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ANCIENT EGYPTIAN MATERIALS

BY

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PREFACE

It is only in comparatively recent years that the chemist has been consulted by the archæologist and has been given an opportunity of examining antique objects, and up to the present little more than preliminary work has been possible and a considerable amount of detailed systematic analysis still remains to be done, and a number of problems in Egyptology that chemistry alone can solve will be found indicated in the present book.

Any consideration of ancient Egyptian materials to be of value should include a description of each material dealt with, its nature or composition, its use and, whenever possible, its place of origin and the date when it was first employed. These particulars the author has attempted to supply, and where there is no certain knowledge he has refrained from speculation.

Information concerning some of the materials is contained in the ancient records, but the author has ventured to disregard this almost entirely, not because he underrates the historical value of the records, but because they are not suitable for the purpose he

has in view, which is to establish certain facts by scientific evidence only, whereas the statements made in the records are often vague or their meaning uncertain and, at the best, can only have been second-hand originally and may be wrong or misleading, and the act of translation may introduce further errors or misconceptions.

The information regarding the nature and composition of the materials has been obtained from a personal examination and analysis whenever possible, or, when this has not been possible, from the published analyses and descriptions of others. The information concerning the sources of the materials has been derived from a knowledge of the mineral resources of the country and from the reports of the Geological Survey of Egypt and of the Department of Mines and Quarries. The dating of the materials has been taken from archæological reports and museum catalogues.

It is realized that the matter presented is only part of a many-sided subject, but it is hoped that not only may it be found interesting in itself, but that it may help to a better understanding of the other sides of the same subject.

In the identification of ancient Egyptian materials mistakes have frequently been made in the past, and these mistakes are reproduced from one book to another without inquiry or verification until many of them have been so often repeated as now to be

accepted without question. As far as possible such mistakes will be pointed out and corrected.

When Egypt is stated to be the place of origin of any material the geographical limits of modern Egypt are meant, which include Sinai and which extend from the Libyan desert on the west to the Gulf of Suez and the Red Sea on the east, as far south as the Sudan frontier. It is realized that this territory embraces Lower Nubia (from Aswan to Wadi Halfa), which was not always a part of Egypt, but any other arrangement would have depended upon the frequently expanding and contracting southern border of ancient Egypt and would often have been uncertain and frequently misleading.

The friends who have helped with information, suggestions and materials for analysis are too numerous to allow of their being mentioned separately by name, though this is done in the text whenever possible, but to all of them the author wishes to tender his thanks.

In order not to encumber the text, the details of the chemical analyses have been placed in an Appendix.

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INTRODUCTION

For the full understanding of ancient Egyptian materials some slight knowledge at least of the history of the country is necessary in order that the great antiquity of the civilization and the remote dates at which many of the materials were used may be realized. A brief historical outline therefore will be given.

The first inhabitants of the Nile valley are classified as Paleolithic and Neolithic respectively, and their age is so remote as to be quite undatable.

The Neolithic period was followed by a long interval of unknown duration termed Predynastic, which for the sake of convenience is divided into three sections, early, middle, and late. During this time the country was split up into a number of petty states, from the chaos of which gradually emerged two kingdoms, one of the North or Lower Egypt (Delta) and the other of the South or Upper Egypt. Nothing certain is known about either the separate states or the two kingdoms, beyond the fact of their existence and the practical commencement of Egyptian history dates from about 3400 B.C. when Menes, the first king of the First Dynasty, joined together the North and South

under one rule and welded the country into the united kingdom of Egypt.

The historical period is conveniently divided into thirty Dynasties, each of which corresponds to a different royal House, analogous to the divisions of English history into the Houses of Normandy, Plantagenet, Tudor, Stuart, Hanover, and so on.

So little is known about the first two Dynasties (3400 B.C. to 2980 B.C.) that they are frequently grouped with the late Predynastic period, the whole being called Archaic. This will be done in the present book.

With the Third Dynasty began the Old Kingdom or Pyramid Age, as it is sometimes called, which lasted until the end of the Sixth Dynasty (2980 B.C. to 2475 B.C.).

The period from the Seventh Dynasty to the Tenth Dynasty inclusive (2475 B.C. to 2160 B.C.) was one of internal conflict and is very obscure.

The Eleventh and Twelfth Dynasties (2160 B.C. to 1788 B.C.) constitute the Middle Kingdom or Feudal Age, a time of great prosperity.

From the Thirteenth Dynasty to the Seventeenth Dynasty inclusive (1788 B.C. to 1580 B.C.) was a period of disorganization, about which present knowledge is very scanty, except that it included an interval of foreign domination under the Hyksos kings.

The Eighteenth Dynasty ushered in the New Kingdom or Empire, which lasted until the end of the

Twentieth Dynasty (1580 B.C. to 1090 B.C.), during which time Egypt conquered Syria and became a great power in western Asia.

In the Twenty-first Dynasty (1090 B.C. to 945 B.C.) the Empire fell to pieces.

Of the next four Dynasties, the Twenty-second to the Twenty-fifth inclusive (945 B.C. to 663 B.C.), very little is known, except that the country was successively under the domination of the Libyans, the Ethiopians and the Assyrians.

In the Twenty-sixth Dynasty (663 B.C. to 525 B.C.) there was a revival of independence and prosperity, which was followed by the Persian conquest (525 B.C.).

The period from the Twenty-seventh Dynasty to the Thirtieth Dynasty inclusive (525 B.C. to 332 B.C.) was one of Persian domination, except for brief intervals when the Egyptians gained temporary independence.

In 332 B.C. Alexander the Great took possession of Egypt, and the Greek domination under Alexander's successors, the Ptolemies, lasted until 30 B.C.

In 30 B.C. Egypt became a Roman province, and the country remained in Roman occupation until the Arab conquest in A.D. 640.

As may be seen from the above short summary, there are several periods of Egyptian history, lasting in some cases two or three hundred years, about which very little is known, and even of the periods that are better known the information is very partial.

With such gaps in the existing knowledge a final statement regarding the earliest or latest production or use of any material is impossible, and all that can be done is to give the dates for which the various materials have been recorded.

The knowledge of the Paleolithic and Neolithic Egyptians respectively is derived almost solely from flint and chert weapons and implements (many fashioned with a dexterity that has never been surpassed for such objects) that have been found in immense numbers in several localities in Egypt. With these, their owners could hunt, fish, and fight, but this is practically everything that is known about them, since their graves have either perished or more probably are now hidden so deeply beneath the cultivated land that they are irretrievably lost.

The Predynastic and Archaic periods are known almost entirely from the contents of graves, a large number of which have been discovered and carefully examined, and from the articles found in them a close estimate may be made of the conditions of life at the time.

For later periods the information derived from buried objects, which include a comparatively small number of written documents (papyri), is supplemented by that obtained from the remains of temples and towns and from inscriptions on the walls of the tombs and temples, in quarries, on the rocks at Aswan and elsewhere and on various monuments.

CHAPTER I

BUILDING MATERIALS

The nature of the building materials employed in any country depends upon many factors, the principal being the climate, the degree of civilization of the people, and the kind of materials available.

With regard to Egypt one may go back in imagination to a period when primitive shelters of dried reeds were erected as a protection from the sun and wind, and one can also imagine the next stage of development when the reeds were plastered with clay in order to keep out the heat and cold more effectually, though naturally such constructions have not survived.

The earliest building material of which any remains still exist is sun-dried clay brick, which dates from Predynastic times, that is before 3400 B.C. At the period when the need for something more substantial than clay-plastered reeds was felt, the materials occurring naturally in the country were the

same as now, namely clay and stone, both of which are found in abundance. The climate also was approximately the same as at present and fuel was scarce, as it still is. Of the materials available clay, as suggested above, had probably already been used and, if so, its properties would be familiar, whereas the knowledge and tools necessary for quarrying and dressing stone in quantity did not exist, and therefore clay, the simpler material and the one already known and more easily worked, was chosen and was made into bricks, which were merely dried in the sun. The use of stone followed later when civilization had advanced sufficiently to provide metal (copper) tools.

Brick and stone will now be considered, as also the auxiliary materials required for building, namely, mortar, plaster, and wood.

Brick Brick-making is one of the oldest of the arts and was known to most of the civilized nations of antiquity, but in few places has it been practised more than in Egypt, where not only are sun-dried bricks the oldest building material of which any remains have survived to the present time, but where they still are, as they always have been, the characteristic building material of the country, and in the villages and smaller towns of

Egypt the houses to-day are built of bricks similar to those that were used more than 5,000 years ago.

The bricks are made of Nile alluvium, or Nile mud as it is usually termed, of which all the cultivated land of Egypt consists, and which is essentially a mixture of clay and sand, containing small amounts of impurities. The relative proportions of the two principal ingredients vary in different localities, and it is on the clay that the plastic and cohesive properties of the mud depend. When the percentage of clay is high the material is sufficiently tenacious to cohere without any extraneous binding material, but when the proportion of clay is low the mud requires an addition of straw to prevent it from falling to pieces when dry. If alluvium too rich in clay were used, the drying would be very slow and the bricks would shrink considerably and lose their shape, and such alluvium therefore is always diluted with sand before use. The bricks are made in wooden moulds, and both the moulds and process in use to-day are practically identical with those illustrated in a tomb painting of the Eighteenth Dynasty in the Theban necropolis.

Sun-dried bricks do not require highly

skilled labour, either for making or using, and houses constructed with them are therefore cheap; they are also warm in winter and cool in summer, and although they would not stand the wet climate of Europe, they are very suitable for Egypt where rain, except in the extreme north, is rare.

Old Egyptian bricks differ considerably in size and, while some are not unlike modern bricks, others are of very large dimensions, the two largest in the Cairo Museum measuring approximately $38 \times 21 \times 12$ inches.

With the advent of stone, both tombs and temples, which previously had been built of mud brick, began to be constructed of the newer material, but the houses, not only those of the poorer classes, but also those of the nobles, and even the palaces of the pharaohs, still continued to be made of brick, and it is for this reason that the houses and palaces have perished while tombs and temples remain, mud brick being a much less enduring material than stone and also lending itself more readily than large blocks of stone to the building requirements of the modern inhabitants.

Burnt bricks were not used in Egypt before the time of the Roman occupation of the country.

STONE

Egypt is the home of stone-working, and possesses both the oldest and the largest stone buildings in the world. This activity in stone on a large scale and at so early a period is due partly to the fact that the country is very rich in stone and partly to the further fact that copper tools for working it were available.

The principal kinds of stone employed for building in ancient Egypt were limestone, sandstone and, to a much less extent, granite, with the occasional use of alabaster, basalt and quartzite for subsidiary purposes. With the exception of a small amount of ornamental stone employed in Alexandria, the city founded by the Greek conqueror of Egypt, whose name it bears, and the residence of his successors the Ptolemies, all the building stone of the country was of local origin, and even in Alexandria the limestone, sandstone and granite were Egyptian, but from the fragments of foreign marble and breccia that have been found during the excavation of the old city, it is evident that a certain amount of these stones, brought probably from Greece, were employed to ornament the public buildings.

Limestone Limestone is a fine-grained, compact, fairly soft and easily worked homogeneous stone, generally amorphous, though sometimes crystalline, consisting essentially of carbonate of lime, but containing varying and usually small proportions of other ingredients, such as silica (sand), clay, oxide of iron and carbonate of magnesia. It occurs extensively in Egypt, the hills bordering the Nile valley from Cairo to Esna, a distance of nearly 500 miles, being formed of this material, and it is also found in other localities, as at Mex near Alexandria and in the neighbourhood of Suez.

Limestone was the first stone employed in Egypt for building, its use going back at least 5,000 years, and the most ancient stone buildings that exist are constructed of this material, for example a stone chamber in a mud-brick pyramid of the Second Dynasty at Abydos,¹ the step pyramid and its adjuncts at Sakkara (Third Dynasty) and the Giza pyramids (Fourth Dynasty).

In order to produce such excellent workmanship as that at Sakkara and Giza, a certain amount of previous experience in stone-working was manifestly necessary, but

¹ W. M. Flinders Petrie. *The Royal Tombs of the Earliest Dynasties*, Part II, London, 1901.

what this means translated into terms of years cannot be stated with any certainty, though on account of the comparatively soft nature of the stone it seems possible that it may not have been more than one or two generations.

Limestone continued to be employed as the usual material for tombs and temples until a little after the beginning of the Eighteenth Dynasty when, though still occasionally used, as in the temples of Seti I and Ramses II ¹ at Abydos, both of the Nineteenth Dynasty, it largely gave place to sandstone. In addition to the use of quarried limestone as a building material a very large number of tombs, including many at Sakkara and Giza and most of those in the Theban necropolis, were cut out of the solid limestone rock.

Although limestone was generally quarried in the immediate vicinity of where it was required, the better qualities of stone were obtained from special localities, and such quarries are frequently referred to in the ancient records, and some of them may be

¹ In this temple sandstone, granite and alabaster were also employed, the sandstone for columns, the granite for door-frames and the alabaster for the sanctuary.

seen to-day, for example at Turra and Ma'sara near Cairo and at Gebelein near Luxor, still bearing hieroglyphic inscriptions on the rock walls. At Turra the inscriptions are of the Twelfth,¹ Eighteenth¹ and Thirtieth² Dynasties respectively, at Ma'sara of the Eighteenth Dynasty¹ and at Gebelein of the Nineteenth and Twenty-first Dynasties respectively.¹ As an example of stone having been quarried on the spot where it was required, the Giza pyramids may be mentioned. The stone of which the pyramids are built is very characteristic, being highly fossiliferous and containing innumerable nummulites and is identical in character with that of the plateau on which the pyramids stand, and some of the depressions near the pyramids are the quarries from which this stone was obtained, although, being now partly buried in sand, they are not easily recognizable. In the case of the second pyramid, there was a considerable amount of stone removed in levelling and in cutting back, on the north and west, the rock on which the pyramid stands, and naturally

¹ J. H. Breasted. *Ancient Records of Egypt*, Chicago, 1906.

² W. M. Flinders Petrie. *A History of Egypt*, Vol. III, 1905.

this would have been used in the construction. The casing stones of the two larger pyramids, although of limestone, were of a different and much finer-grained quality than the rest of the stone, as may be seen from the few that remain, and as this stone is not found in the immediate neighbourhood it must therefore have come from a distance, and most probably from the opposite side of the river at Turra or Ma'sara, and the statement of Herodotus¹ that the stone for the construction of the great pyramid was brought across the river from quarries in the Arabian desert is true only of that for the casing.

Sandstone

This is simply consolidated sand and consists essentially of particles of sand (quartz) derived from the disintegration of older rocks cemented together by very small proportions of clay, carbonate of lime, oxide of iron or silica.

Although sandstone was employed to some extent in the Eleventh Dynasty, for example for the foundations, pavement and columns of the mortuary temple of Mentuhotep at Deir el Bahri, its use on a large scale for building in Egypt began in the Eighteenth Dynasty, and practically all the

¹ II, 124. See also II, 8.

existing temples in Upper Egypt are of this material, the principal exceptions being the remains of the mortuary temple of Amenhotep I (beginning of the Eighteenth Dynasty), in which there are both limestone and sandstone,¹ the mortuary temple of Hatshepsût (beginning of the Eighteenth Dynasty), which is of limestone, the remains of the mortuary temple of Thothmes III (Eighteenth Dynasty), which apparently was largely limestone, though containing some sandstone, and the temples of Seti I and Ramses II at Abydos (Nineteenth Dynasty), both of which are of limestone, though the latter has sandstone columns. The following mentioned temples, the earliest of which dates from the Eighteenth Dynasty and the latest from the Roman period, are all built of sandstone, namely, Luxor, Karnak, Gurna (Seti I), the Ramesseum,² Medinet Habu, Deir el Medina, Dendera, Esna, Edfu, Kom Ombo, Philæ, those in Nubia and those in the Oases of the western desert.

Sandstone forms the hills bordering the

¹ The sandstone probably belongs to later additions and restorations. Howard Carter. *J. Egypt. Arch.*, Vol. III, 1916.

² Contains a little limestone, namely, some columns in a side hall and part of a pavement.

Nile valley from near Esna to near Aswan and again from Kalabsha, beyond Aswan, to Wadi Halfa. It is also well developed in Sinai. The sandstone used in ancient Egypt was obtained largely from Silsila, about 40 miles north of Aswan, where there are extensive ancient quarries with inscriptions of the Eighteenth, Nineteenth, Twentieth and Twenty-second Dynasties respectively.¹ Another ancient sandstone quarry is at Serrag, about 20 miles south of Edfu, a third is situated in the western desert near Aswan, and a fourth at Girtass in Nubia, about 24 miles south of Aswan. This latter was worked from about the Thirtieth Dynasty until Roman times, chiefly for the stone used in the construction of the temples of Philæ, and in the quarry there are numerous Greek inscriptions dating from the Roman imperial epoch.² The sandstone for the temples of Nubia was quarried in the immediate neighbourhood of where it was required, and ancient quarries exist at Dabôd, Tâfeh and Beit el Wâli.²

Granite Granite is the name of a large class of crystalline rocks of igneous origin, which

¹ J. H. Breasted. *Ancient Records of Egypt*.

² A. E. P. Weigall. *A Guide to the Antiquities of Upper Egypt*, London, 1910.

are not homogeneous in structure like limestone and sandstone, but are composed of several different minerals, chiefly quartz, felspar and mica, the abundance of the quartz constituting one of the characteristic features of granite. The various minerals are readily visible to the naked eye, and it is from the granular structure that the name of the rock is derived.

Granite was employed for building from the early Dynastic period onwards, generally as a lining material for chambers and passages, but also for door-frames, and once for an entire construction. Examples of its early use are a granite floor in a mud-brick tomb of the First Dynasty at Abydos,¹ in the unfinished pyramid at Zawiet el Aryan near Giza (Third Dynasty), in the interior of the three large pyramids at Giza, for parts at least of the lowest course of the second pyramid,² for all the existing casing of the third pyramid, in the interior of the temples of both the second and third pyramids (Fourth Dynasty) and for the construction

¹ W. M. Flinders Petrie. *The Royal Tombs of the Earliest Dynasties*, Part II, London, 1901.

² Herodotus (II, 128), describing this pyramid, refers to "the first course of variegated Ethiopian stones."

of the small temple near the sphinx (Fourth Dynasty), and examples of its later use are certain door-frames in many of the temples of Upper Egypt.

In most instances the granite used for all purposes was the coarse-grained red variety from Aswan, where there are a number of ancient quarries, but grey granite, generally dark grey, this too from Aswan, was also employed. Thus in the First Dynasty tomb already mentioned there is grey granite as well as red ¹; a door-frame of the temple at Hierakonpolis (Second Dynasty), of which a jamb has been found, was of grey granite ²; among the red granite of the third Giza pyramid, both outside and inside, there is an occasional block that is dark grey; in the temple adjoining this pyramid there is a considerable amount of dark grey granite; in the temple near the sphinx there are a few blocks of dark grey granite, and, judging from the fragments that lie about, dark-grey granite was employed in the temple of the second Giza pyramid; it was also used for two door-frames in the temples of Karnak

¹ W. M. Flinders Petrie. *Ibid.*, Part II, London, 1901.

² W. M. Flinders Petrie and J. E. Quibell. *Hierakonpolis*, Part I.

(Eighteenth Dynasty), for a door-frame in the Ramesseum (Nineteenth Dynasty) and for a door-frame in the temple of Ramses II at Abydos (Nineteenth Dynasty).

Although for Egyptological purposes it is sufficient to call this stone dark-grey granite, strictly it is a hornblende-biotite granite,¹ probably corresponding to the syenite of Pliny, a name first used by this writer to describe a rock quarried at Syene, the ancient name for Aswan. The term syenite is now, however, applied to a granitic rock in which not only is mica replaced by hornblende, but in which quartz is absent, or only present in small proportion. When quartz is wholly absent the rock passes into diorite. Granite will be dealt with again when describing its use for purposes other than building.

As the use of alabaster, basalt and quartzite for building was only occasional and subsidiary, while their use for other purposes was considerable, their description will be deferred until later.

Alabaster Alabaster was employed in early Dynastic times for lining rooms and passages, as for

¹ Identified by Dr. W. F. Hume, Director, Geological Survey of Egypt, from specimens supplied by the author.

example in the granite temple near the sphinx (Fourth Dynasty), and judging from the blocks lying about, also in the temple of the second Giza pyramid (Fourth Dynasty); it was employed, too, for lining the corridor (Eighteenth Dynasty) leading to the sacred lake at Karnak and for the sanctuary of the temple of Ramses II at Abydos (Nineteenth Dynasty).

Basalt Basalt was used for a pavement in the temple of the large pyramid at Giza (Fourth Dynasty) and is all that now remains of that temple, and also for pavements in the temples of two of the pyramids at Abusir (Fifth Dynasty).

Quartzite Quartzite was employed for lining the sepulchral chamber of the pyramid at Hawara (Twelfth Dynasty)¹ and for walls in the Osireion at Abydos (Nineteenth Dynasty).²

Mortar The mortar used in ancient Egypt before the time of the Roman occupation was of two kinds, depending upon the nature of the construction, namely, clay for use with sun-dried clay brick and gypsum, an impure plaster of Paris, for use with stone. The

¹ W. M. Flinders Petrie. *Kahun, Gurob and Hawara*, London, 1890.

² E. Naville. *J. Egypt. Arch.*, 1914.

former is still used for clay brick at the present day and is the most suitable mortar for the purpose, but gypsum is not now employed as a mortar, having given place to the more modern lime-sand mixture or to the still more modern cement. Lime mortar was not employed before the Roman period.

**Clay
Mortar**

This is ordinary Nile mud, consisting essentially of a mixture of clay and sand, and for use is simply mixed with sufficient water to bring it to the required consistency.

**Gypsum
Mortar**

As stated, the mortar employed in ancient Egypt for stone was gypsum. In much of the stone-work, however, the individual blocks were so large and many, especially the facing stones, were dressed so truly that mortar as a binding material was not necessary, and, although employed, it was largely as a cushion between the stones to prevent the edges from being damaged while they were being placed in position and as a suitable material on which the large unwieldy blocks of stone could slide. Gypsum will be described when dealing with plaster.¹

**Lime
Mortar**

No instance of the use of lime mortar in

¹ For chemical analyses in this and in subsequent cases, see Appendix.

Egypt, or of lime in any form, is known to the author as occurring before Roman times, after which it is found and, from the few specimens analysed, it appears to have been, as is only to be expected, of much the same composition as the lime-sand mixture of to-day.

The reason for using gypsum instead of lime, although limestone is very plentiful in the country, even more plentiful than gypsum and also more accessible, was doubtless owing to the scarcity of fuel, lime, as will be shown later when dealing with plaster, requiring a very much higher temperature for calcination and hence more fuel than gypsum, and it was not until the advent of the Romans, who knew of lime in Europe where gypsum is useless for outdoor work on account of the wet climate, that lime-burning was practised in Egypt.

PLASTER

The ancient Egyptian plaster was similar in composition to the mortar and consisted of the same two materials, namely, clay and gypsum, and although both kinds were doubtless employed in house decoration the houses have largely perished, and beyond a

few fragments of painted plaster found among the ruins of the palace and houses at Tell el Amarna and of a palace at Gurna, practically all the plaster that now remains is that to be found in tombs.

**Clay
Plaster**

The use of clay as plaster dates from very early times. The quality of such plaster varies considerably, but in the main two principal kinds may be recognized, one of coarse quality, which was invariably mixed with straw for use, and the other, possibly limited to the Theban necropolis, of finer quality, employed both with and without straw, sometimes as a finishing coat to the coarser kind, but, as pointed out by Mackay,¹ sometimes in alternate layers with it. Both qualities were generally covered with gypsum plaster in order to provide a better surface for painting. The former is ordinary Nile mud, consisting essentially of clay and sand in varying proportions, with generally a small natural admixture of carbonate of lime and occasionally a small proportion of gypsum, which latter, however, is purely accidental and has no binding property since it has not been burned. The finer quality is a natural

¹The Cutting and Preparation of Tomb Chapels in the Theban Necropolis. *J. Egypt. Arch.*, Vol. VII, 1921.

mixture of clay and limestone, both in a very finely divided condition, found in hollows and pockets at the foot of the hills and plateaux, from which it has been washed out by the occasional rain-storms that occur. This is still employed locally at the present day under the name of *hîb* as a finishing coat to mud brick and mud plaster.

**Gypsum
Plaster**

This is the characteristic plaster of ancient Egypt and no evidence whatever can be found of the use of lime before the Roman period, the plaster frequently but wrongly termed "lime plaster" being always gypsum. The great use of gypsum plaster was to provide for the walls and ceilings of houses, palaces and tombs a suitable surface for painting upon. Where the walls were plastered with mud this was coated with gypsum, and where mud plaster was not used gypsum was employed for the double purpose of covering up faults and irregularities in the stone and of smoothing the walls before painting.

Occasionally the plaster used as a finishing coat, which is white, or practically white, in colour, contains a very large proportion of carbonate of lime and very little gypsum, and it is suggested that in such cases additional carbonate of lime, beyond that natur-

ally present, may have been added in the form of powdered limestone in order to produce a lighter colour in certain plaster that was not naturally very white. Sometimes, however, the surface coating is so thin as to be merely a distemper or whitewash and consists essentially of carbonate of lime, which may or may not contain a trace of gypsum, but this when present is not the binding material, but is simply an impurity, and it seems possible that in such cases the adhesive may have been size.

Gypsum plaster, being a natural material, varies considerably both in colour and in composition. The colour may be white, or practically white, different shades of grey, light brown, or even occasionally pink. This latter, however, is merely a surface coloration and is adventitious, being due to chemical changes that have taken place in the iron compounds of the plaster by exposure to atmospheric influences during thousands of years. When the colour is grey, this is generally owing to the presence of small particles of unburned fuel.

Gypsum occurs plentifully in Egypt in two conditions, one a fairly pure rock-like formation which is found chiefly in the district between Ismailia and Suez and in certain

localities near the Red Sea, and the other in scattered masses of loosely-aggregated crystals which have simply to be dug up from just below the surface of the limestone desert, and it is this latter that was, and still is, so largely used for plaster; at the present time it is worked in the vicinities of both Cairo and Alexandria and in the district stretching south from Cairo to Beni-Suef, but there are small local deposits in other places. As thus found gypsum is never pure, but contains varying proportions of carbonate of lime and quartz sand, together with small amounts of other ingredients. The presence of the carbonate of lime, which is readily disclosed by chemical analysis, has led those who were not familiar with Egyptian gypsum, and who only know the purer European article, to imagine that it is due to an intentional admixture with lime, which in course of time has become converted into carbonate by natural processes, as happens in the case of lime mortar. In the same way the presence of sand, to those who only know of sand in this connection as a deliberate addition to mortar and plaster, is equally confusing and conveys a wrong impression. Ancient Egyptian plaster is simply crude gypsum burned and powdered, and the carbonate

of lime and sand it contains are not artificial additions, but impurities derived from the raw material, in which they occur naturally.

Chemically gypsum is sulphate of lime containing water in intimate combination. On being heated to a temperature of about 100° C. (212° F.) gypsum loses about three-fourths of its water and forms a substance which has the property of recombining with water, producing a hard mass. The temperature usually employed for burning gypsum varies from 100° C. (212° F.) to about 200° C. (392° F.), but is generally kept about 130° C. (268° F.), which is a heat readily obtained. This temperature is not sufficiently high to convert any carbonate of lime present into quicklime. The calcined material in the pure form as made in Europe is known as "plaster of Paris."

In order that the difference of temperature required to burn lime as compared with that needed for gypsum may be appreciated, it may be mentioned that to produce quicklime a temperature of about 900° C. (1652° F.) is required.

Wood Egypt is, and always has been, very poorly provided naturally with timber, and it has always been necessary to import a portion of that required. This importation is fre-

quently mentioned in the ancient records, and different kinds of timber are referred to by name, but in many instances these names have not yet been translated and the identity of the wood therefore is unknown. The two most conspicuous of the imported foreign woods of which specimens have survived are ebony, about which there can be no mistake and which was probably obtained either from the Sudan or from Abyssinia, in both of which countries it is known to occur, and a reddish wood with a very pronounced grain not unlike that of deal or pitchpine, which is generally called cedar, meaning the cedar of Lebanon (*Cedrus Libani*), but although apparently a coniferous wood it is almost certainly not cedar. It is not suggested, however, that cedar was never employed, but merely that much of what is generally termed cedar is not cedar.

The identity of much of the locally grown timber is also doubtful, and many of the statements made in the literature of Egyptology as to the kinds of wood used are little more than guesswork. Trees, although figured in the tomb paintings, are pictured in so conventional a manner that only a few can be recognized with certainty, one of which is the date palm, of which there can

be no doubt, and if confirmation were needed it is supplied by the occasional presence of dates and of date stones in graves. There can be no doubt also that the trunk of a palm, and probably a date palm, was sometimes employed for roofing, since in a tomb of early date at Qau el Kebir near Asiut,¹ in a tomb adjoining the second pyramid of Giza (Fourth Dynasty), and in the tomb of Ptahhotep at Sakkara (Fifth Dynasty) a roof of this kind has been copied in stone. Another tree, the wood of which was probably used for building, was the sycamore fig (*Ficus sycamorus*), the name of which is often confused with that of the sycamore of colder climates, which is a species of maple (*Acer pseudo-platanus*). The sycamore fig was well known in ancient Egypt, and in the Cairo Museum there are six readily recognized models of this tree with fruit in a small model garden of the Eleventh Dynasty; there is also a twig with leaves dating from the Twentieth Dynasty, and the fruit has occasionally been found in graves from the early Dynastic period ² onwards.

The principal use of wood in building was

¹ Villiers Stuart. *The Funeral Tent of an Egyptian Queen*, 1882.

² (a) W. M. Flinders Petrie. *The Royal Tombs*

much the same in ancient Egypt as it is today, namely, for roofs, floors, doors and bonds in walls, but it was also used for the flag staves of the temples, and in the First Dynasty for lining the burial chambers of royal tombs¹ and in the early Dynastic period sometimes for roofing tombs.² The employment of wood as a building material, however, was not its only, or even its greatest, use, and it was required in considerable quantity for boat- and shipbuilding and for making furniture, boxes, statues, and many articles of daily use, as well as for coffins and other requirements for the dead.

The identity of the trees that grew in ancient Egypt, other than the few used for timber, will not be discussed, though it may be mentioned that as shown by the remains that have been found in tombs³ they in-

of the *First Dynasty*, Part I, 1900; (b) W. M. Flinders Petrie. *The Royal Tombs of the Earliest Dynasties*, Part II, 1901.

¹ *Ibid.*

² G. A. Reisner. *Early Dynastic Cemeteries of Naga-ed-Der*, Vol. I, Leipzig, 1908.

³ (a) P. E. Newberry. *The Ancient Botany. In Kahun, Gurob and Hawara.* By W. M. Flinders Petrie. (b) P. E. Newberry. *On the Vegetable Remains discovered in the Cemetery at Hawara. In Hawara, Biahmu and Arsinoe.* By W. M. Flinders Petrie. (c) P. E. Newberry. *Address to the British Association, Liverpool, 1923.*

cluded several species of acacia, the tamarisk, the dom palm, the olive and the pomegranate, all of which still grow in the country. The native Egyptian trees, however, of which the wood was suitable for the use of the carpenter were practically limited to the sycamore fig, the acacia and the tamarisk, the last two, on account of their small size, being useless for large objects.

CHAPTER II

FAIENCE, GLASS AND POTTERY

FAIENCE

Although the term faience may not be strictly correct etymologically and although "glazed siliceous ware" as suggested by Burton ¹ may be more in accordance with its composition, the author proposes to retain the accepted conventional name generally applied to this material. The term glazed pottery often used for faience is entirely wrong.² Faience is a typical Egyptian product, which dates from Archaic times and which by the early Dynastic period had reached a high stage of development; it consists of a body material coated with glaze.

Composition

The body material has been variously stated to be sand, powdered sand, carved sandstone, ground sandstone, powdered quartz rock, ground quartz pebbles, siliceous

¹ W. Burton. *Ancient Egyptian Ceramics*. *J. Royal Soc. of Arts*, Vol. LX, 1912.

² For the definition of pottery, see p. 54.

paste and quartz frit respectively. Three analyses by Burton show a mean of 94.1 per cent. of silica, and one by the author gives 99.6 per cent. A large number of specimens of the Eighteenth, Nineteenth, Twentieth and Twenty-sixth Dynasties respectively have recently been examined.¹ In every instance the body was composed of a finely-divided, crystalline, siliceous material, generally friable and sometimes very friable, frequently white, but almost as frequently tinted slightly blue, green, very light brown, grey, or pink, the colour, except in the case of the brown grey and pink, being due to a small amount of the glaze that had penetrated the body material. When examined microscopically the material was seen to consist of very finely divided angular grains of quartz without any admixture of clay or clayey matter, and it had all the appearance of having been artificially powdered, which is believed to be the case.

Origin The first point of interest about this material is its origin. From its composition and appearance it is undoubtedly some form of artificially powdered quartz, but what par-

¹ Many kindly supplied by Mr. H. E. Winlock of the Met. Mus. of Art, New York; others by Mr. R. Engelbach, Dept. of Antiquities, Cairo.

ticular form it is impossible to say, and different forms may have been used at different times and in different places, that particular variety being chosen that was available locally. A mistake frequently made in these matters is to assume that because there is evidence of the use of a particular material for a certain purpose in one locality that therefore the same material was used at other periods or in other localities, though such is not necessarily the case. Crushed white quartz sand seems one of the most likely substances to have been employed, and is one that would have been generally available, and the author has produced very similar material from such sand; crushed quartz rock, as for example that occurring at Aswan, would also be suitable, but would take more labour to prepare and would only be available in one locality. It was quartz, however, that at a very early date was fashioned into small objects, which were then glazed, from which practice it has been suggested the making of faience originated.¹

Binding
Material

Another interesting problem is how such a material as that described, which is entirely without any natural coherence, was held to-

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*.

gether while being shaped and glazed. Clay is frequently stated to have been the adhesive used, though fat, gum and glue have all been suggested. Reisner writes, "I am unable to determine whether cohesion was obtained by the use of some special binding substance or not, but consider it probable."¹ Burton rejects all these opinions and states that faience objects were carved out of sandstone.² From Burton's analyses and from the analyses and examinations made by the author there can be no doubt that the material analysed and examined did not contain any clay and therefore could not have been held together by clay. Neither was gypsum the binder, since a number of specimens were specially examined for this with negative results. In several cases out of a very large number there were a few small particles of black organic matter distributed throughout the mass, that conceivably might have been the remains of some such adhesive as gum or glue that had been employed to bind the material together, but the evidence was too slight to be in any way conclusive.

¹ G. A. Reisner. *Excavations at Kerma*, Parts IV and V, Camb., Mass., U.S.A., 1923.

² W. Burton. *J. Royal Soc. of Arts*, Vol. LX, 1912.

In a large number of other specimens, however, from the Twenty-sixth Dynasty, constituting one lot of *sharabti* figures, the evidence was more definite and the body material showed an inner grey-coloured core surrounded by a zone of white. Under the microscope the grey core was seen to contain a number of black particles, and there could be no doubt that the dark colour was due to organic matter that had been partly burned. This was confirmed by heating the material in a small gas muffle furnace,¹ when the colour of the core became definitely lighter, though not quite white. It is suggested therefore that some organic adhesive had been used for binding the quartz together and that the darker centre was due to this not having been entirely burned away, as usually happened, during the firing of the glaze. Of the nature of the adhesive there is no evidence. In those instances in which the glaze has penetrated the body material this now acts as a binder, but manifestly it could not operate while the object was being shaped before the glaze was applied. Bur-

¹ Kindly undertaken by Dr. A. G. Innes, the Director, Government Chemical Dept., to whom the author is indebted in many ways in connection with this work.

ton's suggestion that the faience objects were carved out of sandstone cannot be accepted for many reasons, more particularly because the material is not sandstone, but something that has been artificially crushed. That at least some of the smaller faience objects were moulded is proved by the finding of a large number of red pottery moulds for making scarabs, necklace pendants and small figures, in some of which there were the remains of siliceous material.¹

Faience was employed for beads, amulets, scarabs, statuettes, tiles, vases, bowls, necklace pendants, inlay and other objects.

Glaze No record of the analysis of the glaze on faience can be found, but it is generally assumed to be of similar composition to ancient Egyptian glass and from theoretical considerations, as also from its appearance and from the manner in which it sometimes disintegrates, as well as from the nature of the products of disintegration, the generally accepted assumption may be taken as being correct. If this be so, then the glaze consists essentially of a mixture of sodium silicate (silicate of soda) and calcium silicate (silicate of lime), with possibly also potassium silicate

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*.

(silicate of potash), together with small proportions of various impurities derived from the raw materials used and a small amount of colouring matter, the nature of which latter has not been investigated, though it is probable that the ingredients were the same as those employed for colouring glass. Some of these colours frequently change or disappear, thus blue often becomes green or fades to white, indicating the use of copper, and green turns brown, which suggests iron.

Glaze, if of the composition stated, must have been made from the same materials and in the same manner as glass, and it is in fact a vitreous substance that differs from glass only in the manner of its application, glaze never being used alone, but always being applied in the molten condition to the surface of another material, which was generally siliceous, as in the case of faience, though sometimes steatite (especially when this was used for making scarabs) and small objects of quartz (such as beads and figures) were also glazed, the latter at a very early date.

GLASS

Although the chemical composition of ancient Egyptian glass is essentially the same as that of the ancient glaze there is a fun-

damental difference between the two arising from the manner in which the material was used, glaze always being applied to the surface of an object, whereas glass was employed independently, and although with glass there was sometimes a temporary core, as in making vases, it was one to which the material was not intended to adhere and which was eventually removed. This distinction is a most convenient one that should be maintained, since the invention of glass, as distinguished from glaze, marks a definite epoch.

Origin Glaze almost certainly originated in Egypt, and since glass is the inevitable outcome of glaze and since the necessary raw materials exist abundantly in the country it is extremely probable that glass, too, is an Egyptian invention, and that it was not a separate discovery apart altogether from glaze. Thus molten glaze needs only to be fashioned into an independent object to become glass, and the method of making early glass vases by winding rods of the molten material round a sandy clay core and afterwards heating the object until the rods coalesced, the core being subsequently removed, is strongly suggestive of glazing.

The evolution from glass to glaze, however, so far as can be judged from the existing

evidence, took a very long time, the reason possibly being due to the conservatism of the glaze worker, who, like artisans of all ages and particularly of early times, would naturally be very averse to new methods and non-receptive to new ideas. Although molten glaze almost certainly fell occasionally upon a material such as earth or metal, to which it would not adhere, the worker would be so occupied with glazing and research being so foreign to his nature that any experiments respecting new possibilities for his material would not occur to him, and any development would be delayed until there happened to be a glaze-worker with the special inquiring turn of mind that is so rare even to-day, and then some considerable time would elapse before the experience necessary for the manipulation of the material on the new lines could be acquired. Although doubtless originating, as suggested, as a development of glaze, glass-making would soon branch off as a separate industry.

Early
Specimens

At what period glass was first produced is uncertain, and there is little doubt that it was made exceptionally and in small amount before it came into general use, and when occasional early specimens are found in Egypt there is no need to assume that they

are of foreign origin and have been imported. From the evidence at present available the regular production dates from about the beginning of the Eighteenth Dynasty, and by the middle of the Dynasty the technique had reached a high standard of excellence. The earliest known piece of glass bearing a date is a large ball bead with the cartouche of Amenhotep I now in the Ashmolean Museum at Oxford. The most important specimens of glass dating from the Eighteenth Dynasty to the Twenty-first Dynasty inclusive have been summarized by Newberry,¹ and to these may be added a number of beads of the early Eighteenth Dynasty found by Howard Carter at Thebes.² So far the matter is clear and there is no room for any difference of opinion on the subject, but there are a number of other specimens of material of dates earlier than the Eighteenth Dynasty that have been claimed to be glass, but the nature of which has been disputed. The principal of these are a small Hathor head of blue glass³ and a bead,⁴ both stated to be

¹ Percy E. Newberry. A Glass Chalice of Tuthmosis III. *J. Egypt. Arch.*, 1920.

² Howard Carter and Earl of Carnarvon. *Five Years' Explorations at Thebes*, 1912.

³ W. M. Flinders Petrie. *Prehistoric Egypt*, 1920.

⁴ B. Neumann and G. Kotyga. *Z. Angew. Chem.*, 1925.

of Predynastic date and found by Flinders Petrie, the former now in the University College Museum, London, and the latter in the Berlin Museum; beads of Predynastic date found by Maciver and Mace¹; inlay said to be of the First Dynasty from Abydos²; bracelets of the First Dynasty also from Abydos³; beads of the Eleventh Dynasty from Deir el Bahri⁴; a mosaic of the Twelfth Dynasty from Dashur²; inlay of this same Dynasty, also from Dashur³; two specimens claimed to be of the Twelfth Dynasty analysed by Parodi,⁵ and a piece of mosaic stated to be of the Twelfth Dynasty now in the Berlin Museum.²

The Hathor head and the bead in the Berlin Museum apparently are both glass; the latter has been examined by Rathgen and its composition qualitatively determined,⁶ and the question concerning them

¹ D. Randall Maciver and A. C. Mace. *El Amrah and Abydos*, 1902.

² Percy E. Newberry. A Glass Chalice of Tuthmosis III. *J. Egypt. Arch.*, 1920.

³ E. Vernier. Bijoux et Orfèvreries. *Cat. Gen. du Musée du Caire*, 1907.

⁴ *Bull. Met. Mus. of Art.*, New York, Part II, 1921.

⁵ H. D. Parodi. *La Verrerie en Egypte*, Le Caire, 1908.

⁶ B. Neumann and G. Kotyga. *Z. Angew. Chem.*, 1925.

rests upon the dating, about which the author is unable to express an opinion, but manifestly there is a possibility of mistake. With regard to the Predynastic beads found by Maciver and Mace, it is suggested that they may be of faience or of quartz, possibly glazed, and not glass. The inlay of the First Dynasty the author has not yet had an opportunity of examining. From the description of it, however, it may conceivably have been faience, glazed on one side only, from which the body material has fallen away or has been removed. The finder of this calls it both *émail* and *verre émaillé*.¹ The author has carefully examined, both with a lens and with a microscope, the First Dynasty bracelets mentioned, and in his opinion the disputed material is all turquoise, though not always of very good colour. Of the Eleventh Dynasty beads there can be little doubt as they were found recently by Winlock and examined by him. The mosaic from Dashur, which is a small pendant with the figure of an ox, has been examined by the author by means of a microscope and there is no doubt whatever that it all consists of natural stone, the blue background probably being lapis lazuli, and the

¹ E. Amélineau. *Fouilles d'Abydos*, Paris, 1899.

inlay, both the ox and the encircling coloured band, being stone that after insertion has been ground down until it is very thin and almost appears to be all one piece with the blue, so much so that it has recently been suggested that the ox and the coloured band are painted.¹ The cover of this pendant is rock crystal, and neither Iceland spar (*spath*) as stated by the finder,² nor fluor spar as suggested by another writer. The questioned inlay in the Dashur jewellery has also been carefully examined, and is all natural stone without any glass. The two specimens of material analysed by Parodi merit special attention. These are stated to be a transparent eye and a fragment of yellow glass respectively, both from the tomb of princess Khunumuit of the Twelfth Dynasty at Dashur, and to have been given to the analyst by Maspero. From the results obtained there can be no doubt that the material of which the analyses are reported is glass. This, however, is very extraordinary, not merely on account of the early date attributed to the material, but more especially because in the Cairo Museum there

¹ E. Vernier. *Bijoux et Orfèvreries. Cat. Gen. du Musée du Caire*, 1925.

² J. de Morgan. *Fouilles à Dahchour*.

are a number of eyes from the tomb of the princess in question, each of which has a transparent cornea looking very like glass, but which the author has examined and found to be transparent quartz (rock crystal), and until there is more evidence, not only for the correct dating of the specimens, but that the so-called eye was in fact part of an eye, the analyses cannot be accepted. The Berlin mosaic can hardly be other than glass, but the date has been disputed, and about this the author can express no opinion, though if the cartouche is that of Amenemhat III this naturally constitutes strong evidence in favour of it being of the Twelfth Dynasty as claimed.

The earliest glass works of which the remains have been found date from the Eighteenth Dynasty,¹ and several sites of glass-works, though possibly of late date, may still be seen in the Wadi Natron. In the literature of the Roman period there are references to Egyptian glass, which was manifestly an important article of export at the time. It was about this date, too, that blown glass was first introduced, all earlier glass having been moulded. At the present

¹ Percy E. Newberry. *J. Egypt. Arch.*, Vol. VI, Part III, 1920.

day glass is not made in Egypt, but only a few small and inferior objects from broken glass re-melted, and although several attempts have been made in recent years to revive the industry these have proved unsuccessful.

Inlay One considerable use of glass in ancient Egypt was to imitate semi-precious stones for inlay in jewellery and other objects, the glass employed being opaque and coloured, thus dark blue glass was made to imitate lapis lazuli, light blue to imitate turquoise and red to imitate red jasper. This inlay is sometimes termed enamel, paste, or *pâte de verre* : it is, however, certainly not enamel, which, although a vitreous material, is employed in the powdered state and always fused into position by heat ; the terms paste and *pâte de verre* are also unsatisfactory and are often used very loosely, and sometimes are even deliberately intended to be non-committal. The word paste, too, in connection with glass has a very definite technical meaning and signifies the glass with a high refractive index and high lustre employed to imitate certain modern gems, particularly the diamond, and cannot correctly be used to describe the soft glass without brilliance or sparkle made by the ancient Egyptians in imitation of opaque stones. It is suggested

that the terms paste and *pâte de verre*, therefore, should be discarded in Egyptology and that the inlay in question should always be called glass.

Composition Ancient Egyptian glass is essentially a soda-lime silicate similar in the nature, though not in the proportions, of its constituents to a modern glass of ordinary quality. The latter, however, contains much more silica, a much smaller proportion of oxides of iron and aluminium, generally no oxide of manganese, much more lime, practically no magnesia and much less alkali.

The lower proportion of silica and lime, the greater proportion of oxide of iron and the considerably higher proportion of alkali in ancient Egyptian glass, as compared with modern glass, would all act in the way of materially lowering the temperature required for fusion and would make the working of the glass easier, but at the same time they would adversely affect the quality of the product and make it less resistant. Another great difference between ancient and modern glass is that the latter, being so largely employed to transmit light, is frequently transparent, whereas the former, not having been required for that purpose, but being mainly ornamental, is at the most semi-

transparent and more generally translucent or opaque.

From the high proportion of oxides of iron and aluminium shown by the analyses and from the presence of oxide of manganese and of magnesia, the glass represented was manifestly not made from pure materials, and the composition corresponds to what would be obtained by fusing together a mixture of quartz sand and natron, both of which occur plentifully in Egypt. Neither sand nor natron are chemically pure substances, and from a large number of analyses made by the author the impurities contained in ordinary quartz sand are carbonates of lime and magnesia, the former often in considerable quantity, and oxides of iron, aluminium and manganese, and those occurring in natron are chiefly common salt and sulphate of soda. These substances therefore, or rather their products after fusion, would be found as constituents of the finished glass, and this is exactly what the analyses show.

If yellow sand were used for glass-making the iron compounds present would tend to produce a green colour in the glass, but in most cases, except for blue glass, this would not greatly matter, and in some instances it is possible that the effects of the iron might be

neutralized by the oxide of manganese present, which is a substance employed for this purpose in modern glass-making. A considerable proportion of the quartz sand in Egypt, however, contains only a small amount of iron and has very little colour, and sand that is practically white occurs abundantly and might have been used.

It has been stated that glass was made at Tell el Amarna from pure silica obtained by crushing quartz pebbles,¹ but this does not agree with the original account as published,² according to which quartz pebbles were found only in connection with the manufacture of blue frit, where freedom from iron is very essential, and not for glass-making, and the evidence from the analyses, which cannot be ignored, points to the use of sand. If quartz pebbles, or other form of pure silica, were used it would have been necessary to have added carbonate of lime, since lime is an essential constituent of the glass, but with sand the carbonate of lime would have been present as an impurity and its presence would probably not even have been known to the glass-maker, who would merely have

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt.*

² W. M. Flinders Petrie. *Tell el Amarna.*

realized that in order to produce satisfactory results a particular kind of sand was required.

From the analyses it will be seen that the alkali is not wholly soda, but that potash is also present, though generally only in small proportion, and it possibly occurred as an impurity in the natron employed. Potash, however, was never used alone, and the statement that the alkali required was obtained "doubtless from wood ashes,"¹ which can only refer to potash, conveys a wrong impression. Possibly the earliest glaze, from which it is suggested that glass developed, may have been made with potash obtained from wood or plant ashes, but after the natural soda deposits became known there was no longer any inducement to use potash.

The colour of ancient Egyptian glass may be white, red, blue, green, amethyst, yellow, or black, and the nature of these colouring matters will now be considered.

White Glass When white glass is transparent or translucent it does not contain any colouring matter, but when it is opaque this effect is generally produced by the addition of oxide of tin, which is the usual form in which tin

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*.

occurs in nature and which has been found in white opaque glass of the end of the Eighteenth Dynasty¹ and also in the Twentieth Dynasty and later.²

Red Glass Egyptian red glass is opaque, having been made to resemble red jasper, and the colour is due to red oxide of copper. This is evident from the green coating that forms on the surface when the glass begins to decay and is confirmed by analysis. Two specimens of this glass, one from the Eighteenth Dynasty and the other from the Nineteenth Dynasty, examined by the author,³ were both found to owe their colour to a copper compound, and the same result was found by Neumann and Kotyga.¹

Blue Glass The ancient Egyptian blue glass is of three shades of colour, namely, dark blue, light blue, and greenish blue. Of the specimens analysed by the author,³ three of the Eighteenth Dynasty and two of the Twentieth Dynasty, all owed their colour to copper compounds, but a sample of Arab glass examined in the author's laboratory by

¹ B. Neumann and G. Kotyga. *Z. Angew. Chem.*, 1925.

² H. W. Parodi. *La Verrerie en Egypte*.

³ For the specimens the author is indebted to Dr. Howard Carter.

Clifford was free from copper and apparently its colour was due to iron. Parodi found copper as the colouring matter in one specimen of Egyptian glass of Persian times and cobalt in seven specimens, four of the Eighteenth Dynasty, two of the Twentieth Dynasty, and one of the Persian period.¹ Cobalt was also found by Clemm and by Clemm and Jehn.² Neumann and Kotyga, however, failed to find cobalt in any of the thirty-eight specimens of ancient glass they examined, and state that it was never used until Venetian times, and that the blue colour of Egyptian glass is generally due to copper and occasionally to iron.³ Cobalt is the colouring matter employed for blue glass at the present day; it produces, however, only a dark blue, and hence the turquoise blue and the greenish blue of Egyptian glass cannot ever be due to cobalt, and were generally produced by copper, the use of which was the rule for blue glass of all shades and the use of cobalt the exception.

Green Glass A green colour may be due either to copper or to iron compounds, the colour of the

¹ *La Verrerie en Egypte.*

² Lepsius. *Les Metaux dans les Inscriptions Egyptiennes*, Trans. Paris.

³ *Z. Angew. Chem.*, 1925.

modern green bottle glass, for example, being produced by the latter. It was to copper, however, that the green of the ancient Egyptian glass is due. One specimen of Eighteenth Dynasty glass examined by the author¹ was found to be coloured by copper. Parodi also found copper as the colouring matter in a green glass of the Twentieth Dynasty,² as also did Neumann and Kotyga for the specimens of Egyptian green glass examined by them.³

Yellow Glass A specimen of Egyptian yellow glass of the Nineteenth Dynasty was found by the author¹ to be coloured by antimony associated with lead, and these same ingredients were found by Parodi in Egyptian yellow glass of both Persian and Arab times.² Neumann and Kotyga state that the specimens of yellow glass they examined owed their colour to iron and manganese.³

Amethyst Glass Two specimens of dark amethyst-coloured glass, both of the Twentieth Dynasty, examined by the author¹ were found to owe their colour to manganese, and Neumann

¹ For the specimens the author is indebted to Dr. Howard Carter.

² *La Verrerie en Egypte*.

³ *Z. Angew. Chem.*, 1925.

and Kotyga found this same colouring matter in a purple glass of the Eighteenth Dynasty.¹ In this connection it may be mentioned that white glass of ordinary quality containing manganese compounds becomes coloured if exposed to strong sunlight for some time. This colour varies from a very slight amethyst tint to a beautiful deep purple colour, and it is a matter of common observation in Egypt to find in the desert in the neighbourhood of towns pieces of what have been white glass coloured in this manner. The coloration is due to manganese compounds in the glass having undergone some chemical change, which apparently is brought about by sunlight, and is not due either to heat or to radio-activity. It is not, of course, suggested that the colour of ancient Egyptian amethyst glass has been caused by exposure, or that it is other than original.

Black Glass

The author has been unable to obtain any specimens of ancient Egyptian black glass for analysis, and Parodi also does not give any analyses of black glass, but Neumann and Kotyga found that the colouring matter in two cases was copper and manganese and in a third case a very large proportion of iron.¹

¹ *Z. Angew. Chem.*, 1925.

POTTERY

By pottery is meant ware made from clay, moulded into shape while wet and then hardened by being baked, faience, which has already been dealt with, being excluded.

**Raw
Materials**

Egypt, thanks to the Nile, being literally a land of clay, the art of the potter was known and practised from very remote times, and pottery has been found in the earliest Predynastic graves. The technique of pottery-making in Egypt will not be discussed, but only the materials employed. The essential material naturally is clay, which consists of hydrated silicate of aluminium, together with small proportions of impurities, chiefly oxide of iron and sand, but often also carbonate of lime. Clay contains water in two forms, one mechanically mixed and the other chemically combined, and when clay is dried, the former, or interstitial water, is driven off and the material loses its plasticity and becomes soft and friable, but if wetted will take up water and will become plastic again; when clay is more strongly heated or baked the chemically combined water is also driven off and the material becomes hard and entirely loses its capacity for absorbing water, except mechanically, and if wetted does not become hydrated or plastic.

Although clay occurs abundantly throughout Egypt it is not uniform in composition, but varies very much in the nature and amount of the impurities present, and as these affect both its colour and its fitness for pottery-making, this industry is more particularly practised in those localities where the most suitable clay is found, and this was doubtless also the case in ancient times.

Colour The colour of ancient Egyptian pottery, apart from paint, may be grey, buff, red, or black, and these colours may be either those of the body of the pot itself or those of a thin coating of clay (slip)¹ put on to give a smoother surface or a different colour to the ware. The grey and buff, whether of the body or of the surface coating, are the colours natural to the clay used and are only produced when the clay is practically free from iron compounds; the red is due either to the use of clay containing a relatively large proportion of iron compounds, which have become converted into red oxide during baking, or to the use of a slip¹ coloured with red oxide of iron. This oxide is frequently called hæmatite, but the use of this word is very misleading, and in Egyptology the term

¹ Finely ground clay mixed with water to the consistency of cream and applied before baking.

hæmatite is better confined to the black, opaque mineral with a metallic lustre that was employed for making beads, amulets, and other small objects. Although hæmatite consists of oxide of iron and although it gives a red powder when finely ground, it is improbable that it was used for colouring pottery, and the material employed is much more likely to have been a naturally occurring red ochre, which consists of the same oxide of iron as hæmatite with the addition of a little clayey matter and which was well known to the ancient Egyptians and was in regular use as a pigment.

Black Pottery

With regard to the black or black-topped pottery, there are three possible ways of accounting for the black colour: first, the action of smoke from the fire used in baking the objects, or of some volatile matter that would carbonize, such as tarry matter derived from the fuel; second, the production of black oxide of iron instead of red oxide by limiting the air supply during baking; and third, the application of a black colour to the object. The first is the usual explanation, and it would seem to be accepted by Maciver and Woolley as the result of some experiments carried out by Mercer.¹ This is

¹ D. Randall Maciver and C. L. Woolley. *Areika*, Oxford, 1909.

supported by Pollard,¹ so far as the black-topped Predynastic pottery is concerned, since he found that the black colouring matter of the specimens examined was carbon. Pollard states, however, that in a pot of Ptolemaic date the black colour was due to black oxide of iron and not to carbon.¹ Flinders Petrie does not accept the carbon explanation, and as an argument against it mentions that the black colour extends throughout the thickness of the material and contends that smoke could not penetrate in this manner.² The possibility of volatile carbon compounds of a tarry nature, penetrating the pottery and carbonizing, however, is not considered. This authority proposes the second of the solutions mentioned, which from a chemical point of view is very attractive. This production of black oxide of iron by limiting the air supply is theoretically possible in the manner suggested, namely, by covering that portion of the pot intended to be black with ashes, and, as already stated, Pollard found black oxide of iron and not carbon

¹ W. B. Pollard. *Cairo Sci. Journal*, Vol. VI, 1912.

² W. M. Flinders Petrie. *Nagada and Ballas*. Also *The Arts and Crafts of Ancient Egypt*.

in a specimen of Ptolemaic pottery. The third method mentioned was employed for certain types of pottery found by Reisner at Kerma, which had been coloured by means of graphite (blacklead).¹ This, however, gave merely a surface coloration and does not account for the black of the interior of the ware. Graphite, although a form of carbon, is very resistant to heat and does not burn off during baking. The whole subject needs further work, both chemical and experimental, before it can be definitely settled.

Ancient Egyptian pottery, although frequently polished by rubbing before baking, is never glazed, that is to say, it is never coated with a vitreous material like the glaze of faience, or like the modern salt or lead glaze. It is, however, often painted, and the pigments used were similar to those employed for tomb painting and other purposes.

¹ G. A. Reisner. *Excavations at Kerma*, Camb., Mass., U.S.A.

CHAPTER III

METALS

The principal metals in use in ancient Egypt were copper and its alloy bronze, electrum, gold, iron, lead and silver and, to a very small extent, antimony and tin (apart from the tin in bronze), and in addition to the metals themselves, compounds of some of them were also employed, as also compounds of two other metals, cobalt and manganese, that were not then known in the metallic state. All these metals will now be described.

Antimony Only one instance of the use of metallic antimony in ancient Egypt is known, namely, some beads of Twenty-second Dynasty date.¹ Compounds of antimony, however, were occasionally employed in small amount. Thus one specimen of kohl, the black pigment used for painting round the eyes, from a Nineteenth Dynasty tomb,

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*, London, 1910.

consisted of sulphide of antimony; the author has analysed two other specimens of unknown date that proved to be galena containing a trace of antimony, and an antimony compound associated with lead has been found by the author in a specimen of ancient Egyptian yellow glass from the Nineteenth Dynasty and by Parodi in specimens of similarly coloured glass from both the Persian and Arab periods.¹ Traces of antimony are also frequently present in ancient Egyptian copper and bronze objects.

In connection with the specimens of kohl mentioned that contained antimony it may be pointed out that although this eye paint is frequently termed *stibium* (the Latin name for antimony), and although statements are often made that it consists of, or contains, antimony or an antimony compound, yet only in three specimens out of forty-four of which analyses are recorded was antimony present,² and it is suggested that if an antimony compound was ever in general use in Egypt for eye paint, as the name *stibium* would seem to indicate, it must have been at a very late date. So far as is known anti-

¹ H. D. Parodi. *La Verrerie en Egypte*, Cairo, 1908.

² See p. 146.

mony ores do not occur in Egypt, but since antimony is a common impurity in many copper and lead ores, it is highly probable that, if looked for, it would be found in very small proportion in the Egyptian copper and lead ores, though its presence has not yet been recorded; it occurs as a trace in the nickel ore from St. John's island in the Red Sea.¹

Although the beads of metallic antimony referred to must have been imported into Egypt from abroad, and possibly also the specimen of sulphide of antimony found used as kohl, it is probable that in the cases where kohl consists of galena and occasionally contains a trace of sulphide of antimony that this was of Egyptian origin. It may be mentioned that antimony ores occur plentifully in Asia Minor and also in Persia.

Cobalt The chief value of cobalt is in the deep permanent blue colour of some of its compounds, on account of which they are highly esteemed as pigments by artists, and are also employed to produce a blue colour in glass. Both these uses of cobalt compounds were known to the ancient Egyptians, though at what date they were first em-

¹ F. W. Moon. *Preliminary Geological Report on Saint John's Island*, Cairo, 1923.

ployed is uncertain. A blue pigment from the tomb of Perneb (Fifth Dynasty), however, is stated to owe its colour to cobalt,¹ and cobalt has also been found in a pigment of the Twentieth Dynasty,² and the occurrence of cobalt as the colouring matter of blue glass of the Eighteenth Dynasty, the Twentieth Dynasty and the Persian period has been recorded.³

So far as is known cobalt ores do not occur in Egypt, the only cobalt yet found being minute traces in the alum minerals of the Dakhla Oasis⁴ and in the nickel ore of St. John's island in the Red Sea,⁵ the occurrence of which was almost certainly unknown to the ancient Egyptians and which presents almost insuperable difficulties of extraction, and any cobalt used must therefore have been imported, possibly from Persia, where it is known to occur. Cobalt has also been found occasionally in very small amount in ancient Egyptian copper and bronze objects

¹ M. Toch. *J. Ind. and Eng. Chem.*, 1918.

² A. Wiedemann. *Proc. Soc. Bib. Arch.*, Vol. XV, 1892-3.

³ H. D. Parodi. *La Verrerie en Egypte*, Cairo, 1908.

⁴ H. J. L. Beadnell. *Dakhla Oasis*, Cairo, 1901.

⁵ F. W. Moon. *Preliminary Geological Report on Saint John's Island*, Cairo, 1923.

and in a specimen of old slag from the copper mines of Sinai,¹ the latter suggesting that it occurs in the Sinai copper ore.

With regard to the alleged use of a cobalt compound at an early date (Fifth Dynasty) as a pigment, there is need for further investigation, since cobalt minerals are not blue, the blue material used for this purpose being an artificial compound of the nature of a glass coloured by cobalt. If, therefore, the blue of the Fifth Dynasty paint was indeed due to cobalt, this implies more knowledge of the mineral and its possibilities than would be expected in a country where it does not occur naturally. The use of cobalt for blue glass is an entirely different matter, since any cobalt mineral added to glass produces a blue colour, and it is suggested that the use of cobalt as a pigment followed and did not precede its use for glass or glaze.

Copper Copper, which, unlike gold, is not found in nature as an attractive-looking metal, but which must usually be produced artificially from unpromising-looking ores, was yet one of the earliest metals known to man. In Egypt it was employed as far back as Pre-

¹ J. Sebelien. *Ancient Egypt*, Part I, 1924.

dynastic times, since it has been found in graves of that period. In the earlier graves it occurs only occasionally and in the form of small objects, chiefly needles and personal ornaments, but in the later Predynastic graves it is more plentiful and larger objects are then found, such as weapons and tools. Small pieces of a green ore of copper, malachite, are also found in the earliest Predynastic graves.

The source of this early copper and malachite is beyond doubt, since copper ores, particularly malachite, occur both in Sinai and in the eastern desert, and both localities show signs of ancient mining operations.

In Sinai the copper region is chiefly in the south and there are extensive old workings in several places, of which Wadi Magârah and Sêrabît el Khâdim, both on the east side of the peninsula and about 12 miles apart, are the best known, and in each of these places there are, or were until comparatively recently, many hieroglyphic inscriptions cut deeply into the rock. The inscriptions at Wadi Magârah commenced in the First Dynasty and continued in the Third, Fourth, Fifth, Sixth, Twelfth, Eighteenth and Nineteenth Dynasties re-

spectively, and the inscriptions at Sêrabît el Khâdim are of the Twelfth, Eighteenth and Twentieth Dynasties respectively.^{1, 2}

In the eastern desert the copper deposits are all in the region that lies between the Nile and the Red Sea, where there are many old workings, the most northerly being in about the same latitude as Beni Suef and the most southerly near the Sudan frontier. Of the date of these workings there is no proof from the workings themselves, such as is found in Sinai, but from circumstantial evidence they are probably not so old as the Sinai mines.

Although the total amount of copper ore available in Egypt is not sufficiently large to warrant mining at the present day, since copper may be obtained in much greater quantity and in more easily accessible places elsewhere, the local mines were probably able to provide the copper required in ancient Egypt until a comparatively late date. The amount of slag resulting from ancient working in one locality in Sinai has been estimated by an Egyptologist at

¹ J. H. Breasted. *Ancient Records of Egypt*, 1906.

² Alan H. Gardiner and T. Eric Peet. *The Inscriptions of Sinai*.

100,000 tons,¹ but a mining expert states² that the dimensions of the heap do not warrant an estimate of more than 50,000 tons, and he calculates that this represents about 2,750 tons of copper obtained from the ore of which this is the slag.

From the Eighteenth Dynasty onwards a considerable amount of copper reached Egypt from abroad, both as tribute and as the spoils of war, and this imported copper apparently ultimately replaced the local supply since the latest inscription in Sinai, in the temple of Sêrabît el Khâdim, is of the Twentieth Dynasty.³

Although copper is sometimes found in nature in the metallic state, such an occurrence is uncommon, and with one or two notable exceptions, as in North America and in Australia, native copper only occurs in minute quantity. Usually copper is found combined with sulphur in what is termed a "sulphide" ore, or in an oxidized condition in what is called an "oxidized" ore, the former being the more general. So far as is

¹ W. M. Flinders Petrie. *Researches in Sinai*, 1906.

² T. A. Rickard. *Eng. and Mining Journal-Press*, June 20, 1925.

³ Alan H. Gardiner and T. Eric Peet. *The Inscriptions in Sinai*.

known copper does not occur in the metallic condition in Egypt, but only in the form of ores, which are chiefly carbonate (malachite) and silicate (chrysocolla) and therefore of the oxidized class, though pyrites, a sulphide ore, has been reported from the eastern desert.¹ Analyses of Egyptian copper ores cannot be traced, except in so far as the copper content of a few is concerned, and there is no record of the nature or amount of the impurities present. In the Sinai ore the highest proportion of copper that is reported is 18 per cent.² and the lowest 5 per cent.,³ while two specimens from the eastern desert, which however may not be representative, show 36 and 49 per cent. of copper respectively.⁴ One analysis of old copper slag from Sinai showed the presence of 38 per cent. of lead, 2 per cent. of iron, 0.5 per cent. of arsenic, traces of nickel and cobalt, but no antimony, silver, or bismuth,⁵ and a specimen of ore and two other specimens of

¹ T. Barron and W. F. Hume. *Top. and Geo. of the Eastern Desert of Egypt*, Cairo, 1902.

² A. E. Thomas. *Cairo Scientific Journal*, 1909.

³ T. A. Rickard. *Eng. and Mining Journal-Press*, June 20, 1925.

⁴ Analyses supplied by the Director, Geological Survey of Egypt.

⁵ J. Sebelien. *Ancient Egypt*, Part I, 1925.

ancient slag, also from Sinai, were free from tin.¹ Until more analyses are available, not only of Egyptian copper ores, but also of ores from other countries that at a later date supplied Egypt with copper, it would be merely guesswork to attempt to ascertain from the composition of ancient Egyptian copper objects the place of origin of the copper.

At the present day copper is obtained from its ores by means of an elaborate series of complicated metallurgical operations conducted in special furnaces, the exact nature of the operation and the type of furnace used depending upon the kind of ore to be dealt with. It is not proposed to describe these methods, but the treatment in its simplest form of the oxidized class of ores, to which those of Egypt mostly belong, may be mentioned. This consists in mixing the ore with coke and suitable fluxes and heating in a furnace provided with a blast. The ancient substitute for this operation was doubtless to mix the broken ore with wood charcoal in a heap on the ground and to apply a simple form of forced draught by means either of blowpipes or bellows, the

¹ Dr. J. H. Gladstone. *Proc. Soc. Biblical Arch.*, Vol. XII, 1890.

latter, however, not being known until about the Eighteenth Dynasty. In this connection it may be mentioned that copper melts at 1083° C., which is slightly higher than the melting point of gold (1063° C.), but lower than that of iron (cast iron, 1150° C.; wrought iron, 1500° C.).

The metal of which ancient Egyptian copper objects is composed is never pure, but always contains small proportions of other ingredients, the most common of which are antimony, arsenic, bismuth, iron, tin, and sulphur, the total impurities generally amounting to less than 1 per cent., though occasionally they may be more. Of these impurities, tin is the most interesting in view of the problem of the origin of bronze, and though tin is occasionally present it is more generally absent, but whether this indicates different sources for the copper cannot be stated, though this is possible.

No figures can be obtained to show the maximum amount of tin contained in copper produced in a crude manner from ore containing a small proportion of tin, but from the results of the analyses of early Egyptian copper objects of a period when none contained more than a very small proportion of tin, and hence before bronze

was known, this would seem to be of the order of about 1 per cent. Any early copper-metal therefore that contains more than this proportion of tin may reasonably be regarded as bronze.

Bronze After copper, the priority for the discovery of which at present rests with Egypt, came bronze, and since tin, which is an essential constituent of bronze, does not occur in Egypt, bronze cannot be of Egyptian origin.

The word bronze as used to-day has a wide meaning and includes a number of different alloys consisting wholly or largely of copper and tin, but in some cases containing also small proportions of other ingredients, among which zinc, phosphorus and aluminium may be mentioned. The proportion of copper in these alloys varies from about 67 to about 95 per cent., that of tin from about 4 to about 33 per cent., that of zinc is usually about 1 to 2 per cent., that of phosphorus from a trace up to about 1 per cent. and that of aluminium from about 5 to about 10 per cent. The earliest bronze, however, was a much simpler material, and consisted only of copper and tin with traces of such other ingredients (antimony, arsenic, bismuth, iron, and sulphur) as happened to be present in the ores employed. This

early bronze may be defined as an artificially-made alloy of copper and tin, irrespective of the proportions in which the two constituents occur. This definition intentionally excludes copper containing a trace of tin derived from the use of an impure ore, which it would be misleading to consider as bronze, since the production of the artificially-made alloy marks a definite stage in the history of early civilization that it is convenient and desirable to keep separate from the still earlier stage when the only metal employed was copper, although this copper was always impure and might contain a trace of tin. At a much later date an addition of lead was made to bronze, in order to render it more easily fusible, but such a mixture, although of the bronze class, is not a typical or normal bronze.

The advantage of bronze over copper is twofold: first, it is harder than copper, and therefore better adapted for weapons and tools; and, second, it has a lower melting point than copper, and hence can be cast more readily and at a lower temperature.

The early history of bronze is very obscure, but one fact is certain, namely, that, as already stated, bronze was not discovered

in Egypt, since tin ore does not occur in the country.

There are only four possible ways in which bronze could have been made: first, by fusing together metallic copper and metallic tin; second, by smelting a mixture of copper ore and metallic tin; third, by smelting a naturally occurring combined ore of copper and tin; and, fourth, by smelting an artificially-made mixture of copper ore and tin ore. The first two methods are out of the question unless it can be shown that metallic tin was known before bronze, and all the evidence points to a later knowledge. The third method is improbable. It is true that a combined ore of copper and tin (Stannite or Tin Pyrites) occurs naturally and that this, if smelted in the primitive manner anciently used for producing copper, would yield bronze, but it is most unlikely that such an ore was employed: first, because it occurs only in small quantity and in a few localities; second, because if a combined ore had ever been employed its use would have continued for at least some time, and in the then very elementary and purely empirical condition of metallurgy it could never have led either to the use of the principal and only important ore of tin (Cassiterite or

Tinstone), since there would have been no knowledge of the connecting link between the two, nor to the production of metallic tin; and, third, because the use of Stannite, which is a sulphide ore, would have resulted in a bronze containing more sulphur than is found in early bronze. It is probable therefore that the discovery of bronze was due to the smelting of an accidental mixture of copper ore and tin ore, which might easily have happened in a locality where both ores occurred in close proximity to one another as they sometimes do, but only in such a locality, as until bronze was known there was no inducement for the transport of tin ore from one place to another.

The country of origin of bronze has never been certainly established, and claims are made for both Europe and Asia, those of the latter, in the author's opinion, being better supported by the evidence, which points to some country in western Asia, possibly north-east Persia, where copper is known to occur and where tin is stated to have been found.^{1, 2}

¹ F. Haverfield. *Romano-British Cornwall*, London, 1924.

² Introduction to *A Guide to the Antiquities of the Bronze Age*, British Museum, 1920.

Being of non-Egyptian origin, bronze would naturally be scarce, and only occasional examples can be expected from the period when it originally became known, and it would be some considerable time before the new metal was widely used. It is always assumed, however, that bronze was eventually made in Egypt, though of this there is no direct proof, but since other countries in the eastern Mediterranean made bronze (otherwise there would have been no use for the tin, to the commerce in which Herodotus¹ and other classical writers bear testimony), it is not unreasonable to suppose that Egypt was no exception.

Owing to the lack of a large series of chemical analyses of early Egyptian metal objects there is no certainty about the date when bronze was first used in Egypt. It is not unusual to find in archæological reports objects called copper or bronze without any discrimination, and sometimes even called copper in one part of a report and bronze in another, as though the terms were synonymous. Disregarding these loose and frequently wrong statements, there are a few specimens of undoubted bronze that have been assigned to early periods, and these

¹ Herodotus, III, 115.

will now be considered. The first in order of alleged date is a small piece of rod from Medum, which, if contemporaneous with the tomb where it was discovered, is of Third Dynasty date¹: the finder of this calls it a "freak,"² and although he believes it to be of the same date as the tomb, admits the possibility that "it might have fallen in accidentally during the working from the surface."³ After this comes a ring or bracelet said to be of a date a little after the end of the Third Dynasty,^{4, 5} and then a vase described as of the Sixth Dynasty,⁴ but about neither of which are any details given, and in the absence of sufficient information that would enable the period assigned to them to be checked and until more analyses of well-authenticated objects from these Dynasties prove bronze to have been known, there must be doubt about the correct dating of these objects. Of the Sixth Dynasty also are the two statues of Pepy I in the Cairo

¹ W. M. Flinders Petrie. *Medum*, 1892.

² W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*, 1910.

³ W. M. Flinders Petrie. Quoted by Dr. Gladstone in *Proc. Soc. Bib. Arch.*, Vol. XIV.

⁴ Berthelot. In *Fouilles à Dahchour*, J. de Morgan, 1895.

⁵ J. de Morgan. *Les Origines de l'Égypte*, 1896.

Museum, concerning the composition of which there is much confusion. The finder of the statues calls the material of which they are composed copper,¹ and this is the generally accepted opinion. This is confirmed by an analysis made by Dr. Gladstone, F.R.S.,² who found the specimens submitted to him, which were much corroded, to be copper, with a possible trace of tin in the metallic core and evidence of only a very small amount of tin in the crust. An analysis of this same statue quoted by Maspero³ (who disregards it and calls the metal copper) shows 6.6 per cent. of tin, which would make the material bronze. This analysis was made by Professor Mosso of Rome, but there is a possibility that the material sent to him did not belong to the statue.⁴ If the metal of the statues was beaten into shape, and this is generally accepted, save for the head, hands and feet, which are stated to have been cast, but which the author suggests may also have been hammered, there would not have been any reason to employ bronze, even had it been known, since bronze

¹ J. E. Quibell. *Hierakonpolis*.

² In *Denderch*, by W. M. Flinders Petrie.

³ *Guide to the Cairo Museum*, English Trans. 1910.

⁴ J. Sebelien. *Ancient Egypt*, Part I, 1924.

is harder and less malleable than copper.¹ A bowl dated to the Eleventh Dynasty proves on analysis to be bronze, but as this is merely stated to come from Luxor without any further details, the dating may be wrong.² From the Twelfth Dynasty there are a number of well-authenticated specimens of bronze, and from the Eighteenth Dynasty onwards bronze was in regular use.

In this connection it may be mentioned that although occasionally it may be possible to distinguish an ancient copper object from one of bronze by mere inspection, as for instance in the case of thin objects of beaten copper, it is never safe to trust to this for identification, and whenever possible a chemical analysis should be made.

Brass Another alloy of copper is brass, which is a copper-zinc mixture, but this was not known until comparatively late in the history of metals, although it antedated by many hundreds of years the discovery of zinc as an individual substance, and there-

¹ An analysis has now been made by Prof. C. H. Desch, F.R.S., which proves the metal to be copper. This was done for the Brit. Ass. Com. on Sumerian copper origins, to the Sec. of which, Mr. G. A. Garfitt, the author is indebted for the result. ² G. B. Phillips. Quoted in *Ancient Egypt*, Part III, 1924.

fore brass as at first produced must have been made from copper and zinc ore and not from metallic zinc, and like bronze was probably the result of an accident. Brass was occasionally used in ancient Egypt, since a brass finger ring of late date has been found at Karanog in Nubia.¹

Any description of copper and bronze would be incomplete without reference to the much-discussed question of whether or not the ancient Egyptians used some method, the secret of which has been lost, of specially treating these metals so as to impart to them the hardness of tool steel. No evidence of the kind has been found, and in the author's opinion no such method was known, nor is any such hardening possible. Ancient Egyptian copper and bronze chisels and other tools have frequently been analysed by competent chemists and have also been examined by modern microscopical methods, and no trace whatever of any special ingredient or treatment has been found. The properties of copper and bronze, too, are well known, and no metallurgist has been able to suggest a method whereby they could be hardened to the hardness of tool steel. The arsenic and bismuth sometimes present

¹ C. L. Woolley and D. R. Maciver. *Karanog*, Phil., 1910.

in ancient Egyptian copper and bronze, and frequently stated to have been added for hardening purposes, are believed to have been natural impurities in the ore used. Copper ore containing arsenic compounds in large proportion is quite common, and copper ore containing bismuth compounds, though not common, is known, and even the highest proportion of arsenic and bismuth recorded in ancient Egyptian copper and bronze, namely, 2.3, 3.9 and 5.6 per cent. respectively of the former and 1.0 per cent. of the latter,¹ are not higher than would be expected if an arsenical copper ore or an ore containing bismuth, as the case might be, had been employed. Arsenic in the form of the yellow sulphide (orpiment) was employed as a pigment in the Eighteenth Dynasty, but there is no evidence of an earlier use and no evidence that bismuth in any form was known.

As already stated, ancient Egyptian copper articles contain small proportions of certain impurities, including arsenic, bismuth, iron, and sometimes tin, which occur naturally in the ore used and some of which would tend to make the copper very slightly harder than pure copper made by modern processes and the crude method of smelting employed, by

¹ W. M. Flinders Petrie. *Ancient Egypt*, 1915.

producing and leaving in the metal a small proportion of oxide, would also tend to harden the copper very slightly, but such impure copper would never be as hard as bronze. Slight additional hardness, however, would result from the mechanical treatment (hammering) to which the copper was subjected in order to shape it and to give it an edge, and in one case at least there is evidence to show that the hammering was done cold.¹ Again, however, such copper would not be as hard as bronze.

Bronze, as already explained, is copper specially hardened by the addition of tin, but however hard the original copper might be owing to the presence of small proportions of impurities and however carefully the proportion of tin might be regulated, the resultant bronze would never be as hard as tool steel. By slow cooling and hammering bronze may be given a cutting edge, but even such bronze is not of the hardness of tool steel.

But if it be accepted that copper was never hardened beyond the bronze stage and that bronze was not hardened at all, except by a careful proportioning of the tin and by

¹ H. Garland. *J. Inst. Metals*, No. 2, Vol. X, 1913.

such simple treatment as hammering, how then could the Egyptians work the hard stone that undoubtedly was worked? At this stage the evidence goes beyond the province of chemistry and becomes largely archæological and therefore will not be discussed. A few facts bearing on the problem may, however, be given, namely:

1. That before copper tools were known, and therefore without their help, flint was worked and beads and other small objects were fashioned out of quartz and other very hard materials.

2. That in early Dynastic times, before the introduction of bronze, bowls, vases, mace-heads and other objects were made out of hard stone, and some of the most perfect statues that have survived from ancient Egypt were executed in such hard materials as diorite-gneiss and fine-grained schist, while statues, sarcophagi and other objects were made of granite, which was also employed to a limited extent for building purposes.

3. That the advent of bronze brought no new triumphs in stone-working, but merely extended the use on a larger scale of stone already known and employed.

The above facts, which are all well-established, prove that hard stone was worked

on a small scale without the use of copper or other metal tools and that with copper tools the most perfect statuary was made. It is suggested that a consideration of the following points may help towards a solution of the difficulty: ¹

1. That tools of flint and other hard stones were in common use.

2. That abrasive materials were probably known and employed.

3. That although the ancient Egyptians used chisels for stone-working they also employed other tools, such as adzes, saws and drills, including tubular drills, and too much prominence should not be given to the use of the chisel to the exclusion of the other tools. It may be mentioned, too, that both saws and drills can be fed with an abrasive powder, which is not possible with chisels.

4. That the condition of the times and the infinite patience of the Egyptian worker are factors that function very largely in the matter, the latter in particular being rarely taken sufficiently into account, and much

¹ For references to this subject see (a) W. M. Flinders Petrie. On the Mechanical Methods of the Ancient Egyptians. *J. Anthropological Inst.*, Aug. 1883; *The Arts and Crafts of Ancient Egypt*, 1910. (b) R. Engelbach. *The Aswan Obelisk; The Problem of the Obelisks*. And (c) Somers Clarke. *Cutting Granite. Ancient Egypt*, 1916.

that is thought to be impossible is only so because the modern Western workman has neither the time nor the patience to undertake it.

Malachite has already been mentioned as being one of the forms of copper ore occurring in Egypt and as having frequently been found in Predynastic graves, at which period it was used for painting round the eyes. But according to Professor Breasted's translation of the ancient Egyptian records malachite was also very largely employed as an inlay or ornamentation, particularly during the period of the Empire, and it is generally associated in the text with the metals gold and silver and with precious stones, notably lapis lazuli.¹ As malachite takes a good polish and is well adapted for such a purpose and is so employed in other countries, especially in Russia, it is a matter of surprise therefore to be unable to find this use of malachite exemplified in the Egyptian collections of museums, and no instance of its use for such a purpose can be found in the Cairo Museum.² The simplest explan-

¹ J. H. Breasted. *Ancient Records of Egypt*.

² A small amulet of Archaic shape has recently been found at Abydos among objects of Nineteenth Dynasty date. *Egypt Expl. Soc. Cat. of Exhibits*, 1926.

ation of this seeming anomaly is that the material referred to in the ancient records is not malachite. This point will be referred to again when dealing with turquoise.

The value of copper in ancient Egypt was not confined to its use as a metal, either by itself or bronze, but it was extensively employed in the form of compounds for making blue and green pigments and also as a colouring matter for blue and red glass. The former will be considered later, and the latter has already been dealt with.

Electrum Electrum is an alloy of gold and silver, which may be either natural or artificial, but which originally was natural. Such mixtures may contain almost any proportion of the two constituents, and when the amount of gold is high the appearance is that of a light-coloured gold, and when the content of silver is high the colour is silver-white and the metal would pass as silver. Such extremes, however, are not usually called electrum, the term being limited to an alloy of a pale yellow colour, and it was this that the Greeks termed *electron* and the Romans *electrum*, from its resemblance in colour to amber, the name for which, as used by Homer and Hesiod, was *electron*.

The various specimens of ancient Egyptian

electrum of which analyses are recorded show a silver content varying from 11.2 to 22.3 per cent., and some electrum finger rings in the Cairo Museum, that it is not possible to analyse, have approximately the same shade of light yellow as a gold-silver alloy of 15 carats, which corresponds to 37.5 per cent. of silver.

Whether the electrum found in Egyptian tombs is of local origin or not cannot, of course, be stated, but as silver is a constant impurity in Egyptian gold and as the proportion may be sufficiently high for the alloy to rank as electrum, the Egyptian origin of at least some of the specimens is not only possible but probable. The reason that electrum is not usually recognized as occurring in Egypt is that the modern gold prospector considers this particular alloy to be merely a poor quality gold; electrum, however, does occur and the local supply probably sufficed for all needs until about the Eighteenth Dynasty.

In the ancient records, electrum mines situated east of Redesia, which is a little south of Edfu, are mentioned,¹ and this is one of the localities where there are old gold mines.

¹ J. H. Breasted. *Ancient Records of Egypt*.

Electrum was employed in ancient Egypt in the same manner as gold, namely, for jewellery and for coating wooden objects such as furniture and sarcophagi, and was in use to a small extent from a very early period.

Several instances of the modern use of what is almost electrum have come under the author's notice and may be mentioned, thus articles silver-white in appearance have been presented at the Government Assay Office for hall-marking accompanied by a declaration that they were 12 carat (50 per cent.) gold, this being confirmed by the assay. The reason why gold, the more expensive metal, should have been so completely hidden that its presence would not be suspected is not known, though it is suggested that possibly the practice may be a survival of the ancient use of electrum.

Gold Gold is found very widely distributed in nature, chiefly in the metallic state, though practically never pure, but generally containing small proportions of silver, sometimes copper and occasionally traces of iron and other metals. Gold generally occurs in one of two forms, either in irregular masses in veins in quartz rock or in alluvial sands and gravels, these being merely the

debris derived from the breaking down of gold-bearing rocks that has been washed into watercourses, now often ancient and dry, as in Egypt. In Egypt, gold is found in both these conditions. Owing to its local occurrence, its glittering yellow colour and to the simplicity of the treatment required to separate it for use, gold was one of the oldest metals known in Egypt and it has been found in Predynastic graves. Since the extraction of gold from sand and gravel is a simpler process than its extraction from hard rock, primitive races usually begin gold mining with alluvial gold, and it is probable that the Egyptians were no exception to the rule.

The gold-bearing region of Egypt lies between the Nile valley and the Red Sea, chiefly in that part of the eastern desert stretching south from the Qena-Qosseir road to the Sudan frontier, though several old workings have been found considerably north of the latitude of Qena, and it extends also beyond the confines of Egypt into the Sudan almost as far south as Dongola.¹ The greater part of this territory is in Nubia, the Ethiopia of the classical writers, the

¹ Stanley C. Dunn. *Notes on the Mineral Deposits of the Anglo-Egyptian Sudan.*

Egyptian portion being in lower Nubia (from Aswan to Wadi Halfa) and the Sudan portion in Upper Nubia (from Wadi Halfa to Merowe). Gold has also been found (by the author) in very small quantity in mineral specimens from the Oases of the western desert. No occurrence of gold is known in Sinai, although the geological conditions are favourable and although some of the ancient records might seem to imply that gold was obtained from that region. The principal occurrence is in quartz, though, as already stated, there is also alluvial gold. The total number of old workings in quartz have been estimated to be at least one hundred, and Rickard states that in a particular district in the eastern desert there are alluvial workings of "immense extent," the country having "the appearance of having been ploughed," and that over an area of 100 square miles the ground has been worked to a depth of seven feet.¹ It is probable, however, that some of these workings are comparatively modern, as it is known that gold was exploited in the eastern desert during Arab times.

The gold industry in Egypt was revived some years ago, and although it has now died

¹ *Eng. and Mining Journal-Press*, June 20, 1925.

down again, more than 83,000 ounces of fine gold, of a value of over £350,000 sterling, were extracted during the nineteen years from 1902 to 1920 inclusive.¹ Mining was discontinued, not because the gold was exhausted, but on account of the difficulty and cost of working.

In view of the large amount of gold still in the country there can be little doubt that the gold from the local mines (those of Lower Nubia being included) was sufficient to supply all the needs of the country anciently and even to permit of export. Naturally, however, whenever possible additional gold was levied as tribute or taken as one of the fruits of victory in war since it was a valuable and desirable metal to possess.

The method of treating gold ores to obtain the metal is very simple. In the case of alluvial gold the sand or gravel is merely washed with running water, which carries away the lighter material, leaving the heavier gold behind, which is collected and fused into small ingots. With gold rock the old method of treatment was to separate the gold-bearing portions of the rock from the

¹ *Report on the Mineral Industry of Egypt*, Mines and Quarries Dept., Cairo, 1922.

mine by hand labour, roughly crush these into small pieces, powder them more finely, wash the powder free from quartz by means of water, as with alluvial gold, and finally fuse the remaining gold into small ingots. In this connection it may be mentioned that the melting point of gold is 1063° C.

One very noticeable feature of ancient Egyptian gold of all periods is its varied appearance and colour, some being bright yellow, other, though yellow, being dull and tarnished, and other, again, showing patches of various shades of red. The bright yellow gold is manifestly fairly pure and probably corresponds to the "fine gold" of the ancient records, though the word "fine" in this connection has not the same meaning as when used technically to describe bullion, the former meaning merely gold of good quality, but the latter pure gold of 24 carats. The dullness, tarnishing and discoloration of some of the gold is due to impurities in the metal having undergone chemical change on the surface owing to exposure, pure gold neither tarnishing nor changing colour. The author has found in the tarnish small proportions of silver, copper, and iron. The fineness of seven specimens of ancient Egyptian gold of which analyses are available

varies from 21 carats (90.0 per cent.) to 23.5 carats (99.8 per cent.).

Mrs. Williams gives the fineness of the better quality of ancient Egyptian gold jewellery as varying from 17 carats (70.8 per cent.) to 22 carats (91.7 per cent.), but mentions one specimen as low as 9.6 carats (40 per cent.).¹

Modern Egyptian gold from quartz varies from 730 to 930 fine, that is from 17.5 to 22 carats,² the alloy being principally silver with frequently a little copper and a trace of iron.

Occasionally gold in the form of large rings, believed to consist of alluvial gold from Abyssinia, have been received at the Egyptian Government Assay Office and were generally about 22 carats, and in a few instances gold bars from a mine in the eastern desert have been received for assay and found to be about 20 carats, the impurity in both cases being chiefly silver.

The statement therefore that "Asiatic gold was certainly used in the first dynasty as it is marked by having a variable amount

¹ C. R. Williams. *Gold and Silver Jewelry and Related Objects*, New York, 1924.

² Kindly communicated by the Controller, Mines and Quarries Dept.

of silver alloy, about a sixth¹ is very misleading.

The gold used for modern Egyptian jewellery is largely of very good quality, thus of that presented to the Government Assay Office for hall-marking (amounting to about two and a half million pounds in value a year) approximately 70 to 73 per cent. is 21 carats; 20 to 23 per cent. is 23·5 carats; 6 to 7 per cent. is 18 carats, and only a very small proportion is less than 18 carats.²

Whether the ancient Egyptians purified the native gold or not until a late period is unknown, though judging from the analyses quoted any purification, except in the case of the specimen from the Persian period, seems improbable. The ancient records, however, mention gold of two times and of three times, which suggests some degree of refining, and Deodorus Siculus quotes Agatharchides (Second Century B.C.) to the effect that the Egyptians purified gold from silver by heating it with salt and other substances.³

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*, 1910.

² A. Lucas. *Rpt. on the Work of the Gov. Anal. Lab. and Assay Office*, Cairo, 1921.

³ W. Gowland. Silver in Roman and Earlier Times. *Archæologia*, Vol. LXIX (1920).

Some of the different qualities of gold used may be accounted for by assuming that in certain cases the gold was debased by the addition of copper rather than that refining took place to give the better qualities, and that such debasement was at least occasionally practised from the Eighteenth Dynasty onwards is shown by the high copper content of certain specimens which is too high to be natural.

Several gold objects of the Twelfth Dynasty in the Cairo Museum examined by the author show a number of tiny silver-white metallic specks on the surface, which are not silver, but platinum, or one of the platinum group of metals. Mrs. Williams records similar particles as occurring in ancient Egyptian gold,¹ and Flinders Petrie reports the presence of osmiridium.² Platinum occurs in very small proportion in the nickel ore from St. John's island in the Red Sea.³

In addition to its use for jewellery, gold was largely employed in ancient Egypt for

¹ C. R. Williams. *Gold and Silver Jewellery and Related Objects.*

² W. M. Flinders Petrie. *Ancient Egypt*, 1915.

³ F. W. Moon. *Prel. Geol. Rpt. on St. John's Island.*

gilding objects, generally wood, but occasionally bronze, and even stone. In many instances this coating is very thin and corresponds to present-day gilding, though never quite so thin, while in other cases the gold is in the form of sheets or foil. Gilding when thin was always on gesso (a plaster made from whiting and glue), and never directly on the wood, though when thicker sheet gold was used this might either be on gesso or glued directly to the wood. Occasionally gold was also used for vases and other vessels and for statuettes.

Iron

Iron is found in nature almost always in the form of compounds and only occasionally, and generally in very small quantity, in the metallic state, some, though not all, meteorites being a form in which metallic iron occurs.

Ores and other compounds of iron are very plentiful in Egypt, and at a very early date an iron ore, hæmatite, was fashioned into beads and small ornaments, and compounds of iron, ochres, were used as pigments. The ores are found chiefly in the eastern desert and in southern Sinai, and the ochres occur near Aswan and in the Oases of the western desert.

There are few subjects that are more dis-

puted than that of the date when iron first came into general use in Egypt. Just as some wonderful and mysterious hardened copper or bronze (the composition and secret of the preparation of which have been lost) has been postulated to account for the early Egyptian work in hard stone, so it is often claimed that not only iron but steel must have been known and employed for this purpose.^{1, 2} The fact that a few specimens of iron of early date have been found has been used to support this argument, and it is stated that it is only on account of the easily oxidizable nature of iron that tools and other objects of this metal have not been more frequently discovered. Iron, however, although it does oxidize readily in damp soil, particularly if salt is present, is quite stable under the ordinary conditions that prevail in rock-cut and other tombs in Egypt into which water has not penetrated, and the fact that some few specimens of iron have survived is proof that had there been other examples under similar conditions these too would have lasted. It should not be forgotten also that iron when it oxidizes does

¹ Sir R. Hadfield. *J. Iron and Steel Inst.*, No. 1, 1912.

² J. de Morgan. *Les Origines de l'Egypte*, 1896.

not disappear, but is converted into a compound that is not only permanent but which, on account of its reddish colour and of its greater volume than that of the original metal, should not escape observation.

Those who believe that iron tools must have been employed for the early Egyptian work in hard stone attach considerable importance to a piece of iron found at the great pyramid of Giza, and see in this a proof that iron tools were used in its construction, in support of which the reference in Herodotus to iron tools in connection with the pyramid is quoted.¹ By far the greater part of the stone of the pyramid, however, is not hard and there would be no great difficulty in working it without iron tools, and the specimen of iron found is not a tool and does not appear to be part of a tool of any sort, and it is significant that the earliest iron objects are chiefly weapons and personal ornaments and not tools. Herodotus was not discussing the tools employed in the construction of the pyramid, but the cost of the pyramid, and incidentally includes that of the tools, which he assumes to have been of iron because iron tools for stoneworking were familiar to him. Thus he

¹ Herodotus, II, 124.

says, “. . . how much more was probably expended in iron tools, in bread and in clothes for the labourers . . .”

The specimens of early iron found may now be described. The earliest are some small beads of Predynastic date, which when found were entirely in the condition of oxide, but which Professor Gowland, who analysed them, states had originally been of iron.¹ This is in no way improbable, and it is suggested that they may have been made from a small quantity of metallic iron found accidentally and either of meteoric or terrestrial origin, meteorites frequently being composed of iron and native iron of terrestrial origin occurring in small quantity in various parts of the world and possibly in Egypt. As an argument against the use of meteoric iron it has been stated that it is not malleable, but though sometimes this is the case, it is not always so and such iron may be malleable. On the other hand it is conceivable that the beads had been made, not from metallic iron, but from some com-

¹ W. M. Flinders Petrie, G. A. Wainwright and E. Mackay. *The Labyrinth, Gerzeh and Mazghuneh*, 1912. Wainwright discusses the whole question of early iron in Egypt. See also his *Ancient Survivals in Modern Africa* in *Bull. de la Soc. Sult. de Geog.*, Caire, Tom. IX, 1919.

pound of iron that had undergone alteration and had become converted into oxide. It is well known that one compound of iron, hæmatite, was employed from very early times for making beads and other objects, but hæmatite is already oxide and is very permanent and therefore not likely to have become disintegrated, but it may be that occasionally some other compound of iron less stable than hæmatite, iron pyrites for example, might have been employed for the same purpose and might have been converted into oxide, which chemically is quite possible.

The specimen of iron from the Giza pyramid has already been referred to. The age of this is sometimes questioned, but the statements of the finder and of others who examined the spot are very definite and precise and cannot lightly be discarded, and in the absence of evidence to the contrary the formal declarations made at the time, that this iron from its position is contemporaneous with the pyramid, must stand.¹ A chemical analysis of this specimen would be of value and might differentiate it clearly from modern iron.

The next in date order are several pieces

¹ Howard Vyse. *The Pyramids of Giza*, Vol. I, 1840. See Appendix.

of a pickaxe stated to have been found at Abusir and to be of the Fifth Dynasty.¹ These are mentioned very casually and without any details of how they were found, and their authenticity has never been proved. Another specimen is a mass of iron rust from Abydos found together with copper adzes of Sixth Dynasty type, about which there can be little doubt.² An iron spearhead attributed to the Twelfth Dynasty also seems from the evidence to be of the date claimed.³ After this come part of a chisel and part of a hoe stated to be of the Seventeenth Dynasty, about which little is known,¹ a few articles from the Eighteenth Dynasty,^{4, 5} including a dagger and a ring, a sword bearing the cartouche of Seti II (Nineteenth Dynasty),⁵ a halberd, probably of the Twentieth Dynasty,² three knives of about the same date,⁶ a bracelet of the Twenty-second Dynasty⁶ and in the Twenty-fifth Dynasty a group of iron tools,⁷ after which

¹ G. Maspero. *Guide au Musée de Boulaq*, 1883.

² W. M. Flinders Petrie. *Abydos*, Part II, 1903.

³ D. Randall Maciver and C. L. Woolley. *Buhen*.

⁴ Howard Carter. *Ill. Lond. News*, 3 July, 1926.

⁵ W. M. Flinders Petrie. *Ancient Egypt*, 1915.

⁶ J. E. Quibell. *The Ramesseum*, 1898.

⁷ W. M. Flinders Petrie. *Six Temples at Thebes*, 1897.

iron becomes much more common, and at Naukratis and Defenneh, in about the Twenty-sixth Dynasty, it was as much used as bronze.¹

There can be little doubt, therefore, that iron was known in Egypt from a very early period, but that it occurred only very occasionally until some time after the Twenty-second Dynasty and before the Twenty-fifth Dynasty, which would give a date between 945 B.C. and 718 B.C. for the coming of iron into general use.

It may be mentioned, as pointed out by Hall,² that iron is not referred to in the long tribute lists of the Eighteenth Dynasty, but that the name occurs so far as is known for the first time on a stela in the temple at Abu Simbel (Nineteenth Dynasty).

Although iron minerals occur plentifully in Egypt, the production of the metal from the ore certainly did not originate in Egypt, and there is no evidence that the local ores were worked until Roman times and then only to a small extent in the eastern desert, and probably not at all in Sinai. Iron appears to have been an Asiatic discovery,

¹ W. M. Flinders Petrie. *Naukratis*, 1886; *Nebesheh and Defenneh*, 1888.

² H. R. Hall. *Man*, Vol. III, 1903.

and it was certainly known in Asia Minor about 1300 B.C., since one of the Hittite kings sent Ramses II (Nineteenth Dynasty) an iron sword and promised to send him later a shipment of iron for which he had asked.^{1, 2} At this date therefore at least one object of worked iron was imported into Egypt, and since there was a request for unworked iron the metal in its ingot condition must also have been known, and the transaction suggests that the occasional iron objects of about this period found in Egypt were rarities, some imported in the manufactured state and some made locally from small lots of imported metal. From the time of its discovery until comparatively late, both in Egypt and elsewhere, all iron was a malleable iron produced directly from the ore and containing so little carbon that it did not harden greatly when suddenly cooled. The only method of working such iron was by hammering it into shape while hot, and it was therefore termed "wrought" iron. It was only about the Seventeenth Century A.D., when furnace construction had sufficiently advanced to enable the metal

¹ J. H. Breasted. *Ancient Times*, 1916.

² D. G. Hogarth. *The Hittites of Asia Minor*, *The Cambridge Ancient History*, Vol. II, 1924.

to be heated to such a temperature that it would flow freely, that cast iron, which contains a much greater proportion of carbon than wrought iron and is scarcely malleable at all, was made, and steel is a still later discovery. It may be mentioned that cast iron melts at 1150° C. and wrought iron at 1500° C. The early wrought iron, however, either during production or during subsequent forging, never reached the temperature at which it was liquid, but merely became sufficiently soft to admit of being hammered into shape.

Lead Although never very extensively employed in ancient Egypt, lead was among the earliest metals known, and both the metal and an ore, galena, have been found in Predynastic graves. The reason for this early knowledge of lead was doubtless owing to the facts, first that lead ores occur in Egypt, and second, that the metal is very readily obtained from the ore.

The principal locality in Egypt where lead ore is found is at Gebel Rosas, a few miles inland from the Red Sea and some 70 miles south of Qosseir, but small quantities occur in other places, as at Ranga on the Red Sea coast, in the Safaga district near the Red Sea coast, and also near Aswan.

During the four years from 1912 to 1915 inclusive when the Gebel Rosas mine was worked, it produced more than 18,000 tons of ore, which is in the form of mixed carbonate and sulphide (galena) associated with carbonate of zinc.¹ This ore contains from 25 to 55 per cent. of lead, a very small proportion of silver and a trace of gold.²

There can be little doubt that all the lead and galena used in ancient Egypt until about the Eighteenth Dynasty was of local origin, and there is no evidence that it was "probably brought from Syria."³

The production of metallic lead from its ore is one of the simplest of all metallurgical operations, and consists essentially in merely roasting the ore. This, although now done in special furnaces, may be carried out, as it doubtless was in ancient times, by simply heaping the ore on top of the fuel on the ground, the fused metal, which melts at 327° C., or less than one-third the temperature required to melt gold, running out at the bottom of the heap.

¹ Mines and Quarries Dept. *Report on the Mineral Industry of Egypt*, 1922.

² Kindly communicated by the Controller, Mines and Quarries Dept.

³ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*.

Lead was used among other purposes for making small figures and statuettes, for adding to bronze, sometimes for filling bronze weights, and at a late period for bowls and vases and as a core for bronze statuettes; sulphide of lead (galena) was used as an eye paint (kohl) and a compound of lead was sometimes added to glass.

Manganese Manganese in the form of its oxides is very widely distributed in Egypt, the Nubian sandstone especially being permeated with veins of these compounds. Oxides of manganese also occur plentifully in Sinai, where they are worked at the present time on a commercial scale, as much as 77,000 tons having been extracted in one year.¹

Oxides of manganese were used by the ancient Egyptians to impart a purple colour to both glaze and glass, and they were also occasionally employed as an eye paint, but beyond this their use for any other purpose is unknown. The use of manganese compounds for colouring glass dates to the Eighteenth Dynasty, and for glaze probably much earlier.

Oxides of manganese were required in such small quantity and occur so plentifully

¹Mines and Quarries Department. *Report on the Mineral Industry of Egypt.*

in Egypt that it is most improbable there was any importation, the local supply only being used. Ancient workings have been found in one locality in the eastern desert.

Silver Silver occurs in nature generally in the combined state as ore, though it is also found in small quantities in the metallic condition, but seldom pure and usually containing small proportions of gold, copper and other metals; it also occurs in very small proportion in the ores of lead, copper, and zinc. As already mentioned, most gold, and all Egyptian gold so far as is known, contains silver, sometimes in considerable proportion. Five specimens of gold from modern Egyptian mines contained from 9.7 to 16.0 per cent. of silver, with a mean of 13.6 per cent.¹

Although silver has occasionally been found in Egyptian graves of Archaic date, it was very rare until about the Eighteenth Dynasty, when it began to be a little more plentiful, though it was not until Græco-Roman times that it became fairly common.

So far as is known silver ores do not occur in Egypt, though probably all Egyptian gold contains silver, and there is also a very

¹ A. E. Thomas. *Cairo Scientific Journal*, 1909.

small proportion in the Egyptian lead ore ¹ and in the nickel ore.²

Since apparently there was no local silver ore to be treated to obtain the metal, and since there is no evidence and very little probability that the Egyptians of Archaic times had the necessary metallurgical knowledge to enable them to separate silver from gold, much less from lead or nickel, the silver used must either have been found native in the country or must have been imported. Although silver was undoubtedly imported at a later date, it seems probable that the small quantity employed before the Eighteenth Dynasty was found in the country and that it was in fact a poor quality of gold containing a sufficiently high proportion of silver to have the appearance of silver. Such a metal would indeed be "white gold," which is the meaning of the ancient Egyptian name for silver. In support of this the analyses of the few ancient Egyptian silver articles that can be traced show them to contain from 3.2 to 14.9 per cent. of gold, though it is not known of course that the silver of the specimens analysed was of local

¹ See Lead.

² F. W. Moon. *Prelim. Geol. Rpt. on St. John's Island*, 1923.

origin. On the other hand is the fact that no gold so rich in silver as to pass for silver is known to occur in the country, though such an alloy may have existed in small quantity and may have been worked out, or may even still exist and may have escaped notice in modern times.

Silver was used occasionally in jewellery, also for vases, bowls, and other vessels, and for statuettes.

Tin Only a few objects of tin are recorded as having been found in Egypt. These are a finger ring,¹ a pilgrim bottle,² both of the Eighteenth Dynasty, and two finger rings of later date,³ and oxide of tin, the form in which tin generally occurs in nature, was employed in small amount from the Eighteenth Dynasty onwards for imparting a white opaque colour to glass.

The great value of tin in ancient times was for the manufacture of bronze, and it was probably employed for this purpose in Egypt, although, as already mentioned, there

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*.

² E. R. Ayrton, C. T. Currelly and A. E. P. Weigall. *Abydos*, Part III, 1904.

³ C. L. Woolley and D. Randall Maciver. *Karanog*, 1910.

is no direct evidence for this. Assuming bronze to have been made in Egypt, it is unknown whether tin ore or metallic tin was used for the purpose, but, if the latter, the absence of tin at an earlier date than the Eighteenth Dynasty may mean that this was the period at which bronze was first made in the country, as distinguished from being worked from imported metal already in the ingot form. In Professor Breasted's translations of the ancient Egyptian records ¹ only four references to what may be tin occur, but whether the word used means tin or not is stated to be doubtful; three of these references are from the Twentieth Dynasty and one from the Twenty-first Dynasty.

Tin ores do not occur in Egypt, and therefore any tin or tin ore used must have been imported, but from where it was procured is not known. Herodotus (484 to 425 B.C.) states ² that the tin used by the Greeks was obtained from the Cassiterides islands, which are also mentioned by Diodorus Siculus, Strabo, Pliny, and other writers, but the identity of these islands has never been satisfactorily established, and they are prob-

¹ J. H. Breasted. *Ancient Records of Egypt*.

² Herodotus, III, 115.

ably entirely mythical.¹ It would seem fairly certain, however, that in the time of Herodotus tin was procured from somewhere in the west, and that it was an important article of commerce in the eastern Mediterranean. This tin probably came from Spain, where there is evidence that the tin-bearing gravels were worked both by the Phœnicians and by the Romans. Whether the Cornish tin was exported, or even worked, at the very early period sometimes assigned to it is uncertain, and although it was known in Roman times, but probably not worked by the Romans, it was not until the Middle Ages that the Cornish mines produced any large amount of tin. The earliest mention of tin that can be traced is that by Homer (about 800 B.C.).

Tin is found in very small proportion in certain ancient Egyptian copper objects, though not in all, and it is possible therefore that it may occur in traces in Egyptian copper ores, but as no detailed analyses of these ores are available, this is uncertain. Even if this were so, however, the presence of the tin would have been unknown at the time the copper ore was first used.

¹ F. Haverfield. *Romano-British Cornwall*, London, 1924.

CHAPTER IV

MUMMIFICATION MATERIALS

It is frequently assumed that the methods and materials employed by the ancient Egyptians in preserving their dead are secrets not yet discovered. This, however, is not the case and, except for a few minor details, there is nothing about the ancient process of embalming that is not well known, better known perhaps than at the time it was practised, since the methods then were purely empirical, whereas now the underlying principles are understood.

So far as is known the ancient Egyptian records contain no mention of the methods of embalming, and the earliest descriptions are those of Herodotus,¹ who stayed in Egypt from about the autumn of 457 B.C. until about the spring of 453 B.C., and of Diodorus Siculus,² who visited the country some 400

¹ Herodotus, II, 86 to 88.

² *Bibliothecæ Hist.*, ed. P. Wesseling, Amster., 1746, XIX, 98.

years later than Herodotus, both of whom wrote accounts of what they had seen and heard, including a description of the process of mummification.

Methods of
Embalming

According to Herodotus three different methods of embalming were practised. In the first, which was the most expensive, the brain and bowels were removed, the abdomen was washed with palm wine and filled with myrrh, cassia and spices, and the body was then placed in a bath of *natrum* for seventy days, at the end of which time it was removed from the bath, washed and wrapped in linen bandages, which were fastened together with gum. In the second method, oil of cedar was injected into the body, which was then placed in the *natrum* bath. The third method, which was the cheapest and used only by the very poor, consisted in rinsing the abdomen with *syrmaea* and then soaking the body in *natrum* for the prescribed number of days.

The account given by Diodorus, though possibly based on that of Herodotus, supplies several particulars not given by him, but on the whole is not so detailed. The washing of the abdomen with palm wine and the use of a bath in which the body was

soaked are, however, both given us, also the employment of oil of cedar and myrrh, but cinnamon, which is not mentioned by Herodotus, is stated to have been used, while cassia is omitted. Possibly, however, there is a confusion of names, the same material being meant in each case.

The most important of the operations mentioned may be briefly summarized as follows :

1. The removal of the intestines. Since these contain a plentiful supply of bacteria that set up putrefaction, their removal must have been a great factor in the preservation of the body.

2. The washing of the abdomen with palm wine. What this palm wine exactly was is not known, but there can be no doubt that it was some form of alcoholic liquor, and therefore it would be a mild germicide and tend towards preservation.

3. The injection into the body of oil of cedar. The identity of this is uncertain, but it cannot have been the substance that is called by the same name to-day, which is an essential oil distilled from the bark of the red cedar, as this was not known to the ancient Egyptians.

4. The soaking in *natrum*. This is be-

lieved to have been natron and would be an effective germicide.

5. The use of odoriferous resin and spices. These would act as mild insecticides and fungicides.

In addition, there was the desiccation of the body, which, although not specifically mentioned, must have taken place and would be a large factor in preservation.

The other materials mentioned by Herodotus and Diodorus are *syrmaea*, myrrh, cassia, cinnamon, and spices. In addition to these, however, the Egyptians employed a number of other preservatives, chiefly common salt, resins of different kinds and wood pitch, and also enveloped the body in voluminous bandages, which were often impregnated with natron and resin, thus forming a large measure of protection against insect attacks from without.

Natron Natron is a natural soda occurring in several localities in Egypt, chiefly in the Wadi Natron in the western desert, but also at Harrara in the Behera province and near Edfu in Upper Egypt; it consists essentially of carbonate and bicarbonate of soda, but is often very impure, the impurities being principally common salt and sulphate of soda.¹

¹ A. Lucas. *Natural Soda in Egypt*.

Natron has been found in vases and other receptacles in tombs and also on the body and on the bandages, and there is no doubt that it was employed in mummification. A board, of Eleventh Dynasty date, on which the body was placed during the operation of embalming and which is impregnated with natron and resin, has also been found and is now in the Cairo Museum.¹

In addition to its use in mummification natron was extensively employed in ancient Egypt in the manufacture of glaze and glass.

Syrmæa This word has not been translated and its meaning is entirely unknown.

Myrrh Myrrh has been identified in the material from mummies and will be described when dealing with resin.

Cassia and Cinnamon So far as is known neither of these have been identified in ancient Egyptian mummy material.

Salt Salt (sodium chloride) is of very common occurrence in Egypt and is one of the impurities contained in natron, in which it sometimes occurs to the extent of 50 per cent., and hence in using natron the Egyptians also, though probably unconsciously, used

¹ *Bull. Met. Museum of Art, New York, Part II, 1922.*

salt, which is an excellent preservative. In early Christian times the use of natron was discontinued and salt was sometimes employed instead, not however in solution, as with natron, but in the solid state. Thus the preservative material examined from a Coptic mummy of the Fifth Century A.D. from Naga el Deir consisted of salt, and in Nubia in a cemetery of about the same date the bodies, which were in an extraordinarily good state of preservation, were packed in large quantities of salt.¹ In these cases the body cavity had not been opened, the salt being merely placed on the outside of the body, which was then wrapped in coarse cloth. None of the specimens of salt examined contained even a trace of natron, and therefore had not been obtained from the immediate neighbourhood of any natron deposit.

Resin Resins are not now among the products of Egypt, and whether they ever were produced is doubtful; they occur, however, in the countries bordering the Mediterranean and also in the Sudan, in Somaliland and in Arabia, and probably reached Egypt from all these sources.

¹ *The Arch. Survey of Nubia, Bull. No. 1, Cairo, 1908.*

The use of resin in ancient Egypt is long antecedent to the practice of mummification, and pieces of resin have frequently been found in Predynastic graves. Resin, too, is found in later graves apart altogether from the body, and was used in ancient Egypt for many purposes other than in connection with burial, its greatest use probably being as incense, but it was also employed as an adhesive, and was so used, for example, to secure the pins that held in place the lid of the sarcophagus in the second Giza pyramid.¹ In later periods it is found luting on the lids of vases and as a cement for fastening inlay in place, for which purpose it was frequently mixed with whiting. Resin was also used as varnish, two kinds being employed, one colourless or practically so, and the other black; resin was also fashioned into beads for necklaces and was even cut into scarabs and other ornaments, and a black variety was occasionally used for the pupils of the eyes in statues.

In the literature of Egyptology there are many precise statements regarding the nature of the resins used, especially in connection with mummification, but very few

¹ W. M. Flinders Petrie. *A History of Egypt*, Vol. I, 1923.

of these statements rest on the certain knowledge that can only be acquired from systematic chemical analysis and most of them are merely guesswork, the nature of these resins having been very little investigated and very few of them having been identified. This is largely due to the fact that many of them appear to be of kinds that are not only not used, but that are not even known at the present day. The only recent serious attempts to study these resinous materials, of which the results have been published, are an analysis by Professor Florence of Lyons,¹ the work of Dr. Louis Reutter² and the work of the author.³

Professor Florence, using modern methods, identified as colophony (the common resin of everyday use) a specimen of resin from the mummy of a monkey, though he was unable to specify the particular botanical

¹ Quoted by Lortet and Gaillard in *La Faune Momifiée de l'Ancienne Egypte*, Lyons, 1905.

² Louis Reutter. *De l'Embaumement Avant et Après Jésus-Christ*, Paris, 1912, and *De la Momie ou Mumia*, *Bull. Sciences Pharmacologiques*, Paris.

³ A. Lucas. *Preservative Materials Used by the Ancient Egyptians in Embalming*, Cairo, 1911; *The Use of Bitumen or Pitch by the Ancient Egyptians in Embalming*, *J. Egypt. Arch.*, 1914; *The Use of Natron by the Ancient Egyptians in Mummification*, *J. Egypt. Arch.*, 1914.

source beyond that it was a coniferous tree.

Dr. Reutter has done a considerable amount of work on resinous materials from burials in both Egypt and Carthage, and while recognizing its importance and not wishing to depreciate its value nor to impugn the accuracy of the analytical results, the author would like to suggest that the conclusions arrived at may, at least in some instances, be erroneous. The first striking fact in Reutter's results is the comparatively large number of different resins found in each specimen of material examined, thus in one sample, storax, mastic, and Aleppo resin are all positively identified, two unknown resins are stated to be present, one possibly being galbanum, while Chios turpentine and cedar resin are also thought to be probably present; in another specimen of material, storax, three different unknown resins, a gum or gum-resin and balsam of Illurin or balsam of Mecca were all found, and in a third specimen, balsam of Gunjun, and possibly balsam of Illurin or balsam of Mecca. This is quite contrary to the author's experience and, of the very large number of different resins from all periods he has examined, by far the greater number have

been homogeneous resins or gum-resins of well-defined character, and only in a comparatively few instances, excluding incense, has resinous material been a mixture and then generally with fatty matter or natron.

In most cases, Reutter, by well-known chemical means, such as solution and subsequent precipitation, separated certain bodies, of which, in order to identify them, he made an ultimate analysis, determining the carbon and hydrogen directly and estimating the oxygen by difference. When, however, the smallness of the amount of material taken for analysis (from 0.02 to 0.22 gram), which did not permit of a duplicate analysis as a check, the multiplication and division of the original figures necessitated by the calculations and the fact, to take one example, that 77.4 per cent. of carbon and 10.4 per cent. of hydrogen represent one substance, and 77.3 per cent. of carbon and 10.2 per cent. of hydrogen represent a totally different substance, one may be pardoned for thinking there is room for a mistake in identification. In several instances, too, Reutter bases a probable identification upon the smell of the substance or upon a process of exclusion, assuming that because negative results were obtained

when certain specific resins were tested for and hence were presumably absent, therefore another resin, that it was thought might have been used, was probably present.

The author has examined a very large number of resins from both graves and mummies, varying in date from Predynastic to Ptolemaic times, and has shown that these materials may be grouped in two main classes, namely, true resins and gum-resins.

True Resins Among the true resins may be mentioned :
(*a*) a very characteristic dull brown resin found in lumps in Predynastic and early Dynastic graves and which has not yet been identified ; (*b*) a resin akin to ordinary colophony from some species of pine, but which, unlike colophony, has a marked fragrant smell. One specimen of this was from an Old Kingdom grave and another from a Ptolemaic mummy ; (*c*) a reddish, almost orange-coloured, resin which gives a yellow powder when finely ground. This has been found on mummies of the Twenty-first Dynasty and has not yet been identified ; (*d*) black resins, some of which were black originally and others of which have blackened by the changes brought about by age and exposure.

Gum-Resins Of gum-resins various specimens have been examined, some of which, from royal mummies of the Eighteenth and Nineteenth Dynasties respectively and from priestesses of Ammon of the Twenty-first Dynasty, it is suggested, are myrrh. Reutter takes exception to this, but as he merely emphasizes the author's own statement that the identification is provisional and not absolute, and as the specimens resemble myrrh in many respects, the identification will be allowed to stand. Reutter found myrrh in two specimens of mummy material examined by him. Myrrh occurs in Arabia and in Somaliland, from either, or both, of which sources it may have been obtained.

Amber A resin frequently stated to have been found in ancient Egyptian graves is amber, but the greater part at least of what has been called amber is certainly not amber, though what particular resin it is cannot be stated. That amber may have been used by the ancient Egyptians at a late date is probable, and a large resin scarab in a pectoral of the Twenty-first Dynasty in the Cairo Museum is possibly amber. Amber is obtained principally from the Prussian Baltic coast and in small quantity from Sicily. It is mentioned by Homer and Hesiod, both

of whom call it *electron*, and also by Herodotus, and therefore was known to the Greeks at least about 800 B.C.

**Bitumen
and Pitch**

Diodorus Siculus, Strabo, and certain early Arab writers, state that bitumen of Judea was used by the Egyptians in embalming, though strange to say Diodorus in his description of the embalming process omits all mention of bitumen when enumerating the materials employed. Pliny, Josephus and Tacitus, who all refer to bitumen, make no mention of its use in embalming, nor does Herodotus, although he knew bitumen and mentions it on several occasions and although he describes in detail the methods and materials used in embalming. Most Egyptologists and modern writers on mummification follow the old tradition and without any evidence, save that some mummies are black, definitely state that bitumen was used. Such opinions, however, not being based on any scientific examination, need not be taken seriously. The only statements that can be traced where, as the result of chemical analysis, bitumen is said to have been found, are those of Reutter, who identified bitumen in all the specimens (about five altogether) of Egyptian mummy material he examined. Although the author

regards as likely the occasional use of bitumen about the Ptolemaic period, none had been identified as the result of chemical analysis previous to Reutter's work, and before these results can be accepted they need confirmation, since the identification is based on the fact that a tiny residue of black material obtained in the course of analysis smelled somewhat like bitumen and contained sulphur. It is true that bitumen contains sulphur, but it seems to have escaped Reutter's notice that other materials, such for example as wood pitch, which was present in two of the specimens, also contain sulphur. It seems likely too that if bitumen had been employed it would either have been alone or in large proportion in any mixture, and it appears improbable that it should have been mixed in very small quantity with substances like resins and wood pitch, and yet Reutter identifies them all in the same specimen of material. Reutter also found what he identifies as bitumen in eight specimens of ancient Egyptian perfumes,¹ though it seems a most unlikely material to have been used for such a purpose.

¹ L. Reutter. *Analyses des Parfums Egyptiens, Annales du Service des Antiq. de l'Egypte*, Vol. XIII, 1914.

The author, who has made an extensive search for bitumen in Egyptian mummy material of all ages and always with negative results, has no doubt that it was never used until at the very earliest Ptolemaic times when possibly it may have been employed, though no reliable evidence for its use even then has yet been established.

Wood Pitch This has been mentioned as having been found in mummy material, and in the cases examined by the author, who was the first to draw attention to its occurrence, the mummies were of Ptolemaic date. As the name implies this material is an artificial product from wood; it is obtained during the process of charcoal-making. Although black and very similar to bitumen and mineral pitch in appearance it differs from them considerably both in composition and properties.

Beeswax This was sometimes employed to close the mouth, nose, eyes, and embalming incision of mummies, and will be dealt with in connection with oils and fats.

Gum According to Herodotus gum was used to fasten together the linen wrappings on mummies, and the author has identified it on such bandages; it occurs to a limited extent in

Egypt, but plentifully in the Sudan, being obtained from various species of acacia, whence its name of gum acacia or gum arabic.

Bandages These were invariably of linen, which will be described in connection with textile fabrics.

CHAPTER V

OILS, FATS AND WAXES

Although fatty matter has frequently been found in Egyptian tombs, it has seldom been analysed, and of the few analyses of which any record can be traced none is conclusive. This inconclusiveness is almost inevitable as all oils and fats, unless kept under special air-tight and sterile conditions, which is not the case when placed in jars in tombs, sooner or later decompose, and as some of the bodies formed escape, either by evaporation or by soaking into the material of the containing vessel, all that the analyst has for examination, although still looking and feeling like a fat, is merely a portion of the products of decomposition, consisting of a mixture of certain bodies termed "fatty acids," and it is only by the separation, purification and identification of these and by a determination of the proportion in which each occurs in the mixture that the nature of the original oil or fat can be known,

and since what remains is generally only a part of that formed, and not necessarily a representative part, the problem may often be insoluble.

The only analyses of fatty material from Egyptian tombs that can be found are the following :

1. A specimen of very early date, which from the archæological evidence must originally have been more or less solid and not liquid, and hence a fat and not an oil. When found the material had a strong smell like rancid coconut oil and consisted essentially of a mixture of palmitic and stearic acids. No suggestion was made by the analyst as to the probable nature of the original substance ; but it was subsequently assumed by others that the presence of palmitic acid indicated palm oil or coconut oil, and the archæologist stated that "It is obvious that we have to do with an imported product. . . ."¹ Any such inference, however, is totally unwarranted, since although palmitic acid is the characteristic constituent of palm oil, it also occurs in the combined state in most animal and vegetable oils and fats. In the same way the smell of coconut oil,

¹ W. M. Flinders Petrie and J. E. Quibell. *Nagada and Ballas*, London, 1896.

or rather of rancid coconut oil, which is what the smell really is and which has frequently been noted in these ancient fats,¹ is no proof that the original material was coconut oil or contained coconut oil, since the smell is merely the evidence of the presence of a particular product or products of decomposition.

2. Three specimens examined by C. Friedel, who found two to consist largely of palmitic acid, in consequence of which he suggested they had been palm oil, the third being largely stearic acid, which it was suggested had been beef fat or mutton fat.²

3. A specimen of fatty material from a jar found in the tomb of Yuua and Thuiu and a specimen of fatty material from the axle of the chariot found in the same tomb, both of which were examined by the author.³ In each case the amount of material supplied, a few grams of one and considerably less than one gram of the other, was much too small for a complete examination. It was suggested in the report that the first

¹ G. A. Wainwright and T. Whittemore. *Balabish*, London, 1920.

² E. Amélineau. *Fouilles d'Abydos*, 1895-96.

³ J. E. Quibell. *The Tomb of Yuua and Thuiu*, Cairo, 1908.

had been castor oil and the second possibly an animal fat, but it is now recognized that the evidence was not sufficient for identification, especially in the second case.

4. A specimen of fatty material from the surface of some pottery figures of Ptolemaic date examined in the author's laboratory,¹ which was found to consist of calcium butyrate, but no explanation of its presence can be suggested. Butyric acid, however, from which the calcium butyrate had been formed, is the characteristic acid of butter fat.

5. A large number of specimens of fatty matter occurring as white efflorescent crystals on the surface of mummies, examined by the author. In some few cases these crystals were common salt, but in most instances they consisted of fatty acids, frequently almost pure palmitic acid, though occasionally stearic acid and oleic acid were also found, all being probably derived from the decomposition of the body fat. In some instances material from mummies has been noticed to smell of rancid coconut oil and in other instances of rancid butter, the latter indicating the presence of butyric acid.

¹ By Mr. J. Clifford, F.I.C. *Annales du Service des Antiq. de l'Egypte*, 1917.

6. A specimen examined for Wilkinson¹ by Dr. Ure, who thought it was "of the nature of a fixed fat" with probably a mixture of resin.

The oils and fats that were known in ancient Egypt included certainly animal fats, butter fat, castor oil, and probably olive oil, linseed oil, sesame oil, safflower oil, and others. Mineral oil, although it occurs on the Red Sea coast, was probably unknown until Roman times, and then only known from the small quantity that exuded from the ground or floated on the sea. The only wax of which there is any evidence is beeswax. These materials will now be considered.

**Animal Fats
and Butter
Fat**

Since the ancient Egyptians were an agricultural people having cows, sheep, and goats, it is almost impossible that they should not have been acquainted with animal fats including butter fat, which latter is made by melting butter and allowing the melted fat to stand until the water and casein settle out when the fat is poured off, and it is this that constitutes the modern Egyptian *samn* and the Indian *ghi*. Butter fat is largely used in the East for cooking and edible

¹ Sir J. G. Wilkinson. *Manners and Customs of the Ancient Egyptians*, Vol. II, 1878.

purposes, but is not spread upon bread like butter.

Castor
Oil

The castor-oil plant grows wild in Egypt and has probably done so from a very early period; the oil was well known anciently and there is a certain amount of evidence for it having been found in tombs; a few seeds have also been found and identified. Pliny states that the castor-oil plant grew abundantly in Egypt in his day, and both Herodotus¹ and Strabo¹ mention the use of the oil for burning, and the latter refers to its use by the poorer classes for anointing the body, for which purpose, as also for dressing the hair, it is used in Nubia at the present day.

Olive
Oil

Since the olive tree was known in ancient Egypt, as is proved by the finding of twigs, leaves and stones in tombs, it is highly probable that the oil was also known; it was certainly known in Pliny's time, since he states that the olives of Egypt are very fleshy, but have little oil.¹ Strabo also refers to Egyptian olive oil.¹

Linseed
Oil

Flax was extensively grown in Egypt from very early times for the making of linen, and

¹ Sir J. G. Wilkinson. *Manners and Customs of the Ancient Egyptians*, Vol. II, 1878.

probably therefore linseed oil, which is the oil extracted from the seeds of the flax plant, was also known, though if so it was only as an edible and cooking oil, for which purpose it is used to some extent by the poorer classes in Egypt to-day; its use as a paint oil, however, was not known.

**Sesame
Oil**

The sesame plant is grown plentifully in Egypt at the present day for the sake of the oil, as also was the case in Pliny's time,¹ and it seems likely that it was grown for the same purpose in ancient Egypt.

**Safflower
Oil**

This is obtained from the seeds of the *Carthamus tinctorius*, a plant which not only still grows in Egypt, but which was certainly grown in ancient times, since a yellow dye obtained from it has been identified on fabrics, and probably therefore the oil was also known; this oil is still used for cooking and is much esteemed as being a bland, agreeable oil.

Beeswax

Beeswax was extensively employed in ancient Egypt, for example in mummification for closing the eyes, nose, mouth, and the embalming incision in the side, and also as an adhesive for luting on the covers of vases

¹Sir J. G. Wilkinson. *Manners and Customs of the Ancient Egyptians*, Vol. II, 1878.

and for many other purposes. It was also occasionally used for covering painted surfaces, as in certain Theban tombs of about the beginning of the Eighteenth Dynasty¹ and in Ptolemaic and Roman times for painting portraits by the encaustic process. A large number of specimens of ancient beeswax have been examined by the author, and although somewhat dry and friable none had undergone any considerable change. The melting-point in eleven instances in which it was determined varied from 64° C. to 70° C., ordinary modern commercial beeswax melting at about 63° C.

Use of Oils
and Fats

The use of oils and fats in ancient Egypt must have been much the same as to-day, namely, for edible purposes, cooking, lubrication and illumination, and in addition for anointing and libation.

The method of illumination practised, especially during the cutting, carving and painting of rock-tombs (some of which in the Valley of the Tombs of the Kings are more than 300 feet long and have a considerable vertical depth, in one case more than 70 feet, with side chambers at the far end), has given rise to considerable speculation, and it is frequently suggested that large mirrors

¹ E. Mackay. *Ancient Egypt*, 1920.

were employed whereby sunlight could be reflected from outside. This seems most improbable, as the only mirrors likely to have been used were those of polished copper or bronze, which at the best would only give a very poor result which would rapidly diminish with the repeated reflections necessary to reach the far end of a long tomb, and even this dim light would be partly intercepted by scaffolding and workmen. It should not be forgotten, too, that the entrances to some of the tombs are situated in narrow parts of a valley with high cliffs on both sides, and hence that a reflection of sunlight could only have been obtained at certain times of the year and at certain hours of the day, and it seems unlikely that any system of such partial utility would have been employed.

Torches are out of the question on account of the smoke produced, and it is suggested that a very large number of lamps were used, each consisting of a small open vessel filled with oil, or possibly with water having a film of oil on the surface, and provided with a floating wick. Such lamps could have been carried by children and would have afforded sufficient light to men habituated to working in semi-darkness and would have

been free from smoke. Lamps of this kind are very common in the East and take the place of the candle of colder climates. That the principle of a wick floating in oil was known at least in the time of Herodotus (484 to 425 B.C.) is proved by his description of such lamps; ¹ the salt mentioned by this writer as being mixed with the oil would tend to prevent the lamp from smoking. At the present day Egyptian workmen may be seen doing fairly delicate work in the Cairo bazaars, especially in the gold bazaar, in corners and semi-darkness in which a European would find it impossible to work, and it is not unlikely that in ancient Egypt men were also accustomed to work with very little light. It should not be forgotten, too, that the colour schemes of the tombs were stereotyped, that the pigments were few in number and that no matching of delicate shades was required.

¹ Herodotus II, 62.

CHAPTER VI
PIGMENTS AND VARNISH

PIGMENTS

The freshness and brightness of the colours of the old Egyptian tomb paintings have often been commented upon, and it is sometimes suggested that the pigments employed were such as do not exist at the present day, and even that their nature is unknown. This, however, is not the case, as they have frequently been analysed, and most of them are naturally occurring minerals that may still be found in Egypt.

White The white pigment is generally whiting (carbonate of lime), but sometimes gypsum (sulphate of lime), both of which occur plentifully in the country.

Grey The grey pigment is a mixture of white and black.

Red The red pigment has been variously stated to be hæmatite, red ochre, and burned yellow

ochre, all of which owe their colour to oxide of iron. Between hæmatite and red ochre there is very little real difference, except in the form in which they occur, red ochre being merely a soft variety of hæmatite containing a little clayey matter, and although powdered hæmatite may occasionally have been employed, it was naturally occurring red ochre that, in the author's opinion, was generally used. A good quality ochre of a deep-red shade is found in at least two localities in Egypt, namely, near Aswan and in the Oases of the western desert. Yellow ochre also occurs in the same places and if calcined will produce red ochre, and this was the usual method of making red ochre in Europe before the modern methods of production from various by-products were introduced. This method, however, is only likely to have been employed in Egypt in those places where the yellow and not the red variety occurred.

A few instances are recorded in which yellow ochre on a wall painting has changed to red owing to the heat produced by incendiaryism in a tomb.¹ A pink colour from

¹ N. de Garis Davies. *The Tomb of Puyembrê at Thebes*, Part I, 1922.

a tomb painting of the Græco-Roman period was identified by Russell as madder on a base of gypsum,¹ and a similar shade of colour, probably having the same composition, is sometimes seen on coffins of this date. This pigment was in common use by the Romans in Italy, and specimens of it may be seen in the Naples Museum. Another red of Græco-Roman date identified by Russell was red lead.¹

Blue The blue pigment of the ancient Egyptians was of several kinds, the earliest of which any analyses are recorded being, as is only to be expected, a naturally occurring blue compound, namely azurite (chessylite), a basic carbonate of copper that is found native both in the eastern desert and in Sinai. This was employed in the Fourth Dynasty.² Toch found the blue pigment in the tomb of Perneb (Fifth Dynasty), now in New York, to be a cobalt compound,³ and Hofmann is stated to have found cobalt in a pigment of the time of Ramses III (Twentieth

¹ W. T. Russell. In *Medum*, by W. M. Flinders Petrie, 1892.

² F. C. J. Spurrell. In *Medum*, by W. M. Flinders Petrie, 1892.

³ M. Toch. *J. Ind. and Eng. Chem.*, 1918.

Dynasty),¹ but these are the only two instances of the use of cobalt for this purpose that can be traced. The principal blue pigment of ancient Egypt, from at least the Eleventh Dynasty onwards, was an artificial frit consisting of a definite crystalline compound of silica, copper, and lime. This, like glass, was doubtless an outcome of glaze, and if heated too strongly it would fuse and become glass; it was made by heating a mixture of silica, carbonate of lime, a copper compound and alkali. Flinders Petrie shows that in at least one place the silica used was in the form of broken quartz pebbles, this material being employed on account of its freedom from iron, which if present in more than traces would have given a green colour instead of blue.² The carbonate of lime was doubtless powdered limestone, and it is this that Flinders Petrie refers to as lime. The copper compound is likely to have been malachite, the green basic carbonate of copper that was so well known, and the alkali was probably natron, the natural soda from the Wadi Natron. In the original account of the discovery of

¹ A. Wiedemann. *Proc. Soc. Bib. Arch.*, Vol. XV, 1892-3.

² W. M. Flinders Petrie. *Tell el Amarna*, 1894.

this frit factory the alkali is merely called alkali, there being nothing to show whether it was soda or potash, but in a later account it is referred to incorrectly as potash.¹ Since soda occurs naturally in Egypt, whereas potash would have to be specially prepared from wood or plant ashes, it seems more probable that soda was used. Vitruvius states² that this blue frit was made by fusing together sand, copper and soda, and several specimens analysed by the author contained soda, but not potash. This material was in common use as a pigment by the Romans, and specimens may be seen in the Naples Museum.

The composition of this frit has been investigated by many chemists, beginning with Sir Humphry Davy in 1815,³ but especially by Dr. W. T. Russell,⁴ who made specimens in various shades of colour, and more recently by Laurie, McLintock and Miles, who repeated and extended Russell's work.⁵ The author has recently examined

¹ W. M. Flinders Petrie. *The Arts and Crafts of Ancient Egypt*, 1910.

² A. P. Laurie. *Materials of the Painters' Craft*.

³ *Phil. Trans.*, 1815.

⁴ W. T. Russell. In *Medum*, by W. M. Flinders Petrie, 1892.

⁵ *Proc. Roy. Soc.*, Series A, Vol. 89, 1914.

a number of specimens of this frit, two of the Eighteenth Dynasty, one of about the Nineteenth Dynasty,¹ and the others undated. One was in the condition of a coarse powder and the others in friable lumps, of which one was of much finer texture and lighter in colour than the rest. When examined microscopically all were seen to consist of beautiful blue crystals with, in some cases, a small admixture of colourless crystals. This material, although frequently called glass, is not glass, but a frit, the temperature at which it was made not having been sufficiently high to result in complete fusion. For use as a pigment the frit was necessarily powdered, but not too finely, as the finer the powder the lighter the shade of blue, owing to the well-known effect of the reflection of white light from the fine particles produced. The composition found on chemical analysis agrees generally with the results previously recorded for this material.

The date when this frit was first made is not certain, but Laurie has identified it in a specimen of blue paint of the Eleventh Dynasty,² and a similar material, probably

¹ Kindly supplied by Dr. Howard Carter.

² A. P. Laurie. *The Materials of the Painters' Craft*.

of Egyptian origin, dating from about 1500 B.C. has been found at Knossos in Crete.¹ The author has found this same frit in five specimens of paint of the Eighteenth Dynasty, in two from the Nineteenth Dynasty and in one from a period between the Twentieth and Twenty-sixth Dynasties.²

In addition to its use as a pigment this frit was occasionally carved into small objects, such as large scarabs and the small model of a sphinx of the Nineteenth Dynasty in the Cairo Museum.

It is sometimes stated that powdered lapis lazuli, and even powdered turquoise, were employed as pigments in ancient Egypt, but there is no evidence whatever for the use of either, and considerable probability that they were not employed. It is true that an excellent and permanent blue pigment, ultramarine, may be obtained from lapis lazuli by a process of levigating the finely powdered material, but the yield is very low, being only about 2 per cent., and there is no proof that this was known until about the beginning of the Eleventh Century

¹ Noel Heaton. *Papers of the Soc. of Mural Decorators and Painters in Tempera.*

² Several of these were kindly supplied by Mr. H. E. Winlock of the Met. Mus. of Art, New York.

A.D. ; although ultramarine is still used by artists and others, the greater part of that now sold is an artificial product first made in the early part of the Nineteenth Century. Lapis lazuli merely powdered would give a very poor colour. Turquoise, even of good quality and uniform colour, would also make a poor pigment, and even if it could have been obtained in the quantity required it would have been much too precious for use on the large scale needed for tomb painting. The colour of powdered turquoise, too, would be very much lighter than the blue used.

Green It is generally accepted that the green pigment of the ancient Egyptians owes its colour to copper, and two different materials coloured by copper were used, one being powdered malachite and the other an artificial frit analogous to the blue frit just described. Until the discovery of this latter, malachite was the best green colour available ; and it was early used for painting round the eyes, and from this to its use as an ordinary pigment is but a small step. Spurrell records its use in tomb paintings of the Fourth Dynasty at Medum.¹ Two specimens of green pigment from the

¹In *Medum*, by W. M. Flinders Petrie.

Eighteenth, one from the Nineteenth Dynasty and two dating from between the Twentieth and the Twenty-sixth Dynasties examined by the author were all artificial frits,¹ and Laurie mentions a green pigment, undated, which was also a frit.²

Yellow Two shades of yellow paint were employed by the ancient Egyptians, one a dull-brown and the other a bright canary colour. The former has frequently been analysed and is generally accepted as being a natural yellow ochre, the colouring matter of which is due to hydrated oxide of iron; a dull yellow pigment on some fragments of painted coffins dating from between the Twentieth and Twenty-sixth Dynasties examined consisted of yellow ochre in every case.¹

Only a few references to the composition of the bright yellow pigment can be traced. These are a statement by Maspero that orpiment was used as a yellow paint,³ a statement by Flinders Petrie that orpiment was used at Tell el Amarna,⁴ and a statement

¹ Kindly supplied by Mr. H. E. Winlock of the Met. Mus. of Art, New York.

² A. P. Laurie. *The Materials of the Painters' Craft*.

³ G. Maspero. *L'Archéologie Egyptienne*, Paris, 1907.

⁴ *Tell el Amarna*.

by Mackay that orpiment was used as a paint in the Theban necropolis.¹ The author has examined two specimens of bright yellow pigment from the Eighteenth Dynasty that proved to be orpiment, and in the tomb of Siptah in the Valley of the Tombs of the Kings there is a bright yellow pigment on the walls that looks like orpiment, but which is not available for analysis. At one time orpiment, originally the naturally occurring mineral and afterwards an artificial product, was largely employed as a pigment in Europe, but its use was discontinued on account of the very poisonous properties of the artificial material. The natural mineral, however, is not poisonous, and it must have been this that was used in ancient Egypt, since the imitation material was not then known. As orpiment does not occur in Egypt, it must have been imported, and possibly from Asia Minor, where it is found naturally.

Black The ordinary black colour used as a pigment was undoubtedly carbon in some form, but apparently not always in the same form, as sometimes it is very finely divided and in other cases much coarser. The former is soot, while the latter has been stated by

¹ E. Mackay. *Ancient Egypt*, 1920.

some to be charcoal and by others to be bone charcoal or ivory charcoal. Several specimens examined by the author were neither bone charcoal nor ivory charcoal, which latter in any case is most unlikely, but probably wood charcoal. Another possibility, however, is that this coarse material may sometimes be soot that has been carelessly collected and so has become contaminated with various impurities. Laurie found a black pigment of the Nineteenth Dynasty to be powdered charcoal.¹

Kohl In this connection the pigment employed for painting round the eyes, and which has been already mentioned several times, may be described. This kohl, as it is termed, is of two colours, green and black. Its composition has been investigated on various occasions, especially by Wiedemann² and by Florence and Loret,³ and a few specimens have been examined by the author and altogether the results of the analysis of about fifty specimens have been recorded. The green colour, the use of which dates back

¹ *The Materials of the Painters' Craft.*

² A. Wiedemann. In *Medum*, by W. M. Flinders Petrie.

³ A. Florence and V. Loret. In *Fouilles à Dahchour*, J. de Morgan, 1895.

to Predynastic times, generally consists of malachite, though one specimen from Dashur and probably of the Twelfth Dynasty is stated to be chrysocolla,¹ a natural silicate of copper that occurs in Egypt. In a very large proportion of cases the black pigment consists of powdered galena (sulphide of lead), in two instances containing as an impurity a trace of sulphide of antimony, though occasionally other substances were employed, among which were sulphide of antimony (only found on one occasion), oxide of manganese, oxide of copper and clay coloured with black oxide of iron.

A black material employed from about the Eighteenth Dynasty for coating certain wooden funerary objects and frequently called a paint is not paint, but varnish, and will be described later.

**Paint
Vehicles**

Much discussion has taken place as to the nature of the paint vehicles employed by the ancient Egyptians. The colours used, which have been just described, were ordinary well-known materials, but in what manner were they applied? They could not have been used in the dry state as they would not have adhered and must therefore have been mixed with some vehicle. In modern

¹ *Ibid.*

practice this is usually boiled linseed oil and turpentine, but in ancient Egypt there is no evidence of the use of oil even as late as Græco-Roman times, when the vehicle was wax, the encaustic process of painting being employed. Turpentine, too, that is to say the distilled product ordinarily called spirits of turpentine, was also unknown, and it is believed that the process of distillation had not then been discovered.

Since water is used so largely to-day for distemper, this medium naturally suggests itself as the probable vehicle, and Russell states ¹ that a certain red oxide of iron pigment from Medum could be used without the addition of any other medium than water and that it adhered to paper, to wood and to the fingers with wonderful pertinacity. This, however, would not be the case with such a pigment as the coarse blue frit and some binding material would be necessary, and in modern distemper size is used. Gum, glue, white of egg and milk have all been suggested and all these materials were well known. Laurie found gum in one specimen of paint examined.² Toch found glue or gelatine, which, however, may have

¹ In *Medum*, by W. M. Flinders Petrie.

² *The Materials of the Painters' Craft*.

been from the size with which the ground was prepared before painting and not from the paint, but could not find any evidence of white of egg.¹ Spurrell suggests that white of egg was present in one specimen of paint examined,² but his reason for thinking so, namely, its resistance to the action of water, cannot be accepted as conclusive. In any case, if white of egg were ever used it is only likely to have been at a late period, since the domestic fowl, and therefore also the egg, now so plentiful in Egypt as to form a considerable item of export, is not indigenous to the country, but a foreign importation of a comparatively late date.

In this connection it may be stated that the Egyptian wall-painting is never a fresco, using the term in its true sense of meaning painting executed on a damp surface made caustic with lime and without any other medium than water, but is always a tempera painting on gypsum plaster. Lime was not known until about Roman times and also true fresco work could not easily be carried out in a hot, dry climate such as that of Egypt.

The Egyptian painting on wood is rarely directly on the wood itself, though this is

¹ *J. Ind. and Eng. Chem.*, 1918.

² *Medum*, by W. M. Flinders Petrie.

occasionally the case, but is generally on a thin plaster coating with which the wood was faced, the plaster employed being a mixture of whiting and glue, termed gesso. This is an Italian word meaning gypsum plaster (i.e. plaster of Paris) or sometimes a mixture of plaster of Paris and glue, but by Egyptologists it is always applied to whiting and glue and not to gypsum, and since no better name can be suggested it would be well to confine it in Egyptology to its established use. Another term sometimes used for gesso is stucco, which is very ambiguous and may mean any kind of plaster. Gesso is sometimes found directly on the wood and at other times on a surface of coarse canvas-like linen glued to the wood.

VARNISH.

Varnish in appearance very like modern varnish was largely employed in ancient Egypt chiefly to cover painting on wood, though occasionally over tomb paintings on plaster, as for example in a number of tombs in the Theban necropolis, chiefly of the Eighteenth Dynasty.^{1, 2} The use of varnish

¹ E. Mackay. *Ancient Egypt*, 1920.

² N. de Garis Davies. *The Tomb of Nakht at Thebes*, 1917.

dates principally from the Eighteenth Dynasty onwards, though possibly there may be examples of its use in the Middle Kingdom, and even occasional examples in the Old Kingdom, in both cases on wooden funerary models. This, however, although glossy and having the appearance of a thin film of resin varnish, has not been examined chemically and might be gum, glue, or other material. Several specimens of old Egyptian varnish have been examined by the author, one from the Eighteenth Dynasty, and others from the period between the Twentieth and Twenty-sixth Dynasties¹ and all were very much alike and consisted of resin. Crow² and Laurie³ both record similar results. The base therefore of the old Egyptian varnish, as in modern varnish, was resin, but before resin can be applied as a coating to any surface it must be in a more or less liquid state, and in the present-day varnishes the resin is dissolved in boiled linseed oil, turpentine or alcohol. These materials, however, were all unknown in

¹ Kindly supplied by Mr. H. E. Winlock of the Met. Mus. of Art, New York.

² J. K. Crow. *Annales du Service des Antiq. de l'Egypte*, Tome IV, Le Caire.

³ *Materials of the Painters' Craft*,

ancient Egypt and no other solvent can be suggested. The ancient varnish, too, shows no evidence whatever of oil having been used in its preparation, and it is insoluble in turpentine, though readily soluble in alcohol. Spurrell mentions strong wine as a possible solvent,¹ but the author has made several experiments to test the efficacy of this and finds that even in the strongest wine resin is not sufficiently soluble to produce a varnish. The alternative therefore seems to be a resin that did not require an extraneous solvent, which means a naturally occurring resin already liquid. Such resins do exist and are termed oleo-resins, the solvent being a natural volatile oil that gradually evaporates on exposure. These oleo-resins, however, although nominally liquid, are at best of a thick syrupy consistency, too viscous to admit of application as a thin coating, though this viscosity is reduced by warming, which if too prolonged, would evaporate off the oil and solidify the resin. A natural oleo-resin applied warm therefore seems a possible explanation, but it is a matter that might be put to a practical test. Another suggestion that has been made is that the resin

¹ In *Medum*, by W. M. Flinders Petrie.

was applied in a finely powdered condition and was then liquefied by means of heat, but this does not appear very feasible. In some cases the varnish is in the condition of a thin uniform coating, but in many cases it has been applied very badly and there are places where the layer is much too thick.

There can be no doubt that this varnish, which is now always yellow where the coating is thin and reddish where the coating is thick, was originally colourless or practically so, since there are a number of instances where a white-painted surface, which is partly varnished and partly unvarnished, is now yellow or red in the former case and remains white in the latter and the edges of the varnished portion are very irregular and unsightly. This can only be explained on the assumption that when the varnish was applied it was colourless and did not show, or, as aptly expressed, "The original transparency of the varnish is proved by the carelessness with which it was applied."¹

Black A black varnish on funerary objects has already been mentioned. This, which appears to date from about the Eighteenth

¹ N. de Garis Davies. *The Tomb of Nakht at Thebes.*

Dynasty, is a black coating, generally lustrous, though occasionally dull, on such objects as wooden statues, coffins, boxes and models of animals and birds, and as these were originally and intentionally black, the resin cannot have blackened with age, as resins sometimes do, and therefore a naturally black resin must be postulated.

A few such resins are known: thus there is a black dammar, the resin from *Canarium strictum*, which grows in western and southern India and which would be a suitable material for making varnish. Natural black varnishes that require no preparation are also known, such as the resin from *Rhus vernicifera* (Japan and China), the resin from *Melanorrhœa usitata* (Cochin-China and Cambodia), the resin from a species of *Melanorrhœa* (China) and the resin from *Melanorrhœa laccifera* (Indo-China), all of which when fresh are greyish-white viscous liquids, which on exposure in thin films dry to hard, black, lustrous surfaces and are used as lacquers, and it seems probable that something of this kind may have been employed.

In place of varnish, beeswax was occasionally employed for covering painted surfaces as in certain tombs of the early Eighteenth

Dynasty at Thebes. This has been recorded by Mackay,¹ Flinders Petrie,² and Davies.³

¹ E. Mackay. *Ancient Egypt*, 1920.

² W. M. Flinders Petrie. *Ancient Egypt*, 1920.

³ N. de Garis Davies. *The Tomb of Puyembré at Thebes*, Vol. I, 1922.

CHAPTER VII

PRECIOUS AND SEMI-PRECIOUS STONES

The stones used in ancient Egypt for jewellery, amulets, beads, scarabs, and other ornaments, although doubtless very costly and highly prized at the time, are not such as nowadays would be called precious, but at the most semi-precious and often not even that. Many of the same kinds of stones were also employed as inlay for the decoration of furniture, boxes, coffins, and other objects. The more important stones were agate, amethyst, beryl, calcite, carnelian, chalcedony, felspar, garnet, hæmatite, Iceland spar, jasper, lapis lazuli, onyx, pearl, peridot, quartz, rock crystal, sardonyx, and turquoise. The diamond, ruby and sapphire were not known to the ancient Egyptians.

Precious stones are frequently mentioned in the ancient records as being employed for particular purposes and as being received as tribute or taken among the spoils of war,

and occasionally certain stones are referred to individually by name. Many of these names have not yet been translated, but even when this has been done one may perhaps be pardoned for thinking that possibly the translation may not always be correct, and this source of information therefore will be disregarded.

The various stones enumerated will now be described, but before this is done, they may usefully be classified, first, according to colour, and second, according to composition.

Colour White or Colourless: Calcite, Chalcedony, Iceland Spar, Quartz, Pearl, Rock Crystal.

Red: Carnelian, Garnet, Jasper.

Yellow: Jasper.

Green: Beryl, Felspar, Jasper, Peridot.

Blue: Lapis Lazuli, Turquoise.

Black: Hæmatite, Jasper.

Variegated: Agate, Onyx, Sardonyx.

Composition Aluminium Phosphate: Turquoise.

Iron Oxide: Hæmatite.

Lime, Carbonate of: Calcite, Iceland Spar, Pearl.

Silica: Agate, Amethyst, Carnelian, Chalcedony, Jasper, Onyx, Quartz, Rock Crystal, Sardonyx.

Silicates :

(a) Aluminium Beryllium Silicate : Beryl.

(b) Aluminium Iron Silicate : Garnet.

(c) Aluminium Potassium Silicate : Felspar.

(d) Aluminium Sodium Silicate associated with Sulphide of Sodium : Lapis Lazuli.

(e) Iron Magnesium Silicate : Peridot.

Some of these stones were employed in Predynastic times, while others only came into use at a very late period and most of them were local products.

Agate, Onyx
and Sardonyx

These are all banded forms of chalcedony and consist of silica,¹ the difference between them being in the colour of the bands. In agate the bands are generally white and brown with often a little blue; in onyx the bands are milk-white alternating with black, and in sardonyx white alternating with reddish brown or red. All three varieties were used for beads and in jewellery. Their use dates back to Archaic times, but they were more extensively employed at a late date, for example during the Twentieth, Twenty-second and Twenty-sixth Dynasties, and especially during the Græco-Roman

¹ When silica is mentioned as distinct from quartz this means that the material, although of the same composition as quartz, is not crystalline.

period, agate being termed by one writer "essentially a classical stone."¹ The greater proportion of the agate and onyx sold at the present time is artificially coloured. Agate has been found at Wadi Abu Gerida in the eastern desert of Egypt,² but is also of common occurrence in other localities; onyx and sardonyx also occur in Egypt.

Amethyst Amethyst consists of quartz coloured by means of a trace of a manganese compound. It was largely used in ancient Egypt in the form of beads for necklaces, but was also occasionally cut into scarabs; its use dates back certainly to the First Dynasty, of which period there are bracelets (from Abydos) containing amethyst beads, and it was much employed in the Twelfth Dynasty and occasionally during the Empire.

Amethyst workings of ancient date exist near Gebel Abu Diyeiba in the Safaga district of the eastern desert, the stones occurring in crystalline form in cavities in a red granite.

Beryl A considerable amount of confusion exists

¹ G. A. Wainwright. *Annales du Service des Antiq. de l'Egypte*, T. XXV, 1925.

² T. Barron and W. F. Hume. *Top. and Geol. of the Eastern Desert of Egypt. Central Portion*, Cairo, 1902.

concerning beryl and emerald. These are not two distinct kind of stones as is often supposed, but merely different varieties of the same mineral, and both occur in hexagonal-shaped crystals and both have the same composition, being double silicates of beryllium and aluminium, the only difference between them being one of quality, the deeper-coloured and more transparent variety being termed emerald and the lighter-coloured stones and those that are opaque being called beryl. There is, however, no hard and fast line of demarcation between the two and strictly both are beryl, but if the distinction mentioned be accepted then the Egyptian stone is beryl and not emerald, since it is generally of a poor, pale, whitish-green colour with many flaws and sometimes opaque.

Beryl occurs in the Sikait-Zubara region of the Red Sea hills, where there are extensive old workings, largely of the Ptolemaic period. These mines are mentioned by Strabo and Pliny and are sometimes called the Cleopatra Emerald Mines. Several attempts have been made to re-open the mines in modern times, all of which have proved commercial failures. Beryl, however, was apparently employed at least occasionally

as far back as Archaic times, as some beads found in Predynastic graves in Nubia are stated to be of this material.¹

The stones in the Dashur jewellery, called emerald and Egyptian emerald when first described, are green felspar.²

Calcite, Iceland Spar

Calcite is the same material as alabaster; in thin plates it is translucent, and in this form it was employed in the Eighteenth Dynasty as inlay for furniture and other objects.³ A very pure and quite transparent variety, termed Iceland spar, was occasionally used for small objects, and a cylinder seal of this spar of the Sixth Dynasty is known.⁴ The transparent cover of the small "ox" pendant from Dashur, now in the Cairo Museum, however, is not of Iceland spar (*spath*) as stated by the finder,² but of rock crystal. All varieties of calcite occur in Egypt in the eastern desert, and all are much softer than glass and may easily be scratched with a knife.

Chalcedony

Chalcedony is a form of silica, translucent and somewhat waxy in appearance and

¹ C. M. Firth. *The Arch. Survey of Nubia. Rpt. for 1909-10*, Cairo, 1915.

² J. de Morgan. *Fouilles à Dahchour*.

³ Carter and Mace. *The Tomb of Tut-ankh-Amen*.

⁴ H. R. Hall. *Cat. of Egyptian Scarabs*, 1913.

when pure is white or greyish-white in colour with often a slight bluish tint ; it may, however, be of almost any colour owing to the presence of small amounts of impurities, many of the coloured varieties having special names. Chalcedony occurs in Wadi Saga and in Wadi Abu Gerida in the eastern desert,¹ also in the Baharia Oasis of the western desert and in the Fayum province. It was occasionally employed in ancient Egypt for beads and scarabs, the former of which date back to Archaic times.²

**Carnelian
Sard**

Carnelian is simply red chalcedony, the colour being due to the presence of a very small amount of oxide of iron ; it was much used in ancient Egypt to make beads for necklaces, also for amulets and other small objects, as well as for inlay in jewellery and furniture, its use dating back to Archaic times. The name sard is applied to the darker varieties of carnelian, some of which are almost black. An imitation carnelian, consisting of transparent quartz set in a red cement, was used in the Eighteenth Dynasty as inlay, for example on the coffins of Yuua

¹ T. Barron and W. F. Hume. *Top. and Geol. of the Eastern Desert of Egypt.*

² C. M. Firth. *The Arch. Survey of Nubia. Rpt. for 1909-10.*

and of Akhenaten respectively. Carnelian is found plentifully in Egypt.

Felspar Green felspar, or Amazon stone (Amazonite) as it is sometimes called, is an opaque pale green stone, not very uniform in colour, which consists essentially of a double silicate of aluminium and potassium; it is found at Gebel Migif in the eastern desert¹ and was used at a very early period, certainly in the Fourth Dynasty, of which date there are two beads from Qau el Kebir in the Cairo Museum²; it was largely employed in the Twelfth Dynasty, for example in the jewellery from Dashur and Lahun respectively, in the original description of the former of which it was wrongly called emerald and Egyptian emerald³; it was used for beads, amulets, inlay and other purposes and was sometimes imitated in green faience and in green glass. Green felspar is frequently confused with other green stones and is sometimes called "mother of emerald," though it has no connection whatever with emerald.

Garnet Garnets are of many kinds, but that used

¹ J. Ball. *The Geog. and Geol. of South-Eastern Egypt*, Cairo, 1912.

² Predynastic beads of green felspar have recently been found by Miss G. Caton-Thompson in the Fayum. British School of Arch. in Egypt. *Cat. of Exhibits*, 1926.

³ J. de Morgan. *Fouilles à Dahchour*.

by the ancient Egyptians was the ordinary garnet, a dark red or dark brownish-red, translucent stone; it occurs plentifully, both in the eastern desert and in Sinai. Garnets were used as beads for necklaces as early as Archaic times. Chemically garnet consists of a double silicate of iron and aluminium.

Hæmatite Hæmatite is an opaque black mineral with a metallic lustre consisting of oxide of iron and is a very common and valuable ore of iron, much used at the present day, though not in Egypt, for the production of the metal; it occurs both in the eastern desert and in Sinai, and was employed as far back as Archaic times for making into beads, amulets, and small ornaments.

Jasper Jasper is an impure, opaque, compact variety of silica, variously coloured red, green, brown, black and yellow by compounds of iron, the red kind being the one principally used in ancient Egypt, though the other colours were also occasionally employed. Red jasper was chiefly used for amulets, though sometimes for inlay, and its use dates from Predynastic times¹; the use of green jasper can be traced to the Eighth Dynasty,² that of brown and black

¹ R. Engelbach. *Harageh*, London, 1923.

² W. M. Flinders Petrie. *A History of Egypt*, Vol. I, 1923.

jasper to the Middle Kingdom,^{1, 2} and that of yellow jasper to the Eighteenth Dynasty, the best example of this latter being the head of Queen Nofretete.³ From the Eighteenth Dynasty onwards red jasper was frequently admirably imitated in glass.

The jaspers of Egypt are well known and both the red and brown varieties occur in several localities in the neighbourhood of the Hadrabia hills, for example in Wadi Saga and in Wadi Abu Gerida⁴; they are found as bands in certain kinds of rocks and as pebbles derived from these or similar rocks. Probably the green and black varieties also occur, though no record of these having been found can be traced; yellow jasper so far as is known does not occur in Egypt, but is found in Asia Minor in the neighbourhood of Smyrna, as also in Sicily. Specimens of a banded jasper from Egypt are found in mineral collections in England, notably in the Museum of Practical Geology, London,

¹ W. M. Flinders Petrie. *Scarabs and Cylinders with Names*.

² P. E. Newberry. *Scarab-shaped Seals*, London, 1907.

³ Burlington Fine Arts Club. *Cat. Ancient Egyptian Art*, 1922.

⁴ T. Barron and W. F. Hume. *Top. and Geol. of the Eastern Desert of Egypt*.

and in the British Museum (Natural History Branch), but the author is unaware of any ancient Egyptian objects made from this material.

Lapis Lazuli Lapis lazuli is an opaque stone of a dark blue colour with, generally, spots, patches or veins of white, which consist of calcite, and often minute spangles of iron pyrites, looking like specks of gold; chemically it consists of silicate of aluminium and sodium associated with sodium sulphide. So far as is known lapis lazuli does not occur in Egypt, but it is found in Persia, Afghanistan, Siberia, Tibet, and China, from the first mentioned of which countries it probably reached Egypt. It was used from Archaic times onwards, especially for beads, amulets, scarabs and small articles, as well as for inlay in jewellery and other objects, and in the Eighteenth Dynasty and later it was extensively imitated by means of dark blue glass; nowadays lapis lazuli is imitated by means of agate artificially stained blue.

Pearl Pearls are calcareous concretions of peculiar and characteristic lustre and are produced by various molluscs; they were not used in Egypt until Ptolemaic times, when they were obtained from the Red Sea and from the Persian Gulf.

Peridot Peridot, or the gem form of olivine, is a deep yellowish-green coloured crystal found only in St. John's island in the Red Sea and is almost certainly the stone that Strabo and Pliny call topaz, since both writers state that this was obtained from such a locality. The only example of the use of peridot in ancient Egypt of which any record can be found is that of a scarab of the Eighteenth Dynasty.¹ What was possibly an ancient jeweller's stock of stones, which included peridot, was found a few years ago during excavations at Alexandria.

**Quartz, Rock
Crystal**

Quartz is a crystalline form of silica, which when pure is colourless and transparent, but which may be translucent or even opaque. The former is called rock crystal and the latter milky or cloudy quartz, the milkiness being due to multitudes of small air cavities. Sometimes quartz is coloured from light brown to almost black, and is then termed smoky quartz.

Quartz occurs abundantly in Egypt, and there is an outcrop of it to the north of Aswan, which is generally shown to tourists as alabaster and which apparently has been worked anciently.

¹ W. M. Flinders Petrie. *Scarabs and Cylinders with Names.*

Quartz was employed in ancient Egypt from Archaic times and was fashioned into beads and other objects, including small vases; in the Old and Middle Kingdoms respectively it was used for the cornea of eyes in statues and in the Eighteenth Dynasty, as already mentioned, it was used with a red-coloured cement to imitate carnelian. Quartz is much harder than glass, which it scratches readily, and it cannot be marked with a knife.

Turquoise Turquoise has been well known and used in Egypt for jewellery for more than 5,000 years and it is still largely employed for this purpose at the present day. The earliest examples of its use are some turquoise beads of Predynastic date which have recently been found at Abydos.¹ The identity of some of this material, however, has been doubted, and it has been stated to be glass,² but in the author's opinion, after very careful examination both with a lens and with a microscope, all the questioned material is undoubtedly turquoise. Turquoise, too, was employed in the Twelfth Dynasty jewellery from Dashur, and some of this has also been thought to be artificial,² chiefly because of its excellent

¹ Egypt. Expl. Soc. *Cat. of Exhibits*, 1926.

² Emile Vernier. *Bijoux et Orfèrries. Cat. Gen. des Ant. Egypt. du Musée du Caire*, 1907.

colour. This also the author, after examination, believes to be genuine turquoise.

In Professor Breasted's translation of the ancient records no mention whatever is made of turquoise,¹ which, considering the extensive and early use of this material, is remarkable and appears to be due to a confusion between turquoise and malachite. The Egyptians themselves, however, may not always have differentiated between the two, inferior greenish turquoise not being very unlike malachite in colour and appearance and both being obtained from the same locality. A similar confusion appears in a modern work where "turquoise and its matrix malachite" are mentioned, although the two materials are very different in composition and have no connection one with the other.

The source of the turquoise employed in ancient Egypt was undoubtedly in Sinai, principally at Wadi Maghârah and at Sérabît El Khâdim, in both of which places there are old workings which are still exploited unsystematically and intermittently by the inhabitants of the district. In 1900 an English company attempted to work the mines, but was obliged to discontinue on

¹ J. H. Breasted. *Ancient Records of Egypt*.

account of thefts by workmen and local opposition. The turquoise occurs in the form of small nodules or as an incrustation in seams in a sandstone rock. Much of the turquoise now sold in Egypt is obtained from Persia and Turkestan. Chemically turquoise consists of hydrous phosphate of aluminium coloured by phosphate of copper ; the typical colour is a delicate sky-blue, though many stones are of an inferior greenish tint. In the Eighteenth Dynasty and later turquoise was extensively imitated by means of glass.

CHAPTER VIII

STONE FOR MONUMENTS AND PURPOSES OTHER THAN BUILDING ¹

The subject has already been partly discussed in connection with building materials, but stone was employed in ancient Egypt, not only for building, but also for statues, obelisks and other monuments, as well as for small objects such as statuettes, bowls, vases, tools and weapons, and the earliest objects that have survived to the present day in Egypt, as in many other countries, are of stone (flint). The stones employed, excluding precious and semi-precious stones which have been dealt with separately, comprise alabaster, basalt, breccia, diorite, dolerite, flint, granite, gypsum, limestone, marble, obsidian, porphyry, quartzite, sandstone, schist, serpentine and steatite, and few countries possess such a variety of stones

¹ The only published papers on this subject that can be traced are two by M. Jules Couyat in the *Bull. de l'Inst. d'Arch. Orient.* Tomes VI and VII.

as Egypt, many of them being very handsome when cut and polished.

There are few subjects in Egyptology that are so full of confusion, and even of contradiction, as that of the nomenclature of the various kinds of stone employed by the ancient Egyptians, and the author proposes to try and unravel the tangle to at least some extent. It is realized that in any scheme of classification there must be difficulties and anomalies and that it is practically impossible to frame definitions that will be satisfactory from every point of view, and the final court of appeal must of course be the petrologist, but it is thought that guided by a few broad principles, with which it is hoped every one will be in agreement, the matter may be much simplified. The principles suggested are, first, that, for the purposes of Egyptology, any highly technical description of the various rocks is unnecessary and that general features and broad characteristics alone need be taken into account, and hence that many of the finer distinctions of the geologist may be disregarded, and second, that old names that are well rooted in the literature of Egyptology should be retained whenever possible, unless seriously wrong.

Alabaster The name alabaster is applied to two distinct minerals of very similar appearance but different chemical composition, one sulphate of lime and the other carbonate of lime. Which of the two has the prior claim to the name will not be discussed, but although the Egyptians occasionally used the sulphate for making small objects, the term alabaster in Egyptology always means the carbonate, and the name is so well established that it should be allowed to stand, and it is this material that was so largely employed for sarcophagi, statues, vases, and many other objects; it is a compact crystalline form of carbonate of lime, white or yellowish white in colour, translucent in thin sections and frequently, though not always, banded, and crystallographically is calcite, though sometimes erroneously termed aragonite, which is a material of similar appearance and composition, but different crystalline form and different specific gravity. Although aragonite may occur in Egypt it is not common, and all the specimens of alabaster examined by the author have been calcite. Alabaster is fairly soft and may be scratched with a knife.

Alabaster is found in several localities in the eastern desert, and though not now

worked, the ancient quarries may still be seen, the principal one being at Hatnub, some 10 to 15 miles east of Tell el Amarna (slightly south of Deirut), but ancient alabaster quarries extend from Minia to Asiut, and there is also a small ancient quarry in the desert east of Helwan, near Cairo. The Hatnub quarry is frequently referred to in the ancient records, and in the quarry there are hieroglyphic inscriptions beginning in the Fourth Dynasty and continuing in the Sixth, Seventh, Eighth, Twelfth, Nineteenth and Twentieth Dynasties respectively.^{1, 2}

Alabaster was used in Predynastic times for vases, bowls, mace-heads, and other comparatively small objects; in the early Dynastic period for vases, libation tables, sarcophagi and statues (examples of alabaster statues in the Cairo Museum are those of Chephren and Mycerinus respectively); in the later periods it was used for statues (examples in the Cairo Museum are those of Seti I and of Amenartisi), for sarcophagi (examples from both the Twelfth and Eighteenth Dynasties are known), and for canopic and other vases.

¹ J. H. Breasted. *Ancient Records of Egypt*.

² G. W. Fraser. Hatnub, *Proc. Soc. Bib. Arch.*, Vol. XVI, 1894.

**Basalt and
Dolerite**

Basalt, which is a volcanic lava, is a black, compact, heavy rock, often showing tiny glittering particles and apparently homogeneous, or nearly so, in structure, though actually consisting of an aggregate of various minerals most of which are too fine-grained to be distinguished except with a microscope; it is often wrongly termed black granite by Egyptologists.

Basalt is not plentiful in Egypt, but occurs in comparatively small quantities in several localities, as at Abu Zaabal, near Cairo; a little north-west of the Giza pyramids, beyond Kerdassa; in a number of places between Cairo and Suez; in the eastern desert about the latitude of Wasta, but much nearer the coast than the Nile, and also between the latitudes of Edfu and Aswan; in the western desert to the north of the Fayum, between the Fayum and Baharia Oasis and also in the Oasis, and in Sinai. Notable examples of the use of basalt in ancient Egypt are for the pavement of the temple of the large pyramid at Giza (Fourth Dynasty) and for the pavements of the temples of two of the pyramids at Abusir (Fifth Dynasty). In appearance this basalt resembles very much that from Abu Zaabal now being used in Cairo as a road material.

The sarcophagus from the third Giza pyramid (Fourth Dynasty), which was lost at sea, is stated to have been of basalt.

When the separate minerals of basalt are sufficiently coarse-grained to be recognized with the naked eye the rock is termed dolerite. Dolerite occurs both in the eastern desert of Egypt and in Sinai, and in one place in the former locality the rock is marked with the cartouche of Ramses III (Twentieth Dynasty).¹ One use of dolerite in ancient Egypt was for pounders in working hard stone, and roughly spherical specimens of this rock may still be found in the granite quarries of Aswan and in the quartzite quarry at Gebel Ahmar near Cairo, where they have remained from the time the quarries were worked anciently. These pounders resemble the hard spherical masses of dolerite suggesting cannon balls found in the eastern desert.² Dolerite is frequently called basalt by Egyptologists.

Breccia Breccia is composed of angular fragments of one or more kinds of rock embedded in a

¹ T. Barron and W. F. Hume. *Topography and Geology of the Eastern Desert. Central Portion*, Cairo, 1902.

² W. F. Hume. *Preliminary Report on the Geology of the Eastern Desert*, Cairo, 1907.

matrix of another material, the characteristic feature being that the included fragments are sharp-edged and unworn as distinguished from the worn and rounded fragments of a conglomerate. The name breccia therefore denotes the structure of the rock and has no reference to its composition. A number of different breccias occur in Egypt, and were used anciently; of these two may be specially mentioned, namely, a red variety and a green variety.

The red breccia is calcareous and consists of white fragments embedded in a red matrix; it is widely distributed, especially on the west bank of the Nile near Esna and Luxor respectively, but it is also found near Minia and near Asiut; it was used in Archaic times chiefly for bowls and vases, and apparently not again until the Romans worked it, principally for exportation to Italy.

The green breccia consists of fragments of rocks of the most varied description embedded in a matrix which is variable in colour, with green predominating; it is, however, not a typical breccia, as while some of the fragments are angular, others are rounded, and it is sometimes termed a brecciated conglomerate, but since in the past it has always been called breccia and was the

breccia verde antico of the Romans, it is much better to retain the old name. This green breccia is found in several localities, the best known of which is the Wadi Hammamat in the eastern desert on the Qena-Qosseir road, where it occurs extensively and where it was anciently quarried, though apparently not until a very late period; it is not, however, the typical rock of the Wadi, which is schist. It also occurs at Wadi Dib in the regions to the west of Gebels Dara and Mongal in the El Urf chain¹ and at Gebel Hamata,² all of which are situated in the eastern desert, and also in Sinai.

Green breccia was used occasionally at a late period, but was chiefly quarried by the Romans for export to Italy. The principal and possibly the only object of this breccia in the Cairo Museum is a broken sarcophagus of the time of Nectanebo (Thirtieth Dynasty), and in the British Museum there is a similar sarcophagus of the same pharaoh. A broken statuette in the Cairo Museum, possibly of

¹ T. Barron and W. F. Hume. *Top. and Geol. of the Eastern Desert of Egypt. Central Portion*, Cairo, 1902.

² J. Ball. *The Geog. and Geol. of South Eastern Egypt*, 1912.

Archaic date, described as being of green breccia,¹ is not breccia.

Diorite Diorite is the name of a family of crystalline, granular rocks composed essentially of felspar (white) and hornblende (black or dark green) and may be either fine-grained or coarse-grained. Diorite is found extensively in Egypt in several localities, one occurrence being near Aswan and others in the eastern desert and in Sinai. In the eastern desert there is in one place a Greek inscription of Roman age on the diorite rock.²

The rocks employed by the ancient Egyptians for statuary and other purposes that may be described as diorite are of three main kinds, namely :

1. A coarse-grained black and white speckled rock in which the component minerals are fairly evenly distributed and which was used in Archaic times for mace-heads, bowls and vases and occasionally for palettes. This is a coarse-grained diorite.

2. A rock composed of a black, compact

¹ G. Legrain. *Statues et Statuettes. Cat. Gen. du Musée du Caire.*

² T. Barron and W. F. Hume. *Topography and Geology of the Eastern Desert. Central Portion.* Cairo, 1902.

matrix in which are embedded conspicuous white fragments and which is not altogether unlike No. 1 in general appearance, though the white fragments are fewer in number and larger in size. This was employed in Archaic times for bowls and vases, and on account of its particular structure, which is that termed "porphyritic" by geologists, the material is sometimes called porphyry. In view, however, of what will be found stated later when dealing with porphyry, it is better and will save confusion if this is called porphyritic diorite.

3. A banded or mottled black and yellowish-white rock, the white portions being slightly translucent, used in the Old Kingdom and especially in the Fourth Dynasty for statues and the lighter coloured portions of which were employed in Archaic times as well as in the Old Kingdom for bowls and vases. Examples of statues of this material are a large statue and several smaller ones of Chephren and a small statue of Mycerinus, all in the Cairo Museum. This is generally termed diorite by Egyptologists, but gneiss by geologists. The difference of nomenclature, however, merely means that in composition the rock is a diorite, that it is composed essentially of felspar and horn-

blende, but in structure it is a gneiss, that is a banded rock, and though gneiss is the more correct name, and hornblende-gneiss still more correct, diorite is not wholly wrong, and to meet the difficulty it is suggested that it might be called diorite-gneiss. This rock varies considerably in appearance, even in different parts of the same piece, and the general effect may be dark grey, light grey or white slightly flecked with black. The source of this particular diorite has never been definitely identified, though probably it was in the neighbourhood of Aswan.

Flint The earliest Egyptians, of whom any traces survive, left behind them as the principal evidence of their existence, activity and state of civilization, vast numbers of flint and chert implements. Their successors, the Predynastic Egyptians, also used these materials, and axes, knives, arrow-heads, hammers, chisels and other weapons and tools of flint and chert are found buried with them. When copper became known and was employed for weapons and tools the use of flint naturally decreased, though it did not entirely die out, and even after copper was well known flint continued in use for certain purposes, much in the same way as it was employed in Europe for pro-

curing a light and for firing gunpowder long after its use for any other purpose had been discontinued.

Flint occurs plentifully in certain districts in Egypt in the form of nodules and layers in the limestone rock, and in many localities it is found scattered about on the surface of the desert, having been derived from the weathering of the limestone. Chemically flint is an impure form of silica.

Granite Granite has already been described in connection with building materials, where it was stated to be the name of a large class of crystalline rocks of igneous origin, the individual minerals of which, chiefly quartz felspar and mica, were sufficiently large to be visible to the naked eye. The typical granite of ancient Egypt is the coarse-grained red variety which forms the greater part of the hills between Aswan and Shellal. This is a true granite and its recognition presents no difficulty and leaves no room for doubt or confusion. Granite, however, being a natural material, is not uniform in structure, composition, or colour, but varies considerably in all three respects, thus the grain of the rock may be coarse or fine, the relative proportion or distribution of the contained minerals may vary and the felspar

may be either red or white, the rock in the former case being coloured red and in the latter case black and white or light grey, or when the darker minerals (mica and hornblende) preponderate, dark grey, or even practically black. Granite, too, merges into rocks of other types without any hard and fast line of demarcation. Although grey and black granite respectively are not geological terms, it is suggested that they may reasonably be employed in Egyptology when the rock is grey or black and is indeed a granite, the black granite of the Egyptologist and stonemason, however, being frequently either not black, but dark grey, or not granite.

The geologist divides granite into a number of sub-classes in accordance with their composition, but with these divisions Egyptology is not concerned, all that is required being a broad classification, subtle distinctions being quite unnecessary. There will probably be some difference of opinion as to the degree of elasticity that may be allowed in calling stone granite or in other stone nomenclature, but the boundaries should be as wide as possible.

Granite was employed in Predynastic times, though only sparingly and chiefly for bowls and vases, but in the early Dynastic

period it was worked to a much greater extent on account of the increased use of copper tools and, in addition to bowls and vases, statues and sarcophagi were also made, for example the sarcophagus in the unfinished pyramid of Zowiet el Aryan (Third Dynasty) and the sarcophagi in the first and second Giza pyramids respectively (Fourth Dynasty). At a later date it was employed extensively for statues, some being colossal, for example the gigantic statue, now broken, of Ramses II in the Ramesseum, which is estimated to weigh about 1,000 tons ; for stelæ ; for sarcophagi ; for obelisks, and for many other purposes.¹ In the ancient granite quarries between Aswan and Shellal there are a number of unfinished objects, namely, an obelisk, several sarcophagi and several colossal statues.

As already stated, red granite occurs plentifully near Aswan, from which place it was obtained, but it is also found extensively in the eastern desert ; to a small extent in the western desert south of the Kharga Oasis, and abundantly in Sinai. Among the granites used anciently was a white stone speckled with black from Mons Claudianus, which is situated in the eastern desert somewhat

¹ See also Building Materials.

south of the latitude of Asiut, but nearer the coast than the river. This stone, as the name of the place suggests, was worked by the Romans and was principally exported to Italy.

Gypsum Gypsum, as already explained when dealing with plaster, although generally occurring in scattered masses of loosely aggregated crystals and quite useless for carving, is also found in compact rock-like formation in a few localities, for instance in the district between Ismailia and Suez and very plentifully near the Red Sea coast.

Gypsum consists of sulphate of lime, and in appearance much resembles alabaster, which is carbonate of lime, and is often called alabaster, and even claims priority for the name. So far as the author's experience is concerned, gypsum was employed in ancient Egypt very occasionally apart from its use for mortar and plaster, and then only for small objects. Gypsum is softer than alabaster and may be scratched with the fingernail, while alabaster (calcite) cannot be scratched with anything softer than steel.

Limestone Limestone has already been dealt with in connection with building materials. It was, however, also largely used for stelæ, bas-reliefs, sarcophagi, statues, and other objects,

and even for amulets and personal ornaments, such as bracelets, and was the first stone used for most purposes, except weapons and tools, on account of its being soft and easily worked, and because it lent itself admirably to carving on account of its fine texture; it was employed from Predynastic times onwards. The wide distribution of limestone in Egypt has already been mentioned.

Marble Marble is a crystalline form of limestone having a compact structure that enables it to take a high polish; it is usually white or grey, but may be of almost any colour and is often veined in different colours.

Marble occurs in the eastern desert of Egypt, where in one locality, Gebel Rokham, north of Wadi Mia, which is situated to the east of Esna, there are extensive old workings, though of what date is uncertain; it was little used in Egypt before Græco-Roman times when it was employed for statuary. The earlier examples of its use include a few vases of Archaic date,¹ numerous small vases of a light-blue colour of the Eleventh and Twelfth Dynasties and chiefly of the latter, a bowl of the same blue colour

¹ Burlington Fine Arts Club, *Cat. of Ancient Egyptian Art*, 1922.

of the Seventeenth Dynasty,¹ and in white marble a number of small objects, among which may be mentioned a small kneeling statue of Thothmes III (Eighteenth Dynasty) now in the Cairo Museum.

Obsidian Obsidian is a black glassy-looking material which breaks with the conchoidal fracture of glass and is a natural glass of volcanic origin. So far as is known obsidian does not occur in Egypt, but it occurs plentifully in Abyssinia, in Asia Minor and in southern Europe, from one of which places it was doubtless obtained.

Obsidian was used from early Dynastic times onwards and was employed for amulets, small vases, the pupil of the eye in statues and other purposes, notable examples of its use being the head of Ammenemhat III (Twelfth Dynasty)² and a head in the Cairo Museum of about Eighteenth Dynasty date.

Porphyry The name porphyry, which is derived from a word meaning purple, was originally applied to a certain kind of purple-tinted rock, but this primary signification has now given place in geology to one in which structure and not colour is the guiding characteristic. In Egyptology, however, the name porphyry,

¹ W. M. Flinders Petrie. *Qurneh*, 1909.

² *J. Egypt. Arch.*, Vol. IV, 1917.

or imperial porphyry, is so well known as denoting the beautiful fine-grained purple-coloured rock that was obtained from Egypt by the Romans and employed extensively in Italy as an ornamental stone, that this is the sense in which, in the author's opinion, it should be continued to be used, otherwise there will be considerable danger of confusion. Geologically this rock is a porphyrite. It is found at Gebel Dokhan, which is situated in the eastern desert in about the same latitude as Asiut, but nearer the Red Sea than the Nile. Only one example of its use before Roman times can be traced as having been found in Egypt, and this is a part of a small fluted bowl of early Dynastic date.¹ In the Cairo Museum there is a bust of a Roman emperor in this stone.

Quartzite Quartzite is a hard compact variety of sandstone produced from ordinary sandstone by secondary changes; it varies very much in colour and may be white, yellowish brown or red and may be either coarse-grained or fine-grained. It occurs in several localities in Egypt, notably at Gebel Ahmar near Cairo, but also between Cairo and Suez; in the Wadi Natron in the western desert

¹ W. M. Flinders Petrie and J. E. Quibell. *Nagada and Ballas*, 1896.

and in Sinai; it was employed by the ancient Egyptians chiefly for sarcophagi and statues, examples of its use from the Cairo Museum that may be mentioned being a head of Dedefre (Fourth Dynasty), an offering table of the Thirteenth or Fourteenth Dynasty, statues of Thothmes IV and Senmut respectively (Eighteenth Dynasty), several heads and statuettes of this same Dynasty, the sarcophagi of Thothmes I and Hatshepsût respectively (Eighteenth Dynasty), two statues of Ptah (Nineteenth Dynasty) and part of a statue of the emperor Caracalla (Roman). The two sarcophagi in the Hawara pyramid (Twelfth Dynasty) are also of quartzite.¹ Quartzite was employed therefore as early as the Fourth Dynasty and continued in use until the Roman period. This stone is often termed crystalline sandstone by Egyptologists, but this name is both ambiguous and unnecessary.

Sandstone Sandstone has already been dealt with as a building material, but it was also employed for many other purposes, such as for statues, stelæ, and other objects. Notable examples of its use are the recently discovered statues of Akhenaten (Eighteenth Dynasty) from

¹ W. M. Flinders Petrie. *A History of Egypt.*

Karnak and the colossal statues at Abu Simbal (Nineteenth Dynasty).

Schist Schist is the term applied to certain rocks having a fissile or foliated structure, which, however, is not always very evident, and the name has no relation to the composition of the rock, which may be very varied; it occurs extensively in Egypt in the eastern desert.

The particular schist employed so considerably by the ancient Egyptians for statues and sarcophagi, from at least the Fourth Dynasty to the Thirtieth Dynasty, is a dark grey or greenish-grey, fine-grained, highly crystalline rock, resembling slate somewhat in general appearance and often called basalt or green basalt by Egyptologists. It was obtained from the Wadi Hammamat on the Qena-Qosseir road and is the typical rock of the Wadi. These quarries are frequently referred to in the ancient records as furnishing stone for statues and sarcophagi, and on the rocks in the Wadi are a large number of ancient inscriptions, about 256 altogether, varying in date from the Fifth Dynasty to the Persian period and including inscriptions of the Sixth, Eleventh, Twelfth, Thirteenth, Fourteenth, Eighteenth, Nineteenth, Twentieth, Twenty-fifth, Twenty-

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sixth, Twenty-seventh and Twenty-eighth Dynasties respectively.^{1, 2, 3}

A few examples of objects made of schist that are in the Cairo Museum may be mentioned; they include the small triad groups of Mycerinus (Fourth Dynasty), two statues of Thothmes III (Eighteenth Dynasty), a statue of Thueris (Twenty-sixth Dynasty), a group of four statues from the tomb of Psamtik (Thirtieth Dynasty) and a number of sarcophagi of late date, chiefly Thirtieth Dynasty and Ptolemaic.

Slate, which is a clay schist, that is a schist derived from clay, was employed in Egypt in Predynastic times for making palettes. It is found in Wadi Zedoun, south-east of Qift.

These two materials are very similar in composition, though not identical, both, however, being hydrated silicates of magnesium, but in different states of hydration.

Serpentine is a non-crystalline rock of a dull, serpent-like, mottled appearance, usually

¹ W. M. Flinders Petrie. *A History of Egypt*.

² J. H. Breasted. *Ancient Records of Egypt*.

³ J. Couyat et P. Montet. Les Inscriptions hiéroglyphiques et hiératiques du Ouadi Hammamat. *Mem. De l'Inst. Franc. d'Arch. Orient. du Caire*, T. XXXIV, 1912.

dark green to almost black in colour ; it is fairly soft, though harder than steatite, and may readily be cut or scratched ; it is widely distributed in the eastern desert and was worked in ancient Egypt at a very early date.¹ A head of Amenemhat III (Twelfth Dynasty) is of this material.²

Steatite is a form of talc and is usually white or grey in colour, though occasionally smoke-black, this latter colour being natural and not artificial as has been stated ; it has a greasy or soapy feel, and was used from Archaic times onwards for beads and other small objects, which were sometimes glazed, the greater proportion of the scarabs known being of glazed steatite.

Steatite is found near Aswan and also at Gebel Fatira in the eastern desert, a little south of the latitude of Asiut ; from the former locality 139 tons were extracted in 1918 when the ancient mines were temporarily re-opened,³ and it is still worked on a small scale by the local Arabs, who fashion it into bowls and pipes.

¹ A clear almost transparent variety of serpentine, which looks very like light-coloured green glass, as used in Archaic times for beads.

² *J. Egypt. Arch.*, Vol. IV, 1917.

³ Mines and Quarries Dept. *Report on the Mineral Industry of Egypt.*

CHAPTER IX

TEXTILE FABRICS, LEATHER AND DYES

Textile Fabrics

The textile fabrics that have survived from ancient Egypt, like most other objects, are those that have been found in tombs, and since these are almost entirely confined to wrappings for the dead, and since, too, a particular kind of fabric, linen, was always employed for burial purposes, as is the custom with the Copts at the present day, it follows, first, that ordinary garments are practically absent, and second, that the nature of the fabric is not necessarily representative of that worn by the living. Occasionally, however, a shirt occurs on a mummy or fabrics other than those on the body are discovered, thus in the tomb of Thothmes IV a few small fragments of tapestry-woven fabric were found¹ and in the tomb of

¹ Carter and Newberry. *The Tomb of Thothmosis IV*, London, 1904.

Tut-ankh-Amen there were a large number of different kinds of garments.¹

The material used as burial wrappings until Christian times was, as already mentioned, invariably linen, and linen body wrappings have even been found as early as the Predynastic period, long before mummification was practised. The fabric from the tomb of Thothmes IV and the garments from that of Tut-ankh-Amen are also linen, and Herodotus (484 to 425 B.C.) refers to the wearing of linen tunics by the Egyptians and to the linen garments of the priests.²

The old Egyptian linen varies considerably in texture, some being exceedingly fine and very transparent, like the finest cambric, while other specimens are of a canvas-like coarseness, and others, again, of an intermediate grade. The nature and quality of the weaving have been investigated by various experts, notably, J. Thomson,³ W. W.

¹ Carter and Mace. *The Tomb of Tut-ankh-Amen*, London, 1923.

² Herodotus, II, 37 and 81.

³ *Lond. and Edin. Phil. Mag.*, Vol. 5, 1834. This is quoted at great length by Wilkinson in his book on the Ancient Egyptians.

Midgley,¹ T. W. Fox,² W. G. Thomson,³ and A. F. Kendrick.⁴ Spinning and weaving were among the great industries of the country and are represented in tomb paintings at Beni Hassan (Twelfth Dynasty), El Bersheh (Twelfth Dynasty) and at Thebes, and are shown in a model of the Eleventh Dynasty in the Cairo Museum.

In addition to linen, however, there can be no doubt that the ancient Egyptians, who possessed large flocks of sheep, also made use of wool as a covering, though only two instances of the finding of wool in graves until a very late period can be traced. These examples are from the Twelfth Dynasty⁵ and the Eighteenth Dynasty⁶ respectively. In the former case the wool, which was

¹ (a) In *Historical Studies*, Brit. School of Arch. in Egypt, 1911. (b) In *Heliopolis, Kafr Ammar and Shurafa*. By W. F. Flinders Petrie and E. Mackay.

² In *The Tomb of Two Brothers*. By M. A. Murray, 1915.

³ In *The Tomb of Thoutmosis IV*. By Carter and Newberry.

⁴ *Cat. of Textiles from Burying-Grounds in Egypt*. Vols. I, II and III.

⁵ W. M. Flinders Petrie. *Kahun, Gurob and Hawara*, 1890.

⁶ H. R. Hall. *The Contemporary Art of Egypt and the Near East*. *Cambridge Ancient History*, Vol. II, 1924.

coloured blue, red and green, was in the form of yarn and not woven. Occasionally woollen garments have been found in Christian graves, and the use of coloured wool for the decoration of linen garments is fairly common from the Roman period onwards. Herodotus mentions the wearing of white woollen tunics by the Egyptians.¹

Cotton, which is of Indian origin and was known and used certainly as early as 800 B.C., appears in Egypt very late, and although it is now the most important crop in the country the date of its introduction is uncertain. Both Pliny (about A.D. 23 to 79) and Pollux (Second Century A.D.) state that it was grown in their time: Balls states ". . . we can trace the existence of cotton in Egypt to about 200 B.C., but . . . there is no reliable evidence of an earlier date."² Cotton, however, was not cultivated systematically until the Nineteenth Century when Jumel, a French engineer, called attention to its growing in gardens and suggested its cultivation on a large scale, which was subsequently carried out. No cotton fabrics can be traced as having been found in Egypt-

¹ Herodotus, II, 81.

² W. Lawrence Balls. *The Cotton Crop of Egypt. Year Book Khed. Agric. Soc., Cairo, 1910.*

tian graves even as late as the end of the Roman period.

Silk was not used in Egypt until late and probably not until the Fourth Century A.D.

Leather In a country such as ancient Egypt where cattle, sheep and goats were common and where there were also many wild animals, it is only natural that before the weaving of cloth became known animal skins should be used as clothing, and in the earliest Predynastic graves skins have been found wrapped round the body. From raw hide to skin treated sufficiently to render it pliable and thence to fully tanned leather are steps that the Egyptians took at an early date, and leather-working became an important industry and is depicted in a tomb painting of the Eighteenth Dynasty at Thebes.

Leather was used for sandals, harness, seats of stools and many other purposes, the largest piece of leather work that has survived being the funeral tent of queen Isimkheb (Twenty-first Dynasty). Articles of leather were often coloured red, yellow, or green.

Specimens of ancient Egyptian leather varying in date from the Eighteenth to about the Twenty-third Dynasties respectively have recently been kindly examined for the

author by Dr. R. H. Pickard, F.R.S., Director of The British Leather Manufacturers' Research Association, and in several cases goat skin was identified.

Although there has been much guesswork concerning the nature of the tanning materials employed by the ancient Egyptians the matter has never been thoroughly investigated and there is no certain knowledge what these materials were, though probably they were vegetable and not mineral and possibly were acacia bark or pods, as is generally stated. In the case of the specimens of leather examined by Dr. Pickard, although search was made for both vegetable and mineral tanning substances, the results were negative.

Dyes Very little is known about the ancient Egyptian dyes beyond the fact of their use, and there has been very little investigation into either their nature or the methods of their employment. For fabrics the colours were chiefly blue, red, yellow and green; for leather red, yellow and green, and for staining ivory, red. As aniline and other artificial colouring matters were unknown the colours used therefore must have been natural products. Three of these colours, however, have been identified, namely a

blue and two different yellows, the former being indigo and the latter in some cases being the yellow colouring matter from the flowers of *Carthamus tinctorius* (Safflower) and in other instances an iron compound.

Indigo, although cultivated in Egypt within comparatively recent times, is not now grown, and almost certainly it was not cultivated in ancient Egypt, but was probably obtained from India. This colouring matter seems to have first been identified on ancient Egyptian fabrics by Thomson more than 100 years ago, but the date of the material on which it was found is not recorded¹; the author has also found indigo on an ancient Egyptian linen fabric, which unfortunately was also undated.

The safflower still grows in Egypt and yields two dyes, a yellow and a red, but only the latter is now used and is employed for dyeing silk. That the yellow colour of the ancient Egyptians was derived from the safflower was first suggested by Thomson,¹ but he was unable to prove this; it has, however, since been definitely established by Hübner, who also found that another and slightly different shade of yellow was "iron

¹ *Lond. and Edin. Phil. Mag.*, Vol. 5, 1834.
Quoted by Wilkinson in *The Ancient Egyptians*.

buff.”¹ Mordants were employed for fixing the colours to the cloth and are mentioned by Pliny, but their nature has not been determined. The whole subject of the materials and methods used for dyeing in ancient Egypt both needs and merits further attention.

¹ In *The Tomb of Two Brothers*. By M. A. Murray.

CHAPTER X
WRITING MATERIALS

The scribe in ancient Egypt held a position of considerable importance and he is frequently represented in sculpture and depicted in the paintings on tomb walls, often being shown with the implements of his craft, namely papyrus, pens and ink, the pen sometimes behind his ear. These materials will now be considered.

Papyrus Papyrus, which was the forerunner of modern paper, to which it gave its name, was made from the stems of the papyrus plant (*Cyperus papyrus*), which grew abundantly in the marshy districts of Lower Egypt and, although not now found in Egypt, it still flourishes in the Sudan. The methods of making sheets suitable for writing upon from this very unpromising-looking material is described by Pliny, according to whom the stem of the plant, after the removal of the outermost layer, was sliced into thin longitudinal strips which were placed side

by side upon a table and across them at right angles another series of similar strips was laid, the two layers being fastened together by means of an adhesive and the whole then pressed or beaten and dried. Pliny states that the strips were moistened with Nile water, which being thick and slimy, furnished a species of glue. This, however, is manifestly wrong, and although the Nile water at flood time is thick, and may even be considered slightly slimy from the finely-divided clay it contains, yet this clay was certainly not the adhesive used and some other material must have been employed, the nature of which, however, is unknown, and whether it was gum, glue, or starch, to mention the three most likely substances, has not been determined. By joining together a number of sheets of papyrus a single sheet of almost any length could be made, and in the British Museum there is one 135 feet long. The finished papyrus varies considerably in quality, in some instances being coarse and in others of very fine texture. The oldest surviving papyrus known is the Prisse papyrus, which dates from the Eleventh Dynasty.

Although papyrus was the principal material used for writing upon, it was not the

only one, and on account of its being very expensive other and cheaper materials were often used instead. These substitutes were chiefly broken fragments of pottery, pieces of limestone, leather, and also small boards, not unlike the modern school slate in shape and size, which were covered with a thin coating of coloured gesso.

Pens The ancient Egyptian pens, as proved by numerous specimens that have been preserved, were made from narrow reeds, and are about ten inches long and about one-eighth of an inch in diameter, the end being bruised to make the fibres flexible. Strictly, such an article is a brush and not a pen, and a true pen was not employed until about the Twenty-sixth Dynasty, when a much broader reed with the end cut like a quill pen was introduced, and this latter is still in limited use in Egypt at the present day.

Ink Inkstands containing dried ink have often been discovered in tombs and few museums are without one or more examples. Generally the ink is of two colours, black and red, though yellow, blue, green and white also occur. Colours other than black and red, however, were employed by the artist for illustrated scenes and not by the scribe in writing.

The black ink is always described as having been made from carbon, the red and yellow as being naturally occurring red and yellow ochres respectively and the blue and green copper compounds. No analyses of the coloured inks can be traced, though they are probably as given. One recent writer, however, states that the blue was made from lapis lazuli and the green from sulphate of copper. The former is probably incorrect and the latter certainly is, sulphate of copper being blue and not green and a most unsuitable material for ink.¹ In order to make the ink, the finely ground colour was suspended in water by means of some colloid body, probably gum, which in small quantity is still a product of Egypt and a very important export from the Sudan.

Of the black ink only one analysis can be found, which is by J. Wiener given in his account of the papyrus documents from the Fayum province in the collection of the grand duke Rainer,² which date from the Ninth to the Thirteenth Century A.D. Wiener

¹ J. Baikie. *Egyptian Papyri and Papyrus-Hunting*, London, 1925.

² *Die Faijumer und Uschnuineiner Papiere, Mittheilungen aus der Sammlung der Papyrus Erzherzog Rainer*, Wien, 1887.

states that the papyri are written with two different kinds of ink, one a carbon ink and the other an iron ink. W. Schubart¹ also mentions two kinds of ink on papyrus, one very black and one brown, the latter dating from about the Fourth Century A.D., but the nature of this ink, the brown colour of which suggests an iron ink, does not appear to have been determined.

The author has had an opportunity of examining a number of specimens of old Egyptian ink, the results of which will now be described :

1. Black ink taken from an inkstand of the Eighteenth Dynasty in the Cairo Museum. On chemical analysis the black material proved to be carbon.

2. Black ink on various ostraca, undated. This also was carbon.

3. Black ink on papyri varying in date from Roman times until about the Ninth Century A.D. This also was carbon.

4. Ink, now brown, though doubtless originally black, on various parchment documents from Egypt, dating from between the Seventh and Twelfth Centuries A.D. inclusive. In every case the ink was an iron compound.

5. The ink used for a portion of the Old

¹ *Einführung in die Papyruskunde*, Berlin, 1918.

Testament written in Arabic, but bearing the Coptic date 1028 (A.D. 1312). Part of this was a carbon ink and part an iron ink.

The carbon used for making ink was probably soot in most cases, but whether the soot was specially prepared cannot, of course, be determined from an examination of the ink, though this was certainly the case in at least some instances. One method of making carbon for ink to be used for writing religious books, and which was kindly supplied to the author by a priest of the Coptic Church, may be mentioned and was as follows. Put a quantity of incense on the ground and round it place three stones or bricks, and resting on these an earthenware dish, bottom upwards, covered with a damp cloth; ignite the incense; carbon (soot) is formed and is deposited inside the dish, from which it is removed and made into ink by mixing with gum arabic and water. Another recipe is given in an old Arabic book in the Royal Library, Cairo, which unfortunately is anonymous and undated. This is as follows: Take date stones and put them in an earthenware vessel stoppered with clay; heat the vessel for about 24 hours; allow to cool; remove the contents and grind and sift them and make into ink with gum and

water. Such an ink as this last, however, would be of very poor quality and would contain very little free carbon.

Although carbon ink has largely given place almost all over the world to other types of ink it lingers on in Egypt, where it is still used to a limited extent. At what date carbon ink was first employed in Egypt is unknown, but an inscription of the First Dynasty which is probably written in carbon ink is recorded,¹ and the Prisse papyrus, probably of the Eleventh Dynasty, is certainly in carbon ink. The exact date of the introduction of iron ink is also unknown, but, as already shown, it can be traced back to about the Seventh Century A.D. and is probably as early as the Fourth Century.

¹ W. M. Flinders Petrie. *A History of Egypt*, 1923.

CHAPTER XI

MISCELLANEOUS MATERIALS

Various miscellaneous materials used by the ancient Egyptians, most of them from a very early date, will now briefly be described. These are Bone, Charcoal, Emery, Graphite, Horn, Ivory, Jade (or Jadeite), Shells and Tortoise-shell.

Bone Bone was employed in Predynastic times for making small objects, such as personal ornaments, combs, heads of harpoons, piercers and small figures, and is a natural material for primitive man to use for such purposes. The bone employed was principally animal bone, but a few specimens of artificially pointed fish bones have also been found.

Charcoal This has been known in Egypt from Predynastic times and has frequently been found in graves, and until quite recently, when it was largely displaced by paraffin oil (kerosene), it was the principal fuel of the country and is still largely used, though in

greatly diminished quantity. At one time charcoal-burning was extensively carried on in both the eastern desert and in Sinai and it still lingers on to a limited extent. It is this industry that is partly, if not chiefly, responsible for the present scarcity of small trees in the *wadis* (valleys) in both districts.

Emery Emery is a greyish-black variety of corundum and consists therefore essentially of oxide of aluminium, though it also contains an admixture of oxide of iron; its hardness is next to that of the diamond, and when finely powdered it is used as an abrasive.

A few objects of emery dating from Predynastic and early Dynastic times have been found in Egypt; these include a plummet,¹ a double vase,² two small blocks¹ thought to have been used for polishing beads because of their grooved condition and a lump of the material.³ It is generally assumed that emery was employed with tools, such as drills and saws when working hard stone and also for polishing purposes, and although something of the kind mani-

¹ W. M. Flinders Petrie and J. E. Quibell. *Naqada and Ballas*, 1896.

² J. E. Quibell and F. W. Green. *Hierakonpolis*, Part II, 1902.

³ G. A. Wainwright. *Balabish*, 1920.

festly must have been used, it is by no means proved that this material was emery, and its use for carving into various objects is almost a contra-indication. Beyond a statement that some of the sand at Aswan contains 15 per cent. of emery¹ there is no evidence of its occurrence in Egypt, but it is found plentifully in Asia Minor and in several of the Ægean islands.

Graphite Graphite or blacklead, as it is often called, consists of carbon, generally mixed with a small proportion of clay and other impurities; it occurs in small quantity in the gold veins of the quartz rock of the eastern desert and in the schist near Gebel Allawi. The only known specimen of graphite from ancient Egypt is a piece found by Flinders Petrie in an Eighteenth Dynasty tomb at Gurob, but it has also been found by Reisner at Kerma in the Sudan.² The Gurob graphite was analysed by Ainsworth Mitchell and was very impure, containing much siliceous matter and only 39 per cent. of carbon.³

Horn Although horn was necessarily well known in ancient Egypt, apparently it was very

¹ G. A. Wainwright. *Balabish*, 1920.

² *Excavations at Kerma*, Camb., Mass., U.S.A., 1923.

³ *The Analyst*, 1922.

little used, and comparatively few objects of this material have been found in the graves. Among these may be mentioned several handles of weapons, a vase-shaped vessel and a few pendants and bracelets.

Ivory Ivory was much employed in Predynastic and early Dynastic times on account of its being dense and fine-grained and well adapted for carving, in which the ancient Egyptians were very skilled. The ivory objects found include personal ornaments, such as pendants and bracelets, statuettes, plaques, mace heads, combs, spoons, boxes, handles for flint knives, and legs for articles of furniture, possibly chairs. This considerable use of ivory at an early date means that it was well known and fairly plentiful, but it does not necessarily imply that the elephant was then wild in Egypt, whatever may have been the case in earlier times. The fact that the elephant was found in the country immediately to the south of Egypt, namely the Sudan, would always render ivory easily accessible, and it is known that at an early date Aswan was a market for ivory and other Sudan produce. At a later period ivory was much employed for inlay and veneer on boxes, furniture and other objects.

Jade (or Jadeite) These materials, although very similar in appearance, differ considerably in chemical composition, the former being a double silicate of calcium and magnesium and the latter a double silicate of aluminium and sodium. Several specimens of one or other of these materials have been found in ancient Egyptian graves, the principal examples being two axe heads of Predynastic or Archaic date, one now in the Cairo Museum and the other in the Museum of University College, London.¹ Jade occurs chiefly in Turkestan, Siberia, and New Zealand, but to a small extent also in India and Silesia, and jadeite, so far as is known, only in Upper Burma. Unless the material is examined chemically or microscopically it is impossible to distinguish jade from jadeite.

Shells Shells of various kinds were used chiefly in Archaic times, strung together to form necklaces and girdles and also cut into finger rings and bracelets. These shells were mostly from the Red Sea, but fresh-water shells from the Nile were also used. Mother-of-pearl was also occasionally employed.

Tortoise-shell Modern tortoise-shell consists of the epidermic plates of a small species of sea turtle,

¹ Also a large heart scarab of Nineteenth Dynasty date. W. M. Flinders Petrie. *Scarabs and Cylinders with Names*, 1917.

but in ancient times doubtless other kinds of turtle and possibly also the land tortoise were used. A sea turtle is found both on the Mediterranean and Red Sea coasts of Egypt, and a small land tortoise in Sinai and possibly in the western desert, and the remains of very large land tortoises of Eocene times have been found in the Fayum province. A few objects of tortoise-shell have been found in ancient Egyptian graves, among which may be mentioned part of a ring,¹ several bracelets,^{1, 2, 3} a dish,³ and a sound-board for a small harp,⁴ as also several complete shells.^{5, 6} Some of these objects are of Predynastic date and others as late as the Eighteenth Dynasty.

¹ J. E. Quibell. *Archaic Objects. Cat. Gen. des Ant. Egypt. du Musée du Caire.*

² G. A. Wainwright. *Balabish.*

³ D. Randall Maciver and A. C. Mace. *El Amrah and Abydos*, 1902.

⁴ *British Museum Guide.*

⁵ Earl of Carnarvon and Howard Carter. *Five Years' Explorations at Thebes.*

⁶ Gaillard et Daressy. *La Faune Momifiée de l'Antique Egypte. Cat. Gen. du Musée du Caire*, 1905.

CHAPTER XII

SUMMARY

From what is known about a people, to trace their gradual growth from a primitive state to one of advanced civilization is a task for the historian, and the author has no intention of trespassing in this matter, but he hopes he may be pardoned if he endeavours to piece together, very briefly and in a very elementary manner, the most important of the facts he has recorded and to give some little indication of their bearing upon the condition of the ancient Egyptians and upon their intercourse with other nations.

Ancient Egyptian history, like that of many other countries, may roughly be divided into a Stone Age, a Copper Age, a Bronze Age, and an Iron Age, each in turn gradually giving place to the next. The distinguishing feature of these several periods was not the mere employment of stone, copper, bronze, or iron, as the case might be, since each of these was employed in all the

succeeding periods and was even known as a curiosity and occasionally used in the preceding period, but it consisted in the use of the special material, after which it is named, for weapons and tools.

The transition from the Stone Age in Egypt began when the metal copper was first smelted from its ore, doubtless originally an accident, but deliberately repeated when the importance of the result was recognized. The first production of copper in Egypt, so far as is at present known, was also its first production in the history of the world, since in every other country copper appears at a later date. This discovery took place some considerable time before 3400 B.C. and probably before 4000 B.C., and by the early Dynasties the mining and smelting of copper and its use for weapons and tools had become well established. The roots of this industry extend back to the earliest period when malachite, a copper ore, was first used as a green pigment for painting round the eyes, since there can be little doubt that it was this malachite that in some way ultimately led to copper. Other countries besides Egypt had copper ore, but, making no use of it, they missed the opportunity of discovering the metal

that lay hidden within, while in Egypt malachite was in common use, and sooner or later it was almost bound to happen that it would be accidentally heated in a wood or charcoal fire in such a manner as to produce copper.

Copper ores occur both in Sinai and in the eastern desert, and although both sources were worked anciently, it was from the former that the ore employed for the first production of copper was obtained, and by inference this locality, too, was the source of the Predynastic malachite. Southern Sinai, where the copper mines are situated, lies geographically between the Nile valley and Arabia, though not on the direct route, and is well away from the road between Egypt and Palestine and Syria, but whether these facts have any bearing on the discovery of copper cannot be stated.

Closely following and consequent upon the use of copper tools came the phenomenal working of stone for building tombs and the mortuary temples attached to them that was such a marked feature of the Third and Fourth Dynasties, and the oldest and largest stone buildings in the world to-day are the pyramids belonging to that period. This stone-working was the natural outcome of

the need felt at the time for constructing tombs that should be as permanent as human ingenuity could make them, and it was rendered possible by the abundance of suitable stone in the country and by the possession of copper tools to work it.

The next great landmark in the progress of Egyptian civilization was the use of bronze, some 2,000 years or more after the discovery of copper, and since tin, which is an essential constituent of bronze, does not occur in Egypt, bronze therefore must have been introduced in the first instance from abroad, though later it was probably made in the country, using imported tin. Bronze being harder than copper and having a lower melting-point is in these respects the superior metal, and as a consequence it gradually displaced copper for many purposes, the Copper Age being succeeded by a Bronze Age, which dates certainly to the Twelfth Dynasty (2000 to 1788 B.C.), probably to the Eleventh Dynasty (2160 to 2000 B.C.), and possibly even somewhat earlier.

Another important peak in the graph that represents the growth of Egyptian civilization was the regular production of glass, a material for which Egypt became justly famous, and which, so far as present evidence

goes, dates from about the beginning of the Eighteenth Dynasty (1580 B.C.), though probably small objects, such for example as beads, may have been made occasionally before that time. By the middle of this Dynasty the technique of glass-working had reached a high standard of excellence. Glass is the almost inevitable outcome of glaze, a purely Egyptian invention dating back to the Archaic period, and may reasonably be assumed to be of Egyptian origin until definite evidence of its manufacture elsewhere at an earlier date than in Egypt is found. The materials for making glass occur plentifully in the country.

Another event that merits attention is the regular use of iron, which eventually supplanted bronze for weapons and tools, the Bronze Age thus giving place to an Iron Age. This occurred about 800 B.C., by which time Egypt was decadent, and even iron could not restore to the country the supremacy it had lost. A number of instances of iron in Egypt are known long before the metal passed into common use, but the earlier of these sporadic examples were possibly not smelted from ore, but made from small specimens of metal of meteoric or terrestrial origin found accidentally in the country, and

the later of such occasional specimens were probably received from abroad as valuable presents or imported as curiosities. Although iron ores of good quality occur abundantly in Egypt, and although a particular kind of iron ore, hæmatite, was employed as early as the Archaic period, it was only for shaping into beads, amulets and other small objects, and there is no evidence that the Egyptian iron ores, which are found both in Sinai and in the eastern desert, were worked until Roman times and then only in the latter locality and to a small extent, and the iron used in Egypt, except possibly the few earlier examples referred to, was undoubtedly of foreign origin.

Although Egypt is somewhat isolated geographically, and was still more isolated in ancient times on account of the very considerable difficulties of communication between one country and another that then existed, and although it was self-contained and self-supporting and needed no outside help, either for the necessaries or for most of the luxuries of life, yet it was not cut off absolutely from the rest of the world, and two examples of the result of intercourse between Egypt and its neighbours, namely, bronze and iron, have already been mentioned.

But in addition to these, other foreign articles also found their way into Egypt, though, until a comparatively late period, such imports were few in number and small in quantity, the greater proportion of the materials used being of local origin. Thus the building materials were all local; glaze, glass and pottery were all made in the country from native materials; the metals, copper, electrum, gold, and lead, all occur in the country, some as ores and others in the metallic state; the oils, fats and beeswax used were native products; most of the pigments were naturally occurring minerals, or were made from such minerals; the precious and semi-precious stones employed, with one exception (lapis lazuli), were of local origin, as were also the ornamental and monumental stones, except jade (or jadeite), yellow jasper, and obsidian; the textile fabrics were woven in Egypt from fibres that grew in the country; the skins made into leather were local, and the dyes with which the textile fabrics and the leather were coloured were Egyptian products.

Not only, however, were the materials employed in the ancient Egyptian industries largely of native origin, but most of the industries originated and developed without

foreign influence, for example, brick-making, stone-working, the making of glaze, glass, faience and pottery, copper smelting and working, gold extraction and working, oil-pressing, the extraction and preparation of pigments, the cutting and setting of precious and semi-precious stones, spinning, weaving, tanning, dyeing, and many other arts and crafts. Some of these, however, are of such a nature that they develop independently in any country where the circumstances allow.

The principal materials imported into Egypt will now be considered, but only those received up to the early part of the Eighteenth Dynasty, about which time began a much greater intercourse between Egypt and other nations, the natural result of which was a corresponding increase in the import of commodities from abroad, which after the Egyptian foreign conquests included a large number of articles received as tribute or taken among the spoils of war. The imports before the date mentioned, taking them in alphabetical order, were chiefly bronze, emery, gold, iron (occasionally and in small quantity), ivory, jade (or jadeite), yellow jasper, lapis lazuli, obsidian, orpiment, resin, and wood. Of

these emery, gold, ivory, jade (or jadeite), lapis lazuli, obsidian, certain kinds of resin and at least one kind of wood (ebony) were all known in Archaic times, that is before or about 3000 B.C.; bronze was introduced not later than about 2000 B.C., yellow jasper and orpiment in the Eighteenth Dynasty, probably before 1400 B.C., isolated specimens of iron at various dates until about 800 B.C., when it became common, and wood at practically all periods, except the very earliest.

The countries of origin of these various materials are very instructive. Bronze almost certainly came from western Asia; emery probably from Asia Minor or the adjoining Ægean islands, where it occurs plentifully; gold, in relatively small amount compared with the local production,¹ probably from the Sudan, and possibly also from Arabia or Abyssinia, in which latter country alluvial gold is still worked; iron from Asia Minor; ivory from the Sudan; jade probably from Turkestan; yellow jasper probably from Asia Minor, where it occurs near Smyrna, though it is also stated to be found in Sicily; lapis lazuli probably from Persia; obsidian

¹ Lower Nubia with its gold is considered to be part of Egypt, as explained in the Preface.

probably from Asia Minor, where it is found in the Caucasus region, though it also occurs in southern Europe and in Abyssinia; orpiment probably from Asia Minor; of the resins used, some kinds, such as myrrh, came from Arabia or Somaliland, and other kinds, such as those from coniferous trees, probably from western Asia; and wood, except ebony, which came from the Sudan or Abyssinia, from western Asia. Thus of the foreign products used in ancient Egypt, a few were obtained from the south, but the greater proportion probably came from western Asia, and many of these from Asia Minor.

It is worthy of note that so far as can be ascertained there was not any material used in ancient Egypt up to about the time of the Eighteenth Dynasty of Indian origin, except possibly indigo (the date of the use of which in Egypt is uncertain, but probably not before the Eighteenth Dynasty), though India and Ceylon possessed, among other commodities, odoriferous resins and precious and semi-precious stones, materials that were in great demand in Egypt and that are of small bulk and easily transported. That the early specimens of iron, or that any iron, used in Egypt came from India, as has been

stated,^{1, 2} finds no support whatever, and the earliest iron yet known in India is much later than that from Asia Minor.

There is no evidence either of any early intercourse between Egypt and China, which country is sometimes suggested as the home of bronze, and the earliest datable Chinese bronze is of the Thirteenth Century B.C.³ The jade and jadeite, used so extensively in China, are not of Chinese origin.

Intercourse with foreign countries means not only the import of certain commodities, but also the export of other commodities, more particularly as at the time under consideration coined money was unknown and barter was the only means of exchange. Since Egypt was the only country from which copper could have been obtained for some time after its discovery, and since Egypt was the principal gold-producing country of the ancient East, it must have been from Egypt that the two most important metals of antiquity, copper and gold, were at first largely derived, and although

¹ Sir R. Hadfield. *J. Iron and Steel Inst.*, No. 1, 1912.

² J. de Morgan. *Les Origines de l'Egypte*.

³ J. H. Breasted. *J. Amer. Orient. Soc.*, Vol. 39, 1919.

the copper resources of other countries, particularly of northern Syria and Cyprus, were discovered and exploited later and the Egyptian copper mines abandoned, this was not the case with gold, of which Egypt continued to supply a large part down to a very late period, since its production in western Asia was relatively small. Other articles also doubtless found their way abroad even in early times, as they certainly did later, and ancient Egyptian objects have been discovered in Crete, Greece, Cyprus, Asia Minor, Syria, and Palestine, among other places.

But more valuable to other nations than the material objects they acquired was the knowledge obtained from the Egyptians regarding various industrial processes, such as, to mention the four most important, the treatment of copper ore to produce copper, probably the making of glaze and glass, and certainly the production and use of papyrus. To what extent, however, other countries borrowed from Egypt or developed independently is a matter outside the scope of the present book.



APPENDIX I

CHRONOLOGY

<i>Period.</i>	<i>Dynasty.</i>	<i>Date.</i>
Paleolithic . . .	—	Undatable.
Neolithic . . .	—	Undatable.
Archaic Period . . .	{ Predynastic	Before 3400 B.C.
	{ I and II	3400 to 2980 B.C.
	{ III	2980 to 2900 B.C.
Old Kingdom . . .	{ IV	2900 to 2750 B.C.
	{ V and VI	2750 to 2475 B.C.
Period of which little is known.	VII to X	2475 to 2160 B.C.
Middle Kingdom.	XI and XII	2160 to 1788 B.C.
Period of which little is known ¹	XIII to XVII	1788 to 1580 B.C.
	XVIII	1580 to 1350 B.C.
New Kingdom or Empire . . .	{ XIX	1350 to 1200 B.C.
	{ XX	1200 to 1090 B.C.
Period of which little is known.	XXI to XXV	1090 to 663 B.C.
Late Egyptian Period . . .	XXVI	663 to 525 B.C.
Persian ² . . .	XXVII to XXX	525 to 332 B.C.
Greek (Ptolemaic)	—	332 to 30 B.C.
Roman ³ . . .	—	30 B.C. to A.D. 640
Arab . . .	—	A.D. 640

¹ Includes the period of Hyksos domination.

² Includes a brief period of Egyptian rule in the Thirtieth Dynasty.

³ Includes the Byzantine period.

APPENDIX II

COPIES OF THE DECLARATIONS RELATIVE TO THE FINDING OF A PIECE OF IRON AT THE GREAT PYRAMID OF GIZA ¹

1

“ . . . Mr. Hill discovered a piece of iron in an inner joint near the mouth of the southern air-channel . . . ”

2

“ This is to certify that the piece of iron found by me near the mouth of the Air-passage in the southern side of the Great Pyramid at Gizeh on Friday, May 26th, was taken out by me from an inner joint after having removed by blasting the two outer tiers of the stones of the present surface of the Pyramid, and that no joint or opening of any sort was connected with the above-mentioned joint by which the iron could have been placed in it after the original building of the Pyramid. I also showed the exact spot to Mr. Perring on Saturday, June 24th.”

Signed. J. R. HILL.
Cairo, *June 25th*, 1837.

3

“ To the above certificate of Mr. Hill I can add that since I saw the spot at the commencement of the blast-

¹ Col. Howard Vyse. *The Pyramids of Gizeh*, Vol. I, 1840.

ing there have been two tiers of stones removed, and that if the piece of iron was found in the joint pointed out to me by Mr. Hill and which was covered by a larger stone partly remaining it is impossible it could have been placed there since the building of the Pyramid."

Signed. J. S. PERRING, C.E.
Cairo, *June 27th*, 1837.

4

"We hereby certify that we examined the place whence the iron in question was taken by Mr. Hill and we are of opinion that the iron must have been left in the joint during the building of the Pyramid and that it could not have been inserted afterwards."

Signed. ED. S. ANDREWS.
JAMES MASH, C.E.

APPENDIX III

CHEMICAL ANALYSES

MODERN EGYPTIAN GYPSUM ¹

	%	%	%
Sand	7.6	3.7	2.1
Gypsum	75.4	85.2	89.9
Carbonate of lime, etc.	17.0	11.1	8.0
	<hr style="width: 100%;"/>	<hr style="width: 100%;"/>	<hr style="width: 100%;"/>
	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

ANCIENT EGYPTIAN GYPSUM MORTAR ¹

	<i>Early Dynastic</i> (19 samples).		<i>XIth Dyn.</i> (1 sample).
	<i>Min.</i>	<i>Max.</i>	
	%	%	%
Sand	2.0	25.5	36.0
Gypsum	23.4	97.3	45.0
Carbonate of lime, etc.	0.7	71.8	19.0

ANCIENT EGYPTIAN LIME MORTAR (ROMAN) ¹

	<i>(4 samples.)</i>	
	<i>Min.</i>	<i>Max.</i>
	%	%
Sand	22.3	73.5
Lime	10.1	34.7
Carbon dioxide, etc.	16.4	43.8

¹ Analyses by the author.

NORMAL PLASTER FROM THEBAN TOMBS ¹

	XVIIIth Dyn. (13 samples).		XIXth Dyn. (4 samples).		XXth Dyn. (2 samples).	
	Min.	Max.	Min.	Max.	Min.	Max.
	%	%	%	%	%	%
Sand . . .	9.0	17.0	15.0	30.0	14.0	27.0
Gypsum . .	15.5	85.5	36.9	42.7	34.6	83.3
Carbonate of lime, etc. .	tr.	67.5	29.5	45.2	2.7	38.4

LIGHT COLOURED PLASTER FROM THEBAN TOMBS ¹

	XVIIIth Dyn.		XIXth Dyn.	
	%		%	
Sand			11.0	32.0
Gypsum			1.5	9.6
Carbonate of lime, etc.			87.5	58.4
			<u>100.0</u>	<u>100.0</u>

ANCIENT EGYPTIAN FAIENCE

	A. ² %	B. ² %	C. ² %	D. ¹ %
Silica	94.00	94.18	94.18	99.6
Alumina	1.80	0.59	1.93	} 0.3
Oxide of iron	0.89	1.64	0.28	
Lime	2.00	1.73	1.60	
Magnesia	1.05	1.82	0.05	—
Alkalies	0.25	—	1.11	—
Loss on ignition	0.11	0.04	1.00	—
	<u>100.10</u>	<u>100.0</u>	<u>100.15</u>	<u>100.2</u>

¹ Analyses by the author.² W. Burton. Ancient Egyptian Ceramics. *J. Royal Soc. of Arts*, Vol. LX, 1912. Other analyses of faience may be found in (a) *Les Pastes Ceramiques I Els Esmalts Blaus de l'Antic Egipte*, by J. L. I. Artigas, Barcelona, 1922, and (b) *Contribution a l'étude de la Ceramique Orientale. Mem. de l'Inst. Egypt.*, Tome IV, 1901, by Dr. D. Fouquet.

ANCIENT EGYPTIAN GLASS ¹

	XVIIIth Dyn.		XXth Dyn.		Persian.		Byzantine.		
	(5 samples)		(3 samples)						
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Silica	68.3	68.0	59.0	60.7	58.7	60.4	57.9	58.0	60.1
Oxides of iron and aluminium	3.2	4.0	2.3	3.9	3.1	5.0	5.3	5.0	3.8
Lime	4.9	5.0	3.4	3.9	3.7	3.8	5.4	5.6	5.1
Magnesia	1.0	0.9	2.6	3.0	1.8	2.2	1.1	1.0	1.0
Potash	2.0	2.2	29.8	30.5	1.4	1.4	29.7	29.9	28.7
Soda	20.2	19.4			28.3	29.1			
Oxide of manganese	0.3	0.3	0.4	0.7	0.4	1.0	0.4	0.4	1.1
Oxide of cobalt	—	—	tr.	tr.	0.0	tr.	—	tr.	—
Oxide of copper	—	—	—	—	0.0	tr.	tr.	0.0	tr.
	<u>99.9</u>	<u>99.8</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>99.8</u>	<u>99.9</u>	<u>99.8</u>

ARAB GLASS FROM FOSTAT ²

	Blue. %	Green. %	Green. %	Green. %
Silica	71.2	70.5	66.3	49.4
Phosphoric anhydride	0.3	0.6	0.6	1.2
Oxide of iron	1.4	1.9	4.6	{ 8.6 14.5
Oxide of aluminium.	1.0	0.8		
Lime	8.1	7.8	10.5	18.7
Magnesia	3.2	1.2	1.0	1.4
Potash	2.1	tr.	3.8	3.5
Soda	11.4	16.1	11.1	2.4
Oxide of manganese.	1.2	1.1	2.4	0.3
	<u>99.9</u>	<u>100.0</u>	<u>100.3</u>	<u>100.0</u>

¹ H. D. Parodi. *La Verrerie en Egypte*, Cairo, 1908. Analyses slightly rearranged.

² Analyses by J. Clifford, F.I.C., in the author's laboratory.

ANCIENT EGYPTIAN GLASS ¹

	XVIIIth Dyn.		Græco-Roman.		Alexandrian.	
	Min. %	Max. %	Min. %	Max. %	Min. %	Max. %
Silica .	50.90	65.93	55.63	68.12	67.47	68.45
Oxide of iron	0.44	1.08	0.28	9.98	0.14	0.89
Oxide of alu- minium .	0.65	3.00	1.94	5.00	3.85	4.98
Lime .	7.00	10.60	1.51	10.69	9.92	10.30
Magnesia .	2.54	5.20	1.23	3.42	0.76	1.18
Potash .	0.41	7.36	0.37	7.55	0.13	0.21
Soda .	14.86	22.66	0.92	28.98	14.79	15.36
Oxide of man- ganese .	—	0.89	—	0.97	0.51	0.75
Oxide of cop- per .	—	12.02	—	4.40	—	0.31
Oxide of lead	—	0.47	—	6.28	—	—
Oxide of tin	—	0.47	—	0.54	—	—
Sulphur tri- oxide .	—	5.46	—	1.80	—	—

ANCIENT EGYPTIAN COPPER

The results of 56 analyses of ancient Egyptian copper objects have been traced. These comprise 24 analyses by Professor J. Sebelien,² which are the most complete and satisfactory analyses of ancient metal objects that have been published; 19 analyses by Berthelot³; 8 analyses by Dr. Gladstone, F.R.S.⁴; 1 analysis by Dr.

¹ Analyses by B. Neumann and G. Kotyga. *Z. Angew. Chem.*, 1925. Slightly rearranged.

² Early Copper and its Alloys. *Ancient Egypt*, 1924.

³ Quoted by J. de Morgan in *Les Origines de l'Égypte*, 1896 and 1897, and in *Fouilles à Dahchour*, 1895.

⁴ *Proc. Biblical Arch.*, Vols. XII and XIV. Also quoted by W. M. Flinders Petrie in *Illahun, Kahun and Gurob*, and by J. E. Quibell in *El Kab*.

Percy¹; 1 analysis by G. Brinton Phillips²; 1 analysis by the author,³ and 2 of which the analyst is not quoted.⁴

It would not serve any useful purpose to reproduce the analyses in detail and therefore a summary of the nature and proportions of the impurities only will be given. These are as follows:

<i>Impurities</i>	0·0	0·0 to 0·5 %.	0·5% to 1·0 %.	1·0% to 2·0 %.	<i>More than 2 %.</i>
Tin . . .	43	12	1	—	—
Arsenic . .	30	19	3	—	4
Antimony .	49	7	—	—	—
Bismuth . .	48	8	—	—	—
Iron . . .	34	16	3	2	1
Zinc . . .	48	8	—	—	—
Lead . . .	51	3	2	—	—
Nickel and Cobalt . .	53	3	—	—	—
Sulphur . .	55	1	—	—	—

Notes to Table.—

(a) 0·0 = recorded as absent or not recorded as present.

(b) The numbers in the vertical columns represent the number of specimens that contained the percentage of impurity shown at the head of the column.

¹ Quoted by Dr. Gladstone.

² *The Composition of some Ancient Bronzes.* Quoted in a Review in *Ancient Egypt*, 1924.

³ Quoted by J. E. Quibell in *The Tomb of Hesyt*, 1913.

⁴ Quoted by J. W. Mellor in *Inorganic and Theoretical Chemistry*, Vol. III, 1923.

ANCIENT EGYPTIAN BRONZE

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.
	%	%	%	%	%	%	%	%	%	%	%	%
Copper	89.8	76.7	86.2	85.8	68.4	69.2	85.9	96.4	89.6	90.1	89.8	88.0
Tin	9.1	8.2	5.7	3.5	16.3	9.8	12.1	2.2	6.7	7.3	3.1	12.0
Lead	—	5.7	nil	8.5	nil	—	0.8	—	—	—	—	0.1
Antimony	tr.	nil	—	—	—	—	—	—	tr.	tr.	tr.	tr.
Arsenic	0.5	tr.	nil	—	nil	nil	—	0.4	1.0	0.2	0.3	0.4
Bismuth	—	—	—	—	—	—	—	—	—	—	—	—
Iron	tr.	nil	nil	0.2	tr.	—	—	—	—	—	—	—
Zinc	—	nil	nil	—	tr.	—	—	—	—	—	0.4	0.3
Sulphur	tr.	—	—	—	—	—	—	—	—	tr.	—	—

Note.—All undated objects have been omitted and nothing later than the Eighteenth Dynasty has been given.

A, Analysis by Dr. Gladstone. *Proc. Soc. Biblical Arch.*, Vol. XIV. Found at Medum; stated to be of Third Dynasty.

B, Analysis by Berthelot. In *Fouilles à Dahchour*. Found at Dashur; stated to be a little after end of Third Dynasty.

C, Analysis by Berthelot. In *Fouilles à Dahchour*. Stated to be of Sixth Dynasty.

D, Quoted by G. Brinton Phillips. *Ancient Egypt*, 1924. Review. Stated to be Eleventh Dynasty.

E and F, Analyses by Berthelot. In *Fouilles à Dahchour*. Found at Dashur. Stated to be of Twelfth Dynasty.

G, Analysis by J. Sebelien. *Ancient Egypt*, 1924. Stated to be of Twelfth Dynasty.

H, I, and J, Analyses by Dr. Gladstone. *Proc. Soc. Biblical Arch.*, Vol. XII. H is stated to be Twelfth Dynasty and I and J Eighteenth Dynasty. Found by W. M. Flinders Petrie and quoted in *Illahun, Kahun and Gurob*.

ANCIENT EGYPTIAN ELECTRUM

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	
	%	%	%	%	%	%	%	%	%	%	%	
	Min.		Max.		Min.		Max.		Min.		Max.	
Gold	79.7	84.2	84.0	78.0	81.7	77.3	85.9	72.9	82.3	72.1	89.5	
Silver	13.4	13.5	13.0	18.0	16.1	13.8	22.3	20.5	14.3	17.2	11.2	
Copper	—	—	—	—	tr.	0.3	0.5	pres.	1.5	13.1	nil	

A, B, and C, First Dynasty. Analyses by Dr. Gladstone.

Quoted by W. M. Flinders Petrie in *The Royal Tombs of the Earliest Dynasties*, Part II, 1901.

D and E, Sixth Dynasty. Analyses by Dr. Gladstone. Quoted by W. M. Flinders Petrie in *Denderah*, 1900.

F to G, six specimens. Eleventh or Twelfth Dynasty. Analyses by Berthelot. *Annales du Service des Antiq. de l'Égypte*, Tome II, 1901, and quoted by J. de Morgan in *Fouilles à Dahchour*.

H, I, J and K, Eighteenth Dynasty. Analyses by W. B. Pollard in the author's laboratory. Quoted by J. E. Quibell in *The Tomb of Yuua and Thuiu*. *Cat. Gen. du Musée du Caire*, 1908.

ANCIENT EGYPTIAN GOLD

	A. %	B. %	C. %	D. %	E. %	F. %	G. %
Gold	92.3	92.2	90.5	92.7	90.0	96.4	99.8
Silver	3.2	3.9	4.5	4.9	—	1.9	—
Copper	nil	nil	nil	—	—	pres.	—
Carats	22	22	21	22	21	23	23.5

A and B, Eleventh Dynasty. Analyses by Berthelot. *Annales du Service des Antiq. de l'Égypte*, Tome II, 1901.

C, D, and E, Twelfth Dynasty. As for A and B.

F, Eighteenth Dynasty. Analyses by W. B. Pollard in the author's laboratory. Quoted by J. E. Quibell in *The Tomb of Yuua and Thuiu*. *Cat. Gen. du Musée du Caire*, 1908.

ANCIENT EGYPTIAN SILVER

	A. %	B. %	C. %	D. %	E. %
Silver . . .	74.5	69.2	82.5	84.9	92.5
Gold . . .	14.9	pres.	8.7	8.4	3.2
Copper . . .	—	—	8.9	4.3	3.9

A, Eleventh or Twelfth Dynasty. Analysis by Berthelot. *Annales du Service des Antiq. de l'Egypte*, Tome II, 1901.

B, Eleventh or Twelfth Dynasty. Analysis by Berthelot. Quoted by J. de Morgan in *Fouilles à Dahchour*.

C and D, Eighteenth Dynasty. Analyses by W. B. Pollard in the author's laboratory. Quoted by J. E. Quibell in *The Tomb of Yuaa and Thuiu*.

E, Nineteenth Dynasty. Quoted by C. R. Williams in *Gold and Silver Jewelry and Related Objects*, 1924.

NATRON ¹

	From Wadi Natron. (10 samples.)		From Upper Egypt. (3 samples.)	
	Min. %	Max. %	Min. %	Max. %
Carbonate of soda . . .	22.4	75.0	11.0	13.6
Bicarbonate of soda . . .	5.0	33.8	1.5	9.5
Common salt . . .	4.3	26.4	12.3	57.3
Sulphate of soda . . .	0.8	39.3	11.4	70.2

¹ Analyses by the author.

NATRON FROM TOMBS ¹

	XIXth Dyn.		XVIIIth Dyn.	
	%		%	
Carbonate of soda . . .	36.9	16.1	10.7	9.2
Bicarbonate of soda . . .	8.3	10.7	11.9	6.3
Common salt . . .	9.9	25.2	18.2	39.3
Sulphate of soda . . .	33.9	27.8	12.4	13.2

These four samples contained sand in proportions varying from about 5 to about 25 per cent. and one was also mixed with about 16 per cent. of sawdust.

EGYPTIAN BLUE FRIT

	A.	B.	C.
	%	%	%
Moisture	1.6	—	—
Silica	57.2	63.4	70.0
Copper oxide	18.5	19.5	18.3
Oxides of iron and aluminium	0.8	—	0.3
Lime	13.8	14.4	9.4
Magnesia	0.5	—	—
Potash	nil	1.2	2.0
Soda	7.6	0.9	
	<u>100.0</u>	<u>99.4</u>	<u>100.0</u>

A, Nineteenth Dynasty. Analysis by the author.

B, Analysis of specimen prepared by Laurie, McLintock and Miles in imitation of Egyptian material. *Proc. Royal Soc., Series A*, Vol. 89, 1914.

C, Analysis by J. K. Crow. *Annales du Service des Antiqu. de l'Egypte*, Tome IV, 1903.

¹ Analyses by the author.

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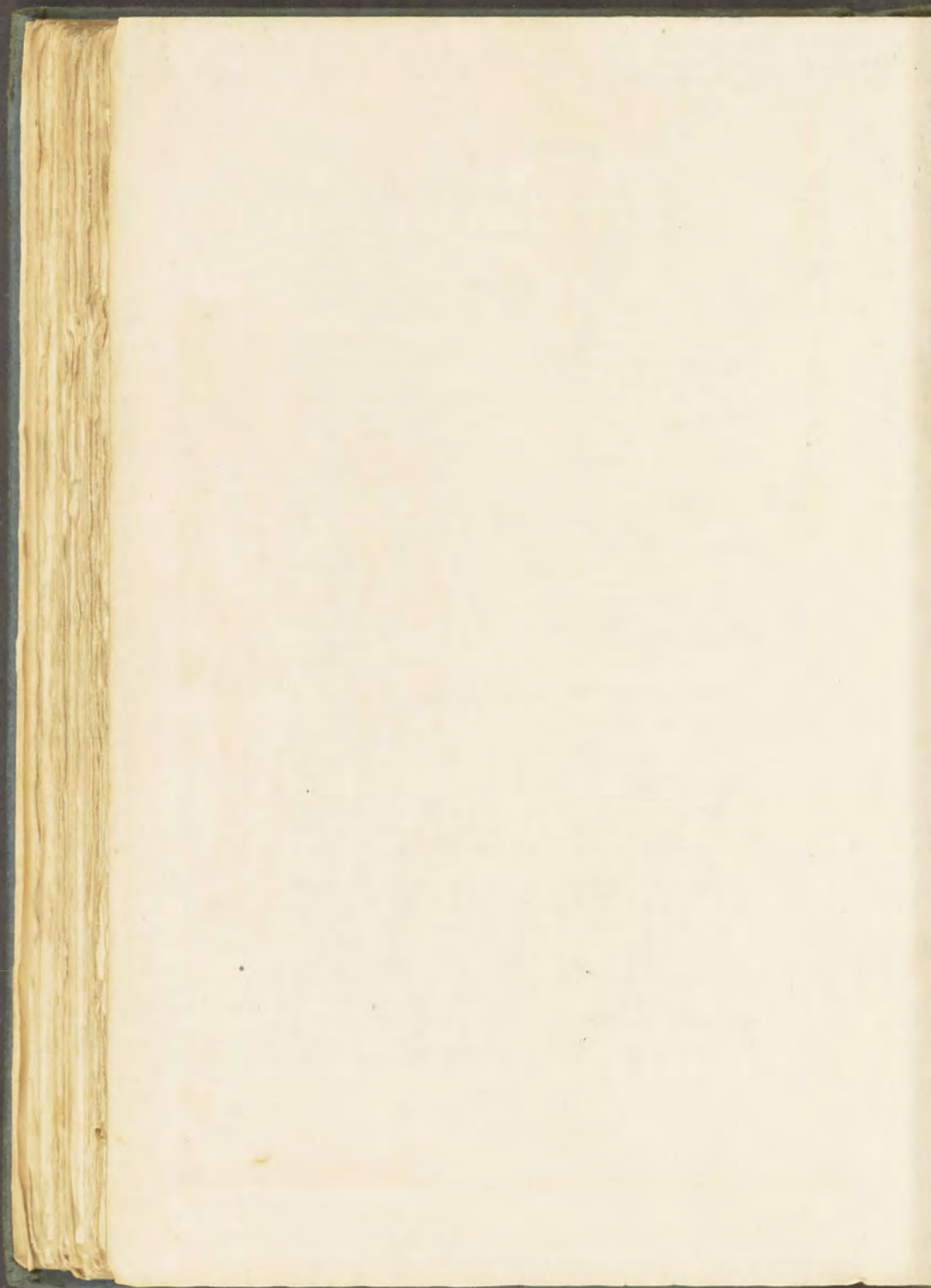
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