 1 to 3 million are completely blind (Wright et al. 2008). The disease-causing agent is transported mechanically by flies, which mass around the eyes, thus making the infection possible.

We have focused above on infectious diseases. But clearly soil fertility is another key issue, with its clear link to crop yields and malnutrition (see chapter 21 by Steinnes, *this volume*).

Soil ingestion is developed in another chapter (see chapter 23 by Abrahams, *this volume*), but we note that soil consumption is at the heart of many cultural practices, including the ingestion of soils for therapeutic, magic or religious reasons (Young et al. 2007). But in the recent food crisis in Haiti (*Newspaper le Monde*, “A main food crisis will come” by F. Lemaître, 02 August 2008 edition), it was sad to see clay soil used as a “normal” food ingredient, the poorest people mixing it with a small quantity of corn or wheat flour for preparing a kind of bread.

Clays are widely used by the pharmaceutical and the cosmetics industries. They have been used for a long time to allegedly prevent the ageing of the skin and the development of wrinkles. Masseurs use hot mud plasters for cosmetic and therapeutic purposes. Indeed, recent studies at Arizona State University showed that some non-soil clays had antibacterial properties. A clay from the French Massif Central has been used successfully against the MRSA [methicillin-resistant *Staphylococcus aureus*] (Williams 2007). But limiting the soil-related health hazards only to these direct relationships would reduce the complexity of the question and limit many actions in terms of prevention and combating disease. In the case of onchocerciasis (“river blindness”), the medical impact of the soils is indirect but nevertheless insidious.

Onchocerciasis is a parasitic disease in humans, associated with the nematode *Onchocerca volvulus*, The larva of *O. volvulus* can invade the eyes causing serious and irreversible ocular disorders whose ultimate stage is blindness. The vector of this parasitic disease is a small biting midge (black fly) of the *simuliidae* family. At the time a blood meal is taken on a sick person, the female introduces larvae of which some (after migration and changes in the midge’s body) will gain again the oral parts. At the time of a later blood meal, these larvae will then be inoculated into another person. These parasite larvae will then transform into adults able to produce millions of new larvae, the pathogenic stage of the parasite. The stage of the parasite in the vector is essential. The distribution of this cumulative effect is thus dependent on that of the vectors. They develop only in rivers where an acceleration of the current produces a greater water oxygenation, essential to the development of the midge’s larvae. These places of reproduction can thus be easily localized, facilitating the fight against the vector.

Onchocerciasis is a parasitic disease in humans. A key component of the disease cycle is the black fly, which by successive bites transmits the parasitic worm *Onchocerca volvulus* from infected persons to healthy persons. In this disease, the gravity of the symptoms depends directly on the number of infecting punctures received by a person per day. This index varies according to the vectorial density (*i.e.*, how many black flies are present) and from the conditions of man/vector contact. For its larval development, the fly needs well-oxygenated water, available in particular in the rapids of the great Sudanese rivers; nations in Africa where the disease is prevalent include Burkina Faso, Mali, Ghana, Guinea Konakry, Ivory Coast, and Sudan. This ecological requirement makes the river valleys of the region places of high risk for river blindness. However in this bioclimatic zone, these valleys have the most fertile soils, inevitably attracting the farmers and their families to a vector-rich environment. So rich soils play an indirect role in that disease by attracting populations to high-risk areas (Hervouët and Prost 1979). One could multiply the examples, but the objective is not so much to draw up a list of all possible risks, but to evaluate the weight that the soil component takes in some of the pathogenic systems mentioned above.

22.3 Soil and Pathogenic System

Following H. Picheral (1983) and his pathogenic system, disease is not just cause and effect, but rather is a complex system with multiple interacting factors and the possibility of feedback loops. According to this concept, that underlies most current studies of health geography in the French-speaking scientific sphere, soils can be understood only as one contributing element of the whole. Let us take the example of a hypothetical pedologist…

Consider the case of pedologist Professor Pierre Solterre who traverses the world in order to enrich his knowledge of the structure and function of certain types of soils for which he is a recognized authority. Using a spade, Professor Solterre starts to dig a pit in order to examine the soil profile. The spade hits a large tree root, which he cuts with a knife and removes by hand. He pricks himself slightly with a splinter while pulling out the root. Tetanus introduced silently on this occasion begins its work, without Professor Solterre noticing any symptoms. Continuing his work, soil starts to stick to his hands and feet, and larbish settles, ready to draw a pretty reddish network under the skin that will itch during long weeks. Engrossed in his work, he does not see the centipede that stings him and injects its venom. The sting is painful and he flails his arms, striking the powdery and unstable walls of the pit—the collapse of one wall sends up a cloud of dust that makes him cough. Rubbing his mouth with his dirty hands, the Professor swallows, without realizing it, perhaps 100 eggs of parasitic worms (helminths) that will hatch and continue their life cycle in his body. The mishaps of our dear Professor Solterre will not, however, prove fatal for him. Indeed, before leaving on his mission, Professor Solterre had the good idea to renew his tetanus vaccination. Moreover, his financial means has enabled him to assemble a large, expert team who could extract him from the crumbling pit. Lastly, on his return to France, he could consult a physician specializing in tropical medicine to treat his larbish and helminths.

This caricature illustrates some of the health hazards faced by an individual in his/her contacts with the soil. It also shows that the exposure will result in a pathological condition only under particular circumstances, and not according to an immediate and obligatory relation of cause and effect. One of the frequent practices in the analysis of the health hazards is to isolate an element from the system to which it belongs and to seek correlations, even causalities, by neglecting the whole system, as well as the interactions and feedbacks which affect it. Rather than adopt this approach, we will analyze the links within a given soil-related pathogenic system, and look for places where it may be possible to decrease the health hazard.

If one again examines the example of Professor Solterre, the health hazards related to the soil depends on several elements that lead to the expression of the disease:

(1) initially, the nature of the soil and its capacity to contain infectious, parasitic or toxic agents,
(2) then, the contact between the human and this soil by pathways and frequencies which make the exposure possible, and
(3) finally, the ability of public health measures to reduce or prevent negative health effects.

According to specificities of each one of these three mitigating factors, the health hazard will be expressed differently within the population, in space and in time.

Ascariasis afflicts hundreds of million individuals in the world. It represents an emblematic example of the soil-related diseases because of the ecology of the causative roundworm, which lives and reproduces in the soil. However, in their treatise *Medical Geography*, Meade and Earickson (2000) show that the variations of the exposure are due, as much if not more, to the cultural environment, than to the physical environment. Indeed, if the cycle of infection is dependent on an essential stage in the soil for the worm, the human contamination will not be homogeneous because of different life styles in the same space. Within a given community, not all individuals will be infected in the same way and same intensity. Controlling variables with respect to infection include facilities and practices for disposal of human wastes, dietary habits, type of flooring in homes, vegetation cover around homes, and soil wetness. The nature of the soils is only one, and not the dominant factor, in determining the risk of exposure to the Ascaris worm.

Research work conducted in the city of Pikine, a vast suburb of Dakar, Senegal, showed the heterogeneity of the incidence in the population of three important parasitic diseases—Giardia, Ankylostomiasis (hookorm infection), and Ascariasis—on the scale of the city (Salem 1998).

Giardia is a protozoan parasitic disease. Three species exist but only *G. lamblia* infect humans (Heresi 2000). It causes diarrhea and interferes with the absorption of fat from the intestine (malabsorption). The contamination of the soil is due to a form of the parasite—cysts—contained in stools. They can remain for a long time in humid soils, and for 2–3 month in fresh water. Human infection occurs by ingestion of cysts, associated with poor sanitation and hygiene.

Hookworm infection is due to parasites from the genera *Necator* and *Ancylostoma* that colonize the upper part of the human small intestine. These soil-transmitted helminth infections are widely distributed throughout the tropics and subtropics. Climate is an important determinant of transmission of these infections, with adequate moisture and warm temperature essential for larval development in the soil. Equally important determinants are poverty, inadequate water supplies, and sanitation. In such conditions, a variety of pathogenic soil-transmitted helminthic species may be present in a given patch of soil (Bethony et al. 2006). Soil is contaminated with eggs of the parasites excreted in stools, associated with poor sanitary conditions. Human infection will occur by ingestion of contaminated soils.

This variability, noted by studies undertaken in population samples from several districts of the city, showed that population densities, availability of utility services (such as roads, and water-supply/wastewater systems) appear to correlate with disease incidence The proximity of the Atlantic Ocean and resultant higher rainfall helps to explain the greater prevalence of these parasitic diseases compared to the African cities of the interior of the continent, but not the internal variability in the city of Pikine. On the other hand, this coastal location and the presence of a high ground-water table maintains moisture in the sandy soils, facilitating the persistence of the parasites in soil, ditches and other shallow bodies of water. Many authors (*e.g*., Asaolu and Ofoezie 2003) underline the importance of education focused on health and sanitation in the control of parasitic diseases.

22.4 Urban Soil and Health

The city, across its demographic and functional characteristics, constitutes a medium where the visible soil is a secondary element of the landscapes. However by the lifestyles and the activities that characterize urban environments, these soils are subjected to intense contamination inputs. The soils receive an uninterrupted contribution of heavy metals resulting in particular from the domestic fuel combustion, motor vehicle traffic, waste incineration, power production and other industrial activities. The city of Turin, Italy (population ~1 million) was the subject of an investigation (Biasoli et al. 2006) whose conclusions illustrate this fact well. In this city of 133 km^2 (of which approximately 10% is covered by green areas), human activities contributed to a significant increase in the contents of lead, zinc and copper in the soil. In parallel, the pH of these soils is rising, thanks to the contribution of alkaline materials resulting from construction (*e.g.*, cinder blocks, concrete). This later phenomenon can then limit the assimilability of these heavy metals.

However, these phenomena should not be perceived as monolithic. A comparison between the towns of Turin, (Italy), Uppsala (Sweden), Seville (Spain), Ljubjana (Slovenia), Glasgow (Scotland) and Aveiro (Portugal) in connection with the mercury content of their soils allows the measurement of the contamination heterogeneity (Rodrigues et al. 2006). Mercury is a powerful neurotoxic agent, widely used in mining activities and gold extraction, activities mainly located in rural areas. But in urban/suburban areas, oil refining, coal combustion, industrial activities, waste combustion, use of pesticides, and use in batteries, medical devices, and electrical switches contribute to pollution by mercury. Through this study, the authors show a great variability of high levels of soil contamination on fine scales, about a few hundred meters, more than the variability between the six cities.

This heterogeneity of pollution is found, beyond the example of mercury, for many other contaminants. Thus, in the environs of Pueblo, Colorado, a town characterized by a long history of steel production and fabrication, arsenic, cadmium, mercury and lead concentrations in soil are higher than the national average (Diawara et al. 2006). In the inner city area, the authors show that areas inhabited by low-income, predominantly Hispanic and African-America people, are often characterized by the highest levels of pollution. So in their conclusions, the authors affirm that exposure to pollutants becomes an element to discuss in an approach to public health taking into account environmental justice. Depending on social behaviour and socio-economical level, children are exposed differently to lead contained in the indoor and outdoor environments (Laidlaw et al. 2005). Soil moisture appears to be an important contributing factor. In the urban areas where airborne dust is prevalent, people are more exposed to lead contamination.

Local characteristics that influence the presence of pollutants in soils make it possible to identify sites whose proximity will generate a risk for the bordering populations. For example pollution will act in different ways according to social conditions, human activities, soil characteristics and so on. The problem will then consist in identifying the areas of special concern with respect to these risks. This difficult analysis, taking in account the systemic dimension of the exposure to pollutants, is seldom chosen. On the other hand, analysis of polluting emissions and their impact on the surrounding soils is the subject of many studies, with an aim of either reducing or eliminating the source of pollution. In Barcelona, soil contamination by a solid waste incineration unit was the subject of a monitoring study whose results showed the weak risk for the surrounding population (Schuhmacher et al. 1997). In Newcastle, England, the analyses of soils showed that the spaces located under the dominant winds from the solid waste incineration unit did not coincide with an increase of heavy metals and arsenic content because of the background noise left by the industrial activities which followed one after another in the city since the 19th century (Rimmer et al. 2005). On the other hand, composted urban organic may represent a risk to public health. Close to Seville, Spain, experimental parcels of land receiving such urban composts showed slow accumulation of zinc and lead, and possible risk to humans consuming agricultural products grown on them (Madrid et al. 2006). The authors suggested the need for lowering the thresholds of toxicity considered to be acceptable by the Spanish government. In these systems, where human activities lead not only to pollution of soils but also to production of soil amendments by transformation of wastes, regulatory controls on multiple fronts becomes important tools for protecting public health. With a view to sustainable development, public authorities can control the risk by adequate measures (Mohan 2006) based on available techniques. For that to occur, it is still necessary that a clearly stated policy and adequate procedures exist (Nathanail 2006).

It is thus valuable in these artificial situations [such as cases where residues produced by urban/industrial activities (as opposed to traditional organic composts produced by natural transformations of biomass) are added to soils as amendments in urban/suburban agriculture] that one is able to identify potentially significant pathogenic pathways contributing to soil contamination, and to assess human exposure from contact with and usage of such contaminated soil. These health-risk situations are the basis of the "pedo-epidemiological systems" we are trying to identify.

22.5 Health of the Soil for a Health of the Man

The analogy between the health of the soils and human health is very old. The reasons are varied: perception of the soil being like a living being, the will to control human health leading to a desire for healthy management of soils, or simple ignorance of the soil processes. Thus, agronomists of past times understood that certain substances improved qualities of the soils. These "manures" were perceived more like drugs than like food (Boulaine 1989). One will notice that in French, the term "engrais" (fertilizer) has the same root as "engraisser" (to fatten). So fertilizer will fatten the soil. A sign of opulence certainly, but probably also an allusion to the fatty and smooth feel of soils rich in fine-mineral matter (clay- and silt- size fractions) and organic matter, recognized as being very fertile by experiment. In certain cases, the analogy goes very far. Thus, in biodynamical agriculture, created by the philosopher Rudolf Steiner (1924), substances are given to a soil in homeopathic amounts, at certain very precise moments (*e.g.*, full moon) to cure it. This approach, very empirical, is eminently anthropocentric.

But it has its limits. Thus, a soil low in trace elements, or in which these elements are poorly available (due to high pH or other factors), will induce deficiencies in the plants which grow them, then in the fauna which take nourishment from these plants, and in the humans living off its native and cultivated vegetation. This is the case, for example, of tropical arenosols (weakly developed sandy soils—*e.g.*, recent dune sand, beach sand). Can one say that the soil is sick? A more rational approach consists of saying that the soil is deficient. Rather than looking at the soils as sick bodies, the scientific approaches prefer to regard them as non-renewable, fragile resources, to be preserved with a view towards sustainable development.

22.6 Can One Connect Soil Types and Health Hazards?

So to the question posed in the title: Can one connect soil types (within the meaning of pedological classification) and health hazards? In certain cases, clearly not: for example, soils can be a simple physical support of varied parasites; even if some physical or chemical characteristics such as particle size distribution, moisture content and pH may influence the presence and the abundance of the parasite, it is seldom possible to correlate these characteristics with a precise type of soil. In other cases, the relationship seems more direct. Thus, a bond exists between hydromorphic soils [soils that are developed in the presence of excess water (all or part of the time)] and various medical problems—transmission of diseases such as malaria and schistosomiasis, the presence of molds, aggravation of rheumatism in damp conditions, and vulnerability to floods. But the correlations are not causal. In fact, as the flood case clearly exemplifies, it is the hydrological cycle, rather than the hydromorphic soils, which is truly at the root of the medical problems.

Another example is related to the landslides. Contrary to other geomorphological and geological risks, such as earthquakes or floods, landslides have a formal pedological component. Although such phenomena can happen in many movable, thick materials, and can be triggered by heavy rainfalls, they are particularly frequent in the ferralitic soils (also known as oxisols in the USDA soil taxonomy or ferralsols in the FAO classification) in wet intertropical areas. Two factors play a central role here: (I) the type of soil—several meters thick and covering movable unconsolidated material (regolith) up to several tens of meters thick, and (II) a particularly wet climate. A third factor is added to it—strong relief. These three factors are not independent. The hot and wet climate has a fundamental role on the thickness of the regolith; the mountainous character accentuates climatic moisture; the relief is accentuated by the nature and the thickness of the regolith, which is more sensitive to geological erosion than unaltered parent rocks. In short, the relationship between landslides and the health hazards associated with them on one hand, and soils of the other hand, is only partial. It is the whole of the environment that has to to be taken into account

22.7 Conclusions

Whether one approaches the relationship of soils and health from one end of the spyglass or the other, it appears obvious that the image can be only be valuable if these terms are put in the perspective of the total environment. This systemic approach that we advocate here, strives to be operational by identifying the causal elements on which it will be possible to act and thereby improve health outcomes. This approach also makes it possible to analyse, in a more realistic way, the concept of risk compared to the total scope of factors influencing health. Thus, in current discussions of global warming, one often sees mention of the medical question, in general, and the evolution of the endemic areas of tropical diseases, in particular (see for example, the "deadly dozen" list of pathogens that may spread as a result of changing temperatures and precipitation levels that was released in 2008 by the Wildlife Conservation Society—including intestinal & external parasites and sleeping sickness—available at http://www.wcs.org/deadly-dozen/wcs_deadly_dozen). To take the example of malaria and its possible return in the countries of the Northern hemisphere, it is thus advisable to remember the factors that were responsible for its disappearance in Europe. Indeed, soil management practices—in particular drainage of large tracts of hydromorphic soils, and limestone amendments on acid soils (making it possible to improve soil structure and increase permeability), eliminated favourable sites for vector development (Fanica, 2006) —namely mosquito-breeding areas. The action of man on the soils, and the management of the environment towards improved habitability and agricultural productivity by human societies made it possible to improve the sanitary situation by eliminating the vector.

Soils must thus be taken into account as one of the elements of environmental systems where active management may lead to positive health outcomes. So, if it is evident that soils play an important role, and we cannot talk about pedo-epidemiogenic system for most of the diseases or syndromes evoked in this paper. Human infection by parasites is more the result of life style, social behaviour, hygiene, and environmental management than of soil characteristics. Indeed, even if the soils constitute a necessary substrate for certain parasite life-stages, human infection is not inescapable and varies according to the types of populations which live in the contaminated zones. The use of composts produced with urban wastes could be considered a contrasting case. Here, contamination of environment with heavy metals or urban waste residues is the direct consequence of a process based on soil amendment. In this case, preventive actions can assure that such amendments will not degrade soil quality This case represents a sub-category of Picheral's techno-pathogenic system.

References

Abrahams PW (2002) Soils: their implications to human health, *Science of the Total Environment*, 291, issues 1–3: 1–32

Asaolu SO, Ofoezie IE (2003) The role of health education and sanitation in the control of helminth infections, *Acta Tropica*, 86: 283–294

Beeson KC, Matrone G (1976) The soil factor in nutrition – Animal and Human, Marcel Dekker, New York

Bethony J, Brooker S, Albonico M, Geiger S, Loukas A, Diemert D, and Hotez P (2006), Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm, *Lancet*, 367: 1521–1532

Biasoli M, Barberis R, Ajmone-Marsan F (2006), The influence of a large city on some soil properties and metals contents, *Science of the Total Environment*, 356: 154–164

Boulaine J (1989) Histoire des pédologues et de la science des sols (History of pedologists and soils Science) *INRA*, Paris, 285 p. + annexes [in French]

Boyer J (1982) Les sols ferrallitiques. Tome X. Facteurs de fertilit et utilisation des sols. (Ferrallitic soils. Volumes X, Fertility factors and land use.) IDT n° 52, ORSTOM, Paris, 384 p. [in French]

Brooker S, Clements A, Bundy D (2006) Global epidemiology, ecology and control of previous termsoil next term-transmitted helminth infections, *Advances in Parasitology*, 62: 223–265

Brunet JL, Brunet PA, Brunet O, Peyramond D (2006) *Les insectes et la santé*, (*insects and health)* John Libbey Eurotext, 124 pages [in French]

Cambier P (1994) Contamination of soils by heavy metals and other trace elements: a chemical perspective. *Analysis Magazine*, 22: 21–24

Chabasse D, Le Clec'h Ch, de Gentile L, Verret J-L (1995) Le Larbish, (Larbish) *Cahiers d'tudes et de recherches francophones / Santé*, 5, n°6: 341–345 [in French]

Diawara M, Litt JS, Unis D, Alfonso N, Martinez LA,Crock J, Smith DB, Carsella J (2006) Arsenic, Cadmium, Lead and Mercury in surface soils, Pueblo, Colorado: implications for population health risk, *Environmental Geochemistry and Health*, 28: 297–315

De Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, Savioli L (2003) Previous term soil next term-transmitted helminth infections: updating the global picture, *Trends of Parasitology*, 19: 547–551

Drancourt M, Houhamdi L, Raoult D (2006) Yersinia pestis as a telluric, human ectoparasite-borne organism, *Lancet*, 6: 234–241

Engelmann R, LeRoy P (1995) Conserving land: Population and sustainable food production. *Population Action International*, Washington DC, 48 p

Fanica PO (2006) La disparition du paludisme dans la France rurale et la régression des terres humides, (Disappearance of paludism in rural France and regression of wet soils) *Etude et gestion des sols*, 13: 53–61 [in French]

Franquin P, Martin G (1962), Bilan d'eau et conservation des sols au Niari. (Water assessment and soils conservation in the Niari) *Coton et Fibres tropicales*, 17, 3: 345–356 [in French]

Glorennec Ph (2005) Explicitation et réduction de l'incertitude liée à l'ingestion de sol en évaluation des expositions environnementales, (Clarification and uncertainty reduction related to soil ingestion in environmental exposures evaluation) *Environnement, Risques & Santé* 4, n° 4: 258–262 [in French]

Goodvaerts P, Webster R (1994) Scale-dependent correlation between topsoil copper and cobalt concentrations in Scotland. *European Journal of Soil Sciences*, 45: 79–95

Gouteux JP, Laveissiére C, Couret D (1983) Écologie des glossines en secteur pré-forestier. (Tse-Tse flies ecology in pre forestall sector) *Cah. O.R.S.T.O.M., série Entomologie médicale et Parasitologie*, Vol. XXI, no 1: 3–12 [in French]

Heresi G, Murphy J, Cleary Th (2000) Giardiasis, *Seminars in Pediatric Infectious Diseases*, 11, No 3: 189–195

Hervouët JP, Prost A (1979) Organisation de l'espace et épidémiologie de l'onchocercose (of Space organization and onchocerciasis epidemiology) in: Marchal JY (éd.), *Maitrise de l'espace agraire et développement en Afrique tropicale (Agrarian space control and development in tropical Africa)ORSTOM*; 89: 179–189 [in French]

Karimi Y (1963) Conservation naturelle de la peste dans le sol (Natural conservation of plague in soils) *Bulletin de la Société de Pathologie Exotique*, 56: 1183–1186 [in French]

Lal R, 2007, World soils and global issues, *Soil Tillage Research*; 97: 1–4

Lapeyssonnie L 1963, La méningite méningocoque en Afrique (The meningococcal meningitis in Africa), *Bull World Health Organ* 28, 3: 114p [in French]

Laveissiére Cl, Grébaut P, Herder S, Penchenier L (2000) Les glossines vectrices de la trypanosomiase humaine africaine (The Tse-Tse flies, vectors of Human African Ttrypanosomiasis) co-éd. IRD – OCEAC, Yaoundé, Cameroun, 256 p [in French]

Laidlaw M, Mielke H, Filippelli G, Johnson D, Gonzales Ch, (2005) Seasonality and Children's Blood Lead Levels: Developing a Predictive Model using Climatic Variables and Blood Lead Data from Indianapolis, Indiana, Syracuse, New York and New Orleans, Louisiana (USA), *Environmental Health Perspectives*, 113 (6): 793–800

Lovelock J (1972) Gaia as seen through the atmosphere, *Atmospheric Environment*, 6: 579–580

Lovelock J, Margulis L (1974) Atmospheric homeostasis by and for the biosphere: the Gaia hypothesis, *Tellus*, 26: 1–10

Madrid F, Lopez R, Cabrera F (2007) Metal accumulation in soil alter application of municipal solid waste compost under intensive farming conditions, *Agriculture, Ecosystems and Environment*, 119: 249–256

Meade MS, Earickson RJ (2000) Medical Geography, second edition, *The Guilford Press*, New York – London, 500 p

Mohan R, Spiby J, Leonardi GS, Robins A, Jefferis S (2006) Sustainable waste management in the UK: the public health role, *Public Health*, 120: 908–914

Nathanail CP (2006) Generic and site-specific criteria in assessment of human health risk from contaminated soil, *Soil Use and Management*, 21: 500–507

Oliver MA (1997) Soil and human health: a review, *European Journal of Soil Science*, 48: 573–592

Picheral H (1983) Complexes et systémes pathogénes: approche géographique (Pathogenic complexes and systems: geographical approach)*in:De l'épidémiologie á la géographie humaine (From epidemiology to human geography). Travaux et documents de géographie tropicale*. 48: 5–22 [in French]

Reinhards J (1970) Flies, sand and trachoma. *World Health Statistics* Q. 9–10

Rimmer D L, Vizard CG, Pless-Mulloli T, Singleton I, Air VS, Keatinge ZA (2006) Metal contamination of urban soils in the vicinity of a municipal waste incinerator: one source among many, *Science of the Total Environment*, 356: 207–216

Rodrigues S, Pereira ME, Duarte AC (2006) Mercury in urban soils: a comparison of local spatial variability in six European Cities, *Science of the Total Environment*, 368: 926–936

Ruddiman WF (2007) "Plows, Plagues, and Petroleum: How Humans Took Control of Climate". Princeton University Press

Salem G (1998) La santé dans la ville. Géographie d'un espace dense: Pikine (Sénégal), (Health in the city. Geography of a dense space: Pikine (Sénégal)), Editions Karthala-ORSTOM, Paris, 360 p [in French]

Sanchez PA (2002) Soil fertility and hunger in Africa, *Science*, 295: 2019–2020

Schemann JF, Laffly D, Malvy D, Mauny F (2007). "Trichiasis and geoclimatic factors in Mali", *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 101: 996–1003

Schuhmacher M, Meneses M, Granero S, Llobet JM, Domingo JL (1997) Trace element pollution of soils collected near a municipal solid waste incinerator: Human health risk, *Bulletin of Environmental Contamination and Toxicology*, 59: 861–867

Steiner R (1924) Fondements spirituels de la méthode bio-dynamique (Spiritual bases of the biodynamics method), *editions anthroposophiques romandes*, 324 p [in French]

Sutter RW, Orenstein WA, Wassilak SGF (1998) Tetanus. *In*: Evans AS, Brachman PS (Eds.) Bacterial Infections of Humans. 3e éd., *Plenum Medical Book Company*. New York.: 741–757

Williams S (2007) Clays that kills: ground yields antibacterial agents. *ScienceNews*, 172, 18, p. 276

Wright H, Turner A, Taylor H (2008) Trachoma, *Lancet*, 371; 371 (9628): 1945–54

Yeloff D, Van Geel B (2007) Abandonment of farmland and vegetation succession following the Eurasian plague pandemic of ad 1347–52, *Journal of Biogeography*, 34, 4: 575–582

Zhang Ch (2006) Using multivariate analyses and GIS to identify pollutants and their spatial patterns in urban soils in Galway, Ireland, *Environmental Pollution*, 142: 501–511

Zumpt F (1965) *Myiasis in man and animals in the old world*. Butterworths, London: 267 p

Chapter 23
"Earth Eaters": Ancient and Modern Perspectives on Human Geophagy

Peter W. Abrahams

23.1 Introduction

Every person reading this chapter has eaten soil. For many, especially the well-to-do and those residing in a developed country, this statement may come as a surprise, but such people will have ingested soil if only accidentally. This involuntary consumption may arise, for example, through the transfer of fine (*i.e.*, typically <250 μm) soil particles that adhere to fingers into the mouth. Young children up to the age of about 4 years are especially prone to this route of exposure, since they use their mouths as a means of exploration (Fig. 23.1) that includes so-called hand-to-mouth activity. Professional judgment suggests that such behaviour leads to toddlers ingesting more soil than children of other ages, who in turn consume more than adults (Calabrese and Stanek 1994). How much soil is ingested involuntarily depends on a variety of factors such as the effectiveness of food preparation procedures in removing adhering soil particles from vegetables and other foodstuffs, personal hygiene, and professions that can bring some people into close contact with soil. Much further research needs to be undertaken on quantifying the rates of involuntary soil ingestion, but investigations on young children to date has indicated a range from less than one to the low hundreds of milligrams per day (*e.g.*, Binder et al. 1986; Calabrese et al. 1997; Davis and Mirick 2006; Van Wijnen et al. 1990). Studies on adults are even more limited than those investigating children, but occupational exposure to soil may result in more variable rates of daily ingestion (Davis and Mirick 2006). An investigation on just 10 subjects indicated that the "average adult" ingested 10 mg/day (Stanek et al. 1997).

Considerable surprise is expressed by many when they learn that some humans also deliberately consume soil. This practice, known as *geophagy* or *geophagia*—the

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Fig. 23.1 A baby sitting on a flowerbed, mouthing a plastic spade. It is easy to appreciate from this image how soil can be inadvertently ingested in significant amounts, perhaps as much as several hundred milligrams per day (Anthea Sieveking/ Wellcome images)

name is derived from two Greek words, *ge*- (earth) and *phag* (eat)—is the most reported form of pica, defined here as a craving for oral ingestion of a given substance that is unusual in kind and/or in quantity (Lacey 1990). Soil-pica involves the recurrent ingestion of unusually high amounts of soil, on the order of 1000-5000 mg/day according to the U.S. Agency for Toxic Substances and Disease Registry (ATSDR 2000), although many geophagists consume significantly more than this. Considering that even the involuntary ingestion of soil has important health implications to humans, being a potentially significant pathway of exposure to environmental pollutants for example, it can be appreciated that the higher rates of soil consumption by geophagists has important consequences. Such implications to health are discussed in a later section of this chapter, along with an assessment on the causes of geophagy. Initially, to appreciate the fact that the deliberate ingestion of soil is more common than many people suspect, the following section considers the geophagical practices of humans from both a historical and geographical perspective.

23.2 Human Geophagy in Time and Space

23.2.1 The Classical Era

It is likely that the earliest humans were geophagists, but the first suggestion of deliberate soil ingestion appears to come from ancient Egypt where yellow ochre (a mixture of clay and iron oxy/hydroxides) was utilized as a medical curative for the treatment of internal maladies (Carretero et al. 2006). Hippocrates (*ca.* 460-377 BC), the Greek physician, is credited as the first known individual who makes reference to geophagy when he stated: “If a pregnant woman feels the desire to eat earth or charcoal and then eats them, the child will show signs of these things” (Woywodt and Kiss 2002, p. 144). Another Greek, Aristotle (384-322 BC), then noted the deliberate ingestion of soil for therapeutic and religious purposes. Such was the influence of Hippocrates and Aristotle, it can be assumed that Greek and Roman physicians were familiar with geophagy as is evident in a number of subsequent texts. In Dioscorides’ *De materia medica* (*ca.* 65 AD) mention is made of the red earth of Sinope (located in Turkey, adjacent to the Black Sea), probably an iron oxide enriched clay, which he prescribed for those with liver ailments, and Samian earth (often referred to as *terra Samia* in other texts, and derived from the Greek island of Samos) enriched in the clay mineral kaolin, used for countering various poisons when taken internally with water (Riddle 1985). Pliny (Gaius Plinius Secundus) completed his encyclopedia in 77 AD, mentioning the stone of Samos—which may have been kaolinite in compacted form—that was used for counteracting stomach ailments, relieving giddiness and correcting disturbances of the mind when taken as a draught (*i.e.*, a suspension in a drink). Among other soil medicaments, he talks about the ingestion of clays from Sinope in doses of one denarius (*ca.* 4 g) for stopping menstruation, and Lemnian earth (*terra Lemnia*) “given in vinegar as a draught in cases of vomiting or spitting blood… taken as a draught for troubles of the spleen and kidneys and for excessive menstruation; and likewise as a remedy for poisons and snake bites… hence it is in common use for all antidotes” (Rackham 1938, vol. 9, p. 405). Celsus (Aulus Cornelius Celsus) also mentions *terra Lemnia* in his medical textbook *De medicina* compiled during the reign of Emperor Tiberius (14-37 AD), and writes of human skin color (*i.e.*, pallor) as a diagnostic sign of geophagy—“… I pass on to indicate signs which may be presented in particular sorts of diseases… Persons whose color is bad when they are not jaundiced are either sufferers from pains in the head or are earth eaters” (Spencer 1935, p. 116-117)—so providing an early reference to the association between geophagy and anemia (pallor is indicative of this symptom, and iron-deficiency anemia (IDA) is linked to geophagy attributable to reasons including: (a) the potential of ingested soils to adsorb iron in the human gastrointestinal environment so preventing its utilization, (b) the supply of intestinal parasites from soils that can lead to blood (and iron) loss, and (c) the effect of ingested soils in replacing dietary iron sources [Moore and Sears 1994; Young 2007]).

The Greek physician Galen (129-*ca.* 216 AD) was so interested in Lemnian earth as a medicament that he records his visit to its source, a hill near to the town of Hephaistias on the island of Lemnos, in order to learn how tablets of the soil medicine were prepared (Sweet 1935). A priestess mixed the soil with water, removed any stones, and stamped (or sealed) the tablets of soft earth with a representative of Diana, one of the goddesses associated with healing, before air-drying (Fig. 23.2). The trademarked tablets of Lemnian earth were regarded as sacred, and it is clear that even about 2000 years ago, this medicament had a wide reputation and high commercial value.

Soranus, the second century AD Greek gynecologist, obstetrician and pediatrician, makes reference to pica and its links with pregnancy, noting that the practice usually commenced some 40 days after conception, persisting generally for about four months (Temkin 1956). Soil is noted as one of the non-customary food items that were consumed during this time period of pregnancy. A similar observation was made by Aetius of Amida (now the Turkish city of Diyarbakir), who compiled an obstetric textbook in the 6th century. Aetius states: "Approximately during the second month of pregnancy, a disorder appears that has been called pica, a name derived from a living bird, the magpie…Women then desire different objects… some prefer spicy things, others salty dishes and again others earth, egg shells or ashes"

Fig. 23.2 A picture (*ca.* 1952) by Robert Thom entitled "*Terra sigillata*: an early 'trademarked' drug". The image shows the sealed earth ceremony at Lemnos around the time it was first described some 2,000 years ago (Printed with permission of American Pharmacists Association Foundation. Copyright 2007 APhA Foundation) (see as color plate following *Index*)

(Wegscheider, cited in Woywodt and Kiss 2002, p. 144). The early Byzantine era is also associated with the use of soil from sanctified sites and its role in supernatural healing (Vikan 1984). Such soils included clays that were powdered and consumed as a draught, or used as a dust or paste that was rubbed on the body.

23.2.2 The Middle Ages

Relatively little was written about the human consumption of soil during the Middle Ages. The Persian physician and philosopher Ibn Sīnā (980-1037; better known in the West as Avicenna) noted the benefit of iron preparations in the treatment of geophagy, and commented on the cravings for soil that could be difficult to control; those beyond correction were "abandoned to the grave", so illustrating the fatal consequences of inappropriate soil consumption. At this time in medieval Europe, both gynecology and obstetrics were largely performed by midwives, and in this context Trotula of Salerno comments on the treatment of geophagy during pregnancy: "But if she should seek to have potter's earth or chalk or coals, let beans cooked with sugar be given to her" (Mason-Hohl, cited in Woywodt and Kiss 2002, p. 144).

The great revival of art, literature and learning associated with the Renaissance of the 14th, 15th and 16th centuries in Europe is coincident with more reports on geophagy from this period. The first known mention in the English language appear toward the end of the 14th century, with Geoffrey Chaucer (*ca.* 1343-1400) making reference to "bole armoniak", a pale-red medicinal clay imported from Armenia and used as a antidote for food and other poisoning, in the *Canon's Yeoman's Prologue and Tale* (Schmidt 1974). At around the same time, the practice of deliberate soil consumption is mentioned in 1398 by John Trevisa in an English translation made of the encyclopedic 13th century Latin work *De proprietatibus rerum* (On the order of things, written between 1240 and 1250) by Bartholomaeus Anglicus who noted how sometimes the appetite could change to desire hurtful substances such as earth (Parry-Jones and Parry-Jones 1992). The first pharmacopoeias that were written at the time of the Renaissance refer to Lemnian soil as *terra sigillata* (from the Latin *sigillum*, *i.e.*, seal). Used as a medicine of great esteem from *ca.* 100 BC, the soil tablets were impressed with an official seal—of Diana at the time of Galen's visit, but a variety of impressions appear to have been used throughout the history of this medicament (Thompson 1913; Nielsen 1974)—so creating a trademark identifying its source and helping to gain customers' confidence. As the tablets were made on only one day in the year—their manufacture is recognized as the longest-lived restrictive practice of all time (Robertson 1986)—the price could be kept high, thus promoting the exploitation of many other valuable and profitable medicinal earths in European countries, and favoring counterfeiters who falsified the seal. The varieties of *terra sigillata* are recorded as being used for a number of ailments including dysentery, plague and as an antidote for poisons, although Thompson (1913) concludes that the medicinal value was overestimated, accounting for their disappearance from pharmacopoeias by the middle of the 19th century.

A revaluation of Lemnian earth by Black (1956) however, showed the effectiveness of these medicines against metal poisoning, attributable to the ion exchange properties of the soil constituents.

23.2.3 The 16th, 17th and 18th centuries

By the 16th century, a number of physicians started to write about the disease *chlorosis*—of which IDA appears to be a conspicuous feature, particularly afflicting pubescent girls and young women—and its association with pica. Woywodt and Kiss (2002) comment on the large number of medical dissertations that deal with pica around this time, and which provide details on the causes (*e.g.*, mental disorder), treatment (iron supplements) and characteristics (cravings; links to pregnancy) of the practice. Complementing such information are valuable insights provided by travelers. In this respect John Covel, doctor, chaplain and later Vice-Chancellor of Cambridge University, provides an account of his visit to Lemnos in 1677, talking about *terra sigillata* and its use in hastening childbirth, and as an "excellent counter-poyson" (*i.e.*, antidote [Bent 1893, p. 283]). Covel records how the sacred earth was excavated on just one day, three hours after sunset on August 6th, making the medicament relatively scarce and valuable. Visiting the island just two years previously Henry Teonge, a ships chaplain, recorded in his diary how the soil came from "one peculiar place in the earth, where it doth come up in one night's time", so confirming that during this period the soil was excavated after sunset on one particular day (Teonge, cited by Robertson 1986, p. 40).

Exploration of the globe also resulted in geophagy being observed, allowing a greater spatial perspective of the practice to be appreciated. There is no doubt that geophagy was undertaken in the New World prior to its discovery by Columbus in 1492. But Alvar Nuñez Cabeza de Vaca, exploring what is now the southeastern United States between 1528 and 1536, provides the first account by writing of a tribe who indulged in soil consumption, both as a means to satisfy the pangs of hunger during times of famine, and (when soil is mixed with fruit of the mesquite tree, *Prosopis juliflora*) to make food sweet and palatable (Bandelier 1905). The earliest record of geophagy in South America is provided by the Portuguese colonist Gabriel Soares de Sousa in 1587. Referring to the Tupinamba tribe of Brazil, he writes of members committing suicide: "when they are seized by disgust or when they are grieved to such a degree that they are determined to die, they begin to eat earth, every day a little, until they emaciate and their face and eyes will swell, and they will finally die" (cited by Laufer 1930, p. 185). But geophagy was not restricted to the Amerindians: the practice was observed among the whites of the Carolinas at least as early as the beginning of the 18th century (Lawson 1709), and Marett (1936) makes the observation that the "tradition" was probably brought over to South America by Spanish colonists. Hunter (1973) also writes about what he calls the cultural transfer of geophagy from Africa. Slaves transported to the New World ingested clay to alleviate gastric pain associated with hookworm disease, and during times of pregnancy continued the practice of clay-eating for possible mineral nutrient supplementation and traditional/cultural reasons. Additionally, Haller (1972) notes the importance of imitation in spreading the practice among the children of plantation slaves, while the poor diet produced desires for “absorbent earths” that either filled the stomach or alleviated digestive disorders. Slaves also believed that following death their spirit would return to the African homeland, and large numbers indulged in the excessive eating of soil as a common way of committing suicide.

23.2.4 The 19th Century to the Present Day

An early account of geophagy in Oceania is provided by the traveler and naturalist Jacque-Julien Houtou de Labillardière, who voyaged to the South Seas in 1791-1793 (Laufer 1930). Visiting villages in Java, he found little square, flat loaves of red ferruginous clay that were produced exclusively for eating purposes, while when visiting New Caledonia he provides an account of a local inhabitant consuming a soft clay-enriched material “as big as his two fists.” Explorers, travelers, anthropologists, missionaries and colonial physicians continued to report geophagy in the Americas and tropics through the 19th century. Arguably, the two greatest explorers of the century, Alexander von Humboldt and David Livingstone, both recorded aspects of the practice. The former, traveling in the Orinoco/Amazon basin at the turn of the century comments on the Ottomac tribe who present “one of the most extraordinary physiological phenomena. They eat earth; that is they swallow every day, over several months, very considerable quantities, to appease hunger, and this practice does not appear to have any injurious effect on their health” (Keay 1993, p. 345). The Ottomacs clearly preferred a certain type of clay, “the most unctuous earth, and the smoothest to the touch” (Keay 1993, p. 346), and could consume three quarters to five quarters of a pound (*ca.* 0.34-0.57 kg) in 24 hours during times of flooding when fish were in short supply. Geophagy was commonly found among other tribes by von Humboldt where individuals—women, children and even full-grown men – could show an irresistible desire for soil, although detrimental health consequences were evident for some.

Ill health was certainly noted by David Livingstone in 1870 when he commented on safura, “the name of the disease of clay or earth eating”, in Zanzibar (Waller 1880, p. 83). Safura often affected slaves and pregnant women, whose preferred choice of clay was obtained from the walls of buildings. Livingstone described his method of diagnosing safura—“squeeze a finger-nail, and if no blood appears beneath it, safura is the cause of the bloodlessness” (Waller 1880, p. 84)—which is indicative of anemia (Loveland et al. 1989). The 19th century literature also makes reference to the disease of this symptom as *cachexia Africana*—or as the French termed the condition, *mal d’estomac* (*i.e.*, stomach sickness). This disease was associated with geophagy especially among slaves in the Americas; the medical symptoms were described in detail by Carpenter (1844), Cragin (1836) and Mason (1833), but have been simplified by Mengel et al. (1964) as sluggishness, mental insensibility, profound muscular weakness, and lassitude. The literature reveals an uncertainty about cachexia Africana and its association with geophagy. Mason (1833) does not consider soil ingestion to be a cause of the disease, but rather a consequence of the medical condition. In a similar manner, writing about the disease—that he called *scorbutic degeneration*—in 1825, the Italian physician Cesare Bressa commented on the deaths of many hundreds of slaves in Louisiana that occurred every year (Mustacchi 1971). He concluded at the time that the disease was nutritional in origin, and today a diagnosis of wet beriberi attributable to a deficiency of vitamin B_1, combined with hookworm infestation, seems a plausible explanation of the characteristics of the condition which caused symptoms that included soil consumption to relieve the gastric pain associated with hookworm disease. In comparison, a number of authors (*e.g.*, Feldman 1986; Mengel et al. 1964; Severance et al. 1988) have reported how geophagy can cause IDA and/or hypokalemia (*i.e.*, an abnormally low potassium concentration in the blood) through the adsorption of dietary iron and potassium by clay minerals, leading to symptoms similar to those describing cachexia Africana in the 19th century.

Irrespective of whether geophagy was a cause or consequence of cachexia Africana, what is known is that the illness was of great public health and economic significance, with Bressa considering it second only to yellow fever as a cause of death among slaves in the area around New Orleans (Mustacchi 1971). The common addiction to eating soil coupled with the indulgence in geophagy to become ill and avoid work or to commit suicide, led slave owners to adopt harsh measures (*e.g.*, threats, stocks, chaining to floors, metallic masks or mouthpieces) in trying to prevent the practice, as illustrated in a number of contemporary 19th century works (MacClancy, 2007; Fig. 23.3). The limited success of such measures is indicated by the antebellum physician Carpenter (1844), who noted that a few plantations in Louisiana had to be completely abandoned. At this time, physicians thought that geophagy was restricted principally to the black races (Haller 1972), even though there appears to be plenty of evidence (*e.g.*, Lyell 1850) that the poor whites of the southeastern states, especially the Carolinas and Georgia, commonly resorted to the practice (Twyman 1971). Only at the beginning of the 20th century was the cause of this soil consumption by poor Caucasians attributed to hookworm disease (Buck 1925).

The conviction among 19th century white physicians, that geophagy was a phenomenon more or less restricted to the black races, was encouraged by the recognition that the practice was uncommon in Europe by this time. There was a gradual disappearance of soil medicaments from pharmacopoeias, with the last appearance of *terra sigillata* in any important work on pharmacy occurring in 1848 (Gray 1848). Occasional reports of geophagy are to be found in the European medical literature published in the 19th century. For example, there are accounts of individual children consuming soil for religious motives (Foot 1867) or to satisfy a gnawing pain in the stomach (Dukes 1884), while Volpato (1848) noted the large numbers of children of the "lower orders" of Italy who indulged in pica that included geophagy. Comments such as depraved, perverted and remarkable in these

Fig. 23.3 A lithograph by Jean-Baptiste Debret (1835) entitled "A countryside visit". The French artist provides important illustrations that document life in Brazil in the first half of the 19th century. Here, behind the mistress of the house, stands a female slave (left) whisking away flies with two tree branches, and wearing a mask to prevent suicide by the eating of soil. With the association of geophagy to cachexia Africana (known as *opilaçao* in Brazil) and suicide, masks were widely used by slave owners to deter the practice in Louisiana, the Antilles, British Guiana (now Guyana), Dutch Guiana (Suriname) as well as Brazil: they appear to have been utilized as late as the 1850's (Lagercrantz 1958)

works indicate how negative and unusual the practice was viewed at this time, feelings that often persist in the literature to this day. Yet there was a renaissance in the internal use of clay by German naturopaths in the late 19th century (Dextreit 1994). This led to the forensic pathologist, Julius Stumpf (1856-1932), advocating in 1906 the use of clay for the treatment of Asiatic cholera and other diseases causing diarrhea and vomiting (Robertson 1996), and Adolf Just (1859-1936) creating the Luvos company in 1918. Using soil in powdered and capsule form, this extant company is one of a number today that supplies "natural" soil medicaments for the treatment of gastrointestinal disorders such as acid dyspepsia and diarrhea (Luvos 2007; Knishinsky 1998). The use of soils in naturopathy in the 20th century is mirrored by their employment in conventional medicine where a growing interest in clays, and the part played by them in prescriptions, has led to a readmittance into pharmacopoeias. Martindale (1993), for example, records the use of light kaolin as an absorbent employed in the symptomatic treatment of diarrhea, smectite clay as an ingredient of Smecta used for gastrointestinal disorders, and fuller's earth/bentonite used in the treatment of paraquat (a herbicide) poisoning.

Travelers and colonial workers/physicians continued the documentation on geophagy into the 20th century. For example, Sir George Watt (1908) commented on a pale yellow earth material eaten medicinally in India, and sold under the name *multani mitti*, while lactating and pregnant women of a number of tribes in Nyasaland (now Malawi) were reported to eat – in private, because of feelings of shame associated with the practice – calcium-enriched soil obtained from ant hills (Berry and Petty 1992). It was thought that a calcium deficiency, revealed by a dietetic survey, was the most likely cause of the craving observed in Nyasaland, with perhaps a maximum of 100 grams of soil per day being consumed. In north Borneo, now the state of Sabah in eastern Malaysia, montmorillonite clay was reported to be eaten by almost everyone, male and female, as a remedy for stomach complaints, a tonic for nursing mothers, and as a sustaining food for long journeys (Collenette 1958). Michael Gelfand (1945), a Medical Officer working in Southern Rhodesia (now Zimbabwe), questioned 100 male patients finding that 31 of them were geophagists for varying reasons: the soil was sweet or tasty; was eaten to make them strong and to give them plenty of children; was consumed with their maize-meal as a relish; and soil was ingested during times of famine.

Much of the detailed information dealing with geophagy in the 20th century can be found in a large variety of journals that consider issues of, for example, earth and environmental science (*e.g.*, soil science, geochemistry), geography, medicine (*e.g.*, dealing with issues in epidemiology, hematology, nutrition, obstetrics, pediatrics, pharmacology and psychiatry) and sociology, so reflecting the fact that this subject is a truly multi-disciplinary research area. However the literature is rather fragmented, with only a handful of authors committing themselves to the subject for any period of time, and only some geographical regions (notably the United States and certain areas within Africa) investigated in any detail. Following the American Civil War, it was generally considered that geophagy as practiced by African Americans would cease following emancipation and a general amelioration in the quality of life, together with the decline of the influence of the "obeah" man (*i.e.*, fetish-man) and a growing belief in Christianity (Haller 1972). Little work on geophagy was undertaken in the United States for about three quarters of a century following the war—with such reports limited to the poor whites of the American South (*e.g.*, Anonymous 1897)—but a number of important investigations commenced in the 1940s which show the prevalence of the practice in a number of Southern states. In rural Mississippi, a survey of 207 African American school children found that 25% had recently eaten soil (Dickens and Ford 1942), with geophagy found more often in the group consuming fewer iron-rich foods. Hertz (1947) commented on geophagy practiced by women in North Carolina, noting how bags of "good dirt" could be purchased in places of employment, or how such desirable, clay-rich soil could be obtained from river banks at specific locations.

Sometimes starch substituted for clay, and Hertz (1947, p. 344) noted how "Clay and starch eating appear to be part of the Negro culture, known to many Negroes and participated by some." In a series of journal articles, Edwards and a number of co-workers quantified the number of women who indulged in the practice in Alabama (58% of 55 respondents to a questionnaire survey; Edwards et al. 1954), and estimated the amounts of soil consumed (6-130 g/day; Edwards et al. 1959). Various motives for eating and craving clay were proposed by Edwards et al. (1964), including its use as a traditional custom during pregnancy, for filling the stomach, for stimulating the appetite, and for aiding relaxation. O'Rourke et al. (1967), working in an obstetrics department located in Georgia, found 55% of the 200 patients randomly selected to have consumed clay or starch, with a daily clay intake ranging from 2 to 650 g/day (mean = 50 g/day). Vermeer and Frate (1979) investigated geophagy in the African American population of rural Holmes County, Mississippi. Twenty five sources of geophagical materials were mapped, and the authors noted how illuvial B-horizon (*i.e.*, subsurface) clays were excavated at depths of 50 to 130 cm from exposed soil banks along roadcuts. These were then mixed with vinegar and/or salt prior to baking, such preparation being undertaken to enhance the flavor. Both women (57% of those surveyed) and children (16%) were geophagists with an "average" daily consumption equaling some 50 g; the practice was not recorded among the adult males and adolescents investigated. Vermeer and Frate (1979) noted how, following migration of African Americans to the urban North, clays were trafficked from Holmes County to the northern metropolitan areas. However, working in Albany, New York, Hook (1978) found a significant difference in the cravings of pregnant women compared to those of the South. Only 1 of the 250 mothers in Albany indulged in geophagy, and Hook (1978) speculated that the difference in prevalence compared to the South was because of cultural and local geographic factors. A more recent study undertaken by Edwards et al. (1994) on 553 African American pregnant women in Washington D.C. found pica occurring in 8.1% of the sample, but none indulged in geophagy. This was hypothesized to be a generational effect, with younger women not exposed to the clays of the American South now seeking more easily obtained sources of gratification (such as starch) during their pregnancies. Indeed, there is evidence that even in the American South geophagy has declined because of the forces of urbanization and modernization, and because laundry starch and baking soda act as substitutes (Frate 1984). Even so, Horner et al. (1991) note that geophagy remains one of the dominant forms of pica during pregnancy in the United States, with the latter still affecting about 20% of high-risk women (defined here as likely to be black, living in a rural area, and having a positive family history of the practice) during pregnancy.

The work undertaken on geophagy in the United States over the last 60 years has concentrated on the African American community. Little work has been focused on the white population—although Vermeer (1986) states that <10% of pregnant white women admit geophagy, a figure that agrees with the findings of Ferguson and Keaton (1950) when undertaking research in the late 1940s—or Native Americans, although regarding the latter, Fisher et al. (1981) noted the practice as widespread among certain desert-dwelling Indian tribes of the American southwest. Migration of Mexican-born women to the United States has also led to a cultural transfer of the practice (Snow and Johnson 1978), with Simpson et al. (2000) reporting a prevalence of pica among this group of women in southern California as 31%; clay and soil were common non-food items consumed. Simpson et al.

(2000) found a higher prevalence of pica (44%) within Mexico itself, perhaps attributable to a greater cultural acceptability. Certainly this would seem to be the case for many countries within the tropics.

Abrahams and Parsons (1996) document the widespread practice of geophagy in a number of low latitude countries, and Mahaney et al. (2000) report the common consumption of soil in Indonesia. Most of the recent research on geophagy in the tropics however has been undertaken in Africa. Thus, the prevalence of soil consumption among school children aged 5-18 years in Nyanza Province, western Kenya, was recorded as 73%, with material from termite mounds being especially preferred, and the median amount consumed equaling 28 g/day (minimum 8 g/day; maximum 108 g/day; Geissler et al. 1997). The health consequences of such ingestion to children has been investigated in a number of African countries, with findings in western Kenya (Geissler et al. 1998a), rural Guinea (Glickman et al. 1999) and rural South Africa (Saathoff et al. 2002) demonstrating that geophagy is an important risk factor for orally acquired nematode (*i.e.*, worm) infestation that leads to the diseases ascariasis and/or trichuriasis (see chapter 22 by Handschumacher and Schwartz, *this volume*). Studies have also been undertaken on the association of geophagy with iron status and anemia (Geissler et al. 1998b); with an investigation on Zambian school children supporting the hypothesis that by interfering with the absorption of iron, geophagy leads to a deficiency of this essential mineral nutrient (Nchito et al. 2004).

Very similar work to that documented above on school children has been undertaken on pregnant women in Africa. The common practice of geophagy by such women was found by Young and Ali (2005) in the Zanzibar archipelago, by Thomson (1997) in Namibia, and by Geissler et al. (1999) and Luoba et al. (2004) in western Kenya. Typically, several tens of grams of soil were reported to be consumed daily, with favored sources being earth from termite mounds and the walls of houses; a soft stone was also consumed in western Kenya (Luoba et al. 2004). Nematode infestation of women following such ingestion was found by Luoba et al. (2005), but in contrast, Young et al. (2007) concluded that geophagy was not associated with *Trichuris* or hookworm transmission in Zanzibar. A strong association of geophagy, anemia and iron depletion was indicated by the work of Geissler et al. (1998c) although no inference about causality could be made. In Namibia, Thomson (1997) found that pregnant women who indulged in geophagy had an increased risk of being anemic, but it was concluded that soil consumption was not likely to be an etiological factor in the disease.

The prevalence of geophagy within the tropics, coupled with the recent large-scale migration of people from these areas to more developed countries, has led to a cultural transfer of the practice and reappearance in Europe. To date, very little research has been undertaken on this recent development, although in the United Kingdom concern has been expressed about soils imported in to the country and sold in ethnic shops and markets (Food Standards Agency 2002). This clearly is just the latest development in a practice – indulged in and taken for granted by many, but also unknown or ignored by equally significant numbers of people – that has a long history and widespread distribution.

23.3 The Causes and Consequences of Deliberate Soil Consumption

The preceding section highlights a number of characteristics regarding geophagy that have been written in the literature for (in some cases) millennia. These include: that the consumption of soil is undertaken especially by pregnant women and children; there is a preference for clay-rich material that is typically obtained from specific sources (*e.g.*, termite mounds, scrapings from walls, illuvial subsoil horizons) that offers the consumer particular qualities in terms of color, flavor, odor, *etc.*, that they desire; that an irresistible craving or addiction can develop—leading to the word *geomania* being invented (Halsted 1968)—even to the point where health can be severely affected; that soils can undergo some rudimentary processing (*e.g.*, baking) and can be effectively redistributed and traded over considerable distances via a well-developed postal or market system. Exceptions to these statements can be found—for example: occasional reports of soil consumption by men (Sayers et al. 1974); the ingestion of sand-textured soils (Bradley 1964; Vermeer 1987)—resulting in geophagy becoming a practice that potentially can be observed almost anywhere humans have settled (Deniker 1900). Laufer (1930) notes that geophagy is not known in certain parts of the world such as Japan (both in ancient and more modern times), Korea, Polynesia (excepting New Zealand), Madagascar and the south of South America, but this is not necessarily correct—with the consumption of earth in Japan, for example, being reported in the 19th century (Anonymous 1895)—and it is clear that even today, either a lack of research or ignorance is contributing to a significant under-reporting of the practice.

23.3.1 GeophagyFrom a Biological Perspective: Links to Psychiatric, Medical and Food Detoxification Causes

With geophagy frequently viewed as an aberrant habit, it is easy to consider the deliberate consumption of soil as representing a form of mental disorder. Indeed such a psychiatric cause of geophagy has been noted for both adults (Danford and Huber 1982; Mitchell 1968) and children (Marchi and Cohen 1990). Writing in the mid 19th century, Copland (1844, p. 110) observed that pica “is frequently observed in idiots, from want of ability to discriminate what is or is not food”, but Danford and Huber (1982) note that in a sample population of 991 American (mainly adult and Caucasian) institutionalized mentally retarded individuals, those indulging in pica were often aggressive and deliberate in their search for the non-food item of their choice. Of this population, 4.7% were recorded as geophagous, and Danford and Huber (1982) concluded that pica in the mentally handicapped was an underreported practice. However, it would be wrong to view geophagy as just a mental aberration, and a number of other causes such as the use of soil to fill the stomach during times of famine have been identified earlier in this chapter.

Fig. 23.4 A geopharmacy in Kampala, Uganda. Soils, often mixed with plant materials and seen here as the baked cylindrical gray objects at the front of the shop, are widely used in Uganda for treating a large number of ailments such as asthma, nausea and vomiting, palpitations, *etc*. (Abrahams 1997). Whilst the medicinal value for treating all such maladies must be questioned, their effectiveness for combating complaints such as gastrointestinal disorders has validity (Photo: Peter W. Abrahams) (see as color plate following *Index*)

For example, geophagical materials have been used since antiquity for the treatment of a large number of maladies, and such practices are still evident today (Fig. 23.4). Whilst the validity in treating such a large range of ailments may be questioned, soils have long been used for the effective treatment of gastrointestinal disturbances and poisoning. Carretero et al. (2006) note how the properties of clay minerals – high specific area and sorptive capacity, favorable rheological characteristics, chemical inertness, low or null toxicity for the patient, and low price – make them useful both as active and inert ingredients in modern pharmaceutical formulations. Whilst effective, such materials should not be used indiscriminately (MedlinePlus®2006), and research in their use—for example in the prevention of aflatoxicosis, a poisoning caused by the consumption of foodstuffs contaminated with aflatoxin [a group of toxic compounds produced by certain fungi, especially *Aspergillus flavus*] (Afriyie-Gyawu et al. 2005; Phillips 1999)—continues.

Humans also consume soil to detoxify foodstuffs. For example, Irvine (1952) mentions how the poisonous wild yam *Dioscorea dumetorum* was consumed during periods of famine in countries such as the Gold Coast (now Ghana) through the use of black cotton soils (now classified as Vertisols) that aids the removal of the toxin dioscorine. Particular interest in the detoxification abilities of soils has centered on the Americas. Nearly every one of the major plants identified through archaeological techniques in the Lake Titicaca basin contain deleterious substances poisonous to the consumer, thus requiring detoxification (or non-toxic mutations to be isolated and propagated) before they could be developed into major food crops (Browman 1981; Browman and Gundersen 1993). The procedures for removing toxins are varied, but Lawson and Moon (1938) noted how potatoes were dipped into an aqueous suspension of kaolin clay, known locally as *Chacco*, immediately before consumption so preventing “souring of the stomach.” A more recent observation by Johns (1986) showed that the glycoalkaloid compound *tomatine*, a heat stable toxin which is not destroyed by cooking, is effectively adsorbed by the clays used in this detoxification procedure. The suggestion is that the domestication of the potato – now the world’s most widely grown tuber foodstuff, and the 4th largest crop in terms of fresh produce—that occurred in South America initially required the use of what may be termed “potato clays” to detoxify the vegetable so making them palatable. Recent laboratory work using an *in vitro* model simulating digestion by the human stomach and small intestine have confirmed the ability of ingested kaolin in effectively adsorbing plant compounds such as tannins that may adversely affect food quality (Dominy et al. 2004). These authors concluded that the gastrointestinal adsorption of such substances is the most plausible function of human geophagy, allowing a greater exploitation of marginal plant foods and reducing the energetic costs of vomiting and diarrhea that occurs should toxic plants be consumed.

23.3.2 Geophagy From a Biological Perspective: Mineral Nutrients—a Special Consideration

An old but still popular belief regarding geophagy is that soils are consumed by humans in an instinctive attempt to alleviate mineral nutrient deficiencies (*e.g.*, Deniker 1900; Grivetti 1978). Certainly, there is strong evidence that members of the animal kingdom actively seek out sodium-rich (saline) soils, and birds and reptiles are known to consume soil in order to obtain calcium (Abrahams 2005). However, despite the attractiveness of this physiological explanation to explain human geophagy, conclusive evidence for such a causal factor is still lacking. Occasional reference to the consumption of saline soils is encountered in the literature, with Laufer (1930) noting the ingestion of such materials especially in South America. Even on this continent, however, much use has been made of non-saline soils, and Laufer (1930, p. 106) concludes: “The fact remains that all geophagists have access to salt, and probably more easily than to clay.” The suggestion is therefore that humans do not in the main consume soils to obtain sodium.

Iron and calcium are the two mineral nutrients that have been most frequently implicated in the physiological causation of human geophagy. Calcium deficiency in Nyasaland has been previously noted in section 23.2.4, and Drummond (cited in Tordoff 2001, p. 1587) mentions that in “East Africa the search for edible earths rich in calcium was frequently a cause of tribal raids and the evidence points to these products being instinctively consumed to make good the lack of lime in the customary diet." More recently Vermeer (1966) and Wiley and Katz (1998) commented on the consumption of soil and of calcium supplementation for pregnant women of non-dairying African societies (Fig. 23.5). Although the evidence is far from

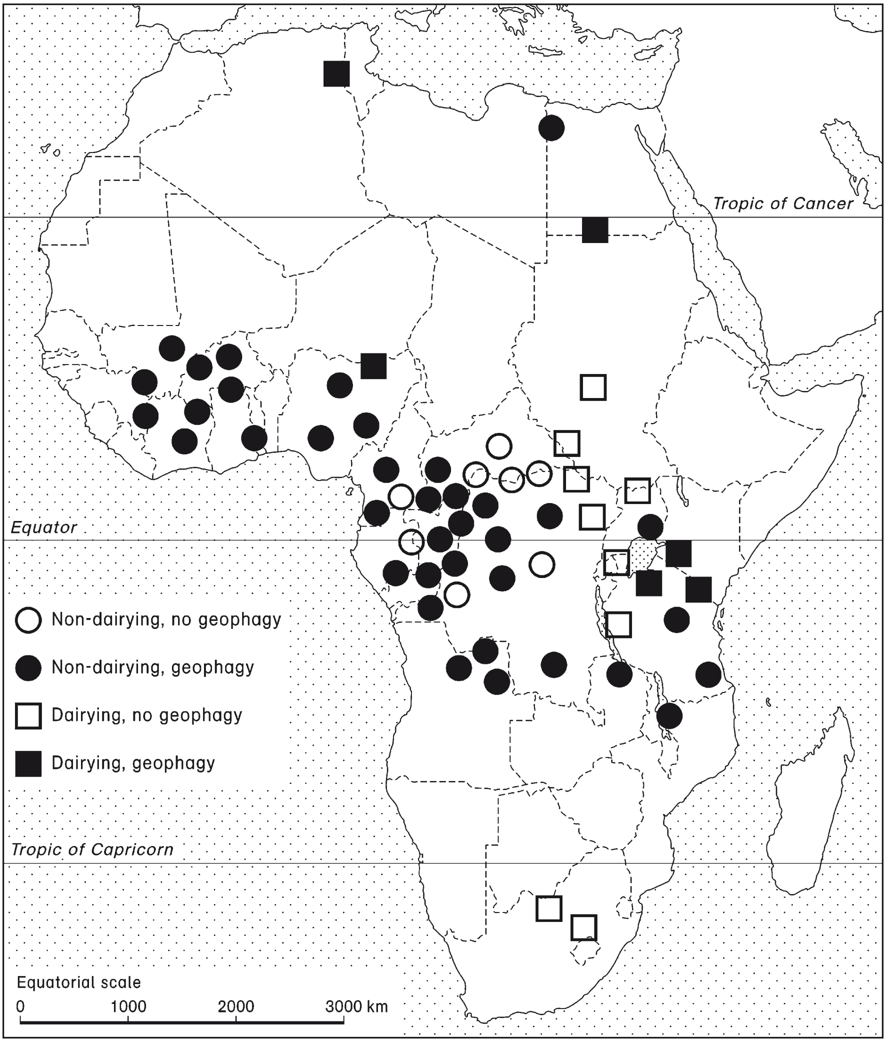

Fig. 23.5 Geographic distribution of geophagy practiced by pregnant women of dairying and non-dairying African societies (Andrea S. Wiley and Solomon H. Katz, Current Anthropology, The University of Chicago Press, Copyright © 1998 The Wenner-Gren Foundation for Anthropological Research). To improve their calcium status, this work concludes that women of non-dairying societies are more likely to practice geophagy during pregnancy, and consume clay more frequently, than those of dairying populations (Wiley and Katz 1998). The reader is directed to this original reference for details of the societies investigated

conclusive, observations like this, alongside other research, make an enticing case for the existence of a human calcium appetite whereby calcium-containing items, including soils, are deliberately sought (Tordoff 2001).

The literature often makes reference to the consumption of ferruginous clays, but in looking at the association between geophagy and iron nutrition, Reid (1992) concludes that the case for the ingestion of soil as a behavioral response to iron deficiency remains unconvincing. Nevertheless, even though a deficiency in a nutrient such as iron has yet to be proven to cause human geophagy, the consumption of soil can still have an important impact on the mineral nutrition of an individual. Laboratory investigations using reagents such as dilute hydrochloric acid – that replicates the acidic conditions of the human stomach – have shown the potential of some soils in supplementing a variety of mineral nutrients including iron and calcium to geophagists at significant rates relative to recommended dietary allowances (*e.g.*, Abrahams 1997; Geissler et al. 1998b; Hunter 1973). Equally, the human gastrointestinal tract is capable of liberating a number of potentially harmful elements (PHEs) such as lead and arsenic from soils to individuals. With interest in both the supply of essential mineral nutrients and PHEs to people who either accidentally or deliberately consume soil, much research over the last decade has focused on the development and refining of laboratory *in vitro* procedures that can rapidly and inexpensively estimate the bioaccessible portion of elements (defined here as the fraction of a substance that is soluble in the gastrointestinal environment and is available for absorption; Paustenbach 2000) from ingested soils.

The human gastrointestinal tract can be regarded as a multi-chambered extraction pathway, with the digestion of food and other items such as soil starting in the mouth. Material is quickly transferred to the acidic environment of the stomach before being passed to the generally neutral/alkaline conditions of the small intestine where the absorption of elements mainly occurs. Several *in vitro* approaches have been developed in attempts to mimic the effects of this human digestion process on the bioaccessibility of elements from soils (Intawongse and Dean 2006). Most methods simulate transit through the human digestive tract by sequential exposure of soil samples to mouth-, stomach- and small intestinal-conditions. The laboratory procedures are typically carried out at normal body temperature (37°C), but other parameters such as the solid-to-solution ratio and the bile type employed (Hooda et al. 2002; Oomen et al. 2004) may vary. Indeed, while 3-compartment models simulating the mouth, stomach and small intestine of the human digestion system have been developed (*e.g.*, Oomen et al. 2003), many procedures ignore the initial mouth extraction stage in the belief that it has little effect on the bioaccessibility of elements from soils. Smith et al. (2000) subjected geophagical termite mound and medicinal soils from Uganda to such a 2-compartment model (developed by Ruby et al. 1996), finding an enhanced bioaccessibility of iron that accounted for a major proportion of the recommended daily intake. Using a slightly modified procedure, Abrahams et al. (2006) considered the bioaccessibility of elements following the ingestion of soils by pregnant women of UK Asian communities. Significant amounts of iron, as well as calcium, copper and manganese, were found to be bioaccessible; indeed with the quantity of soil that may be consumed (in excess of 60 g), the UK Food Standards Agency "Guidance Levels" for both iron and nickel can be exceeded provided all the bioaccessible fractions are absorbed by the body. Concern was also expressed about the bioaccessible lead concentrations extracted from the soils.

The *in vitro* methods that are now employed show that in addition to potentially supplying important amounts of essential mineral nutrients and PHEs, ingested soils can also bind and thereby reduce the bioaccessibility of certain elements. Hooda et al. (2002) developed a 2-compartment model and subjected five geophagical samples collected from India, Tanzania, Turkey and Uganda to the *in vitro* procedure. The results showed that all of the geophagic materials sorbed large amounts of iron and zinc across a range of dietary intake scenarios (thus reducing the bioaccessibility of these essential mineral nutrients), whilst calcareous soils provided significant amounts of bioaccessible calcium.

23.3.3 Geophagy From a Cultural Perspective

Many of the characteristics of human geophagy – the use of soil as a famine food; a detoxifier of foodstuffs; a medicine—have much in common with the functional utilization of soils by numerous domesticated and wild animals (Abrahams 2005), whose indulgences in the practice are readily accepted by people and occur typically without comment. Rather than being seen dismissively as aberrant behaviour therefore, the consumption of soil by humans in its proper context should be appreciated in a more enlightened sense as a normal adaptive practice undertaken in times of need throughout history. The evolution of culture among human societies, with soil being associated as a source of life and fertility, and symbolic of one's homeland, then saw geophagy incorporated into ceremonial rites and magico-religious practices. Brady and Rissolo (2006), for example, argue that the small-scale extraction of clay evident in many remote, dark zones of Mayan caves may have been associated in a ritual involving geophagy. A similar causative explanation is presented by Hunter et al. (1989) for the consumption of soil in present-day Guatemala and neighboring countries. Here, holy clay tablets of soil embossed with religious images are consumed medicinally and during times of pregnancy, but the ingestion always has spiritual connotations. In modern day Africa, the rich cultural practice involving geophagy by children of both sexes and pregnant women has been described by Geissler et al. (1999) and Geissler (2000). Here, beyond the significance of soil consumption in relation to age, gender and power, geophagy relates to fertility, belonging to a place, and the continuity of the lineage. These examples illustrate the importance in certain cultures of perpetuating geophagy, where the practice is a deep-rooted tradition seen today in the setting of a long family history of soil consumption. In such societies soil may even have a role in the human diet, being perceived and consumed as a sort of candy, condiment, delicacy or relish. However, outside of these more traditional societies—that are typically associated with the developing countries—the forces of modernization and education on people, and the perception that geophagy is an unhygienic and deviant habit, leads to a stigmatization of those minority groups who persist with the practice (Henry and Kwong 2003). As a consequence, consumers of soil, through feelings of shame and guilt, are often reluctant to volunteer information about their geophagical habits, so contributing to the underreporting of the practice.

23.4 Human Health: The Costs and Benefits of Geophagy

A summary of the health benefits and the deleterious consequences associated with the deliberate ingestion of soil is provided in Table 23.1. Since a number of these issues have already been discussed, only brief details on some topics now follow. Regarding a positive aspect of geophagy on human health, there is evidence of a psychological causation of the practice, with some soil consumers experiencing a pleasurable, relaxing sensation (*e.g.*, Edwards et al. 1964), and taking comfort from their habit. Vermeer (1971), for example, talks about the positive psychological values of soil consumption undertaken by pregnant women of the Ghanaian Ewe tribe. Traditionally, the clay consumed has the shape of an egg, which in Ewe culture is ascribed the attributes of promoting fertility, health, long life and well-being. The pregnant women consider themselves to be in a subnormal condition and prone to illness, but believe that these qualities of the clay are bestowed on them following ingestion. In the same manner, the holy clay tablets consumed in central America provide psychological comfort by helping to allay anxieties associated with ill health or pregnancy (Hunter et al. 1989).

A further positive role regarding soil ingestion involves the “hygiene hypothesis.” This issue is associated with the increased incidences of allergies and autoimmune diseases in modern developed societies attributable to the use of modern vaccinations, the fear of germs, and obsession with hygiene. There has been a significant rise in diseases such as asthma in affluent societies over the last 30 years; it has been suggested that this is associated, in part, with diminished contact and ingestion of soil mycobacteria. Whilst this remains an intriguing issue, the hypothesis is controversial.

The biological, chemical and physical properties of ingested soils can have a number of deleterious consequences to human health and well-being. Death attributable to soil ingestion, once a notable feature of the slave trade, has only been infrequently mentioned in the literature concerning geophagy since the early decades of the 19th century. Likewise, excessive tooth wear and hyperkalemia (a high potassium concentration in the blood linked with symptoms such as muscular weakness, a slow irregular pulse, *etc.*) associated with the practice have only been rarely reported. More commonly, a number of authors have commented on how an excessive intake of soil can lead to intestinal blockage, detectable on X-ray images (Collinson et al. 2001; Gardner and Tevetoğlu 1957; Ginaldi 1988; Kişlal et al. 2003).

Of considerable concern is the infestation of geophagists by parasitic organisms. The ingestion of feces-contaminated soil—either deliberately or involuntarily—

Table 23.1 The pros and cons of geophagy on human health

Benefit	Reference	Cost	Reference
Mineral nutrient provider: *e.g.*, iron, calcium	Abrahams et al. (2006); Hooda et al. (2002); Smith et al. (2000)	Death	Key et al. (1981); Rake (1884)
Pesticide antidote	Rose (1975)	Excessive tooth wear	Abbey and Lombard (1973)
Protection against allergic and autoimmune disease: *e.g.*, asthma, psoriasis, rhinitis – the "hygiene hypothesis"	Hamilton (1998); Weiss (2002)	Intestinal blockage leading to abdominal pain, fecal impaction and colon perforation	Amerson and Jones (1967); Ginaldi (1988); Kişlal et al. (2003); Wrenn (1989)
Protection from aflatoxins	Afriyie-Gyawu et al. (2005); Phillips (1999)	Labor problems and deleterious fetus/infant outcomes	Gusdon and Tunca (1974); Horner et al. (1991); Key et al. (1981); Ukaonu et al. (2003)
Psychological comfort	Hunter et al. (1989); Vermeer (1971)	Mineral nutrient deficiency: iron, potassium, zinc	Arcasoy et al. (1978); Cheek et al. (1981); Mengel et al. (1964); Minnich et al. (1968); Mokhobo (1986); Nchito et al. (2004); Reimann and Koptagel (1980); Severance et al. (1988); Ukaonu et al. (2003)
Treatment of gastrointestinal disorder: acid indigestion, cholera symptoms, nausea and diarrhea, stomach ache	Guarino et al. (2001); Madkour et al. (1993); Robertson (1996); Vermeer and Ferrell (1985)	Parasite infestation: *Ascaris lumbricoides;* hookworm; raccoon roundworm; T*oxocara* species; *Trichuris trichiura*	Bundy and Keymer (1991); CDC (2002); Frenkel and Ruiz (1981); Glickman et al. (1999); Luoba et al. (2005); Stagno et al. (1980); Wong et al. (1991)
		Toxicity and exposure to PHEs: fluorine, lead, potassium, radionuclides	Abrahams et al. (2006); Fisher et al. (1981); Gelfand et al. (1975); Shellshear et al. (1975); Simon (1998); Wedeen et al. (1978)

containing the eggs of *Ascaris lumbricoides* and *Trichuris trichiura*, for example, has a significant impact on large populations. The resulting diseases, ascariasis and trichuriasis, have been neglected until recently because of their relatively low morbidity and mortality, but they are now recognized as causing substantial chronic effects on individuals with impacts on nutrition, growth, physical fitness and cognitive functions (Abrahams 2006). Exploitation of subsoil material and other earth sources unlikely to be contaminated with feces, together with the preparation of geophagical materials that often includes baking which will be effective in destroying parasitic organisms, helps considerably in avoiding infestation. Indiscriminate soil ingestion, for example of unsurfaced play areas of children's homes (Wong et al. 1991), is more likely to cause infestation and disease.

While ingested soils have been demonstrated to have the potential to supply essential elements to the geophagist, paradoxically because of their adsorptive properties they also have the ability to induce a mineral nutrient deficiency. Iron, potassium and zinc deficiency attributable to this mechanism has been reported in the literature. For example, Cheek et al. (1981) studied 300 Aboriginal people in the north west of Australia, finding that half of the individuals had hypozincemia (a low concentration of zinc in the blood). The authors concluded that adsorption of zinc by ingested soil exacerbates conditions favoring a deficiency of the element in this population: the hot temperature that leads to zinc loss through perspiration; the high cereal diet that causes a decreased absorption of zinc by binding to phytate; intestinal parasites that cause a depletion of zinc through blood loss; low concentrations of the element in soils and vegetation.

The association of soil ingestion with IDA can now be recognized as extending back in human history at least 2,000 years. In Turkey, iron deficiency is a long-standing public health problem caused by geophagy and an inadequate diet. Commenting on the properties of two Turkish geophagical clays, Minnich et al. (1968) noted the high cation exchange capacity (CEC) of the soils that was responsible for the effective adsorption of iron, so preventing its utilization by geophagists. In comparison, three clay samples collected from the United States had lower CEC and a resulting decreased amount of adsorbed iron. Such observations support the view that the impairment of iron in the geophagist varies according to soil properties including clay type (Talkington et al. 1970).

Fluorine and potassium toxicity has been reported in the literature, but the prevalence among the world's geophagists would seem to be limited. More concern has been expressed regarding lead toxicity, and in this respect the work of Abrahams et al. (2006) is especially of note. These authors investigated geophagy practiced by pregnant women of the UK Asian community, undertaking an *in vitro* procedure on soils (imported from Bengal) that determined the bioaccessibility of a number of elements, including lead. The materials examined were not contaminated with this metal, containing normal soil total concentrations, but the amounts consumed together with the bioaccessible contents extracted in the laboratory procedure, raised concerns about lead toxicity affecting both the mother and the unborn child. It is for reasons such as this that it is inappropriate to justify geophagy. Whilst humans have turned to soil consumption in times of need, and noting that ingested soils can provide benefits to the consumer, the large amounts of soil that are frequently observed to be consumed, together with the uncertified properties of the materials that are ingested, makes the eating of even seemingly innocuous soil a potentially hazardous practice.

23.5 Concluding Remarks

While Table 23.1 highlights that recognized benefits of geophagy are evident, it is strange that so many humans deliberately ingest soil bearing in mind the long list of health problems, some of which may be concurrent, that can also afflict geophagists. Solien (1954) considered that perhaps people do not recognize the ills associated with soil ingestion or, if they do, that their beliefs are strong enough to overcome them. The overwhelming compulsion to eat soil, that is so often evident when reading the literature on this topic, may also outweigh any consideration on the negative aspects of the practice.

There is a contradiction between how geophagy is viewed between people of the developed world and those associated with more traditional styles of living. The practice is certainly more common, and more socially accepted, in poorer traditional societies whose attributes such as lack of education have lead to suggestions that geophagy is associated with "uncivilized" people (Bradley 1964). However such thoughts are completely unjustified and geophagy should be viewed with an enlightened perspective. Deliberate soil ingestion is usually considered an adaptive behaviour in nonhuman primates and a wide diversity of mammals (Abrahams 2005), and with soils often consumed for similar reasons including the detoxification of foodstuffs and self-medication to combat illness (in this respect soil can be regarded as the most ancient of human medicines), it is illogical to think differently about human geophagy. Through time, soil ingestion subsequently became part of a custom and cultural tradition, with socialization to the practice through the family contributing to the persistence of geophagy among the more traditional societies that is so evident at present. Taking an anthropological view of geophagy therefore, the practice of soil consumption can be seen from either a culturally-neutral (so called "etic" perspective) or a culture-specific ("emic") perspective (Young and Pelto 2006). The former refers to an external, analytic view as used by scientists when studying cultural/social phenomena; the latter relates to the perspective of the insiders in a culture whose perceptions of (in this case) geophagy differs to those from a more analytical background. Certainly from an etic perspective geophagy can be viewed as being potentially deleterious to health with concerns about, for example, parasitic worms and lead. Among the societies that view soil ingestion in this way, the general consensus that soil ingestion is both unhygienic and indicative of deviant behaviour has led to a decline in the practice. Yet ironically geophagy still endures in such societies following scientific evaluation (as in the manufacture of modern pharmaceuticals) or recommendations from doctors, and/or when soil is attractively advertised, packaged and sold in perceived reputable shops (Henry and Kwong 2003) or even online (*e.g.*, http://www.whitedirt.com). In such cases the ingestion of soil becomes more acceptable, a recent example being the use of culinary red clay salt (reported by Clark (2000) to be selling for $32-a-pound (*i.e.*, 0.45 kg) compared to plain table salt at about 25 cents-a-pound [2009 price *c*. 50 cents-a-pound]) now sold at specialty markets in the United States.

When undertaken in its proper context, geophagy should be appreciated as normal human behaviour. Accepting this, however, does not necessarily imply that soil consumption is safe, and like any activity geophagy can be inappropriate and harmful when undertaken out of context or to excess. With the health hazards of geophagy remaining to be fully quantified, there is a need to discourage soil consumption through health education, and to offer readily available alternatives such as medicines and mineral nutrient supplements prepared under controlled sanitary conditions. With the provision of such alternatives taking time to implement, it might be wise to adopt a strategy similar to that already employed by health professionals who work in traditional societies, by applying provisional classifications of good, neutral or bad (Reilly and Henry 2000). This may lead to the acceptance that the consumption of some soil materials (*e.g.*, surface soils prone to fecal contamination) is definitely bad, whereas others such as baked subsoil may be endorsed in a more positive manner. In the future there seems little doubt that the prevalence of geophagy will decline further, but with soil materials still being consumed for a variety of reasons in the most developed nations of today, it remains to be seen whether the practice will ever be totally eradicated. In the meantime, with the current inadequate database that exists on geophagy, further interdisciplinary investigations by socially/culturally sensitive researchers remain to be undertaken.

References

Abbey LM, Lombard JA (1973) The etiological factors and clinical implications of pica: report of case. Journal of the American Dental Association 87: 885–887

Abrahams PW, Parsons JA (1996) Geophagy in the tropics: a literature review. The Geographical Journal 162: 63–72

Abrahams PW (1997) Geophagy (soil consumption) and iron supplementation in Uganda. Tropical Medicine and International Heath 2: 617–623

Abrahams PW (2005) Geophagy and the involuntary ingestion of soil. In: Selinus O, Alloway BJ, Centeno JA, Finkelman RB, Fuge R, Lindh U, Smedley P (eds) Essentials of medical geology: impacts of the natural environment on public health. Elsevier, Amsterdam: 435–458

Abrahams PW (2006) Soil, geography and human disease: a critical review of the importance of medical cartography. Progress in Physical Geography 30: 1–23

Abrahams PW, Follansbee MH, Hunt A, Smith B, Wragg J (2006) Iron nutrition and possible lead toxicity: an appraisal of geophagy undertaken by pregnant women of UK Asian communities. Applied Geochemistry 21: 98–108

Afriyie-Gyawu E, Mackie J, Dash B, Wiles M, Taylor J, Huebner H, Tang L, Guan H, Wang J-S, Phillips T (2005) Chronic toxicological evaluation of dietary NovaSil clay in Sprague-Dawley rats. Food Additives and Contaminants 22: 259–269

Amerson JR, Jones HQ (1967) Prolonged kaolin (clay) ingestion: a cause of colon perforation and peritonitis. Bulletin of the Emory University Clinic 5: 11–15

Anonymous (1895) Clay eating. Scientific American 72: 186
Anonymous (1897) The clay eaters. Scientific American 76: 150
Arcasoy A, Çavdar AO, Babacan E (1978) Decreased iron and zinc absorption in Turkish children with iron deficiency and geophagia. Acta Haematologica 60: 76–84
ATSDR (2000) Summary Report for the ATSDR Soil-Pica Workshop June 2000, Atlanta, Georgia. http://www.atsdr.cdc.gov/NEWS/soilpica.html. Cited 4 Aug 2008
Bandelier F (translator) (1905) The journey of Alvar Nuñez de Vaca and his companions from Florida to the Pacific, 1528–1536
Bent JT (ed) (1893) Early voyages and travels in the Levant. II. Extracts from the diaries of Dr John Covel, 1670–1679. Hakluyt Society, London: 99–287
Berry V, Petty C (eds) (1992) The Nyasaland Survey papers 1938–1943: agriculture, food and health. Academy, London
Binder S, Sokal D, Maughan D (1986) Estimating soil ingestion: the use of tracer elements in estimating the amount of soil ingested by young children. Archives of Environmental Health 41: 341–345
Black DAK (1956) A revaluation of *terra sigillata*. Lancet 2: 883–884
Bradley FW (1964) Sandlappers and clay eaters. North Carolina Folklore 12: 27–28
Brady JE, Rissolo D (2006) A reappraisal of ancient Maya cave mining. Journal of Anthropological Research 62: 471–490
Browman DL (1981) Prehistoric nutrition and medicine in the Lake Titicaca basin. Special Publication of American Anthropological Association 12: 103–118
Browman DL, Gundersen JN (1993) Altiplano comestible earths: prehistoric and historic geophagy of highland Peru and Bolivia. Geoarchaeology 8: 413–425
Buck PH (1925) The poor whites of the ante-bellum south. American Historical Review 31: 41–54
Bundy DAP, Keymer AE (1991) The epidemiology of hookworm infection. In: Gilles HM, Ball PAJ (eds) Hookworm infections. Elsevier, Amsterdam: 157–178
Calabrese EJ, Stanek EJ (1994) Soil ingestion issues and recommendations. Journal of Environmental Science and Health A29: 517–530
Calabrese EJ, Stanek EJ III, Pekow P, Barnes RM (1997) Soil ingestion rates for children residing on a superfund site. Ecotoxicology and Environmental Safety 36: 258–268
Carpenter WM (1844) Observations on the cachexia Africana, or the habit and effects of dirt eating in the Negro race. New Orleans Medical Journal 1: 146–168
Carretero MI, Gomes CSF, Tateo F (2006) Clays and human health. In: Bergaya F, Theng BKG, Lagaly G (eds) Handbook of clay science. Elsevier, Oxford: 717–741
CDC (2002) Raccoon roundworm encephalitis – Chicago, Illinois, and Los Angeles, California, 2000. Morbidity and Mortality Weekly Report 50: 1153–1155
Cheek DB, Smith RM, Spargo RM, Francis N (1981) Zinc, copper and environmental factors in the Aboriginal peoples of the North West. Australia and New Zealand Journal of Medicine 11: 508–512
Clark M (2000) There's a new flavor in town and it's…salt; Chefs' new obsession: grains from the wild. The New York Times, August 30, F1
Collenette P (1958) Geophagy. British Territories in Borneo. Geological Survey Department. Memoir no. 6: 28–31
Collinson A, Laskey MA, Dibba B, Prentice A (2001) Dual-energy X-ray absorptiometry: a new insight into geophagy. Journal of Pediatric Gastroenterology and Nutrition 32: 615–616
Copland J (1844) A dictionary of practical medicine. Volume 1. Longman, Brown, Green, and Longmans, London
Cragin FW (1836) Observations on cachexia Africana or dirt-eating. American Journal of Medical Science 17: 356–364
Danford DE, Huber AM (1982) Pica among mentally retarded adults. American Journal of Mental Deficiency 87: 141–146
Davis S, Mirick DK (2006) Soil ingestion in children and adults in the same family. Journal of Exposure Science and Environmental Epidemiology 16: 63–75

Debret J-B (1835) Voyage pittoresque et historique au Brésil, ou Séjour d’un Artiste Français au Brésil (A Picturesque and Historical Journey to Brazil, or the Sojourn of a French Artist in Brazil), Volume 2. F Didot, Paris
Deniker J (1900) The races of man: an outline of anthropology and ethnography. Scribner’s, New York
Dextreit R (1994) The healing power of clay. Vivre en Harmonie, Cergy Pontoise
Dickens D, Ford RN (1942) Geophagy (dirt eating) among Mississippi Negro schoolchildren. American Sociological Review 7: 59–65
Dominy NJ, Davoust E, Minekus M (2004) Adaptive function of soil consumption: an *in vitro* study modeling the human stomach and small intestine. Journal of Experimental Biology 207: 319–324
Dukes C (1884) A remarkable case of a juvenile earth-eater. Lancet: 822
Edwards CH, McSwain H, Haire S (1954) Odd dietary practices of women. Journal of the American Dietetic Association 30: 976–981
Edwards CH, McDonald S, Mitchell JR, Jones L, Mason L, Kemp AM, Laing D, Trigg L (1959) Clay- and cornstarch-eating women. Journal of the American Dietetic Association 35: 810–815
Edwards CH, McDonald S, Mitchell JR, Jones L, Mason L, Trigg L (1964) Effect of clay and cornstarch intake on women and their infants. Journal of the American Dietetic Association 44: 109–115
Edwards CH, Johnson AA, Knight EM, Oyemade UJ, Cole OJ, Westney OE, Jones S, Laryea H, Westney LS (1994) Pica in an urban environment. Journal of Nutrition 124: S943–S953
Feldman MD (1986) Pica: current perspectives. Psychosomatics 27: 519–523
Ferguson JH, Keaton AG (1950) Studies of the diets of pregnant women in Mississippi: 1. The ingestion of clay and laundry starch. New Orleans Medical and Surgical Journal 102: 460–463
Fisher JR, Sievers ML, Takeshita RT, Caldwell H (1981) Skeletal fluorosis from eating soil. Arizona Medicine 38: 833–835
Food Standards Agency (2002) Agency warns of the dangers of traditional remedy for morning sickness. http://www.food.gov.uk/news/pressreleases/2002/oct/calabash. Cited 4 Aug 2008
Foot AW (1867) On the form of depraved appetite known by the name of pica. Dublin Quarterly Journal of Medical Science 43: 306–313
Frate DA (1984) Last of the earth eaters. The Sciences 24: 34–38
Frenkel JK, Ruiz A (1981) Endemicity of toxoplasmosis in Costa Rica: transmission between cats, soil, intermediate hosts and humans. American Journal of Epidemiology 113: 254–269
Gardner JE, Tevetoğlu F (1957) The roentgenographic diagnosis of geophagia (dirt-eating) in children: a report of sixty cases. Journal of Pediatrics 51: 667–671
Geissler PW, Mwaniki DL, Thiong’o F, Friis H (1997) Geophagy among school children in Western Kenya. Tropical Medicine and International Health 2: 624–630
Geissler PW, Mwaniki D, Thiong’o F, Friis H (1998a) Geophagy as a risk factor for geohelminth infections: a longitudinal study of Kenyan primary schoolchildren. Transactions of the Royal Society of Tropical Medicine and Hygiene 92: 7–11
Geissler PW, Mwaniki DL, Thiong’o F, Michaelsen KF, Friis, H (1998b) Geophagy, iron status and anaemia among primary school children in Western Kenya. Tropical Medicine and International Health 3: 529–534
Geissler PW, Shulman CE, Prince RJ, Mutemi W, Mnazi C, Friis H, Lowe B (1998c) Geophagy, iron status and anaemia among pregnant women on the coast of Kenya. Transactions of the Royal Society of Tropical Medicine and Hygiene 92: 549–553
Geissler PW, Prince RJ, Levene M, Poda C, Beckerleg SE, Mutemi W, Shulman CE (1999) Perceptions of soil-eating and anaemia among pregnant women on the Kenyan coast. Social Science and Medicine 48: 1069–1079
Geissler PW (2000) The significance of earth-eating: social and cultural aspects of geophagy among Luo children. Africa 70: 653–682
Gelfand M (1945) Geophagy and its relation to hookworm disease. East African Medical Journal 22: 98–103

Gelfand MC, Zarate A, Knepshield JH (1975) Geophagia: a cause of life-threatening hyperkalemia in patients with chronic renal failure. Journal of the American Medical Association 234: 738–740

Ginaldi S (1988) Geophagia: an uncommon cause of acute abdomen. Annals of Emergency Medicine 17: 979–981

Glickman LT, Camara AO, Glickman NW, McCabe GP (1999) Nematode intestinal parasites of children in rural Guinea, Africa: prevalence and relationship to geophagia. International Journal of Epidemiology 28: 169–174

Gray SF (1848) Gray's supplement to the pharmacopoeia. London

Grivetti LE (1978) Culture, diet and nutrition: selected themes and topics. Bioscience 28: 171–177

Guarino A, Bisceglia M, Castellucci G, Iacono G, Casali LG, Bruzzese E, Musetta A, Greco L, and the SIGEP Study Group for Smectite in Acute Diarrhea (2001) Smectite in the treatment of acute diarrhea: a nationwide randomized controlled study of the Italian Society of Pediatric Gastroenterology and Hepatology (SIGEP) in collaboration with primary care pediatricians. Journal of Pediatric Gastroenterology and Nutrition 32: 71–75

Gusdon JP, Tunca C (1974) Pica mimicking abruptio placenta. Obstetrics and Gynecology 43: 197–199

Haller JS (1972) The negro and the southern physician: a study of medical and racial attitudes. Medical History 16: 238–253

Halsted JA (1968) Geophagia in man: its nature and nutritional effects. American Journal of Clinical Nutrition 21: 1384–1393

Hamilton G (1998) Let them eat dirt. New Scientist 159 (no. 2143): 26–31

Henry J, Kwong AM (2003) Why is geophagy treated like dirt? Deviant Behavior 24: 353–371

Hertz H (1947) Notes on clay and starch eating among Negroes in a Southern urban community. Social Forces 25: 343–344

Hooda PS, Henry CJK, Seyoum TA, Armstrong LDM, Fowler MB (2002) The potential impact of geophagia on the bioavailability of iron, zinc and calcium in human nutrition. Environmental Geochemistry and Health 24: 305–319

Hook EB (1978) Dietary cravings and aversions during pregnancy. American Journal of Clinical Nutrition 31: 1355–1362

Horner RD, Lackey CJ, Kolasa K (1991) Pica practices of pregnant women. Journal of the American Dietetic Association 91: 34–38

Hunter JM (1973) Geophagy in Africa and the United States: a culture-nutrition hypothesis. Geographical Review 63: 170–195

Hunter JM, Horst OH, Thomas RN (1989) Religious geophagy as a cottage industry: the holy clay tablet of Esquipulas, Guatemala. National Geographic Research 5: 281–295

Intawongse M, Dean JR (2006) *In-vitro* testing for assessing oral bioaccessibility of trace metals in soil and food samples. Trends in Analytical Chemistry 25: 876–886

Irvine FR (1952) Supplementary and emerging food plants of west Africa. Economic Botany 6: 23–40

Johns T (1986) Detoxification function of geophagy and domestication of the potato. Journal of Chemical Ecology 12: 635–646

Keay J (1993) Eating dirt in Venezuela. In: Keay J (ed) The Robinson book of exploration. Robinson, London: 344–350

Key TC, Horger EO III, Miller JM (1981) Geophagia as a cause of maternal death. Obstetrics and Gynecology 60: 525–526

Kişlal F, Kanbur NÖ, Derman O, Kutluk T (2003) Diagnostic appearance of abdominal roentgenogram in pica. Pediatrics International 45: 491–493

Knishinsky R (1998) The clay cure: natural healing from the earth. Healing Arts Press, Rochester

Lacey EP (1990) Broadening the perspective of pica: literature review. Public Health Reports 105: 29–34

Lagercrantz S (1958) Geophagical customs in Africa and among the Negroes in America. In: Anell B, Lagercrantz S Geophagical customs. Studia Ethnographica Upsaliensia 17: 24–84

Laufer B (1930) Geophagy. Field Museum of Natural History Publication 280. Field Museum Press, Chicago

Lawson A, Moon HP (1938) A clay adjunct to potato dietary. Nature 141 (no. 3557): 40

Lawson J (1709) A new voyage to Carolina; containing the exact description and natural history of that country: together with the present state thereof. London

Loveland CJ, Furst TH, Lauritzen GC (1989) Geophagia in human populations. Food and Foodways 3: 333–356

Luoba AI, Geissler PW, Estambale B, Ouma JH, Magnussen P, Alusala D, Ayah R, Mwaniki D, Friis H (2004) Geophagy among pregnant and lactating women in Bondo District, western Kenya. Transactions of the Royal Society of Tropical Medicine and Hygiene 98: 734–741

Luoba AI, Geissler PW, Estambale B, Ouma JH, Alusala D, Ayah R, Mwaniki D, Magnussen P, Friis H (2005) Earth-eating and reinfection with intestinal helminths among pregnant and lactating women in western Kenya. Tropical Medicine and International Health 10: 220–227

Luvos (2007). Adolf Justs Luvos® Heilerde. http://www.luvos.de. Cited 26 Jul 2007

Lyell C (1850) Second visit to the United States of North America. Volume 2. John Murray, London

MacClancy J (2007) Earthy realism: geophagia in literature and art. In: MacClancy J, Henry J, Macbeth H (eds) Consuming the inedible: neglected dimensions of food choice. Berghahn Books, New York: 224–233

Madkour AA, Madina EMH, El-Azzouni OEZ, Amer MA, El-Walili TMK, Abbass T (1993) Smectite in acute diarrhea: a double-blind placebo-controlled clinical trial. Journal of Pediatric Gastroenterology and Nutrition 17: 176–181

Mahaney WC, Milner MW, Hs M, Hancock RGV, Aufreiter S, Reich M, Wink M (2000) Mineral and chemical analysis of soils eaten by humans in Indonesia. International Journal of Environmental Health Research 10: 93–109

Marchi M, Cohen P (1990) Early childhood eating behaviors and adolescent eating disorders. Journal of the American Academy of Child and Adolescent Psychiatry 29: 112–117

Marett JR de la H (1936) Race, sex and environment: a study of mineral deficiency in human evolution. Hutchinson Scientific, London

Martindale W (1993) Martindale: the extra pharmacopoeia. Reynolds JEF (ed). Pharmaceutical Press, London

Mason D (1833) On atrophia a ventriculo (mal d’estomac) or dirt-eating. Edinburgh Medical and Surgical Journal 39: 289–296

MedlinePlus® (2006) Clay. http://www.nlm.nih.gov/medlineplus/druginfo/natural/patient-clay.html. Cited 4 Aug 2008

Mengel CE, Carter WA, Horton ES (1964) Geophagia with iron deficiency and hypokalemia. Archives of Internal Medicine 114: 470–474

Minnich V, Okçuoğlu A, Tarcon Y, Arcasoy A, Cin Ş, Yörükoğlu O, Renda F, Demirağ B (1968) Pica in Turkey. II. Effect of clay upon iron absorption. American Journal of Clinical Nutrition 21: 78–86

Mitchell WM (1968) Pica in adults. California Medicine 109: 156–158

Mokhobo KP (1986) Iron deficiency anaemia and pica. South African Medical Journal 70: 473–475

Moore DF, Sears DA (1994) Pica, iron deficiency and the medical history. The American Journal of Medicine 97: 390–393

Mustacchi P (1971) Cesare Bressa (1785–1836) on dirt eating in Louisiana: a critical analysis of his unpublished manuscript ‘De la Dissolution Scorbutique’. Journal of the American Medical Association 218: 229–232

Nchito M, Geissler PW, Mubila L, Friis H, Olsen A (2004) Effects of iron and multimicronutrient supplementation on geophagy: a two-by-two factorial study among Zambian schoolchildren in Lusaka. Transactions of the Royal Society of Tropical Medicine and Hygiene 98: 218–227

Nielsen H (1974) Ancient ophthalmological agents. Odense University Press, Odense

Oomen AG, Rompelberg CJM, Bruil MA, Dobbe CJG, Pereboom DPKH, Sips AJAM (2003) Development of an *in vitro* digestion model for estimating the bioaccessibility of soil contaminants. Archives of Environmental Contamination and Toxicology 44: 281–287

Oomen AG, Rompelberg CJM, Van de Kamp E, Pereboom DPKH, De Zwart LL, Sips AJAM (2004) Effect of bile type on the bioaccessibility of soil contaminants in an *in vitro* digestion model. Archives of Environmental Contamination and Toxicology 46: 183–188
O'Rourke DE, Quinn JG, Nicholson JO, Gibson HH (1967) Geophagia during pregnancy. Obstetrics and Gynecology 29: 581–584
Parry-Jones B, Parry-Jones WLl (1992) Pica: symptom or eating disorder? A historical assessment. British Journal of Psychiatry 160: 341–354
Paustenbach DJ (2000) The practice of exposure assessment: a state-of-the-art review. Journal of Toxicology and Environmental Health. B – Critical Reviews 3: 179–291
Phillips TD (1999) Dietary clay in the chemoprevention of aflatoxin-induced disease. Toxicological Sciences 52: 118–126
Rackham H (translator) (1938) Pliny: Natural History. Heinemann, London
Rake B (1884) A fatal case of earth-eating. British Medical Journal: 994-995
Reid RM (1992) Cultural and medical perspectives on geophagia. Medical Anthropology 13: 337–351
Reilly C, Henry J (2000) Geophagia: why do humans consume soil? Nutrition Bulletin 25: 141–144
Reimann F, Koptagel G (1980) Geophagia in iron deficiency disease. New Istanbul Contribution to Clinical Science 13: 63–79
Riddle JM (1985) Dioscorides on pharmacy and medicine. University of Texas Press, Austin
Robertson RHS (1986) Fuller's earth: a history of calcium montmorillonite. Volturna Press, Hythe
Robertson RHS (1996) Cadavers, choleras and clays. Mineralogical Society Bulletin 113: 3–7
Rose MS (1975) The search for an effective treatment of paraquat poisoning. Chemistry and Industry (Issue 10, 17th May): 413–415
Ruby MV, Davis A, Schoof R, Eberle S, Sellstone CM (1996) Estimation of lead and arsenic bioavailability using a physiologically based extraction test. Environmental Science and Technology 30: 422–430
Saathoff E, Olsen A, Kvalsvig JD, Geissler PW (2002) Geophagy and its association with geohelminth infection in rural schoolchildren from northern KwaZulu-Natal, South Africa. Transactions of the Royal Society of Tropical Medicine and Hygiene 96: 485–490
Sayers G, Lipschitz DA, Sayers M, Seftel HC, Bothwell TH, Charlton RW (1974) Relationship between pica and iron nutrition in Johannesburg Black adults. South African Medical Journal 48: 1655–1660
Schmidt AVC (ed) (1974) The general prologue to *The Canterbury Tales* and the *Canon's Yeoman's Prologue and Tale*. University of London Press, London
Severance HW, Holt T, Patrone NA, Chapman L (1988) Profound muscle weakness and hypokalemia due to clay ingestion. Southern Medical Journal 81: 272–274
Shellshear ID, Jordan LD, Hogan DJ, Shannon FT (1975) Environmental lead exposure in Christchurch children: soil lead a potential hazard. New Zealand Medical Journal 81: 382–386
Simon SL (1998) Soil ingestion by humans: a review of history, data, and etiology with application to risk assessment of radioactively contaminated soil. Health Physics 74: 647–672
Simpson E, Mull JD, Longley E, East J (2000) Pica during pregnancy in low-income women born in Mexico. Western Journal of Medicine 173: 20–24
Smith B, Rawlins BG, Cordeiro MJAR, Hutchins MG, Tiberindwa JV, Sserunjogi L, Tomkins AM (2000) The bioaccessibility of essential and potentially toxic trace elements in tropical soils from Mukono District, Uganda. Journal of the Geological Society 157: 885–991
Snow LF, Johnson SM (1978) Folklore, food, female reproductive cycle. Ecology of Food and Nutrition 7: 41–49
Solien NL (1954) A cultural explanation of geophagy. Florida Anthropologist 7: 1–9
Spencer WG (translator) (1935) Celsus: *De Medicina*. Volume 1. Heinemann, London
Stagno S, Dykes AC, Amos CS, Head RA, Juranek DD, Walls K (1980) An outbreak of toxoplasmosis linked to cats. Pediatrics 65: 706–712
Stanek EJ III, Calabrese EJ, Barnes R, Pekow P (1997) Soil ingestion in adults – results of a second pilot study. Ecotoxicology and Environmental Safety 36: 249–257

Sweet JM (1935) Sir Hans Sloane: life and mineral collection. Part III: mineral pharmaceutical collection. Natural History Magazine 5: 145–164

Talkington KM, Gant NF, Scott DE, Pritchard JA (1970) Effect of ingestion of starch and some clays on iron absorption. American Journal of Obstetrics and Gynecology 108: 262–267

Temkin O (translator) (1956) Soranus' Gynecology. John Hopkins Press, Baltimore

Thompson DAK (1913) *Terra sigillata*, a famous medicament of ancient times. In: Proceedings of the 17th International Congress of Medical Sciences (Section 23, History of Medicine), London: 433–444

Thomson J (1997) Anaemia in pregnant women in eastern Caprivi, Namibia. South African Medical Journal 87: 1544–1547

Tordoff MG (2001) Calcium: taste, intake, and appetite. Physiological Reviews 81: 1567–1597

Twyman RW (1971) The clay eater: a new look at an old Southern enigma. Journal of Southern History 37: 439–448

Ukaonu C, Hill DA, Christensen F (2003) Hypokalemic myopathy in pregnancy caused by clay ingestion. Obstetrics and Gynecology 102: 1169–1171

Van Wijnen JH, Clausing P, Brunekreef B (1990) Estimated soil ingestion by children. Environmental Research 51: 147–162

Vermeer DE (1966) Geophagy among the Tiv of Nigeria. Annals of the Association of American Geographers 56: 197–204

Vermeer DE (1971) Geophagy among the Ewe of Ghana. Ethnology 9: 56–72

Vermeer DE, Frate DA (1979) Geophagia in rural Mississippi: environmental and cultural contexts and nutritional implications. American Journal of Clinical Nutrition 32: 2129–2135

Vermeer DE, Ferrell RE (1985) Nigerian geophagical clay: a traditional antidiarrheal pharmaceutical. Science 227: 634–636

Vermeer DE (1986) Geophagy in the American South. Bulletin of the Shreveport Medical Society 37: 38

Vermeer DE (1987) Geophagy in Africa. Bulletin of the Shreveport Medical Society 38: 13–14

Vikan G (1984) Art, medicine, and magic in early Byzantium. Dumbarton Oaks Papers 38: 65–86

Volpato (1848) On allotriophagia, or endemic pica. British and Foreign Medico-Chirurgical Review 2: 254–255

Waller H (1880) The last journals of David Livingstone in central Africa. Volume 2. John Murray, London

Watt G (1908) The commercial products of India: being an abridgement of "The dictionary of the economic products of India." John Murray, London

Wedeen RP, Mallik DK, Batuman V, Bogden JD (1978) Geophagic lead nephropathy: case report. Environmental Research 17: 409–415

Weiss ST (2002) Eat dirt – the hygiene hypothesis and allergic diseases. New England Journal of Medicine 347: 930–931

Wiley AS, Katz SH (1998) Geophagy in pregnancy: a test of a hypothesis. Current Anthropology 39: 532–545

Wong MS, Bundy DAP, Golden MHN (1991) The rate of ingestion of *Ascaris lumbricoides* and *Trichuris trichiura* eggs in soil and its relationship to infection in two children's homes in Jamaica. Transactions of the Royal Society of Tropical Medicine and Hygiene 85: 89–91

Woywodt A, Kiss A (2002) Geophagia: the history of earth-eating. Journal of the Royal Society of Medicine 95: 143–146

Wrenn K (1989) Fecal impaction due to geophagia. Southern Medical Journal 82: 932

Young SL, Ali SM (2005) Linking traditional treatments of maternal anaemia to iron supplement use: an ethnographic case study from Pemba Island, Zanzibar. Maternal and Child Nutrition 1: 51–58

Young SL, Pelto GH (2006) Core concepts in nutritional anthropology. In: Temple NJ, Wilson T, Jacobs DR (eds) Nutritional health: strategies for disease prevention. Humana Press, Totowa, NJ: 425–437

Young SL (2007) A vile habit? The potential biological consequences of geophagia with special attention to iron. In: MacClancy J, Henry J, Macbeth H (eds) Consuming the inedible: neglected dimensions of food choice. Berghahn Books, New York: 67–79

Young SL, Goodman D, Farag TH, Ali SM, Khatib MR, Khalfan SS, Tielsch JM, Stoltzfus RJ (2007) Geophagia is not associated with *Trichuris* or hookworm transmission in Zanzibar, Tanzania. Transactions of the Royal Society of Medicine and Hygiene 101: 766–772

Part VI
Soil—the Dark Side and the Light Side

Chapter 24
Soil and Warfare

C.E. Wood

In 1980, soil caused the failure of a military mission with national consequences. Attempting to rescue its hostages in Iran, the United States launched a covert operation to liberate the captives and free itself from a difficult international situation. In this event, dust's obscuring effect had a tragic consequence at Desert One, the mission's forward operating base. Trying to organize the chaotic situation on the Iranian desert floor at night, a helicopter received permission to move; but rather than taxiing to the prescribed position, the aircraft lifted off. The pilot should have known from a similar experience minutes earlier that the dust created by his own prop-wash would hinder his ability to see until he could rise above the cloud. Despite this knowledge, the helicopter was immediately lost in a cloud of dust, and the combat controller, a ground guide meant to assist him, could not see. The airborne soil so effectively blocked the pilot's vision that the helicopter drifted left about twenty-five feet off the deck and struck a transport aircraft, which caused a massive fireball that killed eight servicemen and led to the mission's demise (Kyle 1990).

24.1 Soil Moisture Effects

Soil has been, and always will be, an essential aspect of war. Admittedly, warfare has occurred on bodies of water and in the air, but neither provides a significant comparison to the magnitude of ground warfare. In addition, humans have fought on all soil types. With the limited scope of this chapter, even a brief examination of how warfare occurred on different soil types is too great an issue to tackle. Soil texture in its natural state, be it composed largely of sand, silt, or clay, does not influence warfare to the same degree soil moisture does. Hence, it is the intent of this chapter to examine how extremes in soil moisture content affect warfare. The organization of this chapter borrows heavily from the author's book *Mud: A Military History*, but the inclusion of dust, the other extreme of soil moisture, is an essential addition.

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Trying to determine the proper air inflation standards for tire classification during World War II, the U.S. Army developed a system for classifying mud, which was necessary to provide a constant for measurement. The individuals leading the experiment decided to divide mud into Type I and Type II, the latter containing two sub-classifications. Type I mud (bottomless) is wet soil so deep that an Army 2½ ton truck becomes immobilized in such a way that its tires cannot grab anything solid beneath it, or when tires are inflated to a pressure of 20 pounds per square inch (1.4 bar), cannot keep the vehicle from immobilization. Type I mud differs from Type II only in the depth of the mud. Type II delineates any variety of mud not deep enough to immobilize a 2½ ton truck. Type IIa mud has more fluidity than Type IIb; it has a cleaning quality to it that is absent in Type IIb. Although the following description does not differentiate Type IIa from IIb, it helps explain it: If a handful of mud is thrown against a wall and it slides down the wall, appearing to 'clean' the wall as it does, then it is Type IIa. If the mud sticks to the wall, then it is Type IIb (U.S. Army War Department 1944).

Soil influences warfare due to its effects and characteristics; depending on soil type and soil moisture, it can be hard or soft, and differ in how easily it is moved from its position on the landscape (Wood 2006). Consider some examples: frozen mud is hard; non-frozen mud is soft. An excellent example of mud's softness was the experience of U.S. Army medic Daniel ("Doc") Evans who, after being thrown from a damaged and falling helicopter in Vietnam, walked away from the crash when he landed in a rice paddy full of mud (Evans and Sasser 1998).

Excessively moist soil exhibits characteristics such as adhesiveness and lubricity. At times, mud can be deep enough to swallow vehicles; but it can also have a slippery or adhesive quality (Wood 2006). When the soil-moisture content of mud is low, it loses its cleaning quality and tends to be more adhesive. Mud that clings to boots and leggings only aids in tiring combatants. As anyone who has walked through a field with sticky mud can attest that it becomes annoying and eventually exhausting to carry additional weight in the form of wet soil (Wood 2006). The other effect of mud is its lubricity—its slipperiness. Without a formative base, slippery mud prevents combatants from gaining the necessary traction and avoiding falling. During World War II, mud's slipperiness allowed mines to move when heavy rains saturated the soil and the mud's lubricity shifted them from their prepared positions. This shifting of the devices did not change their desired effect against the enemy, but made minefield removal more challenging (133rd Infantry 1944; Wood 2006). During the First Crusade, heavy rains in what is now Turkey killed as many Crusaders as had the Turks to that point. The combination of slippery paths of mud with dramatic drops in elevation caused horses to lose their footing and fall, taking entire baggage teams with them. The conditions were so bad that knights did not risk riding their mounts, and the footing was so precarious that the aristocratic warriors were willing to sell their armor to lesser knights to lighten their load and thereby stand a better chance of surviving that part of the trip (Ereira and Wallace 1995).

Three effects of mud that influence warfare are its churnability, its ability to reduce the force of explosions, and the suction it creates. In addition to these effects, soil can also serve as an obscurant. Churnability's effect on trafficability is not as forthcoming to many people as are mud's other characteristics, but it might be the most influential on the conduct of a battle or campaign. What is meant by "churnability" is the soil's alteration due to outside factors. From the standpoint of military operations, a given piece of terrain does not become a bog just because the soil is supersaturated, but only when humans, animals, vehicles, and explosions interact with it, and it then loses it normal structure (that may have taken many years to form). Terrain, especially excessively dry or wet, loses its ability to maintain its foundation and can collapse (Wood 2006). For example, in 1600 when Ishida Mitsunari's Western Army of 50,000 samurai marched toward Japan's pivotal Battle of Sekigahara, the massive number of feet and hooves turned the road into a quagmire (Turnbull 1977). In June 1812, a column of Napoleon Bonaparte's invading army halted in a field saturated by recent rains. The constant plodding of the men in the constricted area churned the open ground into a swamp (Walter 1991). During World War II, Belton Cooper noticed that assaults and roads were not the only things chewed up terrain. As a maintenance officer, he observed that recovery vehicles and the immobilized vehicles they hauled turned maintenance sites into quagmires (Cooper 1998). In Fig. 24.1, vehicle traffic on a muddy road in Talasea, New Britain has destroyed its base effectively enough for a truck to become mired on June 6, 1944.

Mud has the capacity to grab and hold combatants and machines, and this has caused great difficulties in times of conflict. For mud to develop this effect, it needs to be deep enough to enclose the object. To hold boots, the mud must at least be able to grasp the sole. To ensnare a tank, the mud must reach above the road wheels. During the winter of 1917-18, T. E. Lawrence (of Arabia) also discovered mud's hold. He fell through a frozen mudflat and could not free himself from the waist-deep adhesive soil. Luckily, his camel sensed his predicament and came close enough for him to grab her and extricate himself from the mud (Graves 1927). World War I's fighting around Passchendaele, Belgium in 1917 demonstrated the power of General Mud. The battle took place on largely reclaimed marshland, and the intense British bombardment only exacerbated the terrain's inability to support a major offensive. Combined with heavy rains, the ground around Passchendaele became an enormous lake of Type I mud, a result of the heavy British preparatory bombardment of perpetually wetland. For example, when firing on advancing German soldiers, Allan Marriott, a New Zealander, felt that the mud was worse for his foe than his bullets; the wet soil trapped the Germans, making them sitting ducks (Marriott 2005). Also at Passchendaele, the American surgeon Harvey Cushing observed that the mud was so bad that he had to curl his toes within his boots or lose them to the mud. He added that every article of clothing below the waist was susceptible to loss in this way, surmising that the suction created by the mud was one reason why the British wore suspenders (Cushing 1936). In Fig. 24.2, members of the 9th Infantry Division help each other cross a muddy Mekong Delta ditch in August 1967.

Fig. 24.1 On June 6, 1944, a mired truck of the 115th Engineer Battalion is hauled out of the mud on Talasea, New Britain. RG 005S Signal Corps Collection, Box 27, U.S. Army Military History Institute, Carlisle Barracks Pennsylvania

Another effect of mud is its ability to dampen or soften impacts. Dampening is most noticeable with artillery and high explosives. In addition, the softening power of mud, a result of the soil's inability to maintain structure, saves the occasional life. During Passchendaele, Marriott noted that the mud was so deep that German shells penetrated it, but did not explode until well into the mud. The resulting explosion did no more than toss wet soil in the air. He also noted that explosions in the deep mud did force him and his comrades to dig out a few fellow soldiers every night, and although the prospect of suffocating under a wave of mud was anathema, the mud shielded them from shrapnel (Marriott 2005).

Mud's inability to support significant weight is a liability for artillery—not the weight of the gun necessarily, but the need to reset the gun to its original position after each shot. More modern guns with recoil mechanisms still contend with the energy that the gun's fire transfers to the ground. At Poelcappelle, Belgium in 1917, a New Zealand artillery battery described the nightmare of attempting to provide accurate fire. Every time the unit fired its weapons, the gun trails dug into the mud—deeper and deeper—requiring the artillerymen to manhandle the gun back into place and re-lay it—a very inefficient method of fire support (Prior and

Fig. 24.2 In August 1967, infantrymen from the U.S. Army's 9th Division's 3rd Bn., 47th Inf. help a buddy across one of the muddy ditches in Vietnam's Mekong Delta. RG 123S, Vietnam Photos Miscellaneous Collection, Box 6, U.S. Army Military History Institute, Carlisle Barracks Pennsylvania

Wilson 1996). The problem continued half a century later. In Vietnam, the mud was so severe that after firing only a few rounds, entire batteries of towed 155-mm artillery had to shift to more desirable positions, a time-consuming and exhausting process (Collins 1998).

Soil obscures the battlefield and its warriors, hindering visibility in two ways. One is to hinder the ability of the individual to observe when enclosed in a dust storm, or very near to the obscuring agent. Keep in mind that not all dust comes directly from the soil. Much of the dust encountered in urban warfare derives from building materials destroyed in the fighting. The other method, in which soil hinders observation, is to hide the object in question—whether a vehicle, a combatant, or the movement or action of large bodies of troops. Dust is the obscuring agent more often than mud, but mud can also hide combatants and matériel. Rarely, however, do commanders use mud as a way of hiding massive numbers. Mud is more frequently an obscuring agent on the tactical level, when soldiers use mud as a form of camouflage, or to remove the glare from metal objects and optics. With the Japanese preference for edged weapons, Lance Corporal Sakano Toshiyuki, a veteran of World War II, recalled a time when his unit covered their bayonets in mud to camouflage their gleam in the moonlight (Nunneley and Tamayama 2000).

Dust can also hide items on the tactical level, and is capable of obscuring large-scale actions and objects, such as the movement of troops, vehicles, and even the progress of a battle. The obscuring quality of dust can also aid soldiers. It can hide the exact numbers of an attacking unit. Two schools of thought exist on this tactic. Some commanders teach their vehicle crews about 'dust distance', and that no matter how annoying it is, to stay just within the cloud of dust created by leading vehicles. In this way, enemy efforts to count exact numbers prove difficult, as many vehicles and soldiers are unseen within the dust cloud. Other commanders find driving in clouds of dust a hazardous undertaking.

Closely related to the concept of dust as an obscurant is its opposite counterpart—dust being a method of detection. Just as dust has the ability to hide individual tanks in a column, the same dust that hides the tanks also alerts the enemy that something is approaching. The military strategist Sun Tzu (Sun Zi) not only noted the value that dust held for identifying an approaching enemy, but went so far as to explain that the *way* dust appeared gave away the composition of the approaching force. For example, he stated that dust hanging in "high straight columns" foretold the appearance of chariots; but when it hung low and spread out, the dust foretold the approach of foot soldiers. Also, the presence of dust in random locations told a commander that the enemy was collecting firewood, but small patches of dust that came and went meant that the enemy was encamping (Sun Tzu 1982). Not only could the size of the unit be apparent, but veterans of modern combat learned to tell whether the vehicles making the dust were wheeled or tracked (Toppe 1952). Erwin Rommel, Germany's famous Desert Fox, did not stop with just sending trucks to mislead the enemy. In 1942, he also had airplane propellers added to some vehicles for creating dust clouds, and these vehicles became the integral parts of dust-creating units (Toppe 1952).

In desert-like areas, where dust rises with the slightest footsteps, it is nearly impossible to move without creating a dust cloud and telegraphing one's position. While advancing on the Japanese in Burma, William Slim, a British general, noted that his army's movements in March 1945 could not be kept from the enemy, since the dust alerted them to his every move (Slim 1956). Dust also influenced the employment of direct fire artillery. Not only did dust appear with each shot, betraying the position to the enemy, but the rising soil prevented the gun crew from observing their shot (Toppe 1952). Rommel gave dust and smoke credit for his victory at Ras el Madauer. Bombs from Stuka dive bombers lifted so much dust and smoke that the British defenders could not retaliate with accurate fire and could not prevent the assault (Toppe 1952). When enemy guns spotted dust kicked up by movement, they often fired. Fighting the Germans near Caen, France, British tanker, John Hodges, noted that very little movement was necessary for the Germans to respond with a number of shells (Beale 1995).

Fighting in Northwestern Europe, Canadian forces discovered that during armored assaults only their lead tanks escaped the dust that they created, and all those vehicles that followed were in the obscuring cloud. If the number of vehicles involved neared one hundred, then the resulting dust clouds also blinded the follow-on vehicles. Although these intense dust clouds concealed their exact location, they also proved hazardous. During one attack that the Canadians launched against the Germans, such a blinding cloud of dust resulted in the loss of a brigadier and his intelligence officer. In that instance, the Canadian vehicles, being in a dust cloud created by the movement of a preceding armored brigade, were unable to determine their exact placement in the attack formation. The assault's lead vehicles swung too far out of the obscuring cloud of soil and into the observation and range of German tanks, which promptly fired on them (Kitching 1993).

One American Infantry regiment at least tried to remedy the problematic dust clouds raised by their vehicles. Their maintenance section began altering the exhaust pipes on its 2½ ton trucks, moving the exhaust opening to point sideways instead of down and thereby reduce the amount of dust created. The same unit also developed a remedy for mud. To prevent the exhaust pipes from becoming clogged with mud, they welded an extension to the exhaust exit, raising its height (133rd Infantry 1945).

Dust impeded aircraft as well. In desert-like terrain, formation take-offs were uncommon due to the dust thrown up by the first aircraft. German pilots in Africa tried to take-off with a cross wind, so that the dust raised would move across the runway and not hinder the next plane in line (Toppe 1952).

Dust and mud also camouflage. When laying-low against the soil, or moving in a cloud of dust, a covering of soil material worked well to disguise and mislead a potential enemy. German soldiers marching in great clouds of dust noticed that the fine powder had the ability to help them blend in with the cloud, thus obscuring their movement from observation. Harald Henry, a German soldier, observed that dust even caused a loss of distinction between those who were blond and those who were brunette (Fritz 1995). Guy Sajer, an Alsatian fighting against the Soviet Union, wrote that the dust was so pervasive in the summer of 1943 that their uniforms appeared the same color as the ground, providing an excellent method of camouflage (Sajer 1990).

24.2 Seasonal Climate Changes

Soil's most important influence on warfare is as an agent of counter-mobility. The counter-mobility aspect of soil comes in three forms based on temporal factors. Soil moisture extremes can be permanent, seasonal, or random. The mud found in swamps and other wetlands forms a permanent barrier to the efficient movement of armies. Similarly, commanders can expect to encounter dust in deserts and steppes. In geographic regions prone to either excessive amounts of moisture, or during periods when precipitation is insufficient, one can predict seasons when either mud or dust will influence movement. Random instances, such as when a period of unanticipated heavy precipitation or drought alters the normal state of the area, remain as strategic and tactical challenges for field commanders.

Too much soil moisture and the resultant muddy terrain is the greater obstacle to mobility; in contrast, dry soil and its subsequent dust obscures, but rarely prevents movement. Thus, swamps and other wetlands act as one of the great, permanent obstacles to maneuver. An excellent example of how swamps can hinder a battle occurred during the War of 1812's Battle of New Orleans. In that instance, the American general Andrew Jackson anchored his battle-line that stretched from the Mississippi River on one end to a swamp on the other. In all wars, but especially during the age of linear warfare, turning an enemy's flank was a frequent tactical goal. By doing so, the force that attacks its enemy's side could bring more guns into firing position than the foe. A way to prevent this was to tie a line of soldiers to a defensible geographic barrier such as a river, a cliff, or a swamp. The British were aware that conditions would be difficult, and Jackson knew he could count on the mud to hinder, if not prevent, the British from marching around his flank. In the action that resulted, the British did not make any serious attempt to negotiate the excessively wet soil. Instead, they made frontal attacks that not only failed, but resulted in devastating losses to the British and minimal casualties to the Americans (Wood 2006).

Seasonal conditions create mud and dust depending on the climate, soil type, vegetative cover and other considerations. Dust again acts chiefly as an obscurant, but it is mud that truly hinders movement. Seasonal precipitation patterns, such as monsoons, can produce "mud seasons" that can severely hamper military operations. One of the most famous examples of the impact of such seasonal mud is the German offensive against the Soviet Union in 1941. The Germans intended to invade in the late spring, but strategic commitments in the Balkans delayed the invasion. The Germans knew from Napoleon Bonaparte's experiences that the Russian winter warranted their consideration. However, the Germans should have known, but did not consider, the powerful Russian mud season known as the *rasputiza*. In fact, it was the *rasputiza* that halted the German blitzkrieg and not the Russian winter. Thus, the arrival of freezing temperatures in early November finally allowed the mud to freeze, which freed German motorized columns to continue their drive into the Soviet interior.

Mud is a seasonal factor in other areas of the world as well. Monsoons in Southeast Asia played a key role in slowing Slim's advance of British and Commonwealth forces in 1944. More than twenty years later, the North Vietnamese also had to accept the power of the monsoon and reduce the number of troops and the amount of supplies they could move down the Ho Chi Minh Trail. Knowing that the North Vietnamese slowed logistic movement on the trail due to the weather, the United States implemented Project Popeye to lengthen the monsoon artificially by cloud seeding, thus reducing troop movements and deliveries of matériels to South Vietnam. From 1967-1972, the United States used cloud seeding to increase precipitation along the trail. However, the results were inconclusive since gathering accurate precipitation data in an active war zone proved difficult, and no one could confidently state that any increased precipitation along the trail was human-induced rather than the result of normally occurring tropical storms (Senate 1974; Wood 2006).

Dust also has a seasonal nature, especially in deserts. When hot winds roll out of the desert center to the outlying regions, they can bring increased temperatures and limited visibility. Lasting for a number of days, these winds have different names depending on the region, including *Khamseen* in Egypt and *Ghibli* in Libya (Gilewitch 2003).

Soil moisture extremes also appear in a random nature. Heavy rainfall or a rapid thaw can create mud when least expected. In addition, an unseasonable drought and steady winds raise dust when it is not expected. Fighting in the Soviet Union, Wilhelm Prüller, a German infantryman, noted the rather odd instance when mud and dust existed side-by-side. While moving with his unit he discovered that although mud existed along the shoulders of the road on which he traveled, the middle of the road was full of dry, dusty soil (Fritz 1995).

An excellent example of the power of random mud is the Battle of Waterloo. In this instance, mud was not part of the plan used by Napoleon or Arthur Wellesley, the Duke of Wellington, but it played a significant role in the campaign. Wellington won the battle when allied Prussian troops under Field Marshal Gebhard Leberecht von Blücher arrived on the battlefield. Their timely and decisive arrival was possible because they had a head start through the mud, which hindered French pursuit. However, Napoleon could have won the battle before Blücher arrived. On the advice of his artillery commander, Napoleon decided to delay the opening salvo of the engagement. The French felt that the mud at Waterloo was in such quantity that its dampening effect would prevent French artillery from being as effective as possible. Artillery ammunition consisted of shells and cannonballs; the former exploded and threw chunks of metal into the air. For cannonballs to be effective, the soil needed to be firm, allowing the round to bounce and ricochet into concentrations of troops. Neither type of ammunition was effective in mud. Thus, due to the wet soil, Napoleon delayed the battle's opening moves. Had he attacked earlier in the morning, he may have had enough men and spirit to defeat Wellington's force (Wood 2006).

Mud also hinders air power operations. Rain does not normally curtail flight operations, but rain's byproduct-mud can stop sorties if the airfield has a grass or dirt runway. The lack of a sustained Allied air attack during the retreat of the German Afrika Korps following the Battle of El Alamein was the result of heavy rains over the Nile Delta that prevented Allied sorties (Toppe 1952). Not only did mud hinder the ability of aircraft to fly, but on at least one occasion, it prevented birds from their necessary mission. During Passchendaele, the situation was so bad that mud-soaked pigeons, used to convey messages, could not fly (Prior and Wilson 1996).

At Desert One, during the Iranian Hostage Crisis, the dust cloud encountered by the eight-helicopter element of the rescue team caused a delay. The airborne dust was a local phenomenon known as a *haboob* and formed from the downdraft of air that occurs in conjunction with far off thunderstorms. The dust stays in the air for hours after the weather system passes, due to lingering low air pressure. When the leader of the helicopter team could not see the ground, and the only other helicopter he could see was his wingman, he decided to get out of the dust immediately. With this action, he split his force, since the rest of the flight continued despite two more helicopters falling out of formation. The dust cloud proved dense enough to stop part of the formation, whose commander waited for the dust to disperse and allow him to fulfill his mission; but until then, he fell further behind schedule. The mission ended with the catastrophe described at the beginning of this chapter (Kyle 1990).

24.3 Soil and Health

In addition to extremes of soil moisture acting as agents of counter-mobility, soil has significant influence on the health of combatants. Mud can cause death. Deep mud, especially the fluid variety, has drowned men who were wounded or in some way incapable of the energy needed to keep their heads out of it. Animals seem especially prone to expiring in such a horrendous manner, and accounts of such occurrences are common. In January 1863, Alpheus Williams, a Union general, described how he observed mules drowning in large mudholes (Williams 1995). In 1836, as Mexican forces retreated from the Battle of San Jacinto, they encountered a sea of mud; yet some beasts of burden survived. Mexican general Vicente Filisola stated in his memoirs that he saw all the accoutrements of war floating in the morass. Mules, still harnessed, were stuck in the quagmire, and the only thing that kept them from drowning was the buoyant cargo still on their backs (Dimmick 2004).

The deep mud at Passchendaele killed an unknown number of soldiers. Marriott noticed that German stretcher-bearers had dashed out to shell holes to collect wounded comrades, but then halted as they realized that the men had drowned in the depressions (Marriott 2005). One can understand that the mortally wounded are the most likely victims of drowning in mud, but even lightly wounded soldiers are vulnerable. At Passchendaele, the commander of the 7th Seaforth Highlanders recorded how one wounded soldier walked away from the frontline. The next day, fellow soldiers discovered the man stuck in a shell hole. Sixteen rescuers used a variety of hand tools to try to extricate the poor wretch; but finally they were forced to leave him when the battalion rotated to the rear, and they never learned of his fate (Prior and Wilson 1996).

Mud is also responsible for additional deaths when casualty evacuation becomes a problem. This has become less an issue in recent years, due to the development and deploying of tracked vehicles and aircraft. But during World War I, while medical technology was capable of saving soldiers, getting them to it was the problem. According to Marriott (2005) and Cushing (1936), heavy mud required using six to eight stretcher-bearers to carry a wounded man. Slim recorded in his autobiography that rough and dusty roads used for evacuating the wounded out of Burma in 1942 were hellish, and he did not believe that many soldiers survived the journey (Slim 1956).

Dust and mud are excellent vectors for germs and disease to enter the body. The very small size of airborne soil particles makes it easy for dust to penetrate the body through the mouth, nose, ear cavities, and via breaks in the skin. Mud also acts as an excellent vector for the introduction of bacteria. Higher moisture content in the soil gives mud its plasticity, especially Type IIa, and this state allows it to easily penetrate wounds and other breaks in the skin. Also, the close proximity of soldiers to the ground, especially in the modern era, has brought combatants nearer to soil-based bacteria. More lethal weapons like machine-guns forced combatants to hug Mother Earth, increasing the opportunities for soldiers to acquire pathogens from the soil (Wood 2006). One particular health hazard derived from the soil came to light during World War I. Due to the manure-laden farms of France and Belgium, a particular bacillus normally located in a horse's gut, found its way into the wounds and numerous cuts that soldiers had, causing gas gangrene (Ellis 1970).

Dust is an excellent way for soil to enter the mouth and lungs. Marching around Port Arthur during the Russo-Japanese War, Sakurai Tadayoshi remembered how dust billowed up from the feet of the many Japanese soldiers; he described it as having a consistency like ashes, and these dust particles filled his throat (Sakurai 1999). U.S. Marine William Manchester, wondered about the thick air on Okinawa's Sugar Loaf Hill. Due to the coral dust and clouds of smoke, he likened the feeling to being a "blind man trying to identify an elephant by feeling his legs" and wondered what levels of air pollution resulted (Manchester 1979). The amount of dust raised by horses interfered with their breathing as well. Siegfried Knappe, a German officer fighting in the Soviet Union, noticed the horses coughing as the dust rose from all the trampling soldiers' feet and horses' hooves (Knappe 1993).

Daniel Gilewitch noted in his dissertation the presence of sixteen fungi found in a sample of dust that caused medical complaints ranging from lung infections to skin lesions (Gilewitch 2003). Seth Folsom, a Marine officer advancing on Baghdad in 2003, recalled "after the first or second week of being in Kuwait it was expected that everyone would get the 'crud", which he described as an upper respiratory illness caused by pathogens in the feces of humans and animals deposited in the sand and then carried in dust (Folsom 2006). "Of 15,459 surveyed military personnel who were deployed in Afghanistan or Iraq during 2003 and 2004, 69.1% reported some form of respiratory illness" (Griffin 2007) and 36 combatants received a diagnosis of a rare and sometimes fatal condition known as acute eosinophilic pneumonia. A further study led by Mark Lyles, a U.S. Navy captain who holds a doctorate in cellular and structural biology, found 174 different organisms in Iraqi air and identified six genera of bacteria and seven genera of fungi. The fine grit churned into the local air led to so many respiratory problems that troops called it the 'Baghdad hack'—the 'crud' to which Folsom referred (Borell 2008).

One would think that vehicles, both wheeled and armored, had the ability to restrict the entry of dust, but such is not the case. Marines advancing on An Nasiriyah during the Iraq War inhaled large quantities of dust that entered through every means possible in wheeled and armored vehicles; thus when individual Marines moved about, to mention nothing of the dust clouds thrown up by tracked vehicles, they began to cough and choke on the dust entering their lungs. In fact, when a young corpsman realized that he and his Marines were covered in dust after sleeping in the back of a Humvee, he laughed and dust emanated from his mouth (Livingston 2003).

Not only is dust the cause of respiratory problems, it is also an eye irritant. German general Alfred Toppe noted that eye protection proved helpful in reducing problems with his men's eyes. Subsequently, all German soldiers in that theater received dust goggles, which were also a valuable piece of equipment for motorcycle couriers. Major Wladyslaw Zgorzelski, fighting for Polish forces at the Falaise Pocket following the Normandy invasion, observed that the dry soil raised by a plethora of military vehicles found its way into the throats of the soldiers, but was an even worse irritant to the eyes. He wrote in his diary that the dispatch riders had it the worst, being covered in dust; their eyelids were often swollen, and without easy access to water, they found that cider worked poorly as an eyewash (Guttman 2001).

24.4 Morale

Soil also influences warfare as it affects a combatant's morale. Under normal conditions soldiers do not even realize the soil type or its moisture content as they struggle to complete their mission and survive for another day. However, when conditions change enough to hinder movement or obscure vision, then soldiers notice the soil on which they fight. When mud prevails, and its characteristics of stickiness and slipperiness cause degradation in mobility and the inability of an organization to accomplish its mission, morale suffers. Just as deflating is inactivity in muddy or dusty conditions. Living and fighting in large quantities of dust also reduces morale. Marching toward Cawnpore during the 1857 crisis in the Indian army, Sir Colin Campbell remembered that the journey for 3000 people was hellish. The dust created by the column containing wagons, elephants and other beasts of burden was so difficult for the women on the trip that at times, they could not even see the children they held in their arms (Hibbert 1978). In the winter of 1917–18, T. E. Lawrence was on his way to Aqaba over a very wet stretch of ground. His camel fell so often that Lawrence gave in to despair and collapsed in the mud (Graves 1927). In North Africa, German commanders noticed that their soldiers had to struggle against mental depression brought on by great columns of airborne dust (Toppe 1952). The presence of large quantities of airborne soil has annoyed the soldiers of many armies. In 1992, this author hated taking field showers in Somalia. As soon as the shower concluded, it seemed as if a cargo aircraft would land on the nearby grass airstrip and create enough dust to cover his recently clean body.

Having to consume soil, be it mud or dust, as a part of their food, causes morale to suffer accordingly. Sakurai Tadayoshi remembered that dust fully penetrated Japanese lunch boxes. He went on to add that, dust in the food, and the lack of water made his dust-covered march from Yenchia-tun to Changchia-tun, in present-day China, one of his greatest hardships—adding that if such a journey was the price for passing the manhood test of warfare, then he and his colleagues had passed the test (Sakurai 1999).

24.5 Fatigue

Mud and dust degrade the performance capacity and endurance of combatants and matériel. Dust has a considerable effect on automobile performance. When sucked into engine cylinders, soil particles lead to wear on the pistons, causing performance degradation quicker than under normal conditions. When dust combines with lubricants, the resulting mix increases the wear and tear on parts (Gilewitch 2003). For the Germans, operations in North Africa meant moving the air intakes for cars and trucks to the interior of the engine compartments; and for the benefit of tank crews, the dusty air was sucked out of the crew compartment. To emphasize this point, Volkswagen engines had an average lifespan of around 13,000 kilometers in the desert versus an average of 60,000 kilometers in Germany's other theaters of war. Tank engine's life spans fell from an average of 7500 kilometers to 3500 kilometers in the desert.

In addition to vehicles, dust caused the early demise of guns—from larger artillery pieces to handguns. Dust was such a bane that weapons received their own covers for protection against the airborne soil when not in use. Cleaning weapons on a regular basis was essential to prevent not only barrel fatigue, but also wear and tear on moving components within the weapon. Extremely dusty conditions made lubricating the weapons an art form. Lubrication was mandatory to keep the bolts and breeches moving smoothly, but too much lubrication simply attracted more dust and sand (Toppe 1952). Fighting in Normandy, British tanker Trevor Greenwood noted that the dust around Villers Bocage was appalling. The settled dust layer was "an inch deep everywhere" and so much of it covered the guns that they were not to be counted on in a jam (Beale 1995). Gilewitch noted that dust can pit optics, stick to lubricants, jam small arms, and not only cause gun barrels to wear down faster than normal, but on occasion, the weapon can actually plug up with sand and increase the risk of an explosion within the barrel. For vehicles, dust means that lubrication and oil changes are necessarily more frequent, air filters fill faster, and parts fail quicker, requiring a strain on the supply system (Gilewitch 2003). At Passchendaele, a British attack in late October failed to advance when the leading units mired shoulder-deep in the mud. Adding to the debacle, mud prevented rifles and Lewis guns (a type of machine-gun) from operating effectively; additionally Stokes mortars could not fire because the rounds were covered in mud and could not exit the barrel smoothly (Prior and Wilson 1996).

Trying to march or run in mud is exhausting. Whether the mud is deep, slippery, or adhesive, the extricating of boots, maintaining balance, and carrying excessive soil took a toll on a combatant's energy levels. During World War I, Marriott explained that when he and five others helped stretcher-bearers over very deep mud, he could only make two trips before collapsing from fatigue (Marriott 2005). Fighting at Poelcappelle in October 1917, the muddy conditions were so atrocious that soldiers, engaged in what should have been a three-hour movement to the trenches, endured an eleven-hour slog and dropped from fatigue when they arrived at the frontline (Cushing 1936).

The fatigue derived from toiling in Type I mud has led to death. The constant lifting of one's feet in and out of deep mud taxes a combatant's ability to keep going. During the siege of Dien Bien Phu, a French medical doctor, Major Paul Grauwin, mentioned two instances of death from exhaustion. In one such case, he noticed that two men waiting for his attention died before he could care for them. He observed that neither had a wound and the anesthetic was not the cause, but they had died because their vital organs had failed completely (Grauwin 1955).

Dust has also been responsible for deaths. Naval aviators learning their craft at Baron Field Naval Air Station (near Mobile, Alabama) called their base "Bloody Baron" because the soil in the air was prone to be dry, and the dust it created fouled up the air-cooled engines of the Vultee Valiant, ending the lives of more than one student pilot (Hornfischer 2004).

As long as humans continue to fight among themselves, they will fight on the ground, and soil therefore will be a constant presence and factor in warfare. We may wish for wars to disappear, but to really believe that, at this stage in our development, humans will never fight again is naive. In the long term then, combatants will still fight and die on soil.

References

133rd Infantry. (October 1944) "History", 34th Division, World War II Operations Records 1940–48, RG 407, National Archives at College Park.

133rd Infantry. (April 1945) "History", 34th Division, World War II Operations Records 1940–48, RG 407, National Archives at College Park.

Beale, Peter. (1995) *Tank Tracks: 9th Battalion Royal Tank Regiment at War, 1940–45*. Gloucestershire: Sutton Publishing Limited.

Borrell, Brendan. (2008) "Baghdad Hack". The Scientist.com. Volume 22, Issue 12; available at http://www.the-scientist.com/2008/12/1/172/<accessed 14 January 2009>

Collins, John M. (1998) *Military Geography: For Professionals and the Public*. Washington, DC: Brassey's.

Cooper, Belton Y. (1998) *Death Traps: The Survival of an American Armored Division in World War II*. Reprint edition with Foreword by Stephen E. Ambrose. New York: Ballantine Books.

Cushing, Harvey. (1936) *From a Surgeon's Journa*l. Boston: Little, Brown, and Company.

Dimmick, Gregg J. (2004) *Sea of Mud*. Austin: Texas Historical Association.

Ellis, John. (1970) *Eye-Deep in Hell*: *Trench Warfare in World War* I. Reprint, Baltimore: John Hopkins Univ. Press.

Ereira, Alan and David Wallace. (1995) "Volume Two: Jerusalem". *The Crusades*. New York: New Video Group.

Evans, Daniel E., Jr. and Charles W. Sasser. (1998) *Doc: Platoon Medic*. New York: Simon and Schuster.

Fritz, Stephen G. (1995) *Frontsoldaten*. Lexington, KY: The University of Kentucky Press.

Folsom, Seth W. B., Major USMC. (2006) *The Highway War*: A *Marine Company Commander in Iraq*. Washington, D.C.: Potomac Books, Inc.

Gilewitch, Daniel A. (2003) Military Geography: The Interaction of Desert Geomorphology and Military Operations. PhD Dissertation, Arizona State University, United States of America.

Grauwin, Paul. (1955) *Doctor at Dienbienphu*. Translated by James Oliver. New York: John Day, 1955.

Graves, Robert. (1927) *Lawrence and the Arabs*. New York: Paragon House. Reprint.

Griffin, Dale W. (2007) "Atmospheric Movement of Microorganisms in Clouds of Desert Dust and Implications for Human Health." *Clinical Microbiology Reviews*. Volume 20, Number 3; available at http://cmr.asm.org/cgi/content/full/20/3/459<accessed 14 January 2009>

Guttman, Jon. (September, 2001) "Closing the Falaise Pocket". *World War II*.

Hibbert, Christopher. (1978) *The Great Mutiny: India 1857*. New York: Viking Press.

Hornfischer, James D. (2004) *The Last Stand of the Tin Can Sailors*. New York: Random House.

Kitching, George, Major-General. (1993) *Mud and Green Fields: The Memoirs of Major-General George Kitching*. St. Catharines, Ont.: Vanwell Publishing Ltd.

Knappe, Siegfried. (1993) *Soldat*. New York: Dell.

Kyle, James H., Col. USAF (ret.) (1990) *The Guts to Try*. New York: Orion Books.

Livingston, Gary. (2003) *An Nasiriyah*: *The Fight for the Bridges*. North Topsail Beach, NC: Caisson Press.

Manchester, William. (1979) *Goodbye*, *Darkness*. Boston: Little, Brown.

Marriott, Allan. (2005) *Mud beneath My Boots*. Auckland, NZ: HarperCollins.

Nunneley, John and Kazuo Tamayama. (2000) *Tales by Japanese Soldiers*: *Of the Burma Campaign 1942–1945*. London: Cassell.

Prior, Robin and Trevor Wilson. (1996) *Passchendaele*: *The Untold Story*. New Haven: Yale University Press.

Sajer, Guy. (1990) *The Forgotten Soldier*. Reprint, Washington, DC: Brassey's, Inc.

Sakurai, Tadayoshi. (1999) *Human Bullets*. Introduction by Roger Spiller. Lincoln: Bison Books.

Slim, William, Field-Marshal Viscount. (1956) *Defeat into Victory*. New York: Cooper Square Press. Reprint ed.

Sun Tzu. (1982) *The Art of War*. Translated by Samuel B. Griffith. Reprint edition with Foreword by B.H. Liddell Hart. New York: Oxford University Press.

Toppe, Alfred, Major-General. (1952) *Desert Warfare*: *German Experiences in World War II*. Fort Leavenworth KS: U.S. Army Command and General Staff College; available at http://www-cgsc.army.mil/carl/resources/csi/Toppe/toppe.asp

Turnbull, Stephen. (1977) *The Samurai: A Military History*. London: Osprey Publishing.

U.S. War Department. (1944) "*Low Pressure Tires in Mud*." Report No. 796. Fort Belvoir, Va.: U.S. Army Corps of Engineers.

Walter, Jakob. (1991) *The Diary of a Napoleonic Foot Soldier*. Edited and with an Introduction by Marc Raeff. New York: Doubleday.

Williams, Alpheus S. (1995) *From the Cannon's Mouth*: *The Civil War Letters of General Alpheus S. Williams*. Edited by Milo M. Quaife. Reprint with Introduction by Gary W. Gallagher. Lincoln: University of Nebraska.

Wood, C. E. (2006) *Mud: A Military History*. Washington, D.C.: Potomac Books, Inc.

Chapter 25
Yellow Sands and Penguins: The Soil of "The Great Escape"

Peter Doyle, Larry Babits, and Jamie Pringle

25.1 Introduction

To many people, knowledge of "The Great Escape", in which 76 officers of the Allied air forces attempted to escape from a Nazi prisoner of war (POW) camp during the Second World War, is derived from the 1963 John Sturges Hollywood blockbuster of the same name. Sturges' film (starring Steve McQueen, James Garner, and Richard Attenborough) was in turn based on an account by ex-prisoner Paul Brickhill, *The Great Escape* (1951), a book that still holds today as perhaps the best account of the mass escape of March 1944. Central to the plot of both the book and the film is the context of escape from a high security prisoner of war camp built in 1942 to house air force prisoners shot down over the territories of the Third Reich and captured by the *Wehrmacht*.

Accounts of prisoner of war escapes have been popular since the end of the First World War, and it is a fact that many of the escapers of the Second War were influenced by the published accounts of their forebears. Books such as *The Tunnellers of Holzminden* (Durnford, 1920) firmly established tunnelling as a viable means of escape from captivity, itself echoing similar escape attempts in earlier wars, such as the American Civil War of 1861-65. In most cases, the only other alternative to tunnelling was the use of daring and bluff—the act of walking through the gate, hiding in transports, or exploiting weaknesses in the barbed wire that universally surrounded POW camps (Crawley 1956).

Tunnelling from POW camps required appropriate ground conditions, and with most combatants derived from volunteers and conscripted civilians, it is not surprising that amongst the men incarcerated there would be those who had experience of tunnelling. Lt. Jim Rogers of the Royal Engineers was one such man,

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a tunnelling engineer by profession; he was to end up in Oflag IVC, Colditz Castle (the notorious “bad boys camp”), following his failed attempt at a tunnelled escape in 1941 from Oflag VIIC at Laufen, Bavaria (Rogers 1946, 1986). Another was Pilot Officer “Wally” Floody, a Canadian aviator who had spent part of his youth as a miner in Ontario, and the man instrumental in designing the Great Escape tunnels in 1944 (Brickhill 1951). For these men and others, tunnelling through the surface soils of the Reich, and successfully disposing of the waste, were major pre-occupations.

It is not surprising, then that given the central position of tunnelling in the story of *The Great Escape* “soil” (here used in its widest context) is at the heart of the story. Entering popular culture, the relevance of soil to the plot of *The Great Escape* is indicated by the listing (at the time of writing) of “plot keywords” on an internet movie database (www.imdb.com/title/tt0057115/keywords). In the top twenty selected to describe its content are the words “digging” (number 2), “soil” (number 3) and “sand” (number 18). This is to be expected given the popularity of the film and the remarks attributed to *Oberfeldwebel* (Technical Sergeant) Glemnitz, in charge of anti-escape operations at Stalag Luft III (the scene of the Great Escape) “You’ll never get a tunnel out of here, until you find a way of destroying the sand” (Brickhill 1951, p. 51).

At the heart of this problem, expressed forcefully by characters in the film and in Brickhill’s book (and well known by anyone who has seen the movie), is the fact that the surface soil of the camp was “grey dirt”, while just a few inches beneath, the subsoil was universally bright yellow sands, sands that would, as ex-prisoner and escaper Oliver Philpot put it (in an interview for London’s Imperial War Museum), “shine like drops of gold” if spilled anywhere on the camp floor. As Glemnitz had pointed out, “destroying” the sand was to be a major task of any would-be escapers. It is this marked contrast between the surface grey soil and the sub-surface yellow sand of Stalag Luft III (Fig. 25.1) that has entered popular culture, the subject of this contribution.

In 2003, we were presented with the opportunity to examine the former site of Stalag Luft III at Zagan, in order to determine the layout of the camp from the surviving structures, and, if possible, to locate the position of the former escape tunnels, “Tom”, “Dick” and “Harry”. The survey was in association with production company Windfall Films (co-funded by Five/WGBH Boston), and the resulting documentary was aired on Channel Five in the UK and NOVA in the United States (http://www.pbs.org/wgbh/nova/greatescape/). The survey provided a unique opportunity to examine the workings of prisoner of war (POW) escape tunnels, and was ultimately successful, the one tunnel that was not discovered by the prison guards, “Dick” being identified by site survey, geophysics and excavation. Some of the scientific results of the work have been presented previously (Doyle *et al.* 2007; Pringle *et al.,* 2007), this paper is the first to examine one of the most important aspects, the role of the soil in the planning and development of the Great Escape in 1944.

Fig. 25.1 Shallow excavation at the site of the North Compound, Stalag Luft III, showing the distinct colour contrast between the "grey dirt" of the surface soil, and the "yellow sands" below. Displayed are leaf litter overlying 0.1 m humic-rich horizon (A), 0.1 m iron stained horizon (B), with glacial sands (C) beneath. Depth of excavation 0.6 m (see as color plate following *Index*)

25.2 Stalag Luft III: The Camp

Following capture, on land, at sea or from the air, and following transit from holding camps (*Durchlager* or Dulags) the German *Wehrmacht* separated servicemen into their respective arms and ranks. Officers and enlisted men were separated, and sent to many categories of POW camps: *Kriegsgefangener Offizierlager* (Oflags) for army officers, *Kriegsgefangener Stammlager* (Stalags) for army other ranks (NCOs and enlisted men), *Kriegsgefangener Marinenlager* (Marlag), for naval personnel. Not to be outdone, Reichsmarshall Herman Goering, head of the German Air Force insisted that the *Luftwaffe* would take charge of the POW camps (*Kriegsgefangener Stammlager Luftwaffe*) for captured

Allied aircrew. These camps, commonly referred to as *Stalag Luft*, housed both flight officers and NCOs.

Escaping, or attempting to escape, from captivity was a feature of most POW camps (Evans, 1945; Crawley, 1956) and the subject of numerous wartime memoirs (*e.g.*, Williams 1945, 1949, 1951; Brickhill & Norton, 1946; Philpot 1950; Brickhill 1951; James 1983; Rogers 1986), although by no means all captives were engaged in this activity, as many were simply resigned to "seeing out the war" (MacKenzie 2004, Gilbert 2006; Doyle 2008). However, as an indication of the level of activity, in air force camps alone at least 60 escape tunnels were begun between May 1942 and March 1943 (Crawley 1956), and other methods, including deception, climbing over or crawling under the wire fences were also attempted.

The official response to Allied escape attempts varied through the war, with policy in both army and air force camps leaning towards concentration of escapers in specially-constructed camps (*Sonderlager*) with greater escape vigilance. Stalag Luft III, located at Sagan (now Polish Zagan) in Silesia, at the eastern margin of Germany was effectively one such camp. It was situated within a typical East European dense coniferous forest, close to the main Berlin-Breslau (now Wroclaw) rail route, providing access to the camp—as well as a temptation for would-be escapers. Despite this, the camp was well suited to housing troublesome POW's because of its distance from neutral countries (the targets of most escape-minded prisoners), as it was over 600 km from Switzerland and nearly 300 km from the Baltic ports that led to neutral Sweden (Fig. 25.2).

Stalag Luft III incorporated dozens of security measures designed to counter escape attempts, particularly those using tunnels as their primary means of escape. Barrack blocks were built from wood and constructed on raised pillars, designed to inhibit tunnel construction. A three-metre-high double fence was topped with barbed wire, and a two-metre space between each fence was also layered with coils of barbed wire. A low warning wire was situated ten metres away from the wire fences; prisoners were forbidden to cross this without permission. Guard towers—nicknamed "Goon boxes" by the prisoners—were situated at regular intervals along the perimeter fence, and were permanently manned by guards with machine guns and spotlights. The huts were deliberately built between 50 and 100 metres from the camp's perimeter wire to discourage tunneling activity, and in the North Compound at least, the prisoners suspected that seismographs had been set up to detect shallow underground activity. No details have emerged postwar to confirm this, unfortunately, although their presence was a distinct possibility. Nevertheless, these measures did little to dampen the spirits of determined escapers.

The development of Stalag Luft III from its inception in May 1942 was incremental, associated directly with the increasing numbers of Allied airman who were casualties of the intense bombing campaign over the German Reich territories. Each increment formed a self-contained unit, with the first being the Centre and East Compounds, followed by North, South and West Compounds (Fig. 25.3). Escape attempts would be made from them all.

Fig. 25.2 Position of Stalag Luft III, showing its geographic isolation away from neutral countries. (After Brickhill, 1951)

25.3 Stalag Luft III: Site and Soil

Stalag Luft III is situated within the Polish Plain, within Silesia—then part of Germany—near the town of Sagan (now Zagan). This region is heavily forested, the ground characterized by a low gradient, with a great thickness of free-draining Quaternary sediments. These sediments were produced during the Ice Age by the central and northern European ice sheet, the melting of which created vast thicknesses of outwash sands and gravels, and wind-blown loess. In the Silesia, some of the thickest Quaternary deposits in Poland are known, with potential

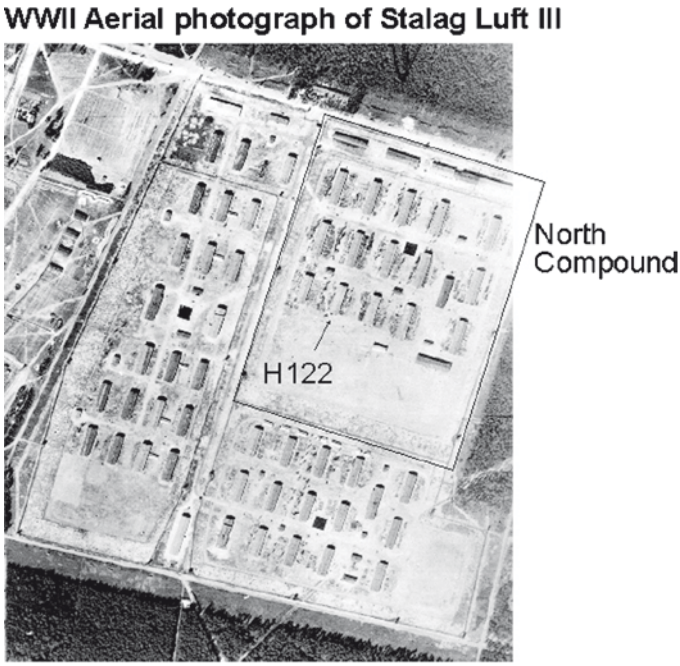

Fig. 25.3 World War II aerial reconnaissance photograph showing the North, West and South Compounds of Stalag Luft III

thicknesses of around 25-30 metres of loess alone. In the middle of all this, Stalag Luft III was established upon soil that could be easily worked in tunnel excavations, but which would be difficult to disguise during dispersal.

Prisoners transferred from Laufen (Oflag VIIC) in Bavaria, established in a castle on the floodplain of the River Salzbach, had experience of tunnelling through soils that were predominantly sands and gravels, but without the strong colour contrast (Rogers 1946, 1983; Williams 1945, 1951); those that ended up in Colditz (Oflag IVC) were less fortunate, the castle walls being constructed directly upon hard, igneous rocks (Rochlitz porphyry tuff) outcropping from a sill in Saxony. Here the problem was less spoil disposal, more making an excavation between the castle walls and the bedrock itself (Reid 1952; Rogers 1983).

The soil stratigraphy at Zagan is of a podzol, with a dark, organic-rich 0.1-0.2 m A-horizon (overlain by leaf litter) at the surface. Below this is are bright yellow sands, iron-stained in places (and forming reddish lenses in the B-layer) of glacio-fluvial origin. The sands that were examined were at least ten metres deep (Figs. 25.1 and 25.4).

Although this material was easy to dig, the colour of the sands from the B- and specifically C-horizons meant that it contrasted with the darker surface horizons of grey, humic soils, and as such, was easily detectable by camp guards as evidence of any digging activities. This was found to be the case during archaeological investigations in 2003 (Doyle *et al.* 2007; Pringle *et al.* 2007; Fig.

Fig. 25.4 Excavation by the authors at the site of Stalag Luft III in 2003. The excavation has reached the level of the main gallery of the tunnel "Dick". The humic (A) and iron-stained (B) surface horizons can be seen in the back wall of the excavation, the remained of the excavation is in glacial sands; in the excavation are assistant archaeologists Gabrial Moshenska (dark top, crouching) and Daniel Phillips (striped top, standing), and in front of them, from left to right, Larry Babits, Jamie Pringle and Peter Doyle. Visible in the excavation is the bright orange iron staining associated with the sub-gallery airline (see Fig. 25.7) (see as color plate following *Index*)

25.4). These investigations provided an excellent opportunity to examine the nature of the soil and underlying geology, which illustrates surprising regularity of the sediments at depth beneath the camp. As described by all prisoners, besides a 0.1 m thick, dark grey fine sand-to-silt humic layer (A-horizon) enriched by the breakdown of forest litter, the remainder of the sands were uniformly medium sand to gravel sized particles, with little or no clay layers or lenses encountered, explaining the free-draining nature of the site.

The colour variation in the surface soil at Stalag Luft III was to be a major challenge for all would-be tunnellers. In the introduction to his best-selling book, *The Wooden Horse* (1949), Eric Williams took time to explain the problem:

> "The surface of the compound was a mixture of sand, powdered leaf mould and dirt, which in the summer formed a thick layer of soft dust sometimes blown by the wind into a blinding cloud which hung like a pall across the camp. In the winter, this dust was churned by the prisoners' feet into a grey sea of clinging mud.
> Under this top layer the subsoil was clean hard yellow sand. When dug up, it is yellow when damp, but dries to a startling white in the sun. The Germans knew that every tunnel

carried its embarrassment of excavated sand and viewed each disturbance of this grey upper layer with suspicion. Every excavation made for a drain, rubbish pit or garden was carefully watched by the ferrets, or security guards. It was only by elaborate camouflage that the tell-tale yellow sand could be hidden in these places. The skin of grey dust formed one of the most effective defences of the camp" (Williams 1949, pp.10–11).

25.4 Wooden Horses and Great Escapes

Stalag Luft III, with its concentration of intelligent and resourceful young men who were prevented from working by the terms of the Geneva Convention (which forbade the use of officers in manual labour), was not surprisingly a hot bed of escaping. There were many attempts (Flockhart n.d.), but two were to be recorded in best-selling books that were to be made into movies: the "Wooden Horse" (after the book by the same name authored by Eric Williams; UK-produced movie directed by Jack Lee in 1950) and the "Great Escape" (after the book by Paul Brickhill; Hollywood-produced movie directed by John Sturges, 1963).

The "Wooden Horse" is overshadowed by the "Great Escape" in modern memory. The Wooden Horse escape was from the East Compound in 1943 (Williams 1949; Philpot 1950). In the early summer of 1943, Flight Lieutenant Eric Williams came up with a plan to start a shallow tunnel much closer to the wire than those commencing from within the huts. A wooden vaulting horse was constructed and used as a base (and disguise) for the tunneling activity. It was carried out every day to the same spot only around 30 metres from the wire. While other prisoners exercised, Williams and two accomplices, Michael Codner and Oliver Philpot would dig, covering the tunnel entrance with a specially constructed trap door, covered with the characteristic surface soil of the camp. The disturbance of the soil by the feet of the vaulters also helped disguise the activity of the tunnellers. After 114 days of work, the three men finally escaped on 29 October. All reached neutral Sweden and were repatriated back to Britain. They were the only men to make successful "home runs" from the East Compound; the escape had been one hundred percent successful.

The first prisoners were to be housed in what was to become known as the North Compound of Stalag Luft III on 23 March 1943 (Crawley 1956). Escape attempts began as soon as the first POWs arrived in the new compound. All attempts were to come under the control of the "X" Organization—a finely tuned escape organization run by the resourceful Roger Bushell (Brickhill 1951). Efforts were made to coordinate escapes, provide false documents, civilian clothing and survival gear (Flockhart n.d.). During 1944, while small-scale attempts did occur, the major effort was devoted to simultaneously digging three tunnels—code named "Tom", "Dick" and "Harry" in 1943–44 (Fig. 25.5, Table 25.1)—for a major breakout. Of these, "Tom" was discovered and destroyed by the camp guards in 1943 (Brickhill 1951; James 1983). Following this discovery, work on "Dick" was discontinued, with "Harry" being used for the "Great Escape" on the night of 23–24 March 1944,

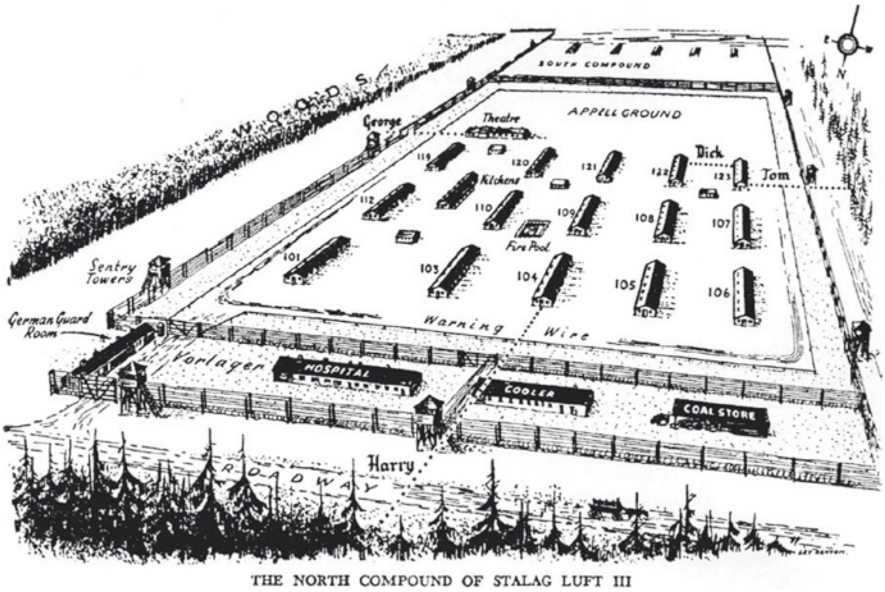

Fig. 25.5 The tunnels “Tom” Dick” and “Harry” in the North Compound of Stalag Luft III (From Brickhill, 1951)

Table 25.1 The “Great Escape” tunnels (from James, 1983: Appendix C; and Flockhart, n.d)

Tunnel	Depth/length (approx.)	Bed boards for shoring (approx. no)	Tins for air line (approx. no)	Tons of sand removed (approx.)	Fate
“Tom”	7.6m/67.0m	1500	500	70 tonnes	Discovered 8 Sept.1944
“Dick”	7.6m/18.2m, 12.8m unfilled	500	150	30 tonnes	Undiscovered/ storage and sand dispersal tunnel
“Harry”	7.6m/111.2m	2000	750	130 tonnes	Operated 24–25 March, 1944

when 76 POW actually exiting the tunnels (see Brickhill 1951; Crawley 1956; James 1983; and Durand, 1988 for more information). “Dick” was to lay dormant until discovered by the authors in 2003 (Doyle *et al.* 2007; Pringle *et al.* 2007)

Each tunnel commenced in a hut (Fig. 25.6), the vertical part of the tunnel (the shaft) exploiting either the centre of the brick piers (“Tom” and “Harry”), or the central sump of the washroom floor, the washroom itself being constructed on brick foundations (“Dick”). Each tunnel was at least ten metres deep to avoid sound detection, and supported by timber shoring made from bed boards. Air supply was pumped along the horizontal element of the tunnel (the “gallery”) using sub-gallery conjoined tins derived from Red Cross parcels sent to the camp. (Evidence of both

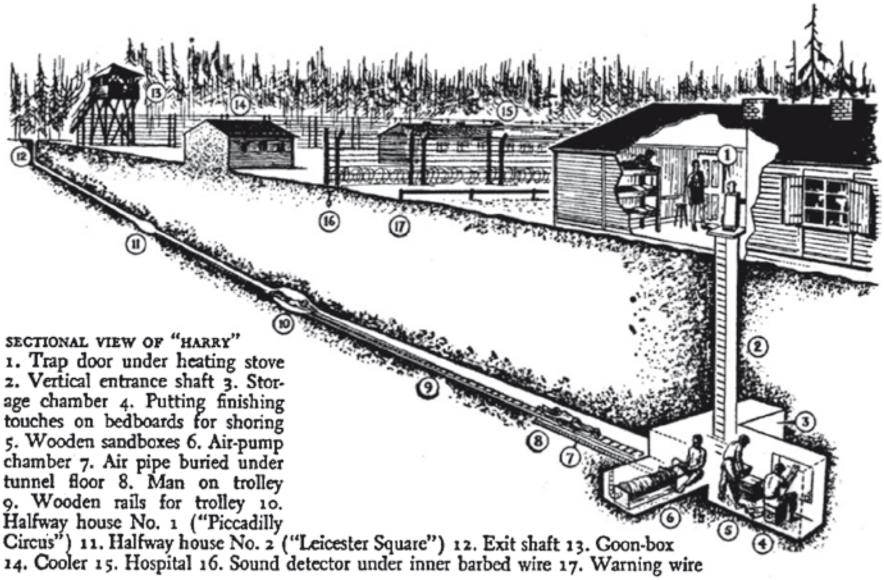

Fig. 25.6 The complex architecture of The Great Escape Tunnels. (After Brickhill, 1951)

boards and air supply tins were identified in the recent archaeological investigations, see Doyle *et al.* 2007; Pringle *et al.* 2007; Fig. 25.7). Each tunnel was lit by electrical light, tapped into the camp supply, and a trolley rail system was used to move the diggers (and escapers) to the end of the tunnel, and to remove the sand spoil, which was then bagged for dispersal before removal from the shaft.

Following the escape, it is estimated that five million Germans were mobilized to recapture them. Of the 76, three escapers eventually made "home runs", reaching Allied territory, but the remainder were recaptured, with 50 of them executed by the Gestapo.

25.5 Yellow Sands and Penguins

Removal and disposal of this amount of sand clearly presented a major problem to the tunnel escapers of Stalag Luft III, an advantage to the Luftwaffe security personnel ("ferrets") led by Oberfeldwebel Glemnitz. Sand had previously been spread underneath the raised barracks, camouflaged by mixing with the surface sand—but this was invariably discovered by the ferrets (Crawley 1956).

The most famous device for sand disposal—introduced in a carefully crafted scene in the movie *The Great Escape*—was the idea of using bags (cut from "long-john" legs) of sand suspended within the trouser legs, a pin being removed by the use of strings to disperse the sand, the penguins using a brushing action with their feet to

Fig. 25.7 Tunnel ‘Dick’ showing the remains of the conjoined tin air-supply line. Assistant archaeologist Gabriel Moshenska examines the tunnel gallery, making notes on the sand’s characteristics with the help of a Munsell Colour Chart (which provides a standard scheme for colour description), and a grain size chart (which allows the soil grains to be compared with a standard range of grain sizes). In the excavation, one can see the remains of the tins (placed under the horizontal tunnel gallery), and the dark parallel stains of the wooden bed-board shoring. The gallery itself is filled with sand (see as color plate following *Index*)

mix the soils (as well illustrated in the movie). The fact that the sand caused the disperser to be somewhat unbalanced—and thereby adopt a rolling gait—led to them becoming nicknamed “penguins”. In his book, Paul Brickhill attributed the idea behind the penguins to Lt-Commander Peter Fanshawe of the Fleet Air Arm (the Royal Navy’s air service), who was, in any case, certainly in charge of sand dispersal (Brickhill 1951, p.52). According to Crawley, the idea actually saw active use in the East Compound in 1942, and was imported to the North Compound, and the Great Escape tunnellers in the April of 1943 (Crawley 1956, p. 185). The same method was also being used in the Wooden Horse escape in the summer of 1943 (Williams 1949, p. 53), and there is also evidence to suggest the technique had currency in other camps, such as at Laufen, Oflag VIIC, in 1942 (Belson 2003, p.71). In any case, wherever and when ever the idea was first brought up for discussion, it saw much active service in Stalag Luft III, the tell-tale yellow sand being dispersed with the surface “grey dirt” in numerous gardens and similar sites across the camp.

25.6 Conclusions

The scale of the excavation at Stalag Luft III is staggering, a testimony to the ease by which soil could be removed compared to other camps, such as Oflag IVC (Colditz). This promoted the development of tunnel activity, perhaps greater here than in any other POW camp in Germany, and led to the “Wooden Horse” and “Great Escape” tunnel escapes of 1943-44.

It seems that the German authorities were well aware of the colour difference between the surface soil and sub-soil, and were vigilant in watching for evidence of disturbance of the surface. The fact that this vigilance was countered by the men charged with dispersal of the soil, the “penguins” (using a technique that may well have been developed in other camps and exported to Stalag Luft III), shows the commitment of the escapers and their extended tail of willing assistants. As pointed out by Aidan Crawley after the war, himself a POW:

“The amount of work done by the dispersal organization can best be given in figures. Sand which came out of the tunnels was frequently weighed on an accurate set of German scales, and it was found that twenty cubic feet weighed one ton. Up to the time that “Tom” was discovered 166 tons of sand was disposed of in four and a half months. Since the average load carried was approximately sixteen pounds, this meant in round figures some eighteen thousand individual journeys on the part of the carriers and corresponded to rather more than three feet of tunnel per day. The record rate of dispersal was 3,600 pounds of sand—a ton and a half—in one hour” (Crawley 1956, p.174).

It is not surprising, therefore, that this achievement was essential to the plot lines of both *The Wooden Horse* and *The Great Escape*, in books and movies, placing the soil of Stalag Luft III very much in the minds of the public.

References

Belson, D (2003) *Caught! Prisoner of War No. 487*. Bentwyck Henry, Henley-on-Thames.

Brickhill, P (1951) *The Great Escape*. Faber, London.

Brickhill, P, Norton, C (1946) *Escape to Danger*. Faber & Faber, London.

Crawley, A (1956) *Escape from Germany – A History of RAF Escapes During the War*. Collins, London.

Doyle, P (2008) *Prisoner of War in Germany, 1939–1945*. Shire, Oxford.

Doyle, P, Babits, LE, Pringle, J (2007) “For you the war is over”: Finding the Great Escape Tunnel at Stalag Luft III. *In:* Scott, D, Babits, LE, Hecker, C (eds.) *Fields of Conflict Battlefield: Archaeology from the Roman Empire to the Korean War*, Praeger Security International, Westport, 398–416.

Durand, AA (1988) *Stalag Luft III*. Louisiana State University Press, Baton Rouge.

Durnford, H (1920) *The Tunnellers of Hozminden*. Cambridge University Press, Cambridge.

Evans, AJ (1945) *Escape and Liberation, 1940–1945*. Hodder & Stoughton, London.

Flockhart, CB (n.d.) *A Typescript History of Stalag Luft III (Sagan), Air Force Personnel, April 1942–January 1945*. Unpublished Manuscript, RAF Museum Archives, RAF Museum, London (RAFM B37992).

Gilbert, A (2006) *POW Allied Prisoners in Germany*. John Murray, London.
James, BA "Jimmy" (1983) *Moonless Night*. William Kimber, London.
McKenzie, SP (2004) *The Colditz Myth*. Harvard University Press, Harvard.
Philpot, O (1950) *Stolen Journey*. Hodder & Stoughton, London.
Philpot, O. Taped interview. (Imperial War Museum Sound Archive, London)
Pringle, JK, Doyle, P, Babits, LE (2007) Multidisciplinary investigations at Stalag Luft III Allied prisoner-of-war camp: the site of the 1944 "Great Escape", Zagan, Western Poland. *Geoarchaeology* 22: 729–46.
Reid, PR (1952) *The Colditz Story*. Hodder & Stoughton, London.
Rogers, DJ (1946) An escape tunnel in Germany. *The Mining Magazine* 75: 87–97.
Rogers, DJ (1986) *Tunnelling into Colditz*. Robert Hale, London.
Williams, E (1945) *Goon in the Block*. Jonathan Cape, London
Williams, E (1949) *The Wooden Horse*. Collins, London.
Williams, E (1951) *The Tunnel*. Collins, London.

Chapter 26
Soils and Soil Pioneers on Stamps

Hans-Peter Blume

26.1 Soils on Stamps

Soils and the science of soils have been depicted on stamps and other philatelic products such as postcards, letter covers, letter grams and postmarks (Blume 2003a, 2004). Pioneers of soil science such as Vassilii Vasilevich Dokuchaev, and of agricultural chemistry such as Justus von Liebig, as well as other prominent scientists who stimulated soil research have been honored on stamps. Descriptions of the commemorative purpose and the day of issue of the stamps are taken from major stamp catalogues published in Germany (Michel 2002-2006), and Great Britain (Stanley Gibbons 2000-2006).

Soil profiles on stamps are rare. The Portuguese Post Office issued four stamps in 1978 with soil profiles (Fig. 26.1):

– The 4.00 escudo (unit of Portuguese currency prior to the adoption of the Euro in 1999) stamp shows a Mediterranean red soil developed on shale (*solos mediterranicos de xistos vermelhos*); under the World Reference Base for Soil Resources (WRB) classification system, this would probably be a Chromic Luvisol formed by clay migration (Fig. 26.1a).
– The 5.00 escudo stamp shows a soil developed on a granitic bedrock (*lito solos*); WRB Lithic Leptosol (Fig. 26.1b).
– The 10.00 escudo stamp shows an alluvial soil (*solos de aluviao*); WRB, perhaps a Haplic Gleysol, *e.g.*, a ground water-influenced soil, with an oxidised subsoil of red-brown ferrihydrite above a reduced blue-green horizon with FeII/FeIII mixed oxides (Fig. 26.1c).
– The *20.00* escudo stamp shows a black loamy soil (*barro negro*); WRB, perhaps a Vertisol developed on basalt (Fig. 26.1d).

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Fig. 26.1 Portuguese stamps with soil profiles (see as color plate following *Index*)

26.2 Pioneers of Soil Science on Stamps

The development of the natural sciences has been, in part, an outgrowth of human exploitation of natural resources. The following discussion of the development of the natural sciences and the later emergence of soil science as a distinct discipline is based on Blume (2003b), Heilbronner and Miller (1998), Krupenikov (1993), Yaalon and Berkowicz (1997), and Warkentin (2006). The focus will be on the history of soil science up until 1883, the publication date of *The Russian Chernozem*, the doctoral thesis of Dokuchaev, considered to be the founding book of pedology. Stamps showing the scientists designated in bold type are shown in Fig. 26.2; details on stamps dealing with other named scientists are listed following the References.

The Greek scientist and philosopher Aristotle (384 BC–322 BC) thought that all life-forms and the earth itself were made up of four elements: *earth, water, air* and *fire*. The terms *earth*, *water*, and *air* then represented solid, fluid, and gaseous phases, and up until the 19th century, material properties were also assigned to *fire* or warmth. The Greek physician Hippocrates [of Cos] (460 BC–370 BC) considered

Fig. 26.2 Stamps with pioneers of soil science

soils to function as plant stomachs, taking not only water from the soil with their roots, but also at least three other essential fluids that he called *φλέγμα* (slime), αίμα (blood) and *Χολή* (bile). He even considered the importance of soil texture, and mentioned its possible method of analysis. In his poem *Georgica* (about agriculture), the Roman author Publius Vergilius Maro (70 BC–19 BC) described a method for assessing the soil quality for agricultural crops. He recommended to *dig a pit and to fill it again: if the pit is filled incomplete, the soil is loose and dry, and can be used for animals, for vineyards. But if a part of the soil material will give a heap above the pit, the soil is tight and wet* (after Herzog-Hauser 1961; translation from German).

The German Abbess **Hildegard of Bingen** (1098–1179) wrote the first descriptions and assessments of the agricultural and healing potential of German soils. She lived in the German Rhineland near Mainz, was the abbess of several nunneries, and strongly influenced the Catholic church during her time. She wrote theological, scientific and medicinal texts, and in addition liturgical songs, poems, and the first surviving morality play, while supervising brilliant miniature illuminations (Kastinger Riley 1998). Her scientific work is contained in writings about nature (*Liber simplicis medicinae* LSM) and the art of healing (*Liber compositae medicinae* LCM) [Riethe 2000, 2001; Reier 1980; translations from German]. In the theoretical part of the LCM, Hildegard's work follows the basic structure of the four elements of Aristotle:

> The elements of the world have been created by God. They are fire, air, water and soil, and these four elements are so connected that one of them cannot be separated from the others. By nature a soil (terra) is cold and has different forces. During summer it is cold in the depth, but on the surface hot because of the sun, for in this reason the sun creates warmth. In winter … a soil is warm in the depth … and cold on the surface, because the sun withdraws its forces from the surface. So a soil shows its fertility in the warmth (*in calore viriditatem*) and its infertility in the cold (*frigiditate ariditatem*). In winter the sun is infertile at the surface and sends its warmth below the soil so that it can help the survival of different grasses. In this way a soil creates germs because of warmth and coldness. A soil takes up and accumulates water, and provides the right ways for flowing. On the soil surface, water is collected to find its correct flow as well as it is collected in the depth that it cannot take the wrong way to the surface.

Descriptions of defined soils in *de elementis* (LSM) refer to the surroundings of Hildegard's nunneries: Didisbodenberg (near river Nahe), Rupertsberg (near Bingen) and Eibingen (near Rüdesheim):

> A soil which is white … and sandy is rather dry, and shows a rough moisture and big raindrops. Because of this rough moisture it produces vines and fruit and some cereals.

It seems that she described a sandy Arenosol of dune sand near the river Rhine. She continued that:

> … soils which are not white or black or red but look greenish or like stone, are cold, dry and unfertile and cannot bring out vines or grains or fruits.

Presumably she described shallow Lithic Regosols developed from the Hunsrück slate (Blume 2003b). Furthermore, she described the use of soils in healing and principles of soil hygiene, recommending:

> …. put this greenish earth under a persons head and feet if he is weakened by age and sickness. The person's fever will migrate into the earth, which on the third day shall be thrown into the fast flowing water of a creek, so nobody will be damaged by the earth which is infected by the sickness.

The multicolored 110-pfennig stamp of the Federal Republic of Germany that was issued on the 800th anniversary of her death, August 9, 1979 (Fig. 2a) shows her, in an author's portrait from her *Liber Scivias* of 1230.

In his work *De Natura Fossilium* (Handbook of Mineralogy; Agricola 1546) the German physician and mining scientist Georg Bauer or Georgius Agricola (1494-1555) described and classified minerals and metals, and he included the *Terrae* (earths) as a special class. The Swedish natural scientist Carl Linnaeus (1707-1778) created a classification system, not only for plants and animals but also for earths, *e.g*., *humus dedalea* (garden soil)*, humus ruralis* (black farm earth), *humus chistosa* (red clay earth), and *humus pauperata* (peat soil), or *argilla marga* (marl earth), *argilla tumescens* (yellow loam), and *argilla figulina* (potter's clay).

The Estonian scholar Salomon Gubert described in his book *Stratagema oeconomicum* [1645; Strategies of (Agricultural) Economics] different soils such as black earths. The Russian natural scientist and founder of Moscow University, Mikhail Vasilevich Lomonossov (1711-1765) translated Gubert's book into the Russian language in 1747, and introduced the term *Chernozem* into the world soil classification (Reintam 2001).

The theologian, scientist and rector of Copenhagen University **Erik Pontoppidan** (1698-1764) wrote the books *Teatrium Daniae Veteres et Modernae* (1730), *Det forste Forsog paa Norges Naturlige Historie (1752)* and *Den Danske Atlas* (seven volumes, partly posthumous; 1763-1781). Besides scientific and economical descriptions, these books contain valuable observations of soils of the contemporary Schleswig-Holstein region of Germany, Denmark and Norway (Bunting 1997). The Danish stamp (Fig. 26.2b) issued on November 5, 1998, shows a fossil snail (genus *Pleurotomaria*) discovered by Pomtoppidan and published in his *Den Danske Atlas*.

The German physician and agrarian scientist **Albrecht Daniel Thaer** (1752-1828) published his *Grundsätze der Rationalen Landwirthschaft* [Thaer 1810-1812; and subsequent translations to French (Thaer 1811-1816) and English (Thaer 1856)], the first book on soil science in the German language. He thoroughly described topsoil and subsoil, and their properties. Thaer was the founder of the German and Austrian soil taxonomy for agricultural use. Although Thaer has been criticized by some historians of soil science for his "Theory of Humus", he is also considered to be the forerunner of the concept of sustainability in agriculture (Feller et al. 2003). A multicolored 220-pfennig stamp commemorating the 250th anniversary of his birth was issued in Germany on May 2, 2002 (Fig. 26.2c); the lower portion shows a cultivating tool developed by Thaer.

As the founder of a modern geography, the German natural scientist **Alexander von Humboldt** (1769-1859) also stimulated the development of soil science. He developed a method for the determination of soil aeration (Humboldt 1799; Blume and Sticher 2006), and described soils during his travels to America and Russia. For example, near Baku in Russia (present-day Azerbaijan), he described soils (Reductic Regosols) with reducing features associated with natural gas release through underlying fissures in the geologic strata (Loewenberg 1832; Blume and Felix-Henningsen 2008). On May 6, 1959, the Federal Republic of Germany issued a dark Prussian blue colored 40-pfennig stamp with a portrait of Humboldt (Fig. 26.2d) to commemorate the 100th anniversary of Humboldt's death.

The French chemist **Antoine Laurent de Lavoisier** (1743-1794) was a founder of agricultural chemistry. He disproved that *phlogiston* theory of plant nutrition that had surfaced in the late 1600s, and helped pave the way for **Justus von Liebig** (1803-1873) to formulate his theory of the mineral nutrition of plants. The violet-ultramarine, four-franc French stamp (Fig. 26.2e) was issued on May 7, 1943, the 200th anniversary of Lavoisier's birth, and featured a portrait by Jacques-

Louis David (1748-1825), one of the central figures in neoclassic painting during the late 18th century. A stamp from the German Democratic Republic followed on July 18, 1978 to celebrate Liebig's work (Fig. 26.2f); it included his portrait, ears of grain, and a retort with the major plant nutrient elements: nitrogen (N), phosphorus (P), and potassium (K).

The English natural scientist **Charles Darwin** (1809-1882) described and sketched soil profiles. Darwin's 1886 book *The Formation of Vegetable Mould through the Action of Worms with Observations on Their Habits* explored the role of earthworms in decomposition, physical mixing, and humus formation in soils. The British stamp, with his portrait and two marine iguanas (Fig. 26.2g), alludes to his certainly better known work in the Galapagos Islands and his 1872 book, *The Origin of the Species*. This 19.5-pence stamp and three others were issued on February 10, 1982, the 200th anniversary of his death.

The modern era of soil science was founded in Russia by **Vassilii Vasilevich Dokuchaev** (1846-1903) with *The Russian Chernozem* (1883) and his work about the horizontal and vertical zones of soils (Dokuchaev 1899), in which he presented a formula about the factors of soil formation. Two equivalent-design stamps, a dark brown 40 kopeck- (Fig. 26.2h) and a green one ruble-stamp, were issued by the USSR in 1949, showing Dokuchaev and experimental fields.

For those interested in the history of soil science, stamps act as miniature gallery pieces. They are bestowed with the minimal postage value associated with the mailing of a letter, but more importantly, they are a reflection of the larger society's recognition of soil as a valued resource, and of the pioneering scientists who molded our present thinking on the nature and properties of this resource.

References

Agricola G (1546) De Natura Fossilium (Handbook of Mineralogy); Basel; translated into German by G Fraustadt, comments by F Krafft; Marix, Wiesbaden.

Blume H-P (2003a) Soil Science and Philately. Mitteilungen der Deutschen Bodenkundlichen Gesellschaft 102: 817–818.

Blume H-P (2003b) Die Wurzeln der Bodenkunde (roots of soil science). Chapter 1.3.1 in H-P Blume, P Felix-Henningsen, W Fischer, H-G Frede, R Horn, K Stahr (1996ff) Handbuch der Bodenkunde (Handbook of Soil Science). Wiley-VCH, Weinheim.

Blume H-P (2004) Bodenkunde und Philatelie (Soil Science and Philately). Arbeitsgemeinschaft Landwirtschaft, Weinbau, Forstwirtschaft im Bund Deutscher Philatelisten. Mitteilungsheft 113: 88–97.

Blume H-P, Felix-Henningsen P (2007) Reduktosole (Reductosols). Chapter 3.3.2.11 in H-P Blume, P Felix-Henningsen, W Fischer, H-G Frede, R Horn, K Stahr (1996ff): Handbuch der Bodenkunde (handbook of soil science). Wiley-VCH, Weinheim.

Blume H-P, Sticher H (2006) Alexander von Humboldt and the characterization of soil fertility. Newsletter, Commission on the History, Philosophy and Sociology of Soil Science. International Union of Soil Science, no. 13, p. 27–33; available at http://www.iuss.org/.

Bunting BT (1997) Pioneer observations on soil formation and environment in Scandinavia: Erik Pontoppidan (1698-1764): His Danish Atlas of 1763 and his Natural History of Norway (1752). Advances in Geoecology 29: 351–364.

Dokuchaev VV (1883) Tschernozème (terre noir) de la Russie d'Europe. St. Petersburg.
Dokuchaev VV (1899) Doklad Zakavkazkomu statističeskoma komitetu ob ocenke zemel'voošč i Zakavkaźja v osobenosti. Počvenny gorizontal'nye I vertical'nye zony (Report to the Transcaucasian committee for statistic about soil taxonomy in total and especially of Transcaucasia. Horizontal and vertical soil zones). Tbilisi.
Feller C, Thuriès L, Manlay R, Robin P, Frossard E (2003) The principles of rational agriculture by A.D. Thaer (1752-1828). An approach of the sustainability of cropping systems at the beginning of the 19th Century. Journal of Plant Nutrition and Soil Science 166: 687–698.
Gubert S (1645) Stratagema oeconomicum (strategy of economy) oder Akker-Student: Denen jungen ungeübten Akkersleuten in Lieffland zum nöthigen Unterrichte vermittelst vieljährigen Observationibus, auch fürnehmer Philosophorum Placitis dargestellet; further editions 1649 – 1757; G Nöller, Riga.
Heilbronner E, Miller FA (1998) A philatelic ramble through chemistry. Wiley-VCH, Weinheim
Herzog-Hauser G (1961) Vergil vom Landbau (About agriculture). German translation of Vergil?s Georgica. Artemis, Zürich.
Humboldt A von (1799) Mémoire sur l'absorption de l'oxigène par les terres simples et son influence dans la du sol (essay on the adsorption of oxygen at soil surfaces and influence on soil fertility). Annales de Chimie 29 (Cah. 2): 123–180.
Kastinger Riley HM (1998) Hildegard von Bingen (Hildegard of Bingen). Rowohlt, Reinbek.
Krupenikov IA (1993) History of soil science—from its inception to the present. A Balkema, Rotterdam.
Loewenberg J (1832) A. v. Humboldts Fragmente einer Geologie und Klimatologie Asiens (Humboldt's fragments of a geology and climatology of Asia);from French; JA List, Berlin.
Michel (2002-2006) Briefmarkenkataloge (catalogs of stamps). Schwaneberger, München.
Reier H (1980) Hildegard von Bingen Physica (Hildegard of Bingen Science); commentated translation of the text of J Migne, Paris 1982. PhD, Kiel university.
Reintam L (2001) Soil stories from the Swedish time up to present in Estonia. Abstract XX. Baltic Confernce on the history of Science, pages 141–144; Tartu.
Riethe P (2000) Hildegard von Bingen De Elementis De Metallis. Original and commented German translation. O Müller, Salzburg.
Riethe P (2001) Hildegard von Bingen Das Buch von den Bäumen (the book about trees) Original and commented German translation. O Müller, Salzburg.
Stanley Gibbons (2000-2006): Catalogues of stamps of the world. Stanley Gibbons Publications. Hampshire, UK.
Thaer AD (1810-1812): Grundsätze der rationellen Landwirtschaft. 4 Bände. Realschulbuchhandlung, Berlin.
Thaer AD (1811-1816) Principes raisonnés d'agriculture. Translated from German by EVB Crud, JJ Prechoud. 4 volumes, Paris.
Thaer AD (1856) The principles of practical agriculture. Translated by W Shaw, CW Johnson. Saxton and Company, New York.
Warkentin BP (ed) (2006) Footprints in the soil. Elsevier, Amsterdam.
Yaalon DH, Berkowicz S (eds) (1997) History of Soil Science. Advances in GeoEcology 29: 15–46. Reiskirchen, Germany.

Details on Stamps not Shown

Aristotle: The multicolored Cyprian 35-milliėmes stamp issued on October 23 1978, the 2300th anniversary of his death, shows an ancient Greek sculpture depicting Aristotle.

Hippocrates: The multicolored Greek 18-drachma stamp issued on November 24, 1979 for the International Hippocratic Institute, Greek island Kos, shows a sculpture of Hippocrates, by D. Kossos.

Vergil: On April 23 1981, the 2000th birthday of Vergil, the Vatican issued two stamps; the light gray 350-lira stamp shows the seated poet and the inscription *P. Vergili Maronis bucolicon georgicano libri bimillenario virgiliano* (P. Vergilius Maro's herdsman and farming poems, 2000th birthday).

Agricola: The dark brown 10-pfennig stamp of the German Democratic Republic was issued on November 21, 1955, the 400th anniversary of Agricola's death.

Linnaeus: On May 23 1978, the 200th death day, Sweden issued six stamps; the dark violet 1.30-crown stamp shows Linnaeus wearing a Lapp dress and a Dutch doctor's hat, and holding a Lapp drum.

Lomonossov: The multicolored six-kopeck Soviet stamp with a portrait of Lomonossov and two others were issued for his 250th birthday celebration, November 19, 1961.

Chapter 27
Soil in Comic Strips and Cartoons

Anne Richer de Forges, Frank Verheijen, Dominique Arrouays, Eric Blanchart, and Martial Bernoux

27.1 Introduction

Soil is a part of our daily lives by virtue of the role it plays in our environment, and by its position at the interface between the atmosphere, hydrosphere, biosphere and lithosphere. Consequently, soil appears in all the artistic fields, including comic strips and cartoons. Comic strips are scripted stories told in images. A comic strip is a means of communication that lies at the interface of graphic art, cinematographic art, and literature. From graphic art, it borrows the composition of the images, and the variations of shading and light, perspective and color. From cinematographic art, it borrows the script, the framing or the angles of sight, and the sequence of the images. From literature, it borrows the texts and the dialogues.

Such stories in images appeared in Europe in the first half of the 19th century. Among the pioneers were "*Histoire de M. Jabot*" (Töpffer 1833), "*Max und Morizt*" (Busch 1865) and "*La famille Fenouillard*" (Colomb 1889; pseudonym: "Christophe"). Primarily humorous, the comic strip became more serious in the United States, with "The Yellow Kid" (Outcault 1896) and "The Katzenjammer Kids" (Dirks 1897). Later, it moved to include fantasy themes, *e.g.*, "Little Nemo in Slumberland" (McCay 1905). During the 1930s, American comic strips grew in popularity as daily features in newspapers, and Superman and Mickey Mouse (1934) became household names. The comic strip remained focused on the child audience for a long time. Its mission was to divert them. Since its birth, the comic strip has been evolving from its early, narrow focus on entertaining children with tales of humour and adventure, to more adult themes in the 1970s and 1980s. By the end of the 1990s, almost all literary styles had been explored (detective story, thriller, fiction, history, humour, heroic fantasy, *etc*.).

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In modern print media, a cartoon is a piece of art, usually humorous in intent. This usage dates from 1843 when *Punch* magazine applied the term to satirical drawings in its pages, particularly sketches by John Leech (Mayhew and Landells 1843). Modern gag cartoons, found in magazines and newspapers, generally consist of a single drawing with a caption immediately below or as a speech balloon. Because of the stylistic similarities between comic strips and early, animated movies, "cartoon" came to refer to animation, and this is the sense in which "cartoon" is most commonly used today. These are usually shown on television or in cinemas, and are created by showing illustrated images in rapid succession to give the impression of movement.

Comic strips and cartoons progressively became a respected art form, providing powerful imagery, expression of universal themes, and timely commentary on society. Thus, it is quite natural that the soil appears in comic strips and cartoons. In this chapter, we will review the various representations of the soil in comic strips and cartoons, structured around the soil functions scheme.

27.2 Soil Functions Scheme

From an anthropocentric viewpoint, soil functions can be defined as "the capacity of soil processes and components to provide goods and services that satisfy human needs, directly or indirectly" (after De Groot et al. 2002). A number of authors have identified, or categorised, soil function schemes (De Groot et al. 2002; Blum 1993; Blum 2005; Brady and Weil 1990; CEC 2006; Nikitin 2005; Sombroek and Sims 1995). Despite the use of different terminologies, and to a lesser extent, different emphases and subdivisions, these authors agree largely on the main, or primary, soil functions. Table 27.1 shows a harmonised soil function scheme, including its main components. In the following section, we will investigate how the individual soil

Table 27.1 Harmonised soil function scheme (HIPER). After De Groot (2002), Blum (1993 and 2005), Brady and Weil (2001), CEC (2006), Nikitin (2005), and Sombroek and Sims (1995)

Primary Soil Functions	Components
Habitat	Refugium function; nursery function; medicinal resources; gene pool; seed bank
Information	Cultural information (archaeological & palaeontological); science and education; spiritual and historic; recreation; aesthetic information
Production	Food; fodder; fibre; raw materials; renewable energy
Engineering	Technical, industrial and socio-economic structures
Regulation	Gas regulation; climate regulation; disturbance resistance; disturbance resilience; water supply; water filtering; pH buffering; biotransformation of organic carbon; soil retention; soil formation; nutrient regulation; biological control; waste and pollution control

functions are portrayed in comic strips and cartoons, before discussing general themes and relative importance.

27.3 Soil Habitat Function in Comic Strips and Cartoons

A handful of soil under grassland is known to contain up to 100 billion bacteria (10,000 species), 50 kilometers of fungal hyphae (500 species), 100,000 protozoa (hundreds of species), 10,000 nematodes (50 species), 5,000 insects, arachnids, molluscs and worms (hundreds of species), and about 500 metres of plant roots from dozens of species (Ritz et al. 2004). That soil as habitat is often recognised in comic strips; however, only a small part of this remarkable soil biodiversity appears in comic strips. Most of the characters are macrofauna (mainly earthworms), but other animals, partly dependent on soil for their habitat, also appear (*e.g.*, rabbit, mole, badger, ant, platypus). In addition, numerous imaginary creatures populate the soils in comic strips.

27.3.1 "Real World" Habitat Function

Nearly all the "real world" soil animal characters that are featured in comic strips are earthworms. Indeed, earthworms are well known by all of us; they are large enough to be drawn and recognizable, and they benefit from a good image. They even appear in books for children, *e.g.*, "There's a hair in my dirt!: A Worm's Story" (Larson 1999); "Tribulations gastriques d'Eric le lombric" {"*The gastric tribulations of Eric the worm*"} (Dahan 1998).

The adventure element was taken one step further by the creation of, first the video game, and later, the comic strip, "Earthworm Jim" (Perry and TenNapel 1994). Although the main character and action hero is an earthworm, his 'ultra-high-tech-indestructible-super-space-cyber-suit' (or simply 'super suit') gives him such powers that the storyline provides little soil-related action. Some of the supporting characters appear to be based on soil organisms, but the fantasy element overrides. Earthworm Jim appears to have enjoyed a loyal and enthusiastic cult fan base in the United States.

Other animals, living in burrows, often appear in comic strips. The most frequent one is the mole, who may be described as a sympathetic character, *e.g.*, in "*le vent dans les saules*" (Plessix 1996), or as a pest, *e.g.*, in "*Arnest Ringard et Augraphie*" (Jannin et al. 2006), or as an earthworm predator (Donald Duck weekly – Walt Disney 2003). Another frequently nice character is the badger. In "*le vent dans les saules*" (Plessix 1996), after the book "The Wind in the Willows" from Kenneth Grahame (1908), he organised a burrow visit for his friend the mole. Unexpected animals, such as the platypus in "*Toto l'ornithorinque*" (Chivard and Omond 1999) also appear in children's books, and innumerable rabbits, foxes, and even ants, populate comic strips and cartoons.

Soil microfauna and microflora are sometimes present in comic strips. In "*Kaze no tani no Naushika*" (Miyazaki 2000), soil fungi and other soil microorganisms constitute the heart of the story. Earthworms may simply appear in gardening activities, e.g. Boule et Bill "*un ver ça va*" (Roba 2001); Achille Talon "*A bout (mal) portant*" [Regnier (Greg) 1984]. They can also be bred or even hunted (Fig. 27.1). Such a feature story, called "The Worm King", is told in probably the most-read children comic strip in The Netherlands: the Donald Duck weekly. The story starts with Donald suddenly realising the commercial potential of harvesting and selling earthworms. His nephews are employed to collect the earthworms, but their stamping attracts vast numbers of moles. This leads to the destruction of the office of their business, which they one day find on top of an enormous mole mound—the moral of the story being that too much interference with a natural system will lead to unforeseen problems. Although this story is one of the more advanced examples of the dynamics and management of soil as an ecosystem that we encountered in comic strips, there is a scientific problem in the assumption that stamping will attract moles. Moles (*Talpidae*) are known to be extremely sensitive to vibrations, which they can sense with mechanosensory organs called "Eimer organs" (Catania 2000), because they locate their prey by the tiny vibrations of their movement through the soil. However, the much stronger vibration caused by stamping people, or indeed humanoid ducks, are more likely to repel moles.

Despite the scientific flaw, or jump in logic, in this story, it remains an enlightened example of soil featured in a mainstream comic strip. It lifts soil from a static entity to a dynamic system—a habitat of multiple species (not just earthworms), showing prey-predator relationships, and highlighting the importance of understanding soil processes for soil management, *i.e.*, to prevent unforeseen negative impacts. Considering the readership of this comic strip, it can be argued that this story also

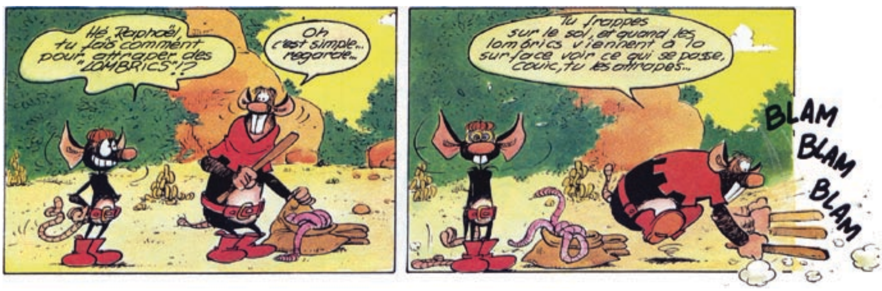

Fig. 27.1 A technique for hunting earthworms in "La dalle maudite" (Carpentier 1980).
"Hey, Raphael, how do you do to catch earthworms ?
Oh, it's easy, look…
You hit the soil, and when earthworms emerge from the soil surface to see what's happening, squeak, you catch them…"
Extract from the book "La Dalle Maudite" (The accursed dale), Louis-Michel Carpentier, © Casterman, kindly authorised by the author and the Casterman editions

delivers on the information function (see 27.4). In contrast, Fig. 27.1 describes a completely unrealistic way of hunting earthworms by rats. Earthworms have also inspired authors to more adventurous or fantastic stories, which are the scope of the next section.

27.3.2 Soil Habitat Function for Imaginary Creatures

Soil, as all natural media, provided a source of inspiration for imaginary creatures and worlds. The fact that the soil is still largely unknown by almost everybody certainly enhances its fantasy potential. Thompson (1969) described an island full of monsters, including an earthworm the size of a python (see Fig. 27.2), although it will seem reassuring to a soil scientist that the one soil-borne monster in the story was harmless.

The comics' character Léonard, (Turk and De Groot 1990) built a giant metallic earthworm to explore the soil. Totally imaginary creatures can also live in the soil in comic strips such as "Fungus the Bogeyman" (Briggs 1977). In "*Le Fluink – enfin*

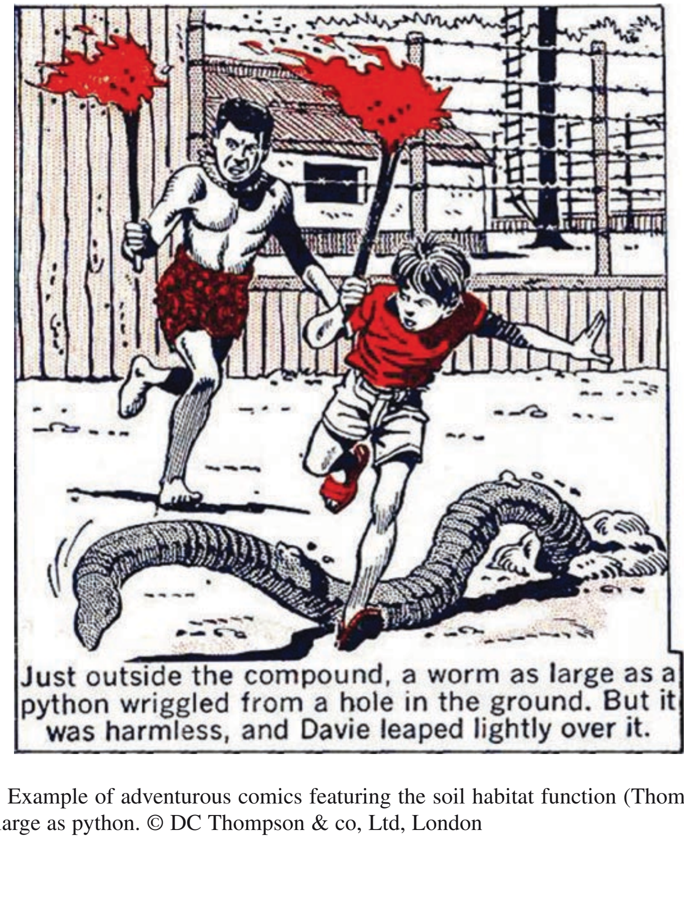

Fig. 27.2 Example of adventurous comics featuring the soil habitat function (Thompson 1969). Worm as large as python. © DC Thompson & co, Ltd, London

libre" (Barou and Renaut 2006) two parallel and symmetric worlds are living and competing above and below the soil surface.

27.4 Information Function

Most material that primarily concerns the information function of soil can be subdivided into i) archaeology-related stories, *e.g.*, treasure hunting, and ii) comic strips that teach about soil processes or properties. A vast volume of educational comic strips in soil have been produced. The Soil and Water Conservation Society in the United States seems to have been particularly active with publications such as 'Help keep our land beautiful' (1966; Fig. 27.3), and the Environmental Adventures series aimed at 8–11 year old children. The National Soil Resources Institute (NSRI) of England and Wales (2006) developed Soil-Net, an online educational tool for children aged 5–16, which features several soil organisms as characters, *i.e.*, earthworm, ant, mole, badger, snail, lady bird beetle, and millipede (Fig. 27.3). The German Umweltbundesamt (Environment Protection Agency) published "The Adventures of Fridolin the Earthworm" in 2004. "Waldorf the Worm" was published by the Earth Science Teachers' Association

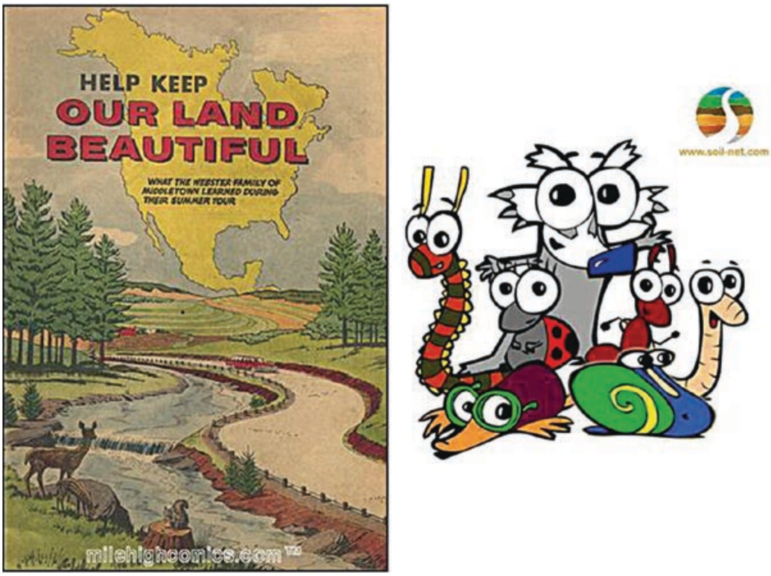

Fig. 27.3 Examples of a comic strip as a tool for soil education. The image on the left is the cover of a 1966 publication of the Soil Conservation Society of America © Soil and Water Conservation Society. The image on the right shows the characters of Soil-Net (NSRI, 2006) © Soil-Net.com, Cranfield University

of the United Kingdom. At the first conference of the Parties of the UNCCD (United Nations Convention to Combat Desertification) a booklet ‘Comics to combat desertification’ was published to raise awareness. The French geosciences agency BRGM (Bureau de recherches géologiques et minières) in the “*les observateurs de la Terre*” series, explained the nature and properties of soil (Goyallon et al. 1996).

Institutional communications about soil and threats to soils sometimes include striking cartoons on soil degradation. The FAO website for instance, shows a picture of the Earth completely degraded by erosion. In this cartoon, the Earth is drawn as an empty skeleton, the bones of which being meridians and parallels (Garner in FAO website, http://www.fao.org/docrep/T0389E/T0389E00.GIF). In this cartoon, it is not clear if the main message from the author is: “non-adapted cultivation practices are accelerating erosion”, or “untolerable rates of erosion lead to irreversible losses of agricultural soils”.

Academic publications do not generally use comic strips or cartoons, although Jastrow and Miller (1998) very aptly summarised the soil organic matter stabilization mechanisms with a cartoon of little Pac Men attempting to eat protected soil organic matter. Coyne (1996) used a series of cartoons to illustrate the history of soil microbiology. The power of comic strips to aid in the education of a diverse section of society seems substantial. Contrary to air and water (and above-ground biology), soil is generally perceived as dark and unseen. Comic strips provide a means of visualising the opaque world of soil. Moreover, comic strips are not hindered by issues of scale, *i.e.*, from macro soil fauna to microbial organisms or molecular-scale processes. At the same time, the ability to visualise across spatial scales carries a responsibility, or at least a challenge, to take scale into consideration in the education process—even a young child should be guided to know that a fungal hyphen is not the size of a python.

Comic strips that primarily aim to entertain (*i.e.*, mainstream comic strips), rather than educate, reach a large proportion of the public. When soil is the topic of a mainstream comic strip, as for example in the Donald Duck story (see part 3), awareness of soil is raised with a large part of an age group outside of a school setting. Although more limited in its depth of soil information, this kind of soil information is a valuable aid in raising the profile of soil.

Archaeology-related stories (*e.g.*, treasure hunting), are widely present in comic strips. The most famous treasure hunting character is the rich and miserly Scrooge McDuck. Very often, however, the treasure is not found, and the soil appears just as a hard-to-dig material—a cause of useless efforts. A famous fruitless treasure hunting is narrated in Tintin - “Le Trésor de Rackham le Rouge” (“Red Rackham’s Treasure”) {1959} [Rémy (Hergé) 2002]. In some cases, the archaeological memory function of soil is highlighted. In “*le vent dans les saules*” (Plessix 1996) an entirely buried village is present in the badger’s sett. In “*Arnest Ringard et Augraphie*” (Jannin et al. 2006) the mole Augraphie discovers gold coins, and uses them to pay the rent for living in the garden soil of Arnest.

27.5 Production Function

That the food we eat was grown in soil is something that all of us should be aware of. However, in most cases, cartoons and comic strips that feature the growing of arable crops do not link this to the soil. Tools for soil tillage are sometimes present, the most common of which is the spade. In "*Le concombre masqué*" (Mandryka 2004), it is the vegetable itself (*i.e*., a cucumber wearing a mask) who ploughs the soil (Fig. 27.4). In this completely unrealistic story, he then sows gravels, which grow into stones and rocks.

In the few cases where the link between food and soil was made, the soil was treated as a 'black box', *i.e*., crops grow better in one soil than the other, but the reasons for this remain unclear, sometimes with an almost mystical element to it. Gardening was, by far, the most frequently encountered topic in soil-related comic strips. This is probably explained by the fact that more of us do small-scale gardening than large-scale farming. Of course, all of us eat food produced by, in, or on soil; but being one step removed from the process appears to have resulted in a limited personal association with soil, and, therefore limited coverage in comic strips.

Other components of the soil production function (Table 27.1) such as the extraction of raw materials are more rarely encountered. However, open-pit mining activities are drawn in some stories, showing directly their impact on overlying soil (Tillieux 1962).

Fig. 27.4 Le concombre masqué " L'intégrale des années Pilote " – le jardin zen – (the cucumber with a mask – the zen garden) (Mandryka 2004). © Dargaud (see as color plate following *Index*)

27.6 Engineering Function

The engineering function of soil is probably the most recognisable soil function to most people. Even people growing up in the city will have experienced digging in soil in a garden or park when they were young. There is really no escape from the engineering function since, ultimately, we all live on the soil. The need for soil to provide a sound foundation for our homes and environs is essential, although probably mostly taken for granted—out of mind, and rarely connected to the pen of the cartoonist. And this is understandable, as there is a lack of comical or ironic element in everyday life and everyday soil. In contrast, situations where soil properties and processes are not considered carefully enough, and lead to disaster, are common topics in satirical cartoons. It is simply assumed that the soil will provide a good quality, stable platform for us and our structures. However, when the performance of the soil is not in check with the structures we have placed upon it, the soil is easily blamed, although in nearly all circumstances, faulty human planning was to blame.

The engineering function of soil is also sometimes evoked through soil sealing (*e.g.*, overlying soil with concrete). The most famous examples are the towns that sprang up following the Gold Rush of the American West (*e.g.*, de Bévère (Morris) and Goscinny 1987; Rémy (Hergé) 1993).

27.7 Regulation Function

The regulation function was the least encountered soil function in the investigated comic strips. From an environmental point of view, as well as from a scientific position, the interaction of soil with other ecosystem components is arguably the most important soil function of all. This is apparent from the list of components in Table 1, ranging from climate regulation to waste and pollution control. However, examples of the regulation function of soil featuring in comic strips proved to be few and far between. Two reasons for this may be postulated. First, it may be that the public is aware of the regulation function of soil, but it does not provide for interesting, entertaining, or visually attractive material in comic strips. Alternatively, the awareness of the soil regulation function with the public is low or absent and, therefore, comic strip authors judge there is no interest (or indeed, they are unaware themselves).

For a rare example of the regulation function of soil, we return to the Donald Duck story mentioned previously (see 27.3.1.). To expel the moles who have created a huge mound underneath the office, Donald puts the fire hose in one of the entrances to the mound, hoping to flush the animals out. His nephews (who among us can forget Huey, Dewey, and Louie!) discover that the water does not infiltrate the soil, but that bypass flow causes the water to exit the mound further down, thereby flooding the neighbour's property.

One other example was found in a 1978 edition of the Star Trek Comic "The Planet of No Life". The *Enterprise* visits an inhabited planet where nothing grows because of the radioactivity of the soil. The situation requires a quick solution and Mr. Spock creates a formula of ‘life-giver’ chemicals within hours. The *Enterprise* crew launches two missiles that hover over a section of the planet. One sprays the ‘life-giver’ chemicals, before the second missile releases young trees. The trees that land in the treated soil live, while nearby the plants released into untreated soil quickly wither and die.

The story does not explain how the soil got to be radioactive in the first place, but the lightning quick formulation of a chemical substance that manages to overcome the physical phenomenon of radioactivity certainly evidences an extremely confident, high-tech attitude towards remediation of polluted soils. Of course, in a comic strip set so far into the future, such reliance on high-tech solutions to environmental contamination can be expected and excused. In “*Nausicaa de la vallée du vent*” (Miyazaki 2000), a polluted soil is reclaimed by a more conventional forest plantation.

27.8 Conflicts Between Soil Functions

As seen above, the soil functions are unequally encountered in comic strips. This section examines examples in which conflicts between functions form the heart of the story. A consequence of the diversity of soil functions is that conflicts often occur between these functions, and that the ‘soil quality’ concept is still in permanent debate (Sojka and Upchurch 1999 ; Karlen et al. 2003 ; Letey et al. 2003 ; Sojka et al. 2003). In comic strips, such as in other arts, these conflicts are mainly reflected in land use clashes of interest. Classical examples come from the history of the American West (*e.g*., extension of the railway, cattle ranchers vs. “sodbusters”). Other numerous examples of conflicts of interest relate to gardening vs. animal habitat (*e.g*., hunting the moles), or gardening vs. animal activity. A large number of figures of the comic strip “Boule et Bill” (Roba 2001) illustrate the fight between a gardener and his dog who digs holes in the soil to bury all the bones that he gets.

27.9 Soil Inventory and Monitoring

As conflicts between soil functions must be solved, and as soil is a natural resource of common interest that is under increasing environmental pressure (CEC 2006), it is essential that soil inventory and monitoring are undertaken, in order to manage this resource properly. Soil inventory and monitoring are quite esoteric subjects, and as such, are almost never encountered in comic strips. Sometimes, however, a character may give the impression of taking the soil into consideration, or at least feeling curious about it. The “cucumber wearing a mask” (Fig. 27.5) behaves like a field soil surveyor testing the soil; he looks carefully to the soil surface, and even uses an unexpected sense (hearing) to examine the soil.

Fig. 27.5 Le concombre masqué " L'intégrale des années Pilote " (the cucumber with a mask, whole pilot years comics) (Mandryka 2004). © Dargaud (see as color plate following *Index*)

From the soil scientist community (newsletters, websites, educational books), comics strips illustrating soil surveyors doing fieldwork are far more numerous. Digging the soil is a very frequent activity in such comic strips and cartoons.

27.10 Discussion and Conclusions

Comic strips aimed at providing educational material are probably the most common type surveyed here. However, by their nature, such comic strips are small-scale initiatives and therefore, not part of the mainstream world of comic strips. They are designed for a local purpose, *e.g.*, to aid student understanding a university course dealing with soil organic matter dynamics However, with the rise of the Internet, this seems to be a growing area with several initiatives by government agencies and research institutes as part of their public education outreach to help raise awareness of soil as an ecosystem component and a fragile resource.

In the more mainstream comic strips, aspects of the production, habitat and engineering functions of soil appear to receive most attention, whereas the regulation function seems to be underrepresented. An obvious explanation for this pattern is that digging and building (engineering function), farming and gardening (production functions), and our fascination with earthworms and other "creepy crawlies" (habitat function), are simply the most visible and recognisable ways in which we, as children and adults, interact with soil. The components of the regulation function of soil (see Table 27.1) are much less easy to understand or to visualise. Although our involvement with soil in the regulation function is actually substantial and important (*e.g.*, supply of water to vegetation, interactions with climate change by oxidation of soil organic matter, or the filtering of water to make it potable), it is in a more indirect fashion than with the other soil functions. For example, our drinking water comes out of the tap or a bottle—without focused thought, most of us see no association with soil. But almost every day we walk past a building site, or we grow plants in our garden or on our window sill. And somewhat less often, depending on where we live, we see earthworms crawling onto the pavement after it has rained. The regulation function may simply be too far removed from the foreground of our conscious lives to meet the interest threshold of mainstream comic strips.

Compared to the other two main natural media on the planet (*i.e.*, water and air) soil appears to receive relatively little attention in comic strips. This can be illustrated by an exercise on the cartoon bank of *The New Yorker* magazine. All 70,363 cartoons appearing in *The New Yorker* from 1925 to 2007, were searched by topic for 'soil'. Only six were found (0.01%). By comparison, the entry 'water' returned 314 hits (0.45%), and 'air' 171 hits (0.24%). While *The New Yorker* is clearly not where one typically goes to assess environmental attitudes and developments, the relative position of soils is perhaps reinforcing of our view of its low attention level in the general culture.

For educational comic strips, however, the regulation function, with all its complex interwoven soil biological, chemical and physical processes, may be a fertile source of inspiration. Soil biology forms the most obvious source of characters for comic strips, and not only the ubiquitous earthworm. One only needs to look at electron microscope images of springtails (*Collembola*) or mites (*Acarina*) to realise the potential for monstrous characters.

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References

Barou D, Renaut P (2006) Le Fluink – enfin libre (The Fluink – free at last). Le cycliste 48pp [in French]

Blum WEH (1993) Soil protection concept of the council of Europe and integrated soil research. In: Eijsackers HAP and Hamers T (Eds) Integrated Soil and Sediment Research: A Basis for Proper Protection 37–47

Blum WEH (2005) Functions of soil for society and the environment. Reviews in Environmental Science and Bio/Technology 4: 5

Brady NC, Weil R (2001) The Nature and Properties of Soils. Prentice-Hall. 960pp

Briggs R (1977) Fungus the Bogeyman. Hamish Hamilton. 48pp

Busch W (1865) Max und Morizt. http://jadukids.de/maerchen/max_und_moritz/index.html. Cited 12 oct 2008 [in German]

Carpentier L-M (1980) La dalle maudite (The accursed dale), Casterman 46pp [in French]

Catania KC (2000) Epidermal sensory organs of moles, shrew-moles, and desmans: A study of the family talpidae with comments on the function and evolution of Eimer's organ. Brain Behavior and Evolution 3: 146–174

CEC (2006) Directive of the European parliament and of the council – Establishing a framework for the protection of soil and amending Directive 2004/35/EC. Brussels 30pp

Chivard Y, Omond E (1999) Toto l'ornithorynque (Toto the Duckbill), Delcourt [in French]

Colomb G (1889) La famille Fenouillard (the Fenouillard family). Journal de la Jeunesse [in French]

Coyne MSA (1996) Cartoon history of soil microbiology. Journal of Natural Resources and Life Sciences Education, 25: 30–36

Dahan N (1998) Tribulations gastriques d'Eric le lombric (The gastric tribulations of Eric the worm). Nathan Jeunesse [in French]

de Bévère M (Morris), Goscinny R (1987) Lucky Luke: A l'ombre des derricks (Lucky Luke: in the shade of derricks), Dupuis 48pp [in French]

De Groot RS, Wilson MA, Boumans RMJ (2002) A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41: 393–408

Dirks R (1897) The Katzen-jammer Kids. American Humorist. http://www.yodaslair.com/dumboozle/katzies/katzdex.html. Cited 12 oct 2008

Garner (date unknown) http://www.fao.org/docrep/T0389E/T0389E00.GIF. Cited 12 oct 2008

Goyallon J, Bouysse P, Courbouleix S, Lévëque C, Vomorin J-P (1996) L'astre des terriens (Terrestrians' star). BRGM. 48pp [in French]

Jannin F, Delporte Y, Franquin A (2006) Les démêlés d'Arnest Ringard et Augraphie (The wrangles of Arnest Ringard and Augraphie), Marsu Production 120pp [in French]

Jastrow JD, Miller RM (1998) Soil aggregate stabilization and carbon sequestration: feedbacks through organomineral association. In: Soil Processes and the Carbon Cycle. Ed: Lal, R. et al. Advances in Soil Science, Boca Raton, Florida., USA

Karlen D, Ditzler C, Andrews S (2003) Soil quality: why and how? Geoderma 114: 145–156

Larson G (1999) There's a Hair in My Dirt! A Worm's Story, Harper Paperbacks. 64pp

Letey J, Sojka R, Upchurch D (2003) Deficiencies in the soil quality concept and its application Journal of soil and water conservation 58: 180–187

Mandryka N (2004) Les aventures potagères du concombre masqué (The edible adventures of the cucumber with a mask), Dargaud 48pp [in French]

Mayhew H, Landells E (1843) Punch Magazine. http://en.wikipedia.org/wiki/Punch_magazine. Cited 12 oct 2008

McCay W (1905) Little Nemo in Slumberland New York Herald

Miyazaki H (2000) Kaze no tani no Naushika (*Nausicaä* of the Valley of the Wind), Glénat [in French]

National Soil Resources Institute (NSRI) of England and Wales (2006) www.soil-net.com. Cited 12 oct 2008

Nikitin ED (2005) Soil Ecology and the Study of Soil Functions. Eurasian Journal of Soil Science 38: 922–930

Outcault RF (1896) The Yellow Kid. Truth magazine. http://www.neponset.com/yellowkid/. Cited 12 oct 2008

Perry D, TenNapel D (1994) Shiny Entertainment, Earthworm Jim video game. Virgin Interactive

Plessix M (1996) Le vent dans les saules (The Wind in the Willows), Delcourt [in French]

Regnier M (Greg) (1984) Achille Talon "A bout (mal) portant" (Exhausted but still carrying), Dargaud [in French]

Rémy G (Hergé) (1993) Tintin en Amérique (Tintin in America), Casterman Editions 61pp [in French]

Rémy G (Hergé) (2002) Le trésor de Rackham le Rouge (Red Rackham's treasure), Casterman [in French]

Ritz K, McHugh M, Harris JA (2004) Biological diversity and function in soils: contemporary perspectives and implications in relation to the formulation of effective indicators. In Agricultural Soil Erosion and Soil Biodiversity: Developing Indicators for Policy Analyses, ed R. Francaviglia, OECD, 563–572

Roba J (2001) Boule et Bill – Bwoufallo bill? (Wooffalo Bill?) Dargaud 48pp [in French]

Sojka R, Upchurch D (1999) Reservations regarding the soil quality concept. Soil Science Society of America Journal 63: 1039–1054

Sojka R, Upchurch D, Borlaug N (2003) Quality soil management or soil quality management: Performance versus semantics. Advances in Agronomy 79: 1–68

Sombroek WG, Sims D (1995) Planning for sustainable use of land resources: towards a new approach. FAO Land and Water Bulletin 1024–6703 (2), ISBN 92-5-103724-8, FAO, Rome, Italy

Thompson DC (1969) Island of Monsters. DC Thompson & co, Ltd, London

Tillieux M (1962) Gil Jourdan, L'enfer de Xique-Xique (the Hell of Xique-Xique), Dupuis [in French]

Töpffer R (1833) Histoire de Mr Jabot (Story of Mr Jabot) [in French]

Turk P, De Groot B (1990) Léonard – Génie en sous-sol (underground genius), Dargaud 48pp [in French]

Walt Disney (2003) Donald Duck Weekly 24: 5–13 [in Dutch]

Chapter 28
Soils and Terroir Expression in Wines

Cornelis van Leeuwen

28.1 Introduction

No other agricultural product has as strong a relationship with the soil as does wine. The link is immediately perceptible in the label, as most wines bear the name of the place of their origin. In a multitude of locations, each with particular characteristics with regard to soil and climate, a myriad of wines are produced, all differing in taste and quality. Some conditions are particularly favourable to wine growing and allow the production of wines of exquisite quality. The market acknowledges these differences in quality and accepts that some wines are worth tenfold, or even hundredfold, the price of those grown in less favourable environments. The hierarchy of wines has become more and more sophisticated over the years, resulting in the delimitation of production areas and the classification of famous growths. The most striking example is found in the Burgundy region, where selling prices vary from one to tenfold depending on the location of the vineyard plot, although viticultural practices and winemaking process are basically identical across plots belonging to the same grower. As a result, value can be attributed to wine production in terms of quality rather than quantity, which is a quite unique situation among agricultural products. In most wine growing areas, productivity is three to five times lower than possible attainable yields. Vines are often grown under environmental stress, which reduces yield but enhances grape quality potential. In wine production, the effect of the environment on wine quality is referred to as “the terroir effect”. Although “terroir” has similarities with the French word “terre”, it has a broader meaning than the influence of the soil on the taste of wine. Terroir is concerned with the relationship between the characteristics of an agricultural product (generally wine) and its geographic origin, which might influence these characteristics. It can be defined as an interactive ecosystem, in a given place, including climate, soil and the

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vine (Seguin 1988). To understand the way terroir functions, it is essential to take into account the interactions among the factors that contribute to terroir. While very high quality wines are grown in various climates, it is impossible to define the ideal climate for fine wines in terms of temperature, rainfall (amount and distribution), or solar radiation. Nor can one define the best possible soil for growing high-quality wines in terms of pebble-, clay- or lime-content, soil depth, or organic matter content. These factors of the natural environment have to be considered in terms of their interaction with the vine. Human factors, such as history, socioeconomics, as well as viticultural (vine growing) and oenological (winemaking) techniques, are also part of terroir (Seguin 1986). Viticulture is a human activity. The history of the socioeconomic environment may be important in understanding why a given vineyard has emerged in a given site, and why it has prospered.

28.2 Human Factors

It is important to consider the human factor in terroir, because no vineyard exists without the intervention of mankind. Wine is an essential element in eating and drinking, especially in Mediterranean regions. Because vines (like olive trees) have low agronomic needs in terms of mineral and water supply, farmers used to reserve richer soils for cereals and grazing, and planted vines on poor soils, either because they were shallow or stony, or because they were located on steep slopes. Mankind also played an essential role in the evolution of grapevine varieties through selection on the basis of their ability to produce high-quality wines, because none of the currently cultivated varieties of *Vitis vinifera* existed in nature.

Vineyards emerge in locations where the socioeconomic conditions are favourable for wine growing. The difficulty of transporting a liquid beverage in the past should not be overlooked. Many vineyards arose in the vicinity of a concentration of consumers, or near a harbour or a navigable river. Vineyards that were established in locations where the natural environment was favourable for growing quality wines survived, while other, less favourable locations, disappeared. Because Paris was (and is) an important centre of wine-consumption, a flourishing wine growing region developed close to the French capital, which produced up to 4.8 million hectolitres of wine in 1820 (Logette 1988). However, climatic conditions in that part of France are not optimum for wine growing since it is difficult to attain ripeness. Wine growing sharply decreased around Paris after the phylloxera crisis. *Phylloxera vastatrix* is an insect that was imported with plant material from America in the second half of the 19th century. It attacked the vine roots and destroyed most of the European vineyards. After several years of research, the grafting of vines on phylloxera-resistant root stocks was found to be a solution. Some vineyards were rapidly replanted on rootstocks. Others, like the vineyards around Paris, never recovered from this insect-pest crisis. The opening of the Paris-Lyon-Marseille (PLM) railway in the second half of the 19th century made it possible to transport wine to Paris from the South of France, where climatic conditions were more favourable for wine growing. Around La Rochelle and Bordeaux, two flourishing vineyards developed during the Middle Ages because of the possibility of transporting wine overseas to England and Holland. The vineyard at La Rochelle, where the soils are not particularly favourable for vine growing, disappeared with the decline of the port; the vineyard at Bordeaux survived, even when its port lost in economic significance, because the environmental conditions (soil and climate) and the cultivars used around Bordeaux were particularly suitable for the production of high-quality wines. Even today, new vineyards develop where the socioeconomic context is favourable for the production of wine. The emergence of the Pic Saint Loup area in the Languedoc can largely be explained by the beauty of the countryside, which, combined with the vicinity of Montpellier and the Mediterranean Sea, makes it an attractive site for investors. In Australia, wine growing in the Hunter Valley was introduced by early settlers who brought in vine cuttings via Sydney, although the humid climate is far from ideal for wine growing. Later, wine growing extended to more favourable sites, although vineyards in the Barossa and Yarra Valleys also largely benefited from the vicinity of Adelaide and Melbourne. There are very few examples of famous wine growing areas developing in inhospitable and remote areas, far from centres of consumption.

It was due to the trade with England that Bordeaux developed the production of wines of origin. Since the Middle Ages, wine was sold in Bordeaux by the name of the parish. Selling prices varied from one to fourfold according to the name of the commune, which means that it was already acknowledged that some origins produced better wines than others (Markham 1997). The first estate to sell its wines under its own name was Château Haut-Brion, located near the small city of Pessac, under the ownership of Arnaud de Pontac, in the 17th century. He was convinced that the wines of Haut-Brion were superior to other wines of Pessac, justifying higher prices. When Arnaud de Pontac's son opened a tavern in London, Haut-Brion soon became an acclaimed wine in the capital of England. This brought the philosopher John Locke to visit Haut-Brion in 1677. Locke refers to this visit in his complete works (*in* Pijassou 1980): "The vine de Pontac, so much esteemed in England, grown on a rising open to the West, in a white sand mixed with a little gravel, which one would think bear nothing; but there is so much a particularity in the soil, that at Mr. Pontac's near Bordeaux the merchants assured me that the wine growing in the very next vineyards, where there was only a ditch between, and the soil, to appearance, perfectly the same, was by no means so good." This suggests that as early as the second half of the 17th century, the soil was already thought to be an important factor in wine quality in Bordeaux.

Inspired by the example of Château Haut-Brion, rich Bordeaux merchants created large estates in the Médoc between the end of the 17th century and the 18th century. Some of today's most famous Médoc estates were among the first to be planted with vines in that region. Apparently, enough empirical knowledge was available at that time for efficient site selection. Qualitative differences among the wines produced led to a sophisticated hierarchy in selling prices, which was the basis for the classification of 1855 (Markham 1997). Although terroir-related factors such as climate and soil were not directly taken into account in the classification of 1855, the wines from the

Médoc châteaux can be considered “terroir wines”. These châteaux produce their wines exclusively from grapes grown in their own vineyards.

In today’s wine production, a distinction should be made between “terroir wines” and “branded wines”. Terroir wines are produced in a specified location. They owe their specific characteristics to the influence of climate and soil on vine behaviour and wine quality. Examples are estate wines or single-vineyard wines. The volume of these wines cannot be increased, which can make some famous terroir wines very prone to speculative investment. Branded wines are produced by blending wine or grapes from larger areas and from a variety of sources, which may vary from year to year. They owe their characteristics to oenological processes and blending. Their volume can be increased to meet demand. Traceability is an important issue in today’s agro-business. Terroir wines have always had excellent traceability. Three centuries ago, a consumer who enjoyed a bottle of Lafite could visit the vines that produced the fruit, know when the wine was made and bottled, and meet the people involved in its production.

28.3 Factors of the Natural Environment

28.3.1 Climate

28.3.1.1 Macroclimate and vine-climate interaction

The vine is a perennial plant adapted to a wide range of climatic conditions. The main cultivated vine species for quality wine making is *Vitis vinifera*, which can survive temperatures as low as –15°C to –20°C (depending on the cultivar) in winter. The temperatures needed for grapes to attain full ripeness are highly variable among cultivars. At high latitudes, temperatures can be too low to ripen the grapes, even for early ripening varieties. In equatorial regions, vine vegetation is continuous, and all the reproductive stages exist simultaneously in the same plot. Although viticulture is possible in equatorial regions, especially for table grape production, fruit grown under these conditions does not have a high oenological potential. Taking into account these limitations, it appears that the zone most suited to growing high-quality grapes is between the 35th and the 50th parallel of latitude in the Northern hemisphere, and between the 32nd and 45th parallel in the Southern hemisphere. In some cases, high altitude can compensate for low latitude.

Precociousness for fruit ripening is a genetically determined property that is highly variable from one cultivar to another. When a wide range of cultivars is grown in the same vineyard (so-called “ampelographic” collections in research centers), it is common to observe a two-month time lag between the moment of ripeness of the earliest and the latest ripening varieties (Huglin and Schneider 1998).

In traditional wine growing regions in Europe, growers have used this property to adapt the vines to local climatic conditions. At high latitudes, the limiting factor for producing high-quality wines is the level of ripeness of the grapes. Unripe grapes give green, acidic wines, with low alcohol levels, as a result of insufficient sugar accumulation in the fruit. For this reason, early ripening varieties such as Pinot noir, Chardonnay and Gewürztraminer are grown at high latitudes, to optimise the chances of attaining correct ripeness. At lower latitudes, where the climate is warmer, grapes might attain ripeness early in the summer. Quick ripening of the grapes reduces aromatic expression in the wines produced: "the best wines are produced with cultivars that just achieve ripeness under the local climatic conditions, as if quick ripening of the grapes burned the essences that makes the finesse of great wines" (Ribéreau-Gayon and Peynaud 1960). According to this empirical knowledge, growers have planted late-ripening varieties such as Grenache and Mourvèdre (called Monastrel in Spain) in warmer climates at low latitudes. As a result, in traditional wine growing regions in Europe, grape picking generally takes place between 10 September and 10 October, despite huge climatic differences between, for example, the Mosel in Germany and Alicante in Spain. This type of viticulture is also called "cool climate viticulture", not necessarily because the climate is particularly cool, but because the ripening of the grapes occurs in cool conditions, at the end of the summer or in the early autumn.

28.3.1.2 Mesoclimate and topoclimate

Climatic variability within a wine growing region can be described as mesoclimatic variability. When it is the result of relief (altitude, aspect, slope), it is called topoclimatic variability. Especially in cool regions, where it is difficult to achieve grape ripeness, topoclimate can be a major terroir factor. In the Mosel Valley in Germany, quality wines can only be produced on steep, south-facing slopes. In Burgundy, the best wines are produced in the Côte d'Or, at approximately 250 m above sea level. In the Hautes-Côtes, where the altitude is higher, it is harder for grapes to reach complete ripeness. Picking is delayed by ten days, and wine quality is generally good, but rarely outstanding, despite the fact that fine soils for vine growing can be found in this part of Burgundy.

28.3.1.3 Microclimate

Microclimatic variation in the fruit zone can be induced by the soil type and through canopy management. It can have a great impact on the quality performance of a vineyard. Dry soils (for instance, stony soils) warm up more quickly than do wet soils, inducing early ripening. This is an essential quality parameter in cool climate viticulture. Soils inducing low vine vigour [for instance, because of low water and/or nitrogen availability for the vines (see below)] improve light penetration inside the canopy and on the fruit zone, which is essential for growing high quality fruit. Leaf removal in the fruit zones increases fruit exposure to sunlight and enhances grape ripening.

28.3.2 Soil

Vines can be grown on a huge variety of soils. In deep, rich soils, vines are vigorous and highly productive, but better wines are generally produced when the vines are cultivated on poor soils. The effect of the soil on vine behaviour and grape composition is complex, because the soil influences not only vine mineral nutrition and water uptake conditions, but also rooting depth and temperature in the root zone. Soils can be studied from a geological, a pedological, or an agronomic perspective.

28.3.2.1 Geology

The possible role of geology on wine quality has since long been discussed (for instance for the Alsace: Erhart 1939). Geology deals with topics such as rock types and dating of sedimentary strata. Geology influences topography, with rocks that resist weathering forming ridges. The soil type is also related to the sort of rock on which it has developed. In some regions, there is a rather good correspondence between the type of geological substrate and the quality of the wines produced on it. The example most often cited is Chablis, where all the famous vineyards are planted on Kimmeridgian limestone and marl, while vineyards on Portlandian limestone produce the less famous Petit Chablis (Pomerol 1989). In this case, the relation is probably based on the influence of the rock type on the geomorphology of the region. South- and east-facing slopes developed on the soft Kimmeridgian limestone and marl, provide good exposure, compensating for the cool climate of the Chablis region. The harder Portlandian rock is found on a wind-exposed plateau, located at higher altitudes, where it is harder for Chardonnay grapes to attain complete ripeness (Wilson 1998).

In most other regions, the link between geology and wine quality is less obvious. In Bordeaux, very good wines are produced on sedimentary rocks of a large variety of geological origins: Oligocene heavy clay sediments, Oligocene limestone and Quaternary alluvium (Seguin 1983). Some of the finest wines are produced on Oligocene Asteries limestone in Saint-Emilion, while lesser wines are made on the same rock type in the Entre-Deux-Mers region. Excellent descriptions of grape growing region worldwide by their geology and geomorphology are available in Fanet 2001.

28.3.2.2 Topography

Topography influences climatic conditions at the plot level. Well-exposed slopes (South in the Northern hemisphere, North in the Southern hemisphere) receive a higher amount of solar radiation, resulting in higher temperatures and better ripening conditions. Topography also acts on soil distribution. On concave slopes, erosion on the upper part of the slope limits soil depth. On the lower part of the slope,

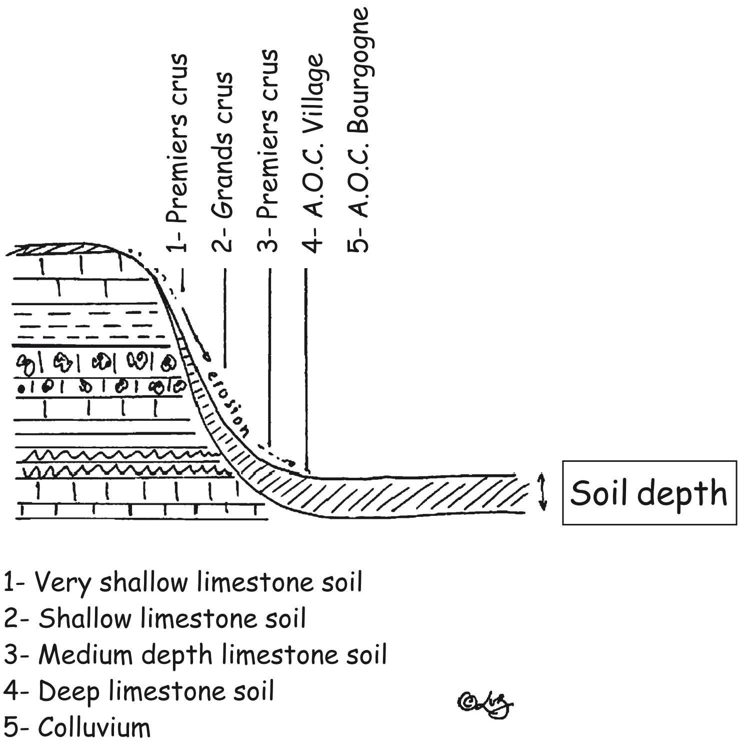

Fig. 28.1 The effect of slope on soil distribution in Côte d'Or (Burgundy, France)

soil depth is increased through accumulation of colluvium. An example of the effect of slope on soil distribution in Côte d'Or (Burgundy, France) is shown in Fig. 28.1. The best vineyard soils are located halfway down the slope. In the upper part, soils are too shallow (less than 10 cm in depth) to allow vine rooting. In the lower part of the slope, soils are deep and rich, increasing vine vigour and productivity, and reducing grape quality potential.

28.3.2.3 Pedology

Soil types can be mapped, based on a pedological classification. Some soil types, such as limestone soils, are known for producing generally high quality wines, while others, such as soils subject to water logging, are known for being less suitable for producing quality wines. For a long time, pedologists have tried to relate wine quality to soil type (for instance for the Graves region near Bordeaux: Lafforgue et al. 1936). However, throughout the world, outstanding wines are grown on a huge variety of soils. In the Bordeaux area, top wines are produced on soils as different as alkaline limestone soils (Ausone), acidic gravelly soils (Lafite-Rothschild), neutral gravelly soils (Cheval Blanc) or heavy clay soils (Petrus, Cheval Blanc). It is generally not possible to equate a soil map of a given region with a map of quality potential for wine growing (van Leeuwen 1989).

28.3.2.4 Agronomic approach

To understand the effect of the soil in viticulture, it is necessary to take into account the interaction between the soil and the vine (agronomic approach). Soil influences vine behaviour and wine quality through the temperature in the root zone, and through mineral and water supplies. Barbeau et al. (1998a and b) showed that vine precocity (the moment that a vine reaches a specific phenological stage), especially at budbreak (when shoots start developing from winter buds), is related to soil temperature in the root zone. Soil temperature in the root zone is high in dry and shallow soils, and low in deep, humid soils. Vine precocity can be an important quality factor in cool climates, as in the Loire Valley, where it is difficult to ripen Cabernet franc in cool vintages.

Among the minerals that the soil supplies to the vine, nitrogen is clearly the one that most influences vine vigour, yield and grape ripening. Many studies deal with the influence of various levels of nitrogen fertilization on these parameters (Kliewer 1971; Bell et al. 1979; Delas et al. 1991; Spayd et al. 1993; Spayd et al. 1994). Cover crops are used in vineyards to prevent soil erosion, improve soil structure, reduce the use of herbicides, enhance trafficability during wet weather and create a beneficial habitat for arthropods. Cover crops compete with vines for soil nitrogen (Soyer et al. 1996).

Much less documented in scientific literature is the fact that vine nitrogen uptake is likely to vary considerably in relation to soil parameters such as soil organic matter content, C/N ratio of soil organic matter, and organic matter turnover, even when no nitrogen fertilization or crop cover is implemented. Soil organic matter turnover depends on soil temperature, aeration, pH, and moisture content. It is also slowed down by the presence of free calcium carbonate ("active lime") in the soil. As a result, the level of natural soil nitrogen supply to the vines can be considered as a component of terroir, and it is highly variable depending on the soil type (van Leeuwen et al. 2000). Choné et al. (2001) showed that limited nitrogen supply to the vines due to soil parameters increases quality in red wine production because it reduces vine vigour and increases berry and wine phenolic content. This is not true in white wine production, where vine nitrogen supply should be at least moderate to obtain high aroma potential in grapes (Peyrot des Gachons et al. 2005; Choné et al. 2006). The effect of other minerals on vine development and grape quality potential is much less obvious, as long as neither excess nor severe deficiency alters vine physiology (Seguin 1983; van Leeuwen et al. 2004). The widespread myth that the taste of wine is influenced by deep roots searching for particular minerals in the soil is not supported by any scientific evidence.

28.3.3 Vine Water Uptake Conditions

Vine water status depends on climate (rainfall and potential evapotranspiration), soil (water holding capacity) and training system (canopy architecture and leaf area). Vine water uptake conditions are key factors in understanding the effect of the terroir on grape quality potential, because the main terroir factors (climate, soil, grapevine) are involved and interact. Vine water uptake was first studied by means of a neutron moisture probe in the soils of the Haut-Médoc (Seguin 1969). The same author showed that grape quality potential was related to a regular but moderate water supply to the vines (Seguin 1975). Under non-irrigated field conditions, berry size is decreased and total phenolics are increased when vines face water deficits, which results in higher grape quality potential for red wine making, but lower yields (Duteau et al. 1981; van Leeuwen and Seguin 1994; Koundouras et al. 1999; Choné et al. 2001; Tregoat et al. 2002; van Leeuwen et al. 2004). These effects were confirmed in irrigation trials by Matthews and Anderson (1988) and Ojeda et al. (2002). Berry ripening speed is increased when vine water status is low (van Leeuwen et al. 2003). Aroma potential of white grapes might be decreased under severe water deficit stress (Peyrot des Gachons et al. 2005). Water deficits are likely to occur under dry climates or in soils with a low water holding capacity. Water holding capacity is reduced either when soils are stony or when they are shallow. Because water deficit is a quality factor in red wine production, quality potential is often linked to limited soil depth (Coipel et al. 2006). This observation is in contradiction with a widespread belief that deep rooting of the vines is an important aspect in terroir expression.

Vine water uptake conditions can be modified by means of irrigation. Irrigation increases not only the production of sugar and skin phenolics per vine, but also yield (Matthews and Anderson 1988). Yield is generally more rapidly increased than sugar and skin phenolics on a per vine basis, which might result in dilution. Only deficit irrigation can result in economically acceptable yields with high quality-potential grapes in very dry regions. Irrigation is likely to modify terroir expression. The ideal water status with regard to grape quality potential is highly dependent on yield. In dry farmed vineyards in dry areas, excellent red wines can be made from fruit grown on severely water stressed vines, as long as the yield is very low. For higher yield, the best results in terms of quality are obtained when water deficit is mild, which might be obtained through deficit irrigation in dry areas.

28.4 Examples of Viticultural Soils Producing Famous Wines

Great wines are produced on a diversity of soils. It is not possible to predict the quality potential of a soil for wine production without taking into account the interactions between the soil and the vine, with regard to water and mineral uptake conditions. As an illustration, two famous wine-producing Bordeaux soils are presented.

28.4.1 Shallow Limestone Soils

Shallow limestone soils on hard parent rock are found in Saint-Emilion, where parent material is Tertiairy Oligocene ”Asteries” limestone. Some of the finest wines from this region are produced on this soil type. Vineyards are planted with the varieties Merlot or Cabernet franc. Soil texture is about 20% clay, 20% silt and 60% sand. Cation exchange capacity is moderately high. Soil organic matter content is moderate, generally around 2%. However, because of the presence of active lime, organic matter mineralization speed is reduced, and there is no risk of excess nitrogen nutrition. Active lime leads to poor iron uptake, and rootstocks have to be carefully chosen to avoid chlorosis (leaf yellowing due to inadequate iron absorption). Despite being shallow (50 cm in depth, above hard bedrock), this soil never induces symptoms of severe water deficit on vines. Although the vines barely colonize the hard parent rock, it has been shown that during dry summers they use water stored in the limestone rock, which rises by capillarity to the roots (Duteau 1987). The limestone is porous; in case of heavy rainfall, excess water easily drains out of the soil profile. Hence, vine water uptake conditions are particularly well regulated. To some extent, the shallowness of the soil compensates for its relative richness.

Budding is precocious whereas flowering, veraison (the start of grape ripening materialized by a change in colour of the grape berries), and harvest times are average. Early-to-medium ripening varieties such as Merlot and Cabernet franc perform well on this soil type, while the late-ripening Cabernet-Sauvignon has difficulty attaining full ripeness. Vine vigour and productivity are moderate. The wines produced show medium concentrations of silky tanins, providing a very soft mouth-feel. Their taste is very balanced (*i.e.*, harmony among tactile and aromatic perceptions). Aromas are discrete when the wine is young, but gain considerably in complexity and finesse as the wine ages. Very fine sweet wines are produced on similar soils in the Barsac Appellation (close to Sauternes, Bordeaux area).

28.4.2 Gravelly Soil

Gravelly soils in the Bordeaux region are located on Quaternary alluvium of local rivers: the Garonne (Pessac-Léognan Appellation), the Dordogne (Saint-Emilion), the Isle (Pomerol), as well as on the Gironde estuary (Médoc). These soils are planted to Cabernet-Sauvignon, Merlot or Cabernet franc. Soils contain a high proportion of gravel and other coarse materials (generally over 50%) The fine earth is mainly composed of sand, with up to 20% clay. Cation exchange capacity is very low, as is soil organic matter content (often around 1%). However, organic matter mineralization speed is high in this warm, well-aerated soil, and nitrogen is seldom a limiting factor for vine development. Soil water holding capacity is low; water deficit stress may be severe in a vintage with low rainfall. Deep rooting is possible; however, compact layers at 1.5 or 2m in depth sometimes limit root penetration.

Gravelly soils warm quickly in the spring. Budding is early, and so are flowering, veraison and ripeness. Harvest is generally early. Because of water deficit stress, shoot growth ceases early in the season, and berry growth is also limited. These two aspects are considered as important quality enhancing factors in red wine production. Photosynthesis may also be reduced in vintages with low rainfall. Hence, only a small crop will attain perfect ripeness and yields should be low. Wines here are tannic and need aging to soften. Aromas are very complex, particularly after some ten years of bottle aging.

28.5 Conclusion

The taste of wine reflects the natural environment in which the grapes are grown, particularly in cool-climate viticulture, where precociousness of grapevine varieties allows fruit to ripen at the end of the growing season (at the end of September in the northern hemisphere). In terms of red wine production, high grape quality is obtained when a limiting factor, generally water deficit stress, reduces both vine vigour and berry size, and increases grape skin phenolics. These conditions are met, either when the climate is dry (low rainfall), or when the soil water holding capacity is low. Shallow or stony soils are favourable to the occurrence of water deficits. Low nitrogen supply, resulting from soil parameters, may also be a quality-enhancing factor in red wine production. For white wine production, water and nitrogen supply to the vines should be at least moderate, because severe stress can negatively affect grape aroma potential. Wine can, to some extent, be compared to art. Wine stimulates the senses, as does art. Great wines can be a speculative investment, as can be pieces of art. If a great wine is a piece of art, then this is a form of art that is shaped by the soil.

References

Barbeau G, Morlat R, Asselin C, Jacquet A (1998a) Relations entre la précocité de la vigne et composition des baies de divers cépages du Val de Loire. Progrès Agricole et Viticole 6: 127–130.

Barbeau G, Asselin C, Morlat R (1998b) Estimation du potentiel viticole des terroirs en Val de Loire selon un indice de précocité du cycle de la vigne. Bulletin de l'O.I.V. 805–806: 247–262.

Bell A, Ough C, Kliewer W (1979) Effects on must and wine composition, rates of fermentation, and wine quality of nitrogen fertilization on *Vitis vinifera* var. Thompson seedless grapevines. Am J Enol Vitic 30: 124–129.

Choné X, Van Leeuwen C, Chéry Ph, Ribéreau-Gayon P (2001) Terroir influence on water status and nitrogen status of non irrigated Cabernet Sauvignon (*Vitis vinifera*): vegetative development, must and wine composition. South African Journal of Enololgy and Viticulture 22: 8–15.

Choné X, Lavigne-Cruège V, Tominaga T, Van Leeuwen C, Castagnède C, Saucier C, Dubourdieu D (2006) Effect of vine nitrogen status on grape aromatic potential: flavour precursors

(S-cysteine conjugates), glutathione and phenolic content in *Vitis vinifera* L. cv. Sauvignon blanc grape juice. J Int Sci Vigne Vin 40: 1–6.
Coipel J, Rodriguez-Lovelle B, Sipp C, Van Leeuwen C (2006) « Terroir » effect, as a result of environmental stress, depends more on soil depth than on soil type (*Vitis vinifera* L. cv Grenache noir, Côtes du Rhône, France, 2000). J Int Sci Vigne Vin 40: 177–185.
Delas J, Molot C, Soyer J-P (1991) Effects of nitrogen fertilization and grafting on the yield and quality of the crop of *Vitis vinifera* cv. Merlot. Paper presented at the International Symposium on Nitrogen in Grapes and Wines, J. Rantz (ed.), American Society of Enology and Viticulture, Davis, 242–248.
Duteau J, Guilloux M, Seguin G (1981) Influence des facteurs naturels sur la maturation du raisin, en 1979, à Pomerol et Saint-Emilion. Connaissances de la Vigne et du Vin 15: 1–27.
Duteau J (1987) Contribution des réserves hydriques profondes du calcaire à Astéries compact à l'alimentation en eau de la vigne dans le Bordelais. Agronomie 7: 589–865.
Erhart H (1939) Les terroirs du vignoble d'Alsace. Institut Pédolologique du Bas-Rhin, 47p.
Fanet J (2001) Les terroirs du vin. Ed. Hachette, Paris, 239p.
Huglin P, Schneider Ch (1998) Biologie et écologie de la vigne. Lavoisier Tec et Doc, Paris, 370p.
Kliewer W (1971) Effect of nitrogen on growth and composition of fruits from "Thompson seedless" grapevines. Am J Hort Sci 96: 816–819.
Kliewer W (1991) Methods for determing the nitrogen status of vineyards. Paper presented at the International Symposium on Nitrogen in Grapes and Wines J. Rantz (ed.), American Society of Enology and Viticulture, Davis, 133–147.
Koundouras S, Van Leeuwen C, Seguin G, Glories Y (1999) Influence de l'alimentation en eau sur la croissance de la vigne, la maturation des raisins et les caractéristiques des vins en zone méditerranéenne (exemple de Némée, Grèce, cépage Saint-Georges, 1997). J Int Sci Vigne Vin 33: 149–160.
Lafforgue G, Riedel C, Franc de Ferrière J (1936) Les Graves de Bordeaux. Relations entre l'évolution pédologique et la vocation culturale. Direction des Services Agricoles de la Gironde, 110p.
Logette L (1988) La vigne et le vin. La Manufacture, Lyon.
Markham D (1997) 1855, A history of the Bordeaux classification. Wiley, London, 560p.
Matthews M, Anderson M (1988) Fruit ripening in *Vitis vinifera* L.: responses to seasonal water deficits. Am J Enol Vitic 39: 313–320.
Ojeda H, Andara C, Kraeva E, Carbonneau A, Deloire A (2002) Influence of pre- and postveraison water deficit on synthesis and concentration of skin phenolic compounds during berry growth of *Vitis vinifera* cv. Syrah. Am J Enol Vitic 53: 261–267.
Peyrot des Gachons C, Van Leeuwen C, Tominaga T, Soyer J-P, Gaudillère J-P, Dubourdieu D (2005) The influence of water and nitrogen deficit on fruit ripening and aroma potential of *Vitis vinifera* L. cv Sauvignon blanc in field conditions. J Sci Food Agric 85: 73–85.
Pijassou R (1980) Un grand vignoble de qualité: le Médoc. Tome premier. Tallandier, Paris. 747p.
Pomerol C (1989) The wines and winelands of France. Geological journeys. Robertson McCarta Ltd, London, 370p.
Ribéreau-Gayon J, Peynaud E (1960) Traité d'œnologie. Tome premier. Librairie Polytechnique Ch. Beranger, Paris et Liège.
Seguin G (1969) Alimentation en eau de la vigne dans des sols du Haut-Médoc. Connaissance de la Vigne et du Vin 2: 93–141.
Seguin G (1975) Alimentation en eau de la vigne et composition chimique des moûts dans les Grands Crus du Médoc. Phénomènes de régulation. Connaissance de la Vigne et du Vin 9: 23–34.
Seguin G (1983) Influence des terroirs viticoles sur la constitution et la qualité des vendanges. Bull. De l'O.I.V., 56 (623): 3–18.
Seguin G (1986) "Terroirs" and pedology of vinegrowing. Experientia 42: 861–873.
Seguin G (1988) Ecosystems of the great red wines produced in the maritime climate of Bordeaux. Paper presented at the Symposium on Maritime Climate Winegrowing, L. Fuller-Perrine (ed.), Department of Horticultural Sciences, Cornell University, Geneva, NY, 36–53.

Soyer J-P Molot C, Bertrand A, Gazeau O, Lovelle B, Delas J (1996) Influence de l'enherbement sur l'alimentation azotée de la vigne et sur la composition des moûts et des vins. In: Lonvaud-Funel A (ed) Œnologie 95, Lavoisier Tec et Doc., Paris, 81–84.

Spayd S, Wample R, Stevens R, Evans R, Kawakami A (1993) Nitrogen fertilization of white Riesling grapes is Washington. Effects on petiole nutrient concentration, yield, yield components, and vegetative growth. Am J Enol Vitic 44: 378–386.

Spayd S, Wample R, Evans R, Stevens R, Seymour B, Nagel C (1994) Nitrogen fertilization of white Riesling grapes in Washington. Must and wine composition. Am J Enol Vitic 45: 34–41.

Trégoat O, Gaudillère J-P, Choné X, Van Leeuwen C (2002) Etude du régime hydrique et de la nutrition azotée de la vigne par des indicateurs physiologiques. Influence sur le comportement de la vigne et la maturation du raisin (*Vitis vinifera* L. cv Merlot, 2000, Bordeaux). J Int Sci Vigne Vin 36: 133–142.

Van Leeuwen C (1989) Carte des sols du vignoble de Saint-Emilion et sa notice explicative. La Nef, Bordeaux, 92p.

Van Leeuwen C, Seguin G (1994) Incidences de l'alimentation en eau de la vigne, appréciée par l'état hydrique du feuillage, sur le développement de l'appareil végétatif et la maturation du raisin (*Vitis vinifera* variété Cabernet franc, Saint-Emilion, 1990). J Int Sci Vigne Vin 28: 81–110.

Van Leeuwen C, Friant P, Soyer J.-P, Molot C, Choné X, Dubourdieu D (2000) L'intérêt du dosage de l'azote total et l'azote assimilable dans le moût comme indicateur de la nutrition azotée de la vigne. J Int Sci Vigne Vin 34: 75–82.

Van Leeuwen C, Trégoat O, Choné X, Jaeck M-E, Rabusseau S, Gaudillère J-P (2003) Le suivi du régime hydrique de la vigne et son incidence sur la maturation du raisin. Bulletin de l'O.I.V. 76: 367–379.

Van Leeuwen C, Friant P, Choné X, Trégoat O, Koundouras S, Dubourdieu D (2004) The influence of climate, soil and cultivar on terroir. Ame J Enol Vitic 55: 207–217.

Wilson J (1998) Terroir, the role of geology, climate and culture in the making of French wines. University Press of California, San Fransisco, 336p.

About the Authors

Peter Abrahams is an environmental geochemist with research interests in human health, agriculture, and geoarchaeology. Outside academia he looks after the pet llamas, listens to *The Who* and associated contemporaries, and gets depressed when sampling his collection of American blues music. Spirits are revived by the finding of 'edible earths' on his travels, most recently in Madagascar, a country not noted for its geophagical customs.

Dominique Arrouays is the Director of French soil mapping and monitoring national programmes. He is a collector of comic strips, and when he was a young researcher, he drew comic strips and cartoons on soil mapping in the field.

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Paul Belasky is a geologist, paleontologist, and translator. A native of St. Petersburg, Russia, and a graduate of the University of California (Berkeley and UCLA), his research centers on the Paleozoic displaced terranes of the Pacific region. He has written poetry in Russian, dabbled in music and football, and translated for the Mayor of Moscow, Yuri Luzhkov.

Martial Bernoux is a soil scientist whose main research interests are soil organic matter and soil biology. He has conducted studies aimed at assessing soil carbon inventories in the Amazon Basin—an issue of major concern with respect to global climate change. An art-lover and comic strip collector, he works at the French Institute of Research for Development (IRD).

Eric Blanchart is a soil biologist working for the French Institute of Research for Development (IRD). His research has focused on the activity of macrofauna (especially earthworms) in soils of the tropics. He is interested with the historical development of soil biology, and really enjoys reading comic strips in which soil animals are present.

Hans-Peter Blume was on the soil science faculty of the universities of Stuttgart-Hohenheim, Berlin, and Kiel. His research has investigated the nature and properties of soils in cities, as well as warm and cold deserts. He has explored the history of soil science, and his stamp collection is particularly focused on soil science, land use, and soil protection.

Margaret Boozer is an artist and educator in Mt. Rainier, Maryland, just outside of Washington, DC. A graduate of the New York State College of Ceramics at Alfred University, Boozer is founder and director of Red Dirt Studio—a sculpture and ceramics seminar, an artist incubator, and cool hang out space for neighborhood kids who, by the way, love to help dig clay. Her soil-centric ceramic work is included in the collection of the Smithsonian American Art Museum and in many private collections.

Lydie Chapuis-Lardy is a soil ecologist at the French Institute of Research for Development (IRD). Her current research focuses on the emission of nitrous oxide—a greenhouse gas—from tropical soils.

Bruno Chavane is an economist who has participated in development programs in Africa under the auspices of the French Cooperation for Development and the International Labour Organization (ILO-UN). His interest in archaeology lead him to interrupt his professional activity to do a master's degree in history and a thesis on African archaeology. This archaeological investigation in Senegal was carried out in collaboration with soil scientist Christian Feller.

Peter Doyle is a consultant geologist and Visiting Professor, Department of Earth Sciences, University College London. A battlefield specialist, his research has aided in our understanding of the impact of terrains on military actions during the two World Wars. He has served as a member of the British Commission of Military History, and as a technical consultant to a 2004 documentary (http://www.windfallfilms.com/productions/production-details/great-escape.html) on World War II's The Great Escape.

Christian Feller is a soil scientist working for the French Institute of Research for Development (IRD) on the nature, functions and dynamics of organic matter in tropical soils. He has visited museums and exhibitions of fine art all around the world, and cannot observe a modern or ancient painting without looking in detail at how the artist depicted the soil. He is also a collector of antiquarian soil science books, and indeed his passion for soil science history was lit when he discovered several ancient agronomy books in the cupboard of his wife's family house—a 17th century stone building in the historic district of Uzès where they presently reside.

Pascal Handschumacher is a health geography researcher with the French Institute of Research for Development (IRD). A strong proponent of applying multidisciplinary approaches to the solution of public health problems, his main research has focused on the impact of environmental factors on the spread of infectious diseases (schistosomiasis, plague, dengue) in developing countries (West Africa, Madagascar, Bolivia).

Heinrich Jennes studied Cultural Sciences, Philosophy and Ancient History at the Free University in Berlin, and subsequently architecture at the University of Arts in Berlin. He has worked as an architect in Spain, Germany, and Austria. Since 2000, he has been a free-lance author in Berlin, and he recently collaborated with Gerd Wessolek on the design for a "Tree-Top-Walk" in the city's Tiergarten park http://www.kunstundboden.de/html/index.php?id=105. His books include *Architecture of Horizon* (2001), and *Between Skyline and Earthline* (2009).

Fred Kirschenmann is Distinguished Fellow at the Leopold Center for Sustainable Agriculture in Iowa, and President of Stone Barns Center for Food and Agriculture in New York. He has successfully combined work in farming, academics, agricultural activism and philosophy. He still manages a 3500-acre, family-owned organic farm in North Dakota.

Lisa L. Kriner earned a BS in Textile Technology at North Carolina State University and an MFA at The University of Kansas. She is an Associate Professor and the Art Department Chair at Berea College in Kentucky. Her textile surface designs are often rooted in a connection to the land, and she notes: "Any chance I can escape from my office, I go play in the mud…. I mean soil."

Martine Lafon is a multimedia and installation artist with studios in Uzès and Paris. For her, the landscape and the colour red have special significance. She has a long-standing interest in pigments derived from soils, and this naturally led her to a survey of the soils the south of France—a wonderful colour palette for the artist!

Edward Landa is a soil scientist with the U.S. Geological Survey. A graduate of the University of Minnesota, his research has focused on the fate and transport of metals and radioactive materials in soil and water. His screenplay "Artists", dealing with the radium dial painters, won the Governor's Screenwriting Competition at the 1991 Virginia Festival of Film.

Suzanne Mériaux is a poet and soil scientist. She is the former scientific director of the physical environment research group at the National Institute of Agronomic Research (INRA). She has written many books of poetry, and an essay "Science and poetry: Two ways to knowledge".

Lorena Mihok, a certified indoor cycling instructor, is a doctoral student in applied anthropology at the University of South Florida. Her research focuses on early colonial culture contact in the Americas. She recently completed a project on the ways in which the ancient Mexican god of rain and lightening, Tlaloc, was depicted in pictorial manuscripts before and after the 16th century conquest of Mexico.

Walter Parham is a geologist specializing in clay mineralogy. While studying clay-mineral formation and rock weathering in tropical South China, he saw that a thick "soil" cover or residuum of low fertility blanketed the region, and he became interested in how such land could support a rapidly expanding human population. In the process, he searched the region's historic art works for clues to help him answer this question, and to illustrate past environmental changes.

Nikola Patzel is trained in environmental sciences and depth psychology, and has research experience in both fields: tree-litter-earthworm interactions, soil fertility; dreams, symbols. He is particularly interested in exploring possible insights from depth psychology and related humanities to the understanding of human-nature-relations. His doctorate, from the Department of Environmental Sciences at the Swiss Federal Institute of Technology, Zurich, dealt with soil science and the unconscious; an essay on this work can be found at http://archiv.ethlife.ethz.ch/e/articles/sciencelife/patzel_buch.html.

Jamie Pringle is a Lecturer in Engineering Geology & Applied Geophysics at Keele University, UK, and has research interests in geoarchaeology and forensic geology. His investigations have included evaluation of geophysical methods for identifying the locations of shallow graves, and he is affiliated with the Burials Research Group, established in 2006 by Keele & Staffordshire Universities to provide a national centre of excellence in the Midlands for the detection of clandestine burials. Together with Peter Doyle and Larry Babits, he served as a technical consultant on documentary focused on the site of the 1944 'Great Escape'.

Lovatiana A. Rakotonirina is a Malagasy forest engineer, with a MA in Environment and Forestry (University of Antananarivo), whose work involves the application of soil science knowledge to the practice of forest management. After being employed as a project officer in a biofuel project, he currently works as a consultant for the Malagasy Environmental Program.

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Anne Richer de Forges is a soil surveyor with the French national soil mapping unit. She is also an artist, doing oil & watercolor painting and pen-and-ink sketching (see her web gallery at http://perso.orange.fr/anne.richerdeforges/). Her soil survey manuals are profusely illustrated with soil profiles sketches. She collects comic strips, and is currently drawing one on Charles Darwin and earthworms.

Dominique Schwartz is a soil scientist who was formerly associated with ORSTOM/IRD, and now Professor of physical geography at Strasbourg University. His studies have looked at the dynamics of the dense forest-savanna mosaic in Congo (Brazzaville), and the landscape history of the Vosges Mountains in France.

Georges Serpantié is an agronomist with the French Institute of Research for Development (IRD). He focuses his multidisciplinary research on the dynamics of agricultural systems in the context of small farming systems of developing countries (West Africa and Madagascar) and slash and burn practices.

Eiliv Steinnes is a professor of environmental science at the Norwegian University of Science and Technology. He is a chemist by training, and his scientific research deals mainly with trace elements in the environment.

Alexandra Toland was born in Boston, received her BA in 1997 from the University of Wisconsin, MFA in 2001 from the Dutch Art Institute, and is now completing her diploma in Landscape Architecture and Environmental Planning at the Berlin University of Technology (TU-Berlin). She has exhibited her environmental artwork in the U.S. and Europe. She currently works as a teaching assistant in the Department of Soil Protection at TU-Berlin, and as a research fellow and designer at the Wriezener Open Space Lab (Wriezener Freiraum Labor), a federally funded project to develop a prototype for a solar-generated, Wi-Fi seating area, website, and documentary as part of an ecologically and socially sustainable inner city park in Berlin-Fiedrichshain (in cooperation with freifunk.net and tx architects).

Fiorenzo Ugolini is a soil scientist who has taught at universities in the United States and Italy. “My father was a wine merchant. Although he was not a man of culture, being a Florentine, he was very much in love with the works of art of the city. On Sunday morning, he used to take me to the Uffizi Gallery to show me the paintings of famous artists. I remember that once we stood in front of a 13th century Madonna that had a gold background and rested on a rocky ground. When I asked my father why all the gold in the sky and the rocks on the ground, his answer was that the gold represented the Heaven where God, the Angels and the Blessed live. Evidently with no gold, the ground was not very good. No, my father said—the ground, the soil is good! In Tuscany it produces excellent wine—the Chianti! Rather, the people are sometime not very good. With this simple statement, my father had summarized the Christian Middle Age concept. As I grew up, studied soils including the “heavenly” imagery of possible permafrost terrain on Mars, and viewed art on display around the world, I became interested in the choices that artists make in their representation of soils.”

Nico van Breemen retired as a soil scientist with Wageningen University in October 2004. On the same day, he and his wife started *Gallery Wit* (http://www.galeriewit.nl), devoted to contemporary art. He enjoys the new job. Good artists have much in common with good scientists, and to start from scratch appeared to be fun and very stimulating.

Cornelis (Kees) van Leeuwen is Professor Viticulture at ENITA – Bordeaux University, and a consulting viticulturist for Bordeaux First Growth Château Cheval Blanc (Saint-Emilion). His research focuses on the effect of soil and climate on vine behaviour and wine quality—the so-called “terroir” effect. He started his career as a wine lover, which he still remains.

Frank Verheijen is a soil scientist working for the Joint Research Institute of the European Commission (and previously at the National Soil Resources Institute of England and Wales). He is a comic strip enthusiast and, controversially, succumbed to mounting pressure not to publish comic strips in his PhD thesis, only moments before submitting.

E. Christian Wells is an archaeologist at the University of South Florida, where he coordinates the Cultural Soilscapes Research Group, a faculty/student collaborative that examines the long-term consequences of land use legacies in Central America. During a recent National Geographic Society expedition to Honduras, he excavated the house remains of pre-Columbian Maya farmers to learn how they cultivated the countryside.

Gerd Wessolek is a soil physicist and painter who has pioneered efforts at giving soils and soil science a broader exposure to the wider community through presentations, exhibitions—and even a calendar—on soil and art. His project's on-line gallery can be seen at http://www.kunstundboden.de/html/.

C. E. Wood is a historian who teaches at Glenville State College in West Virginia. A former Marine and soldier, he is the author of *Mud: A Military History*, published in 2006.

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