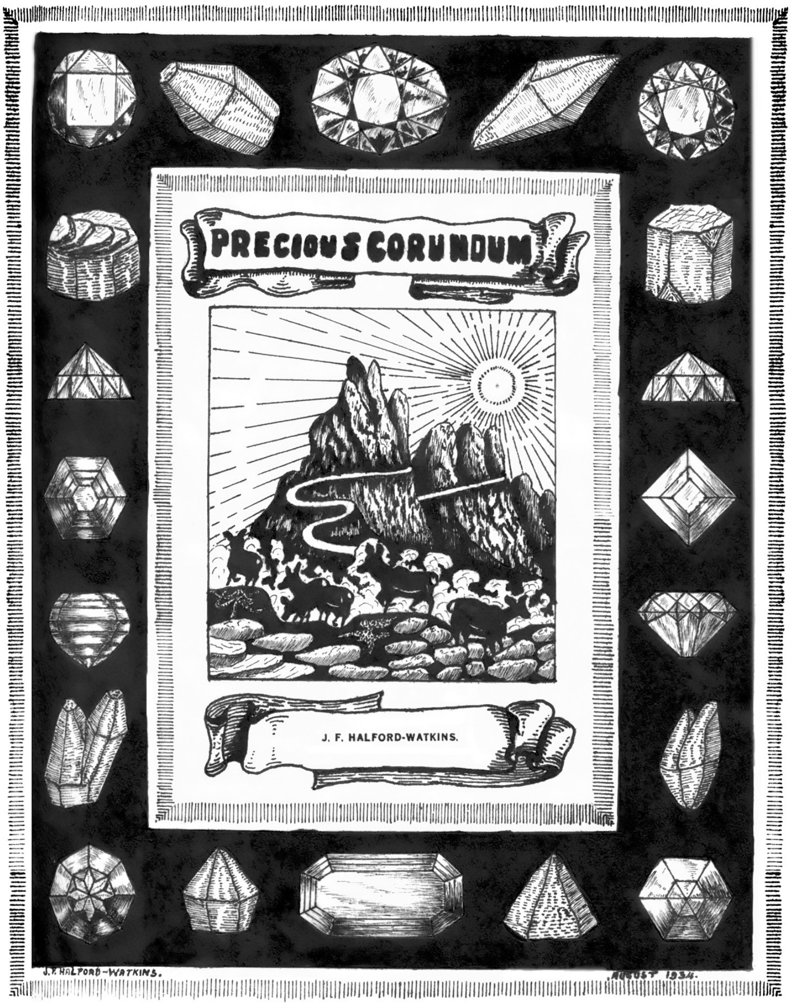
THE BOOK OF RUBY & SAPPHIRE



Frontispiece from the original manuscript.

THE BOOK OF RUBY & SAPPHIRE

Being a Description of the Minerals of the Corundum Group Used for Gem Purposes

By

Col. J.F. Halford-Watkins

Late Deputy Agent and Valuer to the
Burma Ruby Mines, Ltd.
Author of Practical Gemmology,
Identification Tables for Gemstones, etc., etc.

Edited by
Richard W. Hughes
with
Wimon Manorotkul
Marcus Origlieri
Phyllis J. Hughes

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'the price of wisdom is beyond rubies' Job 28:18

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RWH Publishing & Books
52/94 Langsuan Road
Bangkok 10330, Thailand
Tel: +66 (0)8 3988 0539
E-Mail: rubydick@ruby-sapphire.com
Web: www.ruby-sapphire.com

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Dedication

The world is a book;
Those who do not travel, read but a page.

St. Augustine

We dedicate this volume to all those who, when gazing upon ocean shore, see not black water, but visions of lands magical across the seas.

Richard Hughes
Wimon Manorotkul
Marcus Origlieri
Phyllis J. Hughes

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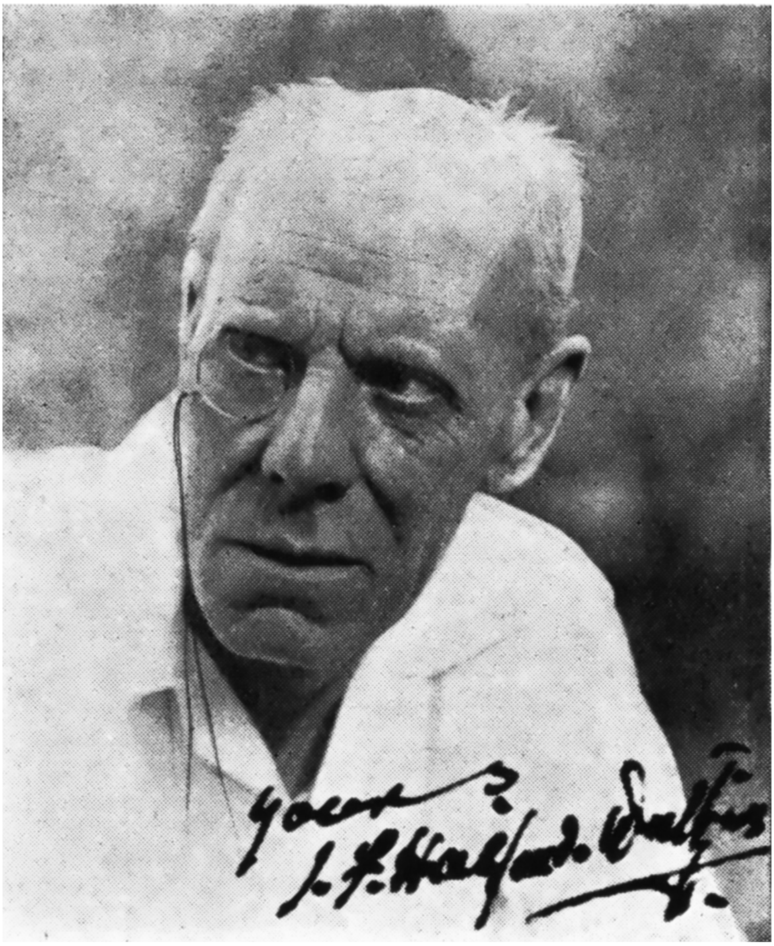
***	Illustrations not called out in the original manuscript, but added by the current editors to enrich the reading experience



Portrait of J.F. Halford-Watkins (from the *Gemmologist,* Jan., 1938).

INTRODUCTION

I hate quotations. Tell me what *you* know.

Ralph Waldo Emerson, *Journals,* May 1849

One of the great pleasures of historical research is the thrill in uncovering undiscovered masterpieces, arcana that somehow dripped unnoticed through the cracks of time. I say this with full awareness; the statement comes from someone who has spent decades opening shells with pitifully few pearls to show for the labor.

During the later stages of the research for my book, *Ruby & Sapphire*,[1] I came across a reference to an obscure manuscript in a wonderful book about the famous London jeweller, Edwin Streeter, written by his great grandson, Patrick.[2] Apparently the library of the Gemmological Association and Gem Testing Laboratory of Great Britain (GEM-A) contained an entire volume on ruby and sapphire written by one J.F. Halford-Watkins [b. date unknown; d. 1937].

The name was not new. Halford-Watkins had spent several decades living at the famous ruby and sapphire mines of Mogok, Burma, and had authored a number of classic papers on the subject. I *knew* this gent. And the prospect of an entire unpublished manuscript on ruby and sapphire lying dormant in an obscure London bibliotheca had me enthralled.

Plans were quickly laid to obtain a copy. Through the fine efforts of my friend, Robert Frey (R.I.P.), and the cooperation of the GEM-A library, a photocopy was procured and sent speeding to my door.

I will never forget the moment the package arrived. But a brief glance demonstrated that herein lay a work of incredible depth and value. So many books are based upon secondary sources or brief visits to an area, but here – *on my desk* – lay the real deal. *Lordy!* An entire monograph from someone who had spent the better part of his adult life in ruby Mecca, Mogok, Burma. No quotations. Just straight talk from someone who knew. *Double lordy!*

1 Hughes, R.W. (1997) *Ruby & Sapphire*. Boulder, CO, RWH Publishing, 512 pp.

2 Streeter, Patrick (1993) *Streeter of Bond Street: A Victorian Jeweller.* Harlow, UK, Matching Press, 174 pp.

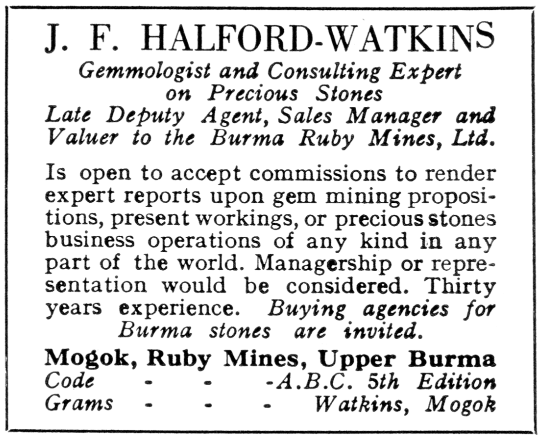
The man

What follows is the brief obituary published in the January 1938 issue of the *Gemmologist*:

> Our saddest task as the new year opens is to inform our readers of the death of Lieut. Col. J.F. Halford-Watkins, on November 9th.
>
> We have no precise details yet of this happening, merely a note of the sad event from Mrs. Halford-Watkins, saying that it occurred at Mogok on the above date.
>
> All readers of the *Gemmologist* will recall the many learned and yet genial articles that Halford-Watkins contributed to the paper and the many new facts he brought to light in them.
>
> Although we were only correspondence friends we were looking forward to a visit next year, when he was intending to come to England, and we had in mind arranging a fitting reception for a man who had taken so much trouble to assist us and, through the paper, every student of gemmology.
>
> We do not know how Halford-Watkins first got to hear of the *Gemmologist* but we do remember his first letter arriving. It was a revelation of intimate knowledge and enthusiastic love of gems such as we had never before encountered. His article dealing with the methods of finding rubies employed by the natives, how they moved through narrow fissures in the earth with great risk of not returning, with so little room that any find they made could scarcely be carried with them, impressed us, more than anything we had previously read, with the difficulties and dangers through which men go to provide the world with jewels.
>
> Halford-Watkins was a director of the Ruby Mines, Ltd., Mogok. Previously he was deputy-agent of the Burma Ruby Mines and in one of his articles he gave us a thrilling account of how the first discovery of rubies at Mogok was made, how it was discovered that the site of the best gem producing spot was covered by the town, so the town was promptly shifted and the mine dug. Eventually when the gems gave out, the mine went derelict and the site is now a lake.
>
> With the end of this enterprise Halford-Watkins apparently devoted himself to dealing and prospecting in other parts of the same district.
>
> He wrote us long descriptions of the trade in jade. How it was discovered in Burma, taken to China for working and shipped thence to all parts of the world. His correspondence was the liveliest thing imaginable. He would give one flashes of wit and biting sarcasm. It is our untold loss that he was never able to finish half the wonderful articles he promised to send.
>
> We recall that for the twenty-first birthday issue of the *Goldsmiths Journal* we asked him to write something special because in a letter he had mentioned his activities during the early days in the Rand gold and Kimberley diamond mines and his personal dealings with many of the "Randlords."
>
> In reply to this request, he sent us the true story of the famous Nga Mouk ruby. He told us in confidence that it had taken him years to dig the whole thing out and he gave us the right story, which was printed. He added "I could go on a little further and say where they (the Nga Mouk and other rubies) actually are now and that would be a story really worth reading, but dare not to be told."
>
> At that time he was contemplating a journey to Japan and had undertaken to send us sheaves of articles on the Japanese cultured pearl industry. To our loss, he became ill. In reply to our letters he wrote "I suddenly went down with a rather nasty go of asthma and the doctors thought the jolly old pump was prepared to jack up. So without more ado I was packed off up in the Shan Hills, and once there, I was not allowed to write or receive letters or even receive a newspaper."

In another letter he wrote that he looked upon the *Gemmologist* as a pet child and to us would come all his new information and discoveries. "In a way I am beginning to look upon several of us regular contributors (to the *Gemmologist*) as being more or less members of the same family or some special sort of club, and the paper as a channel whereby we gain an interchange of personal ideas."

Halford-Watkins was one of the most industrious workers and writers on gemmology in the world. We have in our keeping information we hoped to publish eventually, an extensive manuscript of some hundreds of pages covering the entire field of gemmology, which we were waiting to be revised and completed. Alas! now that the author is no more we fear that work may never be finished.



Small note that appeared in the *Gemmologist* during the last years of Halford-Watkins' life, advertising his services.

The eminent gemologist, B.W. Anderson, added the following in the *Gemmologist* a month later:

I can well remember the pleasure with which I received my first letter from Halford-Watkins. It was written in terms of friendliest informality, and naturally called forth a reply on the same cordial level. That was little more than two years ago; since then, at very irregular intervals, long letters and small gifts of specimens, etc., have passed between us. In his letters the breezy gusto which made his articles so readable was even more pronounced, giving the impression of a very vigorous personality.

As a gemmologist he had boundless enthusiasm, and he welcomed in the most generous fashion that quality in younger men. From the little I gathered about his past life he could have written a most exciting autobiography. Scribbled on the margins of one of his letters is a note that he was "...head of the Regent Street Polytechnic Dayschool of Engineering when the South African war broke out. I cleared out to that as an expert in X-rays for a start, finished the job in two months, and then cleared out to do a spot of real war! Fortunately I had fully qualified on the engineering side, and was going on for my B.Sc., for which I had only to sit the finals, the idea being to then go on for the D.Sc. But all that went by the board and I never

> graduated. I have an honorary degree of Doctor of Science in America, but I never use it… During the war I was on a hush-hush job, with Lawrence as one of my opposite numbers; my headquarters were at Aden for four years, and my air patrol was bounded by Addis Ababa, Cairo, Bagdad, Basra, Muskat and back to Aden! Quite interesting."
>
> It is sad to think that the last year of his life was made unhappy by the death of his partner, the death of his son, and by his own ill-health. Though I knew him only by correspondence, I feel that by the death of Halford-Watkins I have lost a loyal and warm-hearted friend.

It is unfortunate that we know little of J.F. Halford-Watkins beyond the above and his published words. Incredibly, from this distance we do not even know his full name. Was it John Frank, Jacob Fred or Johann Ferdinand? The published record gives no indication.

A web search reveals the following:

> Asst.Supt. Darryl R. Halford-Watkins, F of M Police born Burma 6/8/1922, died Ottawa, Canada 2/7/1974.

Thus it appears he had at least two children. But what else? We simply don't know. To measure the mettle of this man, we must simply take him at his words. And from these, there can be no doubt. This man.

J.F. Halford-Watkins was one of those extraordinary Englishmen who, from the time of Ralph Fitch[3] onward, seemed to multiply across the planet. Halford-Watkins was apparently involved in diamond mining in South Africa before moving to Mogok, which became his home. And in the best cowboy fashion, he died with his boots on, passing away in Burma's Rubyland on November 9, 1937.

Edits

In any older work of this type, editing choices abound. So much has changed since 1934, our knowledge of the subject has increased exponentially.

In the end, the decision was made to edit the work as if we were living in Britain during the 1930s and the manuscript were plopped onto our desks. Obviously, an editor would rewrite awkward statements, correct spelling and grammar, etc. And so we have. However we have strived to wield the red pen with a feather-light touch. All things considered, the number of changes have been surprisingly few.

3 Fitch was the first Englishman to visit Asia and return home to tell the tale. His experiences resulted in the founding of the British East India Company.

Illustrations

The manuscript contained just 31 figures, but 97 were called out in the text. Apparently Halford-Watkins was still in the process of gathering illustrations at the time of his death.

Of these 31, a handful were of such poor quality that we are unable to reproduce them here. To rectify this, we have substituted similar illustrations from a variety of other sources, carefully selecting those sympathetic with the original time period and intentions of the author.

The editing team

This work was a combined effort of several people. First of all, my lovely wife, Wimon Manorotkul. What can I say? In my time on this planet, I have yet to meet a more beautiful human being.

Second was Marcus Origlieri, a California mineralogist and computer expert who helped this project with typing, editing, printing and miscellaneous elbow grease. Indeed, this project came about when I mentioned the manuscript to Marcus. He immediately said: "Let's publish it!" And so it was.

Third was my dear mother, Phyllis Hughes, who carefully proofed the manuscript. She is the best.

Acknowledgements

Of tremendous help was William Larson of Pala International, mineral and book collector *extraordinaire*, who provided editorial and illustration assistance. Bill Larson's personal mineralogical/gemological library is one of the finest in the world, including a particular strength in Burmese precious stones.

John Saul of Paris, France, helped in proofing the typeset manuscript. *Merci!*

We would also be remiss if we did not acknowledge the assistance provided by Ian Mercer and Michael O'Donoghue of the Gemmological Association of Great Britain. When we informed them of our intentions to publish the Halford-Watkins manuscript, they immediately set to work assisting us in obtaining information about the author, along with his original manuscript photos. We send a big note of thanks for their hard work and cooperation.

I would like to extend a very special thanks to John Emmett of Brush Prairie, Washington. Not only did John provide the needed swift kick in

my hindquarters to finish the project, but he has also helped me understand that the path of science is a commitment to the egalitarian spread of knowledge. This gift is beyond words, beyond value. Thank you, John.

The George Skelton Streeter diaries

Providence was definitely smiling upon us during this work. During the early stages, a letter landed on my desk from London, written by none other than Patrick Streeter, grandson of George Skelton Streeter (who accompanied the first British expedition to the Mogok ruby mines in 1887). It was from Patrick's book, *Streeter of Bond Street,* that I first learned of the Halford-Watkins manuscript. He had obtained a copy of my book, *Ruby & Sapphire,* and sent me a letter mentioning that he had his grandfather's diaries from his 1887 visit to Mogok, along with the original photographs of the expedition. When I explained our intent to publish the Halford-Watkins manuscript and suggested that his grandfather's work would form a valuable addition, Patrick generously agreed to edit his grandfather's diaries, as well as permit the reproduction of G.S. Streeter's original photographs, and these are found in Appendix C. The photos are of particular importance, for, to the best of our knowledge, they are the first photographs ever taken in the Mogok Stone Tract. Scholars take note. It was from these photos that the excellent woodcuts from the *Illustrated London News* and *London Graphic* were produced.

On knowledge and knowing

I've spent much of my life dipping deep into works both ancient and modern. So many shells, so few pearls.

What you now hold is a sublime creation, a genuine jewel, one which occurs only once in a great while. For the editors, its publication has been a labor of love. We hope you too find beauty in its pages. Treasure it, for pearls are but dew drops from heaven sent…

Richard W. Hughes
Bangkok, Thailand
2009

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THE BOOK OF RUBY & SAPPHIRE

I

EARLY HISTORY AND BELIEFS

Derivation of names ⚜ Early confusion of species ⚜ Early writings ⚜ Early superstitions ⚜ Modern superstitions ⚜ Burmese superstitions ⚜ Early confusion of colour varieties ⚜ Supposed early source of origin ⚜ Early nomenclature

The word corundum conveys but little to the average person save possibly to call to mind a high-class grindstone, or a form of emery; little do they realize that it is the family name for a number of stones used for gem purposes, some of which are the most esteemed and valued in the whole category of gemstones. It is the mineralogical name for a mineral compound of aluminium and oxygen commonly known to the chemist as alumina, which occurs in nature in a variety of forms and colours, and is designated by a number of common names, under which it will be found to constitute a large proportion of the stock-in-trade of the average jeweler and dealer in gems. The best known of these varieties are the ruby and sapphire, and the crude commercial form under its humble name of emery, but intermediate between these there are a range of very beautiful gemstones which are in fairly common use, but about which comparatively little is known.

The mineral in gem form was first introduced into Europe from India, where it was known by the name of korund, an ancient Hindi word of such great antiquity that its derivation, and indeed its original meaning have long since been forgotten. The word is used in the German language today, but has been corrupted by the French into corindon which is often quoted as the derivation of our own word; this would however appear to be incorrect as the two words bear but a superficial resemblance. It is much more likely that korund is itself a corruption of the far older Sanskrit word kuruvinda from which the Tamils of southern India obtained their word kurundam for the mineral, and that our own term corundum was derived from this source by the simple expedient of altering the spelling.

The word ruby came to us from the French *rubis,* which was in turn derived from the Latin *rubeus,* meaning red. Sapphire on the other hand comes direct from the Greek word σαπφειροσ *(sappherios)* meaning a blue gem, and which in the early days did not refer solely to the sapphire we know today, although it was also included in the general list to which the word refers.

There are no very clear indications as to when the gems of the corundum group first became known in ancient times, and although gems which have since been translated as both ruby and sapphire have been described from the very earliest times it is by no means clear that the actual gems described by the early writers are those recognised today as the ruby and the sapphire; in fact the general weight of evidence tends to show that they were not. Both Theophrastus and Pliny when writing of the sapphire speak of the specks of gold with which the stone was bespangled, which clearly shows that it was not the true sapphire that they were writing about, but were referring to the gold-like specks of iron pyrites to be found in practically every specimen of lapis lazuli. In the biblical references to the same stone we read in the book of Job that "Sapphire hath the dust of gold," and in Ezekiel, Exodus, and Revelation we find almost identical, and between these references centuries elapsed. It is now almost universally accepted that the sappherios of the ancients was lapis lazuli, while the true sapphire was known to them as hyacinthus and yellow corundum as chrysolithus, but the evidence upon which this supposition is based is by no means clear or convincing.

With regard to the ruby the position is even more complex still, as there was then very naturally a great deal of confusion between all the red stones of a similar appearance, and which were variously described as *carbunculous, indicus,* or *anthrax.* There is however not the slightest doubt that some of the stones so described were indeed true rubies, but on the other hand it is equally certain that there was considerable confusion between ruby, spinel, and garnet. It seems to be quite clear that the "carbunculous alabandicus" of Pliny was either a garnet or spinel, possibly both, but more probably an almandine garnet which derives its name from the town of Alabanda in Asia Minor, from whence carbuncles originally came. The description of anthrax by Theophrastus approximates most nearly the red stone we now know as ruby, but it is doubtful if the knowledge of those days was sufficiently advanced for them to distinguish between ruby and any other red stone. Even the description given by Theophrastus strongly supports this view, as he speaks of the anthrax as sometimes being of great hardness and strongly resisting the grinding efforts of the workmen, from which it is evident that more than one species of stone was then passing under the name of anthrax. The Greek word ανθραξ (anthrax) merely meant charcoal or coal, and was applied to the stones on account of their colour and general resemblance to a live coal, in exactly the same way as the Latin carbunculous, with precisely the same meaning, was applied to red stones.

The ancients held these red stones in the greatest esteem, and some proof of the value then set upon them may be found in the many references to rubies to be found in the Old Testament. They also gave them credit for possessing the power to purge the mind of all evil thoughts, and to effectively prevent their return to a person who wore a ruby. Likewise their mere possession was thought to induce an even state of mind, to produce joy, and also to prevent an over-indulgence in luxuries. Medicinally they were considered to be an antidote to all forms of poison, and to be a preventative of all kinds of sickness, while they were also believed to indicate the approach of evil or harm to their owner by changing colour. The early Indians regarded the ruby as influencing the sun, and therefore controlling the signs of the Zodiac; they also regarded it as increaser of blood in the human system, and to impart sexual strength and vigour. From a religious point of view they also held it in very high esteem.

Neither were blue stones very far behind in the high estimation of the ancients, as the numerous Biblical references to the sapphires show. They were credited with possessing extraordinary medicinal powers, which superstition prevailed until comparatively recent times. *Inter alia* they were considered to be a certain charm against unchastity, and to effectively scare away all the imps of darkness and other kindred evil spirits. It is recorded that Pope Innocent III (1161–1216) issued an edict to all his Bishops to wear a sapphire in order to conform to those superstitions. By the early Greeks the stone dedicated to Apollo, their argument being that on account of its heavenly colour and nature it would surely bring its occasion to consult the oracle. Saint Jerome (346–430 AD) also wrote that if a sapphire were worn it would protect its owner from captivity, and enable him to make peace with his enemies.

Today that the ruby will become paler on the approach of sickness or calamity, and regain its full colour once more on the passing thereof is the firm belief of many credulous persons. The ruby is the birthstone for July, and the talismanic gem for March, the sapphire being the birthstone for September, and the talismanic gem for December, being popularly supposed to bring good luck to wearers born in either of these months. This superstition originated with the ancient custom of wearing gems as charms for the purpose of averting the evil eye, and other similar misfortunes. Another curious modern superstition is regarding the appropriate luck bearing gems to be presented on the occasions of certain wedding anniversaries, at which a sapphire should be given on the 23rd, a star sapphire on the 26th, a ruby on the 40th, and a star ruby on the 52nd.

The Burmese miners have a strange superstition regarding both rubies and sapphires. They firmly believe that the stones will mature in the ground, first of all being opaque and cracked, and then becoming solid but colourless, afterwards slowly ripening in the earth until they obtain their full rich colour. Thus they speak of a pale coloured ruby as being unripe; which absurd as it may appear is perhaps not so very far wide of the mark, so far as the ruby is concerned, if we accept the radioactivity theory. They also maintain that both stones will grow in the earth like so many potatoes, and it is an almost universal custom for a native miner when he is abandoning a site as worked out to bury a few small stones in the sincere belief that they will produce a new crop for the benefit of posterity.

The ancients were early in their recognition of the extreme hardness of corundum, and as the first authenticated references to diamonds occur at a much later period, it seems but reasonable to assume that the *adamas* (meaning invincible) of the early Greeks was not the diamond at all, but the variety of colourless corundum now known as sapphire, which is sometimes confused with diamond even today.

Of the various colour varieties of corundum we have neither early history nor superstitions attached to them, owing to the stones in the early days being confused with those of other species. It is only in comparatively recent times that there has been any attempt to classify them, and even in the present classification the early confusion seems to have perpetuated as we find that many of the gem varieties still bear the name of a more lowly species to which the word *oriental* has been prefixed, as *oriental amethyst* for the beautiful purple variety of corundum.

Although Upper Burma is, and always has been, the real home of fine rubies it would appear that these deposits were quite unknown to the very early writers, and they considered that all the rubies came from India. It is certainly quite true that in those days a lot of them did do so, most probably from the deposits of Badak Shan; but it is also equally certain that a large number of them also came from Ceylon, while others were brought to India from Burma by overland traders. This is rather confirmed by the fact that the Burmese have no actual name for the ruby, merely calling it by a name which signifies a red stone. For sapphire they also use the Hindustani word *nila*, which simply means dark blue. For all the other colour varieties they now have distinctive names. For instance a pale coloured pink ruby is known by a term which signifies *soldier's face,* as they say that the colour resembles the complexion of a British soldier.

About 1658 Tavernier very truly wrote that in those days all the stones of the country were called by the name of ruby, and were only distinguished by their colour. Thus in the language of Pegu, then the center of the ruby selling industry, a sapphire became a blue ruby, and so forth. This professor [Valentine] Ball once described as "A very legitimate system of nomenclature, as they were all of the same chemical composition, *viz* alumina, or corundum," a statement which according to modern practice can only be described as erroneous.

2
CHEMICAL COMPOSITION, CRYSTALLISATION & COMMON FORMS OF OCCURRENCE

Chemical composition

Chemically corundum is one of the least complex of the gemstones, consisting merely of a simple oxide of the metal aluminium and the gas oxygen, known to the chemist as *alumina,* and designated by the chemical formula Al_2O_3; the constituent proportions being aluminium 53.80% and oxygen 46.80%.

When absolutely pure, alumina is colourless and perfectly transparent, but in the coloured varieties analysis will invariably reveal traces of impurities. These are smaller in amount in proportion to the lighter the shade, and the nearer the specimen approximates to perfect clearness, and greater and darker the colour, and as the specimen becomes translucent, invariably being highest in quite opaque stones.

In the transparent gem varieties any one of these impurities will seldom be found to exceed 1.75% of the total weight, and will usually be considerably less. The impurities consist of various metallic oxides, principally of iron and chromium, but traces of other metals as well as silica may often, but not always, be met with.

The actual presence of silica has long been disputed, and its occurrence as an actual constituent part of the mineral corundum may perhaps rightly be regarded as very doubtful. The small amounts usually found could quite easily have been introduced by abrasion from the agate utensils in which the sample is crushed to a fine powder in preparation for analysis; but as silica normally persists in the final results of almost every examination the presence of varying small amounts is now generally accepted.

Table 2.1: Typical analysis of corundum of different colours

Chemical constituents and formulae	Colour of the specimen					
	Colourless	Red	Blue	Yellow	Green	Brown
Aluminium oxide Al_2O_3	99.50	97.50	96.30	96.60	95.97	85.45
Iron Oxide Fe_2O_3	–	1.10	1.75	1.00	1.32	8.15
Chromium Oxide Cr_2O_3	Trace	0.40	1.20	1.30	1.75	–
Fluorine F	–	–	–	Trace	Trace	–
Potassium K	–	Trace	–	–	Trace	1.10
Silica SiO_2	0.50	1.30	0.75	1.10	0.96	4.30
Titanium Ti	–	–	Trace	–	Trace	Trace

It is solely to the presence of these impurities in varying amounts, and combinations, that the widely differing colours of the various varieties of corundum are due; and the manner in which they are present, either in the form of a chemical compound or a mechanical mixture, has also an important bearing upon the colour produced. As will be seen in Chapter 3, this is particularly so in the case of the blue colouration, which is unaffected by strong heat, and the other which is either destroyed or altered by it. It was for a long time considered that the presence of some undetermined volatile organic matter accounted for the change in colour, but as this could never be found by any known method of analysis, the idea has now been abandoned.

Crystallisation

All the gem varieties of corundum crystallise in the hexagonal system, but the commercial variety may be found massive with a nearly rectangular parting, or false cleavage, also coarsely to finely granular. It occurs in the form of long crystalline fibres arranged in a radial manner, when it frequently forms a nodule enclosing an hexagonal crystallised stone of gem quality.

Common forms of occurrence

The two most common habits of crystal occurrence are, firstly, in the form of well developed crystals in the rhombohedral division of the hexagonal system, as six-sided hexagonal prisms terminated at either end by plane faces at a direct right angle to faces of the prism, and with rhombohedral faces more or less well developed at alternate corners (Figure 2.1, A, C) but these faces may be, and often are, partly or entirely absent (Figure 2.1, B, C).

The prisms are frequently much flattened and tabular in habit (Figure 2.1, D, E), and although they may be several inches in diameter they are often to be found not more than a quarter of an inch in thickness. In such cases they will frequently present a stepped or platey appearance, as though the crystal were built up of a number of very thin plates superimposed upon each other, each plate being a trifle smaller in certain, or all directions than the one immediately below it. This appearance is very common in the opaque varieties, and may also often be seen, but less markedly, in the transparent gem varieties, but the microscope will usually very clearly reveal its presence, more especially on the rhombohedral faces (Figure 2.1, A).

This particular form of crystallisation would appear to be peculiar to the red varieties, and the writer has not observed it in any other colour; although it is common enough in other minerals which crystallise in limestone.

In conjunction with this platey structure it is not at all uncommon to find groups of crystals growing together which would at first appear to be twin growths, but careful examination will always show them to be aggregates of separate crystals. Dr. Spencer describes a large crystal of this class from Mogok, and now in the British Museum at South Kensington, weighing 1½ pounds which he considers to be an aggregation in parallel position

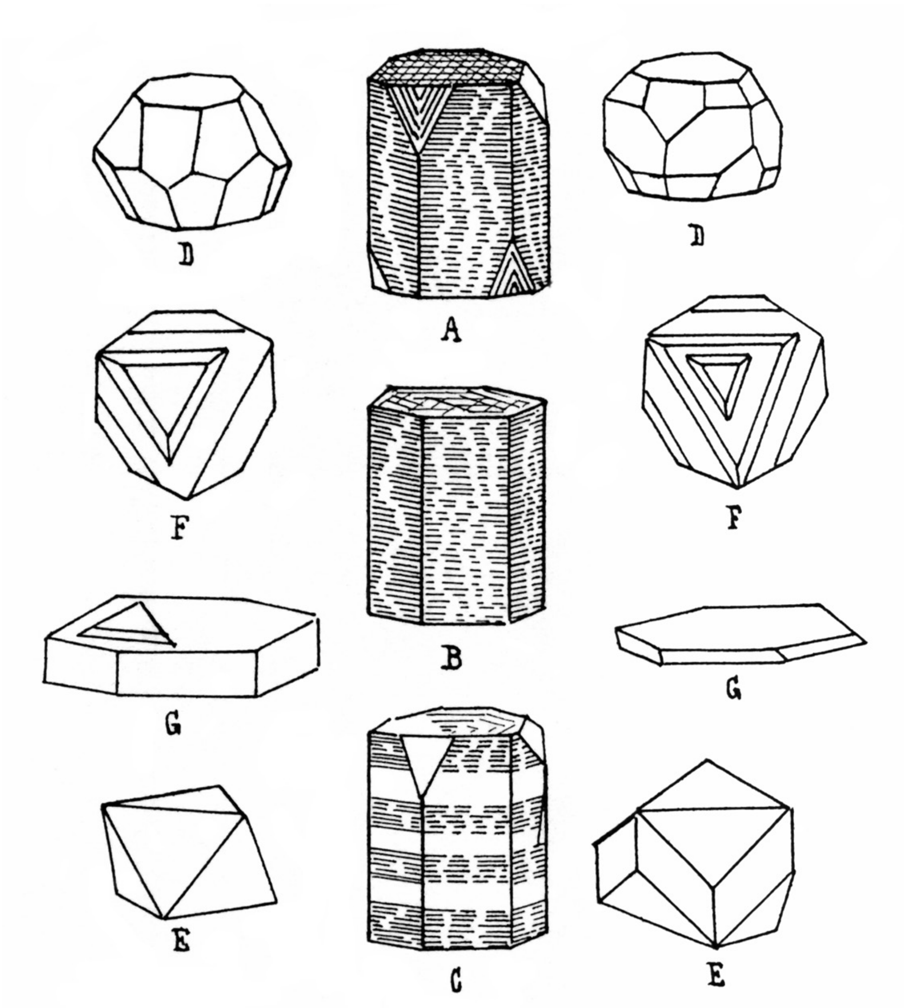

Figure 2.1
Typical crystal forms of corundum in the rhombohedral prismatic habit.

on a number of smaller crystals, somewhat like a colony of polyps on a mass of coral.[1]

The prismatic habit of crystallisation is, with the exception of the abnormal stones from the Montana deposit, almost exclusively followed by the red varieties of corundum, which but rarely occurs in any other form.

1 Spencer, L.J. (1933) Nation acquires large ruby. *The Gemmologist,* Vol. 2, No. 18, pp. 176–178.

Figure 2.2
The platey crystal structure in ruby.

The second common habit of crystallisation takes the form of an hexagonal with twelve faces, six above and six below, meeting at a central girdle (Figure 2.1, A, B, C). This form also freely occurs in different combinations of hexagonal prisms and pyramids with different inclinations (D), and also in combination of two or more pyramids with a narrow central prism (E, F). The crystals may end with a sharp point to both pyramids (A, D, F) or may be terminated by a plane face at any part of their length (B, E); but crystals with one pyramid terminating in a point and the other in a plane surface (C) are very rare indeed, and although they are often stated to be nonexistent they do sometimes occur. Crystals consisting of a single pyramid with either form of termination at the apex, and a flat basal plane (G, H) are, however, moderately common.

The pyramid habit of crystallisation is usually followed by the blue, and all other coloured varieties of corundum except the red, but in some of the stones from the Montana deposits, exactly the reverse will be found to occur.

Figure 2.3
Pseudo twinned crystals of ruby.

As Figure 2.1 and Figure 2.4 clearly show, there are many modifications of the crystal habit, but the prism and pyramid predominate. The faces of these prisms and pyramids are often deeply striated in a horizontal direction, or at right angles to the crystallographic axis (Figure 2.1, B, C; Figure 2.4,B, C), which is due to the frequent repetition, or oscillation, between the various pyramids. The tendency of this form of crystallisation is to produce distinctly elongated forms, and crystals in the pyramid habit will but seldom be found to occur flattened or tabular.

Twinned growths of crystals (Figure 2.4, I) are common enough amongst the cloudy and opaque varieties, more especially so amongst the sapphires, but they are exceptional in the clear transparent crystals of gem quality.

It is by no means uncommon for crystals of either variety to occur so deeply striated and contorted as to give them a knobby appearance, which makes them seem to have occurred massive without any outward crystal

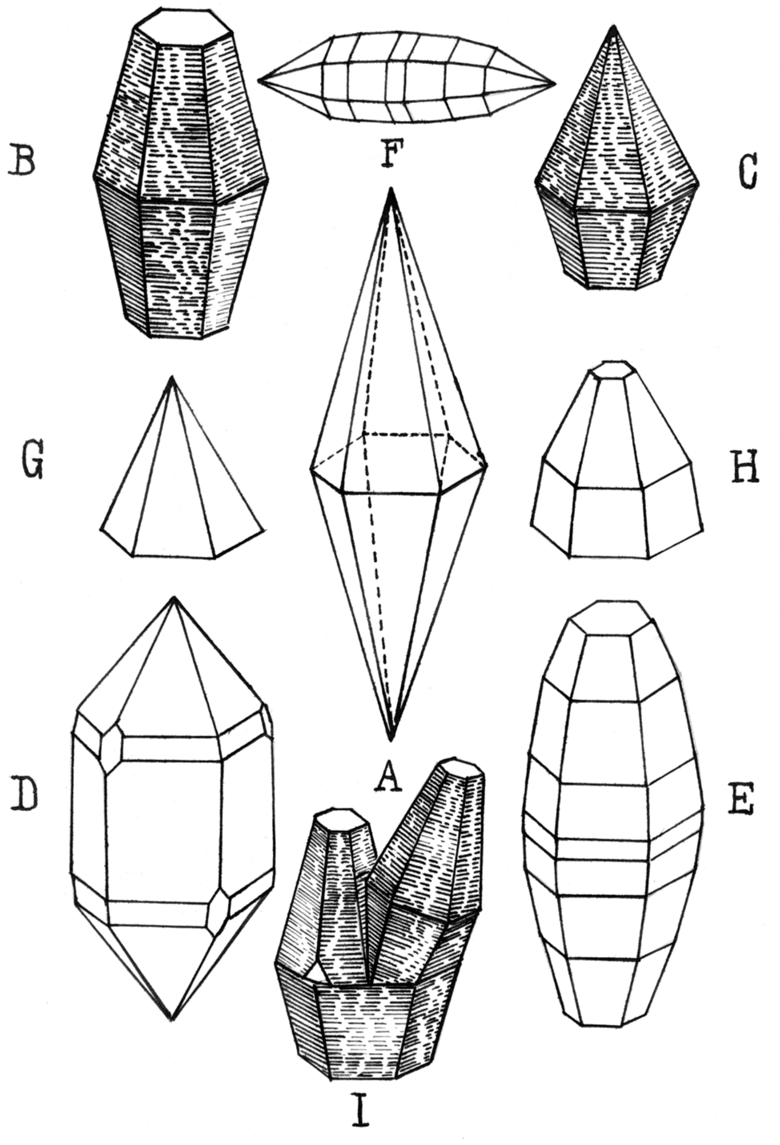

Figure 2.4
Typical crystal forms of corundum in the pyramid habit.

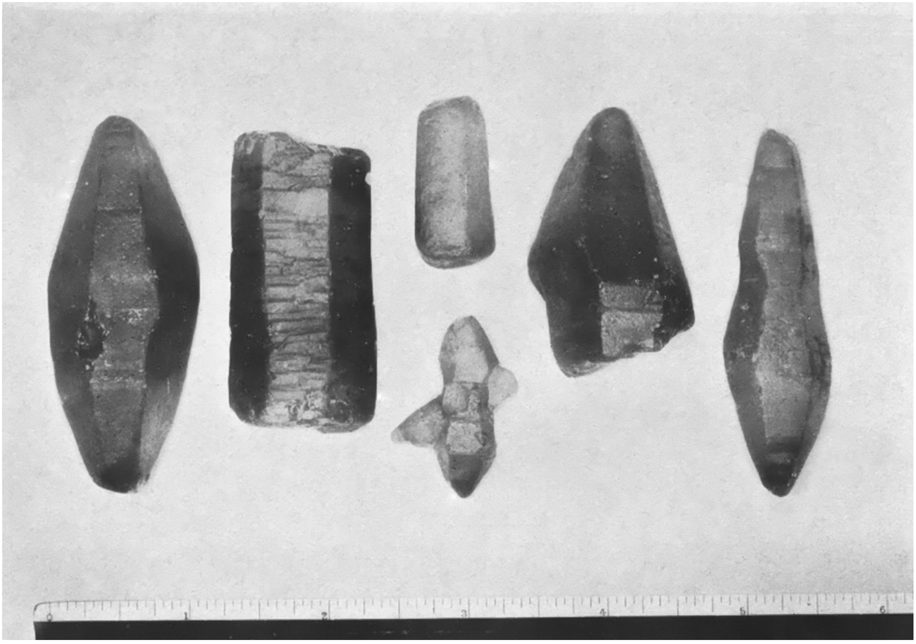

Figure 2.5
Crystals of yellow sapphire from workings at Palmadulla, Ceylon. From Adams, F.D. (1927) A visit to the gem districts of Ceylon & Burma. *Annual Report of the Smithsonian Institution,* 1926, pp. 297–318.

form. Examination will, however, always show that they are true to their own type of crystallisation.

The largest recorded crystal of corundum is a bluish-grey commercial sapphire of non-gem quality now preserved in the Geological Survey Museum at Pretoria. It was found at Leydsdorp in the Transvaal, and measures two-feet three-inches long by one-foot, three-inches across the widest part. It is in the form of a rough hexagonal bipyramid, and weighs 335 pounds.

Clear transparent crystals with sharply defined angles and clean bright faces, such as are so highly desired for museum and collectors specimens, are exceedingly rare in both rubies and sapphires. The largest observed by the writer was a perfect crystal of ruby measuring one centimetre long by seven millimetres across the faces, and of fine gem quality. The majority have, however, been much smaller, about six millimetres by three, and even these very small crystals are by no means common. The same class of crystals in sapphires are usually more elongated, and may reach two or more centimetres in length, but are very slender, seldom being more than three or four millimetres in diameter. These crystals are also very uncommon, but are more frequent occurrence than similar crystals of ruby. Larger crystals running to two or three inches and even more in length, but cloudy to quite opaque, and with the edges and angles much rounded and worn, with the faces dull and often waterworn are much more common, but at the same time cannot be regarded as being exactly plentiful. Even when crystals are found *in situ,* embedded in the rocky matrix, this worn appearance is quite a normal condition.

Ruby seldom assumes the crystalline form of a bipyramid, but such crystals have very rarely been observed. An attempt to crystallise in the form of a single hexagonal pyramid has also been noticed but is very uncommon. The famous *Peace ruby* (see page 395) was an effort of this kind.

Crystals occurring as double pyramids may be met with which are a fine clear transparent blue at one end and a fine red at the other. These two colours are usually, but not always, separated by a narrow band of quite colourless material, the dividing lines between the colours being sharp and distinct. Such crystals are not altogether unknown in the Mogok deposits,

Figure 2.6
Crystals of rough ruby. From Heaton, N. (n.d., ca. 1912) *Rubies: Some Practical Hints on the Detection of Artificial and Imitation Stones.* London, Burma Ruby Mines Ltd., 15 pp.

Figure 2.7
Examining a parcel of rough rubies in the market. From Gübelin, E.J. (1967) Burma, Land der Pagoden. Zurich, Silva-Verlag, 131 pp.

but they are exceedingly rare. Two specimens, stated to have originated in Ceylon, are shown in the Ansell Collection in the Birmingham Art Gallery.

By far the greater part of the corundum cut for gem purposes does not reach the market in the form of distinct crystals at all, but as more or less indistinct crystals, water-worn pebbles, granules, or more commonly as broken fragments. These come from the sands, clays, gravels, and other forms of alluvial deposits, and also from the beds of streams. The occurrence of fine crystals, and stones in the matrix is more in the nature of mineralogical curiosity than a commercial proposition.

In the rock masses corundum forms a primary constituent of the igneous rocks, which may either show high or low silica values, but are rich in alumina, which may be as high as 40% of the whole mass. It thus occurs in granite, syenite, nephelite-syenite, and the felspathic rocks. Its occurrence is also to be noted in coarse pegmatites and aphanitc-porphyries, and it may also be found in the crystalline rocks such as granular limestone or dolomite, and in the mica and chlorite slates. It is common as a contact mineral of a secondary nature in the metamorphosed limestones due to contact with the molten igneous rocks.

In the Mogok alluvial deposits, the best qualities of gem rubies are invariably to be found in larger quantities in situations where the limestone is in intimate contact with the granite; such stones are usually clean, transparent, and of a fine colour. On the other hand the stones from other parts of the deposits away from the contact zones will normally show very marked signs of wear and rolling, and taken on the whole are of a much poorer general quality, the proportion of useless rejections to good gemstones usually being very much higher.

The commercial variety known by the common name of *emery,* which is usually intimately mixed with iron, in the form of magnetite or haematite, occurs in veins or layers in crystalline schists, and has the appearance, and also the feel, of a finely grained black iron ore, which at one time it was actually considered to be. It ranges from an almost impalpable fine sand to large lumps in which the corundum shows as distinct crystals. It may also occur greyish, yellowish, or brown in colour, in which case it is usually in the form of nodules which show an internal structure of long crystalline fibers with a radiating arrangement. It is not at all uncommon in the Mogok deposits to find largish nodules of such emery, often dark chocolate coloured on the outside but yellowish in the interior, which enclose crystallised rubies firmly embedded in their centre. In outward appearance these nodules closely resemble an ordinary brown flint stone, and have nothing save their weight to indicate their precious contents, which are frequently of fine gem quality. Sapphires so enclosed are rare at Mogok, but in the Montana deposits they are of more or less common occurrence.

A study of the associated rocks as given in the descriptions of the individual deposits will show that ruby always occurs in conjunction with either a limestone or a felspathic rock, and that it is further to be found embedded in both of them. It is also always intimately associated with some form of igneous rock, but so far there is no record of stones of gem quality ever having been found embedded in such rock. In 1931 samples of an ultra-basic peridotic rock – which is a primary igneous rock – were obtained near Pretoria, South Africa which enclosed well, and distinctly crystallised red corundum, but it was of the opaque non-gem quality. This, so far as the writer has been able to ascertain, constitutes the only known occurrence of red corundum being found embedded in an igneous rock.

Sapphire of gem quality on the other hand, while intimately associating with the ruby in the alluvials, is never to be found embedded in limestone,

Figure 2.8
Rubies in the matrix.

but is found so enclosed in both the felspathic and igneous rocks. From this fact a theory was evolved that the original crystallisation of the ruby took place in the limestone, and the sapphire in the felspar, and this was for quite a long time generally accepted as being the true facts of the case. That it is entirely in error is very clearly proved by existence of the parti-coloured crystals already described, it being quite out of the question for a single small crystal to have crystallised out in two separate kinds of rocks in such a manner as to leave a sharp line of demarcation between the two colours. It is further discredited by the fact that many rubies, more especially those from Ceylon, contain large patches of pure sapphire blue freely scattered throughout their mass, thus proving that the two colour conditions can function in the same stone at the same time, and therefore have no connection with the magma in which they crystallised.

Another, and more feasible, theory is that the stones crystallised neither in the limestone nor the felspar, but were originally formed in the molten, or cooling, magma of the igneous rock, from which they were afterwards released and the limestone or felspar subsequently formed round them; during the movements and rearrangements of the constituent atoms during the metamorphisation which followed, the harder corundum was not affected by the heat but became scattered through the substance of the rock, somewhat like currants in a bun. This theory is to a certain extent

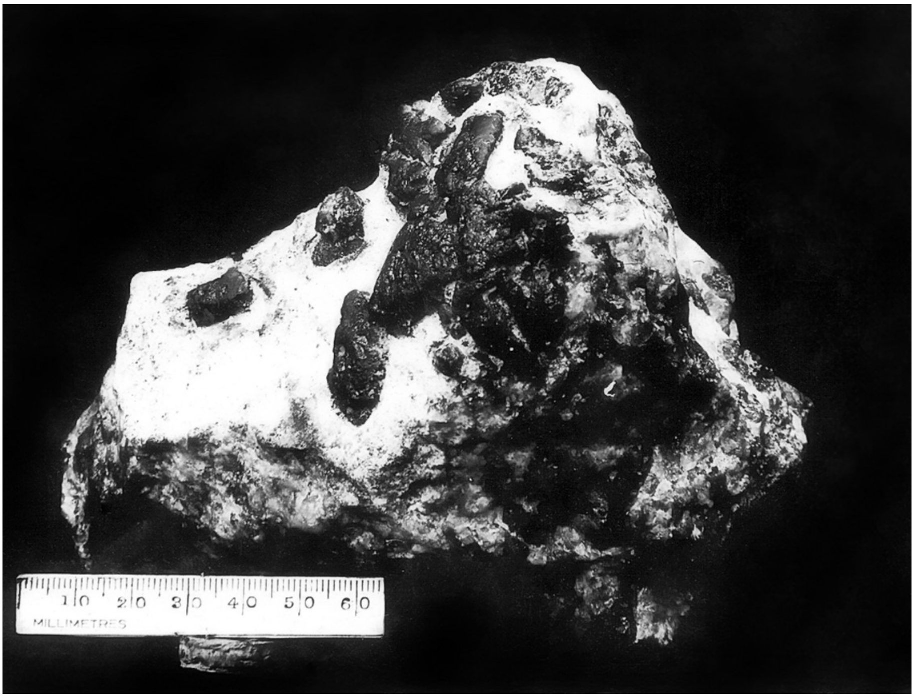

Figure 2.9
Sapphires in the matrix.

supported by the fact that the crystals to be found in the matrix usually show distinct rounding of the angles, and other signs of wear and movement, which normally should not be there if the crystal as found had remained embedded in the rock from the moment of its first formation. On the other hand the heat attendant upon the metamorphisation would have entirely destroyed the blue colour of the sapphire; which the writer has conclusively proved by heating many sapphires removed from the matrix. Consequently on the whole this theory remains somewhat unconvincing, although it is well worthy of further and serious investigation.

The occurrence of gem quality and either ruby or sapphire in the matrix is by no means general, and the plain fact remains, whatever may have been said to the contrary, that so far as the actual genesis of the gem varieties is concerned we are still without accurate knowledge, or even a reasonable theory, as to when, where, or how the actual crystallisation did take place.

It is, however, quite certain that the original crystallisation took place in a rock of some kind, as it is quite impossible for the crystals to have appeared in the ground from nowhere, or in spite of the firm belief of the

Burmans to have grown like mushrooms or potatoes. So we have now to consider the fact that all the workable deposits of gem corundum, excepting a negligable amount of stones found in the matrix, are to be met with in the form of alluvial deposits, or in some product of such deposits, under which the general conditions are the same throughout the world. That is to say they are not found as crystals firmly embedded in any form of solid rock, but as free or loose constituents of sands and gravels; these are often intimately mixed with clays and other forms of earth, or have been cemented into hard concrete-like masses by the action of water containing certain chemical salts, notably of iron, settling upon them and setting up a chemical action which has resulted in the formation of a hard cement.

If these gems were not originally formed in the alluvium, the question may naturally be asked, how do they come to be found in it? And the answer to this is really very simple. The deposited masses of ruby, sapphire, and other gem corundum as we meet with them today are nothing more or less than the products of the natural erosion, disintegration, and decay of the earth's surface, due to the action of water, frost, ice, alternations of heat and cold, and to the chemical action of both rain and the atmosphere, all assisted by such natural phenomena as earthquakes, volcanic action, and general movements of the earth exposing new surfaces to be acted upon. These natural forces in the course of years wore away and broke up the original rocks in which the gems were embedded, and either entirely dissolved them, or reduced them to a more or less fine mass of sand and gravel, which is easily moved. The corundum being of intense abrasion hardness, and not chemically liable to any great change, would not be materially affected by the forces which so released it from imprisonment within the rock and left it free to be either washed away, or to move along with the newly formed earth sand and gravel. During this movement, which would normally take place mostly under water, and accompanied by great pressure from the weight of the material being moved, the crystals would be subjected to an intense grinding action which would cause them to lose their sharp edges and bright faces, and so to become what is known as *waterworn.* The extent of this wearing depends upon the distance travelled, the time taken to perform the journey, and very greatly upon the intensity of the grinding action put upon them. Consequently it may extend from a very slight rounding of the edges and dulling of the faces to the conversion of the crystals into a completely rounded pebble with no outward sign of crystal form, and with a dull matte or frosted appearance.

Such stones will normally make the cleanest and most perfect gemstones provided that the colour is right, as they are normally quite free from internal flaws and other imperfections. This is after all but a very natural thing to expect, and is due to the fact that nothing but the hardest and most perfectly solid and otherwise perfect material would stand up to the enormous strain put upon it during the movement, which would quickly cause weak and flawed crystals to break up, leaving only the soundest pieces to survive and so be ground into waterworn pebbles.

The moving masses containing the gems were carried along by streams, rivers and floods, often for very considerable distances, and were then deposited either by the mere act of settling down over a large tract of country owing to the water having formed a shallow lake, or to the subsidence of flood waters, or again to a large river having completely changed its course. This would produce the poorer grades of alluvial deposits, in which the gem-bearing layer would be thin, and the gem content comparatively low when compared with the large amount of ground that would have to be treated for its recovery.

In other cases the travelling mass would meet with some form of obstruction in the form of barriers of rock, or large hollows in the ground, which would hold it up either permanently or until a level surface had once more been formed which would allow it to pass on again. This would cause a deeper and more concentrated deposit to be laid down as the corundum, on account of its high specific gravity, would have a tendency to sink to the bottom of the soft settling mass, even after the lighter material was moving forward once more. The result was that a larger number of gems would be caught up and held over a smaller area of ground, so forming a deposit which would be very rich in its gem content in proportion to the useless gravel and sand, these constituting the very rich and highly paying deposits so eagerly sought after by the prospector and miner.

As the years passed by, both of these forms of deposit would become covered up with ordinary earth and other forms of detritus produced by the continued disintegration of the whole of the earth's surface, which accounts for the deposits being found at varying depths below the present surface level. In many instance two or more such deposits have been laid down in a similar manner at different intervals of time, each having a considerable thickness of completely barren earth separating them.

The usually very profitable deposits to be found in the interior of the hills were found by disintegration in exactly the same manner, but in this case the detritus did not move laterally across the open country, but more or less vertically downwards from its place of origin. The forces of nature first of all caused fairly large fissures to appear on the surface of the rocky gem-bearing mountains, in which the solvent waters collected and acting upon the more soluble portions of the rock gradually worked their way downwards forming smaller fissures and cracks; these eventually penetrated far into the interior of the mountains, forming as it were a network of canals provided with a funnel shaped opening. Such crevices were subjected to further solvent action, with according to the local solubility of the rock, caused them in places to open out into immense caverns, and in others to be mere narrow fissures or tiny tunnels, and into these the detritus of the continual disintegration from above found its way, and was carried sometimes for enormous distances deep down into the mountain. Layer after layer would thus be washed down and carried along by the water, which would either entirely dissolve or carry away the majority of the lighter portions, and so leave a very highly concentrated gem deposit caught up by obstacles and hollows. Sometimes a somewhat similar action would cause a deposit to be caught up in large hollows situated on the surface of the hills, and so produce what are known as the *hillside deposits,* which as a rule are not so highly concentrated, but are still very workable propositions.

If the general run of stones from a deposit of corundum is carefully examined, it will be found that a large proportion are in an advanced state of disintegration, which in view of the great hardness of corundum, and its strong resistance to the action of all acids, and therefore to natural decay, can only show that such stones must be of an immense age, and that they were originally formed at a very early geological period. Now in geology a single period of time is a very long one indeed, and it is no stretch of the imagination to say that the corundum we mine today was originally crystallised anything up to nine hundred million years ago. During such an immense period of time quite a lot of disintegration can have taken place at a very slow rate, and it must be realised that the surface of the country, as we now see it, will in no way resemble its appearance when the gems were first formed. As an illustration of the immense amount of strata that can thus be removed it is estimated that earth and rock to a thickness of nearly two miles has been in the past removed by natural action from above the present surface level of the Kimberley diamond mines.[2]

2 Williams, A.F. (1932) *The Genesis of the Diamond.* London, Ernest Benn Ltd., 2 Vols., xv + 352, xii + 353–636 pp.

The alluvial corundum deposits of Upper Burma are all contained in some form of valley, all of which are very distinctly valleys of disintegration, and not of erosion, from which it would appear very highly probable that the original rock in which the gems first crystallised has now entirely disappeared, and is therefore not known. Thus the incidence of the rubies and sapphires in the limestones and felspathic rocks is due to some, at present, undetermined cause.

3
THE COLOUR OF CORUNDUM AND ITS BEHAVIOR UNDER HEAT

Colourless corundum

When quite pure corundum is transparent and absolutely colourless, being what is termed *water clear* and then closely resembles a piece of very pure ice. Crystals of this degree of purity are, however, uncommon as there is usually a very faint trace of colour, blue and yellow being the most common, with red and green but only occasionally to be found. This trace of colour may be so faint as to be hardly perceptible, yet it will be quite sufficient to spoil the purity of the specimen, and traces of the causing impurity in the form of metallic oxides will invariably be found on analysis.

Such stones are known to the trade as *white sapphires* and being colourless would naturally not exhibit dichroism, but should the faintest tinge of colour be present the dichroiscope will at once reveal it by showing the stone to be slightly dichroic.

Red corundum

The red variety is universally known as *ruby* and the colour ranges in the transparent varieties from an almost imperceptible shade of pink through all shades of red to a very dark red which appears almost black by reflected light, and from a very pale yellowish-red to a deep bluish-red in opaque varieties.

The red colouration is without the slightest doubt primarily produced by the presence of a small amount of oxide of iron in conjunction with a smaller quantity of chromic oxide, but it should be noted that it would be quite possible for the chromium alone to produce a red colour.

Variations in the shades are produced by higher or lower percentages of the above impurities, and may also be due to the presence of minute traces of other metals. For instance a very minute trace of potassium will produce a very marked brown tint as an extraneous colour; yellow and green tints are due to an excess of chromium, as also is the permanent blue tint. No other impurities save these can be traced by ordinary analysis; as we can obtain the same colouration by adding them to the pure alumina before fusion in the making of synthetic rubies, it is reasonable to assume that they are also responsible for the production of the colour in the natural stones.

There is, however, a perplexing point which has very important bearings, and regarding which, so far, no satisfactory explanation has been put forward. In the majority of red corundum there is to be observed a very decided blue tint intimately mixed with the red, which is frequently so very marked as to cause the stones to be known to the trade as *blue rubies;* by this it must be understood that reference is being made to the distinct blue patches and spots so often to be seen in rubies, but to a general bluish appearance of the basic red colour itself which is generally throughout the stone. This blue tint is sometimes referred to as "the blue in the ruby" and quite often spoils the appearance of an otherwise fine stone; it is much more marked by transmitted than reflected light, and is commonly, but incorrectly, said to be caused by the ultra-strong dichroism of the specimen. This is, however, but a symptom, and not the actual cause of the disease itself, and the idea has mainly been arrived at from the fact that the pleochroic colours of the average ruby are a bluish red and an almost pure red, and is further assisted by these blue rubies invariably being strongly dichroic. In such stones the blue tint will always appear stronger when the stone is viewed, without a dichroiscope, in a direction across the optic axis, and less strong when viewed directly along the axis. But when viewed through the dichroiscope straight along the axis the stone will often appear to be strongly dichroic, whereas being uniaxial a normal stone should be monochroic in this direction.

If we carefully examine and strongly heat such a stone, in the majority of cases on cooling it will be found that two things have happened. First, the blue tint will either be lessened or will have disappeared altogether. Second, the stone has become less dichroic than before heating and is now quite normal, being monochroic along the line of the axis. In a few cases, more especially where the blue is only slightly apparent, there will be no alteration after heating, which as will afterwards appear is a very important point.

By merely heating the stone nothing has been done in any way to alter either its physical or optical properties, which will be found to be precisely the same as before the heating was commenced. This clearly proves that the dichroism was not the cause of the blue tint, but was merely intensified by its presence, and not vice versa.

We also know that the blue colour of a sapphire can, in the majority of cases, be entirely destroyed or lessened by heating, and have seen that the extraneous blue tint in a ruby may be removed in a similar manner. Further we have now good reasons to believe that the deep blue colouration in the sapphire is in part due to a very minute trace of the metal titanium (Ti), combining with the iron and so forming colloidal ilmenite ($FeTiO_3$; an oxide of titanium and iron.) So that if a trace of titanium, which is so exceedingly minute as to only be detectable by the very delicate method of spectra-analysis, will produce the fine deep blue of the sapphire, it is possible that this faint blue tint in a ruby, which behaves in exactly the same way as the blue in a sapphire, is also caused by a trace of titanium, which is so infinitesimally small that it cannot be detected even by spectra-analysis, yet is capable of producing undesirable colloidal ilmenite in exceedingly small quantities in exactly the same way.

The very fact that the blue in the ruby is identical in its behaviour with that of the ruby, even not being affected by heat in a minority of cases, clearly points to the actual causation of the blue in both cases being the same, and also that the cause may be a dual one. The indestructible blue of course being due to the titanium combining with the chromium.

There is a very interesting point in connection with these blue tinted rubies in that they are normally very sound, solid, and clean stones, internal cracks, flaws and other imperfections usually being very rare indeed.

It is known from experiment that the red colour of a ruby may often be improved upon and darkened by judicious heating, and it is more than possible that subterranean heat during the process of crystallisation, and afterwards, had a great deal to do with the production of the fine red colour in natural rubies.

From the published experiments of Sir William Bragg and others, it will be seen that certain rubies when exposed to the action of radium will show a distinct and permanent improvement in colour. Experiments and researches in this direction regarding the origin of colour are of utmost importance, and it is indeed a matter for great regret that while it is possible to reproduce in the laboratory almost all the natural conditions to which a stone would be subjected, it is quite impossible for us to reproduce the all-important time factor. Attempts have been made to overcome this by submitting stones to a very violent bombardment of radium atoms for a comparatively short period of time; but this is not reproducing the original time factor of nature, and it is quite possible that a weak bombardment, such as nature alone could supply, spread over a period of time running into hundreds of millions of years, would have a vastly different effect to a very violent bombardment lasting but a matter of months, or even a few years. This may be aptly illustrated by the fact that a dish may be cooked to perfection when exposed for several hours to the comparatively low heat of the hay box, but would be burnt to a cinder in a second if exposed to the full heat of a blast furnace.

It is the writer's seriously considered opinion that the rarer colours of fine rubies are in part due to weak radioactivity spread over an immense period of time while the stone was held imprisoned within its original mother rock. This theory is greatly strengthened by the fact that the incidence of ordinary silk in corundum is directly due to the action of radioactivity.

The most prized colour in a ruby is what is commonly termed *pigeon's blood,* a term of Chinese origin, the colour being likened to the two spots of blood which appear at the nostrils of a freshly killed pigeon. The descriptions of this colour as being that of fresh arterial blood, or of the centre red ray of the solar spectrum are not correct and therefore misleading; it may perhaps best be described as a deep bright carmine without the slightest trace of visible blue, and very closely resembles the colour of a good clear red currant jelly. It may be said at once that this colour is of the greatest rarity, and is only accurately known to a very few people; which accounts for the many people who regard themselves as being authoritative experts on rubies utterly failing to recognise it when they do see it. It is therefore most decidedly the work of a thoroughly experienced expert to decide what is really true pigeon's blood colour and what is not.

Under the dichroiscope, stones of this colour will show two distinct shades of red, that of the ordinary ray being the lightest. Blue or any trace of it will be entirely absent. It must, however, be noted that twin colours of red alone do not of necessity indicate that the colour of the stone is the true pigeon's blood, as other grades of colour will also produce the same effect; but if the faintest trace of blue is detectable it is at once decisive that the colour is not true pigeon's blood, however near to it the appearance may be.

The term pigeon's blood is commonly stated to be of Burmese origin, but such is not the case as it has no significance to them, neither do they recognise or use it. It is of very great antiquity, and undoubtedly originated with the Chinese in the very early days when they owned the present Burmese ruby mining area.

The next most esteemed colour is a deep crimson, which holds just a faint tinge of blue. This is the best known colour amongst very high grade rubies, but it is not the true pigeon's blood, although it is very often sold as such. Under the dichroiscope there will always be found a faint trace of blue in the colour produced by the extraordinary ray.

The deeper coloured stones of the transparent varieties now commence to show an ever increasing amount of blue until they become almost violet in colour, and so merge imperceptibly into the pure purple of the so-called oriental amethyst. The lighter coloured stones, however, decrease in colour in blue and the red tints predominate, becoming gradually paler until they lose all signs of pink and become the water-white of the white sapphire. Pale pink rubies are very commonly offered by the trade under the name of *pink sapphire.*

Still another grade that stands alone is known as the *black ruby;* this is really of a very dark red colour which by reflected light appears to have a blackish sheen upon its surface. Such stones are only esteemed in Southern India, and are very seldom to be seen on the Western markets.

Instead of blue, some stones will show decided tinges of brown or yellow as extraneous colours, which will normally considerably lower their value. Transparent stones with a very marked yellow tint are sold as *oriental hyacinth.*

The opaque red varieties have two distinct colour schemes, the darker stones being a deep red with a very strong tendency towards blue, which is often so pronounced as to cause the general appearance of a rough stone to closely resemble a piece of raw beef of doubtful freshness. The lighter coloured stones have a marked leaning towards yellow, and finally become almost pure yellow with just a faint tinge of pink. This the writer once had described as a dead Chinaman, which exactly fitted the case.

The colour distribution in a ruby is very often far from being even, the deeper shades being in clouds, bands, swirls, or streaks, with layers of a lighter colour in between; concerning which it should be noted that these bands should be more or less straight and parallel to each other, or distinctly irregular and wavy. Under no circumstances should they consist of regular concentric curves or arcs of circles, as such an appearance at once indicates a synthetic stone.

The optic axis of the ruby lies in a direction vertical to the basal plane of the crystal, and parallel to the faces of the prism, and it is directly along this line that the deepest colour will always be observed. If there is just a faint tinge of extraneous blue, it will also be more pronounced when the stone is viewed in this direction; this may not always be the case when the blue is at greater strength, unless it is very pronounced indeed. This fact is taken advantage of by the lapidary, as it is often possible to obtain a better shade of red in a cut stone, as well as a larger stone, by arranging the table at an inclination to the axis instead of at right angles to it; but if the blue is very pronounced the stone will be utterly ruined if this procedure is followed.

As an example of the difficulties many experts seem to experience in correctly estimating the colour of a ruby, the following is illustrative. For various reasons a large rough ruby once passed through the writer's hands many times, and eventually reached London, when he was much amused to note that the widest publicity was given to the fact that the stone was "of the much prized pigeon's blood colour, which is the finest shade of ruby-red". In reality the colour was several degrees removed from being of this highly desirable shade.

The above descriptions apply more particularly to the rubies from the Mogok deposits of Burma, which are the only ones at present worthy of any real consideration. The rubies from Siam are as a general rule quite different, being of a dark shade of red tinged with blue, and are often of a decided brownish-red inclining to purple. The Siamese rubies when compared with those from Burma will normally be found to present a very inferior and unattractive appearance.

Many of the stones from Ceylon also closely resemble the Siamese rubies, while others are of a bright rose red colour faintly tinged with blue, and stones of an almost purple colour are quite common. The majority of

Ceylon rubies are decidedly on the pale side, and are frequently quite spoiled by inclusions of small nests of small spots, and large blotches of a pure deep blue colour, which are sometimes so thickly scattered through the substance of the stone as to make it appear more blue than red. These markings are very commonly removed by heating, resulting in a very attractive palish rose-red stone. Such blue inclusions are very exceptional in the Burmese rubies, but are so common in those from Ceylon that it is almost safe to say that in every case a bright rose red stone without any trace of blue from the Island is a fired stone.

The better quality rubies from Afghanistan, Australia, and America approximate more to the Burma rubies in colour and general appearance, but really fine stones very seldom, if ever, occur. The majority are light in colour and show much blue, which it is often impossible to even lessen, much less remove altogether by heating. Many of the Australian rubies show a very distinct or purple tint.

Unlike many sapphires all rubies will be found to retain to the full their original colour and beauty by artificial light.

Blue corundum

The blue variety of corundum is generally known by the name of *sapphire,* but this name is also applied to all shades of corundum, including pale red, with some sort of prefix added. So far as this book is concerned, however, the word sapphire alone always refers to the blue variety only.

The colour of sapphire ranges from an almost water-white, with just the faintest tinge of blue, to a deep indigo which appears almost black. In many stones there is a marked tint of red as a subsidiary colour, while in others yellow and green will be found. Parti-coloured stones are also very common.

Such sapphires as show strong traces of red by daylight will ordinarily turn a beautiful violet, purple, or even almost pure red by artificial light, and may be found offered for sale under the name of *alexandrite sapphire.* As a general rule it may be taken that sapphires of the lighter shades will tend to become more brilliant by artificial light, while those of a very deep shade will have a tendency to appear black and lifeless, presenting a most unattractive appearance.

The most prized colour is a fine royal blue, which must be bright, but above all not too dark. This colour is much more esteemed if in addition a velvety lustre is also present, which imparts to the stone a soft sheen similar to that to be seen on the surface of fine velvet, and which appears to emanate from the interior and then to spread itself out over the entire surface. In a fine stone this colour and appearance should be perfectly retained by artificial light, and there should not be slightest tendency to appear lighter, or above all darker, in shade. Fine stones of this description are exceedingly rare and consequently of very high value.

The next most esteemed colour is a deep intense cornflower-blue, which is also more valued if accompanied by a velvety lustre. These stones fully retain their fine appearance, and in fact often considerably improve, by artificial light.

Another colour which is held in very high regard is a deep cornflower blue characterised by a slight degree of silkiness, which gives the stone a somewhat sleepy appearance, but in no way detracts from its beauty. These stones, which should also have a velvety lustre, are perfect night stones, with a remarkably attractive appearance. They come exclusively from Kashmir.

The actual cause of the blue colour in sapphire is the subject of many theories, some of which are very ingenious but none appear to be wholly convincing. From the behaviour of sapphire when strongly heated it is at once obvious that the colour is in all cases not due to a single cause alone, as one blue will be entirely destroyed, and another not affected at all. Ordinary wet analysis proves the presence of both iron and chromic oxides in varying amounts, which the more delicate spectra-analysis fully confirms, and at the same time introduces a new element in the metal titanium in undetermined quantities, which are, however, so small as to be undetectable by ordinary means of analysis. Examination with an ultra-powerful microscope will also reveal the presence of very minute colloidal particles in varying sizes and numbers held in suspension in the substance of the stone, and whose presence had hitherto been unsuspected.

Experience in the manufacture of synthetic sapphires and glass imitations has taught us that it is possible to reproduce the true blue of sapphire by adding to the mixture before fusion definite proportions of titanium oxide and iron oxide, and that a greenish blue may be obtained by also adding chromic oxide, both of which colours are not destroyed by the intense heat necessary in the manufacture of these imitations. Therefore, as we have all these ingredients present as constituent parts of the natural sapphire, and having no direct proof to the contrary, it seems a very natural thing to assume that the indestructible colour of the genuine sapphire is also produced by these oxides acting in combination, and which is the most generally accepted theory today. But this indestructible colour is only present in a minority of cases, being more persistent in the sapphires from Montana, and certain of the Australian stones, but it may be met with at times in stones from any deposit.

Again in certain cases it will be found that the blue colour has merely been lessened in intensity by strong heat, which clearly shows that the original blue colour consisted of two blue colours, both due to different causes, one of which has been destroyed, and the other not affected.

With regard to the blue colour, which heat entirely destroys, leaving in its place a pinkish, greyish, and sometimes water-white stone, we have no definite data upon which to work. This is because the materials to be handled are in such exceedingly minute quantities that with the methods at our present disposal it is quite impossible to accurately analyse them quantitatively, but only to observe their general behaviour in a somewhat imperfect manner. But backed by our definite knowledge of the behaviour of larger quantities we are able to make comparisons, and to form some idea of what is actually taking place. It has therefore been assumed that the minute colloidal particles now revealed by the powerful ultra-microscope are due to a certain proportion of the iron impurity having entered into combination with the titanium and therefore formed ilmenite, but only in its colloidal, or jelly-like, form, and that these have not entered into intimate combination with substance of the stone, but have remained as very minute particles in a state of suspension. If these are in sufficient quantities, which need only be very small in amount, they would result in the formation of a blue colouration, which would be more of a mechanical than a physical nature. Being colloidal it can be proved by experiment that heat would remove the colouration by the simple process of resolving it back again into its original constituents, or by otherwise altering its general properties in a manner which is peculiar to colloidal substances.

The foregoing in a way also explains the now abandoned – although still often quoted – theory that the colour was due to some untraceable organic matter. Even today colloids are imperfectly understood, and in earlier days instruments for observing such minute particles were not available; consequently the early investigators, who fully realized that there was secondary cause for the colour but were without means of observing it, ascribed it to some undeterminable organic matter. This was not quite right, but it was at least along the right lines, as colloidal substances often behave in a generally similar manner to organic substances, and in point of fact many of them, such as gelatine and glue, are of organic origin.

The most esteemed velvety lustre, the cause of which does not appear to have ever formed the subject of serious investigation, may likewise be laid to the door of these colloidal particles, which act as inclusions and so break up the light within the stone. This is to a certain extent proved by the fact that when a sapphire showing this lustre is strongly heated it loses both its colour and the lustre. The same effect may also be noted in such emeralds as exhibit this lustre, but with the difference that, while the colour is not affected to any great extent, the lustre is utterly destroyed by heat.

It would appear to be very unlikely that radioactivity was in any way concerned with the production of the blue colour in sapphires, as it has been shown that the effect of radium on the colour of these stones is markedly destructive. But in view of the abnormal behaviour of certain star sapphires under the influence of both X-rays and ultra-violet light, it is more than possible that it was very actively engaged in a destructive way in the production of the exceedingly silky, pale grey star sapphires.

Normally the colour of sapphires will be found to be in a most uneven state of distribution, occurring in bands, streaks, patches, swirls and clouds. Often, examination of a fine stone will show the colour to consist of two different shades of blue, one being slightly darker than the other, either arranged in layers, or one permeating through the other in the form of an irregular cloud, which appearance may be very marked indeed in certain cases. The colour again may be found to consist of distinct coloured patches floating about in a perfectly colourless body and as will afterwards appear such stones have a very decided value for cutting purposes. The blue may also be found as patches or streaks alternating with pure yellow, or a greenish colour, while it is very common indeed to find a pure yellow patch or streak in the centre of an otherwise fine blue stone. Tinges of red of varying degrees of intensity are quite common, but these seldom take the form of distinct patches of pure colour.

Crystals are frequently to be met with blue at one end and yellow at the other; sometimes the centre will be blue and the ends yellow or colourless, and very rarely red at one end and blue at the other, or red, white and blue.

Often the colour will be found to be darker towards the outside of the crystal, which may become almost colourless towards the centre. It is also very common to find crystals which, while being perfectly evenly coloured throughout, are covered with a thin skin of very dark blue to almost black colour. This skin is always of paper thinness, and there is not the slightest diffusion between the two colours, the darker one almost looking as though it had been varnished onto the original crystal.

As in the case of the ruby, a distinct and regular curved arrangement of alternating light and dark colours is a certain indication of a synthetic stone; this appearance often being very clearly observable, and may sometimes be seen by the unaided eye. In sapphires, a perfectly even distribution of colour, more especially when met with in stones of a very fine colour, should always be regarded as a very suspicious circumstance, and the stone should be submitted to a careful microscopic examination.

Owing to the very strong dichroism the colour is always more intense, as well as at its best, when the stone is viewed in a direction directly along the optic axis, which is a line joining the apices of the bipyramids. Even a very fine coloured stone may appear to be of an objectionable greenish colour when viewed in a direction across this line, or even at a slight angle to it. This is one of the most important points to be considered in the cutting of sapphires.

As briefly remarked earlier many sapphires show a marked aptitude to change their colour and general appearance by artificial light. This may be attributed to three main causes:

a. The presence of some extraneous colour, such as red, yellow, or green.
b. A peculiar condition obtained in certain dark coloured stones, which affects their power of absorbing certain coloured rays of light.
c. Faulty cutting.

With the stones of class (a) the tendency is for them to become lighter in colour, and to increase in brilliancy, and further to often assume a different colour. Where red is the extraneous colour, they may become very attractive in appearance taking on beautiful shades of violet, purple, and bright red; but when yellow is the second colour the stones, although becoming more brilliant, they often assume nasty yellowish-green tints, which are not at all pleasing and may often closely resemble a badly coloured peridot. But where the shades are pale, both the colour and appearance may become very attractive. When green produces the change, the stones are usually far from being attractive, being of an objectionable yellowish or bluish-green colour. Light or colourless portions in a stone will often make it appear quite brilliant, and usually lighter in colour.

The stones of class (b) are solely sapphire of a dark blue colour, and more particularly those of indigo or dark greenish blue shades, which while being fairly presentable by daylight, become opaque and black by artificial light with a generally dull and lifeless appearance, which makes them closely resemble a piece of facetted coal, making one of the most objectionable gems imaginable. It is a condition to be found in a number of the Australian and Siamese stones, and to a lesser extent in some of the Burmese stones, more especially those from the Bernardmyo deposits. It is caused by the colour of the stone entering into combination with the yellow of the artificial light and so forming a kind of light filter which absorbs nearly all the coloured rays of light incident upon it. With no light rays reflected back, the stone appears black.

In class (c) the change is due to either carelessness or ignorance on the part of the lapidary, which may cause the stone to change to either a lighter or a darker shade, seldom inducing an increase in the brilliancy, but on the contrary, often making the stone appear dull and lifeless. It is caused by either the table being arranged the wrong way with regard to the dichroism of the stone, or to the general distribution of the colour. A frequent error is also in the general design of the stone's make (cut), which may be either too thick or too thin, and thus provided with wrongly angled back facets.

As a general rule it may be taken that the majority of the stones from the Montana deposits will become lighter in colour and more brilliant by artificial light. Those from Australia becoming darker, and the stones from Siam may become either. The normal stones from Burma and Ceylon will show little or no change; and the Kashmir stones may become lighter, but will usually show no change at all. The above is only a generalization of the tendencies, and exceptions will be found in all cases.

Yellow corundum

This colour variety is most usually known as *yellow sapphire,* but also passes under several other names. It is moderately plentiful, and the colour ranges from the very palest tint of yellow through all shades to a beautiful deep golden colour. Greenish and brownish tints as extraneous colours are fairly common.

Ordinary pale shades of yellow are the most common, while the deep golden-yellow is comparatively rare, and these very brilliant and beautiful stones are thoroughly deserving of a great deal more attention than they receive, and should command a far higher price than they do. Such stones are known as *golden sapphires* and come mainly from Ceylon.

The dichroism is quite variable, being quite strong in the deeper shades, but at times only to be definitely observed with the greatest difficulty in the paler stones, even though their colour may be sufficiently deep to lead one to suppose that the dichroism would be quite distinct. But on the other hand such stones are sometimes intensely dichroic. In all cases the colour is always at its best when viewed directly along the optic axis.

Contrary to the case with the majority of corundums, the yellow colour is usually of very even distribution. While being remarkable for its high degree of transparency, yellow corundum will often exhibit a strong internal sheen, which may impart a curious aventurine appearance to the stone, but which, when only slight, has been confused with the velvety lustre. It is due to a multitude of minute internal cracks and fissures, which this variety appears very prone to develop. Yellow corundum may be found either chatoyant or asteriated.

Yellow corundum makes an excellent night stone, being very brilliant, and often increasing in depth of colour by artificial light.

Purple corundum

This variety passes under several names, the most common being *oriental amethyst.* It may be found of a fine gem colour and quality either transparent, translucent, or quite opaque.

The colour ranges from very pale violet to a deep rich purple, but medium shades are the most usual. As a colour variety, it is fairly common, but good deeply coloured stones may be considered to be on the rare side. It makes an excellent night stone, usually showing a beautiful colour and becoming very brilliant by artificial light. It may be noted that the true (quartz) amethyst will become dull, and from a greyish to lavender under the same conditions.

In the purple, either the blue or the red colour may predominate, and an outstanding feature is the extreme dichroism of the stones, which is often clearly visible to the unaided eye, many stones being deeply coloured when viewed along the optic axis, and almost colourless when viewed across it. Therefore the utmost care is necessary in the first orientation when preparing for cutting, if the very best colour effect is to be secured.

It has more than once been definitely stated that the colour of purple corundum is due to microscopic bands of red and blue colour alternating with each other. In this we have a perfect example of the reckless jumping at conclusions without making an accurate personal observation, for nothing could be further from the actual facts of the case. Corundum may certainly be met with in which irregular bands of red and blue have become intermixed in such a manner as to impart a purplish appearance to the stone, but such instances are not common; and also there are sapphires containing extraneous red, which become purple by night. But neither of these belong to the true purple variety, the colour of which is beyond the shadow of a doubt perfectly homogeneous, and in the case of transparent stones allochromatic. But if an opaque purple stone is reduced to a fine powder, the colour will be found to be practically idiochromatic which fact very effectively disposes of the alternating bands of colour theory.

That the colour is due to a combination of the same primary causes as that in the ruby and sapphire is shown by the behaviour of the stones under heat, as in some cases they will become pinkish, and in others not affected to any appreciable extent, if at all. The change to pink being more frequent in stones where the blue predominates in the purple.

Purple corundum is very commonly to be found chatoyant and asteriated, and makes most attractive star stones.

Green corundum

Commonly known under the names of *green sapphire, oriental emerald,* and *emerald sapphire,* this variety ranges in colour from a darkish green to almost colourless and may be transparent, translucent, or opaque; it is sometimes chatoyant and very rarely asteriated. The colour is never a true emerald green, always being more or less tinged with yellow. Some specimens may appear to be quite a different colour by transmitted light to that shown by reflected light. The distinguishing feature is the extreme dichroism.

On the whole, green corundum may be regarded as unattractive, but certain stones when of a good deep colour may sometimes be very effective. But these are very rare, and good specimens will command fancy prices.

Opaque greenish corundum is fairly common but really good transparent specimens are almost unknown in Burma, and are but very rarely mined in either Ceylon or Siam. They are, however, somewhat more plentiful in the Montana deposits.

Strong heat would appear to have no appreciable effect in the majority of cases; but in certain instances a marked decrease in the depth of colour after heating has been noticed.

Grey corundum

A miner once described this variety to the writer as "a sapphire gone wrong" which was not an inapt description. It belongs to the translucent to opaque class, and ranges in colour from a deep bluish grey to a pale dirty lavender grey, while the writer has handled stones of this class which are milk-white in colour.

They are really palish stones of various body shades of blue, which are rendered almost, if not quite, opaque and their colour masked by densely packed masses of plainly visible silk, which imparts the greyish appearance. They are to be found quite plentifully on the market as the poorer forms of star sapphires, and are on the whole quite unattractive, their fine star often being their only redeeming feature.

Of the sapphire rejections to commercial corundum, this class forms about ninety percent.

Heating such stones may have no effect upon them, but will often destroy what little blue there is, leaving the stone of a very nasty dirty grey colour, but in no way damages the effect of the star.

Brown corundum

This is another variety of the semi-transparent to opaque class, commonly known as *adamantine spar* and occurs in various shades of brown, ranging from a cinnamon-brown to almost chocolate.

It is strictly speaking a variety of commercial corundum, and is only of gem value when asteriated, or displaying a marked bluish-white chatoyant sheen. It may occur in any deposit of corundum, but the gem variety is not at all common. It is very highly esteemed by the Chinese and is seldom to be seen on other markets.

Heat has no appreciable effect in the majority of cases, but will sometimes cause the stones to become lighter in colour, and has been known to turn them dark red, and also black.

Black corundum

This is purely the commercial variety, and is of no interest from the gemmological point of view.

From the foregoing it will be seen that stones of the corundum group may be found in any of the following colours. Shades of red, blue, yellow, purple, green, grey, colourless, brown and black, as well as particoloured. They may be transparent, translucent or opaque, and also chatoyant or asteriated.

The effects of strongly heating corundum

Using the ordinary mouth blowpipe, all forms of corundum are alone absolutely infusible, showing no signs of rounding, even at the edges or when in the thinnest of splinters.

It is, however, easily fusible in the intense heat of the oxy-hydrogen blowpipe (2000°C) the oxy-acetylene blowpipe flame (2400°C) or in the electric arc (3500°C). This capability of being reduced to a semi-fluid molten mass at such great heats was originally made use of in the manufacture of reconstructed rubies, and now forms of the basis for the manufacture of synthetic corundum.

If corundum is very finely pulverised and then mixed with borax or microcosmic salt (phosphate of soda and ammonia) and the whole heated on charcoal before the ordinary blowpipe, the corundum will fuse with difficulty to a clear glass, which will be coloured to various shades if iron is present. The ordinary salts of sodium do not produce fusion; but potassium bisulphate will produce fusion, and the mass when cold will then be soluble in water.

If finely powdered corundum is moistened with a solution of salt and cobalt, and then strongly ignited by means of the blowpipe it will slowly fuse, forming a mass with a fine blue colour, which is known as *Thenard's salt.* This is not only used in chemistry as a distinguishing test for alumina, but also has a commercial application in the manufacture of artists' materials.

Crystallised corundum is capable of withstanding very high temperatures and, provided that both heating and cooling are slowly done and the heated stone protected from contact with cool air during the process, stones may be heated to any degree of temperature short of complete fusion, without any danger of their cracking or breaking up. It is, however, essential that a stone so treated should be entirely free from internal cracks or fissures, more especially the tiny ones technically known as *feathers,* the presence of which would in almost every case be fatal, and cause the stone to fracture into two or more pieces.

When a ruby is strongly heated it will first turn green at a comparatively low temperature, and as it becomes hotter it will turn cloudy to quite opaque, and of greenish gray colour, shortly afterwards turning colourless and transparent, in which condition it will remain without further change the whole time it is at a high temperature. It has been stated that there is a further change to either cherry or rose red; but such is not the case as it is a true colour change, but merely the action of the heat causing the stone to emit the luminous red rays of the spectrum as it reaches the stage termed red hot. As the stone cools it will slowly reverse the above colour changes, turning from colourless through greyish green to darkish green, until when it is comparatively cool it will reassume its red colour.

When quite cold, various changes may be found to have taken place. The red colour is never weakened in its intensity from the original red, but is very frequently improved by becoming darker, but in many cases it will be precisely the same as previous to the heating. Where in the first instance the colour was of an uneven or patchy nature, heating will usually cause it to become much more even and homogeneous. While, where there is a strong tendency to extraneous blue, this will normally be found after heating to have been destroyed altogether, or at least very considerably reduced, which also reduces the basic colour to a more even shade of red. Cases will, however, be found where heating will not have the slightest effect on the extraneous blue, which will usually, but not always, be when the blue is only small in amount. But where the blue is very pronounced a decided improvement in colour may be anticipated in almost every case.

In Ceylon quite a large number of rubies are mined of a very pretty shade of rose red, which are rendered worthless as gems by containing blotches, spots, and streaks of a pale or dark pure blue colour scattered about throughout the substance of the stone. In fact some such stones will show far more blue than red. These stones are invariably “fired” by being enclosed in a ball of fireclay about the size of a cricket ball, which is then very slowly dried to remove every trace of moisture from the clay. It is then placed in an ordinary blacksmith’s fire and slowly heated until at the end of about three hours it is white hot. It is maintained at this temperature for some two hours, or even longer if there is much blue to be removed, and is then allowed to cool very slowly over a period of several hours, after which it is placed in a box of sand and left until the next day to become quite cold. The clay is then knocked off with a hammer, when the blue in the stone will then be found to have entirely vanished leaving a rose red stone evenly coloured throughout; pale certainly, but very bright and most attractive. The whole secret of success lies in knowing exactly how to time the total period to suit each individual stone; and to ensure that every particle of moisture has been dried out of the clay before the heating is commenced, and further that the stone itself is absolutely cold before the clay is broken off. If any of these points are neglected the enclosed water will cause the stone to crack during the heating, and so break up when the clay is removed, or it will certainly crack, and most possibly completely fracture immediately when the cool air comes into contact with the still cooling stone.

The above process is in almost daily use in the Island for the treatment of the spotted and evil looking bluish-purple star stones, so common in Ceylon, the stones turning out an attractive rose red colour from the most unpromising looking material, while the star effect is in no way interfered with. Needless to say that this process is carried out secretly, and is never shown to visitors.

When sapphires are heated they behave in an entirely different manner to rubies. They will first assume a greenish colour, and then become a cloudy grey to almost opaque white, in which condition they will remain throughout the entire period of heating; but some stones will show a further change to colourless and become transparent again. On cooling, in the majority of cases, it will be found that the blue colour has been entirely destroyed, and that the stone is now colourless, or a pale dirty greyish colour. In some cases there may be a change to pink of various shades, but usually quite pale. In a minority of instances the blue colour will be regained on cooling, usually much weakened in intensity, but it may be of the original shade. This will usually happen with stones of a palish shade, or those of a hard steely blue colour; but stones of darkish shades will normally either lose their colour, or become considerably lighter in shade. The change to pink may usually be expected in stones which show a decided tendency to hold extraneous red. Yellow or green as extraneous colours would appear to make no difference to the complete loss of colour. Heating will also invariably destroy the velvety lustre whenever it is present.

Beyond the colour changes mentioned, strong heat would not appear to have any effect upon either the physical or optical properties of corundum.

Even on complete fusion, the colour of the ruby is not wholly destroyed, and is often not affected at all, while that of the sapphire would appear to invariably disappear; this accounts for the early success in making the reconstructed rubies and for the complete failure to make similar sapphires.

4
THE PHYSICAL PROPERTIES OF CORUNDUM

A. Mechanical: Mechanical, Specific Gravity, Hardness, Cleavage and Parting, Fracture, Frangibility

Specific gravity and its uses ✤ The S.G. of corundum ✤ Comparative tables of specific gravity ✤ Hardness defined ✤ Rosiwal's determination of actual hardness ✤ Mohs' Scale ✤ Sapphire harder than ruby ✤ Pyramids harder than prisms ✤ The reasons for the variation ✤ Correct hardness of the corundum group ✤ Corundum as an abrasive ✤ Safe method of applying the hardness test to cut corundum ✤ The wheel test for synthetic corundum ✤ False cleavage and parting in corundum ✤ Parallel structure and disintegration ✤ Decomposition in crystals of pyramid habit ✤ Conchoidal fracture ✤ The fracture of synthetic corundum ✤ Frangibility defined ✤ Comparative scale of frangibility ✤ The frangibility of corundum ✤ The commencement of feathers ✤ The danger of damaging valuable stones

Specific gravity

When we speak of the specific gravity, or comparative density, of a substance we refer to the weight of the substance when in air, as compared to the weight of an equal bulk of distilled water at 4°C. Thus if one cubic centimetre of a given substance weighs exactly half the weight of one cubic centimetre of water its specific gravity will be expressed by the figure 0.50; if the weight is twice that of water by the figure 2.00, and so on. So that when we say that the specific gravity of ruby is 4.00, we know at once that it weighs exactly four times as much as an equal bulk of water. As this comparative density will be found to show a variation for almost every substance, and to also be more or less constant for all specimens of the same substance, it forms a ready means of discriminating between one substance and another, and as its determination is a matter of comparative simplicity, specific gravity is a very powerful factor in the determination of the species of a gemstone, and in the detection of imitations and substitutions.

The specific gravity of corundum as a group is somewhat variable, but the variation is not so great as in some of the other groups of gemstones. Cases are known of very impure specimens having an S.G. as high as 5.00, but this will only be found to occur in opaque stones, and is even then uncommon. The S.G. of the normal transparent gem varieties is usually taken as varying between 3.90 and 4.20, giving a mean of 4.05.

The readings will usually be found to be highest in the case of sapphires in which stones of a good average blue colour will normally give fairly constant readings of from 4.00 to 4.10, but paler stones will often be as low as 3.95, which gives a mean reading of 4.016 for average sapphires. The higher readings usually being found in stones which incline to a darkish shade, while the paler the stone becomes, the lower will the S.G. usually fall below the mean.

In the case of very high-class rubies the S.G. is very constant between 3.95 and 4.00, giving a mean of 3.975, which only permits of the very small variation of 0.025 on either side. Very pale stones may fall as low as 3.90, and very dark stones be as high as 4.10. As the stones of all varieties tend to become more impure and consequently opaque the S.G. will invariably be found to rise.

It is noteworthy that the darkish rubies from Siam normally show a very high S.G. usually being about 4.10. This is most probably due to their high content of iron impurity, which often takes form of microscopic, but quite distinct, enclosed crystals.

Table 4.1: The specific gravity of red corundum

Stone, Quality & Place of Origin	Colour	Observed Specific Gravity			Remarks
		Highest	Lowest	Mean	
RUBY Fine gem Burma	Pigeon's blood	4.00	3.95	3.975	Very constant
RUBY Good gem Burma	Fine red	4.00	3.96	3.980	Very constant
RUBY Black ruby Burma	Dark red	4.10	3.97	4.035	Variable
RUBY Gem Siam	Dark red	4.10	4.05	4.072	Constant
RUBY Gem Burma	Bluish red	4.05	3.97	4.010	Constant
RUBY Gem Burma	Pale red	4.00	3.94	3.970	Slightly lower
RUBY Gem Ceylon	Pale pink	3.95	3.90	3.925	Constant
STAR RUBY Fine gem Burma	Fine red Translucent	4.05	3.98	4.015	Fairly constant
STAR RUBY Fired gem Ceylon	Pale red Opaque	4.08	3.97	4.025	Variable
RUBY Non gem Burma	Deep bluish red Opaque	4.75	3.99	4.370	Variable
RUBY Very impure non gem Burma	Yellowish red Opaque	5.00	3.98	4.490	Variable
Combined mean of above for all varieties of red corundum		5.00	3.94	4.470	Transparent stones lower Opaque stones higher

The highest and lowest readings, together with the mean, which have come under the writer's observation are given in the following tables.

Table 4.2: The specific gravity of blue corundum

Stone, Quality & Place of Origin	Colour	Observed Specific Gravity Highest	Lowest	Mean	Remarks
SAPPHIRE Fine gem Burma	Royal blue Velvety	4.10	4.00	4.050	Fairly constant
SAPPHIRE Fine gem Burma	Cornflower blue	4.08	3.98	4.030	Fairly constant
SAPPHIRE Fine gem Kashmir	Cornflower blue Milky	4.06	3.97	4.015	Slightly lower
SAPPHIRE Gem Australia	Very dark blue	4.10	4.06	4.080	Slightly higher
SAPPHIRE Gem Burma	Medium pale blue	4.05	3.95	4.000	Slightly lower
SAPPHIRE Gem Siam	Pale blue	4.00	3.95	3.975	Lower
STAR SAPPHIRE Fine gem Burma	Deep blue Translucent	4.10	4.00	4.050	Slightly higher
STAR SAPPHIRE Gem Siam	Pale blue Translucent	4.10	3.98	4.040	Fairly constant
STAR SAPPHIRE Poor gem Burma	Pale grey Opaque	4.05	3.95	4.000	Constant
Combined mean of above for all varieties of blue corundum		4.10	3.95	4.025	Constant

The notes in the remarks column refer to the average tendency shown by a large number of observations to compare with the mean of the highest and lowest readings as given.

Table 4.3: The specific gravity of the other coloured varieties of corundum

Stone, Quality & Place of Origin	Colour	Observed Specific Gravity Highest	Lowest	Mean	Remarks
YELLOW SAPPHIRE Fine gem Ceylon	Deep golden yellow	4.10	4.00	4.050	Slightly higher
YELLOW SAPPHIRE Gem Burma	Honey yellow	4.10	3.96	4.030	Fairly constant
YELLOW SAPPHIRE Gem Burma	Pale yellow	4.05	3.95	4.000	Fairly constant
GREEN SAPPHIRE Gem Gem	Deep green	4.10	4.05	4.075	Fairly constant
GREEN SAPPHIRE Non gem Burma	Cloudy green	4.10	3.98	4.040	Slightly higher
PURPLE SAPPHIRE Fine gem Burma	Deep purple Transparent	4.10	4.00	4.050	Fairly constant
PURPLE SAPPHIRE Gem Burma	Pale purple Transparent	4.10	3.97	4.035	Fairly constant
PURPLE SAPPHIRE Fine star stone Burma	Deep purple Opaque	4.10	4.05	4.075	Fairly constant
WHITE SAPPHIRE Gem Burma	Water white	4.10	3.95	4.025	Usually about 4.000
Combined mean of above		4.10	3.95	4.025	In practice the average is about 4.000
BLACK STAR SAPPHIRE Poor gem star Burma and Siam	Adamantine spar Darkish brown	4.20	3.90	4.050	Variable
Black, opaque	Non gem Commercial corundum from Burma, India, and America	5.30	4.10	4.700	Variable

With regard to the practical determination of specific gravity the above figures clearly show that so far as corundum is concerned the process known as the *flotation method,* which involves the use of heavy liquids of a known specific gravity, would not be altogether satisfactory in the manner in which it is normally arranged. It is quite clear that stones would be found that would fall into any of three groups, i.e. Group S where the S.G. is above 4.61, Group A (S.G. from 4.60 to 4.01), or Group B (S.G. from

4.00 to 3.71). Consequently serious confusion would be liable to arise with the stones of a similar appearance but of an entirely different species,[1] owing to the overlapping of the specific gravities. So that, unless careful confirmatory tests were made, grave errors in identification might arise if the S.G. as determined by this method were solely depended upon. As a fairly reliable approximation, the flotation method can be very useful indeed when applied by experienced persons, but on the whole, without confirmation, its accuracy cannot always be depended upon; therefore its general use is not recommended. Where extreme accuracy is required, the determination should be made by means of weighing in a pycnometer. But for all ordinary purposes the *hydrostatic method* of weighing first in air and then in water by means of an adapted jeweler's balance, or a Jolly or Westphal balance, will usually be found all that is necessary.

Practically every set of published specific gravity tables will be found to show the figures for corundum, as a group, as varying from 4.20 to 3.90, and very few will differentiate between the varieties, so that the above figures are applied alike to both ruby and sapphire.

Hardness

By the term of hardness it must be clearly understood that it is not the resistance to fracture as the result of a blow that is referred to, which in mineralogy is known as the *frangibility* of the stone. When we speak of the hardness of a gem, or any other mineral, we mean the resistance to abrasion or scratching by other substances; therefore for the sake of greater clearness the terms *scratch hardness* or *abrasion hardness* will often be found to mean exactly the same thing.

In every recognised table of hardness the figures for all the members of the corundum group are given as 9.00, and the ninth place is allotted to corundum in the *Mohs' Scale of Abrasion Hardness.* Further, in practice, all sets of points and plates sold for hardness testing purposes will be found to consist of either ruby or sapphire, but very frequently a ruby point will be provided with a sapphire plate, or vice versa, which is incorrect and apt to lead to confusion and error, as will be apparent later.

Corundum therefore ranks only second in hardness to the diamond, which has the greatest resistance to abrasion of all known substances. But the progressive numbers as 9 is to 10, as indicated by the scale, in no way

1 See Appendix B. and also the author's *Identification Tables for Gemstones.*

indicates the actual difference in this resistance between the two minerals, which would be much more clearly expressed as 1,000 is to 140,000; in other words, the diamond offers 139,000 times more resistance to abrasion than does a ruby.

This difference in comparative hardness has been very clearly proved by the researches of Rosiwal, who made a thoroughly scientific and exhaustive investigation into the relative hardness of all ten minerals comprising Mohs' Scale, which he reduced by actual experiment to a system of units. In 1896 Rosiwal published the results of his research (found in Table 4.4), which gives a splendid idea of the extreme hardness of corundum when compared to the other standard minerals, and at the same time its comparative low resistance when compared to that of the diamond.

Table 4.4: Mohs' scale of hardness, with Rosiwal's determination of the actual hardness

Number on Mohs' Scale	Mineral	Actual Hardness as Determined by Rosiwal
1	Talc	0.33
2	Gypsum	1.95
3	Calcite	4.50
4	Fluorspar	5.00
5	Apatite	6.50
6	Orthoclase	37.00
7	Quartz	120.00
8	Topaz	175.00
9	Corundum	1000.00
10	Diamond	140,000.00

Nearly a century ago, the Viennese mineralogist F. Mohs selected the above ten minerals and arbitrarily formed them into a scale by which the hardness of all substances, mineral or otherwise, could more or less be measured; and crude as Rosiwal shows the comparison to be, so far nothing has been found to satisfactorily replace it, and so it still remains in use as the only ready means we have of measuring the resistance to abrasion offered by any substance. It is true that there are now laboratory instruments such as the *sterioscope,* which are capable of making very accurate determinations, but they are expensive, and can only be used by persons specially trained in their use.

Various other minerals of intermediate hardness have since been introduced, such as chrysoberyl, 8.50, so that we are now able to measure to certain decimal points in a rough way. No one, however, seems to have thought of introducing an intermediate point between 9 and 10;[2] hence the whole of the corundum group is designated as hardness equals nine according to that scale.

This figure to cover the entire group is, however, incorrect, and in practice is apt to be misleading. In the first place, the hardness of both ruby and sapphire is variable, some stones of either variety often being appreciably harder or softer than other stones of the same variety; while there is frequently a slight variation in the hardness in different directions in the same stone, the direction of least resistance being a line parallel to the striations, or in a stone with plane faces at right angles to the optic axis. Both of these facts are well known to practising lapidaries; yet they are very seldom mentioned anywhere. This variation will be found to be less in the red corundums than in the other varieties, and to be greatest in the blue coloured stones.

Although the blue sapphire will often be found to show very considerable differences, the actual variation in any other coloured variety of corundum is more a matter of scientific interest than practical importance, as with the exception of the sapphire the difference in hardness between any two stones of the same colour is comparatively small. This fact led to it being very early commented on that the blue sapphire is often harder than the red ruby. But it really goes much further than this as it is an undoubted fact that the softest sapphire is invariably a trifle harder than the hardest ruby; although no one seems to have considered it worthwhile to investigate this interesting fact.

The writer finds that colour alone plays but a minor part, if indeed it plays any actual part at all, in this variation in hardness, which appears to be more intimately concerned with the common crystalline habit of the species. It has been noticed that stones which crystallise in the prismatic

2 The use of the artificial abrasive known as *carborundum,* whose hardness is given as 9 has been suggested for this purpose, but as its abrasive powers are variable, it is found to be unsatisfactory.

habit are normally softer than those which adopt the pyramid habit, and that those which occur as bipyramids are again harder than those which show the form of a single pyramid. This will be found to be true of the stones from all of the corundum deposits except certain stones from Montana, which appear to be distinctly abnormal, and to behave in a manner directly contrary to general custom in many respects. It is thus often the case that when a ruby is being tested it will only feebly mark, or entirely fail to scratch another piece of corundum of a different colour; and should the piece so tested be a blue sapphire it will often make a deep scratch with the greatest of ease upon the surface of the ruby which will not make the slightest impression upon the sapphire.

This difference in hardness may be accounted for by the constituent atoms being arranged in a slightly different manner in the various forms of crystals. We know that in corundum there is a very uniform and closely linked arrangement of these atoms, as there is in all very hard stones; but X-ray photographs *(Laue diffraction patterns)* tend to show that the distances between adjacent pairs of atoms are relatively larger and thus the attractive forces between them are proportionally less in the prismatic forms than in the single pyramids, there being a still closer arrangement with a higher attractive force in the bipyramids. This would make for an increased hardness, and also account for the difference in hardness along the lines of the striations, which in the case of the ruby will be more apparent when we come to deal with the basal parting in these stones.

In view of the above it would be more in accordance with actual facts if instead of designating the whole of the corundum group as having the common hardness of 9.00 the following figures were substituted.

Hardness of the Corundum Group .... 9¼ to 9
Hardness of Sapphire 9½
Hardness of Ruby 9

This high degree of hardness makes corundum of great use to the lapidary as an abrasive, and in fact until comparatively recently it was the only hard abrasive used by Eastern lapidaries, while today many of them use it solely for all purposes, save the grinding of diamonds. Ruby may be quite satisfactorily cut with finely crushed commercial sapphire, while both rubies and sapphires may be cut with their own dust, provided that the lap is run at sufficiently high speed, but it is a slow process, so for cutting these stones a small proportion of diamond dust is added to give an extra bite.

Figure 4.1
Microscopic parallel structure in a fine ruby.

Next to diamond dust, crushed corundum is the most satisfactory abrasive for the lapidary to use, save for quite soft stones, as it is tougher, more lasting, and has a much more efficient grinding action than the slightly harder artificial abrasive known as *carborundum.*

The hardness test may be applied to all forms of cut corundum in a very simple manner, without the slightest fear of damaging the stone, provided that ordinary care is taken to avoid rough or violent action. All that is required is a small piece of chrysoberyl across which the edge of the girdle of the cut stone is drawn with a slight scratching action. All forms of corundum will freely scratch the chrysoberyl, but no other stone with the exception of diamond will have the slightest effect upon it. Therefore there is no need at all to use the cutting points, as these are very apt to seriously damage a valuable stone, and which, however carefully they may be applied, often leave an unsightly scratch.

The hardness test is quite useless in discriminating between genuine and synthetic corundum, save perhaps that a genuine sapphire will invariably scratch a synthetic one, as all forms of synthetic corundum have an even hardness of 9. The statement that certain lapidaries can immediately distinguish between a natural and a synthetic stone by its behaviour on the lap, or wheel (the so-called *wheel test*) has not been borne out on investigation, several lapidaries declaring it to be utter nonsense.

Cleavage and Parting

There is no true cleavage in corundum, but there is a very distinct *false cleavage* or *parting* in certain stones which lies in a direction parallel to the basal plane of the prism, and which would appear to be due to incipient decomposition. This has given rise to the often made, but entirely erroneous, statement that the ruby has a perfect basal cleavage. Signs of a similar, but much less distinct, parting may sometimes be noticed in a direction parallel to the faces of the prism, and a third parallel to the faces of the rhombohedron. These are thought to be due to pressure and lamellar twinning on these faces, the planes of which act as *glide planes.*

Reference has already been made to a platey, or parallel, structure which is frequently very marked in the lower grade of ruby (Figure 4.1), but which may also quite often be found in a microscopic form in the very finest grades of rough rubies. This is due to microscopic cavities arranged in a horizontal direction parallel to the basal plane, and sometimes to the faces of the rhombohedron, and which in the first instance were most probably due to the presence of ordinary silk. These cavities may therefore be regarded more in the light of *solution planes* along which corrosion will most likely take place, and along which parting is already taking place, owing to the commencement of decomposition. In many instances there is a pearly or bronzy sheen accompanied by a very distinct lack of cohesion between the plates, which may often quite easily be separated by means of a finger nail, and thus present what at first sight would appear to be a perfect basal cleavage, but is in reality only a parting. It is quite usual to find between these plates an appreciable amount of decomposition products in the form of a very fine yellowish-brown dust, which on being tested chemically gives a strong reaction for iron. Some of the separated plates when cleaned and polished will appear to be quite clear and solid, even when examined under the microscope; but others will be found to be permeated with the brown disintegration material which would appear to be contained in the microscopic fissures which follow the original lines of the black silk inclusions, and cross each other at regular angles of 120° and 60°. There is not the slightest doubt that stones which exhibit this appearance to a marked extent are in an advanced stage of decomposition, while those which only show it in a lesser degree are only in the comparatively early stages.

So far as the writer has observed, this very regular form of disintegration accompanied by the parallel structure would appear to be confined to such

Figure 4.2
Typical fracture of corundum. This royal blue stone of magnificent colour and quality weighed in the rough 390 carats and realised over £3,000 at first sale.

stones as crystallise in the prismatic habit. Decomposition may also be found in the crystals of the pyramid habit, but it is always more or less local, patchy to uneven, and never in parallel planes, so that it does not give rise to the parallel structure. It would also seem reasonable to attribute this fact to a different arrangement of the constituent atoms in the two varieties of crystals.

Fracture

With the exception of adamantine spar, the fracture of all the varieties of gem corundum is always *conchoidal.* That is to say that it exhibits the typical fractured surface shown by newly broken ordinary glass, which is characterised by a peculiar circular ripply appearance, the ripples occurring as arcs of circles circumscribed about a common centre, not unlike the ripples produced by throwing a stone into water. These markings have been likened to the lines of growth in certain shells, which has caused it to be described also by the name of *shell-like fracture.* In fact the word conchoidal comes from the Greek χοειδης *(konchoeides),* meaning shell-like, in allusion to its general appearance.

The fracture is induced to take this form by the outward transmission, in the same manner as the ripples on the pond, of an intense local vibration from a small area within the stone, which is often indicated by a dome shaped lump or depression, known as the *lobe of percussion* being found immediately below the point of impact which set up the vibration. The appearance of the ripples, and the general surface of the fracture may vary to a very considerable extent; as also may the degree of curvature, which at times may be almost planar. In corundum, however, there is usually a fairly deep curvature, with distinctly marked rippling, while the lobe of percussion is often very prominent.

A fracture across the thin layers of a stone with a parallel structure may at first appear to be *splintery,* but examination with a lens will always show it to be conchoidal, although it may not always be an easy manner to determine this accurately.

The fracture of synthetic corundum being to a large extent influenced by the stresses and strains within the stone, differs somewhat from that of natural corundum. It is still conchoidal in type, often with very well marked rippling, but the surface is much flatter, sometimes with a curious wavy appearance, and often shows a long narrow curved groove, or raised ridge, while a distinct lobe of percussion is rarely to be observed. The natural fractured surface which follows the splitting of the *boule* on cooling may often very closely approximate to the *uneven* type.

The fracture of adamantine spar is uneven to splintery.

Frangibility

The frangibility of the stone, often to be found expressed by the term *nature* of the stone, is very commonly confused with the term hardness, which is an entirely different property. By the frangibility of a stone, we mean that quality which depends on the ease, or otherwise, by which the stone may be fractured by a blow from the hammer; or in other words its resistance to fracture as opposed to resistance to abrasion in the case of hardness.

There is no clearly defined or even recognised scale of frangibility, but all stones may be conveniently referred to the comparative scale in Table 4.5 devised by the author for his own use.

Table 4.5: Frangibility

No.	Frangibility	Description
1	Super tough	Resistance to fracture very high, as in jadeite
2	Very tough	Resistance high, as in ilmenite
3	Tough	Resistance fairly high, as in agate
4	Brittle	Resistance low, as in corundum
5	Fragile	Resistance very low, as in cordierite or fibrolite

All varieties of corundum distinctly fall into Group 4, which is Brittle, but the resistance to fracture may be found to be considerably higher in some stones than in others, which may be almost Fragile. As a general rule, however, the frangibility of gem corundum may be taken as easy, and they should always be regarded as being liable to be fractured by a chance blow, or a fall onto a hard surface. Even if the fracture is not at once complete, or even if there should be no damage at all apparent to the naked eye, there is always the gravest danger of minute internal cracks, or feathers being started up. At first these may only be visible under the microscope, but they may, and usually do, eventually spread and complete the fracture, which may then occur several months, or even years afterwards. Some rubies, but by no means all, show a decided tendency to split in a direction parallel to the basal plane of the prism.

In view of this great danger, the greatest care should always be exercised in handling valuable rubies or sapphires, as, if they should be dropped onto a moderately hard floor, or even the glass top of a show case, a very valuable stone may be irrevocably ruined.

5
THE PHYSICAL PROPERTIES OF CORUNDUM
B. Optical: Diaphanity, Lustre, Refraction, Interference Figures, Refractive Indices, Dispersive Power, Pleochroism

Diaphanity ⚜ The diaphanity of corundum ⚜ Lustre defined ⚜ Natural and artificial lustre ⚜ Maximum lustre ⚜ Grades of lustre ⚜ The lustre of corundum ⚜ Type of refraction, axiality, and sign ⚜ Direction of optic axis ⚜ Anomalous refraction ⚜ Normal uniaxial interference figure ⚜ Anomalous biaxial figure ⚜ The refractive indices of corundum ⚜ Dispersion defined ⚜ The importance of dispersion and correct cutting ⚜ The dispersive powers of corundum ⚜ Pleochroism defined ⚜ The use of the dichroiscope ⚜ The pleochroism of corundum ⚜ Table of pleochroic colours ⚜ The effect of dichroism and cutting on the final colour

Diaphanity

By the term *diaphanity* is understood the power possessed by substances of transmitting light, or in simpler language their degree of transparency.

This power is divided into five grades as follows:

Table 5.1: Diaphanity

No.	Diaphanity	Description
1.	Transparent	Can be seen through without difficulty
2.	Sub or semi-transparent	Can be seen through, but only with difficulty
3.	Translucent	Transmits light easily, but cannot be seen through
4.	Sub- or semi-translucent	Transmits light, but with difficulty
5.	Opaque	Transmits no light at all

Both opacity and translucency are very often but a matter of mass, so that certain stones which may be quite opaque when in the form of a lump, will be quite transparent in thin splinters, or when cut into sufficiently thin plates. Unless it is otherwise stated, however, the diaphanity of stones as given in the various tables always refers to that of the mass.

The stones of the corundum group may be met with in every one of the above degrees of diaphanity, which applies to all colour varieties except commercial corundum which is always sub-translucent to opaque.

Colourless corundum being pure alumina should normally be perfectly transparent, but due to mechanical causes it may become translucent, and the presence of dense masses of ordinary silk may cause it to be quite opaque. But in every case the microscope will show that, apart from the inclusions, the main body of the stone is quite transparent.

All the better grades of the gem varieties are usually stated to be perfectly transparent, and in fact they usually are, sometimes very highly so. But there are exceptions as instanced by the milky sapphires from Kashmir, which may be only sub-transparent, and in the star stones, which may be anything from sub-transparent to quite opaque, and still be of fine gem quality. In the lower grades, stones may be found used as gems in all stages of diaphanity, and in the carved stones and beads, transparent stones containing opaque patches are very common indeed.

Much of the opacity in corundum will be found to be due to either densely packed masses of plainly visible silk, large accumulations of microscopic bubbles, or to a myriad of microscopic fissures. It may also be caused by inclusions of foreign matter. The presence of black silk is a prolific cause of sub-transparency or translucency.

It is quite a common thing to be able to cut several stones illustrating the complete range of diaphanity from a single crystal, while it is by no means uncommon to find a comparatively large crystal which will only contain one, or perhaps two, small portions of sufficient transparency to be of any real gem value.

Lustre

The term *lustre* is understood to mean the intensity, character, and general appearance of the light reflected from the natural, fractured or artificially polished surface of a stone or other substance.

In the case of a worked stone which has passed through the hands of the lapidary this lustre may be purely natural, or purely artificial. That may appear to be somewhat ambiguous, but some stones possess a natural lustre that the lapidary cannot improve upon, while others which may have only a poor natural lustre, will show a very fine artificial one when the lapidary has finished with them, or he can produce a fine polish on certain stones which have no natural lustre at all.

Each class of stones, however, has a maximum lustre, or saturation point of polish which, once reached, cannot be further intensified. In nature, certain crystals may be found which have a high degree of natural polish that cannot be equalled, much less intensified, by artificial means. Certain crystals of corundum will show this very markedly, but they are very rarely to be met with.

There are nine main recognised and classified grades of lustre and many entirely unofficial sub-grades and refinements, many of which are but a matter of personal opinion. But with corundum we are only concerned with the following four.

Table 5.2: Lustres

No.	Lustre	Description
1.	Adamantine	A lustre that almost approximates to the metallic in type, which is characteristic of certain stones, which may be either transparent or only sub-transparent, but will normally have a high index of refraction. It is typically shown by diamond.
2.	Vitreous	The lustre shown by the newly fractured surface of ordinary glass, as typically shown by quartz.
3.	Silky	A shimmering appearance similar to the sheen observed on the surface of silk. It is characteristic of stones with a fibrous structure in which the fibers lie approximately parallel to the surface. Typical of gypsum.
4.	Velvety	A peculiar rich appearance in the interior of the stone which spreads to the surface and imparts to it a soft blush very similar to that shown by fine velvet, or a freshly gathered plum. It is typically shown by certain sapphires and emeralds.

All the transparent gem varieties of corundum show a lustre which is vitreous in type and is frequently so intense as to very closely approximate adamantine, but on the other hand may incline to be quite weak; in such cases it may, however, be so greatly improved by the art of the lapidary that it can be brought to closely resemble the lustre of a cut diamond. Owing to the hardness of the stone, this fine artificial lustre will be retained for a very long time, even though the stone may be subjected to more than its fair share of wear and tear.

Many stones will exhibit a very distinct silky lustre in a direction at right angles to the optic axis. This may be merely in isolated patches, or may cover the entire surface of the stone. It is due to bands of silk which may be present in such quantity as to render the stone quite opaque, and may also give rise to both asterism and chatoyancy. A very similar appearance may be created by enclosures of minute fissures when present in sufficient quantities, but in this case the silky lustre may lie in any direction in the stone.

Certain sapphires, usually of the royal or cornflower-blue shades, in addition to possessing a fine strong vitreous lustre will also show a peculiar rich appearance which commences in the interior of the stone and, ascending to the surface, spreads over it and imparts to the vitreous lustre a soft blush-like effect which is perhaps best likened to the soft appearance of the pile of fine velvet. This lustre is peculiar to sapphires and certain emeralds and there are no records of its ever having been the subject of scientific investigation, but it is the writer's considered opinion that it is due to ultra-microscopic colloidal particles[1] which acting as inclusions within the stone deflect and break up the internal light and so cause it to react in peculiar manner. This type of lustre must not be confused with "velvety lustre" (4) which is merely a dull sheen on the surface of the stone, and is characteristic of stones with a fibrous structure.

The lustre of some of the opaque varieties of corundum may be intensely silky and yet at the same time quite dull.

Refraction

The refraction of corundum is double, but weak in amount, only being equal to a mean of 0.0086 for the entire group; the birefringence being uniaxial and negative in sign.

The direction of the optic axis, directly along which the stone or crystal will only exhibit single refraction, is parallel to the faces of the prism, and in the single pyramids a line drawn vertically from the base through the apex, in the bipyramids a line joining the apices.

Some of the larger, and more especially twinned, crystals may be found to be anomalously biaxial, in which case the axes will be doubled in number, and may lie in slightly different directions.

Interference figures

The interference figure of corundum is normally a very clear and distinctly defined uniaxial one, but it is by no means uncommon to find sections which show an anomalous, but very distinct, biaxial figure, which may have a very small angle between the figures. This anomaly would appear to

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1 See also Chapter 3, page 61.

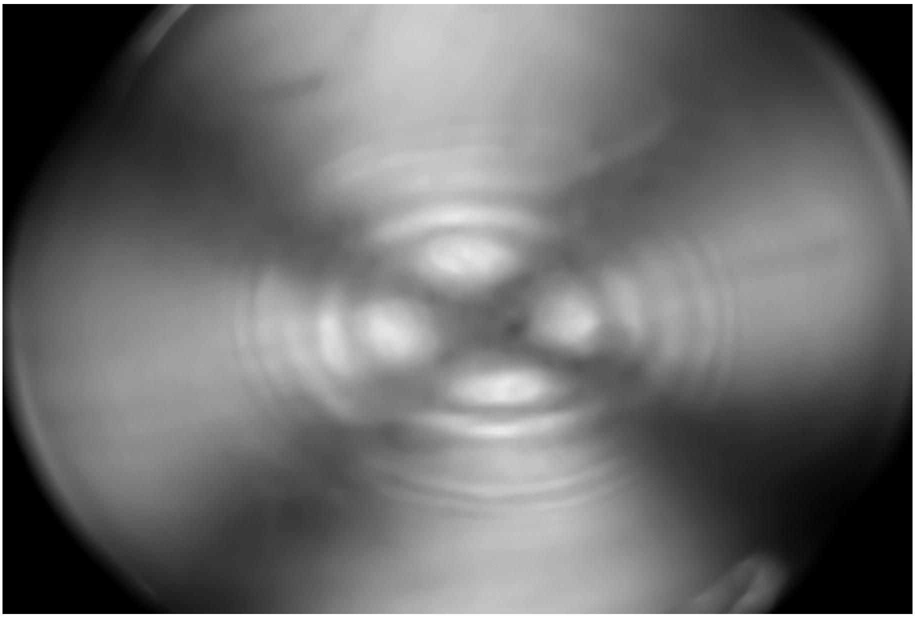

Figure 5.1
The interference figures of Corundum. (A) Normal uniaxial (B) Anomalous biaxial

be directly concerned with twinning, and is usually explained as being due to the laminar structure produced by the secondary twinning on the rhombohedral faces; but other authorities contend that such crystals are really triplets, and so are either orthorhombic or monoclinic. If the section is thin enough to prevent the basic colour from masking the colours of the figure, they will be found to be almost identical with those for quartz for sections of equal thickness.

Refractive indices

The refractive indices of the corundum group stand high and are usually taken as being 1.770 for the ordinary ray (ω) and 1.761 for the extraordinary ray (ε) the amount of double refraction (ω–ε) thus being 0.009. This is quite near enough for all practical purposes, although some authorities prefer to adopt slightly lower figures.

The following table shows the writer's observations of the slight variation shown by differently coloured varieties, the figures representing the mean of a very large number of readings taken from different stones.

Table 5.3: The refractive indices of corundum

Colour	Mean Observed Readings			Remarks
	Ordinary ray (ω)	Extraordinary ray (ε)	Amount of double refraction (ω–ε)	
Pigeon's blood red	1.770	1.761	0.009	Slightly lower
Fine red	1.768	1.761	0.007	Constant
Pale red	1.767	1.759	0.008	Variable
Royal blue	1.774	1.765	0.009	Constant
Cornflower blue	1.766	1.757	0.009	Constant
Pale blue	1.768	1.759	0.009	Constant
Colourless	1.767	1.759	0.008	Variable
Yellow	1.769	1.759	0.010	Very variable
Green	1.767	1.758	0.009	Constant
Purple	1.776	1.767	0.008	Variable

The remarks refer to the general tendency of the figures comprising the entire series of observations to compare with the mean figures shown in the table.

It was observed that no matter to what extent the actual figures representing the indices may vary in individual stones the actual amount of the double refraction was in the majority of cases remarkably constant for the stones of the same colour.

Dispersive power

The *dispersive power* or more commonly *dispersion* of a stone is its power to split a single ray of white light passing through it into its component coloured rays, and so produce a spectrum; its actual power or strength being in proportion to the width of the spectrum it produces. For the purpose of making comparative measurements, this has been reduced to definite figures by subtracting the refractive index for the red ray from the refractive index for the violet ray of the same stone.

It is upon this power of dispersion, combined with the correct forms of cutting, that a number of stones depend for the beautiful internal brilliancy, and fine display of chromatic light known as *fire,* which is their sole claim to recognition as gemstones.

It will be noticed that there is a combination with correct forms of cutting mentioned, and by this it is meant that if a stone possesses a high dispersive power, this can be increased in effect, and made still more beautiful by making the facets of a cut stone such a shape, and arranging them at such an angle, that has been calculated to produce the best results. But on the other hand, if the original dispersion is low, no amount of wangling the arrangements of the facets is going to materially improve upon it. For instance, a diamond has a high dispersive power varying between 0.044 and 0.053 which accounts for its fine display of fire, but rock crystal (quartz) has a low dispersion between 0.013 and 0.025 which makes it a comparatively dull affair when compared with a diamond.

The dispersion of both rubies and sapphires is quite low, only averaging 0.018, so that no matter what skill the lapidary may bring to bear in the cutting, they will show but little internal fire, and must therefore entirely depend upon their fine colour for their claim to recognition. Colourless corundum and certain pale sapphires may have a dispersion equal to 0.025, and golden-yellow stones have been known to reach 0.028, while pale yellow may be as high at 0.030, which accounts for the greater brilliancy of these stones, more especially by artificial light.

On account of their low dispersion all varieties of corundum will be found to produce a very wide spectrum when examined by a refractometer in white light.

Pleochroism

Pleochroism or as it is often termed *selective absorption* is the power possessed by certain stones of exhibiting one (monochroic), two (dichroic), or three (trichroic) colours when examined in polarised light in certain definite directions; but which may in certain cases be clearly observed by the unaided eye.

The most usual method of observing this phenomena is by the means of a small instrument known as the *dichroiscope,* which broadly consists of highly doubly refracting rhomb of Iceland spar carried in a tube between a small square hole and a lens. On looking through the lens the hole will appear as two adjacent squares, one representing the extraordinary ray. The square representing the extraordinary will, when the instrument is looked

Table 5.4: The pleochroic colours of corundum

Colour of Specimen	Pleochroic colours observed		Strength
Origin	**Ordinary ray (ω)**	**Extraordinary ray (ε)**	
Pigeon's blood red Burma	1. Deep carmine 2. Deep carmine	1. Light carmine 2. Medium pure red	Distinct Distinct
Fine red Burma	1. Deep red 2. Deep pure red 3. Pure bright red	1. Faint bluish red 2. Bluish red 3. Faint bluish red	Strong Strong Strong
Red, with blue tint Burma	1. Deep red 2. Pure red 3. Bright red 4. Deep red	1. Deep bluish red 2. Almost blue 3. Bluish red 4. Almost purple	Strong Strong Strong Strong
Deep red (black ruby) Burma	1. Deep dark red 2. Deep bright red 3. Deep dark red	1. Lighter red 2. Brownish red 3. Deep red, tinged blue	Not strong Distinct Distinct
Pale red Ceylon	1. Pale red 2. Pinkish red 3. Bright pale red	1. Faint bluish red 2. Almost pale blue 3. Bright bluish red	Distinct Distinct Strong
Pale pink Burma	1. Pure pale pink 2. Pure pale pink 3. Pale pink	1. Colourless 2. Pale blue 3. Pinkish blue	Distinct Distinct Distinct
Deep royal blue Burma	1. Deep blue 2. Deep blue 3. Pure deep blue	1. Paler blue 2. Bright blue 3. Pinkish blue	Strong Very strong Strong
Cornflower-blue Burma	1. Pure blue 2. Pure deep blue 3. Pure deep blue	1. Aquamarine blue 2. Paler blue 3. Blue tinged green	Very distinct Very distinct Strong
Milky cornflower blue Kashmir	1. Pure deep blue 2. Pure deep blue	1. Pale greenish blue 2. Medium pure blue	Strong Distinct
Indigo blue Burma	1. Deep blue 2. Deep blue 3. Intense blue	1. Deep greenish blue 2. Deep yellowish blue 3. Greenish blue	Strong Very Strong Very Strong
Dark blue Australia	1. Deep blue 2. Deep blue 3. Intense blue	1. Greenish yellow 2. Pale reddish blue 3. Greenish-blue	Strong Very Strong Very Strong

Table 5.4: The pleochroic colours of corundum

Colour of Specimen	Pleochroic colours observed		Strength
Origin	Ordinary ray (ω)	Extraordinary ray (ε)	
Dark greenish blue Siam	1. Deep blue 2. Deep blue 3. Pure blue	1. Dark yellow 2. Greenish blue 3. Almost pure green	Very strong Strong Very Strong
Pale blue Ceylon	1. Strong blue 2. Blue 3. Very pale blue	1. Very pale blue 2. Yellowish blue 3. Colourless	Very strong Distinct Indistinct
Deep golden yellow Ceylon	1. Golden yellow 2. Golden yellow 3. Deep yellow	1. Pale yellow 2. Colourless 3. Yellow tinged pink	Intense Intense Intense
Yellow Burma	1. Deep yellow 2. Bright yellow 3. Yellow	1. Pale yellow 2. Colourless 3. Pale lemon	Very strong Intense Distinct
Deep purple Burma	1. Deep red 2. Red 3. Medium red	1. Deep blue 2. Purple 3. Dark plum	Very strong Intense Intense
Light purple Burma	1. Light red 2. Light red 3. Bluish red	1. Bluish red 2. Medium purple 3. Pale bluish red	Strong Intense Distinct
Dark green Ceylon	1. Strong blue 2. Medium blue	1. Dark yellow 2. Bright yellow	Very strong Intense
Cloudy green Burma	1. Dirty pale blue 2. Pure blue 3. Bluish green	1. Darkish yellow 2. Smoky yellow 3. Pale yellowish green	Very strong Strong Intense
Colourless Burma	1. Pale blue 2. Pale pink 3. Pale yellow 4. Very pale blue 5. Very pale violet	1. Colourless 2. Colourless 3. Colourless 4. Very pale yellow 5. Colourless	Indistinct Indistinct Indistinct Indistinct Indistinct

through in a plain white light, show along its inner edge a faint narrow red border, and upon its outer edge a similar blue border, but the square for the ordinary ray will have sharp uncoloured edges. If a coloured doubly refracting stone is held in front of the aperture the two squares will appear to be of different colours, which will change places if either the stone or the instrument be slowly rotated. This is due to the fact that the two rays into which the stone splits up the single incident ray have been differently absorbed within itself, with the result that on emerging they appear to be of different colours.

Singly refracting stones, or amorphous substances, do not split up the ray and so both squares will be of the same colour, thus showing the stone, or substance, to be monochroic. It must, however, not be overlooked that doubly refracting stones, when viewed in a direction directly along one of the optic axes, will also only show single refraction, and, therefore, the two squares will be of the same colour. There are two such directions in a uniaxial stone, and four in a biaxial one. So that if a strongly dichroic stone be viewed along any one of these directions, it would appear to be monochroic. Consequently it is absolutely essential that all stones should be examined for pleochroism with the light passing through them from several different directions, and that a single examination made in one direction only should never under any circumstances be relied upon.

All varieties of corundum, with the exception of the water-white, are dichroic, which is usually very strongly marked in the deeper coloured stones. Some specimens will be found to be intensely dichroic, but in the paler coloured stones it may become very faint and difficult to observe, but even in such cases, with a little care it is always distinct enough to be conclusively observed. The pure water-white specimens will naturally show no dichroism at all, but frequently a stone which, to the eye will appear to be quite colourless, will contain just a tinge of colour, which will make it distinctly dichroic when viewed through the instrument. All the opaque stones, with the exception of commercial corundum, will be found to be dichroic when in the form of splinters or thin sections.

To draw up a comprehensive scale of the various pleochroic colours observable is almost a matter of impossibility, as the actual colours and combinations of them will vary in almost every individual stone. The following table shows a selection of the colours observed by the writer, and is merely given as a general guide as to what may be expected from the various coloured varieties, but it is by no means complete, and wide variations from it may be encountered.

As all varieties of corundum depend solely upon their colour for their beauty, and consequently for their value, a very close and careful study of the dichroism of each individual stone before attempting to cut it is of vital importance, if the best colour effect is to be obtained. In the majority of cases the object will be to retain the purer colour of the ordinary ray, and either to subdue or eliminate altogether the objectionable colour introduced by the extraordinary ray; but sometimes exactly the opposite will have to be done to secure the best effect, each case having to be decided upon its merits after careful study. This will be more fully discussed when dealing with the actual cutting of the stones.

6

THE PHYSICAL PROPERTIES OF CORUNDUM

C. Miscellaneous

Solubility; Streak; Phosphorescence; Electric Properties;
Behaviour Under the Action of X-rays; Ultra-violet Light; Radium; Thermal Properties

The action of acids and alkalies ⚜ Corundum cannot be chemically etched ⚜ How solution may be obtained ⚜ Resistance to natural decay ⚜ Solubility in nature ⚜ The streak of corundum ⚜ The false streak of commercial corundum ⚜ The phosphorescence and fluorescence ⚜ Phosphorescence under radium and strong light ⚜ The electric properties of corundum ⚜ The erratic behaviour of corundum under X-rays ⚜ The fluorescent test unreliable ⚜ Laue figures and what they reveal ⚜ Synthetic corundum under X-rays ⚜ Star stones under X-rays ⚜ The possibilities of X-ray examinations ⚜ Apparatus for making the examination ⚜ The use of ultra-violet light and its production ⚜ Ultraviolet light an unsafe test ⚜ Corundum under ultra-violet light ⚜ Crookes experiment with diamond and radium ⚜ The effect of radium on colour ⚜ The thermal conductivity of corundum

Solubility

In its natural state, corundum offers a very powerful resistance to the action of chemical reagents and solvents, and so far as we have been able to observe it is quite insoluble in all strong acids or solutions of alkalies. Prolonged exposure to the action of hydrofluoric acid (HF) will have no visible effect on it, so consequently corundum gems cannot be chemically etched in a similar manner to certain gems of other species.

If, however, corundum is first reduced to the form of a very fine powder and then fused with alkalies and bisulphate of potassium ($KHSO_4$) a mass will be produced which is capable of passing into solution. Mendeleeff states as follows:

> The effects of purely mechanical subdivision on the solubility of alumina are evident from the fact that native anhydrous alumina (i.e. corundum) when converted to an exceedingly fine powder by means of levigation dissolves in a mixture of strong

Table 6.1: The phosphorescent colours of corundum

Colour of specimen	Phosphorescent colours observed
Red	Brilliant rose red; pale pink; violet; pale green
Blue	Rose red; pale bluish pink; violet; green; pale green; yellow
Yellow	Intense yellow; orange; pink; pale greenish yellow
Green	Greenish shades; pink; bluish shades; yellowish shades; almost colourless
Purple	Brilliant red; pink; violet; mauve; bluish shades
Colourless	Pink; pale bluish shades; pale green; very pale yellow
Commercial corundum	Invariably inert

sulphuric acid (H_2SO_4) with a little water, more especially when heated in a closed tube, or fused with acid sulphate of potash.[1]

The writer has performed this experiment many times, but has never been able to find the slightest trace of solubility that could be detected by any known method of analysis either from the cold, or previous to fusing the powdered corundum.

Corundum clearly has a powerful resistance to chemical action, and an equally powerful resistance to the processes of natural decay and disintegration, which are primarily caused by the action of natural chemical reagents contained in the atmosphere and waters, etc. with which the stones come into contact, setting up a chemical action within the stone itself, and so producing both chemical and structural changes. This resistance explains the perfect condition in which many stones are found. But despite this, it is obvious from the fact that large numbers of stones are found in a very advanced state of decay, that there must be a very slight degree of solubility in all cases. This is so exceedingly small after the comparatively short time that we can allow for treatment, even though this may extend over a period of hundreds of millions of years, and has become markedly apparent in the corrosion and disintegration which is to be found along the solution planes, and in the fissures of so many natural specimens of corundum. It is, of course, very highly possible that this solution and

1 Mendeleeff, D. (1905) *The Principles of Chemistry.* Third edition of Kamensky's translation. Vol. 2, p. 86.

decay has been aided by other natural causes, of which it is more than probable that radioactivity was one.

Streak

If any variety of corundum is rubbed across a piece of unglazed porcelain, there will be no mark known as the *streak* left behind upon the porcelain. It is often stated that commercial corundum, and sometimes adamantine spar will leave a streak, which may be either black, red, or brown. This is, however, not due to the corundum, but to the enclosed impurities such as haematite or magnetite, and, as it is often absent altogether, it is unreliable and should be ignored.

Phosphorescence

When gently heated in a dark room by means of a bunsen burner, or spirit lamp, many specimens of corundum, but by no manner of means all of them, will become luminous and glow with an internal phosphorescent light of varying degrees of intensity. This must not be confused with the luminosity due to the stone becoming red hot, as phosphorescence will begin at a much lower temperature.

Where mentioned at all, this phenomena is usually dismissed with the words corundum will phosphoresce with a red light; but the writer's experiments show this to be quite incomplete, as, although a large number of stones will show no signs of luminosity until they become red hot, he has observed that the phosphorescent colours of such stones as do show it is very far from being confined to red alone, and also that it does not of necessity always conform to the colour of the specimen under test. Contrary to the general belief, many opaque and densely silky stones were found to exhibit a very marked phosphorescence.

The light emitted was at times quite brilliant, and at others barely perceptible, but on the whole may be classed as quite distinct. In certain cases the luminosity lasted for two or three minutes after the source of heat was removed, but usually ceased almost immediately.

A number of theories have been advanced to show why phosphorescence should be so marked in some stones and entirely absent in others of the same species, but nothing very definite, or in the least convincing, has yet been arrived at. The actual cause of both phosphorescence and fluorescence is due the stone transforming the invisible energy imparted to it by the exciting cause into visible radiations, and often continuing to do so for a considerable time after that exciting cause has been removed. When the

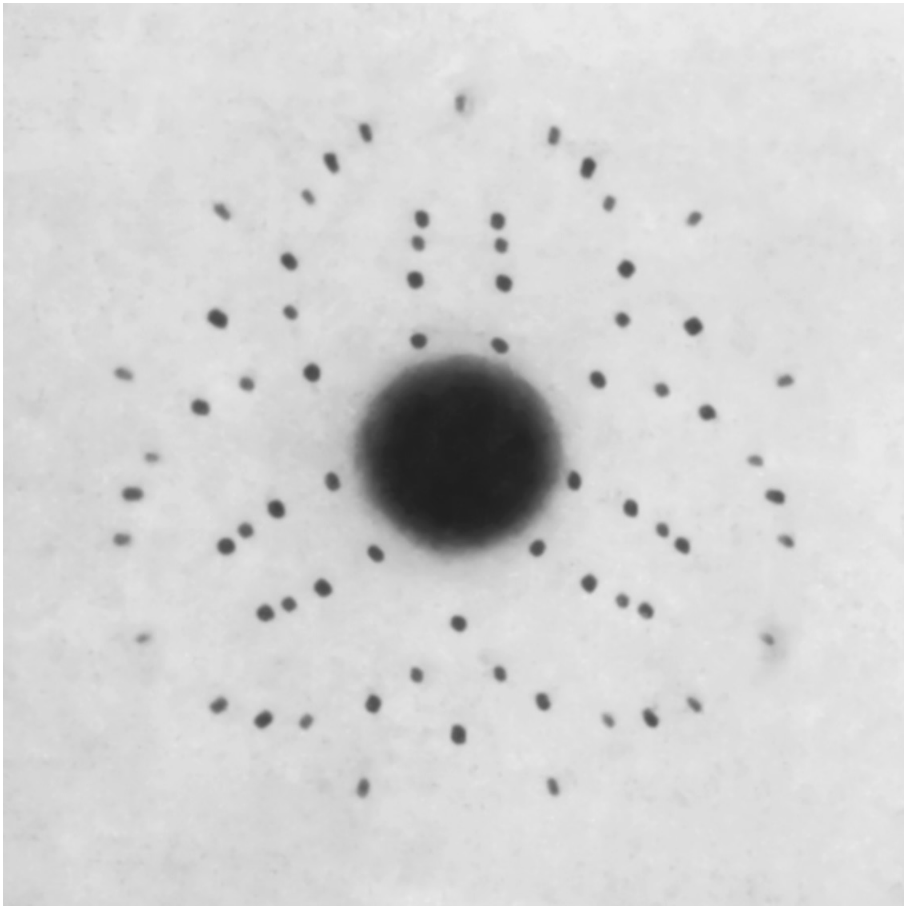

Figure 6.1
Laue diffraction pattern of natural ruby. From Michel, H. (1926) *Die künstlichen Edelsteine.* Leipzig, Verlag von Wilhelm Diebener, 2nd edition, 477 pp

energy has been imparted in the form of light rays, the phosphorescent rays so produced will have a greater wave length than that of the energising rays.

All varieties of corundum will phosphoresce with varying degrees of luminosity when exposed to the action of radium; but phosphorescence would not appear to be induced by any form of exposure to intense light.

Electric properties

Corundum is a non-conductor of electricity. When rubbed upon silk or cloth, or gently heated, all varieties will acquire a charge of positive electricity, which may sometimes be quite strong, and at others almost undetectable. It is, however, invariably present, but usually only of moderate strength. When very strong, the charge may be retained for as long as thirty minutes, but is normally only of short duration.

When the charge has been induced by heat, a change of polarity as stone cools has not been observed.

Pressure would appear to have no effect in inducing a charge of electricity in corundum.

Behaviour under the action of X-rays

It has been claimed that the observation in the dark of the fluorescence induced in corundum by passing a narrow beam of X-rays through it is a certain and conclusive test for the distinction between natural and synthetic corundum. While this test is to some extent useful as an indication, it is very far from being one hundred percent perfect as a final argument, as the behaviour of corundum under X-rays is of a very erratic nature, and it never seems to do quite what is expected of it. For instance, it has been noticed that a stone may show only a very faint fluorescence, but when examined on another occasion will exhibit a very distinct glow, and at yet another time be quite inert. So that with normal stones behaving in this erratic manner, any fluorescent test made with X-rays must, at the present time, be regarded as being merely exploratory and indicative, and as a conclusive test for anything to be quite unreliable.

By the *fluorescent test,* it is meant that when a narrow beam of X-rays is passed through certain stones from below, and the stones then observed from above, they will be found to exhibit a luminous glow, which may be distinguished from phosphorescence by appearing to be more or less confined to the surface. This glow may vary in intensity from fairly brilliant to so faint that it can scarcely be seen. In all cases it is essential that the observations should be made in complete darkness.

The examination of gemstones by means of X-rays is very much in its infancy, and most of the experiments so far have been in the direction of determining the crystal architecture by means of special photographs variously known as *Laue figures, spot diagrams* or *Laue diffraction patterns,* with the result that this branch has now been reduced to a fairly exact science which is of great use to the scientific research worker, and has also a very considerable commercial importance.

By means of these photographs and calculations made from measurements upon them, the size and relative positions of the atoms which go to make up the structure of the crystal may be determined with considerable accuracy, and it is thus definitely possible to distinguish one variety of crystal from another, no matter whether it be in the form of the original crystal, a cut stone, or only a broken fragment. So that by this means it is possible to discriminate between corundum and stones of a different species but similar appearance, much in the same manner as is now being done commercially in the case of natural and cultured pearls. But there is still a great deal of work to be done before this method can become the everyday one of the working gemmologist, although it is practically certain that sooner or later it will be in general use.

The experiments with the fluorescent method are not so far advanced, and all that we really know regarding corundum is that the natural gem varieties will only fluoresce with difficulty, the effect when present usually being very faint; that it is often entirely absent, and generally erratic in its behaviour; and that some natural stones will show a bright fluorescence, but only rarely so.

On the other hand synthetic corundum will normally show a bright fluorescence, which is much more intense than that shown by the natural stones, and in the case of the synthetic ruby the red glow is usually more intense than the actual colour of the stone warrants. But here again the behaviour is erratic, as in some synthetic specimens the fluorescence may be scarcely observable.

Another instance of the erratic behaviour of corundum is that while in the natural transparent varieties the effect is generally poor, the opaque silky stones will often fluoresce with great brilliancy. This is especially the case with certain star sapphires, but star rubies will seldom do so; here again it is not general, as some star stones will be quite inert.

There is still an enormous amount of experimenting to be done, and vast quantities of material to be examined, and the results carefully compared before sufficient data can be collected and tabulated to render this method of discriminative examination at all reliable. Much work in this direction has already been done with pearls and the combination of the X-ray fluorescent and photographic tests are now accepted as conclusive for the distinction between natural and cultured pearls; and there is no reason to suppose that in the near future it will not apply with equal reliability to corundum.

For the purpose of making X-ray examinations Messrs. Phillips Industrial of London have placed upon the market an excellent apparatus under the name of *Phillips Metalix* which is absolutely safe to use, portable, simple in use, and fool proof. It may be used for taking Laue Figures without previous experience, and it is equally simple to make fluoroscopic examinations. It is, however, somewhat expensive, costing about £200.

Behaviour under the action of ultra-violet light

The use of ultra-violet light is yet another method by which an examination may be made of the fluorescence induced by invisible radiations. The light may easily be produced by using a quartz mercury vapour filled lamp, or a special arc lamp sold for the purpose, and passing the light through a *Woods screen* which is a very dark glass containing a percentage of nickel oxide. This filters the light and absorbs practically all the visible rays, only allowing those of a very short wave length equal to between 3000Å and 4000Å to pass.[2]

This method is, however, only in its early infancy, even as a purely laboratory method, and very little is really known about it save to a few keen experimentalists. It is therefore not available as an everyday test, and even if it were it would be a very unsafe one to adopt in view of our present very limited knowledge of it.

Its present unreliability is very clearly shown in the case of corundum, as good coloured Burma rubies will usually show a bright red fluorescence, but the dark stones from Siam and Ceylon are often quite inert, or at the best show only a very poor fluorescence. This was at first hailed as a conclusive test for the place of origin of rubies, until it was discovered that the very dark rubies (*black rubies*) from Burma behaved in a precisely similar manner. The reason for this is not known, but it is most possibly connected with the large quantities of black silk usually to be found in such stones. Sapphires and other colour varieties of corundum are by no means constant in their behaviour; but synthetic corundum would appear to be fairly regular in exhibiting a fairly bright fluorescence.

In spite of much that has been said to the contrary, and the many unsupported claims that have been made on its behalf, the use of ultra-violet may be looked upon as being of considerable scientific interest, but at present of no practical use to the gemmologist.

2 These measurements are given in Angstrom units (Å), one Å being equal to 0.00000001 of a centimetre in length.

Behaviour under the influence of radium

About 1905, Crookes discovered that if an off-coloured diamond was subjected to a bombardment of electrons (Beta rays) from radioactive compounds, their colour would be changed to a pale bluish green. In this experiment he exposed a small yellow diamond to the intense action of fifteen milligrams of radium bromide for fifteen months before he obtained any visible change of colour.

Various experiments of a similar nature have been tried with corundum, and it was found that all varieties would phosphoresce freely when exposed to the action of radium. In the case of rubies some of the stones were found to have undergone a permanent change of colour, and to have become appreciably darker. But with sapphires the reverse is usually the case, the colour becoming much lighter, while some stones assumed a pink tinge. Purple corundum became more red in colour, while yellow did not appear to be affected at all. Colourless corundum would also appear to be quite unaffected, although one authority claims to have induced a pale red colouration in it. This claim was never clearly substantiated, neither was it confirmed by subsequent experiments; but it would appear, from the behaviour of rubies, to be quite possible that a pale red tint might be induced in what to the eye would appear to be a colourless stone, but which really contained a faint tinge of pink. What it comes to is that the red was really there in the first instance, and was merely intensified by the action of the radium. There are no records of the action of radium on either green or synthetic corundum.

The writer was once permitted to keep a small diamond, ruby, and sapphire in the vessel used for the storage of the radium used in a large hospital for a period of two years, at the end of which there was no apparent change in either the ruby or the sapphire, but the diamond did appear to have taken on a slight greenish tinge. As there was no means of ascertaining the actual amount of bombardment undergone, the experiment was of little scientific value, as it could only be said that the stones had been in intimate contact with an unknown and varying quantity of active radium for two years.

Thermal properties

Corundum is a very good conductor of heat, and in comparison with the feel of glass imitations will decidedly feel cold when placed upon the cheek, or touched with the tip of the tongue.

The expert's trick of picking out the real rubies and sapphires from glass imitations while blindfolded is based more upon the coldness to the touch, than upon the slightly greasy feel of the genuine stones, as is so often stated. Care must, however, be taken not to be led into attempting this trick with a view of picking out the natural stones from a mixture of synthetic ones, as both will feel equally cold to the touch.

7
ENCLOSURES IN CORUNDUM

A. Silk
Ordinary Silk, Black Silk, Pseudo-Siamese Silk, Red Silk

The general appearance of silk ⚜ The arrangement of silk ⚜ The angles formed by silk ⚜ The undetermined form and cause of silk ⚜ Theories regarding the nature and cause of silk ⚜ The figures formed by silk ⚜ The detection of visible silk ⚜ Microscopic silk, and its detection ⚜ Silk is the cause of chatoyancy and asterism ⚜ The incidence of silk in the colour varieties ⚜ Silk as a defect and as an asset ⚜ Silk cannot be imitated ⚜ Pseudo-silk in synthetic corundum ⚜ How to look for silk ⚜ The copper sulphate test for silk ⚜ Black silk described ⚜ The incidence of black silk ⚜ The cause of black silk and theories concerning it ⚜ Black silk conclusively for genuine natural corundum ⚜ Absence of ordinary silk in Siamese rubies ⚜ The so-called Siamese silk due to enclosures of tito-magnetite ⚜ Star stones from Siam ⚜ Black silk in Siamese rubies ⚜ Red silk is merely fine black silk

Ordinary silk
The most frequent enclosure in any variety of corundum is what is termed *silk,* or more generally spoken of as *ordinary silk.* This is a structural fibrous enclosure which shows as a distinct lustrous patch of pearly white light, and which may be so abundant and well marked as to render the stone quite opaque, but showing an evenly distributed pearly white silky sheen over its entire surface. In other specimens it may be found as white lustrous lines, patches or flecks scattered over the surface, or freely distributed in different planes throughout the entire substance of the stone.

Ordinary silk has a very characteristic appearance and may be plainly visible to the naked eye or extremely microscopic. When examined under the microscope it will be found to consist of alternating bands of white and coloured material, or rather as minute white fibres alternating with equally minute bands of coloured material of the corundum itself, arranged in a strictly parallel order with regard to each other, and always parallel to one of the faces of the hexagonal prism, or pyramid, in one direction, and to the basal plane, or at right angles to the optic axis in the other direction.

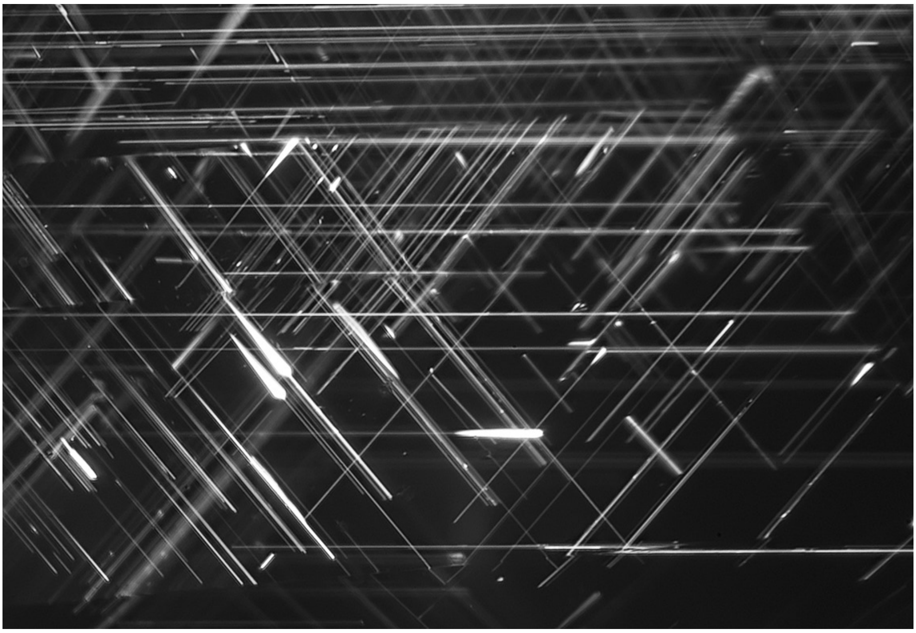

Figure 7.1
Ordinary silk in corundum. Photo: Richard W. Hughes

These directional planes never vary, and are therefore conclusive proof that silk is of structural origin.

Silk therefore always lies in straight parallel lines to one of the faces of the crystal, and when turning from the direction of one face to run parallel with the adjacent face, will always do so in the form of a clearly marked elbow, the enclosed angle of which is invariably 120°. It is not common for the superimposed layers of silk to cross each other, but this does sometimes happen, when the lines of crossing will always be found to make two angles of 120° and two of 60°, which angles will never be found to vary no matter how irregular the figure formed may be.

The exact nature of this form of fibrous enclosure is not thoroughly understood, but it is assumed to consist of millions of ultra-microscopic tubes arranged in parallel layers in the form of bundles, these bundles again being grouped together in further parallel layers of bundles, and so on through a series of such arrangements, but all of them being arranged strictly parallel to the basal plane, with a further very definite arrangement with regard to the crystallographic axis. This assumption is, however, by means a certain fact, since the individual tubes are so extremely microscopic that no observer has been able to isolate a single fibre, and so definitely establish its form as that of a tube.

Even the most powerful ultra-microscope will only reveal silk as a series of misty white lines, which also alternate with the more or less clear coloured ones, and as the magnification is increased each line is found to consist of another series of yet more microscopic misty white lines, which also alternate with coloured ones. Where the silk is plainly visible this splitting up into further bundles may often be observed with an ordinary microscope by making several examinations of this same spot with increasing powers of magnification, but as this breaking up appears to go on indefinitely it has so far been impossible to determine the actual form or structure. From the knowledge we have of the larger, and more easily studied, enclosed tubes in other minerals such as quartz, and their power of producing certain optical effects such as chatoyancy, it has been assumed that silk is of a similar structure, but ultra-microscopic in size. This is, however, but a matter of pure assumption, and is in no way clearly proved; neither can the evidence upon which the assumption is based be regarded as overwhelming, or conclusive.

The actual cause of silk is quite unknown, and there are several theories put forward regarding it, some of which are very ingenious, but all of which are conflicting and inconclusive. Some authorities contend that the fibres are colloidal inclusions produced in some unexplained manner. This would clearly seem to be erroneous as heating almost to the point of fusion would appear to have no effect upon them, whereas if they were colloidal they would either be completely destroyed, or very considerably altered by such intense heat. Others think that they are minute tubes formed in the natural process of crystallisation, and that they contain liquids or organic matter. Our knowledge of the formation of crystals is against this, and analysis entirely fails to support it. Another theory is that they are undefined alteration products of the corundum itself; an elaboration of which is that they are cavities filled with disintegration materials, which produces the pearly sheen so characteristic of silk. This is quite a feasible theory, and might well form the subject of further serious investigation.

An alternative theory to the above is that they are the foundation of disintegration or solution planes, and that these planes are finally brought about by the continued action of radioactive atoms. To this theory the writer personally inclines, and thinks that it is quite possible the solution of the problem will be found by investigation along these lines. Stones of all kinds found in the matrix normally show definite signs of disintegration, much more so than those found in the alluvials, which is probably due to their longer detention in the mother rock where they have been exposed to bombardment by radioactive atoms contained in the rocky mass. Schillerisation is usually very strongly marked in such stones as show signs of decay, a fact which is very clearly observable in the moonstones.

Where silk is clearly defined and the white banding is plainly visible to the naked eye it will often be found to take the form of a series of concentric hexagons nesting into each other, often completely covering the whole area of a section cut across the crystal at right angles to the optic axis. Or it may take the form of a few narrow concentric hexagons alternating with broader bands of colour, with a centre entirely free from silk. Where the crystallisation is regular in form, the figures so produced by the silk will be more or less true hexagons. But where the faces of the crystal are uneven the figures may also be very uneven, and with sides of different lengths; but the type will always be hexagonal and the angles will invariably measure 120°. The silk may follow all the six sides of the hexagon, or any number of them from one upwards, the most common forms being where it follows two sides and includes one angle, or where it only appears as a series of parallel lines following a single face, and showing no angles at all.

These form the patchy variety and may occur in any position on the basal section, in which case they will lie parallel to one or more sides, and will become smaller the nearer they approach to the optic axis. They may also occur in any vertical plane in the crystal, often being in several distinct layers, which may be superimposed upon each other, or occur in different positions in the various planes, as though they were tiny sheets floating at different planes in the pure coloured material of the corundum.

This variety may often be noticed in cut stones as a fine, almost invisible, band of silk extending right across the table, but appearing to extend downwards toward the base in a vertical plane, as a thin sheet. This being the case, we know at once that the table has been arranged parallel to the optic axis. In fact, it is often deliberately so arranged in order to minimise the appearance of the silk on the surface by showing it as a scarcely visible fine band instead of as a broad sheet which would completely spoil the appearance of the stone.

The next most common form is as closely packed concentric hexagons completely covering the horizontal section, and also in closely arranged vertical layers which persist throughout the entire length of the crystal, rendering it quite opaque. This form produces the majority of the star stones.

Figure 7.2
Silk in Corundum. Very highly magnified. Photo: Richard W. Hughes

These forms are closely followed by the hexagonal figures described above showing six complete sides and six contained angles of 120°. These may also occur in any position on the horizontal section, with due regard to correct centring round the optic axis. A very common form is a tiny hexagon in the exact centre of the axis, or one or two situated about the middle third, the rest of the section being clean. These may also occur at different planes in the vertical section. Occurrences of silky figures showing three sides and two complete angles are not so common, while those with three, four, or five angles are unusual.

Silk of this description is very easily observed by the unaided eye, and once having been seen, its appearance is so characteristic that it should never be forgotten; therefore its definite detection should at no time present the slightest difficulty. But silk of precisely this nature very commonly occurs so thin and widely scattered throughout the stone, or in the form of a single thin patch, that it is not clearly visible to the eye and its detection may then become a matter of great difficulty, more especially so in a rough stone. It may take the form of a more or less distinct white patch, but is usually so thin and unevenly distributed that it only imparts a slight silky sheen, or dull shimmering cloudy appearance to the stone, which may be large in extent or very small indeed. When it is large and on, or near, the surface it is fairly easily seen, but when it is of moderate size and situated deep down in the interior of the stone it is very difficult to spot, even with a good hand lens.

The next variety, which is very dangerous is where the silk, which is still of the same form, is entirely microscopic and cannot be observed by the eye alone, and but seldom with a hand lens. This form of silk in a rough stone is exceedingly difficult to detect without a considerable amount of training, but experts recognise its presence from the fact that where it lies there is a curious dull appearance in the stone. This appearance is, however, very subtle, and is quite easily mistaken for something else; but while a really expert buyer is but seldom deceived, the tyro will be let down every time unless he is very lucky. The microscope will reveal it to be true silk, and its presence in any quantity in a cut stone is always fatal, as it will invariably cause that stone to be more or less dull and lifeless, and to have what is termed a "sleepy" appearance. Thus even though it may be of a very fine colour, such a stone will have but a comparatively low value.

It should, however, be noted that very few rough rubies or sapphires, or cut ones for that matter, are entirely free from slight traces of this microscopic silk, and it is purely a matter of expert training and judgement to be able to say how much of this is permissible without spoiling the appearance of the stone when cut, or how much of it can be eliminated in the process of cutting.

Ordinary silk is very definitely the cause of chatoyancy in corundum, which may take the form of a very marked sheen of almost opalescent light over the entire surface of the stone, as isolated patches, or as a single patch or cloud which appears to float about as the stone is moved. It may also take the form of a single chatoyant band of light similar to that seen in true cat's eye, or of a six-rayed star of chatoyant light upon the surface, which is termed *asterism* and produces the star stones.

The incidence of silk is far more common in the blue than in any other variety of corundum, where it occurs in larger masses and is much more clearly defined. Some of the sapphires from Siam show this silky structure to a very marked degree, the proportion of useless opaque sapphires carried to rejections for commercial use solely on account of excessive silk often being as high as 90% of the total output. The ruby closely follows the sapphire in its silk content, but it is normally not in such large masses; neither is it usually so clearly defined, the proportion being rejected to commercial use on account of silk normally being under 30%. It is more or

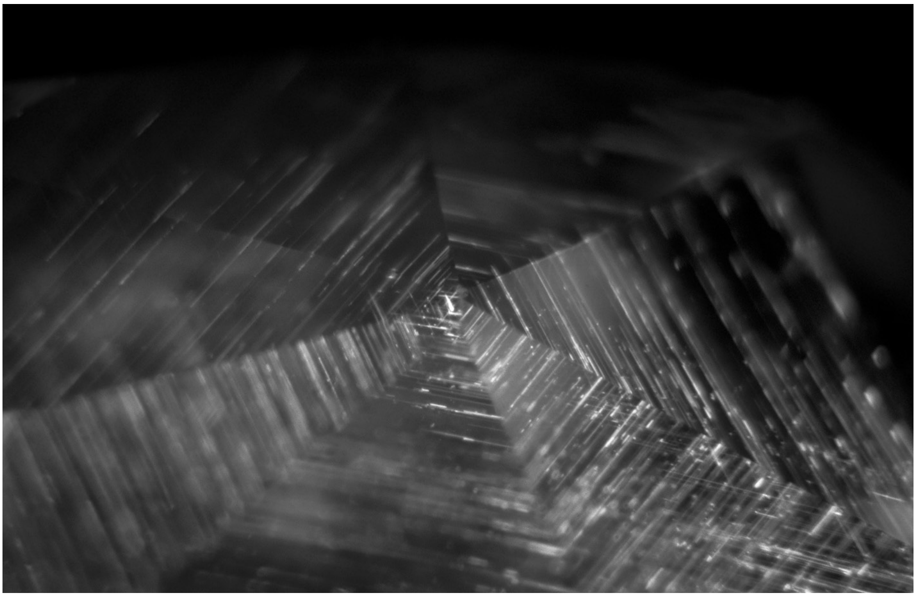

Figure 7.3
Silk in a cut stone. Photo: Richard W. Hughes

less common in the purple varieties, and often renders the stones quite opaque; but in this case, although it is densely packed, it is very fine in substance so that there is no marked banding but rather a strong milkiness which does not detract from the value of the stone for certain gem purposes. In the yellow varieties, it is not nearly so common, but at the same time is not exactly rare. It may be observed in colourless corundum, but it is not of common occurrence in this variety, while in green corundum it is so rare as to be practically unknown. The result of this is that star sapphires are much more common than star rubies, purple or violet stars also being fairly common, but on the whole scarcer than star rubies. Yellow stars are uncommon, colourless or milky-white ones rare, while green stars are known, but are of very great rarity.

Apart from the fact that silk is the cause of asterism, and so produces the beautiful star stones, and also the much appreciated milkiness of the Kashmir sapphires, the only thing that can be said in favour of silk is that it cannot be imitated. Paradoxical as this may appear, it is therefore a great asset, as owing to the structural formation of the boule, it is quite impossible for it to occur in synthetic corundum of its own accord, while it is equally impossible to place it there by artificial means. Therefore its presence at once affords a conclusive means of discriminating between natural and synthetic corundum. It is, however, necessary that care should be taken not to mistake for silk the whitish patches often to be found in synthetic corundum. The two are frequently confused, although there seems to be no reason why they should be, as to the eye alone the resemblance is very superficial, while under the microscope they are utterly dissimilar.

The slightest trace of silk in a facetted stone, no matter where it is situated, is at present looked upon with the greatest disfavour, and will at once utterly condemn a stone in the eyes of a connoisseur. The writer utterly disagrees with this view, and seriously considers that a slight trace of silk in either a valuable ruby or sapphire, provided that it is so situated that it will neither interfere with the beauty of the stone, nor the action of the light within it, should not be considered a defect. On the contrary, it should be regarded as a valuable asset with a tendency to enhance the value of the stone, as it is nature's hallmark that the stone is not synthetic, and as such is the owner's guarantee that he has got the genuine article and not an imitation. In this connection it has been argued that all fine stones are sold under either a written or implied guarantee, which is quite sufficient without having an obvious defect in stone as well. But it must be remembered that this tiny speck of silk is immovably present for all time to speak louder than any written guarantee, and that further it is quite impossible for some future unscrupulous person to apply it to an entirely different stone for a purpose of effecting a sale, a procedure which is not altogether unknown in the case of written guarantees.

We have seen that the presence of silk can be a decided defect and will often considerably lower the value of an otherwise fine stone; we have also glanced at a few of the difficulties surrounding its detection. How then may it best be detected by a prospective purchaser? An examination in direct sunlight or by a powerful electric spotlight will often be all that is required and this should be made first by the unaided eye, and then with a good hand lens. For the microscopic kinds, examination under a microscope is essential, and then frequently involves the use of highly refracting liquids.

During experiments regarding the colour absorption in rubies, the writer observed that the silk showed up much more plainly when the stone was immersed in solutions of certain colours, which led to a new series of experiments and the final evolution of the following conclusive test for the presence of silk, other than the exceedingly microscopic kinds in either rubies or sapphires. A small glass cell of about an inch in depth is filled with

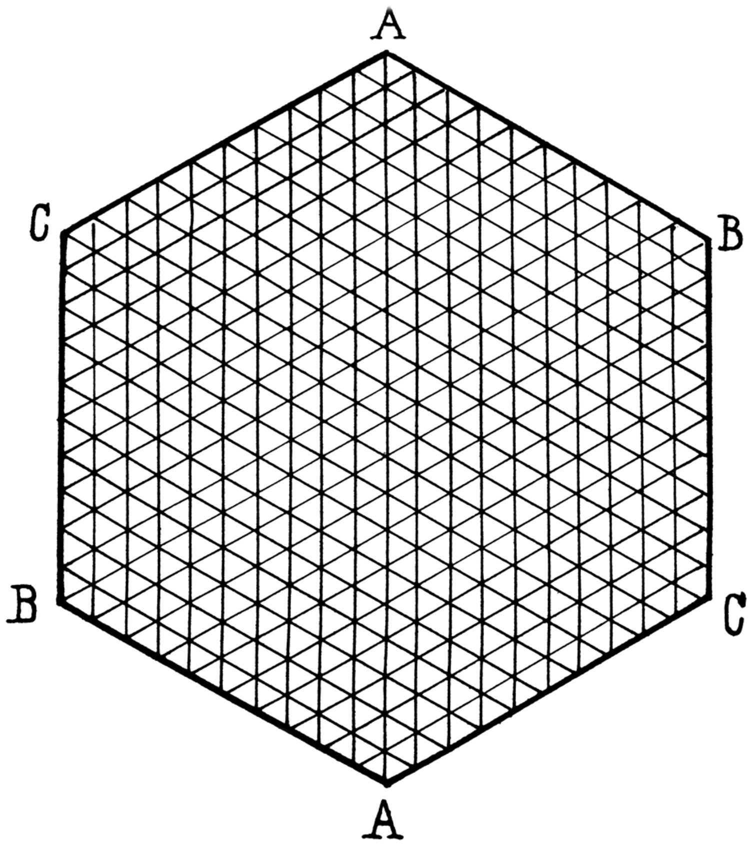

Figure 7.4
The arrangement of black silk in corundum.

a cold saturated solution of copper sulphate ($CuSO_4$) and the stone either dropped into this, or preferably held about two thirds down by means of forceps. The stone, either ruby or sapphire, will then appear to be of a very dark blue, almost black, colour upon which the slightest trace of silk will show up as vivid white lines, or patches against the black background. Internal silk, which may be quite invisible to the eye at once shows up as faint white lines, or shimmering clouds. The test is equally effective for cut stones or transparent rough ones, but with water-worn or semi-opaque stones it will only show up the surface silk, owing to the impossibility of seeing into the interior of the stone.

Figure 7.5
Black silk. Highly magnified.

This method has been tried on a very large amount of material, and is now put forward with every confidence as an infallible method of detecting the faintest trace of visible silk in rubies, sapphires, and purple corundum. Owing to the difference in colour absorption it is not so effective with the yellow variety, but it is still useful. To obtain the best results, it is necessary to stand the cell on a black background, and that the solution should be of the correct strength and about one inch in depth. The solution itself is best prepared by dissolving three ounces of copper sulphate in eight ounces of boiling water, and while hot filtering it through blotting paper into a bottle. When cold, the solution will be of a clear bright blue colour, with residual dark blue crystals at the bottom of the bottle. Wastage may be made up by adding more water, but when there are no longer crystals at the bottom of the bottle, a fresh solution should be made up.

Black silk

Another very important, although often purely microscopic, enclosure in corundum is known as *black silk* and consists of a series of sharply defined but very fine black lines, which are always parallel to the base of the crystal, except in the ruby when they may also be parallel to the rhombohedral faces. They are also always parallel to one of the faces of the crystalline figure, but no matter which face they are running parallel to once started they carry on right across the crystal, and do not turn off at an angle to follow another face. There are three distinct sets of such lines (A–A, B–B and C–C) each set being parallel to two different faces of the crystal; these cross each other at an invariable angle of 120° in one direction and 60° in the other direction, thus dividing the area up into a number of tiny equilateral triangles.

Close observation will show that these lines do not occur evenly distributed throughout the substance of the stone, but are usually in the form of isolated patches of various sizes, and sometimes consisting of but two or three lines, situated in different planes in the crystal, which may frequently be some distance apart, but always parallel as regards one layer with another.

Sometimes these lines are coarse enough to be plainly visible to the naked eye, but are more frequently exceedingly microscopic, and may be entirely absent. They may be found in any of the colour varieties, but are uncommon in the quite colourless stones. They are quite common in conjunction with ordinary silk, and also freely occur in stones which do not show the slightest trace of it.

Their actual cause is quite unknown, but from the fact that in stones showing the platey parallel structure, disintegration products are to be found following the planes of these lines, and also apparently contained in the lines themselves, they would appear to be microscopic cracks or crevices of some kind. One theory is that they are due to lamellar twinning on the rhombohedron, but from the fact that they occur abundantly in crystals of the pyramid form, which show no traces of the rhombohedral structure, the theory is not convincing. But the prismatic forms in which they occur (parallel to the basal plane and also to the rhombohedral faces) would appear to support the theory that such forms are not simple crystals.

There are some authorities who contend that black silk is the direct cause of both chatoyancy and asterism, but as will appear when we come to discuss these phenomena, this is very highly improbable.

Usually black silk occurs in such small patches that it has not the slightest effect upon either the beauty or general appearance of the stone; but it is not infrequently to be found in such quantities in the form of dense patches as to cause the stone to be dark, and sometimes almost opaque. When such patches are small and scattered they will give the stone the appearance of containing patches and clouds of a darker colour, but if only moderately dense they will merely impart a sleepy appearance to the stone.

Black silk may be entirely absent, but careful examination with a microscope will usually reveal a few scattered lines somewhere in the stone; and when making a discriminative examination once these fine lines have been seen and clearly identified, there is no need to proceed further, as they are absolutely conclusive proof that the stone under examination is genuine natural corundum, because they are not to be found in any other species of gemstone, and cannot possibly occur in synthetic corundum. It is, however, necessary to take care not to confuse the surface scratches left upon the stone by the polishing lap with black silk, which would appear to be a simple thing to do, but against which the definite and invariable crossing angles of genuine silk should be a sufficient guide to prevent such mistakes. When this appearance is noticed and the fine adjustment of the microscope is given a slight turn to alter the focus it will often be found that the set of lines under examination will vanish and an entirely new set of lines situated in either a higher or lower plane will come into focus. When this happens there is not the slightest doubt that you are looking at black silk.

Pseudo-Siamese silk

The rubies from the deposits of Siam are notable for the almost complete absence of ordinary silk, and have hitherto always been credited with carrying a peculiar variety of silk which is entirely confined to these stones, and was quite different to any form of silk which occurs in any other variety of corundum. This has been described as having the appearance under the microscope of a coarse black silk, but at the same time having a close resemblance to minute enclosures of some foreign matter, and which only occurs in isolated patches.

This form of enclosure, which has so far always passed under the name of silk, has now been definitely isolated and identified under the microscope to be enclosed microscopic acicular crystals of titanic iron (tito-magnetite) which identification has been fully confirmed by the very delicate method of spectro-analysis.

These enclosures are confined to the Siamese ruby, and the sapphires from the same deposits would not appear to carry them. Being irregular in arrangement and having none of the characteristics of either form of true silk, it does not give rise to either chatoyancy or asterism; and this combined with the almost complete absence of ordinary silk accounts for the fact that star rubies from Siam are almost unknown, while star sapphires from the same deposits are quite common.

Contrary to the general idea, true black silk does occur in the Siamese rubies, but appears to have always been confused with the enclosures of tito-magnetite, which is of somewhat similar appearance, but with entirely different and irregular angles of crossing. This fact, combined with the absence of asterism in such stones, is a very sound argument against the theory that black silk is in any way concerned with the production of the phenomena of chatoyancy.

Red silk

In certain classes of Burma rubies, and more especially in the better qualities, there is often a curious colour effect in the interior of the stone, which has the appearance of being a small cloud of an appreciably darker colour than the main body of the stone, but which is not diffused in appearance, having very definite boundaries with more or less clean-cut edges. By the local traders this is termed *red silk* and the writer has seen it described as an entirely new and distinct variety of silk. It is really nothing of the kind, and although its general appearance might create the impression that it is something unusual and new, the microscope reveals it to be caused by patches of exceedingly fine black silk, the lines of which are set very closely together, and which, though not being sufficient in itself to show up as a black patch, is still quite dense enough to produce a distinct darkening of the red colouration in its vicinity.

8

ENCLOSURES IN CORUNDUM

B. Miscellaneous
Bubbles, Foreign Matter, Rutile Needles, Coloured Spots, Spangles, Feathers and Cleavage Cracks

Bubbles universal in all varieties ⚜ How to search for bubbles ⚜ The shape of the bubbles in natural corundum ⚜ Negative crystals and their formation ⚜ Bubbles containing liquids and gasses ⚜ Cavities containing loose crystals ⚜ Bubbles in amorphous substances ⚜ Bubbles in synthetic corundum ⚜ The distribution of the bubbles in corundum ⚜ Shell bust ⚜ Embedded foreign crystals do not occur in corundum ⚜ The distinction between enclosed and embedded crystals ⚜ The fallacy regarding enclosed needles of rutile ⚜ The cause of differently coloured spots, etc. ⚜ Spangles and their cause ⚜ The distinction between cleavage and ordinary cracks and feathers ⚜ The appearance of cleavage cracks and feathers ⚜ A stupid test advocated for feathers ⚜ How to look for feathers ⚜ An absurd use of the hand lens ⚜ Cutting a stone containing a cleavage crack ⚜ The aventurine appearance in yellow corundum, and its cause

Bubbles

It is almost impossible to meet with a specimen of corundum in which at least one enclosed bubble will not be found if you only look long enough for it through a good microscope, but it may be so extremely microscopic that a careless or unskilled observer would fail to detect it. The careful seeker will, however, usually be rewarded by finding a few very minute bubbles in every apparently clean stone, one or two of which, small as they may be, will usually be found to be large and distinct enough to permit an accurate observation. When searching for these extremely minute bubbles, the use of a strong converging light thrown to different planes in the stone, with a dark patch stop in the condenser will often be found to be of great assistance; while it is of course essential that the stone should be completely immersed in a clear highly refracting liquid such as monobromonapthalene alpha.

In the majority of cases, by making a dry examination with a two-inch objective in the microscope, there will not be the slightest difficulty in finding several bubbles of quite a fair size. In fact the bubbles may sometimes be so apparent as to be plainly visible to the naked eye, but even in

Figure 8.1
Bubbles in natural corundum. Highly magnified. Photo: Richard W. Hughes

this case a hand lens is unreliable and their shape can only be satisfactorily studied under the microscope.

These bubbles in natural corundum will normally be geometrical in form, always to some extent angular, and showing plane faces of one kind or another; even though the bubble may be greatly elongated, these plane faces and angles will always be more or less clearly observable.

Frequently they will appear to be miniature enclosed crystals of corundum, which may be either of the prism or pyramid type. Bubbles of this type are in fact microscopic *negattive crystals* which have been formed after the solidification of the parent crystal, owing to a cavity having been left during the process of crystallisation. In this cavity was trapped some of the original liquor of crystallisation, which subsequently deposited its molecules round the walls of the cavity, which would then arrange themselves in precisely the same manner as though they were producing an entirely new crystal, and would therefore produce more or less the same crystal faces; but owing to the restriction of the solid walls of the cavity this build-up would be unable to expand in the normal outward direction, and so to meet the case the crystallisation would proceed in an inverse direction. That is to say the crystal faces would grow on the inside of a hollow. If the cavity is very small this new crystal growth may completely fill it leaving but very slight traces of what has taken place. But if it is large, the available molecules would be exhausted before this could take place, and would thus leave a cavity, the sides of which would to a certain extent conform to the general shape of the parent crystal, or at least to the type of crystal common to its species, but in an inverse direction.

The cavity left may still contain a liquid which may consist of the exhausted liquor of crystallisation, usually plain water, or it may consist of carbon dioxide (CO_2), which originally in the form of a gas has been reduced to its liquid state by the enormous pressure caused by the decreased size of the cavity. Again it may be a liquid rich in a chemical content which does not crystallise out, as illustrated by the saline solutions with which so many cavities are partly filled. Or the pressure may not be sufficient to reduce the gas to its liquid form, when the cavity will be filled with some form of gas, or on the other hand it may be a complete vacuum.

In the first instance the entrapped liquor may have been saturated with molecules of an entirely different substance to that of the enclosing crystal, in which case it may also crystallise out against the walls of the cavity, but after the crystalline habit of its own species, and so produce an enclosed negative crystal of an entirely different form and species to the parent, an enclosure which is quite common in corundum. But with such foreign liquids it more frequently happens that the molecules refuse to attach themselves to the walls of the cavity, and will crystallise quite independently within the cavity, but as a *positive crystal,* that is with the faces outside in the normal manner. In this way we may find a cavity containing a perfect crystal of an entirely different species, which may be surrounded by either a liquid or a gas, or may be contained in a vacuum. Sometimes these crystals will almost completely fill the cavity, and will then have the appearance of being embedded crystals, which of course they are not, as they are of secondary origin.

As corundum is a highly crystallised substance crystallising in a very definite system, it follows that under no circumstances can its contained bubbles be either completely spherical, or even generally globular in type, with rounded faces and no distinct angles or edges. Such types of bubbles are characteristic of amorphous or fused substances which have solidified from a cold plastic state, such as amber, or from a hot plastic state, as in glass. Such substances have no distinct internal crystalline structure, and the bubbles are caused by enclosed globules of gas or air, caught up during the plastic state and held imprisoned on solidification.

Synthetic corundum being manufactured by a process of fusion at atmospheric pressure, and being only pseudo-crystalline in internal structure, can only enclose such globular bubbles, and modifications of them, which also applies to glass imitations; and under no circumstances can the bubbles in such substances be either geometrical in shape, or angular in form, or above all take the form of negative crystals. They may be elongated or flattened, but will invariably be found to be rounded in section. This at once places in the hands of the gemmologist a ready but sure means of distinguishing natural corundum from the fused imitation; but it does not discriminate between synthetic corundum and glass or any other fused substance.

In corundum the enclosed bubbles may be few and far between, or more or less evenly distributed throughout the substance of the stone, or again in isolated groups or colonies. Some stones will enclose remarkably few bubbles, while in others they will be like currants in a cake; and in some cases they will occur in such dense masses as to render the stone almost, if not quite, opaque.

On the whole, sapphires will be found to enclose fewer bubbles than rubies, and some sapphires may be found which will appear to be entirely free from bubbles; such a condition should, however, always be looked upon with the greatest suspicion, and the stone submitted to searching tests for synthetic corundum. Large cavities containing liquids, crystals, and other foreign matter, especially some unknown black substance, which is probably a form of ilmenite, are more common in sapphire than in any other variety of corundum. Cavities containing liquids cannot possibly occur in synthetic corundum.

A not uncommon occurrence for bubbles has the appearance under the microscope of a photograph of a miniature explosion, or shell burst, with bubbles being flung out from it. The appearance of certain of these bubbles is misleading, as when viewed in certain directions they have the appearance of being rounded forms. Careful examination from several angles, and more especially just at the point of a cone of strong converging light, will, however, always reveal their angular or crystalline shape. Great care is necessary in making this examination as synthetic corundum will often show a very similar appearance, and the distinction between the two may present considerable difficulty. The cause is unknown, but the general appearance is as though a violent disruption had taken place just at the moment of an almost instantaneous solidification. That this may happen in the case of synthetic corundum is understandable, and its occurrence in the natural variety goes a long way to support the theory that corundum originally crystallised direct from the molten magma.

Enclosures of foreign matter

Embedded microscopic crystals of other minerals having distinct colour, such as rhodolite, have from time to time been reported as occurring in corundum, but none of these reports have ever been clearly substantiated. Such embedded enclosures beyond black spots of some unknown material, but probably a form of titanic-iron, and the tito-magnetite enclosures in Siamese rubies, have never come under the writer's observation. These reports are possibly due to a hasty jumping at conclusions after insufficient observation of enclosed spots of a different colour, or of colour reflections from the interior of microscopic negative crystals. But at the same time there is no real reason why such embedded crystals should not occur. It is quite possible for foreign crystals to become embedded in any form of crystal during its formation, due to a sudden change taking place in the rate of crystallisation while the forming crystal was gathering these aliens together for the purpose of expelling them, with the result that they became firmly imprisoned. Such embedded crystals are therefore purely primary enclosures which were already in existence before the surrounding crystals were formed. They will usually be found firmly embedded in small groups and colonies, and are nearly always situated near one of the faces, or at a corner of the crystal carrying them. They must not be confused with the more or less isolated enclosed crystals already mentioned, which are not so firmly embedded, and are secondary enclosures as they were produced after the original formation of the carrying crystal.

Rutile needles

An idea seems to have originated in America and has often been quoted elsewhere is that fine needles of rutile are to be found embedded in corundum. This is not so, and whenever an occurrence of these so-called rutile needles has been investigated they have invariably been found to consist of ordinary black silk. So far as the writer is aware there is not a single authenticated instance of the mineral rutile having been found as an enclosure in corundum. It is possible that the general appearance of acicular crystals of rutile, and the similar angles which may be formed when these crystals are twinned, has led to this confusion of thought. But the fact remains that black silk is not rutile, and neither does rutile occur as an enclosure in corundum, therefore the idea must be classed as mistaken.[1]

Enclosures of coloured spots

Enclosures of colour in the form of distinct spots, blotches, bands, and clouds, of an entirely different colour to the main body of the crystal, are very common in all varieties of corundum. This is most probably due to isomorphous replacement in part amongst the various metallic oxides present as impurities, but which give rise to the colour and, in the case of the blue colouration, to the formation of colloidal particles.

Spangles

In certain cut stones of all varieties of corundum, especially by artificial light, there will frequently be found curious little scintillating points of light in the interior of the stone, which as the stone moves will glint and glitter as though they were caused by some bright metallic enclosure. These are known as *spangles* and it has often been stated that they are due to distinct microscopic enclosures of a metallic or micaceous origin. This is incorrect, as they are solely caused by light being reflected from the interior of enclosed bubbles, or minute cracks situated deep in the interior of the stone.

Feathers and cleavage cracks

Although distinctions are often made, the above two terms are really synonymous, and one is but a variety of the other; they are really cracks due to the partial separation of the stone along either a   or a parting plane, and may be found developed to any extent, from being extremely microscopic to very distinct large cracks, which cause the stone to be on the verge of complete fracture.

In appearance, they show as planes of iridescent, or milky, almost opalescent, whiteness in the interior of the stone, the conditions often being favourable to a considerable play of prismatic colour, due to the interference of light between the two surfaces. The only difference between cleavage and ordinary cracks is that the cleavage variety follow a distinct

1 Editor's Note: This statement by Halford-Watkins is incorrect. Rutile is the most common form of silk found in corundum, and is also common as included primary crystals.

even plane in the interior of the stone, while the ordinary cracks are irregular and follow no plane. The cleavage plane thus lying along a distinct plane of structural weakness has less resistance to overcome, and has therefore always a tendency to enlarge and spread along its own plane.

A cleavage crack is a well defined crack, while a feather is a less distinct separation, which is ragged and feathery at its edges. Feathers may be exceedingly microscopic, and even under the microscope may not be observable unless the stone is immersed in a highly refracting liquid, when they will show as a minute spot of bright light. At other times they may be quite large, and plainly visible to the naked eye, usually appearing as a faint white opalescent cloud following a distinct plane in the interior of the stone, and sometimes very ragged indeed.

No matter how large or how minute they may be, any form of cleavage crack or feather is very rightly regarded as the worst and most dreaded fault that a stone can possibly have. They are always exceedingly dangerous because, sooner or later they will inevitably enlarge, and will frequently cause the stone to fracture for no apparent reason. A chance blow or a change of temperature will often cause an unsuspected feather to develop and rapidly spread, completely ruining an otherwise fine stone. The writer had a bad feather develop in a very valuable ruby which had been examined in the sun and then replaced in a cold safe; the next morning the feather was right across the stone.

It has been seriously stated that the best way to determine whether a stone contains feathers or not is to heat it and then drop it into cold water, when any incipient cracks will be developed. That is, of course, patently clear to anyone, and it should be equally obvious to any thinking person that even if there were no cracks at all there in the first instance, there most certainly would be after this drastic test had been applied. Therefore the test is absurd and one that should never be made use of.

On account of their very dangerous nature, feathers should always be most diligently searched for when purchasing either a cut or a rough stone. Examination in strong sunlight is often effective in showing up a slight iridescent spot in the interior of the stone, which should then be submitted to a microscopic examination. A beam of light thrown into the stone by means of a powerful electric spotlight is also very useful. But the common practice of using a strong hand lens to focus a spot of bright light on some particular spot in the interior of the stone is not only foolish but also exceedingly dangerous, as it is particularly liable to cause overheating, even if only used for a second, and so to set up a feather which was not originally there, and ruin the stone. A good hand lens should always be used when searching for feathers, but whenever possible all observations should be confirmed and amplified by means of the microscope; the stone should always be examined in a highly refractive liquid, as well as in the dry state.

When cutting a stone known to contain a cleavage crack or feather, it is always necessary to use the greatest cautions, as the slightest degree of overheating, especially if the stone is suddenly cooled in water, may cause it to instantly break up.

Yellow corundum frequently contains enclosed minute cracks in such quantities as to give it the appearance of being filled with bright metallic scales, which is a peculiarity belonging to this variety alone.

9
WHERE CORUNDUM COMES FROM
A. The Deposits of Upper Burma

The early transit of rubies from Burma to India ✤ Burma, the home of fine rubies ✤ Mogok, their home in Burma ✤ The Mogok Stone Tract ✤ Mogok and how to get there ✤ Labour ✤ The deposits being worked ✤ The geology of the district ✤ The contact zones ✤ Corundum in the matrix not mined ✤ Theories regarding the formation of the deposits ✤ The different varieties of *byon* ✤ *Kyaukpok* ✤ The thickness and depth of the *byon* layers ✤ How the gems occur in the byon ✤ Other gemstones of the deposits ✤ The sapphire area ✤ The proportion of sapphires to rubies ✤ The future possibilities of the Tract ✤ The uses of a geological survey ✤ Estimating the productive value of an area ✤ How to test an area ✤ The results of tests for values worthless ✤ The Thabeitkyin Stone Tract ✤ The Mong Mit Stone Tract ✤ The Naniyazeik Stone Tract ✤ The Sagyin Stone Tract ✤ The Kentung Stone Tract ✤ Sporadic occurrences ✤ Rubies found under Mandalay ✤ The future possibilities of Burma ✤ Pegu and Syriam were never corundum-producing centres ✤ The fallacy of Tavernier's visit to the ruby mines

All the very early writers state that the rubies then known all came from India and it is not until the fifteenth century that we find any reference to Burma in connection with them; but it must be remembered that in those early days Burma was but a wild unknown country which formed part of that mysterious hinterland known as the Orient. Nevertheless, as it is today, so it was in even those early days the real home of the very finest rubies and sapphires procurable. That the origin of the stones was attributed to India may be accounted for by the fact that even in those days India was a comparatively civilised country, and was the trade centre through which the early Chinese, and afterwards Burmese merchants, disposed of the stones they had obtained by various means from the deposits of Burma; and who travelling to India by overland routes found the Indian Princes ready customers for their pretty stones.

From what we know of the past and present history of the Indian corundum deposits, it is considered impossible for them to have produced a tithe of the fine rubies known to have existed in India in ancient times; and as the same remarks apply to Ceylon, the stones can only have come from Burma; but it is equally certain that many of both the darker and

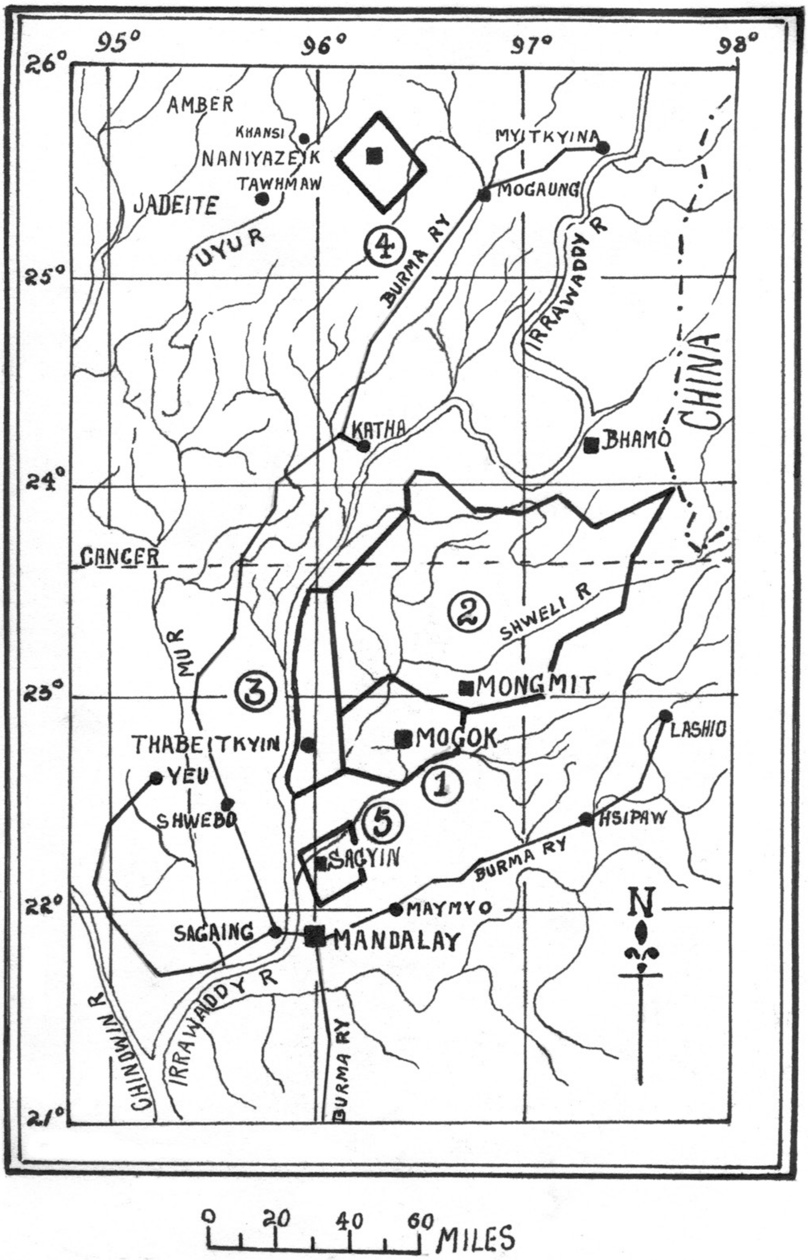

Figure 9.1
Sketch map of the corundum deposits of upper Burma.
1. The Mogok Stone Tract. 2. The Mong Mit Stone Tract. 3. The Thabeitkyin Stone Tract. 4. The Naniyazeik Stone Tract. 5. The Sagyin Stone Tract. The Kengtung Stone Tract is not indicated.

Figure 9.2
Mogok

lighter stones were also introduced from Ceylon in a similar manner. That Burma was and still is the home of the finest rubies, and that the stones were first introduced into Europe from India and not Burma, are, however, indisputable facts.

In Burma, the real home of the finest rubies is a comparatively small tract of country some 70 square miles in area situated round and about the town of Mogok, but which forms a part of a larger demarcated tract of some 500 square miles area known as The Mogok Stone Tract. There are six such demarcated stone tracts in the country which are known to produce gem corundum, but the Mogok Tract is the only one at present worthy of serious consideration, the others being so poor that neither the Government or the miners appear to consider them worthy of exploitation, with the result that they have scarcely been touched for years. While of great scientific interest, these lesser deposits for the practical purpose of either their past or present influence on the supply of corundum gems to the market may be regarded as being quite negligible; but whether they will have any future significance it is impossible to forecast, but it is quite possible that at least some of them may become producing centres.

The town of Mogok is one of the most picturesque places in Burma; being situated in the Katha Division, it lies in a deep but open valley at an

Figure 9.3
A steamer on the Irrawaddy River. From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., 842 pp.

elevation of some 3,900 feet above sea, in latitude 22° 50\q, and longitude 96° 33\q, being therefore just within the Tropic of Cancer, and about 500 miles northeast of the Port of Rangoon. It may be reached from Rangoon to Mandalay in sixteen hours, followed by a journey of ninety miles up the Irrawaddy River in one of the very comfortable Flotilla steamers to the river post of Thabeitkyin, which trip is considered to be one of the sights of Burma. The journey is then continued by motor car over a splendid road 60 miles long, rising to an elevation of just over 5,000 feet before dropping into the Mogok Valley. The mountain and jungle scenery during this part of the journey is magnificent, and the road passes through some of the finest big game country in the world, where anything from a snipe to an elephant may be encountered. There is a good service of motor busses and touring cars from Thabeitkyin, and the whole journey from Rangoon to Mogok may now be accomplished in the greatest of comfort in thirty-six hours.

The town is without banking facilities or hotels, but accommodations may be had at the Public Works Rest House, or at the Circuit House, to occupy which permission must first be obtained from the Deputy Com-

Figure 9.4
Scenes on the road to Mogok. From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., 842 pp.

missioner of Katha. The locality is decidedly pretty, being surrounded by lofty forest clad mountains, the highest peak, Taung Me, rising to 7,700 feet, but there are several others only a trifle short of this. The population of Mogok itself is only about 5,000, but there are several small towns and villages in the vicinity, which brings the total up to about double that number, all of whom are entirely dependent in some way or other for their livelihood upon the gem mining industry.

As the map shows, the actual Stone Tract is a very large area of country, but the real stone producing area which can, so far as is at present known, be worked at a reasonable profit, is but a comparatively small tract of country, all situated within a range of 25 miles of Mogok on two sides, and under 10 on the others. Some of the mines are actually within the boundaries of the town; and it is known that there are still rich deposits underneath certain parts of the town itself, which cannot be worked owing to the buildings on the land, many of which are religious and thus it is impossible to move them.

The climate is good and permits the majority of the English flowers and vegetables to be cultivated. The maximum temperature is 92°F, but in the cold weather from December to March there are frosts at night. The rainy season is from June to October, the annual rainfall averaging 105 inches. There is a certain amount of malaria, but epidemic tropical diseases are rare, so that on the whole it may be regarded as a decidedly healthy place.

The majority of the indigenous labour is fully occupied with its own mining affairs, and for outside mining ventures, or other purposes, this has to be supplemented by an annual influx of Meingthas (Chinese Shans) and Yunnanese Chinese, who mostly arrive for the cold season, and depart at the commencement of the rains, but a certain proportion of them become permanent settlers in the district. The local inhabitants are mostly Shans and Burmese Shans, with a sprinkling of pure Burmese. There are also several other wilder tribes such as Leishaws, Palaungs, Kachins, and Chins, who mostly work as cultivators; a few Chinamen act as shopkeepers, market gardeners and pig farmers. Natives of India are plentiful, acting as shopkeepers and money lenders, while a few are purely gem merchants, and active partners in mining ventures. There are also large numbers of Gurkhas, who act as milkmen, farmers, and general labourers.

After the main Mogok Valley, the next most important mining centre starts at Kathe, a village some eight miles to the west, and passes through the small town of Kyatpyin, situated about a thousand feet higher than Mogok. From here the principal workings stretch along a narrow tract of country immediately north of the main road as far as the village of Khabaing, with a few poorer ones still further west to Kin village, beyond which in the direction of the river there is no ground known to be payable. This deposit continues south for about six miles to the village of Laungzin. To the north of Mogok there is a small area round Chaungyi which has produced some very fine sapphires and also some quite good rubies. Further still to the north, and about a thousand feet higher than Mogok, are the deposits round the small village of Bernardmyo, an abandoned British Military Cantonment; once extensively exploited, this deposit produced a number of very fine sapphires, and also some very bad ones, but comparatively little mining is carried on there now, save by a few seekers after peridots, which occur in considerable quantities. The deposit follows a line in a south-westerly direction over the hills through the village of Kyauksin, forming an area knows as the "Western Slopes" which are reputed to carry well, and then joins up with the Kyatpyin deposit near the village of Sinkwa to the east, and Khabaing on the west. The Mogok

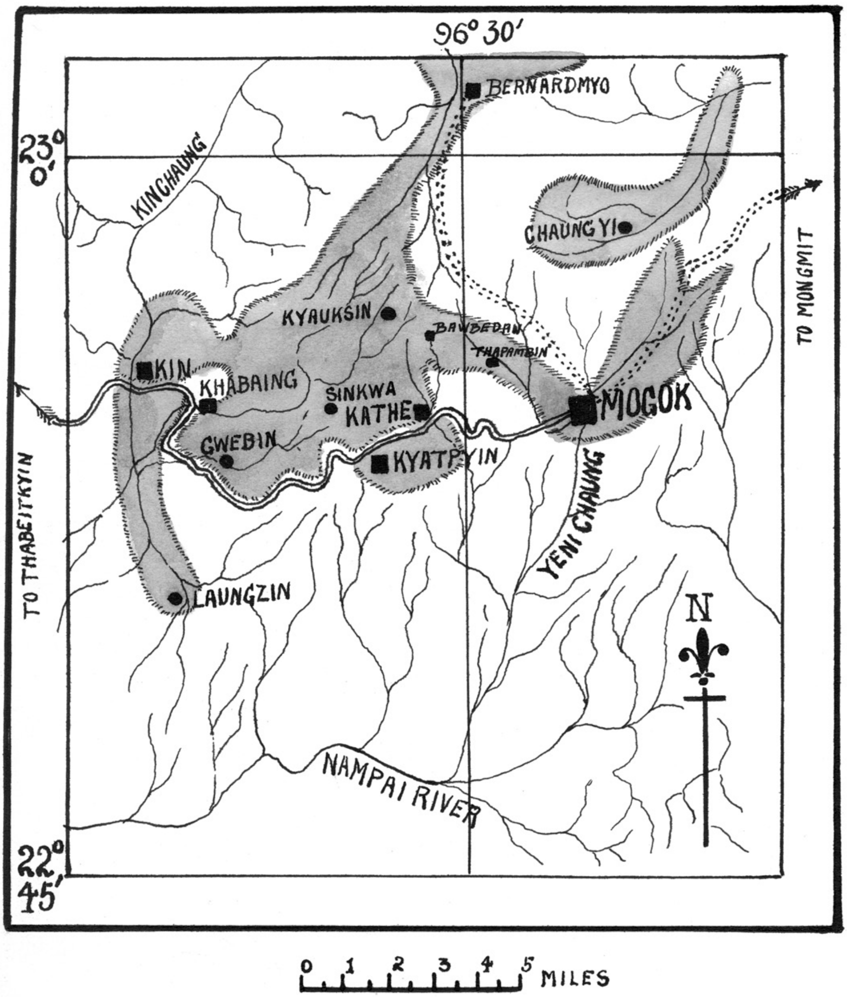

Figure 9.5
Sketch map of Mogok and district. The payable ground being worked is shown shaded.

deposits also take a turn to the north-west passing through another large valley, and then over the hills to Kyauksin to the north, and on the south side joins the Kyatpyin deposits a little distance above Kathe village. The large deep valley running from Mogok almost to Kathe on the northern side of the main road is quite barren. Besides the above, there are several small patchy deposits scattered about the district, which are at odd times exploited by adventurous beings, with varying results, but mostly disastrous.

The district forms a portion of the Shan Highlands and is geologically made up of gneisses and their associated rocks of the Archaen Age. These rocks contain large masses of dolomitic crystalline limestone, or marble, in which the rubies may often be found embedded; this limestone is very common, and entire mountain ranges are partly composed of it. It was at one time a compact sedimentary limestone of the ordinary kind, but has become metamorphosed by contact with intrusive masses of molten igneous rock, which caused the calcium carbonate to recrystallise out in the form of marble.

One theory is that its contained impurities also crystallised out at the same time in the form of corundum and other species of minerals, many of which are of gem interest; but whether they actually did crystallise in the limestone, or were previously crystallised and the limestone subsequently formed round them is a point upon which there is a great deal of dissension.

These limestones occur in bands interfoliated with the country gneisses, which are themselves a highly metamorphosed group, partly of sedimentary origin. The most common forms are garnet-biotite gneisses and garnetiferous granulites, some of which make most excellent building stone, while others are in such an advanced state of disintegration that they will crumble in the hand. Other local rocks are augite, calc-gneisses, calciphyres, augite-syenite, and nepheline rocks; while veins of feldspar rock and granite pegmatites are common in the limestone masses.

Besides ruby, the granular limestones are found to carry a variety of minerals, amongst others being diopside, tremolite, chondrodite, pyrite, apatite, and spinel. The calc-gneisses carry diopside, forsterite, chondrodite, scapolite, and zircon.

Sapphires do not occur in the limestones themselves, but are to be found embedded in the felspathic rocks and pegmatites which intrude into the limestones, and which also carry scapolite, moonstone, apatite, diopside, rock crystal, and topaz. Beryl, from time to time, is also found under the same conditions.

It is a noteworthy fact that gems of the very good to finest qualities are almost invariably to be found in the alluvials which have accumulated in the immediate vicinity of a contact between the igneous rock and the limestone, or where one of the intrusive veins of felspathic rock or pegma-

Figure 9.6
Ruby crystallising with tourmaline.

tite makes contact with the igneous rock; while other very interesting mineral occurrences may also be observed in these contact zones.

Apart from ruby being found embedded in the limestone, it has been observed locally, in common with sapphire, crystallising quite intimately with tourmaline and other minerals; while sapphire of gem quality has been found in a nepheline-corundum-syenite, which only goes to prove that corundum has modes of occurrence other than in the limestone or felspathic rocks.

Although it is not uncommon to find both ruby and sapphire firmly embedded in the rocky matrix, it is not from this source that the gemstones for the market are obtained, as the stones are usually so widely scattered in immense quantities of rock, and when extracted with difficulty are normally so cracked and of such poor quality as to be practically valueless. Furthermore, even those of fair quality will often break up as soon as they are removed from the matrix. Therefore their extraction is by no means a commercial proposition. All the marketable stones from the Mogok deposits are thus obtained from some form of alluvium.

There are two theories regarding the alluvial deposits in the Mogok Valley itself, one being that the valley is an old lake basin in which the alluvium was laid down in two distinct layers under more or less still water at different times. It is also considered by these theorists that the deeper layer was the last to be laid down; but on what precise grounds it is difficult to understand. It is significant, however, that practically all the larger fine quality gems have been found at depth in this lower layer; and that all the old prehistoric implements also come from it, and are seldom, if ever, recovered from the upper one.

The other theory, which the writer considers to be the most probable and correct one, is that the valley is primarily one of disintegration and not of erosion, and that the deposits were not laid down under any great body of water, but merely settled down in their present position as the detritus from the disintegrating surrounding hills was washed to the lower levels by small streams and heavy rains. Certain portions of this were caught up at an early stage of its journey by rocks and crevices, and formed what is known as the *hillside deposits* or by the supporters of the lake theory, the *first upper deposit,* mainly on account of its being generally poorer in its gem content, through not being so highly concentrated owing to its earlier setting down. The remainder, passing onwards to the floor of the valley, would have more of its lighter material washed away or dissolved out during the longer journey, and would therefore become more highly concentrated and thus form the so-called *valley deposits,* or the *second lower deposits.*

The disintegration theory is strongly supported by the fact that the stones found in the vicinity of a present contact between the limestone and the igneous rock are usually of a better quality, and the crystals are cleaner, less worn, and generally present the appearance of either having been originally formed, or released quite near at hand. Furthermore, the stones contained in one part of the deposit will be of a distinctly different type to those normally found in other parts; which difference in type is often so distinctly marked as to make it possible for an experienced person to be able to say from what particular area a specimen stone, or group of stones were mined. In one small area, spinels will be found to be plentiful, while they are comparatively scarce elsewhere. Another area will produce fine sapphires and show a poor ruby content; while yet another will reverse this and produce fine rubies but no sapphires. It is quite obvious that this distinct grouping could not have taken place if the whole mass had simply come tumbling down the hillside and then come to rest at the bottom of a lake.

The actual deposit itself is normally of a brownish yellow, almost curry powder colour, which colours the local streams a dirty yellow, and immovably dyes cotton materials yellowish brown. The colour may, however, be all shades of brown from quite pale to deep chocolate, various shades of grey, and even quite black. All forms of corundum-bearing earth are locally known by the general name of *byon,* but there are endless varieties of it, each with its distinctive Burmese name, and many of which appear to be quite irrelevant, while a number of them are absolutely unprintable.

At times the byon takes the form of a heavy compact sandy clay, which may often be quite gravelly and thus is difficult to cut with either a shovel or hoe, and is equally hard to break up and dissolve in water. If this type of byon is left to weather for a few weeks in the sun and wind, solution then becomes much easier, but if allowed to become wet by rain it will settle into a very compact mass. Another type is quite soft and sandy and may be dug and dissolved with the greatest of ease. This type may become almost a pure free gravel, varying from very fine to very coarse. A comparatively rare form is a medium to coarse gravel conglomerate firmly cemented together by a black or reddish iron cement. The black variety of byon, which is ordinarily regarded as likely to contain good sapphires, is a fairly soft decomposed sandy clay of a dark greyish, greenish grey, or quite black colour; this is easily worked with an ordinary hoe *(momootie)* coming away in large solid lumps which dissolve almost instantly in a small quantity of water, or fall to powder if left exposed to the action of the sun. It contains a large amount of fine sand, and a high content of free decomposed mica, together with pebbles of various sizes. This variety frequently contains sapphires of large size and fine quality, and also rubies of fine quality but of small size. It is often associated with pegmatite veins, and sometimes with felspar.

The byon very often overlays a layer of soft white yellowish, or reddish decomposed rock closely resembling kaolin, and known to the miners as *kyaukpok.* When a native miner reaches this layer, he considers that there will be no further byon and immediately stops sinking. It is, however, within the writer's personal experience that gems are frequently to be found enclosed in the kyaukpok itself; while this rotten rock very often only overlays groups of the solid country rock in the cracks and crevices of which small quantities of really rich byon carrying valuable gems may frequently be found; but the native miner will have none of this and immediately when he strikes the kyaukpok he abandons the site as worked out.

The layers of byon vary from a few inches to twenty or thirty feet in thickness, and sometimes a great deal more, and lie at anything from three inches to over a hundred and fifty feet below grass level; but between twenty and eighty feet may be reckoned a fair average depth in open deposits, while in the crevices of the hills it may extend to almost any depth. There is, however, no certainty where a good stone may be found, as there are several instances of fine stones being found almost on the surface in ground that an experienced person would say was only fit to be thrown away without being looked at; that magnificent sapphire, the *Gem of the Jungle,* was an outstanding example of this. The writer's experience has been that the richest byon which carries the finest gems is normally to be found at medium to considerable depth caught up in the cracks, large cavities and fissures formed in underground masses of rock. The byon found in such situations may often be very concentrated indeed, and when encountered should always be very carefully extracted to the last ounce, and then washed under personal supervision. The extra trouble will almost invariably be well repaid.

The gemstones occur in the byon in all forms, from bright clear perfectly formed crystals, which are rare, to dull water-worn pebbles showing no trace of outward crystalline form, while broken fragments of all sizes are very common. On the whole, the gem varieties are quite small, but the opaque and commoner varieties run considerably larger, and may often weigh several pounds. Large fine sapphires are of far more common occurrence than fine rubies, and are frequently to be found in sizes which are quite unheard of in the case of fine rubies.

Rubies, sapphires and spinels form the bulk of the gems recovered from these deposits, and in the above order, but they by no means exhaust the gem content as the following gemstones are also to be found in lesser quantities, some being moderately common, while others are distinctly rare: adularia, almandine garnet, amethyst, apatite, aquamarine, beryl (various), black moonstone, cairngorn, carnelian, chrysoberyl, chrysolite, cordierite, corundum (all colours), danburite, dravite, elaeolite, epidote, euclase, fibrolite, fluor-spar, haematite, iron-pyrites, lapis lazuli, moonstone, opal (semi), phenacite, rubellite, rock crystal, scapolite, sodalite, spinel (all colours), spodumene, topaz, tourmaline, and zircon.

Sapphires are to be found all over the district, but in the Mogok Valley itself, where rubies are plentiful and run to fine quality, sapphires are on the whole comparatively scarce, and really fine stones very rare. Nevertheless, some very fine sapphires have been mined in the valley. Westward from the village of Kathe, the sapphires commence to improve, and the general quality of the rubies to fall off to a certain extent, although fine stones are by no means unknown. This sapphire tract carries on along a deep valley passing south of Sinkwa and north of Gwebin to Khabaing, and it is from this tract that the majority of really good sapphires come. At Khabaing, the deposit takes a sharp turn to the north-east, and at first follows another deep valley, and then passes over the hills to Bernardmyo, good sapphires being met with for about two thirds of the way. Bernardmyo at one time produced large quantities of sapphires, many of which were large, clear, and of a magnificent colour; but there were also large numbers of stones of a peculiar indigo shade which were of very poor quality and low value, owing to their appearing either quite black or a nasty greenish tint by artificial light. Large quantities of these stones were placed on the market in 1913, and were largely responsible for the general bad name now held by Burma sapphires in the trade. Some of these stones were coated with a thin layer of almost opaque indigo colour, while the centre was clear and sometimes of a fine colour, but usually of an objectionable greenish shade. Many of these stones were found in a very hard black iron-cemented conglomerate. A curious thing regarding Burma sapphires is that they almost invariably occur either in the valley or open hillside deposits, the finding of a good sapphire in the crevices of the hills *(loodwins)* being practically unknown.

In the above tract of country, the proportion of very fine sapphires found exceeds the proportion of very fine rubies, and taking an average wash the amount of sapphire corundum, including the non-gem rejections will be found to exceed the ruby corundum, but in the Mogok Valley exactly the reverse is the case. However throughout the entire deposits of the district, sapphire of fine gem quality, although a valuable asset, must be regarded so far as actual value goes as of but secondary consideration, forming but about twelve percent of the value of the total output.

In spite of the very extensive working which has been carried on for innumerable years in the area shown shaded in Figure 9.5 on page 135, the Mogok Stone Tract is by no manner of means anything like worked out. It is only natural that the native miner, who lives from hand to mouth, should as far as possible confine his workings to ground which has been proved to repay for working, so that under normal conditions he will be more or less assured of a reasonable return for his outlay. This would possibly not be the case were he to venture forth to exploit new and untried sites. Although it is more than possible that he would be more than amply repaid in the long run, it would depend on his having the capital to see it through. This means there are still very large tracts of country almost, if not quite, untouched, as well as considerable areas only partly exploited, much of which has very distinct possibilities, and may in the future be found to contain large quantities of gems.

The entire district is now undergoing a thorough geological survey by Government geologists, with the general idea of separately mapping the complex system of rocks, and from this, deducing the actual areas which are favourable to the accumulation of the secondary gem deposits of detrial and alluvial origin. From the point of view of scientific geology, this is a very praiseworthy idea, but from the practical angle of telling where rubies and sapphires may be found in such quantities, and of such quality as to make the deposits so indicated workable at a reasonable profit, such a survey can only be regarded as a waste of time.

The situations where alluvial deposits are likely to occur are obvious to anyone with only a partly trained eye, and all such situations in the district have long been known to the ordinary miners, the real question being whether they are worth working or not; and to satisfactorily settle this question presents a problem of far greater magnitude than would at first seem apparent. It may sound a perfectly simple thing to say "Just test this deposit, and find out what it is worth" and such an order is frequently given, little realizing that it is quite impossible to carry it out in anything like a satisfactory manner. In the first place it has to be taken into account that gems are normally not evenly spread over a large area, but are in patches or nests. Thus, while a large area may be comparatively barren, quite a few small ones perhaps only a few feet in area could be extremely rich. This means there is no method whereby we can anything like accurately estimate the probable yield of any deposit on a basis of values, as the gems are not laid down in such a manner as to produce any fixed value per unit of ground treated, no matter whether it be by weight or measurement. Therefore it is only possible to test the ground for either the presence or complete absence of gems, anything intermediate between that being the purest guesswork.

The only way to test an alluvial deposit is to sample it. This is done by carefully washing known quantities of earth from various parts of the deposit, and, from the value of the product recovered, calculating a ratio to cover the entire deposit. The earth so washed may be obtained by digging a number of systematically arranged small pits, or by making cross cuts at various points. On the whole, pits six feet square dug at regular intervals across the length and breadth of the deposit are the most satisfactory, bore holes being far too small to be of any practical value.

Let it be assumed that over a given area one hundred such pits have been sunk, and a total of four hundred tons of earth removed from them, which, on being washed, yielded gems to the value of eight hundred pounds. In dealing with gold, tin, or any other form of alluvial it would then be safe to regard the deposit as being rich, and to assume that it would yield an average return of two pounds per ton over the entire area, or say thirty shillings to allow a factor of safety. But in dealing with gems it would be quite unsafe to assume anything of the kind, or even that the area would produce even a small fraction of the above sum per ton of earth treated, for the simple reason that one or two of the test pits may have been in exactly the right spots to recover the only nest, or nests, of gems in the whole area, the remainder of the ground being more or less barren. An extreme case, if you like, but it has actually happened many times. On the other hand, if the total return had been but a few pounds, it would be equally unsafe to regard the area as being poor and not worth working, because the test pits may have missed several very rich nests by a matter of inches, and the area may in reality be very rich indeed in spite of the poor returns shown by the pits. The writer has seen this happen a great many times.

Test pits will therefore only serve to indicate the presence or absence of gem material, and, as data upon which to base any estimate or valuation of any kind, are absolutely useless. A method sometimes adopted to assume a possible value for the returns of a given area is to compare it with the returns from a previously worked area of a similar appearance. But this is equally futile, as experience shows that two deposits may appear to be in every respect identical, and may reasonably be expected to produce more or less the same results, yet one may be very rich, and the other practically barren and valueless.

The only real way to prove the value of a deposit is to work it systematically and more or less trust to luck for what comes out. But even this may be quite unsatisfactory as the following experience of the writer's clearly indicates. A large area had been worked for over a year at a heavy loss, and as it was then considered that the ground was proved to be practically barren of gems, work was stopped. Native miners subsequently encountered very rich paying ground covering a very considerable area within a few feet of, and in a direct line with where the previous work had ceased. Had the original work been continued for a week or two longer that mine would have shown a very considerable profit instead of a heavy loss. In working gem deposits it must be remembered that very often a single stone will make all the difference between a heavy loss and a substantial profit, while two or three fine large stones will put the credit side up to an enormous extent.

In general principles the above description of the Mogok deposits may be taken to apply to all the other deposits of Burma. As will be seen from Figure 9.5 on page 135 , the Thabeitkyin and Mong Mit tracts are adjacent to the Mogok tract. So far as is known at present, both of them are quite negligible, but as neither of them have been exploited to any extent, their actual possibilities cannot even be guessed at. So far only a few sporadic occurrences of corundum have been found in either of these tracts, and no really good stones have ever been reported from them, all the finds being of a more or less inferior quality. At the same time there would seem to be no real reason why good stones should not occur, and it may be that in the future valuable deposits may be located in one or both of these tracts. It would rather seem as though the authorities had this possibility in view when they demarcated two such large areas as the Thabeitkyin Township District, and the whole of the Mong Mit State as Stone tracts.

The next tract is some 180 miles north of Mogok, near the village of Naniyazeik in latitude 25° 45′, being some 50 miles distant from the jadeite and amber mines. This deposit is regarded as being of more importance than either the Thabeitkyin or Mong Mit tracts, as in the past it has produced stones of medium quality in fair amount, but anything really fine has never been reported. It is much smaller than the Mogok Tract, and if properly exploited would appear to have very distinct possibilities; but at no time has it been worked to any great extent, and nothing at all has been attempted for a considerable number of years past. The gems occur in small alluvial deposits scattered all over the tract, and are also to be found embedded in the granular limestones, so that in their mode of occurrence they conform very closely to those of Mogok. Spinels are here very prominent, and considerable quantities of fine to medium quality may be met with. Naniyazeik is reached by train from Mandalay to Mogaung, and thence by motor car. Malaria fever is very prevalent, and the district is generally regarded as being very unhealthy.

A small tract of which a great deal has been written in the past is situated round and about the village of Sagyin, some twenty miles due north of Mandalay and from which it may be reached by either train or motor car. Here the gems, mostly rubies with a few spinels, are found in the alluvials, and embedded in the limestone. Their point of origin is apparently in a series of low hills composed of crystalline limestone which rise up from the alluvial plain of the Irrawaddy river, normally a couple of miles to the eastward but which almost reaches Sagyin in the rainy season. The limestone itself is extensively quarried and used for the carving of the images of Buddha used in the Burmese shrines and temples. Besides the alluvial deposits, rubies are also to be found in the caves and crevices in the hills, which are filled with a detrial material in the form of a reddish brown clay; which is again very similar to the occurrences at Mogok. In the early days, many of the very fine rubies in the possession of the Burmese Kings were reputed to have come from these deposits; this is, however, very much open to doubt, as, although there is not the slightest question that considerable quantities of rubies have been mined here, they would all appear to have been of but medium quality, and there is not a single authenticated instance of a really fine ruby ever having been produced in this district. In the writer's opinion, next to the Mogok Tract, this is the most favourable area in its future possibilities, and it would seem well worth a thorough and systematic investigation. The climate is very hot, but quite healthy.

A few occurrences of poor quality corundum have been found in the Kentung State, a large tract of country situated to the southwest of Mandalay, from whence it can only be reached by a long and tedious motor car journey taking several days in the fine weather, and weeks in the rains. These discoveries of sporadic corundum have led to the whole state being proclaimed as a stone tract, but so far it is quite negligible, no good stones ever having been found there, and no active mining is being carried on. The country is wild and mountainous, and but very little is known regarding its mineral contents. The geological conditions are in places similar to those of Mogok, and would appear to be favourable to the free occurrence of corundum; so that it is quite within the bounds of possibility that good workable deposits may be located in this area in the future.

Corundum has also been reported from other parts of Upper Burma, but they would all appear to be merely sporadic occurrences, while many of them are only reports which have never been substantiated. During the building of the railway, some ancient workings were discovered at Kyaukse, about thirty miles south of Mandalay, and were by some considered to be old ruby mines, which is very doubtful indeed as the geological conditions are not favourable. There is, however, a very clearly authenticated instance of a few rough rubies of quite fair quality having been recovered from a considerable depth during the sinking of a tube well in Mandalay itself.

The above are the only deposits of corundum presently known in Burma, but it must be remembered that it is a very large country, much of which is but sparsely inhabited, and being largely covered with either dense forest or jungle, but little is really known regarding its full mineral possibilities. There are many out of the way places where the geological conditions would seem favourable to the occurrence of corundum, and it seems reasonable to assume the possible discovery of new deposits as the country becomes more opened up.

Two glaring mistakes are to be found in the majority of books dealing with precious stones in that they give the towns of Pegu and Syriam as ruby-producing areas in Burma. This originated from an error which is usually attributed to Tavernier, but which really arose at a far earlier date, and was accepted on hearsay evidence by Tavernier, who mentions in the accounts of his travels that: "The ruby mines are situated in the Capelan Mountains in Pegu, some twelve days journey from the town of Syriam". This erroneous statement, first published nearly three hundred years ago, has been repeated through the succeeding ages and may now be found in books published but a year or two ago. Such a firm hold has this mistaken idea obtained that the term *Syrian garnet* applied to a variety of almandine is but a corruption of the word *Syriam*, in the belief that these stones were also mined there. The truth is that neither corundum nor any other form of gemstones has ever been mined at Pegu, a large town 45 miles N.W. of Rangoon, or at Syriam, another large town on the river bank some 15 miles W. of Rangoon, and which was at one time the capital of the ancient Kingdom of Pegu, the geological formation at both places being entirely against the occurrence of such stones. It is well known that in ancient times both of these towns were famous markets for stones brought down from Mogok and Mandalay, and also that immense quantities of rubies and other precious stones were in the possession of the ancient kings of Pegu; but that they were ever mined at either of these towns, or anywhere else in the Kingdom of Pegu is quite out of the question.

We are told that Prinsep has definitely proved that the mountains round Kyatpyin are identical with the Capelan Mountains of Tavernier.[1] There are two very definite things which contradict this idea. Firstly Tavernier clearly states that they were situated in Pegu and twelve days journey from Syriam.

1 (a) Bauer, M. (1904) *Precious Stones.* Trans. by L.J. Spencer, London, Charles Griffin and Co., First published in German in 1896; 647 pp. (see p. 270).
(b) George, E.C.S. (1915) *Burma Gazetteer: Ruby Mines District.* Rangoon, Supdt., Govt. Printing and Staty., Burma, Volume A, 151 pp., map; (see p. 29).
(c) O'Connor, V.C.S. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., American edition 1905, 842 pp.

Kyatpyin was never in the old Kingdom of Pegu, and it was then utterly impossible to accomplish the journey to Kyatpyin from Syriam in anything like twelve days. Secondly, the often quoted visit of Tavernier to the ruby mines between 1651 and 1658 must be regarded as a complete fairy tale. Intrepid traveller as the gentleman undoubtedly was, it is quite inconceivable that he could have undertaken the journey, which in those days would have involved many months of travelling through dense, fever-stricken forest, inhabited by fierce, war-like tribes, and infested with wild animals of the most dangerous kinds. Apart from which he would not have been allowed to approach the mines, the actual location of which was then one of the most jealously guarded secrets of the Burmese Kings, of whose private estates they formed a part, and they were kept secluded so that it was not until nearly a century later that recognised traders, who paid heavily for the privilege, were allowed to visit them. As the history of his travels indicates, Tavernier probably did reach Pegu, which he could have done by means of a small ship, but that is about as far north as he did get, and his so-called Capelan Mountains were most probably the present Pegu Yomas.

10

WHERE CORUNDUM COMES FROM

B. The History of the Mogok Stone Tract

The great antiquity of the deposits ✤ Early legends ✤ Early writings ✤ Capelan ✤ The first European to visit the mines ✤ The Tract passes from the Chinese to the Shans ✤ Sangermano on the Shans and the Burmese Kings ✤ How Mogok and Kyatpyin obtained their names ✤ The annexation of the Tract by the Burmese ✤ The King sends labour to work the mines ✤ The appointment of *So-thugyis* ✤ The first taxation of the district ✤ The early prices of stones at the mines ✤ Royal stones the property of the King ✤ The powers of the *So-thugyis* and how they were abused ✤ Forcing sales from the miners ✤ The shortage of labour causes the sending of Manipuri captives to the mines ✤ The mines become a place of exile ✤ The appointment of a sole Governor and the imposition of an enormous taxation ✤ The district in a state of rebellion ✤ The district deserted ✤ Concessions to induce the miners to return ✤ The Royal Stone Mart at Mandalay ✤ The scarcity of royal stones ✤ Penalties for dealing in illicit stones ✤ Swindling the traders ✤ Further increases in taxation ✤ The climax, and the district in a state of chaos ✤ The annexation by the British ✤ Thebaw negotiating with the French for the grant of a concession

One of the proofs that the corundum deposits round and about Mogok are of great antiquity and that they were also well known to, and worked by, the early ancients is to be found in the comparatively large numbers of prehistoric implements of the stone, bronze, and iron ages, which are to be found in the alluvium all over the district.

While all other traces of these very ancient workings have completely disappeared, the tools and protective weapons of the early workers, mostly laboriously fashioned from a variety of jadeite, remain as mute evidence of what was probably one of the world's oldest industries, but completely unknown outside its own immediate neighbourhood until a few hundred years ago.

We are quite without knowledge as to when, or how, these deposits first became known, and the earliest reference would appear to be contained in a Burmese legend of untold age, but which must have descended to them from the very early Chinese. It relates of an inaccessible valley in the Chinese country into which it was death for human beings to descend; but

Figure 10.1
Prehistoric implements from the Mogok Stone Tract.

when raw meat was flung into it from the surrounding crags it was retrieved by the vultures and rubies were to be found adhering to it. This story corresponds almost exactly with the writings of Marco Polo (1323). Upon which a part of the story of Sinbad the Sailor is founded, but it is extremely unlikely that he ever reached Burma at all, much less the ruby mines, and must therefore have heard the legend during his wanderings in Cathay (China), and it most probably dated back for several centuries before his time.

Rubies would seem to have first become associated with Burma, so far as Europe is concerned, early in the fifteenth century, and probably the earliest written reference to this was made by Nicolo di Conti (1420–1444), followed by Santo Stefano and Ludovico di Varthema who visited Pegu in 1496 and make special reference to the rubies seen there. Further references are made by Duarte Barbosa (1501–1516) and Caesar Fredricke (1569); but it was not until 1586 that the first Englishman, in the person of Ralph Fitch, a London merchant, arrived at Pegu and made a prolonged stay there.

All these early writings mention that the rubies come from a place called *Capelan* or *Capelangan,* which is variously referred to as a Kingdom, a city, or a great mountain. Fitch says:

> Capelan is the place where they find the rubies, sapphires, and spinelles, it standeth sixe days journey from Ava in the kingdom of Pegu. There are many great high hilles

> out of which they digge them, and none may go to the pits onely those which digge them.

There is, however, an obscure reference to Capelan (here written Kanpalan) to be found in the early Talaing chronicles dated in the thirteenth century,[1] but it is uncertain whether this refers to the Mogok or the Saygin tracts, or even to an entirely different place long since forgotten.

The first recorded European to visit the mines was Father Guiseppe d'Amato in 1833; but the writing of Father Sangermano, another Italian priest who resided in Ava from 1783 to 1806, shows such an intimate knowledge of the early mines that it appears unlikely to have been gained without a personal visit having been made at a date much earlier than that of d'Amato. Although this is entirely unrecorded, it was probably made, but secretly and in disguise.

It is known that in the very early days the district belonged to the Chinese, and at some unknown date passed into the possession of the Shans, and then formed a part of the Mong Mit State (often written Momeit or Momeik). Writing of this, Sangermano says:

> All that tract of land between the Chinese Province of Junan (Yunnan), Siam, and the Kingdom of Ava is inhabited by a numerous nation called "Sciam" (Shans) who are the same as the Laos. Their kingdom is divided into small districts under different chiefs called "Zaboa" (*Sawbwa,* or petty princes.) From the time of Alompra (1752–1781) till the beginning of the present reign, all these Zaboa were subjects and tributaries of the Burmese, but the continual vexations and oppressions of their masters have forced many of them to rebel.

He then goes on to relate that the revenues of the Burmese King consisted of duties imposed on all merchandise brought by foreigners into any of the ports of the Kingdom of Pegu, of the produce of the mines of silver, amber, and rubies – the latter most possibly only from Sagyin – and of certain contributions of rice and other products for use in the palace, and also of special unspecified presents which had to be made to the King on certain fixed days. Now although the Burmese Monarch had no other fixed revenues than these, his income was by no manner of means limited to them alone, for he had a happy knack of looking upon the whole of the property of his people as also belonging to himself, and therefore extracted

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1 Mason, F. and Theobald, W. (1882) *Burma, its People and Productions; or Notes on the Fauna, Flora, and Minerals of Tenasserim, Pegu, and Burma.* Hetford, 2 Vols., (see p. 435).

from them anything that he pleased. This meant that the populace by their labours were not acquiring riches for themselves and descendants, but were merely gratifying the avarice of the Kings, as their possessions sooner or later invariably found their way into the Royal Treasury, and the people remained poverty stricken.

The Sawbwa of Mong Mit had failed to meet certain of these demands, and it is by reason of his default that we have the first authentic and official reference to the stone tract in Burmese history. The Burmese King NUHA-THURA MAHA KHAMA-YAZA issued a Royal Order in the year 959 B.E. (1597 A.D.)[2] annexing this tract of country from the Mong Mit State; which this very interesting document reads as follows:-

> SHWE-WA-MYO (Ava) was established on the 12th Labyigyaw Tawthalin (September) 959 B.E. It is the Ratna Pura (Gem City). Mogok and Kyatpyin are names for gem. They should be included in the SHWEWAMYO. These two are part of the Momeik Sawbwa's States, but should be excluded and Tagaungmyo and its surrounding villages should be included in the State instead. It is ordered that the Momeik Sawbwa take possession of Tagaungmyo, and that Mogok and Kyatpyin be given over to SHWEWAMYO. The Wuns (ministers) concerned must take over the rubies, big and small, with a list of all descriptions, and pay them into the Government Treasury. No appointments are therefore to be made by the Sawbwa of Momeik to Mogok or Kyatpyin, which have been given to SHWEWAMYO in exchange for Tagaungmyo.
>
> (Signed) NAKHANDAPYAGYIMA.
> 5th Thadingyut Labyigyaw (October) 959 B.E.

And so the Mogok Stone Tract first became the property of the Burmese Kings, and was ever afterwards regarded as forming a part of their own personal estates. The above document also makes it perfectly clear that the ruby mining industry must have been very firmly established at that time.

The area thus filched from the Shans was at first a comparatively small one, but more ground was gradually added until at the time of the British annexation the area so claimed constituted the whole of the Mogok Stone Tract as we know it today.

It appears to be quite clear that as late as 1597 the town of Mogok did not exist, but that the name was merely applied to a mining area and series

2 This document is still in existence, and is clearly dated 959 B.E. in two places, although according to Phayre (1883; *History of Burma;* see p. 128) this King did not succeed to the Burmese throne until 1605 A.D. While other authorities give the date as 999 B.E. (1637 A.D.) and state that the annexation was from the Chinese, and not from the Shans.

of paddy (rice) fields situated in the present valley which were worked by the inhabitants of Thapambin, a village some five miles away to the north-west. Owing to the difficult nature of the country, the journey between the two places could not be completed before nightfall, which in the Burmese language is termed *mochok,* so that the site was merely a night camping ground for the workers who knew it as Mochok, which afterwards became corrupted into Mogok. There is another often quoted derivation of the name in that it means the place where the mountains meet the sky, in allusion to the mountain tops being hidden by clouds during the rainy season. This is, however, somewhat far fetched, and is severely discounted by the fact that there is more than one Mogok on the map of Burma, and that none of the other would fulfill the required conditions.

Likewise Kyatpyin did not occupy its present site, but was undoubtedly situated somewhere to the north of the present village of Kathe; but it was at that time a firmly established and flourishing village. There are two versions as to how the present settlement came about, one being that the first settlers were a contingent of free pure Burmese labourers sent up by the King immediately after the annexation to work the mines on his behalf; the other being that they were convicts transferred from Madaya, in which district the Sagyin mines were situated, for the same purpose. It is of course quite possible that both of these things happened; the convicts would be skilled labourers from their work in the Sagyin mines and would have been sent to supplement the first contingent of unskilled labour. The application of the name to the village is said to be from an old Burmese expression meaning a *spread platform*, and was due to the fact that the inhabitants found it necessary to maintain fires under their sleeping platforms in order to keep warm at night.

The King at once proceeded to declare all the local inhabitants to be service men and appointed two Governors, who were designated *So-thugyis* (a.k.a. *So*), one at Kyatpyin and the other at Mogok, to take full charge and safeguard his interests. At the onset the main responsibility of each So-thugyi seems to have been to collect and make over to the King three times in each year, one large ruby, known as a *gaung* (head) worth one *viss* of silver,[3] one lesser ruby, known as a *pon* and worth 15 *tikals* of silver, 150

3 In those days all payments were made in roughly cast discs of silver, rupee coins not coming into general use until about 1874. One *viss* of silver weighed 3.6 pounds, and was then worth about one hundred rupees. It was subdivided into 100 *tikals.*

still lesser rubies each worth at least one tikal of silver, and one *tok* (bundle) of zircons, spinels, sapphires, and other mixed stones upon which no value was placed.

On the face of it, the above would not appear to be a very exorbitant demand, but it must be remembered that the prices then realised at the mines can in no way be compared with present values. Fitch writing of the prices obtained in Pegu says "Ruyes and safyres are so abundant that they know not what to do with them, but sell them at the most vile and base prices". If that was true of the then market prices of stones retailed to foreigners, who were ever looked upon as a legitimate source of enormous profits, it is obvious that the prices and values obtained at the mines themselves must have been exceedingly low.

Beyond the regular contributions it was declared that all stones found which exceeded a certain value were *de facto* Royal property and for which the miner received nothing at all. It was the duty of the So to seize all such stones and forward them to the King.[4] There is no record of what valuation was at first placed upon such stones, but it afterwards became fixed as individual stones of and above the value of two thousand rupees. This practice was continued throughout the whole time of the Burmese Kings, and was on the whole a very stupid one, as evasion was so easy by simply breaking up the stone, the miner at least getting something for the smaller pieces.

The King would appear to have early mistrusted the original So-thugyis, as when he imported the first labour contingent to work at Kyatpyin he appointed several headmen, or *Gaungs* to supervise them, and over the whole he placed a special So-thugyi, whose task it was to produce five hundred stones, worth seven viss of silver, as an extra annual present for the King, as well as to generally control the labour, and keep a very watchful eye upon the doings of the So's of Kyatpyin and Mogok. This quickly led to friction between the So's themselves, and it became necessary to allot to each a separate jurisdiction over a definite area; which incidentally led to another large slice of country being added to the stone tract.

The So-thugyis were uncrowned monarchs within their own territory, their authority being so vast that they even held absolute powers of life and

4 According to Sangermano (1893; *The Burmese Empire a Hundred Years Ago*), the death penalty was the punishment awarded to any person who concealed, sold, or even bought, one of these stones.

death over the unfortunate inhabitants. They were given an entirely free hand in the administration of their own territory, and in their methods of collecting the taxes, all that mattered being that the taxes were collected, and the constant demands of the King promptly met. The So's were appointed by the King himself, and were constantly being changed at his pleasure in the most haphazard manner. Consequently having no fixed tenure of appointment, and not the slightest security as to how long a good thing was going to last, it is not at all surprising to find that next to satisfying the demands of the King, each holder of office promptly proceeded to feather his own nest, and to make as much for himself as he possibly could in the shortest time, which of course he accomplished by oppressing and robbing the unfortunate miner. Mining was then supposed to be free to everyone, and the So had no authority to say who should mine and who should not, nor could he restrict mining to any particular place, or interfere with the actual work in any way. Yet all of these things were done, and the So's also found other ways and means of bleeding the miners to their own advantage.

Beyond seizing such stones, as were the Royal prerogative by reason of their high value, the So had no power to lightheartedly confiscate any stone which took his fancy, but he did hold the right to demand the first refusal to purchase any stone mined, and right royally did he abuse this privilege. The miner received a command to produce his stones for valuation with a view to purchase on a certain day, and to impart some show of equity, an assessor, of course appointed by the So himself, was also present to value them. The stones were placed upon a brass tray, and the miserable miner who dared not approach the exalted personage of the So, who by a mere wave of his hand could consign him to durance vile, if not to the place of execution, was forced to crouch in a state of abject fear at a very respectful distance, while the stones were being examined by the precious pair. As the stones were being moved about, the So would trace upon the tray with his finger the absurdly low price he was prepared to offer, which the assessor immediately declared as his valuation, and that was all the luckless miner received for his property. There was no possibility of appealing to a higher authority regarding this barefaced form of robbery, as the words of the So and his assessor were absolutely final. Naturally there was great dissatisfaction, but there was no redress.

The entire district was then covered by dense forests, and was by general repute notoriously unhealthy, which fact together with the tales of oppression by the So's prevented an influx of fresh settlers to work the mines. The bad behaviour of the So's had also caused an influx of the original free labourers, while the extra labour sent by the King instead of multiplying appeared to be dying out altogether. This caused a very serious shortage of labour to work the mines, and the So's promptly declared themselves unable to meet the Royal demands. To counteract this, King Bodawgyi (Bowdawpaya) about 1780 sent some thousands of captives, including entire families, taken in the expedition to Manipur, to work in the mines. These people were settled in Kathe village (now open mining ground) and distinct traces of them are to be found amongst the present day inhabitants. From this time on the mines came to be regarded as a place of exile to which were despatched those who had in any way incurred the Kings displeasure, the brilliant idea apparently being that once in Mogok they would quickly die. But the district does not seem to have been so unhealthy as it was painted, for many of these exiles refused to die, save in the fullness of time, and lived to found families, numbers of whose descendants still remain to work the mines. This additional labour did but little to alleviate things, as the Manipuris were not miners and seemed unable to adapt themselves to their new conditions of life, so that things were not going at all well, so far as the Kings own personal pickings were concerned, and very soon began to grumble in a no uncertain manner.

These difficulties reached the ears of two astute natives of India who in 1863 approached King Mindoon Min (1855–1878) with the proposal to pay him 200 viss of silver a year (about 20,000 rupees) for the sole right to purchase all the stones, other than the Royal Stones, mined in the tract; this payment was to be made irrespective of the customary presents which were to be made the basis of a tax upon the people, and collected and paid over to the King as usual by the So-thugyis. Mindoon Min thought this a very sound scheme, and was on the point of accepting it when he was approached by the three So's: U. Bwin (Mogok), U. Tha Dun (Kathe), and U. Chein (Kyatpyin), who, seeing a good thing slipping away from them, combined together and offered to pay 300 viss of silver for the same privilege, but stipulated that the customary present must cease. The King agreed to this, and the matter was considered as good as settled when Tha Dun went behind the backs of his companions and made the direct offer to pay 600 viss of silver, plus the customary presents, and to hand over to the King all stones mined of and above the value of two thousand rupees, but only on the condition that he was appointed sole Governor of the entire tract. The other proposal was immediately rejected in favour of Tha Dun, who thus obtained sole control of this enormous tract of country, with the responsibility of finding and paying into the Royal Treasury an equally enormous tax. He proceeded to raise this money by using his now tremendous powers to oppress the miners to such a terrible extent that the decline of the district, already set in, now progressed by leaps and bounds, the people deserting their homes and leaving the Tract for the Shan States. This exodus more or less coincided with a rebellion in the Shan States, which resulted in the destruction of the towns of Momeit, and Mainglon (Mong Lon) and caused large gangs of homeless men to take to dacoity (robbery with violence) for a livelihood. Hence for about a couple of years the entire tract was overrun by gangs of robbers, which caused it to become practically deserted, and brought about a complete suspension of work, with nothing at all finding its way into the Royal Coffers.

It was soon apparent that something had to be done, and strenuous efforts were made to induce the miners to return. Tha Dun was exiled, and three So-thugyis were appointed to collect the annual tax of 60,000 rupees which the King still thought fit to impose upon the district. Much of the So's powers were taken away from them, and mining was made free to all in any part of the district; while the miners were now at liberty to sell their stones to whomsoever they liked and for whatever price they could obtain them, the reservation of the so-called Royal Stones as the property of the King still remaining. But these sales could only take place within the stone tract itself, no exportation of stones being allowed except under Royal control; even the traders who purchased the stones had to produce them for valuation, and pay an *valorem* tax before they could take them out of the district. To assist in the due execution of these new rules, and to prevent smuggling, a customs house was established at Kin where travellers both to and from the mines were examined before being allowed to proceed.

If the miner was unable to dispose of his stones to the local traders, he was bound to produce them on certain fixed dates before the local So, who wrote out a full description of them, which included the miner's valuation, and then sealed them up, the miner also affixing his own seal to ensure that the parcel was not tampered with, and the stones were then forwarded to the "Royal Stone Mart" *(Kyauk-yondaw)* at Mandalay. The miner was legally bound to pay the So a small Seal Tax for his trouble, but it also became the custom for the So's to extort a further payment of 25% on the valuation of the parcel, which was but one of the many abuses of the system. Also, as the So knew when large or particularly valuable parcels would be travelling, the robbery of the carrier on the way to Mandalay was not an unknown incident. On an appointed day, the seals were broken by an officer of the Stone Mart and the miner, or his agent, was then free to show the stones to the assembled buyers, after the contents of the parcel had been verified. If a bargain was struck, the buyer had to pay a tax of 10% on his purchase price, and the sellers 5% of their receipts. But if the stones were not sold, the owner could then pay 10% on the valuation and take the stones away to sell anywhere outside either Mandalay or the Stone Tract: or he could reseal them and try his luck another day, which resealing could be repeated until the stones were eventually disposed of.

Much has been written regarding the practice of seizing all the large and valuable stones, causing such stones to be broken up wherever possible, and thus accounting for the great scarcity of large fine rubies. It is known that a certain number of such stones were so treated, but that they were in any way in the majority is extremely doubtful. We have records of many of these valuable so-called Royal Stones having been surrendered, and modern experience, when the area was being extensively mined in a scientific manner, shows that such stones were very few and far between. Thus the numbers recovered by the comparatively few native miners working by crude methods in the olden days must have been very small indeed.

The penalty for concealing such a stone was death, but this was frequently preceded by the most hideous forms of torture of all concerned. The punishment for illicit dealing in, or the possession of smuggled stones, was public flogging inflicted piecemeal at the corners of various streets in Mandalay, and the confiscation of all stones found. The Stone Mart at which all the traders proceeding to the mines had to report themselves and obtain licenses, and at the same time declare what money and merchandise they were taking with them, was used as a sort of Central Intelligence Office, and all information so gained was promptly passed on to the officials at the mines. But the traders also had to again report themselves on their return, and produce for valuation all the stones they had purchased, when, if this valuation proved to be in excess of the amount taken to the mines, they were regarded as having been dealing in illicit stones. The result was that all their purchases would be confiscated and the wretched trader promptly hauled off to undergo his round of whipping at the street corners. Up to the end of Mindoon Min's reign, these punishments were strictly enforced, and several Royal stones were recovered, and others surrendered to the King. But it is significant that when Thebaw came to the throne, both the system of espionage and the infliction of punishments was relaxed, and there is no record, either written or verbal, of his ever receiving a single stone of this class. However, there were statements by ex court officials that he received none at all; while it is known that large quantities of illicit stones were being sold every year in Lower Burma and in India.

Mindoon Min's new system seemed to be fair to the miners and created a new confidence which for a time restored a certain amount of prosperity to the district. But it was open to abuses, and these soon began to make themselves felt; besides which the King had hoped for very considerable profits from the Stone Mart, which quite failed to materialise. To make up for this loss, he calmly proceeded to place an extra demand upon the already over-taxed district. In order to meet this, the So's created a fund known as *Mindaing* ('Kings Fund', or bank) by levying an irregular cess (tax) upon the villagers, which they collected at odd intervals, just whenever they wanted money, so that no one knew the moment that a heavy demand would be made upon him. From this fund the So's compelled the traders to take advances of cash to pay for their purchases, Kyatpyin and Kathe only moderately charging 30% on these loans, but Mogok was much more greedy, with the interest often as high as 100%. The loans were all short-time ones, and were immediately repayable in full together with the interest, upon demand, irrespective of whether the trader had made a profit or a heavy loss over the transaction. In the first instance, the trader was literally blackmailed into incurring the loan, and upon repaying it was promptly saddled with a fresh one on similar terms. It was a downright swindle, but the traders had no option but to submit, as refusal would have incurred being hounded out of the district, and possibly a whipping for dealing in illicit stones, brought via a false charge.

The demands of the King for more and still more revenue went on apace, and the So's were called upon to find larger amounts every year, which they met by further oppressing the miners and devising new methods of swindling the traders. This caused great unrest in the district and the inhabitants, who were normally a peaceful law-abiding community, began to take to crime, so that dacoities and other forms of robbery became of frequent occurrence, while everybody was leading a most miserable existence. The Kings were, however, far too short-sighted to realise that the people had already more than reached the limits of bearable taxation, and continued to increase their demands. The climax came in 1885 when King Thebaw appointed U. Gaing as chief So-thugyi with the responsibility of producing the terrific sum of two *lakhs* and forty thousand rupees (about £16,000) a year. This was the last straw and the district immediately descended into a state of chaos; raids by armed gangs upon the villages became an almost daily occurrence, and the villagers themselves were

Figure 10.2
Mogok at the time of the British annexation. From Illustrated London News (1887) [The ruby mines of Burmah]. *Illustrated London News,* London, Feb. 19, pp. 205–206.

forced to move about in large bodies for self protection, and even then to go armed. The Mogok–Thabeitkyin road was particularly infested with gangs of desperate cut-throats, and just before the annexation things had come to such a pass that three enterprising local swashbucklers established a convoy system to and from Mogok and compelled travellers to pay a toll for a safe journey, which sometimes reached as much as ten rupees a head. If they refused to pay they were invariably robbed and quite often murdered. With the advance of the British troops, one of these bandits, fearing the consequences, fled, but the other two threw in their lot with the invaders, and were made Head Constables, in which capacity they did good work in policing the road for several years. A British Political Officer who was thoroughly conversant with all sides of the situation said that, had it not have been for the annexation taking place when it did, the Stone Tract would have been utterly deserted.

Just prior to the annexation by the British, which took place on the 1st of January 1886, King Thebaw had received several offers, including at least one from London, from syndicates seeking concessions to work the mines, and was actually in active negotiations with a French syndicate for the grant of such a concession.[5] Wild tales are told of the fabulous inducement offered to the King by this syndicate, but the real truth will never be known. Although other reasons are officially given, it has always been considered that these negotiations with the French were one of the deciding factors which led to the taking of Upper Burma by the British, and the loss of their throne to King Thebaw and his wicked Queen Supyalat.

Such is the history of the Mogok Stone Tract for some three hundred years under the regime of the Burmese Kings, and for a story of the downright swindling, and deliberate oppression of a hard working peaceful people, it is difficult indeed to find an equal.

5 Streeter (1892; *Precious Stones and Gems,* 5th edition, p. 180), says that Thebaw had actually granted a provisional concession to Messrs. Bouveillein and Co. of Paris, at an annual payment of Rs 3,00,000/-, with an agreement to pay four years rent in advance plus Rs 1,00,000/- as a personal present to the King, a total of about £33,330 down, for the sole right to mine for rubies in the district.

II

WHERE CORUNDUM COMES FROM

C. The Other Corundum Deposits of the World

SIAM AND INDO-CHINA: History ⚜ Situation ⚜ Siamese and Burma rubies compared ⚜ Siamese sapphires ⚜ The deposits ⚜ Labour ⚜ Output ⚜ The Kamins ⚜ Synthetic corundum in Siam ⚜ CEYLON: Production declining ⚜ Ceylon and Burma rubies compared ⚜ Ceylon sapphires ⚜ The deposits ⚜ New mining grounds ⚜ Output ⚜ KASHMIR: Appearance of the Kashmir sapphires ⚜ Situation and history of the deposits ⚜ Work done ⚜ Associated minerals ⚜ The peculiarity of Kashmir sapphires ⚜ Magnificent sapphires in the Royal Treasury ⚜ MADRAS AND MYSORE: The deposits of no importance ⚜ AFGHANISTAN-JAGDALAK: Situation ⚜ Mode of occurrence ⚜ BADAKSHAN: Early history ⚜ Mode of occurrence ⚜ AUSTRALIA: Australian sapphires of poor quality ⚜ Distribution ⚜ Output ⚜ UNITED STATES OF AMERICA: American corundum abnormal ⚜ Mode of occurrence ⚜ American and Burma rubies compared ⚜ Associated minerals and rocks ⚜ MONTANA: Early history ⚜ Country rocks and mode of occurrence ⚜ Anomalous crystallisation ⚜ Size of stones ⚜ Colours ⚜ YOGO GULCH: Situation ⚜ Mode of occurrence ⚜ Theory regarding crystallisation ⚜ Size and colour ⚜ Output ⚜ EUROPE: Occurrences of no importance ⚜ OTHER MINOR OCCURRENCES: All insignificant and quite unimportant

Siam and Indo-China

After the deposits of Burma, the next most important occurrence of precious corundum takes place in Siam, and in the neighbouring territory of Cambodia in French Indo-China; but here the sapphire predominates, and it may almost safely be assumed that at least fifty percent of the sapphires used in modern jewellery have emanated from these deposits.

Like the Burma deposits, the occurrence of sapphires in Siam was known in the very earliest days, but their working would always appear to have been regarded very much in the light of Royal monopoly and so jealously guarded that we know absolutely nothing at all about their early history. Even as late as 1650 we hear that the exercise of royal and other privileges rendered the prospecting for new deposits a matter of such great difficulty that no one was prepared to undertake it.

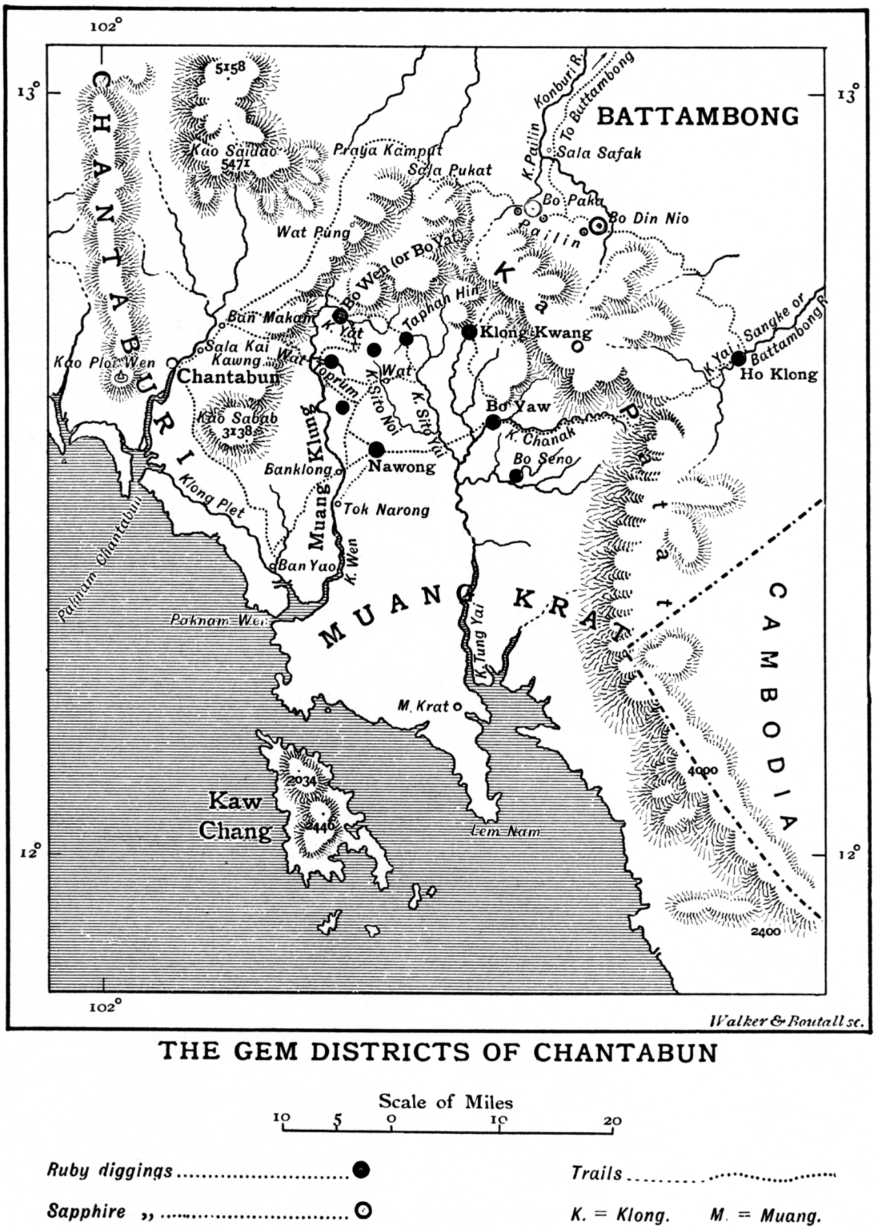

Figure 11.1
The corundum deposits of Siam. From Warington Smyth, H. (1898) *Five Years in Siam – From 1891 to 1896.* New York, Scribner's, 2 Vols., 330, 337 pp.

The centre of the Siamese gem trade is the town of Chantabun (Chantaburi), the capital of the province of that name, and situated about ten miles from the mouth of a small river which joins the sea some twenty hours by steamer in a south-westerly direction from Bangkok. In the olden days, the mines in this district were reputed to be most prolific in their production and an early report states that within the space of half an hour it was possible to gather a handful of rubies from the Hill of Gems just outside the town of Chantabun. This is most possibly a gross exaggeration, and at the present moment the actual mining in this locality is quite negligible in amount.

The deposits are scattered over a very wide tract of country extending in a southerly direction through the provinces of Krat, Klung, and Kanburi, the workings being mainly situated near the villages of Nawang, Channa, and Ban Yat, and also in the Bo Pai mining area. In a north-easterly direction they reach to the town of Battambang. They also pass across the frontier into French Indo-China where important deposits of sapphire occur in the alluvium of the Pailin stream, a tributary of the Nam Mong river in Cambodia, which is quite close to the frontier and some 170 miles E.S.E. of Bangkok, the workings being mostly at Boyaka and Bodinheo. There are also lesser deposits in the Ban Houei Sai district on the Upper Mekong river.

Everywhere the sapphire predominates, but rubies occur in the deposits in Chantabun, Krat, and Cambodia, sometimes in quite appreciable quantities and to a lesser extent at Battambang. From the very earliest days it has been recognised that the rubies from Siam were far inferior to those from the Burma deposits, their main fault being an objectionable dark brownish colour. Maxwell Stuart, however, contended, and Streeter fully concurred in his opinion, that many of the individual Siamese rubies could be considered to rival the best of the rubies from Burma.[1] These gentlemen may have been very fortunate in their experience of Siamese rubies, but so far as the writer's extensive experience goes, such is very far from being the case, and he has yet to see a ruby from Siam which is in any way comparable with a Burma ruby of but medium quality. He is further of the considered opinion that fine rubies do not emanate from Siam, neither have they ever done so. It is, however, quite possible that the rubies seen by

1 Streeter, E.W. (1892) *Precious Stones and Gems.* London, Bell, 5th edition, 355 pp. (see p. 157).

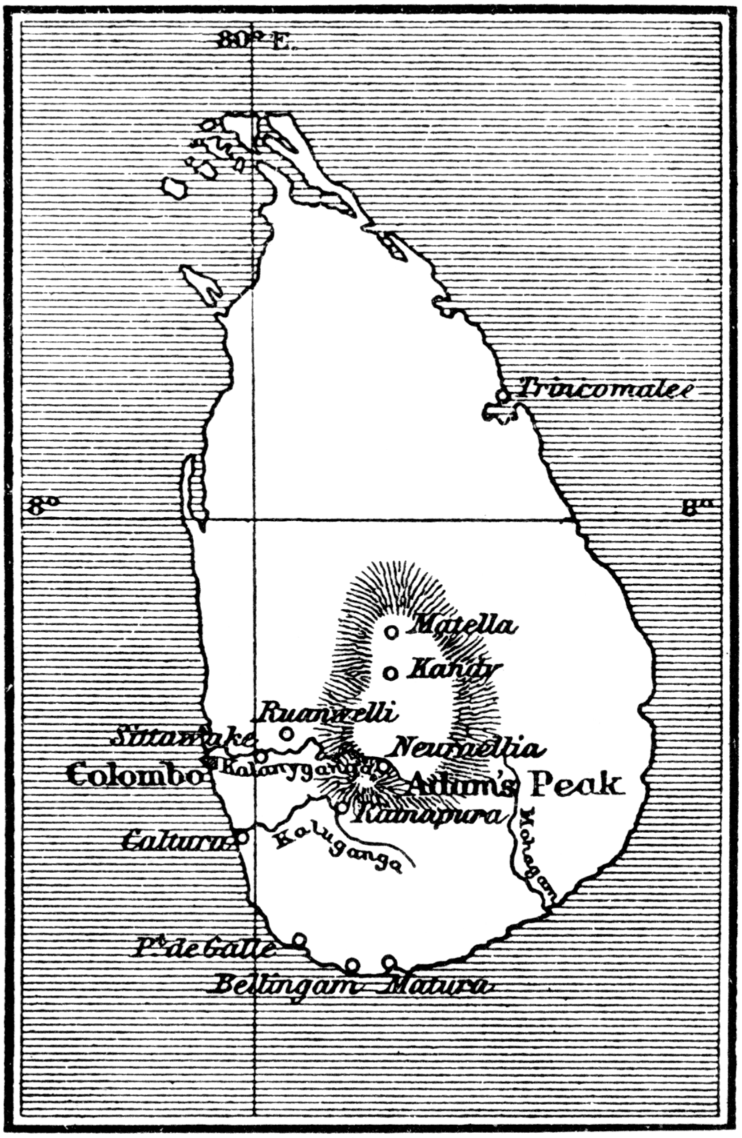

Figure 11.2
The mining areas of Ceylon. From Bauer, M. (1904) *Precious Stones.* Spencer, L.J., London, Charles Griffin and Co.

both Maxwell Stuart and Streeter were really Burma rubies which had been taken from Mogok to Siam for sale as Siamese rubies, a proceeding which has very often been indulged in. On the other hand, they may have merely been engaged in a selling propaganda for Siamese rubies.

The Siamese sapphires are, however, sometimes of very fine quality, but here again the very best of them can in no way be compared with the superfine sapphires of Burma. The colour of the Siamese sapphires may often be one hundred percent perfect, but very rarely indeed do they show the rich velvety lustre of the Burma stones, and, even when it is apparent, it is usually but imperfectly developed. Dark inky stones are very common, and no art of the lapidary can improve their appearance in any way, as they will mostly appear to be quite black and opaque in artificial light. A large number of the stones are of an intense cornflower-blue colour, and being very brilliant make most excellent night stones, and are generally very pleasing in appearance. A very common fault with Siamese sapphires is a decided tint of extraneous green, which imparts a most objectionable colour appearance; but cases of extraneous red in the colour are very rare. Excessive silk is another very common fault, but this causes a limited number of quite fine star stones to be produced. The majority of the Siamese star sapphires, however, cannot be considered to be of good quality as they are of an objectionable bluish or greenish-grey colour. Star rubies from Siam are unknown. On the whole, the better classes of sapphires from Siam may be regarded as being very good, but only a few of them are of really first-class quality, and none of them are superfine.

The main country rock is everywhere of a grey granitic nature, with adjacent limestone which often intrudes into the igneous rock. The gems, however, are invariably mined from the gem-bearing sands, gravels and clays in the form of alluvial deposits, which frequently overlay a trap rock of a basaltic nature, leading to the erroneous statement that basalt is the mother-rock of the Siamese corundums.[2] These alluvials are detrial deposits in the form of shallow beds from six inches to two feet in thickness, and which normally lie at from six to eight feet below the surface, although mining pits of over twenty feet have been known. Occurrences of the gems embedded in any form of rocky matrix have not so far been observed. The associated gemstones are good transparent crystals of quartz and zircons,

2 Editor's Note: This statement by Halford-Watkins is incorrect. Basalt is now understood to be the mother rock of Siamese (Thai) corundums.

and also ilmenite in quantity; topaz is also found but is uncommon, while commercial corundum of the poor gem quality is abundant.

The local labour is mostly Burmese with a sprinkling of Shans, Laos, Siamese and Cambodians; and all told there are now probably less than a thousand people engaged in the industry.

It is said that the unhealthy nature of the climate has been a ban to European enterprise, but on the whole this is nothing nearly so bad as it has been painted. In 1889, *The Sapphires and Rubies of Siam, Limited,* an English Company, was formed to work the deposits in Chantabun and Krat, but its career, at first so very promising, proved to be unfortunate and it has long since ceased to operate.

The official figures for the exports of precious corundum from Siam for the period 1927–1932 are given as being £58,900 for sapphires and £4,800 for rubies, but it is very doubtful if these in any way represent the correct total output; and it is also possible that the value of imported parcels of stones has also been included. For French Indo-China the official figures for the production of precious stones (mostly sapphire) are quoted as being 45,809 carats for the period 1919–1932; but these should be accepted with caution as it is known that a considerable amount of the production finds its way across the border into Siam, which may, or may not, get the credit for it.

In the early days there was a sect of wild country workers known as *Kamin* who, when they wished to sell their sapphires, would not let a prospective purchaser examine them, but would place the stones in a closed hollow bamboo tube which the buyer was allowed to shake and, from the sound emitted, to estimate the value of the contained stones. It is needless to say that the prices realised by such fantastic sale methods were always very low.

It is necessary to exercise very great care when buying parcels of uncut stones in Siam, as many of them will be found to contain quite a considerable admixture of synthetic corundum faked to represent waterworn stones, and even natural crystals. Cut synthetic stones are also to be found in plenty as traps for the unwary, while pale blue synthetic corundum is frequently offered as cut blue zircon.

Bangkok may be reached direct by air from Europe or Rangoon, by rail from Penang, or by a somewhat tedious steamer journey from Singapore. From Bangkok to any part of the mining areas, the journey is now a matter of little difficulty.

Ceylon

Ceylon, or the *Taprobane* of the ancient classical writers, has from the earliest days been renowned for its precious and other gemstones, and is even today in many quarters regarded as being the home of the ruby and sapphire. It was never quite that, although rubies and very fine sapphires are produced; but it is now fairly safe to say that so far as gem production is concerned, Ceylon has seen its best days, and that workable deposits are now daily becoming more difficult to locate.

Like Siam, Ceylon has been credited with producing rubies that are comparable with the finest stones from Burma, and as in the case of Siam this supposition is entirely without foundation, as, when judged by the required standards for a fine ruby, the majority of the Ceylonese stones will be found to be but very poor affairs indeed. Many of the stones closely resemble the Siamese rubies in being too dark, but the majority are of various shades of rose red, which, while being pretty and making very attractive stones, are by no means of a high class, and are of a comparatively low value.

Sapphire in all its varieties is the most prominent gem of Ceylon, some of them being of first-rate quality and quite often of an outstanding size; but the supply of such stones has been steadily on the decline for several years, and it is within the writer's personal knowledge that sapphires of all grades have been sent from Mogok to Ceylon to be sold as the product of that island.

Large numbers of the sapphires are of quite attractive pale shades, while many are parti-coloured, quantities being utterly spoiled by being badly spotted with pure red. The paler shades make very good night stones, but often show such distinct traces of extraneous red as to appear purple or violet by artificial light. Good star stones are produced, but the colour is seldom quite right, being either an objectionable bluish grey or showing a distinct trace of purple. The star rubies are mostly of pale shades of rose red, which are very attractive indeed, but cannot be regarded as being first class; while the majority have been treated by fire to remove enclosed blue spots. All the other coloured varieties of corundum occur more or less freely.

Gems are to be found in isolated patches in many parts of the island, but so far the richest deposits located have always been toward the south, the neighbourhood of Ratnapura ('City of Gems') and Rakwena probably being the best known. Others were situated near Neuraellia, Kandy, Matella, Pelmadulla, and Ruanwelli, on the banks of the river Kalang

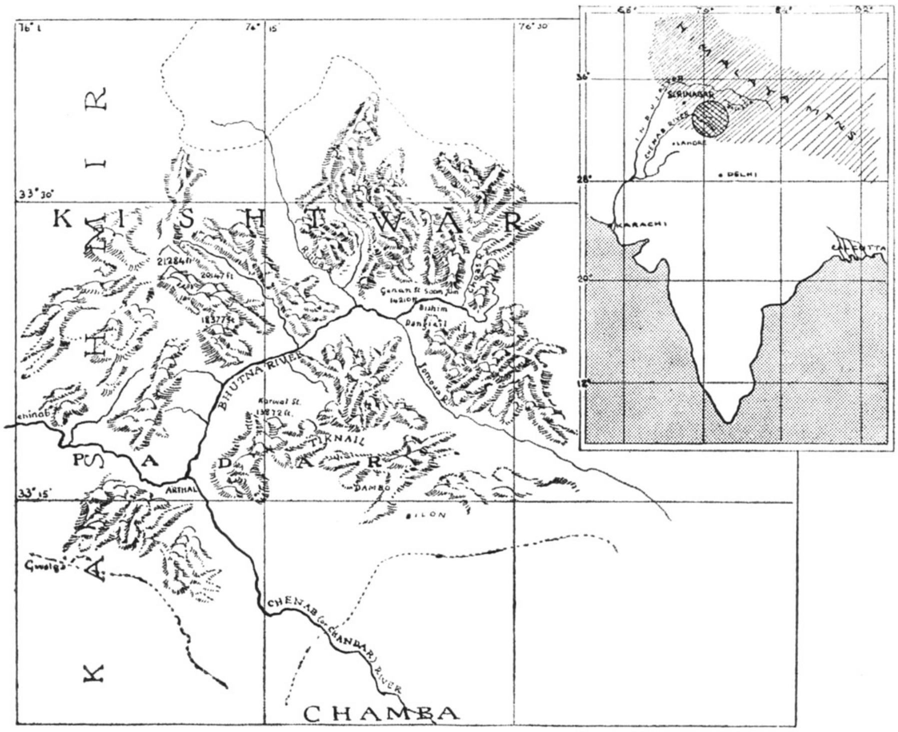

Figure 11.3
Where the Kashmir sapphires come from. From Halford-Watkins, J.F. (1935) Kashmir sapphires. *The Gemmologist,* Vol. 4, No. 42, January, pp. 167–172.

Ganga near Colombo, and the river Mohagm, while the country round Matura was at one time famous for its richness. Practically all the smaller streams in the south of the island will be found to carry gems to a certain extent.

Once more we find the country rocks to consist of granites, various gneisses, and schists of the Archaean age, with their attendant metamorphosed dolomitic limestone, or marble. Sapphires are very rarely to be found embedded in a matrix, and rubies in any form of rocky matrix are said to be quite unknown; but from the geological conditions it would seem most likely that they were originally formed in precisely the same manner as the Mogok corundums. Sapphires may sometimes be found in decomposing boulders of a gneissic rock, but have never, to the writer's knowledge, been located in an undecomposed gneiss. It would be a point

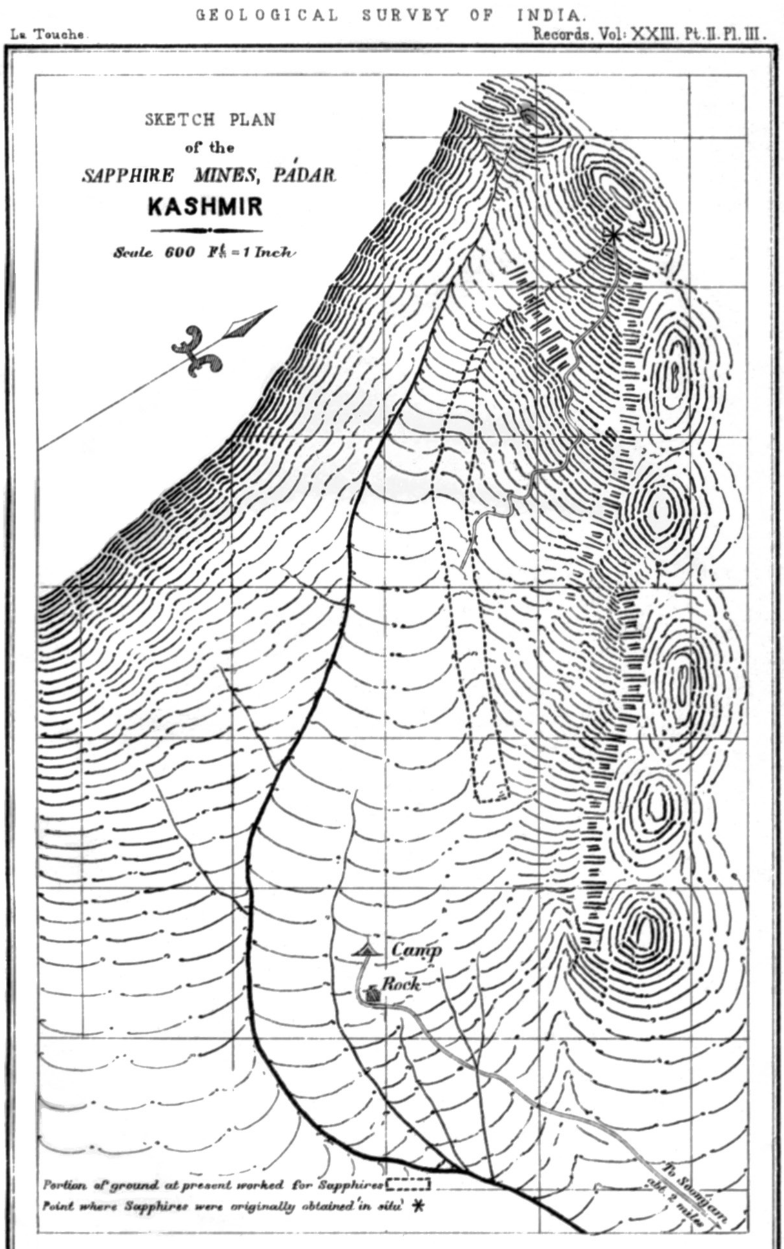

Figure 11.4
Sketch of the Kashmir sapphire mines. From La Touche, T.D. (1890) The sapphire mines of Kashmir. *Records, Geological Survey of India*

of great interest if some future geologist should find this occurrence amongst the gneisses of the mountain known as Adam's Peak which would appear to have been much concerned in the original formation of the gems of the locality.

The actual mining for gems, locally known as *gemming,* is confined to small isolated alluvial patches mainly situated on the hillsides in the neighbourhood of streams, but above the present level of the streams, and it is from the erosion of these beds of alluvium that the stones to be found in the beds of the streams themselves originally came. There are also other deposits which occur on the floors of the valleys carrying the larger river.

Near Ratnapura, these secondary deposits consist of an upper layer of heavy yellow clay, below which is a layer of black clay and a clayey sand, followed by a layer of bituminous clay containing much organic matter and animal remains. Below this again lies a layer of yellow, white, red, blue, or green clay carrying a large amount of variously sized pebbles and decomposing boulders of the country gneiss. This constitutes the gem layer known to the miners as both *malave* and *illam;* and which may be anything from a few inches to a few feet in thickness. It may normally lie at anything from three to thirty feet below the surface, but has been found as deep as a hundred and fifty feet.

The malave containing the largest pebbles is considered to be likely to carry the largest amount of gems; which besides rubies and sapphires consist of a variety of zircons, topaz, beryl, amethyst, garnets, tourmaline, chrysoberyl, cymophane (cat's eye) spinel, moonstones, iolite, alexandrite, and quartz.

In spite of the fact that most of the old and well-known deposits are now more or less exhausted, discoveries of new mining sites are from time to time being made, although the majority of these would appear to show a tendency to become increasingly difficult, and so, more expensive to work. That this is not always the case is shown by the discovery of a very easily worked deposit under a rice field near Ratnapura in 1922, which for some time continued to yield some very fine sapphires of great purity and magnificent colour, some of which were of a great size, one very fine stone weighing 2,030 carats in the rough. This deposit was rushed and soon exhausted, rice again growing on the surface. Other, but less important, deposits were discovered in the same neighbourhood in 1927, and again in 1929.

to believe that this deposit had been known to the wild local inhabitants for untold ages, but they considered the stones to be of no value. It is said that a *fakir* (holy man) took up his abode nearby and collected these stones, trading them in a small way as pretty and unusual stones which could be used with steel for the purpose of striking fire. His customers were passing petty peddlers with whom he exchanged the crystals for food and similar domestic merchandise. These men in turn disposed of them to the merchants in Delhi and Simla, who, in order to obtain the stones as cheaply as possible, pretended that they were only a form of blue quartz, but really thoroughly realised their true species and value. One piece of about a foot long and four inches in diameter the fakir attempted to have made into an idol, but the lapidary who was engaged on the carving recognised the true species of the stone from its great hardness, and communicated with the authorities, who very quickly forced the fakir to disclose the spot from where he had obtained it. The Maharajah realising that he had found a good thing, kept it as a secret for a number of years, while quietly working the deposit for his own purposes.

The site, being of difficult access and situated near to the limits of perpetual snow, was only approachable a few months per year, the rest of the time lying buried under deep snow. So that until the hunter with an eye for minerals accidentally stumbled upon it, and what is more, freely talked of his discovery, the preservation of the secret was really a very simple matter. La Touche of the Geological Survey of India was quickly upon the scene, and described the location of the mine, and its geological conditions in the official records.[4] In his report he states that the occurrence is situated in a small upland valley in the upper part of the Padar District, about thirteen days journey south-east of Srinagar, and between the villages of Machel and Soomjam, on the Butna river in latitude 33° 25′ N, and longitude 76° 28′ E, the valley being 1,000 yards long by 400 yards wide at the lower end.

The sapphires were found to occur in veins of decomposed gneiss and pegmatite which penetrated into the harder granitic and gneissic country rock, which consists of mica-schists, garnetiferous gneiss, and crystalline limestone, intersected by veins of granite. For several working seasons the sapphires were recovered by merely picking them out of the face of the

4 La Touche, T.D. (1890) The sapphire mines of Kashmir. *Records, Geological Survey of India,* Vol. 23, Part 2, pp. 59–69.

The generality of the rubies from Ceylon may be classed as poor, and the sapphires to only average medium quality with a fair percentage of very fine stones.

Sapphires of outstanding size are found upon the island, but very seldom appear upon the market in their entirety, owing to the difficulties attendant upon the sale and the subsequent mounting when cut of such enormous stones. Due to the very limited uses to which they could be put when mounted, the local dealers prefer to slit them into several smaller and more easily handled stones before marketing them. There are, as a class, few dealers in any part of the world more wide awake to the possibilities of their business than those of Ceylon.

The authorities in Ceylon publish no returns regarding the output of precious stones, and from the secret manner in which business is done it is impossible to form any real idea of the actual figures. One estimate puts it at £150,000 a year,[3] and another shows the total exports of precious stones, other than diamonds and pearls, for the period 1928–1932, as being only £2,767. With two sets of figures so greatly at variance, they should only be accepted with the greatest reserve, if not totally rejected.

Kashmir

After the superfine Burma sapphires, probably the next most esteemed at present are those from Kashmir, which in their finest state are an intense cornflower-blue in colour, with a well marked rich velvety lustre, and characterised by a slight degree of milkiness. This is quite distinct from schillerisation or chatoyancy, but imparts a most attractive softness to the general appearance of the stone. Such sapphires make most perfect night stones, and if there is any change at all they somewhat improve by artificial light. They are, however, now very difficult to obtain, and good specimens will command fancy prices.

The Kashmir deposits lie at an elevation of some 15,000 feet above sea level, in a small valley in the Zanskar Range of the North-West Himalaya Mountains, about midway between Jammu and Srinagar in the Independent State of Kashmir, and on a tributary of the river Chenab. Their existence was first made public in 1881 when, it is stated, a European hunter discovered a spot where an avalanche had laid bare a cliff, the face of which was studded with large sapphires. There are, however, strong reasons

3 "Gemstones" p. 66. – 1933.

rock, and so plentiful were they in this state that large quantities of fine large sapphires were so collected. It was then accidentally discovered that the whole floor of the valley was only overlain by a few feet of ordinary earth, underneath which was a thick layer of pegmatitic and granitic detritus which carried sapphires in such quantity that for a time they could be picked up almost like pebbles on a beach.

Many attempts have since been made to work these deposits on a commercial mining basis, but owing to their inaccessibility, severity of the climatic conditions, and the shortness of the only possible working season, nothing very definite has ever been done. And indeed at one time it was even reported that the deposits were completely exhausted. That this is erroneous is clearly shown by the following statement made by Mr. Middlemiss in his Presidential Address to the Geological Institute of India in 1929:

> Of precious and semi-precious stones, the famous Kashmir sapphire deposits of Soomjam, Padar, easily come first. This has been carefully reported upon, and mapped, and has been worked experimentally by the Department last summer with good results. The idea that it is exhausted has been proved to be a fable, and the fact that elaborate policing of the mine area at altitudes of thirteen to fifteen thousand feet has become necessary to stop pilfering by organised gangs of raiders is sufficiently significant. A few pale ruby crystals have also been found with rubellite and green tourmaline near the old sapphire mines.

All the work that is going on there today, is, however, done by a handful of hardy workmen who take out the necessary licences to work for about three to four months in the year.

Besides this particular deposit, the existence of others of a similar nature is now thought to be a certainly, but their actual location still remains the secret of the wild tribes of this remote and inaccessible country, so that as far as their production is concerned, they may be regarded as unimportant; but this may not be so for all time.

The following minerals have been found associated with the sapphires in various quantities: spodumene, prehnite, tourmaline, beryl, lazulite, quartz crystal, and a rare mineral known as cookeite. Large quantities of brown and green tourmaline in small crystals have been found growing parasitic on the crystals of sapphire, and are common as actual enclosures within the sapphires themselves. Other coloured corundums are rare in these deposits, and red is almost unknown.

The sapphires recovered from the veins in the rocks are in the form of fairly clearly defined crystals of the hexagonal bipyramid habit, but are

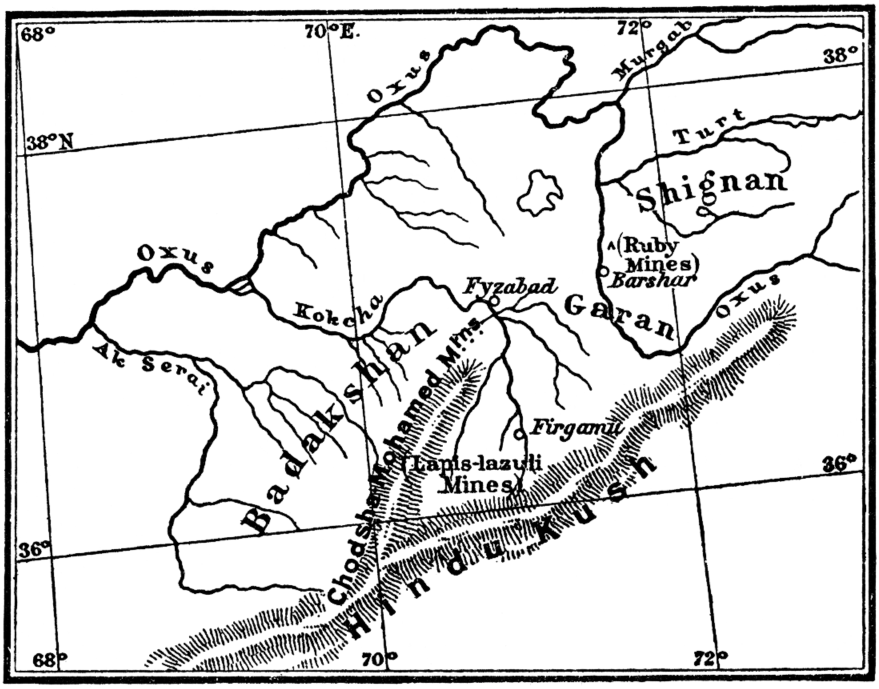

Figure 11.5
The deposits in Afghanistan. From Bauer, M. (1904) *Precious Stones.* Spencer, L.J., London, Charles Griffin and Co.

often very irregular in shape, much flattened, and deeply eaten into by horizontal striations. They, however, present the general appearance of being found at, or near to, the site of their original crystallisation. On the other hand, the stones found in the beds on the floor of the valley rarely show outward crystalline form, but consist of fragments and much rounded worn pebbles which would appear to have travelled a considerable distance, or to have at some time been subjected to an intense rolling action, either by running water, or more possibly by continuous avalanches. Some of the crystals run to quite large sizes, many fine specimens suitable for cutting and measuring some five inches long by four wide having been found, while gem crystals of over a foot in length and of corresponding thickness are not unknown. The rounded nodules also occur in quite large sizes of fine gem quality, stones weighing a hundred carats being of quite ordinary occurrence, and up to three hundred carats not uncommon, while very much larger ones have been found.

The distinct peculiarity of many of the Kashmir sapphires is their slight milky appearance, which gives the stone a very markedly sleepy look, but being evenly distributed in no way detracts from their great beauty or value. This is caused by very even layers of thinly distributed and exceedingly microscopic silk which, provided that it is not in excess and that the basic blue colour of the stone is sufficiently strong, and is further accompanied by the rich velvety lustre due to inclusions of colloidal particles, will all enter into combination to produce a faint evenly distributed milky-white mist, which shows not the faintest suspicion of a sheen, but has a beautiful soft plushlike effect which is most pleasing to the eye, and very considerably enhances the value of the stone. This is an appearance quite characteristic of the Kashmir sapphires, and is not to be found in the sapphires from any other known deposit. On the other hand should the silk be excessive, or the body colour of the stone not of sufficient depth, then it will take on a pale bluish-grey milky colour which is far from being beautiful. Such stones form a very considerable proportion of the total recovery, but still they have their uses, and the better of them may be found in the form of carved sapphires and beads, but are only of a comparatively low value. Many of the crystals will only possess this milky appearance in parts, and then great care in the cutting is necessary to secure the best effect. Crystals which are only blue in parts, the remainder being colourless, are also quite common. As is usual in all sapphire deposits a very large proportion of the total output is quite useless for gem purposes, being rendered so by dense masses of silk.

Some very good quality star sapphires are produced, and a fine cornflower-blue milky star cut from a Kashmir sapphire is a thing of exquisite beauty, but unfortunately such stones are very rare indeed.

The writer has handled some magnificent stones from the Kashmir deposits, and has had described to him stones of astonishing size and beauty which repose in the treasure chamber of the Maharajah of Kashmir and never see the light of day. An expert who officially examined these stones said that they were present in immense quantities, both rough and cut, and that some of them were of quite unheard of sizes. He spoke of large leather sacks full of rough sapphires. The existence of this large accumulation of fine stones has long been known to prominent merchants, and many expensive attempts have been made to purchase them without the slightest result.

Table 11.1: Australian sapphire output

Year	Value
1913	£43,292
1915	£600
1919–20	£65,831
1926	£6,799
1927	£2,202

Madras and Mysore

In Southern India there are considerable occurrences of commercial corundum both in the State of Mysore and in the Madras Presidency, but they very seldom produce a stone which may be considered as even of poor gem quality, and never anything which is worthy of serious consideration.

The alluvial deposits along the course of the river Cauvery very closely resemble the gem alluvium of Ceylon, with the exception that it is almost barren of gems, but a few rubies and sapphires of no importance have been found in it. The reputed occurrence of rubies in large quantities in this and other rivers of India may be regarded as complete fairy tales, as such occurrences are really quite unknown. It is possible that in the early days the red garnet which abounds in many parts of India was confused with ruby, and so started this mythical story; but it is far more likely that rubies smuggled into India from Burma and Badakshan in the very early days were, for obvious reasons, said to have been obtained from the Indian rivers.

Afghanistan – Jagdalek

There is a small deposit of gem corundum at Jagdalek in Afghanistan, some thirty miles east of the town of Kabul, in latitude 340° 2′ N, and longitude 70° 0′ E. In the early days this was a famous deposit, but today is only worked by a few odd miners at intervals of time, when they can afford to take out a license. Their returns are usually very poor indeed, and nothing of note has been mined there within living memory. That they still have an attraction is, however, shown by the fact that the writer has several times been approached by Indian speculators with wild schemes for getting rich quickly by reopening these mines.

Here the rubies are found in the alluvial and detrial deposits of a micaeous crystalline schist, the country rock being granite and gneiss interfoliated with crystalline limestone. The rubies are of fairly good quality and colour, and the crystals show little signs of movement. Fine spinels are also to be found here, but sapphire is said to be entirely absent.

In the past this deposit is reported to have produced some very fine large rubies of remarkable purity, and in large quantities. There may be a certain amount of truth in these assertions, but there is also good reason to believe that many of these so-called large fine rubies were in reality only spinels.

Afghanistan – Badakshan

These are probably the most famous mines of early Indian history, and it is from them that the Great Mogul (Emperors of Delhi from 1526–1858) are known to have obtained a large number of their jewels. Its ancient name was Balascia, from which is derived the term *balas ruby,* a very common, but utterly false name applied to spinel.

The deposits lie in the far north-eastern corner of Afghanistan, in a wild inaccessible region on a bend of the river Oxus, near to the small town of Barshar in the district of Badakshan, in latitude 37° 0′ N, and longitude 71° 30′ E.

Marco Polo describes a visit to these mines in the thirteenth century, and says that the output was even then strictly limited by the authorities in order to keep up the value; and also that of all the stones actually mined only but a very small proportion found their way onto the open market, the majority being retained as tribute by the Mogul Emperor and other subordinate rulers. Work would appear to have ceased very suddenly at these mines, and they were not reopened until about 1866, and then work would only seem to have been carried on in a very spasmodic manner, until at the present day there are but a handful of workers scratching about, and so far as is known finding practically nothing at all.

The general mode of occurrence and the country rocks are strikingly similar to those of Mogok; and some very fine large rubies are reputed to have been mined in the early days, but here again it is very probable that many of these were only spinels, which are also abundant.

It is now reported that these deposits are practically exhausted, but the general geological conditions would appear to favour an extension of the gem-bearing area, which many perhaps be found to be considerably larger than is even suspected.

One large ruby mined about 1873 gave rise to the frequently quoted term “a pigeon’s-blood ruby as large as a pigeon’s egg”. The location of these mines also probably produced the erroneous impression that rubies were found in Tibet.

Australia

It has been said that Australia is the largest producer of sapphires, but the originator of this truism forgot to add that very few were of any real gem value. The vast majority of sapphires from Australia may be said to suffer from one of two very distinct complaints, being either too dark, or of an objectionable shade of green. The darker stones are of a peculiar intense dark blue colour, which may perhaps best be described as inky, and which at a short distance, even in daylight, cannot be distinguished as a blue sapphire, while by artificial light they appear to be black and opaque, and closely resemble facetted jet or coal. The lighter stones are more transparent, and fairly brilliant, but are of a most unpleasing shade of sage-green. Both of these classes of sapphires, which are exceedingly common in Australia, are only suitable for use in the very cheapest forms of jewellery compatible with using genuine sapphires; but unfortunately they are often to be found mounted in the better class forms of jewellery and offered at high prices as traps for the ignorant or unwary. These stones should be regarded as abominations, and as being absolutely valueless, besides being a standing danger to the good name and popularity of the better class sapphires from other deposits, and consequently keeping prices low. A certain number of stones of fair quality are mined from time to time, but on the whole the sapphires from Australia must be regarded as a very mediocre lot, stones of good quality being rare, and really fine stones unknown. Fairly good star sapphires may, however, sometimes be met with.

The sapphires are of fairly wide distribution in New South Wales, where they occur in Tertiary and recent alluvials. The deposits at Anakie in Queensland were first discovered about 1870 and occur in old alluvials which lie parallel to, but some distance above, the banks of the present streams, and vary from a loose sand to a heavy reddish clay, the contained sapphires being irregular in their distribution. Besides sapphires, stones of the other coloured corundums, and a few poorish rubies also occur. The stones are often associated with gold, tin, and diamonds. A small and quite unimportant occurrence has also been reported from Tasmania.

Figure 11.6
The situation of the corundum deposits of Montana.

Table 11.1 on page 178 gives some indications as to the Australian output of sapphires, but there is some doubt as to whether they refer to only the gem qualities, or also include the commercial corundum.

The number of persons employed is given as varying between 840 and 2000.

In 1921, a system was introduced whereby the state acquired the whole of the sapphire production and marketed stones on a profit-sharing basis with the miners, but this proved to be unsatisfactory and was abandoned in 1928.

A few rubies of small size and no great value are also associated with these deposits of sapphire, but many of the reported occurrences of ruby in Australia have merely been mistakes in the original identification of almandine garnet, which may still be found offered under the false name of *Adelaide ruby.* In the early days, a large occurrence of these stones under their mistaken identification was reported from the Mackonnell Mountains in South Australia, which resulted in some thirty companies being floated to work the deposits. But it was only another instance of the uncertainty of investing money in gem mining, as they all went into liquidation immediately after the mistake was discovered.

A very larger proportion of the gems mined are now cut and polished in Australia in quite a satisfactory manner.

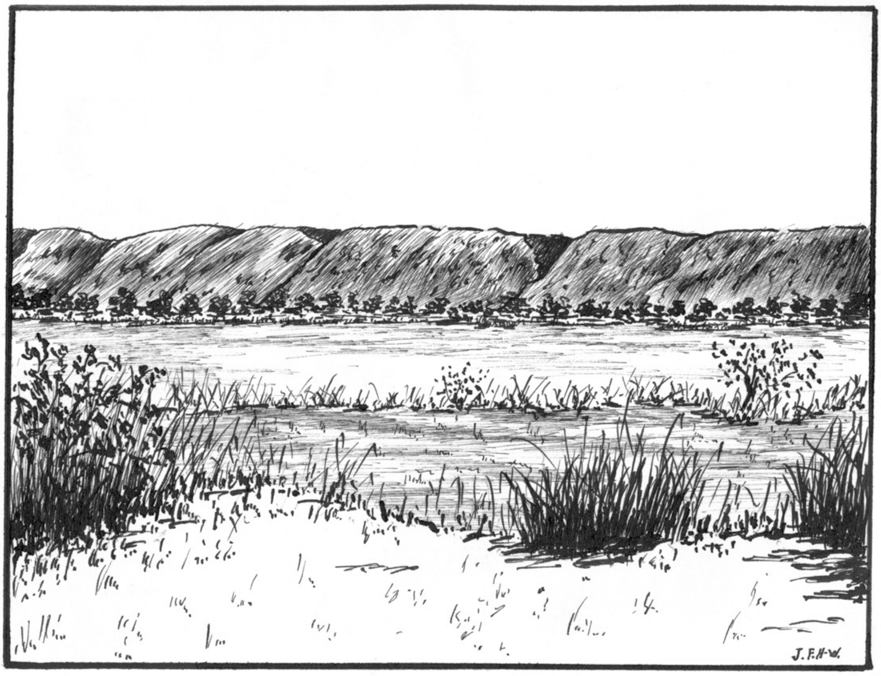

Figure 11.7
A sapphire bar on the Missouri river.

United States of America

These are important occurrences of commercial corundum at many places in the United states of America, and associated with a number of them are a certain amount of the gem varieties, but here again there is much evidence of great confusion in discriminating between ruby and red garnet.

There are three remarkable things in connection with certain of the occurrences of corundum in America, the first being that in the alluvial deposits which produce red corundum (ruby), very few of them will be found to show limestone as a prominently associated mineral, as it is in practically every other deposit. The second being that in the Montana deposits where limestone occurs, red corundum is practically absent, while blue and other colours are abundant. Thirdly, many of the blue and other coloured varieties are found crystallising in the prismatic rhombohedral habit, and often terminated by flat plane surfaces, a form which is peculiar to red corundum alone in other deposits. Besides this, they are abnormal in other respects when compared with the corundum from other deposits.

Table 11.2: Gem production at Yogo Gulch, Montana

Year	For gem purposes		For commercial purposes		Total	
	Carats	Value (£)	Carats	Value (£)	Carats	Value (£)
1924	46,950	4,052	278,317	1,113	325,267	5,165
1925	54,494	5,827	211,873	847	266,368	6,674
1926	42,469	3,800	179,895	699	222,364	4,499
1927	6,451	1,290	83,235	44	80,686	1,334
Total	150,324	14,969	753,320	2,703	894,685	17,672

Professors Judd and Hidden when reporting on the gem corundum from Cowee Creek in 1899 stated that the gems occurred in garnet bearing basic rocks as small tabular prismatic crystals which exhibit the transparency and colour of the Oriental ruby. These basic rocks include eclogite, amphibole, and other similar rocks of an igneous nature, but are so weathered that they are now represented by a soft decomposition product. It is in this that rubies occur in nests and bands in what appear to have been cavities in the original rock. Where the corundum was pale coloured, these cavities would appear to have been filled with a felspathic material, but where it was of a good ruby red colour, the filling was of a chloritic nature. In this connection there is nothing to show that the limestone was not originally there, and has now entirely disappeared, and it is significant that it may still be found only a few miles away. It must, however, be remembered that ruby also occurs at Mogok embedded in the felspathic rock, although not usually so; and also that it is by no means a proven fact, but only a much disputed theory, that limestone had anything at all to do with the original crystallisation of rubies.

That the American rubies are in any way comparable with the finest Burma rubies, as has been so freely stated, is entirely mistaken; the writer has never seen one, neither has he heard of a single authenticated instance where such a comparison could possibly be made.

The associated minerals in America are garnets (including rhodolite), fibrolite, kyanite, staurolite, cordierite, zircon, tourmaline, cassiterite, and gold; spinel being conspicuous by its absence except in its black opaque form (pleonaste). The corundums freely contain enclosures of many kinds, but to say that enclosures of rhodolite and rutile are of common occurrence is quite incorrect.[5]

In the United States corundums of both the gem and commercial varieties have been reported as occurring in the following rocks: peridotite (dunite and saxonite), biotite (in contact with saxonite), enstatite, serpentine, chlorite-schist, amphibole, norite, andesite, syenite, amphibole-schist, gneiss, mica-schist, limestone, and cyanite.

U.S.A. – Montana

The only occurrences of gem corundum in America of any real commercial importance are situated in Montana County, some 2000 miles W by N of New York City, and in between latitudes 46° and 47° N, and longitudes 110° and 112° W. The first of these is situated on the banks of the upper reaches of the Missouri river to the north of the town of Helena, and was first discovered by some gold washers about 1865. These deposits, which carry blue and other coloured corundums, red being almost entirely absent, were not at first recognised as being of any particular value; in fact the stones were thought to be merely coloured quartz, and the finds of gold not being satisfactory, the site was soon abandoned. Several years later, Messrs. Tiffany (the New York jewellers) came into possession of a few of these stones and recognising their value caused an investigation to be made, with the result that the stones were first described by Lawrence Smith in 1873.[6] Another eighteen years were, however, to elapse before any active mining was done. In 1891 a number of companies were floated to work these deposits, the chief of which was a London company under the name of *The Sapphire and Ruby Company of Montana, Limited,* but which was reorganised as an American Company in 1897 and then known as *The Eldorado Gold and Gem Company.* This company worked the deposits in a scientific manner by hydraulic methods, and concentrated the gravels by means of sluices and pulsators. Owing to over capitalisation, the colour, and small size of the stones, this venture was not at first a financial success, but later a time of fair prosperity was entered upon, and this and other companies continued to work until 1929, when operations were entirely

5 See Chapter 8, page 125.

6 Smith, J.L. (1873) Notes on the corundum of North Carolina, Georgia, and Montana, with a description of the gem variety of the corundum from these localities. *American Journal of Science and Arts,* Vol. 6, 3rd Series, pp. 180–186.

suspended, it is said owing to the impossibility of profitably marketing stones weighing under a carat which formed the bulk of the production. Side by side with these modern mines were to be found single individuals and small syndicates who worked ordinary small staked claims by crude methods, much of which was underground, washing their gravel in pans and hand rockers.

The country rocks are quartzite and a dark argillaceous slate, which is possibly of the Lower Silurian Age, and of limestone, but the gems are found in a mass of what appears to be glacial debris from 10 to 15 feet in thickness resting upon the slate. These rise in the form of gravelly bluffs, or terraces, the bases of which may be anything between 50 and 200 feet above the present river level; these are locally known as *bars* and it is in the lower layers of the sands of these bars, normally only a few inches in thickness, that the majority of the gems are to be found.

The bars are broken through by eruptive dykes of trachytes, diorites, hornblende, porphyrite, and a mica-augite-andesite, and the corundum may often be found embedded in the rocks forming these dykes, from which they have evidently been set free by the ordinary processes of disintegration. It is, however, contended that these are not the original mother rocks of crystallisation, which is thought to have taken place at some unknown centre prior to the fusion and eruption of the dyke rocks; or alternatively that the original matrix of the corundum was melted a second time to form the present rock substance. In any case, the incidence of the corundum in the rock is only of a secondary nature, the contention being based on the fact that the crystals are seldom clean or show sharp edges, but rather take the form of fragments of worn crystals with dull and rounded edges, which form persists in those found embedded in the rock equally with those occurring free in the sands and gravels.

It has already been mentioned in Chapter 2, page 185 that the stones from these deposits exhibit an abnormal habit of crystallisation when compared with corundums from other deposits, in that they mostly crystallise in the rhombohedral prismatic habit, forms such as D, E, F and G in Figure 2.1 on page 38 being quite common, which in other deposits are almost solely adopted by the red corundums only. Crystals showing the pyramid habit have been observed, but they are uncommon. Apart from this anomaly of crystallisation, these stones also differ from the normal corundums in possessing a characteristic hard metallic lustre, which almost verges on the adamantine, and also in being of an appreciably higher abrasion hardness than the corundums from other deposits, which renders the lapidaries task of working them much more difficult.

The crystals, which are often deeply striated, are invariably small in size, the largest recorded being nearly an inch long by three eights of an inch in diameter, but the majority of them are very much smaller than this, and will only yield cut stones which are so small as to be only suitable for calibre work. For this purpose they are particularly suitable, as their regularity of colour in the parcel renders them very easy to match large quantities almost exactly; but very few of them when cut will exceed a carat in weight, and a large percentage will fall as low as ten or fifteen stones to the carat. A stone of nine carats in the rough was regarded as a great rarity. Nevertheless, small as these stones are, they make up for it in abundance, and one acre of the alluvial is said to have yielded no less than 350,000 carats of gem quality, in addition to a very much larger amount of material not suitable for cutting.

The colours are almost always pale, but practically every colour of the spectrum, and their intermediate shades may be met with, but pure red and pure dark blue are very rare. Crystals with a reddish centre and an outer skin of another colour have been met with, and some of the green and blue stones carry such a strong extraneous red tint that they will appear to be quite red by artificial light. The prevailing colour is a pale greenish or bluish-green, and asteriated stones have been met with, but are very uncommon. Practically all the Montana stones make most excellent night stones, their effect being considerably heightened by their almost adamantine lustre.

U.S.A. – Yogo Gulch

Situated at Yogo Gulch, in Fergus County, Montana about 80 miles N.E. of Helena is another important occurrence of sapphire which takes place near the entrance to Yogo Gulch, on the eastern slope of Prospect Ridge of the Little Belt Mountains. Here the stones occur in a yellowish material which is a disintegration product of the local igneous rocks, from two parallel dykes about 800 feet apart extending for about a mile and a half, besides which there are other deposits.

The rocks of these dykes are of an igneous type containing much biotite and pyroxene with granules of calcite and a little iron ore, and are closely related to the basic minettes. The sapphires themselves are but rarely embedded in the rock, but from their sharp distinct crystals it is thought that they crystallised out of the molten magma at the time of its intrusion.

It is further thought that the alumina was not an original constituent of this magma, but was taken up by it from inclusions of clay sediment through which it passed, and then dissolved it, forming local areas which were very rich in alumina, which as the magma cooled would crystallise out as sapphire corundum.

The clean crystals are of the rhombohedral prismatic habit, but the great majority of those found in the alluvials are in the form of worn and rounded granules. Here again the stones are normally quite small, averaging when cut about twelve to the carat, but a certain proportion of larger stones are also found. The colour varies from a deep to a very light blue, but the prevailing colour is a nice shade of cornflower blue, while many are amethystine, and a number of a distinct reddish-violet colour. A curious thing about these crystals is that they frequently show etched surface markings, to an extent which is not observable in the corundums from other places. Practically all the Yogo Gulch sapphires make most excellent night stones.

Mining has been carried on for years by individual workers by crude methods, and by big companies by scientific mining methods. *The New Mines Sapphire Syndicate,* an English company, operated continuously for many years. Falling demand for stones of under a carat in weight restricted its output for a number of years, and it finally ceased working in 1929. Some idea of the production of this company may be gathered from Table 11.2, which is quoted from official sources.[7]

Europe

There are several slight occurrences of gem corundum known in Europe, but all of them are of far more interest to the scientific mineralogist than to the practical gemmologist or to the dealer in precious stones, and their output is absolutely without significance to the trade. Red corundum suitable for cutting is practically unknown, but sapphires of gem quality, although of no importance, so far as size is concerned, have been found in the Ural Mountains, Czecho-Slovakia, Roumania, Germany, Saxony, and France.

7 U.S.A. Bureau of Mines (1931), *Information Circular,* No. 6471, p. 6.

Other minor occurrences

Minor occurrences of gem corundum have also been reported from Borneo, Madagascar, Rhodesia and the Belgian Congo, but all of these are quite unimportant with regard to supplying gems to the market, and so far as our present knowledge of them goes, are of but little scientific interest.[8]

8 The author desires to express his thanks for information utilised in this chapter which was kindly supplied by Dr. L.L. Fermor (Director) and Mr. E.L.G. Clegg, of the Geological Survey of India; and the United States of America, Bureau of Mines, and also for their courteous permission to reproduce Figure 11.4 and Figure 11.6.

12

THE MINING OF CORUNDUM

A. The History and Methods of a Large British Company in Burma

E.W. Streeter obtains the grant of a lease ✤ The floatation of the Burma Ruby Mines, Limited ✤ The terms of a badly drafted lease ✤ The native miner defaults, causing a large loss of revenue ✤ New arrangements made with Government ✤ Loss of control of the ruby market ✤ Moving Mogok to a new site ✤ The difficulties of transport ✤ Construction of water channels ✤ An electric power station opened ✤ A drainage tunnel constructed ✤ Sub-soil water trouble ✤ The Mogok Valley opened up ✤ System of working the mines ✤ Washing the earth by means of mills ✤ Work in the sorting enclosure ✤ Grading and disposing of the gems ✤ Objections to the methods used ✤ Theft and its punishment ✤ Synthetic rubies cause a panic ✤ A bad fall in prices ✤ Bad times ✤ Prosperity revives ✤ Alteration of mining methods ✤ The adoption of gravel pumps and sluices ✤ Methods and operation costs of mining with gravel pumps and sluices ✤ Robbery by organised gangs rampant ✤ The Company goes into voluntary liquidation, and surrenders its lease ✤ What the Company did during its working life

When the annexation of Upper Burma by the British took place on the 1st of January 1886,[1] there were at once several offers from various syndicates anxious to obtain a concession to work the deposits of the Mogok Stone Tract. Amongst the earliest of the applicants was a syndicate headed by Mr. E.W. Streeter, the Bond Street jeweller, who it is said had already been in active treaty with King Thebaw, with the same object in view, prior to the annexation, but he does not admit to this.[2]

After prolonged negotiations and many breakdowns, during which Streeter's representatives accompanied a military expedition to the mines in November 1886, and remained there as technical advisors to assist the authorities in the administration of the tract, a lease from the Secretary of

1 King Thebaw actually surrendered to Sir Douglas Sladen at Mandalay on the 3rd of December 1885, but for some unknown reason the date of the annexation is always officially given as being the 1st of January 1886.

2 Streeter, E.W. (1892) *Precious Stones and Gems.* London, Bell, 5th edition, 355 pp. (see p. 179; 'The Author's connection with the Ruby Mines of Burma').

State for India was finally granted on the 22nd of February 1889. This conveyed to Streeter a lease of the Stone Tract, with certain restrictions, for a period of seven years, with the option of renewal, at an annual rental of four lakhs of rupees (about £30,000) plus one sixth of any profits made by actual mining and gem trading, without deducting payments debitable to capital expenditure.

The Burma Ruby Mines, Limited was immediately formed to work the concession, and its floatation was easily the financial sensation of the year. On the morning of the issue – the 26th of February 1889 – St. Swithins Lane, London, was so thronged with eager speculators clamouring for application forms that Lord Rothschild, the world's leading financier, who sponsored the issue, was forced to leave his brougham and to elbow his way through the dense crowd to a side door of his offices in New Court. One account has it that he used a ladder to climb to an upper window, but this is not correct. The whole issue was over-subscribed in a few minutes, and three times the amount of the required capital of £300,000 could just as easily have been raised.

The lease only gave the company the right to work on any unoccupied land by means of machinery, or by any other method; and strangely enough gave them no real water rights, for, although it granted them the right to take water for mining purposes, this was so hedged round by restrictions as to prove almost valueless, eventually putting the company to a great deal of unnecessary expense. The native miners were to be allowed to work as before by purely native methods, for which they were to pay the company 30% on the valuation of all stones mined by them, while the company had the further right of being able to enforce the sale of any stones they may wish to purchase. From either a mining or a business point of view, it was a thoroughly badly drafted lease. But who worried when there was an Eldorado at stake which must be secured at all costs? They secured it, but when they came to work it, the lack of ordinary foresight at once became apparent.

It was considered that the company would be able to obtain a monopoly, and to so control the market, while fixing the price of the world's supply of fine rubies at its own sweet will. Shock number one was not long in happening, and they received a very nasty jolt when it was realised that the simple faith placed in the native miner to declare the true value of his finds, and pay his thirty percent thereon was proving a fallacy. He very naturally concealed the greater part of his finds, and swore by all the gods that the absurdly small parcels that he did produce were everything that he

Figure 12.1A ruby mine. From Anonymous (1905) A city built on rubies: The marvelous mines of Mogok. *Booklovers Magazine,* Philadelphia, Vol. 5, No. 1, January, pp. 15–26.

had mined. Everyone knew that he was lying, but it seemed impossible to bail him out, and so that expected source of a large revenue amounted to almost nothing at all. But it really went a great deal further than this, as the disposal of the concealed stones was really a very simple matter, and the company seemed unable to check the smuggling in any way, while the placing of these illicit stones on the open market prevented their obtaining any sort of control, and in many other ways affected their original business intentions. Still, the terrible drain of £30,000 a year in dead rent went on relentlessly.

Some £50,000 had already been paid in promotion and preliminary expenses, which added to the heavy expenditure for machinery and stores, heavy working expenses, and yearly rental. In addition, the loss of revenue through the default of the native miners soon made it obvious that the original capital was too small to stand the strain, and different arrangements became imperative. So the 30% payable by the native miner was abolished, and he was made to take out a license to mine, for which he paid twenty rupees a month for each workman he employed, these license fees being part of the income of the Company, and the stones mined became the absolute property of the miners without further taxation. The annual rental was then reduced by half, and at a later stage abolished altogether; but the Government then took possession of the license fees (known as *Royalties*) but allowed the company 10% for collecting them and supervising the work of the native miners. In addition to this, Government now took 30% of any profits made.

These new arrangements at once created an open market side-by-side with that of the company, and effectively put a stop to all ideas of ever obtaining a monopoly, or in any way obtaining control of the market. Besides which, they opened up a very safe channel through which to dispose of stones stolen by the company's workers. It is known that more than one dealer made a handsome living by almost exclusively purchasing such stolen stones.

When the company's engineers arrived on the ground, they found a mining proposition of some magnitude and of considerable difficulty awaiting them. They quickly realised that the richest alluvial gravels were situated under the town of Mogok itself and its surrounding privately-owned paddy fields, the remainder being at depth in heavily waterlogged valleys. This meant that before any mining plans could be properly formulated, the whole of the land had to be purchased from the owners, the buildings dismantled and re-erected on new sites. What it came to was that, before a penny could be earned, practically the whole town had to be removed to a new site, a long and expensive business.

Expensive and very heavy pumping plant and other machinery was then required to work the ground, and this had to be transported from Thabeitkyin to Mogok over a road which was merely a rough mule track, passing through dense jungle infested with wild animals and robbers and passing over mountains five thousand feet high. It took over a year to construct a road passable by light bullock carts, which took three weeks to perform the journey in the dry weather, and could not travel at all for over six months

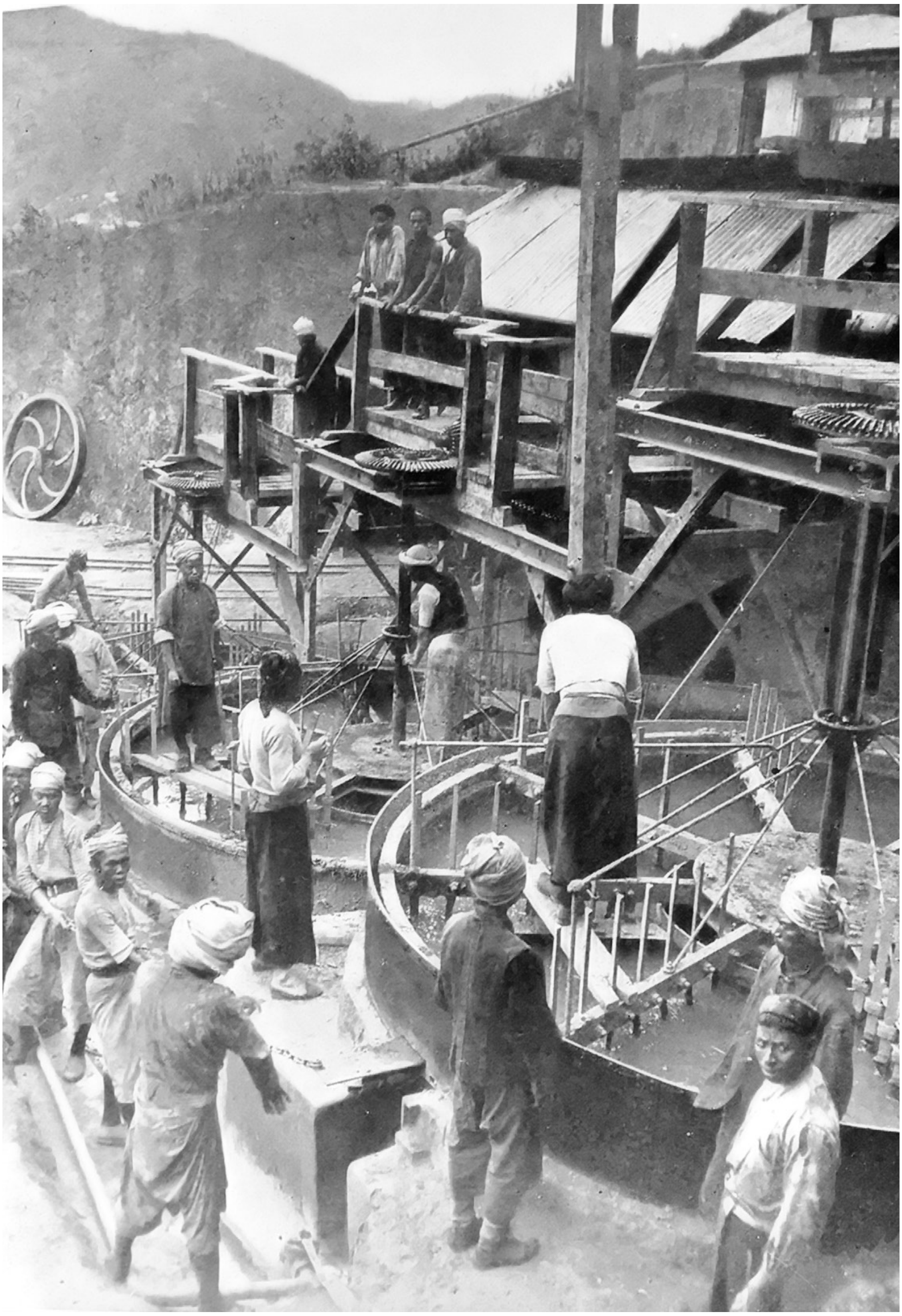

Figure 12.2A washing mill. From Talbot, F.A. (1920) Mining the ruby in Burmah. *The World's Work,* London, May, pp. 594–607.

in the year. Then rinderpest broke out, and the cattle died wholesale, leaving the machinery lying abandoned on the road for months merely from the want of transport.

These difficulties were all overcome, and a decent road constructed, washing mills were erected at Mogok, and work in the valley was commenced on a large scale. A certain amount of preliminary work had in the meantime been done at Kyatpyin, both in the valley deposits and in the interior of the hills, but this was now abandoned in favour of an intense concentration on the Mogok Valley.

On account of the prohibitive cost of fuel, steam power was found to be too expensive, so water power to drive the machinery was obtained by construction of a series of ditches and channels high up in the surrounding mountains, and piping the water under pressure down to the main valley. It was here that the want of foresight in not securing proper water rights in the original lease was badly felt, as every little spring in the mountains produced someone who claimed to use it for his own mining purposes. Thus to buy these claimants out, the company was compelled to part with heavy sums of money, the majority of which were purely blackmail.

The mines were worked by the open-cast method, which meant that they were merely large open excavations, and in these the sub-soil water soon began to give considerable trouble. To cope with this, a dam was thrown across the Mogok river and a hydro-electric power station developing 400 kilowatts was opened. This installation was the first of its kind to be erected in Burma, and is at the present day working at full capacity, supplying power for lighting, and for pumping purposes by the native miners. This provided power for driving certain of the machinery, and for pumping water out of the mines, which in the dry weather amounted to 10,000 gallons a minute, with a very considerable increase in the rains.

As the excavations grew larger and deeper, the volume of water became so great that it was impossible to deal with it by means of pumps, so a low-level drainage tunnel was next driven through a mountain range for a distance of over a mile. As this had to be blasted through solid granite for practically the entire distance it took three years to construct and cost £40,000; but it effectively dealt with the surplus water problem, and enabled the excavations to be extended as well as deepened, right down to the bed rock, so that the very last bit of the caught-up alluvium could now be removed.

By this time there were five large washing mills operating in the Mogok Valley, each dealing with about two thousand tons of earth in the twenty-

Figure 12.3 Flow sheet A. From the mine to the sorting enclosure.

four hours, with three similar mills at Kathe, eight miles away. Thus a very large quantity of earth was now being treated continuously night and day, except on Sundays, which was general repair and overhaul day for the machinery.

The system of mining adopted was to take every scrap of earth as it came, mostly by tearing it down from high faces by means of coolies armed with a *momootie* (large hoe) and allowing it to fall into trucks. It was then hauled by means of long endless ropeways to the washing mill, which was situated above the surface level of the mine, and often some distance away. On arrival at the mill, the truck was run into a tippler, inverted and its contents hosed out onto a grid, to remove any large boulders, the remainder passing through into a series of slowly revolving perforated steel cylinders.

Fine sprays of water were allowed to fall upon these cylinders, which converted the hard dry gravelly clay into the form of a semi-liquid slurry. This was then led away by shoots to the washing pans, the larger clean stones and unbroken lumps of hard clay passing out of the ends of the final set of cylinders, where the stones were examined for any contained gems before being sent to the dump, and the lumps broken up and returned to be repassed through the cylinders.

After leaving the cylinders, the slurry was conducted to a series of three large rotary washing pans, through which a strong stream of water was constantly passing, each pan being about eighteen inches deep by twenty

Figure 12.4 A sorting enclosure. From Atlay, F. and Morgan, A.H. (1905) *The Burma Ruby Mines.* London, The Burma Ruby Mines, Limited, pamphlet with map and photos.

feet in diameter, and provided with eight revolving steel arms carrying a series of triangular tempered steel teeth reaching down to the bottom of the pans. These teeth were staggered on the arms, so that every portion of the bottom of the pan was scraped over at least twice during each revolution, of which there were ten to fifteen to the minute; they were also set at certain calculated angles which caused the stones of high specific gravity, which by reason of their greater density had sunk to the bottom of the mass, to also work their way outwards towards the centre, where a weir (dam) overflow was arranged to allow this light material to pass over together with the useless sands and liquid muds, into a second pan, where the process was repeated, and thence into a third, or safety, pan, from which anything passing over the weir simply went down the tailings drain to the dump.

These mills, some of which were driven by electric power and others by undershot pelton wheels, would concentrate about a thousand tons of earth from the mine to some three tons of heavy gravel per pan in the course of a twelve-hour shift. They were remarkably efficient in their action, the escape of heavy concentrate into the tailings drain under

Figure 12.5 Flow sheet (B). From the washing mill to the main office.

normal conditions being very low, while the loss of gem material in the same way was practically unknown. At the end of the shift the contents of the pans were drawn off through a sliding door in the bottom into locked trucks which were then sent under guard to the sorting enclosure.

On arrival at the sorting enclosure these first concentrates were placed in a hopper from which they passed into a long slowly revolving cylinder composed of eighth-inch steel wire mesh, upon which a strong spray of water was directed. The purpose of this was to remove from the concentrate every particle of fine but heavy sand, the gem content of which did not pay for the labour of sorting, so it was sold to outside contractors, and passed direct to them out of the enclosure. The remainder then passed into a grading trommel, which consisted of a cylinder with four bays, each four feet long composed of steel wire mesh of different sizes, the first bay being of ¼-inch mesh, and the others increasing by an eighth of an inch for each bay, the oversizes passing into a second trommel of perforated steel plate with one and two-inch holes. All the stones which passed through the bays of the first trommel were led to four ordinary pulsating jigs, each with two boxes, which made a further concentration to about three hundred pounds of very heavy black gravel containing the gemstones. This concentrate was retained within the pulsator, and the lighter overflow, which theoretically contained no gems although it actually did in practice, passed into trucks of pits. The oversizes fell directly onto tables and were hand sorted without further concentration.

Figure 12.6 Flow sheet (C). From the sorting enclosure to the consumer.

Each enclosure was in charge of a senior European sorter, with European assistants, and it was their duty to personally sort all the concentrates from the pulsators, and to remove therefrom everything that bore the slightest resemblance to a gemstone, no matter of what class or species. In the enclosure they were allowed no discretion at all, as everything was supposed to be removed by them personally. To make them extra careful in their work, Anglo-Indian second sorters were employed, who resorted everything when the sorters had finished with it, and the sorters were obliged to pay them a commission of 2% on the value of all that they recovered. Coolies were employed to sort the lighter overflow, and to again go through everything after the second sorters had finished with it. To prevent them from stealing, they were carefully searched both on entering and leaving the enclosure, and wore masks of fine wire mesh sealed over their heads, while every movement they made was closely watched by a special staff of Indian supervisors; yet in spite of all these precautions they still managed to steal stones.

When work in the enclosure was finished, the sorters took the finds in locked boxes to the main office, and there immediately removed from it the most obvious of the rubbish, which was carried to commercial rejections. The remainder was then weighed and handed over to the officer in charge of production, who locked it up for the night. Each morning this officer, assisted by a staff of expert Burmese sorters, would carefully grade the stones into about forty different classes. So delicate and tiring was this

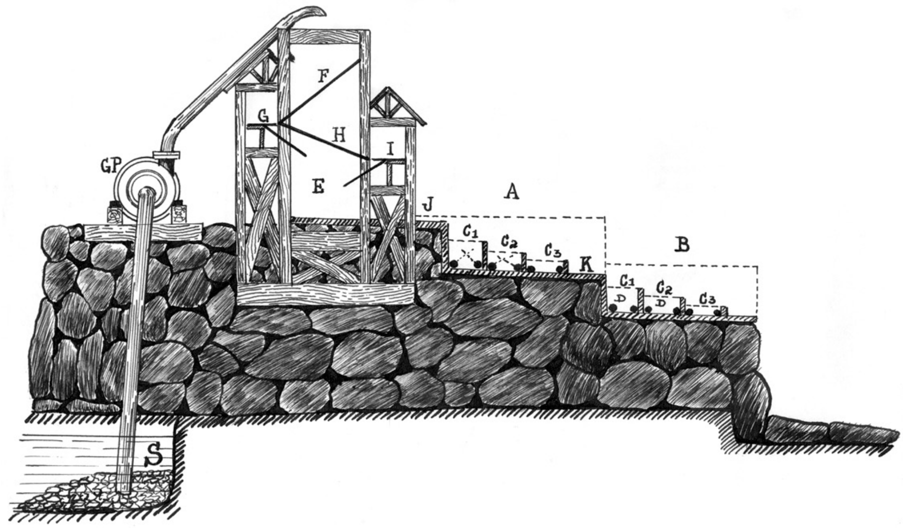

Figure 12.7 Diagrammatic sketch of a gem sluicing plant.

work that it could only be done between the hours of eight and eleven o'clock in the morning. Twice monthly a sale was held, when all the local buyers assembled on the large office verandah, and the lower grades and speculative stones were disposed of by secret written tender to the highest bidders, and the better qualities of stock grades sold in parcels at prices fixed by the Company's officials; stones not so sold were carried to stock and sold privately when opportunity offered. All fine large specimen stones and the higher grades of the smaller stones were consigned through the post office in the ordinary way to the London office for disposal on the European and American markets. This was a somewhat short-sighted policy as it was more than evident that better prices could often have been obtained by selling such stones locally. All the stones were sold in the rough, it being considered better to sell them in this condition, for what they would fetch, than to run the risk of making a loss in the cutting. This again was a doubtful policy which was inspired more by timidity than anything else, on account of a few early excursions into the realms of cutting having turned out badly.

This system of working, which to a great extent was modelled on the methods employed at the diamond mines at Kimberley, worked quite efficiently, but it had two great drawbacks. The first was that it was very costly to operate, as it required large gangs of men to be maintained for each shift in mine, washing mill, and sorting enclosure. It also consumed an enormous amount of expensive material and stores for upkeep. But it was the only method known in those days for dealing with an alluvial deposit covering a large area, and partly situated amongst rocks, with anything like efficiency.

The second objection was that every bit of material had to be manhandled several times, and was more or less exposed to view from first to last, which was at once conducive to theft by the employees. It is known that a considerable amount of valuable material was lost in this way.

Any coolie detected stealing was promptly arrested and brought before a local magistrate, who in the old days had but one standard sentence, which was invariably thirty cuts with a rattan cane, a most cruel and brutal form of punishment, but it did act as a deterrent to a certain extent. Retribution was usually swift, and the writer has known a coolie to be caught, tried, and thrashed all within the space of six hours.

Things were now going splendidly, large quantities of gems were being recovered, and dividends paid, so that a period of quiet prosperity seemed to be assured. This condition of things was maintained until 1908, when two things occurred to cause grave anxiety. In that year the synthetic ruby first made its appearance on the open market, and immediately caused such a panic amongst the dealers and others that many jewellers refused to handle rubies at all.

At the same time, America was passing through a time of financial stress, with disastrous results to all luxury trades. The combination of these two things caused the price of fine two carat rubies to decline by 70% from Rs200 to Rs60 per carat, while the lower grades fell much lower still. From that time the prices have never recovered, although those obtainable for fine large specimen stones have been more or less maintained, and on account of their great rarity always will be. Operations were, however, continued with a greatly reduced income, and a full staff until the end of 1914 when a large number of the company's European officers departed to take up military duties in the Great War, leaving a staff of local hands to carry on through the lean years that followed to the end of the war, during which they certainly kept the wheels turning round, but at a loss. At the end of 1918 there were distinct signs of a boom, prices improved somewhat, and rubies became easier to sell, which seemed to indicate a coming return to prosperity, so work was once more commenced on a more ambitious scale.

It was now realised that the old system of rotary washing mills was out of date, and far too expensive to operate, and that, if dividends were to be paid, the costs of production had got to be very considerably reduced. It was therefore decided to supplement the mills with a series of small sluicing plants, and to eventually scrap the mills altogether should the new method prove satisfactory.

The difficulty of carrying this decision into effect lay in the fact that, in the treatment of gem gravels, it was the heavier coarse material which had to be conserved for further treatment, the heavy fines being simply so much waste, which is exactly the reverse for all other deposits, such as gold or tin, which had hitherto been treated by sluicing methods, so that no form of sluice had yet been designed which would fulfil these special requirements. After a short period of experimenting, the writer devised the following sluice which would make the required concentration in an efficient manner.

This consisted of a sloping, stout wooden trough about sixty feet long by ten feet wide, arranged in two portions (A) Main, and (B) Safety, each portion being subdivided into three riffle boxes (A-C/1–3 and B-C/1–3), each box being 2′ long, 10′ wide, by 2′–6″, 2′–0″, and 1′–6″ respectively in depth, with a platform of from 15 to 20 feet long (J and K) in front of each set of boxes, the object of these being to allow the gravel and sand to spread out evenly, and also to make a partial separation. To keep the gravel retained in the boxes in a state of constant agitation, and so thoroughly wash out all the contained mud and sand, two-inch pipes (D) were placed at the bottom corners of each box, which ejected a stream of water at high pressure through a series of quarter-inch holes drilled at intervals of two inches throughout their entire length, the jets being arranged at such an angle that they would cross each other at the centre of the box. In later models where pressure water could not be easily obtained, these pipes were often dispensed with, but wherever possible they were always fitted as standard, and greatly assisted in the concentration. The earth from the mine was delivered to the top of an enclosed wooden tower (E) and fell upon a sloping platform of steel grissly bars (F), set about 2½ inches apart, to remove all the larger stones, which were examined for gems on the table (G), and then passed down a shoot to the dump. The remainder then fell upon a sloping grissly plate (H) of steel perforated with one inch holes, where the above process was repeated at (I); the gravel being thus brought to a condition of containing no stones larger than one inch in diameter, the experiments showing that larger stones had a tendency to choke the boxes.

The gravel, which was in the proportion of about one of gravel to twenty of water, then fell directly onto the sloping wooden platform (J) along which it was washed until it tumbled over the edge into the first riffle box (A–C /1). Here the stones of the highest specific gravity, irrespective of their size, would at once sink to the bottom, and be retained in the box, while those of lighter S.G., together with the useless sands and mud would pass on from box to box, dropping its material of the highest S.G. on the way, until it fell upon the second platform (K) to be again spread out before passing through the second set of riffle boxes, and thence to the tailings drain.

When box (A–C/1) became full of material of the highest S.G., it would then commence to reject the smaller sizes of it, which would then replace an equal amount of material of a lower S.G. than itself in box (A–C/2), and so on throughout the entire series. The second set of boxes (B–C) were merely provided as a safety device in case of the packing or otherwise inefficient working of the upper boxes; but in practice it was found that normally all the gems would be trapped in the first two boxes (A–C/1–2), the remainder holding nothing at all. However, due to various causes the upper boxes would sometimes fail to act, and then the lower boxes took up the good work, and caught the gems. This type of sluice was quite capable of dealing with about five hundred tons of earth per shift, and of giving a concentrate only slightly inferior to that of the rotary pans. At the end of each shift the contents of the three upper boxes was drawn off, through doors provided at the sides, and forwarded to the sorting enclosure. The lower boxes were, however, only drawn off once a week, unless the upper ones had failed.

The earth in the mines was broken down by directing onto the face a three-inch jet of water, under very high pressure, from a large monitor, which not only did the actual mining of the earth itself but also transported it along drains to a central sump (S) from which it was elevated to the top of the tower (E) by means of gravel pumps (GP) with suction pipes varying from three to eight inches in diameter.

The efficiency of these pumps is on the low side, only being about half that of centrifugal pumps designed to lift water alone, but in addition to the water they will also lift all stones and gravel of a size sufficiently small to just pass through the orifice of their suction pipes. Plenty of water is essential to their efficient working since they require about twenty parts of water to lift one part of earth. Their capacity varies with the square of their size; that is to say, whereas a pump with a six-inch suction will deliver about 7,000 cubic feet of water and 400 cubic feet of earth per hour, one with an eight-inch suction will deliver 14,000 cubic feet of water and 700 cubic feet of earth in the same time. Their maximum lift is about eighty feet, and if higher lifts are desired it is necessary to use two or more pumps in series. Once the desired elevation is reached the delivery may then be led through pipes or open launders to the point of discharge.

The first pumps were purchased, but afterwards they were all made in the Company's workshops to their own designs. At first the pumps were all erected on solid foundations, and had to be dismantled when it became necessary to remove them nearer to the working face; but subsequently they were mounted on pontoons, so that it was then only necessary to let a little water accumulate under them and then float them to their new position; which was also a great advantage when a large hole became suddenly flooded by torrential rain. The drive for the pumps was by electric motors, either direct coupled or by belts. To avoid excessive lifts these plants were not erected on the surface, but were kept as low down in the mine as possible, the tailings being discharged into worked out hollows.

These arrangements effected a reduction in coolie labour alone from two shifts of two hundred coolies in each mine, and a hundred on each washing mill, costing say Rs600/- a day, to two shifts of twenty men to work each sluicing plant costing but Rs40/- per day; so that with two sluices practically the same amount of work could be done at a cost of Rs80/- a day as with one mine and mill, a clear saving of over Rs10,000/- a month. Over and above this there was also a very considerable reduction in the costs of supervision, as the gravels were not handled at all, and being under water until they reached the sorters the risk of theft by the coolies was to a very large extent eliminated. The costs of the maintenance of heavy machinery and expensive haulages thus being done away with meant that very much less money was being spent on upkeep, stores, and general overhead charges. Besides which the cost of opening up a new area by means of a new sluicing plant was only roughly about Rs8,000/- (£533) as compared to Rs100,000/- (£6,666) with a haulage and mill, in which old plant would be utilised, the above figures being merely the costs of re-erecting a mill, etc.

After the war the policy of the local authorities with regard to the suppression of theft underwent a great change, which was possibly due to the district being largely placed under the jurisdiction of Burmese Magistrates. These gentlemen seldom inflicted a whipping sentence, and would acquit a person accused of theft on the slightest pretext, and when convictions were with difficulty secured, the sentences passed were usually absurdly lenient, a flagrant case often getting away with a trivial fine, or a few days imprisonment. These acted as no deterrent at all, and open thieving soon commenced to be carried on with impunity, and it soon became a common sight to see hundreds of women invade the mines by day and openly dig baskets of earth which they boldly carried to adjacent streams to wash. They claimed this to be the legitimate right of *kanase,*[3] while the Burman Magistrates who were in full sympathy with them refused to interfere in any way, and in fact actively encouraged them in their depredations. After nightfall, large gangs of men armed with spears and large knives would take possession of parts of the mines and openly dig large quantities of earth, which they either carried away to wash in secret, or deposited it close to the nearest stream to be washed by their womenfolk in the morning. Clashes between the Company's employees and these thieves were of frequent occurrence, and often resulted in pitched battles, which more than once culminated in fatal results. Things got so bad, and the local authorities became so supine that representations had to be made to higher authorities, who, to preserve law and order, stationed an armed detachment of military police at the Kathe mines; but in Mogok nothing was done, and, until they eventually became flooded, they were nightly the scenes of wholesale robbery.

In 1919 a profit of over £30,000 was made, but after that financial slumps in both America and Europe caused another decline in prosperity, and the sale of the lower grades of rubies again became a matter of extreme difficulty; and as it was to the sale of these stones that the Company looked for their working expenses, leaving the higher grades to pay overheads and profits, this was a most serious outlook. Slump followed slump in quick succession, and following a series of losses the Company went into voluntary liquidation in December 1925. The property and remainder of the lease was offered as a going concern, but failed to attract purchasers, while a skeleton staff carried on the work in a small way. In 1928 a very rich pocket of sapphires was discovered at Kathe, which for a time produced great quantities of fine large sapphires, which considerably brightened prospects, and yielded a handsome profit. This, however, was exhausted in a few months, and the coup de grace was delivered by the world-wide slump which followed, and on the 30th of June 1931, the Company surrendered the remainder of its lease to Government, and ceased to operate.

3 For an explanation of the term *kanase,* see Chapter 13, page 225.

So ended the career of the only Public Company who ever attempted to work Burma rubies as a commercial proposition. During the forty-two years of their working life they washed over thirty million tons of earth, and recovered from it gems to the value of nearly two and a third million pounds. They provided regular employment for over two thousand men a day for well over thirty years, and paid to the Government some six hundred thousand pounds on account of native mining royalties, and an enormous sum by way of yearly rental, while that was in force, as well as thirty percent of any profits that they made. Thus, on the whole, the Government did not come so very badly out of their bargain, although it would probably be very difficult to induce them to agree to this statement.

13

THE MINING OF CORUNDUM

B. Native Methods

Methods in Burma ✤ Types of license ✤ The List of Registered Miners ✤ How the rules are evaded ✤ Conditions of an ordinary license ✤ Conditions of an extraordinary license ✤ Penalties for mining without a license ✤ The control of the mining ✤ How the workmen are paid ✤ *Twinlon* workings ✤ *Lebin* workings ✤ *Inbye* and *kobin* workings ✤ Methods of pumping ✤ *Hmyawdwin* workings ✤ The construction of water channels ✤ *Loodwin* workings ✤ *Kathe-yaik* working ✤ *Se* working ✤ Washing the *byon* ✤ Sorting the gravel ✤ *Kanase* women ✤ Theft ✤ Grading the stones ✤ The process of valuation ✤ A secret finger language ✤ Selling the stones in the ruby market: brokers ✤ How dealers buy large stones ✤ Blackmail ✤ Stolen stones ✤ Working in Siam ✤ Methods in Ceylon ✤ Locating the *malave* ✤ The Ceylonese pits and workmen ✤ Washing the *malave* ✤ Sorting the gravel ✤ Another method of washing ✤ Dredging the streams ✤ Illicit working ✤ Working on a large scale not practicable ✤ Working in Kashmir

Licenses to mine for precious stones in the Mogok Stone Tract are now of two kinds, ordinary and extraordinary; to obtain an ordinary license it is necessary that the applicants name should appear on what is known as the *List of Registered Miners*, which is supposed to be a list of those natives of the stone tract who habitually practised native mining prior to 1930. The list, however, was so badly compiled that it is really nothing of the kind, and is the cause of a certain amount of discontent. The privilege of being placed on this list is not extended to the members of the miner's family, and when he or she dies, the name is automatically removed from the list, the idea being to ultimately do away with the old class of *Hereditary Miners* altogether, by simply letting them die out. In the meantime these are the only class of people who are officially allowed to take out an ordinary license. This rule is almost daily evaded by a registered miner, who, for a consideration, lends his name to some unregistered person for the purpose of obtaining a license. The consideration usually takes the form of a very small share in the profits of the mine, which brings the registered miner in as a partner, so that, although the law is being deliberately broken, legally nothing can be done about it, and the unregistered miner is free to proceed to work.

The holder of an ordinary license now pays a fee of ten rupees a month for every workman employed by him, the number he may employ being apparently unlimited. He is only allowed to work by purely the old native methods, and is not under the bare license allowed to use machinery of any kind; but should he desire to use mechanical pumps, for lifting water only, he may do so on the payment of an additional fee, which varies with the size of the pump used. He is obliged to obtain special permission to do this, and under no circumstances is he allowed to use a gravel pump. Explosives may be purchased from the Government, but may only be used under their direct supervision. The miner is free to work anywhere on unoccupied land, and pays no rental for the ground he occupies; he may also move his site at any time on giving notice. All the stones he mines are his own absolute property without further taxation, excepting the payment of income tax, and he makes no returns whatsoever to the authorities regarding the results of his mining.

An extraordinary license may be granted to any person for a period of three years, with an option of renewal; this covers a definitely demarcated area, which may be large or small, and for which a surface rental of five rupees a month per acre is charged, irrespective of whether the ground has not yet been worked or has already been worked out. The licensee has to state the minimum number of workmen he wishes to employ and has to pay for that number of men at the rate of Rs20/- per man each month, no matter whether he employs the full number or not. But should he wish to employ more men, he may do so by paying another Rs20/- for each extra man so employed, which covers the employment of that man for the current month. He is further obliged to make accurate returns of all stones mined by him, and also of all stones sold, and to pay thereon a royalty fee of 10% on all amounts which exceed a total sum of which the license fees and ground rent already paid are ten percent; moreover, when he ceases to mine he is required to pay a tax of 2½% on the valuation of all stones then remaining unsold. His license permits him to work by any methods he may chose, with the full use of any machinery, including gravel pumps; he may also use explosives without supervision.

In both forms of license, the fees paid only cover one set of workmen during any twenty-four hours, the licensee not being permitted to work in shifts. Therefore he can only work by day, but special men to attend to

Figure 13.1
The implements of the native miner. From Enriquez, C.M. (1930) Fire-hearted pebbles of Burma. *Asia,* Vol. 30, No. 10, October, pp. 722–725, 733.

mechanical water pumps to keep the mine dry by night are allowed, although they must not raise bearing earth after sunset.

The penalties for mining without a license are one year imprisonment for the first offence, and two for the second, or a fine or both; for failure to observe the conditions of the license one month imprisonment for the first offence, and six months for the second or subsequent offences, or a fine, or both. In all cases, the stones in relation to which an offence has been committed, or which cannot be proved to have been raised under a license, are confiscated.

Mining is regulated by a special set of laws known as *The Upper Burma Ruby Regulation,* and is supervised by an Inspector, who is a member of the Burma Civil Service, assisted by a staff of sub-inspectors, all of whom

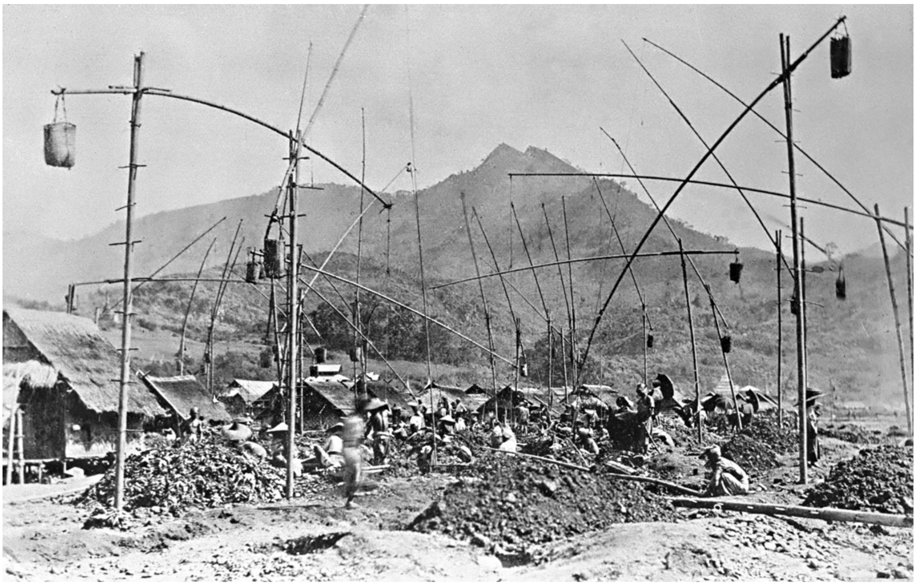

Figure 13.2
Twinlon workings. From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., American edition 1905, 842 pp.

possess special and extraordinary police powers. Electric power for pumping, and also all machinery for any purpose is supplied by Ruby Mines, Limited.

The usual procedure for an ordinary licensee is to engage three or more workmen, to whom he pays no regular wage, but allows them a trifling sum every fifth (market) day for the purchase of food and absolute necessities. The accounts of the mine are balanced monthly, and if there is any profit accruing, half of it, less the amount advanced for food, is at once paid to the workmen as a return for their labour; should there be no profits they receive no money, but the debt for advances made for food is wiped out, and the men start with a clean slate for the next month. This continued loss may go on for many months on end, but the men still cheerfully labour on the hopes that something will turn up in the end.[1] There are frequently many partners to a mine, but the workmen always receive their full half

1 The Burmans are very firm believers in *nats* (spirits), which may be either good or evil, and when a continued run of ill luck occurs at a mine the men say that there is a bad nat present, and proceed to propitiate it by erecting near the mine a small, but elaborate, bamboo platform, on which is placed daily offerings of food, fruit, and flowers, with lighted candles at night. They also frequently do the same thing when

Figure 13.3*Lebin* workings.

share of the profits, no matter how large, or how small they may be, the balance being divided amongst the partners *pro rata* with their share. In the sale of any large or very valuable stone which may be mined, the workmen are always regarded as being 50% partners, and are fully consulted in everything that is done. This method serves a very useful purpose so far as the prevention of theft is concerned as every man's hand is against his neighbour, so that any attempt at dishonesty either on the part of the workmen or the licensee usually comes to light very quickly. On the other

opening up a new mine, but in this case it is the good nats whose kind offices are solicited.

hand the few licensees who prefer to pay their men a daily wage, with no share in the profits, undoubtedly do suffer to a considerable extent from theft, and, as the men usually work together in this, detection becomes a matter of great difficulty.

In the dry season, and in good ground, the majority of mining is done by means of small pits known as *twinlon,* which consist of a small round, but sometimes square, pit only just large enough to allow a man to descend into them by placing his feet into small notches cut in the sides. These pits have no timbering whatsoever and usually go down from twenty to forty feet, but may sometimes be as deep as a hundred feet, although this is rare for this type of pit. Up to about fifty feet the work is comparatively easy, but beyond this it is usual to sink a second pit close to and parallel to the first, and to connect them up underground for the purposes of ventilation. The actual work of sinking is done by two men, one at the bottom of the pit and the other on top hauling up the earth removed from below, the third man acting as a relief to either of the above men, and is frequently the cook of the party. The man at the bottom of the pit squats and loosens the earth between his feet with a small pointed steel bar (*thangyaung*) and a tiny hoe (*tauywin*) which he then scrapes with his hands into a small bamboo basket provided with a handle (*chingon* or *saukoo*) which, when full, he places upon a bamboo hook lowered from above, and it is then hauled to the surface by means of a bamboo balance crane (*maung-daing*). This is merely along bamboo pivoted onto a sturdy upright bamboo post, with a counterweight consisting of a large basket filled with heavy stones hung upon its shorter, and stouter, arm.

A double bamboo hook is attached to the thicker end of a long tapering bamboo arm by means of a piece of stout cane. This crane is quite efficient, and by regulating the length of the arm, the suspended bamboo can be made to operate to very considerable depths, and to raise quite heavy weights. Light is provided to the man below by means of a mirror, or more often a piece of bright tin, set at an angle to reflect the light downward, naked lights being but very seldom used. Sinking is rapid, and in ordinary good ground two men can easily go down fifty feet or more in a day.

Until the ruby-bearing strata (*byon*) is reached, the earth removed is thrown away, and is hunted over by *kanase* women, who are not infrequently well rewarded for their pains. When the byon is reached, lateral side tunnels are driven along the seam in all directions and which may extend for a distance of over forty feet. As the byon is removed from a tunnel, it is allowed to fall in and thus act as a support for the overburden

Figure 13.4
Inbye or *kobin* workings. From Gübelin, E.J. (1967) *Burma, Land der Pagoden.* Zurich, Silva-Verlag, 131 pp.

while other tunnels are being driven. By this means every scrap of byon within a radius of about forty feet round the *twinlon,* or *twin* as it is commonly called, is extracted, an operation not unattended by considerable danger. When byon is actually being extracted, it is not unusual for all the workmen to be underground at the same time, each driving a different tunnel and stacking their baskets of byon in a disused tunnel to be hauled up afterwards, when it is carried to a washing place and carefully guarded until it is finally washed. Often the miners will work a number of twins, one after another over a large area, accumulating all the byon recovered in a large heap which is washed at their leisure during the rainy season.

Figure 13.5
A bamboo pump used by the Burmese miner for pumping out the pits. From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., American edition 1905, 842 pp.

If the ground contains much sub-soil water, or is very soft and sandy, an untimbered twinlon would at once collapse, so here the miner puts down a square pit with sides of about two feet known as a *lebin.* This is timbered vertically with round poles of about three inches in diameter, cut from the nearest jungle, and with similar horizontal cross timbering at intervals of every three feet in depth. Behind this, round sticks of about an inch in diameter are packed close together side by side in a horizontal direction, and behind them again is placed a thickish layer of leaves or brushwood to hold the wet or loose earth in place. This very crude form of timbering is quite effective, and lebins have been known to be over two hundred feet in depth. The sinking to and removal of the byon is done in exactly the same manner as in a twinlon but the whole business is naturally much slower and also more expensive to operate.

The more ambitious miners will often work a larger area by increasing the sides of the pit to four and a half feet, and placing in it timbers of a much stouter section, which divide the pit up into nine compartments for every three feet of depth, the different layers of this timbering being ingeniously laced together by bands of stout raw cane also cut from the nearest jungle, and twisted to take a continuous strain by means of short pole. The sides are packed with sticks and leaves as in a lebin, but the sticks are much stouter. Such a pit is know as a *kobin,* but there are even larger pits with sides which may exceed twenty feet; these are known by the name of *inbye* and contain a very large number of compartments. The kobin and inbye are expensive to work, requiring a large number of workmen, and using up a lot of expensive timber; therefore they are only used where very rich ground containing much water is being worked, and are even then not commonly to be met with.

The water in the twin or lebin is usually removed by simply bailing it out by means of a kerosene or petrol tin tied to the end of the maungdaing, three of which may be used at the same time. But in the larger types of pits it would not be possible to cope with the water by this means, so the miner makes use of a very ingenious homemade bamboo pump, the original idea of which came from China.

The barrel (A) merely consists of a hollowed out bamboo of about four inches in diameter and anything up to twenty feet long, and into the lower end of this is plugged a flap valve (B) carved from thick bamboo, with a piece of old leather or motor tyre forming the flap. Inside the barrel is placed a rod (C) about six feet long, the lower end of which has been passed through and then firmly bound to the centre of a piece of soft rawhide about eighteen inches square, the corners of which are then loosely connected to the rod by strips of thin cane. This forms the plunger and when the whole is placed at a slight inclination with the foot valve well under water and the barrel filled with water, this will be retained by its weight keeping the foot valve flap closed. As the plunger is pushed downwards (E) the soft hide will close up to the rod like an umbrella, and so pass quite easily through the water; but immediately the up stroke (F) is commenced, it will open out, owing to the weight of the water, and completely fill the bore of the barrel, and as it is pulled up will carry with it all the water above in an upward direction so that it will overflow from the top of the barrel. At the same time, the suction produced below will cause the flap of the foot

Figure 13.6
Hmyawdwin working. From Anonymous (1905) A city built on rubies: The marvelous mines of Mogok. *Booklovers Magazine,* Philadelphia, Vol. 5, No. 1, January, pp. 15–26.

Figure 13.7
Above a *loodwin.* From Enriquez, C.M. (1930) Fire-hearted pebbles of Burma. *Asia,* Vol. 30, No. 10, October, pp. 722–725, 733, 6 photos.

valve to lift and admit water to fill the vacuum produced, thus leaving the barrel full of water for the next down stroke. Very simple, but very efficient for lifting water from depths up to about twenty feet, beyond which it is necessary to use two or more pumps in series. By using batteries of three or four of these pumps in several relays at different depths, a very large quantity of water may easily be lifted from almost any depth.

Sometimes the mine will merely consist of a large open excavation, either in the open ground or between the rocks, and without timbering or special arrangements of any kind. This is known as an *inn,* which simply means a mine, and is quite a common method employed in the dry weather.

Crude as these methods are, and to the trained eye, full of hidden dangers, it is remarkable how infrequent serious accidents really are, while fatalities are very rare indeed.

Pit workings are only suitable for the dry season, as during the rains the influx of water into the pits is too great to be dealt with either by bailing or by ordinary pumping methods. So the miner then turns his attention to the deposits situated on the hillsides, which he proceeds to work by the

Figure 13.8
Kathe-yaik workings.

methods known as *hmyawdwin* or more simply as (pronounced *mure*, through the nose). This merely consists of a cutting in the hillside, which may vary from being an insignificant gap, little more than a ditch, to an enormous excavation which has laid bare the side of a mountain. In fact, many of the side valleys and nullaks in the district today are only ancient hmyawdwins. But no matter what their size may be, the general method of working them is the same in all cases.

A hillside deposit usually consists of a band of stiff hard clay containing gravel and boulders of all sizes, situated at almost any depth below the grass level of the hill, but not infrequently quite near to the surface, and normally ranging from a few inches to twenty feet in thickness, but may be considerably more. Such a deposit having been located, the first essential is to have a plentiful supply of water immediately above it. If there is a stream available it is made use of; if not, then the water must be brought to the mine from some source in the hills, which may be a very considerable distance away. In doing this the Burman shows great skill, as with no engineering knowledge, and without the crudest form of levelling instrument to assist him, he finds a source of water, which may be twenty miles away from the mine, and proceeds to dig ditch. As he digs, the water follows, passing through tiny tunnels under high places and over deep valleys in bamboo mats luted with clay, and, carried on high bamboo aqueducts, it winds along the side of the mountains until the miner gets it exactly where he wants it. There is no trial and error about him; once he has started to dig he goes straight on, and never has to go back to regrade his work. Neither will he waste height but always keeps the grade as flat as possible consistent with a steady flow of water. When completed, these channels become valuable assets, and disputes regarding them are frequently the subject matter of long and expensive litigation.

The water having been brought to the desired site, it is first used to wash away the top soil, which is allowed to run to waste until a sufficiently large area of the underlaying byon is exposed to view. The miner in the meantime has laid down a large circular or pear-shaped floor of large flat stones at the foot of the byon, and above it as high as possible has projected a series of long bamboo pipes; these are closed at the lower end, but about six inches from the obstruction have an opening cut in the top of about six by two inches. The byon is then cut down and allowed to fall onto the paved floor, and the water turned into the bamboo pipes where, meeting with the closed end, it shoots upwards through the opening and falls upon the byon, often fifty feet below, in the form of a fine spray, which breaks it up and, forming a slurry, carries the lighter portions away through the single opening left in the wall surrounding the floor into the tailings drain (*myaung-mi*). This is a deep and narrow ditch arranged in the form of three or four low falls, and at the bottom of each fall a pit of about two feet wide and deep is dug, which acts as a trap to retain any stones of a high specific gravity which may have escaped from the floor, the lighter material passing over as so much waste is allowed to wash away.

The law specifies that there shall only be one such myaung-mi per license, so that two or more small hmyaws cannot be worked simultaneously on the same license. This process of disintegration goes on night and day for a couple of weeks, more byon being added daily to make up for the reduction, and at the end of this time the floor will be covered with a thick layer of concentrated sand gravel and boulders. The boulders are removed and used for building retaining walls, and the larger stones for backing purposes, the remainder of the concentrated then being removed for further washing and sorting. The whole process is then repeated; and a hmyaw may be worked for a large number of years during the rains only, and closed down during the dry weather, the license retaining his right to a hmyawdwin for eight months after he has ceased to work it, a concession which does not apply to any other form of mine should another person desire to work it once it has been abandoned.

Figure 13.9
A *ye-ban-gwet.* From Enriquez, C.M. (1930) Fire-hearted pebbles of Burma. *Asia,* Vol. 30, No. 10, October, pp. 722–725, 733, 6 photos.

Another form of mining, which is carried on all the year round by more or less specialists, consists of working the deposits which have found their way into the cracks and crevices far into the interior of the mountains. This is known as *loodwin* or shortly as *loo,* and is a difficult and dangerous proposition for the workmen engaged in it. They frequently have to find their way through passages which may ramify for enormous distances, and are often so constricted that it is with the utmost difficulty a man is able to worm his way inch-by-inch through them, dragging behind him a small basket filled with byon attached to his great toe. The air is often poisonously foul, and it is not unknown for a man to lose himself and have to remain for several days underground before he can again find the exit.

It is not an unusual thing for these fissures to open out into vast caverns, which are often places of great beauty with enormous stalactites hanging down from a glittering white roof, or jutting out from the sides, and which if struck a smart slap with the open hand will give out a sound which grows until the echoes thunder round the cavern with a mighty sound. One of these caverns was so large that twinlons and hmyawdwins were actually worked inside it, but unfortunately the roof fell in, killing several people, and the place has never been reopened. It is quite an ordinary thing to come across chasms of great depth at the bottom of which the subterranean waters can be heard dashing and boiling in a manner which makes one realise that nerves are a very excellent thing to leave at home when one goes down a loo. Loodwin workings are often very rich indeed, and some of the finest rubies known have been found in them. The older and well known ones are, however, now mostly worked out, but when a new one is discovered, it usually proves to be a source of considerable profit to the lucky miner.

Still another method sometimes used is known as *kathe-yaik* and consists of washing a poor quality of shallow surface byon by passing it through a crude form of ground sluice cut in the hillside. These are merely hillside scratchings of but a few feet in depth, and normally give but very poor returns, although it is not unknown for good stones to have been recovered by this method. It is not very extensively used, and is said to have originated with the Manipuri captives who, knowing nothing of mining, resorted to scraping the surface and washing it for whatever they could find.

The stones from the beds of the streams are recovered by means of a *se,* which consists of a rude dam of logs and brushwood thrown across the stream, forming a pool which holds up any gravel coming down. This is dredged out by hand, the miner diving to the bottom with a basket which he quickly fills with his hands and feet and brings the result to the bank to sort. The finds are usually poor, but large and valuable stones are sometimes found.

The Burmese miner is a very simple industrious individual, who does not as a rule indulge in alcohol in any form, and but seldom uses opium, rarely quarrelling, and on the whole very law-abiding; but when roused he can be very evil tempered, passionate, and intensely cruel. His ways are primitive, and his real necessities of life but few. Caring but little for money when he does make any, he usually indulges in a bout of gambling, or promptly builds a pagoda with it, so that it never lasts long. His staple food is boiled rice eked out with a few stewed jungle leaves and a little putrid fish paste, the whole being washed down by a bowl of Burmese tea, and finished off with a cigarette or a cheap cheroot. Besides the tools already mentioned, he uses a long steel bar for moving heavy rocks, and a large

Figure 13.10
Washing the *byon.* From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., American edition 1905, 842 pp.

hammer with which to smash them up, and if they are very large he will light a large fire round them, and when well heated dash cold water over them before using the hammer. He also uses a very crude wire basket of large mesh *than-saga* for sieving the larger stones from the gravel. His most used implement is a large knife, which may aptly be described as a hybrid between a sword and a chopper known as a *dah.* Many an illicit miner has been found working a mine in quite an efficient manner with nothing but a dah and a few bamboos.

For all the above systems, excepting Se and Kathe-yaik, a special washing place has to be arranged in which to make the final concentration, in order that the contained gems may be easily seen and picked out by hand. To this end, a shallow pear-shaped basin called *ye-ban-gwet* is constructed of large boulders well luted together with clay at the sides, and paved with large flat stones, the whole having a slight slope away from the constricted end, which leads into the myaung-mi, or a separate channel altogether. A piece of wood or large stone is placed across the exit to act as a dam and to prevent the concentrated gravel from flowing over until the proper time, while allowing the water carrying the surplus mud and sand to freely pass away.

The byon, looking like so much mud or sandy earth, in which the contained gems cannot be seen, is piled upon this floor; sprays of water from bamboo pipes, arranged as for a hmyaw, are allowed to fall upon it, but sometimes a stream of water is simply let in at the end of the ye-ban-gwet. The byon is then vigorously stirred with hoes so that the useless mud and sand will mix with the water and flow away in the form of a slurry, more byon being added until all that is to be washed is used up, and the stirring is then continued until the water runs quite clear over the dam, and almost every trace of sand or clay has been removed.

The exit in the ye-ban-gwet is restricted to about a foot in width, and is situated from one- to two-feet above the *myaung-mi* or drain, which is about eighteen-inches square in section, but immediately below the exit from the ye-ban-gwet is enlarged into a pit about three-feet square, and two-feet deep below the bottom of the drain, this is known as the *zalok* and there may be two or three more placed at intervals along the drain to act as safety traps. Across the drain and facing the zalok is placed a bamboo seat upon which the washer sits with his feet in the zalok, and upon the bank at his side squats the supervisor, who is usually the licensee or his wife, or perhaps the pair of them, and in front of them squats the sorter, a trusted man is placed in the ye-ban-gwet, and all the others are kept at a distance. The washer is provided with a than-saga and several round shallow trays (*pauk-tau*) made of closely woven bamboo fibres. He places the than-saga immediately under the opening and a portion of the concentrate is allowed to run through it into the zalok. When this wire basket has became filled with large stones, the dam is replaced across the exit and clean water allowed to flow over, the washer keeping the contents of the zalok in constant motion the whole time by means of his feet. The large stones are quickly looked over and anything precious removed, and the refuse thrown away. This refuse is known as *kyauk-pon* and, by an ancient right, anyone is allowed to search through it, and retain for themselves any stones they may find, but present law lays down that any male who is not in possession of a license is guilty of mining without a license every time he picks a stone up from the ground, and is therefore liable to imprisonment, so it is only women who now indulge in this right of free search, and have been known to find some very valuable stones which have really been overlooked.

Figure 13.11
Kanase women. From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., American edition 1905, 842 pp.

The process is repeated until the zalok becomes about two thirds full of gravel, when the washer then scoops up a supply of the gravel with his hands into one of the pauktaus, and finally washes with a quick circular motion near the surface of the water to get rid of any remaining sand and as many of the lighter stones as possible. He then gives it a few quick up and down jerks below the surface before he inverts it with a slam into a second pauktau, which is at once handed to the supervisor. So skillfully has this final washing been done that all the light gravel now lies at the bottom, with the heavy black ironstones, etc. forming the next layer, and the gems glittering on the top of all in full view for all to see. The supervisor quickly picks out the visible gems, which he places in a hollow bamboo tube (*sinlebauk*) filled with water and stuck into the ground by his side. The sorter then goes through the remainder of the pauktau's contents, after

Figure 13.12
Sorting the stones. From Atlay, F. and Morgan, A.H. (1905) *The Burma Ruby Mines.* London, The Burma Ruby Mines, Limited, pamphlet with map and photos.

which it is placed in a heap to be again run through. After this it is known as *thebat* and is no longer the property of the miner.

This goes on until all the concentrate is exhausted, when the contents of the sinlebauk are emptied into a piece of rag and sealed up by both the licensee and the workmen, and these seals are not broken until all the representatives of the different partners, and of the workmen are present to verify the day's finds.

Now comes the turn of the *kanase* women, an institution of which little really seems to be known. According to an ancient right descended from the times of the Burmese Kings, any person was permitted to freely search for rubies in the bed of any stream, or in the rejected earth from any mine, as well as in any already-sorted gravel. That is to say in the tailings washing away down the myaumgmi, in the earth removed from a mine and thrown away without being washed, or in the kyaukpon or thebat. But they were not allowed to dig any earth from the bed or banks of a stream, or from any other place, although, in practice, they actually dig very considerable quantities. The present Ruby Regulation also recognises this right, but only

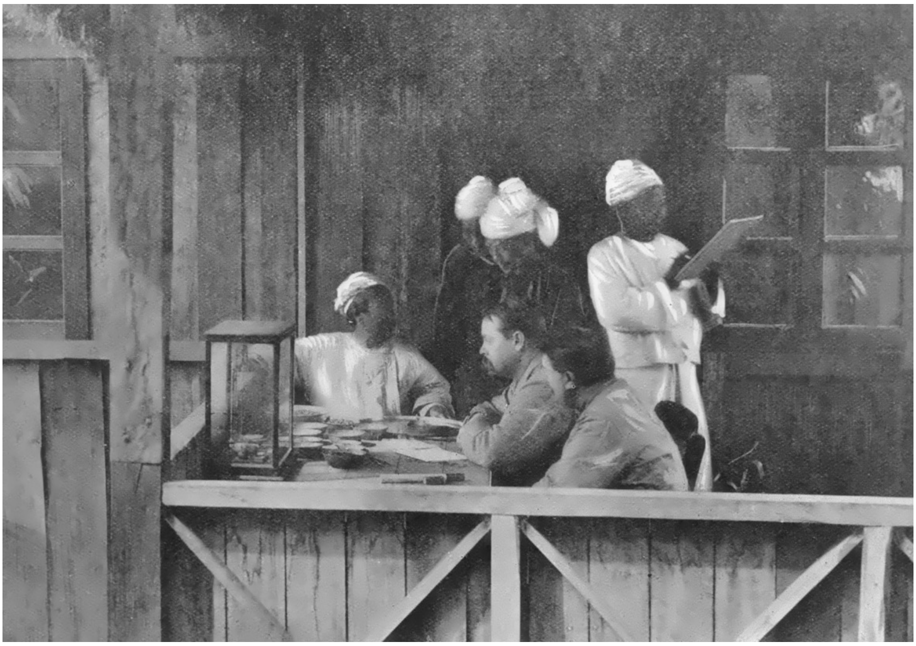

Figure 13.13
The process of valuation. From Claremont, L. (1906) *The Gem-Cutter's Craft.* London, Bell, 296 pp.

insofar as women and female children are concerned, and woe betide any male who is caught trying it on. It is known as *kanese,* which literally means *washing rubbish*, and is altogether a most pernicious evil. The women swarm round the workings, and will often fight like perfect devils amongst themselves to secure prominent places; the reason for this is not far to seek as these women are by far the most convenient channel through which to remove a stolen stone from the vicinity of the mine. It is often possible to see a valuable stone, and for a dishonest workman to obtain possession of it, and what is easier than to flick it to a woman relation working nearby, or to tread it into the soft earth and quietly tell her exactly where it is. In a few minutes there is a shout, and another valuable stone has been found by a kanase women in the myaung-mi, or in the kyaukpon, and no court case on earth is going to restore this deliberately stolen stone to its rightful owner. There are large numbers of poor and even very aged women who make a living by searching in the streams, armed only with a pauktau, and who daily find a few tiny stones worth but a few pence, and it was for such as these that kanase was properly intended. As it is at present practised, it is

Figure 13.14
What is happening up the sleeve. Men skilled in valuing gems assemble at Mogok. Certain jewels are bid for mysteriously, sellers and buyers seating themselves with the stones between them and holding hands under the table. By a code-squeezing of fingers, they arrive at a price secretly; for it is thought that a beautiful ruby, like a beautiful woman, depreciates in value by being publicly discussed. From Enriquez, C.M. (1930) Fire-hearted pebbles of Burma. *Asia,* Vol. 30, No. 10, October, pp. 722–725, 733.

little more than a cloak for deliberate theft wherever possible, and is often systematic mining on a small scale without taking out a license. On washing days, the women will throng into the myaung-mi and endeavour to get as near to the zalok as possible, and after the washing is finished, every scrap of sorted sand and gravel and any unwashed byon that they can lay their hands on is thoroughly ransacked by them. In the best interests of all concerned, the practice should be restricted to working in the streams and, so far as the refuse from the mines is concerned, be abolished altogether.

When the licensee breaks the seal, the stones are placed upon a brass tray in the bright sunlight and the sorters squat round it and first of all remove the *sonzi* or rejections, which consist of small, cracked, and very inferior stones, and absolute rubbish, that are crushed and used for abrasive purposes. The remainder of the gems are then roughly graded to various sizes, either by eye or by passing them through a series of brass of tin sieves. The licensee then picks out the cream of each size and personally grades them, and the sorters then arrange each size into a number of little heaps, each of a different grade round the edge of the tray, by going through the main heap and removing the lowest grades one after another, the highest grades always being the last to be taken out. The trays are then passed to the licensee who carefully goes through each little heap and regrades it to his own satisfaction, in which he is assisted by his brokers, who are persons of considerable importance when the next stage of valuation is arrived at.

A graded heap of stones is now spread out on a separate tray and a broker proceeds to arrange them into several small groups of a few stones each. Then another one will make a partial rearrangement, the tray being passed round and round until all the brokers are agreed upon the arrangement. Each group is then counted and sometimes weighed, but not always so, as the brokers are remarkably accurate in judging the weight of a group of stones by the eye alone. Next comes the process of actual valuation, and it is here that the uninitiated will begin to wonder what on earth is taking place for not a single word is spoken the whole time. The licensee and a group of brokers will solemnly squat round the tray and gaze at the stones and each other in absolute silence, when suddenly the licensee will draw his right hand well up within his sleeve and extend it towards one of the brokers who also places his hand within the sleeve so that it is completely hidden, and two absolutely expressionless faces will look into each other, the hands are withdrawn and each writes something in his note book. In the meantime the other brokers have been carefully examining the stones, and some will even make mysterious passes over certain of the groups, but these are merely tricks and quite without meaning. Another broker will then try conclusions up the sleeve, and probably be met with a savage snort, which causes him to hurriedly withdraw and make another examination, and then more hands up sleeves and entries in the note books.

As each partner has his own brokers, and there are different brokers for various grades, the valuation is a long and wearisome business, and to the ordinary person nothing appears to have been done when the party finally does break up; but in fact every group of stones has been allotted a definite selling value, although no one but the licensee, who will have the final disposal of the stones, knows what the collective values really are. The truth is that all mentions of either price or value has been made in a secret finger language, each particular hand or finger grip meaning a price, and to ensure complete secrecy these grips are always exchanged either up the sleeve or under cover of the loose jacket. Between buyer and seller, and employer and broker this rule is never relaxed, and all mentions of either prices or values are invariably made in this secret manner.

Every fifth day is Bazaar (Market) Day at Mogok, and two days later at Kyatpyin, and the stones are then taken to the Ruby Market for sale. This mart consists of a few open sheds in the market place in which the stones for disposal are exhibited on a brass tray which stands upon a low box with two large holes cut in the opposite sides. The seller sits smoking behind his tray of stones, and presently a prospective buyer accompanied by the inevitable broker arrives and squats in front of him. They carefully examine the stones and there is much placing of hands up sleeves or under jackets on the part of the buyer and his broker, while all the time the seller sits quietly smoking his cheroot, apparently quite oblivious to what is taking place. But suddenly the buyer will pass his hand into one of the holes in the box and the seller, instantly alert, will do likewise through the opposite one. Thus commences a period of silent haggling upon the fingers until a decision is finally arrived at one way or the other. It is very deliberately and leisurely done, and a deal of but a few shillings may take a couple of hours. But throughout the entire transaction not a single word is spoken, offers and demands are made, and either accepted or rejected in silence; although there may be dozens of witnesses to a sale, not one of them will have any idea of the price actually paid.

When a bargain is struck the stones are sealed in a piece of rag by the buyer, and are retained by the seller until payment is made in a similar secret manner. Nothing is done without the assistance of a broker, who usually draws a commission from both sides, which fact he will always strenuously deny. He is often in the permanent employ of the buyer, which does not prevent him also demanding his pound of flesh from the seller. They are, however, reliably reticent, and although they know exact prices they will not reveal them to outsiders even after the lapse of many years. This intense secrecy may at first seem strange, but it is a business essential, as the stones purchased are re-sorted and are then re-traded amongst the traders themselves according to the requirements of their own individual markets. As the profits made on these resales are frequently very high, it follows that if the original prices paid were openly known, it would have a very considerable effect on the prices obtainable at a resale.

Each of the larger traders maintains a force of regularly employed brokers whose job it is to assist him in his valuations and business generally, but particularly to bring him first news of any valuable stone just mined, or which comes secretly on the market as a stolen stone. The trader will also very handsomely reward any outsider who gets ahead of his brokers and brings him first information of this kind.

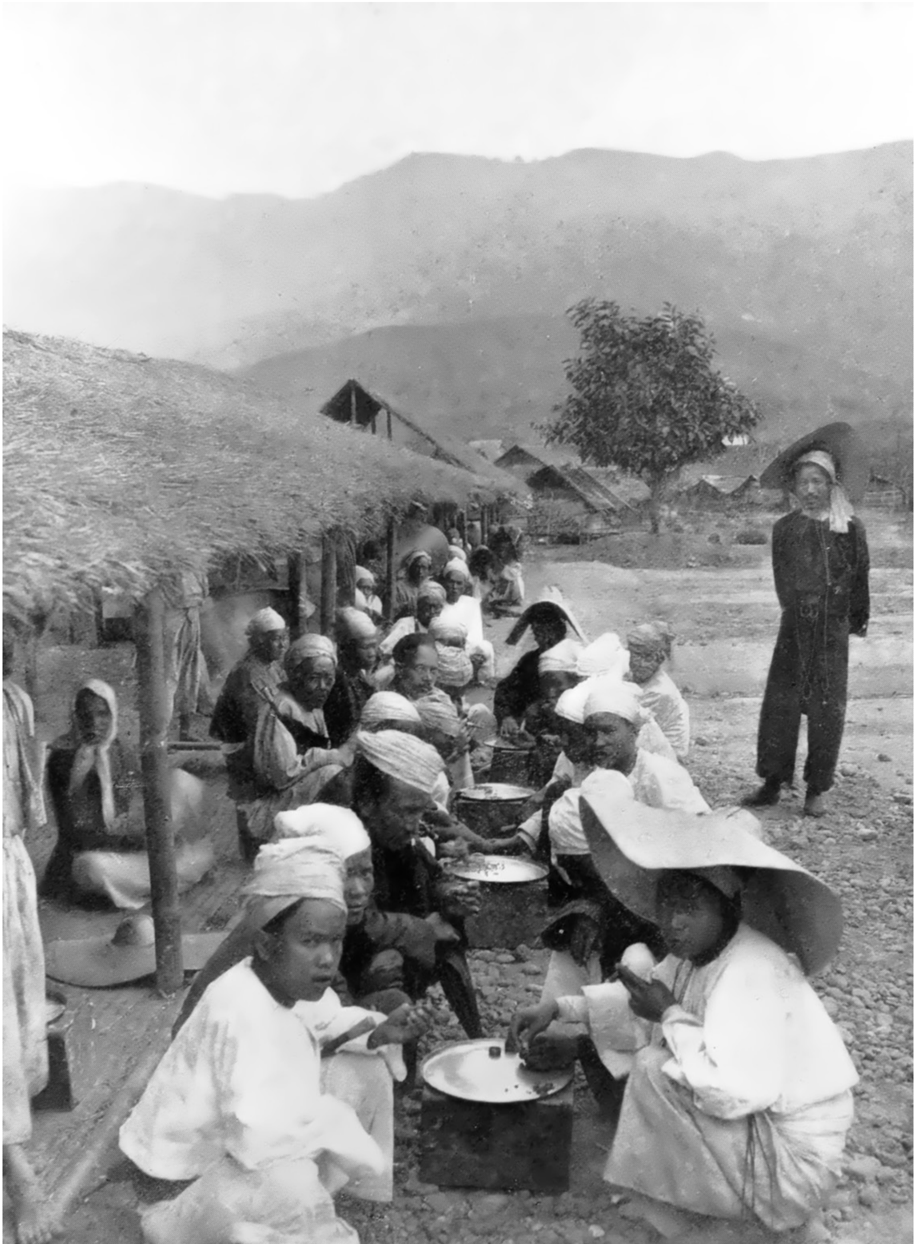

Figure 13.15
A scene in the ruby market. From Anonymous (1905) A city built on rubies: The marvelous mines of Mogok. *Booklovers Magazine,* Philadelphia, Vol. 5, No. 1, January, pp. 15–26.

When such stones as these come upon the market, there is usually great rivalry amongst the prominent traders to get first sight of it, and it is generally the man with the smartest secret service and the fastest motor car who wins. Their main object is to rush the miner into a hasty sale before he has had time to place a considered value upon the stone, which they do by making a lavish display of currency notes of a high value, the sight of which very few Burmans can resist. Or if they fail to purchase it outright in this way, they attempt to place a seal upon it so that no one else may examine it, and then to make a definite offer for it at some future time. For this, the buyer will often deposit a fairly considerable sum of money, which is usually forfeited if he does not subsequently make a reasonable offer, or otherwise backs out of the deal.

Brokers play a very important part in all transactions of this kind, which are always carried out in the finger language and usually in a private room as well. And it is surprising the number of parasites who will attend at all important sales and demand to be paid for purely imaginary services. It is purely a species of blackmail, but both traders and miners are bound to tolerate a certain amount of it, otherwise they would be marked men the next time there was a good stone for disposal. Secret commissions are not at all unknown as being paid to one or more partners to use their influence with the others in favour of a certain dealer, and in the case of the dealer succeeding in buying a very important stone by these means, such commissions will often run into many thousands of rupees.

Stolen stones are usually sold in the depths of the jungle, or in the greatest secrecy in the dead of night; in which case the buyer often runs a very considerable risk in having to make his valuation by the light of an electric torch.

In Siam, the workers being mostly Burmans who have learnt their business in Mogok, the native mining methods are practically identical with those of Burma.

The procedure in Ceylon is also very much the same in general principles. A license to mine is obtained from the Government at a very nominal fee, or a block of Crown Land may be leased for purely mining purposes. But where mining is carried on under a license, and privately owned land is being worked, the owner of that land is then usually regarded as a fifth share partner. And the actual licensee himself is usually in the hands of someone who has advanced the money to finance the undertaking, and he also takes a fifth share of any profits, in addition to the return of his capital. Similar to Mogok, workmen are engaged on the half-share system; further, as it is the custom to sell all the stones mined to the highest bidder via auction, it often follows that, by the time the licensee has paid out all the shares and working expenses, he has but very little remaining to show for his month's work.

The site of a possible deposit is first of all located by searching the surface for signs of rolled waterworn boulders and pebbles which are believed to be certain indications of gem bearing gravel (known as *malave* or *illam)* below. When a likely spot is found, it is probed with a long steel bar sharpened to a point which is carefully polished. This bar is pushed down and when it meets with resistance is twisted round several times before it is withdrawn. From its appearance the prospector estimates at what depth the malave lies, and also its thickness and character. All this is very crude and speculative, as all that he has to go on is the presence of a few grains of adhering clay, and a few slight scratches on the polished point made by the hard corundum pebbles if they are present. However they swear by the method, and when the indications are regarded as being favourable they trust to luck and proceed to sink a pit, which goes down until they either strike the malave, or at last realise that there is nothing there. In the latter case, they will sink another trial pit quite close by, and continue doing so until they either find the malave, or finally abandon the ground as barren. The law specifies that every pit or excavation made must be completely filled up again before it is left.

The pits sunk are of various sizes, and appear to follow no regular system. They are very crudely timbered by driving down vertical poles side by side, which in wet ground are backed by layers of palm leaves. As these pits seldom go down for more than fifty feet, nothing much happens to them, and accidents are rare. Two workmen usually occupy the bottom of the pit, digging the earth into small bamboo baskets which are elevated to the surface by throwing them from man to man through a series of men perched at intervals on poles placed across the pit. Since the weather is typically hot, the mouth of the pit is usually covered by a small thatched roof, and the workmen wear no clothing save a loin cloth and turban. They are a happy crowd, and all the time they are at work carry on a general lively conversation, in which laughter holds a very prominent place, and the whole thing makes a great deal of noise.

Where water is encountered, it is removed by bailing with kerosene tins, for lifting which they use a very heavy and clumsy form of balance crane. This has a young tree trunk for an arm which is swung on a tall tripod of poles, and is generally a very inefficient piece of apparatus, so no wonder they do not use it for lifting earth.

When the malave is met with, it is removed and stacked in much the same way as in Burma, after which it is washed. There are two ways of doing this, and where there is a fairly large stream available, this is dammed up to form a large pool about three-feet deep, in which the washers, of whom there may be five or six, stand. Each man has a large bamboo basket some 2½ feet in diameter, shaped like a Burmese pauktau, which is filled with malave carried from the main stack in small baskets by other workmen. This is broken up under the water and simply swirled about until all the useless clay and sand has been dissolved or washed away, when the basket is given a few up and down jerks, and placed upon the bank without emptying it, the washer taking a fresh basket for his next supply of malave. The larger stones of the washed gravel now lie at the top of the basket, and the fine but heavy sand at the bottom. When there is a sufficient accumulation of these baskets of washed gravel the sorters commence their work, and it is at once evident that they do not mean to pass any stones for the want of carefully sorting the gravel, for at least half a dozen of them will squat in a row. The first man takes a basket and places it on the ground in front of him, tilting it at such an angle that the sunlight falls directly upon it. Then, placing his hands together, he makes obeisance to it several times, while in a loud voice he offers up a prayer for good luck, after which with a rapid sweep with the flat of his hand he scoops the top layer of stones to the side of the basket, and picks out any stones revealed, repeating the process down to the last layer of sand. A small boy then passes the basket to the next man who goes through it carefully, and so on right down the line.

Another method of washing, where there is only a limited amount of water available, is to have a large tall bamboo basket which is very closely woven together at the bottom, increasing in size of mesh until at the top the holes are over an inch in diameter. This is submerged in a pond or large vessel of water, and partly filled with malave which is then vigorously stirred up with a pole to break up the clay and form a slurry. The stones of a high specific gravity, even though they may be very tiny, will then sink to the bottom of the basket, while the lighter material will pass out of the larger holes towards the top. The residue is then swilled with clear water to clean it, after which it is sorted as before.

Sometimes the beds of the streams will be dredged in a crude native fashion to recover their contained gems, but this is regarded as being very speculative indeed, even by the Ceylonese, and no one appears to be very keen upon it. Most of the mining is carried on in a regular manner under a license, but illicit working by men who hold no license to mine is not altogether unknown.

To the uninitiated, the apparent haphazard manner in which the mining sites are selected, and the fact that only certain parts of an area will be worked while adjacent patches will be quite untouched, would seem to favor gross inefficiency and very casual workmanship which might be greatly improved upon. But there is a reason for it, as the writer, when advising upon a proposition to work an extensive area by means of dredges some years ago, found that the paddy fields were only held in very small areas by different owners, and that the majority of them were covered by mortgages and other encumbrances, which were of such a complicated nature that it was impossible to get a clear title over any tract of land sufficiently large to warrant the preliminary expenditure necessary for such a venture.

In Kashmir, the stones are still mostly picked out by hand, but sometimes a crude form of ground sluice similar to a Burmese kathe-yaik is used for the recovery of the smaller sizes.

14
THE CLASSIFICATION OF CORUNDUM

The classification adopted by the mineralogist compared with that of the jeweller ⚜ Where both of these systems fail ⚜ A new classification ⚜ How the corundum gems are classified in Burma ⚜ The units of weight used in Burma

There are two entirely different systems at present in use for breaking up the main mineral group corundum into sub-divisions, both of which use nomenclature which has by general use become associated with gemstones. Yet neither of them seriously take into account the following three main divisions into which corundum obviously naturally divided itself by virtue of its different uses and values – (a) Precious corundum. (b) Gem corundum. (c) Non-gem, or commercial corundum.

The first of the present day systems is that of the mineralogist, who is not particularly concerned with either precious or gemstones as separate entities, but only insofar as they occur as part of a distinct mineral group; so he adopts a hard matter of fact classification which divides the main group into three, as follows.

1. Ruby and sapphire

This sub-group includes all the transparent and highly translucent varieties, quite irrespective of their colour; but those of a red colour only are designated ruby, and all the other colours are classed under the general name of sapphire. It will therefore include the highly translucent star stones, but exclude the opaque ones.

It is a general attempt to form a group of the gem varieties, but does not go far enough for the special purposes of the gemmologist, as it directly excludes several varieties which are used as gemstones, and furthermore the grouping is too general for practical purposes.

2. Corundum

This includes all the corundums which are dark, or dull in colour, and of a diaphanity lower than highly translucent.

It therefore includes all the sub-translucent and opaque star stones, the chatoyant stones, and the darker stones which are used in jewellery, and many of which are of quite high grade. But at the same time it will also include opaque crystalline corundum which is quite useless for gem purposes.

3. Emery

This group primarily includes the massive, compact, and granular corundums, but it also includes corundum which is clearly crystalline, either in the form of distinct crystals of massed radial crystalline fibres, or opaque masses, which are also used in various forms of jewellery such as beads, carved stones, etc., and also adamantine spar.

It will at once be seen that the above classification, while meeting with all the requirements of the mineralogist in enabling him to identify and group his specimens, is of absolutely no use at all to the practical gemmologist, or to the ordinary wearer of gems, in enabling them to discriminate between one gem variety of corundum and another.

The next system is that in use by the jeweller, who is only concerned with the gem varieties, and from either a scientific or a practical point of view this classification is worse than the one quoted above, as it is confusing and involves a system of nomenclature which apart from being misleading is often utterly false; and it is unfortunately obvious that this system of false naming, where it is not due to stupidity, was originally intended to be deliberately misleading for purposes which must be regarded as being intentionally dishonest, in which the corundum group does not stand alone.

In a way the jeweller bases his classification on that of the mineralogist, but not being concerned with the commercial varieties he ignores them altogether and simply splits the parent group into two as follows.

1. Ruby

Into this group are placed all the corundums which are of a distinct red colour, no matter what their diaphanity may be. But for some unearthly reason pink stones are specifically excluded, while it includes the colour described as pale rose red.

2. Sapphire.

This group consists of all the other varieties of corundum irrespective of their colour or degree of diaphanity which are used for gem purposes. It even includes deepish pink stones under the name of *pink sapphire.*

The pure blue variety is simply termed *sapphire,* but very often a colour or other prefix such as *royal blue* or *Burma* is also added, which, so long as it is a correct and truthful description, is quite a good thing.

All the other colours are also designated sapphire, but are distinguished by using either a colour prefix such as *yellow sapphire,* or what is far worse, by using the name of an entirely different species of similar appearance with some sort of qualifying prefix added, such as *oriental amethyst* for purple corundum or *king topaz* for deep yellow. Such a practice is indefensible as the names are absolutely false and misleading. The use of the term *fancy sapphire* is less objectionable, but is still confusing and should be discontinued.

It has been argued that this system of classification is so ancient that it has become a fixed trade nomenclature and so cannot conveniently be altered. Ancient it may be, in fact it is almost comparable with the simple minded Burmans of old Pegu who called a sapphire a blue ruby;[1] but that is no reason at all why it should not be changed. Apart from being misleading and confusing, it is not scientific, neither does it represent actual facts. Corundum is not quartz-amethyst, neither is it topaz, so why introduce a false description, and designate a stone as belonging to gem species of more humble origin than it really does? If anyone were to refer to a fine Rolls-Royce motor car as a mechanical donkey cart, they would be called insane, but it would be quite on all fours with the present system of naming the colour corundums. Again it is often but a matter of personal opinion for who is to decide when a rose red stone ceases to be a ruby and becomes a sapphire. These are all very sound reasons why the present system of false nomenclature should be scrapped, and something more in line with actual facts adopted, which will not be misunderstood by the general public, or create confusion in the average untrained mind.

It is essential for gemmological purposes that there should be a very clear and definite classification of such a highly important group as corundum, so that everyone may know exactly where they stand with regard to the different varieties used for gem purposes. Therefore the writer, dealing

1 See page 33

with the gem varieties only, suggests that the present misleading names should be abolished, and the group more clearly reclassified as in Table 14.1.

As the use of the word precious when applied to gemstones should be reserved for gems of the very highest grade, which by reason of their rarity and beauty invariably command the highest prices on the market, it

Table 14.1: Classification of corundum

Parent Group	**Corundum**
Divisions	**A. Precious corundum** **B. Gem-corundum** **C. Non-gem, or commercial corundum**
Group 1 Ruby	All shades of red and pink, irrespective of the shade of diaphanity, but not including purple or violet shades
Group 2 Sapphire	All shades of true blue, from very pale to very dark, irrespective of the degree of diaphanity. But excluding such shades of greenish-blue where the green tint predominates, and all shades of bluish-grey.
Group 3 Colourless corundum	Only such stones as are transparent and water-white
Group 4 Coloured corundum	Stones of all other colours, transparent to opaque. These should be designated according to their colours as *yellow corundum,* etc.
Group 5 Natural star corundum	Such stones as exhibit a six-rayed star which is not due to the optical phenomenon of asterism, but to a peculiar arrangement of colour. It would be permissible to designate the blue variety as *natural star sapphire,* but not the yellow.
Group 6 Asteriated, or star corundum	Translucent and opaque stones of all colours which show a distinct six-rayed star of chatoyant light which is purely due to optical asterism. For convenience, this group may be sub-divided as follows: A. Star ruby: All shades of red and pink, but never purple or violet. B. Star sapphire: All shades of true blue, but never shades of bluish-grey. C. Asteria: All other colours, which should be designated *purple asteria, blue-grey asteria,* etc.
Group 7 Chatoyant corundum	Transparent to opaque stone of all colours, which either show a chatoyant band, or a patch of chatoyant light. It would be permissible to use the terms *chatoyant ruby* or sapphire for the red or blue varieties, but not for other colours. The term *cat's eye* should never on any account be applied to any form of corundum.

follows that only the higher grades of groups 1 and 2 could strictly be regarded as belonging to division (a) Precious corundum, but the writer is of the opinion that the finer stones of group 6, A and B, should also be regarded as being precious, but that no other colour of asteriated corundum should be included under this heading.

All the other groups, and the lower grades of those already mentioned, should be regarded as belonging to division (b) Gem corundum. The present term *semi-precious,* being an abomination, and grossly misleading, should on no account be used.

Any specimen of corundum, although crystallised and apparently belonging to one of the above groups, but which is for any reason unsuitable for gem purposes, and all the lower grades not considered in this classification should be relegated to division (c) Non-gem, or commercial corundum.

It will be seen that this classification is based either upon the colour, or upon some natural characteristic which makes the stone suitable for gem purposes; which would appear to be the only way to arrive at a clear and definite classification suitable for the purposes of the gemmologist.

The term *asteria* has been adopted as it is from the Greek word αστπρ ('aster' – a star), which was used for all forms of star stones in the early days; and of which the corundum group provides practically the entire series likely to be met with outside a museum or specialised collection.

To dealers in the corundum gems residing in other countries, a knowledge of the classification adopted by the Burmese traders will be found of use, as it forms the basis of nomenclature upon which all business has to be transacted when dealing direct with Mogok. The main classification is, however, only given below, as the individual traders will sub-divide each of the grades into endless classes, each with a distinctive name, but these are quite unimportant as they are only understood on the individual Eastern markets upon which they are placed.

In the Burmese classification in Table 14.2–4, for the sake of clearness, the relative weights have been shown in metric carats, and although that unit of weight is understood by the majority of the traders, the actual unit by which all fine quality stones are bought and sold is the *rati,* which is equal to 0.91 metric carats or 0.182 of a gram. Cheaper stones are sold by the *bali,* equal to 1 *tola,* or 58.30 carats, pr 64 ratis, or 11.66 grams. Parcels of very cheap stones are sold by the *tikal,* which is equal to 80 carats or 88 ratis. 100 tikals are equal to 1 *viss,* which is equal to 3.6 pounds (Avd.).

Table 14.2: Burmese classification of rough rubies

No.	Burmese Name	Weight in Carats per Stone	General Description
1.	*Lonbouk*	Over 4	An affix applied to fine large rubies, or sapphires
2.	*Anygyi lonbouk*	-:-	As above, but only applied to stones of a good rose red colour
3.	*Awah*	-:-	Stones of the same class, but rougher and yellowish
4.	*Kyaukme*	-:-	Stones of fine gem quality, but very dark red, which is almost black by reflected light
5.	*Gair*	All sizes	Sub-translucent to opaque stones of good colour which may be chatoyant but not asteriated
6.	*Gairsa*	-:-	As 5, but inferior
7.	*Anyun*	1¾ to 4	Fine first-water rubies of good shape; this includes the highest grades
8.	*Anygyi*	-:-	Similar to 7, but paler in colour
9.	*Laithi*	1¾	As 7, but smaller
10.	*Athaibouk*	⅞	Smaller than 9
11.	*Sagathai*	½	Smaller than 10
12.	*Amaithai*	⅓	Smaller than 11
13.	*Atetkya*	½ to 4	Mixed sizes similar to 7 to 11, but slightly inferior, although of good colour, shape and purity; a high-class, but speculative
14.	*Amai*	1 to 4	Stones of the No. 4 class, but smaller. Also speculative
15.	*Gaungsa*	1 to 5	Mixed sizes of good shape, and purity, but third grade colour
16.	*Gaungsakya*	-:-	Inferior to 15
17.	*Sayo*	2 to 6	Mixed sizes of good colour, but rough, impure, and cracked
18.	*Sayokya*	-:-	Inferior to 17
19.	*Sayokya nouk*	-:-	Inferior to 18

Table 14.2: Burmese classification of rough rubies

No.	Burmese Name	Weight in Carats per Stone	General Description
20.	*Apya*	½ to 4	Mixed sizes of fine quality flat stones
21.	*Apyasa*	-:-	Inferior to 20
22.	*Apyazone*	-:-	Inferior to 21
23.	*Apyazone nouk*	-:-	Inferior to 22
24.	*Akyan*	½ to 1¾	As No. 17, but smaller
25.	*Akyansa*	-:-	Inferior to 24
26.	*Pingoocho*	All sizes	Fine quality star rubies, sold either as individual stones, or in parcels of mixed sizes; always speculative
27.	*Pingoosa*	-:-	Inferior to 26; very speculative
28.	*Aneethai*	⅓	Medium colour, of good shape and purity
29.	*Ameethai nouk*	-:-	Inferior to 28
30.	*Aneethai galay*	Under ½	As 28, but very tiny
31.	*Akyawthai*	⅓	As 28, but paler in colour
32.	*Apyothai*	-:-	As 28, but very pale
33.	*Atwe*	All sizes	Very impure mixed stones of all sizes, too impure to be included in any other class
34.	*Sonzi*	-:-	Ruby rejections to commercial corundum

Table 14.3: Burmese classification of rough sapphires

No.	Burmese Name	Weight in Carats per Stone	General Description
35.	*Nila lonbouk*	Over 4	Fine large individual sapphires
36.	*Nilas*	1 to 4	Fine smaller sapphires
37.	*Nilas*	All sizes	Parcels of mixed sizes, and qualities; speculative
38.	*Nila gawcho*	-:-	Fine to good star-sapphires; very speculative
39.	*Nila gawdone*	-:-	Inferior star sapphires; exceedingly speculative
40.	*Hmatsa*	-:-	Sapphire rejections to commercial corundum

Table 14.4: Burmese classification of rough coloured corundum

No.	Burmese Name	Weight in Carats per Stone	General Description
41.	*Mogok sein* or *okthapaya*	–	Colourless corundum
42.	*Mogok sein* or *okthapaya*	–	Pale yellow corundum
43.	*Okthapaya*	–	Deep yellow corundum
44.	*Ainda nila*	–	Purple corundum
45.	*Mogok mya*	–	Green corundum

15
THE OUTPUT AND VALUE OF THE CORUNDUM GEMS

The impossibility of compiling a correct estimate in the early days ⚜ A London merchant's recent estimate ⚜ The output of Burma for thirty-seven years ⚜ The output of large stones ⚜ The selling prices of rough stones ⚜ The output from other centres ⚜ The prices of cut stones ⚜ A London merchant's list of current prices

Many things have combined in the past to make the task of compiling evenly moderately accurate statistics regarding the world's output of the corundum gems, and more especially estimating their total value, a matter of impossibility. To a very large extent these difficulties still exist.

In the first place, a very large number of these gems have always been mined by men working independently and to whom it is often of vital importance that the strictest secrecy should be maintained regarding the value of their production. And where they have been mined by large companies, it is but natural that they would not broadcast the true valuation of their productions, and so lower the market prices which depend entirely on the comparative rarity of the stones.

Added to this, the official figures published by many countries are known to be quite inaccurate, being based upon reports made by their Customs Departments, etc., who could only take into account such stones that actually passed through their hands, leaving unaccounted for vast quantities of material which they never saw. Or the values were based upon preliminary book valuations, which for many reasons may have been either under- or over-estimated, and in no way represented actual facts. These again leave unaccounted for unknown quantities produced by independent miners, which were quite often estimated by the most fantastic guesswork. The majority of estimates were further rendered inaccurate by seriously taking into account the grossly exaggerated valuations placed by the sensational press upon any remarkable stone which appeared on the market. This practice is, of course, purely dealers' advertising propaganda, which is not unknown today.

Now that the company has ceased to operate, the writer is in a position to quote an accurate summary of the production of The Burma Ruby Mines, Limited, over an extended period, which together with many years' close study of the native miners. A very large number of business dealings with them, enable him to throw a little authoritative light on this vexing question, and to give a fairly accurate idea of the amount of gem material emanating from this very important centre of production.

Some conception of the mistaken ideas prevailing on this subject may be gathered from the very conservative estimate put forward by a London Merchant in 1931, who considered that the total annual production of rubies in Burma would be covered by *a few hundred thousand pounds.*[1] This was by no means a wild guess, but an estimate arrived at after much thought and research.

Another fruitful source of over-estimation lies in the wild tales of rubies of immense size and value which have from time to time appeared, and which will always be believed in. Such tales were no doubt largely responsible for the extraordinary scenes of excitement witnessed when the company to work the Burma ruby mines was floated. We now know that such stones are largely mythical, and it has been conclusively proved that really fine rubies of over four or five carats in weight are among the rarest things on earth.

To arrive at an estimate for the production of Burma, the writer deals with the official figures of The Burma Ruby Mines, Limited for the period of 37 years ending December 1930, which covers the real active producing period of the company when in full work. During this period they also controlled the activities of the native miners, of which department the writer was for a time in charge, so that the figures quoted may be regarded as the only really authoritative ones which have ever been available.

During the period under review the total value of the gems mined by the company was £2,038,600, an average of £55,100 a year in round figures, of which ruby would account for about 85%, the balance being sapphire and spinel, with minor gems not considered. To arrive at the total output, it is necessary to add to the above the output of the native miners, for which the only authoritative figures we have as a guide is the sum of £535,400 actually paid by them as license fees. The writer's experience

1 Wyatt, C. (1931, 1932) The world's gem production. *The Gemmologist,* Vol 1, August, 1931, p. 25; February, 1932, p. 11.

Table 15.1: Rubies mined from 1893 to 1930 which sold for £66 or over per carat

Serial No.	Year Mined	Weight in the Rough Carats	Price Realised	
			Per Stone (£)	Per Carat (£)
1.	1919	43	27,500	654
2.	1895	18 7⁄16	7,001	378
3.	1922	22 ¾	4,000	175
4.	1927	22⅝	2,447	108
5.	1903	23½	2,005	85
6.	1893	8 7⁄16	1,762	207
7.	1924	21½	1,667	77
8.	1915	22½	1,600	71
9.	1901	13	1,514	116
10.	1901	15½	1,500	96
11.	1902	9½	1,444	152
12.	1904	9	635	70
13.	1904	7	534	76
14.	1906	7	490	70

teaches him that the total production of these miners may be approximately valued at three times the amount paid by them in license fees, which is a pretty fair average. So working on this basis, their production for the entire period would have amounted to £1,606,200, an average of £43,400 a year. This gives a total of £3,644,800, and if we add £1,500 a year to allow for stones stolen or disposed of secretly, we get a grand total of £3,700,300, or say £100,000 a year, which is considerably lower than the estimate quoted above.[2]

These figures do not represent book valuations, but the actual sales value of the total output at Mogok. The majority of the stones were completely

2 Editor's Note: If we adjust Halford-Watkins' numbers for inflation, £100,000 in 1930 would be worth approximately US$5 to 6 million in 2005. This figure represents the average yearly production of the world's finest ruby deposit at its peak of production and underscores the incredible rarity of fine rubies and sapphires.

Table 15.2: Average prices realised for stock grades of rubies

No.	Quality	Average Normal Price Per Carat £	s	d
1.	*Anyun*	4	10	-
2.	*Anygyi*	1	2	6
3.	*Laithi*	1	17	6
4.	*Athaibouk*	1	2	6
5.	*Sagathai*	-	18	6
6.	*Amaithai*	-	8	-
7.	*Atetkya*	-	7	6
8.	*Amai*	-	12	-
9.	*Gaungsa*	-	1	10
10.	*Gaungsakya*	-	-	9
11.	*Sayo*	-	1	10
12.	*Sayokya*	-	-	10
13.	*Sayokya nouk*	-	-	9
14.	*Apya*	-	12	-
15.	*Apyasa*	-	4	10
16.	*Apyazone*	-	-	10
17.	*Apyazone nouk*	-	-	9
18.	*Akyan*	-	2	-
19.	*Akyansa*	-	1	-
20.	*Pingocho*	-	6	-
21.	*Pingoosa*	-	1	6
22.	*Aneethai*	-	3	6
23.	*Aneethai nouk*	-	2	2
24.	*Akyawthai*	-	-	8
25.	*Apyothai*	-	-	1
26.	*Atwe*	-	-	1

Table 15.3: Average monthly output of fine rubies over a five-year period

Type	Carats	Type	Carats
Anygyi	25.0 carats	*Athaibouk*	186.0 carats
Anyun	73.5 carats	*Sagathai*	147.5 carats
Laithi	197.0 carats	*Amaithai*	97.5 carats

absorbed by the Eastern markets, and never appeared in Europe or the West at all; but practically all the finer qualities, including the production of the native mines, found its way to the Western markets.

It is common knowledge that fine large rubies are rare things, but how exceedingly rare they are is by no manner of means realised even today. It was the practice of the Company to class all rubies which realised £66 or over per carats as *Exceptional stones,* and those which sold for £133 or over per stone as *Notable stones.* It will therefore probably come as a great surprise to many to learn that during the entire thirty-seven years, the Company, with its vast resources and extensive mining area, only mined fourteen stones of the exceptional class.

Neither were the stones of the notable class a great deal more plentiful as only 182 of these were mined, which aggregating 8,903 carats in weight and selling for £78,003, were mostly of the *anyun lonbouk* class, and ranged in weight from 3³⁄₁₆ carats to 1,432 carats each, and in price from £133 to £1,432 each.

It is of interest to note that, with the exception of the *Peace Ruby* (No 1.), which was the finest, but not the largest, ruby ever mined, all the exceptional stones were under 24 carats in weight. And that the price paid for the Peace Ruby (£27,500, or £654 per carat) was the highest price ever realised per carat for a rough ruby.

Pure fine coloured rubies of the finest grades in the smaller sizes were also very far from being plentiful, as may be gathered from the following figures which represent an average month's output mined by the company, calculated on the total production over a consecutive period of five years.

Exceptional sapphires were those which sold for £6 and upwards per carat, and of these but 36 stones were mined, weighing 1,751 carats and selling for £20,954, an average of just over £11 a carat. These stones varied in weight between 12 and 200 carats each and in price from £310 to

£2,686 per stone. The highest price realised per carat was £44 for a stone of 30 carats.

Notable sapphires were those selling for £133 and over per stone, of which 158 were mined, weighing 16,429 carats and selling for £57,624, an average of just over £3.5 per carat, which is misleading, but is accounted for by there being several stones of a high weight but which only realised a low sum per carat, their total weight, however, bringing them into the notable class. These stones ranged between 14 and 1812 carats each in weight, and in price from £133 to £2,686 per stone. It being noticed that, as the size of the stones increased so did the price per carat decrease, owing to the amount of waste material in the majority of rough sapphires.

Owing to the secret manner in which the native miners transact their business, and to the very wildly exaggerated tales which are circulated regarding prices realised and paid,[3] it is not possible to give accurate figures for their production of similar stones; but for the same period if it be taken at about one third that of the company's figures, the resulting estimate of the total production will be sufficiently near for all practical purposes.

Insofar as it is possible to form an accurate estimate, the above figures give a very fair idea of the total output of the corundum gems from the world's most important producing centre during a little more than a third of a century; and as no other centre produces fine rubies, they conclusively prove that really large fine rubies are by far the rarest of all the precious stones.

Apart from individual stones and parcels of speculative grades sold by tender to the highest bidder, the average prices realised for the ordinary stock grades sold in parcels at a flat market rate are summarized in Table 15.2.These figures are the average first selling prices obtained in normal times during the five years ending December 1931, during which period the writer personally fixed the prevailing market rates. In the early days prior to 1908, they were a great deal higher. Nos. 1 to 6 were sold in parcels of from 10 carats upwards, and practically all went to the Western markets. Numbers 7, 9, 20 and 22 were also partly disposed of on these markets, all the other grades being sold to the Eastern markets in lots of 80 carats upwards. The rates quoted are those for taking the entire parcel as shown, irrespective of its total weight. If only a portion was purchased

3 The writer once purchased a stone for Rs2,500/-, yet the miner boasted to everyone that he had received Rs10,000/- for it.

without picking, an increase of 30% was charged, but if the parcel was lightly picked over and a portion of the stones rejected, the rates were doubled, and if closely picked, trebled. In prosperous times, or when there was a boom in progress the above rates would show a considerable increase, and in times of a slump they would decline.

Of the output from other centres, we have no reliable figures, or even authoritative estimates, to enable us to complete an estimate for the whole world, and it would seem that this must always remain a matter of pure guesswork. It is known that the trade in sapphires from Siam is still fairly extensive; but it is nothing like what it was in say 1889, when one London Merchant alone certified that he had done business in that year in sapphires from Siam to the extent of £70,000. As we have already seen in Chapter 11, the production of all the other deposits has declined, and now that the production of Burma is also curtailed, it would seem but reasonable to anticipate a substantial rise in prices unless some new deposits are found to supply the market with really fine rubies and sapphires.

The prices mentioned so far have been those for the raw material at the source of production, and these will naturally be very much enhanced by the time the stones are offered retail as finished gems. It is, however, impossible to lay down hard and fast rules for the valuation of fine large specimens of either rubies or sapphires, as the selling price of such stones must always largely depend upon the personal taste of the purchaser, and to a great extent upon the depth of his pocket, coupled with how badly he really wants a particular stone. Exceptionally large fine rubies will realise almost any price, and well over £1,000/ct is by no means unheard of, while £500/ct has been paid for quite ordinary stones, and £100–200/ct for stones with nothing out of the ordinary about them is a fairly common price. Small cut stones of quite fair quality may, however, be bought for £3–4/ct, while second- and third-grade stones can be obtained at much lower prices.

Superfine Burmese sapphires and fine Kashmir stones have been known to realise over £300/ct for square-cut stones of three carats in weight, while £200/ct is by no means extraordinary. Lower grade sapphires of fair quality may be bought for a £1/ct upwards, but stones of poor quality may be obtained for a few shillings a carat.

Fine large star rubies and sapphires will realise very high prices, but poor stones are almost worthless.

Table 15.4: London prices of cut corundum gems

Stone	Quality	Value per carat in pounds for stones weighing			
		1 carat	2 carats	3 carats	4 to 8 carats
Ruby	Fine	30	50	100	200 to 1,000
	Medium	10	20	40	70 to 250
Sapphire	Fine	12	20	25	35 to 80
	Medium	5	8	10	15 to 35
Star Ruby	Fine	2	5	10	25 to 50
	Medium	1	3	5	6 to 12
Star Sapphire	Fine	1	1½	2	6 to 12
	Medium	½	¾	1	2 to 4

Large and fine specimens of the coloured corundums will also command fancy prices, but ordinary small stones are only worth a few shillings a carat.

Mr. Charles Mathews, a prominent London gem merchant, has quoted the prices in Table 15.4 for cut corundum gems as obtaining in London in June 1933.[4]

It must, however, be noted that this estimate of retail sales values was made at a time of universal depression, with the prices of all gemstones at about its lowest ebb. It must therefore be taken as being very much on the low side for all the weights quoted, those for the star stones being particularly low as at that time far higher prices were being paid in Mogok by the dealers who supplied the Western markets. As a table of comparative values, it serves a most useful purpose as a basis upon which to compute the value of a stone due to increased weight up to four carats, when the current rate of a one carat stone is taken as unity, but beyond that weight is useless. As an example of this, the writer was in March 1934 commissioned from London to purchase a fine cut Burma ruby of about 26 carats weight, and to pay up to £30,000 for the stone, but unfortunately such a stone could not be procured.

4 The Imperial Institute, London (1933) *Gemstones,* p. 27.

16

ASTERIATED AND CHATOYANT CORUNDUM

The early knowledge of star stones ✤ Chatoyancy defined ✤ Asterism defined ✤ Chatoyancy on a reel or ball of silk ✤ Chatoyancy due to a fibrous structure ✤ How chatoyancy is produced in calcite ✤ All chatoyant or asteriated stones are fibrous ✤ Ordinary silk constitutes the corundum fibrous structure ✤ How silk produces asterism ✤ The cause of missing or broken rays in the star ✤ Abnormal stars ✤ Other species of star stones and their distinction ✤ The black silk theory, and where it fails ✤ Other theories ✤ Producing small star stones from fragments of a larger one ✤ The molecular atom theory ✤ The varieties of asteriated corundum ✤ Chatoyant corundum ✤ Asterism cannot be imitated ✤ Natural star stones ✤ The markets for and value of asteriated corundum ✤ The difficulties of obtaining fine star stones ✤ Some curious star stones ✤ The cutting of star stones ✤ Points in judging star rubies and sapphires ✤ The defects of star stones ✤ The arrangement of the light when examining star stones ✤ The Asteriascope

Both chatoyant and star stones were known in the early days, and the term *asteria*[1] was at various times used by the ancient writers in different senses, but always with reference to a stone exhibiting a play of light upon its surface. It is not at all clear whether some of these references were not to stones showing either schillerisation or iridescence (such as moonstone or opal), or to those exhibiting chatoyant light in the form of a band or sheen, such as scapolite, cat's eye, tourmaline, or corundum, or to the true asteria or star stone. We are, however, pretty safe in assuming that the very earliest references were neither to banded chatoyancy or to asterism, both of which require the art of the lapidary to develop them. Neither from the descriptions would they appear to refer to what is known as the natural star stones, and it is highly improbable that they were the true (cymophane) cat's eye.

Plutarch (46–120 A.D.) tells of a gem called *aster* which came from the river Sangaris, and was known to the Phrygians as *Ballen* or *The King,* and was credited with being luminous in the dark. This might very well have been some form of moonstone, or equally well, aventurine quartz or opal,

1 For the derivation of this word see Chapter 14, page 239.

Figure 16.1
Coloured plate. Star corundums. From Marcus and Company (1936) *The Story of the Star Stones.*

all of which would show a play of light or colour in a faint light which was possibly confused with luminosity. Ptolemy Hepaestion (80–158 A.D.) describes a gem called *asterites* which was found inside a large fish, and here again the reference was most possibly to either moonstone or opal. But there is not the slightest doubt that the stone described by Pliny (23–79 A.D.) under the name of *ceraunia* or *lightning stone* was a true purple star corundum, and this is the first real reference we have to these stones. He also describes another lightning stone under the name of *astrapia,* which reads like a variety of opal, but it may have been corundum.

The optical phenomenon of a single band of bright light reflected from the surface of certain stones is known as *chatoyancy,* from the French *chat* (a cat) and *oeil* (the eye) in allusion to a fancied resemblance to the pupil in the eye of a cat. Stones exhibiting this are known by a variety of common names, many of which end in cat's eye with some sort of qualifying prefix; such names may be aptly descriptive of the appearance of the stones, but they are nevertheless false and misleading, as the true cat's eye is the cymophane variety of chrysoberyl. The band may, however, take a spread form and then appear as a shimmering cloud or patch of light, which appears to float over the surface of the stones as it is moved about. Stones showing either of the above forms are said to be *chatoyant.*

Instead of being either a band or a patch, the light will frequently take the form of several distinct thread-like lines radiating from a common centre in the form of a conventional star, this effect being known as *asterism,* and stones exhibiting it are called *asteria* or *star stones;* in America quartz showing this phenomenon is known as *starolite.*

If we examine a reel of tightly wound sewing silk in a brilliant light, a distinct band of bright light will be observed to be reflected from its surface, and it will be seen that this band always lies in a direction at right angles to the layers of silk. If this experiment is carried still further and a tightly wound ball of fine silk is obtained, with the surface windings all arranged in one direction, and is then examined in a bright light coming from one direction only, it will be seen that this reflected light now takes the form of a single band of bright light curving right across the ball, and crossing the silken fibres at right angles. This constitutes chatoyancy, and is produced in precisely the same manner as the chatoyancy to be observed in stones. This apparently childish experiment is really of considerable importance, as it not only enables us to understand the production of chatoyancy, but also to be able to definitely contradict certain of the very ingenious, but erroneous, theories which have been put forward to account for it. It is of importance to note that the chatoyant ray is always at right angles to the direction of the fibres, and that there is no chatoyant effect in the direction of the length of the fibres. Before we leave this little ball of silk let us squeeze it quite flat in a press, when it will be noticed that the banded chatoyant effect has vanished, and that its place has been taken by a soft sheen of reflected light which is more or less spread over the entire surface, but is more distinct when viewed in a direction across the fibres. This effect is very clearly observable on a piece of corded silk, and is the same as the chatoyancy we see on a stone cut with a flat surface; the experiment showing that a curved form is necessary to reduce the sheen to the form of a single ray or band.

The above is the only fundamental way in which chatoyancy can be produced, and asterism is but a variety of chatoyancy brought about by a peculiar arrangement of the fibres. It therefore follows that, before any stone can exhibit this phenomenon, it must have a fibrous structure of some kind. In practice it will be found that all stones which show either chatoyancy or asterism are so constituted, even though that fibrous structure may be so ultra-microscopic as to be quite unobservable by ordinary means.

If we examine a block of calcite it will be found to be of a distinctly fibrous nature, and the fibres will be seen to be arranged in one direction only, and parallel to each other, not unlike matches in a box. If this block be rounded of in the direction of the curve A–B, it will be seen that the top of the curve will cut the different rows of fibres in slightly different directions, the difference being more marked the steeper the angle of the curve, so that, in the case of a very flat curve the difference would hardly be perceptible. To proceed and round off the block in the direction of the curve A–C would produce a dome-shaped stone, with either an oval or circular base, so that we would now have the same conditions of the curve cutting the fibres in different directions throughout the length and breadth of the stone, but with the difference that in two directions it would be cutting the fibres in the direction of their length, and in the other two directly across their ends. Now the cut *edges* of these fibres, but not the cut *ends,* would present tiny prisms which would totally reflect back the light incident upon them, and so produce a chatoyant band at right angles to the direction of the length of the fibres, as shown by the white line in the figure, and the cut ends which do not form prisms would reflect back no light.

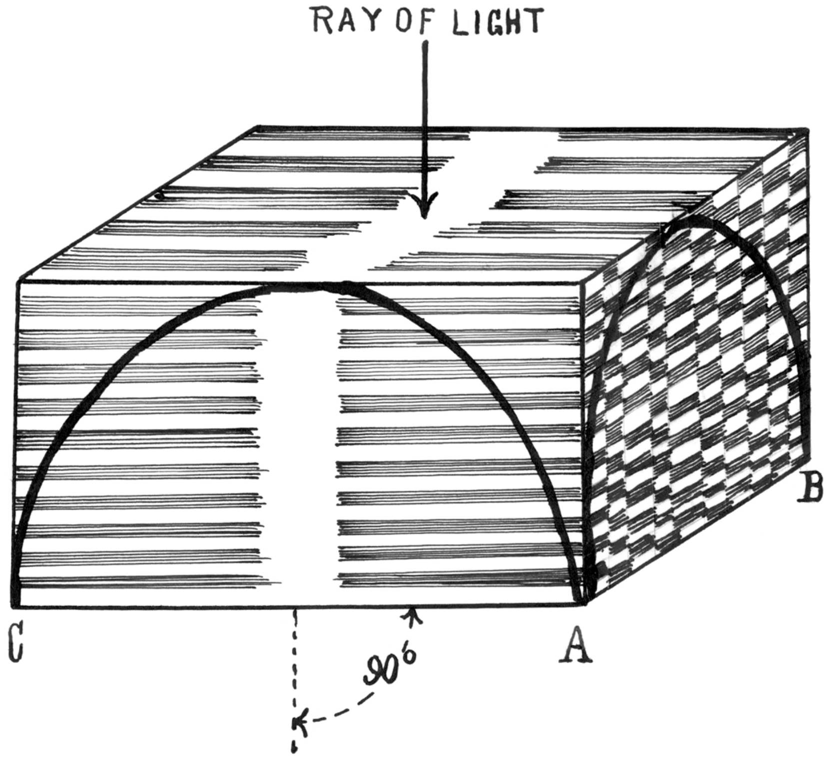

Figure 16.2
Chatoyancy in a block of calcite.

This also clearly indicates that normally owing to the very slight differences in the angles of incidence between the fibres and a very flat curve, the band of light produced will be broad and diffused, while the higher the curve, and steeper the angle, the narrower and more sharply defined the band will appear to be. This is true in the great majority of instances, but there are rarely cases where exactly the reverse will happen, but these are abnormal. If the curve is made almost flat, the effect of the single band will almost invariably be lost altogether and only a patch of chatoyant light produced, while if the stone is polished with a perfectly flat surface this effect will be further reduced to an evenly distributed sheen.

Calcite has been selected for the above demonstration on account of its easily observable fibrous structure, and, in all the stones of the corundum group which show this phenomenon, and some of them are very highly asteriated or chatoyant, a precisely similar fibrous structure will always be

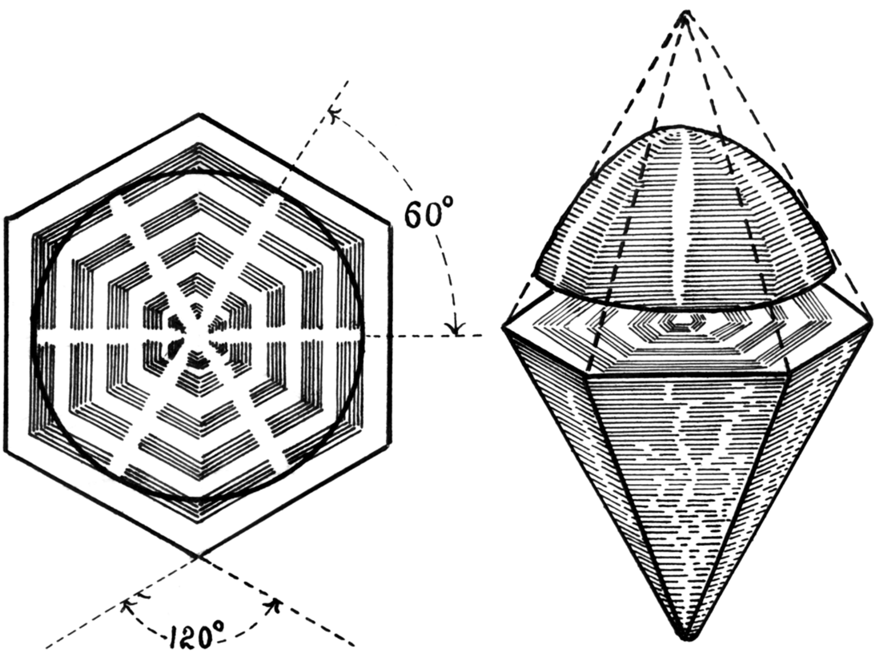

Figure 16.3
How silk produces asterism.

found. This is, without exception, always provided by ordinary silk, as described in Chapter 7, page 107, and which may take the form of a very distinct banding which is plainly visible to the naked eye, or it may be so fine as to present to the eye only an appearance of general cloudiness, or again may be so exceedingly microscopic as to impart only a very slight mistiness to the stone. But no matter how fine it may be, if it is present in sufficient mass to produce chatoyancy, its effects will always be exactly the same. Exactly what form of chatoyancy the silk will produce will depend entirely upon the arrangement of its fibres with regard to the curvature of the cut stone.

We have seen that silk will often occur in the form of a series of hexagons nesting into each other, as shown by the shaded lines in the figure, and also that this structure will often persist in parallel layers superimposed upon each other throughout the entire length of the crystal. If a slice is cut from such a crystal in a direction across its axis, there will be produced a similar block as described for calcite, but with the great difference that the fibres of silk will lie in a direction parallel to all six sides of the hexagonal-shaped block, so that there will be no distinct ends to cut through in a vertical direction. If this block is now rounded off to produce a dome-shaped stone, there will still be present in that stone six sets of fibres, all lying parallel to the base of the stone in a horizontal direction, and parallel to the six faces of the original crystal in a vertical direction. As the curve of the dome rises, it will cut through different hexagons formed by the fibres, each decreasing in size from base to apex. This will create a chatoyant band of light on each of the six sets of fibres representing the six original faces of the crystal, which will unite at a common point situated at the apex of the stone. Thus will be produced the thread-like star of chatoyant light which we call asterism, as shown by the white lines in Figure 16.3.

If the crystallisation is normal and the silk regularly developed parallel to each face, it follows that each ray of light must of necessity form an angle of 60° with the next ray. But such regularity of angle will not invariably occur, for if the original crystal was not symmetrical the difference in the size of the faces would throw the angles out. Or again the silk may be entirely absent from one of the faces, which would also upset the angles, besides reducing the number of the rays. This may also be caused by faulty cutting in which part of a face, or even a complete face or faces, of the original crystal has been completely removed, which, besides reducing the number of the rays, would also throw the star out of centre from the apex of the stone. Therefore it is possible to find asteriated corundum with any number of rays from two to six, but from a single crystal there will never be more than six rays. There are, however, rare cases in which the stone has been cut from a twinned crystal, and has parts of both crystals included in it, which may then have the effect of a star with any number of rays from seven to twelve. However, careful examination will always show the presence of two distinct stars, either complete or only in part, radiating from two entirely separate centres, although these centres may be situated very close together.

Should the stone have been cut from only a portion of a crystal which has but one set of fibres, only a single ray will be produced. The resulting stone is known in the trade by several false or misleading names such as *ruby cat's eye.* But few of these so-called corundum cat's eyes possess a distinct or sharply defined band of light, the chatoyant effect more usually taking the form of a diffused cloud or patch.

Although corundum furnishes the majority of the star stones, there are also other species to be found asteriated. Emerald and quartz, both belonging to the hexagonal system of crystallisation, are the only other species showing six-rayed stars. While both almandine garnet and spinel may also be found asteriated, as they both belong to the cubic system of crystallisation, they will never exhibit more than four rays to the star, which will be separated by an angle of 90°.

From the above it is quite clear that when a perfect star is present it is a simple matter to determine the system of crystallisation by simply counting the rays, and so at once be able to discriminate between a star ruby and a star garnet or spinel.[2] Even with a faulty star, the system of crystallisation may still be determined by observing the angles. If any two rays either cross each other, or are in relation to each other at an angle of 90°, it is conclusive that the stone belongs to the cubic system. But if the main rays are related at an angle of 60°, or if the angle between two rays with a missing centre one is 120°, it cannot belong to any other than the hexagonal system. Since these two systems are the only ones which produce asterism, it only needs a further quick examination of the more obvious physical characteristics to establish the true species of the stone.

It is exceedingly unlikely that a star emerald will be met with, as these are so very rare that they have often been stated to be non-existent. However, the writer has personally examined two specimens and definitely proved their species beyond the slightest shadow of a doubt. Asteriated garnet and spinel are more common, but are not likely to be met with outside a museum or highly specialised collection. Star quartz is, however, fairly common and is quite likely to be encountered in the ordinary course of events. Contrary to the popular idea, true topaz, which belongs to the orthorhombic system, has not been found to display asterism, and all the so-called star topazes are really asteriated yellow corundums.

Chapter 7 also describes another enclosure in corundum known as *black silk,* which consists of a series of very fine, often ultra-microscopic, black lines arranged in a very definite manner with regard to the faces of the crystal (see page 117). It has been contended by several observers that light incident upon the rounded surface of the stone is totally reflected back again by the cut ends of these lines where they come to the surface of the stone, and that this is the true cause of asterism, ordinary silk being in no way concerned in its production. They also contend that the reflective powers of the cut lines is more active near to the apex of the stone, but are

2 Editor's Note: This statement is untrue, as star spinel and star garnet can display either four- or six-rayed stars.

silent as to the reason for this. It is quite an ingenious and well-thought out theory, which at first sight would appear to have a great deal in it, but it will not stand up to close investigation, and the examination of a large number of specimens under all sorts of conditions clearly proves the theory to be quite untenable, and shows that black silk cannot possibly have had anything at all to do with the actual production of either chatoyancy or asterism.

In the first place it has been clearly proved that to produce a band of chatoyant light it is essential to have a fibrous structure which must be evenly distributed over at least the surface of the cut stone. This applies to ordinary silk in all cases, but does not apply to black silk, which is very often entirely absent from stones which are highly asteriated. Furthermore, when black silk is present it very seldom shows regularity of arrangement, but occurs in isolated patches scattered about in the stone. And again, black silk is quite common in perfectly transparent stones which show no signs of chatoyancy, but if ordinary silk is present in such stones, even in the most minute quantities, it will always produce a sheen of some kind. More conclusive still is the fact that very distinct chatoyancy and asterism will be found in other species of stones in which black silk is never to be found at all; as a matter of fact neither is ordinary silk, but in all such cases some other form of fibrous structure is always present. In any case, the description *fibrous* cannot possibly be held to apply to black silk. These few obvious facts only too clearly prove that the theory is erroneous, and must therefore be rejected.

The often quoted theories that the phenomenon is due to enclosed negative crystals, or to enclosures of the so-called rutile needles, are so childish, and show such a lack of ordinary common thought that they are quite unworthy of consideration.

Apart from being the actual exciting cause of asterism, there is a possibility that black silk has connection with its production, but in quite a subsidiary way. Mr. Albert Ramsay, the well known connoisseur and expert on star stones, makes the following statement:

> Star sapphires possess a property of which even many jewellers are ignorant, i.e., no matter into how many parts a star sapphire may be cut each fragment will contain a six-pointed star of elusive light.[3]

3 Ramsay, A. (1925) *In Search of the Precious Stone.* New York, Albert Ramsay & Co., 50 pp. (see p. 26).

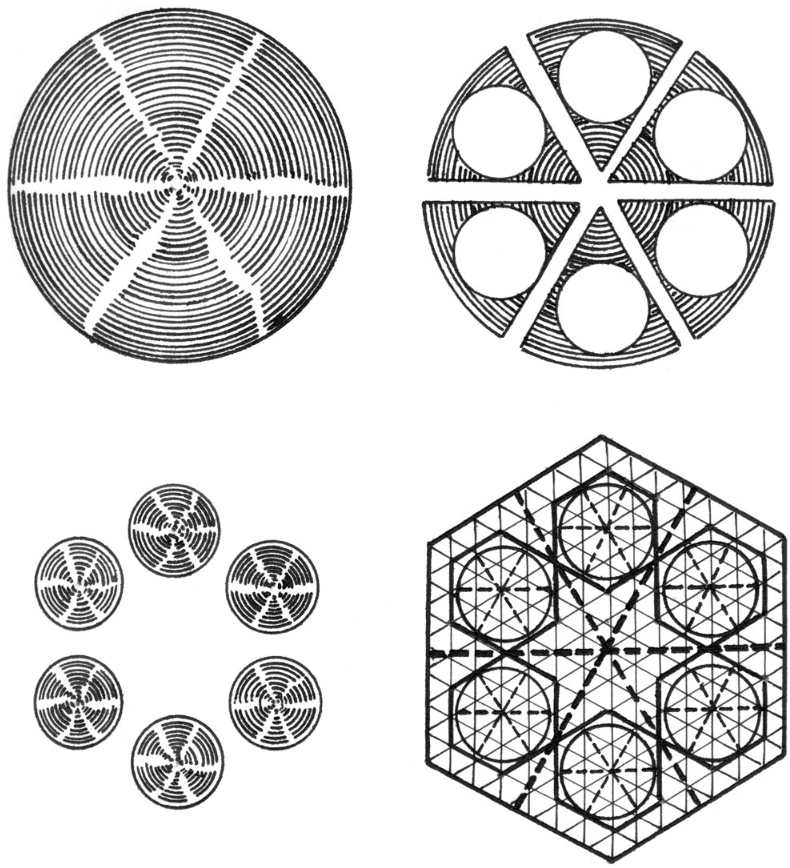

Figure 16.4
The production of several smaller stars from a larger one.

This statement is, however, somewhat like the curate's egg. Parts of it are excellent, as the writer has experimented quite extensively in this direction, and finds that some of the fragments when rounded off will produce a star, but by no means all of them will do so. In these experiments the fragments were ground to the shape of a sphere and carefully polished, after which they were examined for any signs of either chatoyancy or asterism. In a fair number of cases a distinct and perfect star would be found; in others a distorted or mutilated star, sometimes only a single chatoyant line, but most frequently only a general pearly sheen was apparent. However, these experiments show that Ramsay's statement, amazing as it may read, is at least partly correct.

This would appear to entirely upset all the preconceived ideas already explained to account for the actual cause of asterism, but it really does not and only induces a new line of thought, which in a sense takes us back to the time of the Abbe Haüy (1742–1822 A.D.), upon whose ideas are based the modern knowledge of cleavage, and the entire science of crystallography. He imagined crystals to consist of minute particles each having the shape of the actual cleavage figure for that particular crystal, and assumed that a crystal with say a cubic cleavage was built up of an immense number of exceedingly minute cubes entirely filling the crystal space, but without interstices. This theory was afterwards discredited and held to be utterly impossible, but modern knowledge has since proved the old Abbe to have been substantially correct. The modern space-lattice theory in which the arrangement of the atoms composing a crystal is photographed by means of x-rays, and then measured, shows that they are actually arranged in the form of a cube, although not necessarily a solid one. The minute size of which may be gathered from the calculation that one cubic millimetre of a diamond would contain 22,831,487,053,000,000,000 such molecular cubes of carbon.

In the case of black silk we have seen that the fine black lines bear an intimate relation to the solution planes, and that disintegration products may be found along the lines of such planes, which points to the very obvious fact that corundum crystals, as we observe them, are not simple crystals.

If we closely study the heavy black lines in the above reconstruction of Figure 16.5, it will be seen that if the fine lines crossing each other at angles of 120° are joined up, they will produce a series of smaller hexagons which are so intimately twinned together that the faces of one hexagon will provide similar faces for other hexagons, and that further, each of these small hexagons is built up of six equal triangles whose apices meet at the centre. Other combinations of these smaller hexagons will again build up larger ones, all twinned together in precisely the same manner, and the whole of the hexagons so produced will be found to centre round one small hexagon composed of six triangles with their centres in the exact centre of the figure. From these observations it is but a step further to assume that the main crystal itself is really composed of an orderly mass of countless millions of other microscopic, but still perfect crystals. Further, each of these crystals will contain its own ultra-microscopic ordinary silk and the

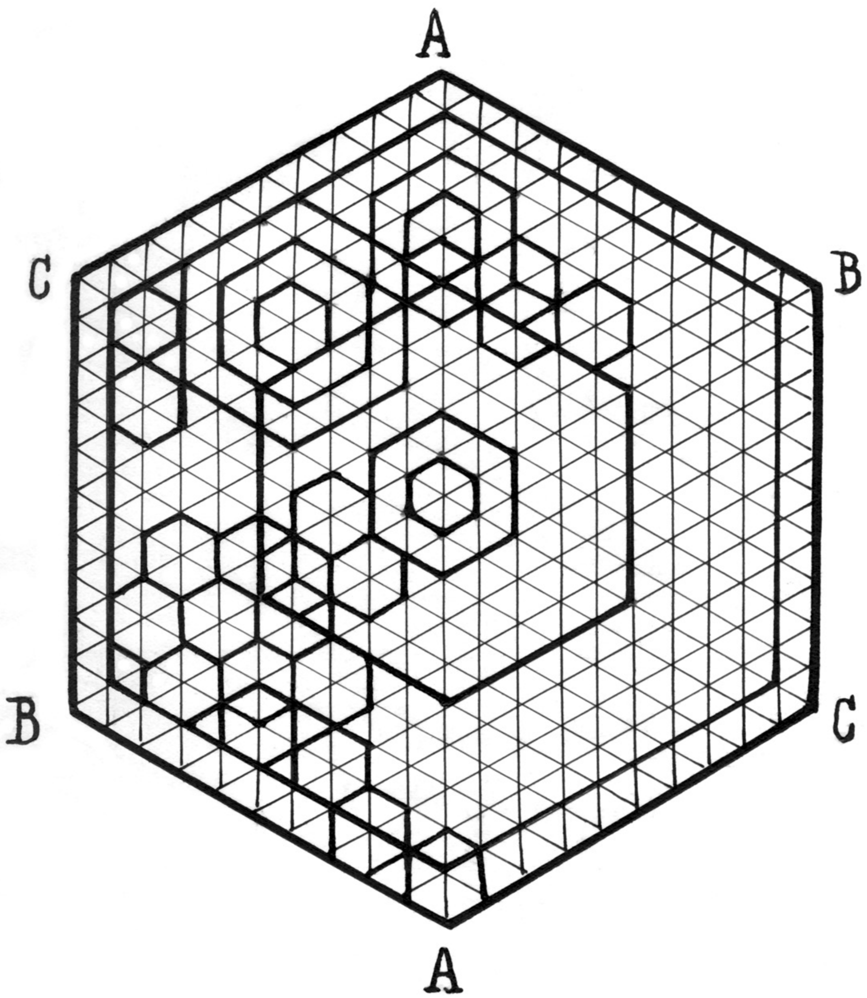

Figure 16.5
The molecular atom theory in regard to black silk.

distinct black lines of the black silk are but microscopic lines of parting along the faces, or parts of faces, or groups of these ultra-microscopic hexagonal crystals, which have combined to form a larger and optically visible crystal. This shows that the complete crystal is in the incipient stage of breaking up, which is clearly proved by the presence of disintegration products along the planes occupied by these lines. It will also be observed that the faces of the hexagons so produced will always be parallel to the faces of the parent crystal, no matter in what position they may actually occur. Therefore in breaking up a crystal, or cut stone, certain of the fragments, but not all of them, would be found to have hexagonal faces, with their own ordinary silk parallel to them, and these when rounded off would produce the effect of asterism on a smaller scale. So even in the tiniest fragment, the ordinary silk would still be responsible for the incident of asterism.

Asteriated corundum occurs in all colours wherever gem corundum is found, but it is uncommon in the corundum from Montana, and, although it has been observed, is almost unknown in the rubies from Siam, owing to the almost complete absence of ordinary silk from these rubies, its place being taken by included acicular crystals of tito-magnetite, or the so-called Siamese silk. Star sapphires are the most abundant, although stones of fine colour and of really first-class quality are decidedly scarce. Paler blue stones are much more common, while those of a bluish to almost pure grey are very common; but such stones, even when quite large and showing a fine star, are of but comparatively little value. Really fine star rubies of the best colour are exceedingly rare, and even fine stones of a paler colour are very much on the scarce side, but rose red, pink or opaque red to pink stones with much visible silk, and often a broken or distorted star, are moderately common. But everywhere the occurrence of red star corundum is very much less than the blue variety. Quite opaque stones of purple ranging through magenta to pure violet are fairly common and make very attractive gems. It is a common practice to offer such stones as star rubies, which is ethically wrong and should be discontinued. Yellow star corundum is also fairly common, but green is rare. Pure milky-white star corundum may sometimes be met with, but is on the whole far more curious than attractive. A somewhat uncommon form is the sub-translucent to quite opaque variety known as *adamantine spar,* which may be found in various shades of light to dark brown, and is often very distinctly asteriated, but may only show a single band of light, or merely a chatoyant patch. This is really a variety of fibrous commercial corundum which may occur in any deposit, but stones suitable for gem use are not at all common; it is very highly esteemed by the Chinese.

Chatoyant corundum may also be found in all colours being marketed under such names as sapphire, ruby, topaz cat's eye, or opalescent sapphire or ruby. These stones are normally cut as very low cabochons, or as flat plates, and are also common in the form of beads and carved stones.

It is an important point that the stellate appearance of asteriated stones cannot be imitated, so that the slightest trace of it is proof conclusive that a

Figure 16.6
Natural star stones.

stone is genuine, but not of necessity that it is corundum; although it does prove that it is not synthetic corundum.

There is another rare form of star corundum which may conveniently be dealt with here, although the effect is not due to optical causes; but the two forms bear a certain outward resemblance, and have been confused with each other. In true optically-asteriated corundum, the star is very seldom visible in the rough stone, although it very rarely may be so, but in the so-called natural stars, it is always distinctly visible before the stone is cut or polished. Also in the optical stars the effect is always upon the surface of the stone, and in the natural stars it is in the interior of the stone itself, and penetrates right through it. In these stones, the colour is arranged in the form of six triangles with their bases towards the edge of the crystal and the apices pointing to the centre, each triangle being separated by a perfectly colourless band. The coloured portion may often appear to be faintly fibrous, but this is in no way concerned with the production of the star. Such stones are very rare indeed, and are only found in the blue and yellow varieties, their occurrence in ruby never having been noticed. A somewhat similar appearance may sometimes be observed in haüynite, but there the star is ragged and often indistinct. Natural stars are usually to be found in the form of flat plates, which are of insufficient thickness to round off even into the flattest form of cabochon; and are often but very imperfectly polished owing to usually being so badly cracked that they have to be set round with a band of gold to prevent them falling to pieces. They are worn in the form of amulets, and are considered to bring the wearer great luck. Therefore they are much sought after by certain superstitious sects in the East, and indeed in some parts of Northern India they are objects of veneration, and will realise quite high prices.

There is also another variety which but very rarely occurs in crystals of sapphires, in which the opaque silk is arranged in the same manner as the colour in the above stones, with a line of some dark included material separating each triangle, thus forming a star. These stones are always opaque, and their appearance, if not very attractive, is certainly unique.

Until comparatively recently star stones of all kinds were quite neglected and only realised very poor prices, and were even then merely regarded as curiosities. But today they are much sought after, and fine specimens will command very high prices upon either the American or French markets, but less-perfect stars may still be bought at quite moderate prices. Poor specimens, more especially sapphires of a dull insipid grey colour, are almost valueless; although the writer has known unwary tourists to pay very high prices for them both in Rangoon and Siam.

Really first-class stars of either ruby or sapphire are exceedingly difficult for the ordinary dealer to obtain at first hand, as all the larger American and European dealers maintain agents at all the mining centres whose business it is to snap them up immediately as they are mined, and they will pay almost any price for superfine stones, so that it is only by an accident that one ever appears upon the open market.

It has been noted that the fibrous structure producing asterism will often persist throughout the entire length of the crystal, although such is not always the case, as it is frequently possible to cut both clean transparent stones and perfect stars from the same crystal. But where it does so persist, a clever lapidary will be able to produce quite a number of perfect star stones from a single crystal.

Once in Ceylon the writer examined a sapphire which was remarkable both as an example of a curious star, and in illustrating the skill of an expert native cutter in adapting the peculiarities of a stone to suit his own purpose. This stone consisted of a large transparent sapphire of good colour, cut with a trap-cut base and facetted top, but only so far as the side facets were concerned, for the table which was translucent was cut to the shape of a moderately high dome, and exhibited a perfect star. It was at first thought that this was a cleverly arranged doublet, but examination proved it to be a solid stone.

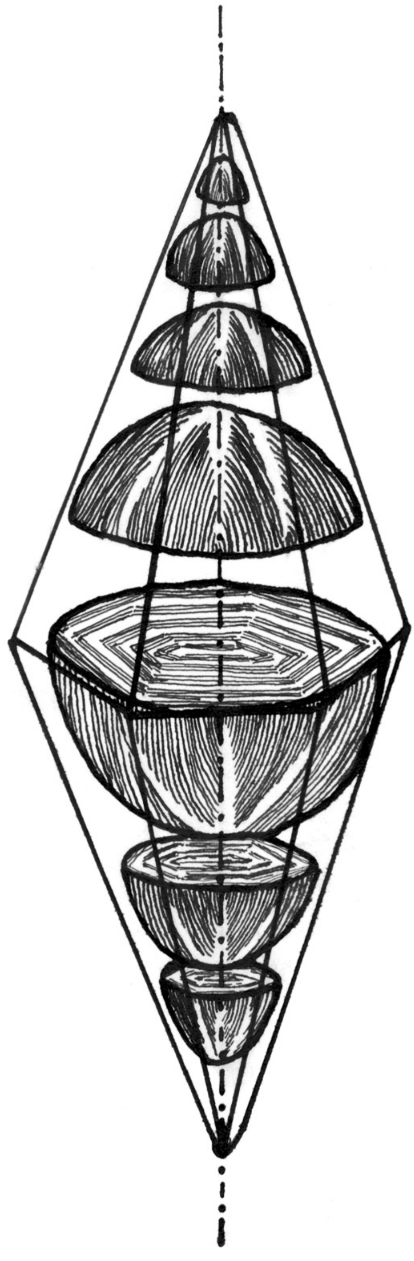

Figure 16.7
Cutting several stars from a single crystal.

Figure 16.8
A star corundum with a carved top.

Another curious star corundum from Mogok was one in which the portion bearing the star was of a reddish-violet colour and the carved top of a fine dark red, intersected by bands of pure white opaque silk. It was produced by a local lapidary, and the back of the stone was engraved with an intricate design, which included quite a good portrait of Queen Victoria.

To obtain the best effects, star stones are always cut in some form of cabochon, usually as high as possible, with the base either round or oval. This is usually left unpolished, which is said to enhance the effect of the star, but how it does so is difficult to understand, and in the writer's opinion is nonsense. Neither is the very high form of cutting an absolute necessity, and is very often greatly overdone, resulting in the production of an ugly stone which is both difficult to mount effectively, or to wear. The writer once had brought for examination a large dark transparent ruby cut to the form of a very flat shell, yet on one side of this flattish surface there appeared a small but perfect six-rayed star. The microscope showed this to be caused by a very tiny isolated patch of silk.

The points to be noted in judging a star ruby are that it must first and foremost be of a good even red colour, and preferably translucent, but this is of secondary importance so long as both the colour and star are perfect. There should be no signs of bands of silk being plainly visible on the surface, and cracks or other surface imperfections should be entirely absent, while it is essential that the polish should be superfine. The point of junction of the rays of the star must always be central at the apex of the stone, with the full number of six rays extending in an unbroken, and undistorted, line down the full sides of the stone to the base, or very nearly so. The rays must be fine but not too thin, or the effect will be poor; but above all they must not be too thick, or they will appear to be coarse and diffused, whereas they should be bright, delicate, and perfectly sharply defined.

The points of a good star sapphire are exactly the same, but a good blue colour is of vital importance, and also the absence of visible bands of silk; but the milkiness of the Kashmir sapphire is a point in their favour.

The defects of star stones are bad colour, uneven distribution of colour, plainly visible bands of silk on the surface, which gives the stone a patchy appearance, or imparts a grey colour. Visible cracks or surface blemishes and pits are fatal faults, as also are a poor polish, uneven shape, or ugly form of curvature. Missing, broken, or distorted rays to the star, or a poor dull diffused effect, are the worst faults of all. Owing to the opaque nature of the stones, internal flaws and cracks should always be carefully watched for, as star stones, especially when bought mounted, will often be found to be so badly cracked that they will fall to pieces when worn.

If a star-stone is examined with two strong lights a few feet apart, and directly overhead, it will very often, but not invariably, show two distinct stars with their centres slightly removed from each other near to the apex of the stone. Therefore when examining a star-stone it is always necessary to do so in a single light, as two lights coming from different directions will completely spoil the effect of the star, and may obliterate it altogether. A star should always be examined in a room lit by one window, or in a passage where the light only enters by one door, and never in a room lit by windows placed both at the back and front; and never under any circumstances should it be examined in a semi-darkened room.

The ideal way to examine a star-stone is in direct bright sunlight and, failing this, at the bottom of a cardboard tube about three inches in diameter and four long, lined with black velvet, and with a powerful electric light directly overhead.

For the purpose of enabling star stones to be quickly examined under ideal conditions of lighting, the writer has devised a little instrument which he calls the *Asteriascope* (Figure 16.9), which consists of a round metal box (A) which is a tight sliding fit over a second box (B) secured to a heavy base (C). The stone to be examined (E) is secured by a touch of wax to the small

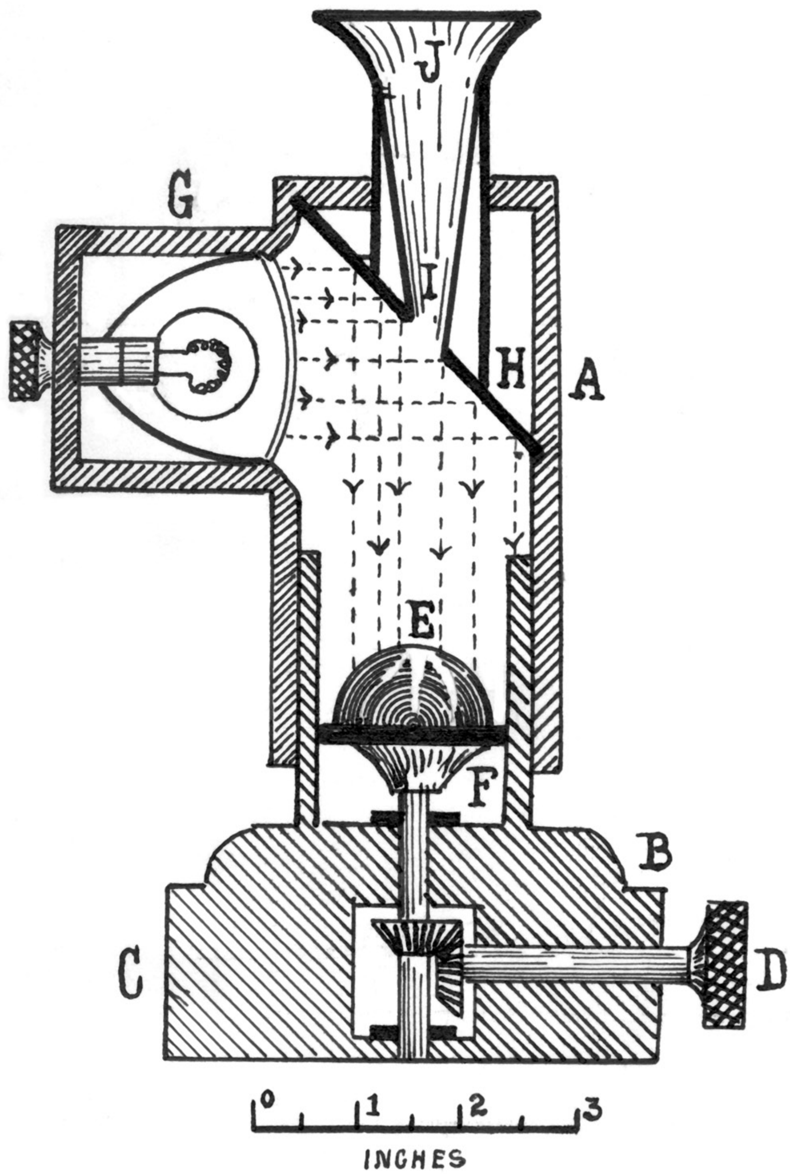

Figure 16.9
The Asteriascope.

stand (F), which can be rotated by the knurled knob (D). Across the top of A is placed a mirror (H) set at an angle of 45° to reflect directly downwards; above this is placed a tapering eyepiece (J) and where this meets the back of the mirror at (I) an unobstructed view of the stone below can be obtained. At the side of A is attached a small box containing a powerful electric light (G), so arranged to throw a strong beam of light onto the mirror, which reflects it vertically downwards directly onto the apex of the stone; the whole of the interior of the instrument is lined with black velvet. The stone is then examined by looking downwards through the eyepiece, and is slowly rotated so that the star and stone may be examined from every side. This is also a very useful instrument for examining any form of cut stone by artificial light; and is especially useful to the lapidary for examining a roughly polished star stone to enable him to judge the best shape in which to finish the stone, and the exact position in which to place the apex to obtain the best effect in the completed stone.

17
IMITATIONS AND LABORATORY PREPARATIONS

Early glass imitations ✤ Modern glass imitations ✤ Paste or Strass ✤ How paste is made ✤ The physical characteristics of paste ✤ How paste is coloured ✤ How to distinguish between paste and a natural stone ✤ Composite stones ✤ Doublets ✤ Triplets ✤ Artificially coloured doublets ✤ Hollow doublets ✤ Built-up stones ✤ The detection of composite stones ✤ The reconstructed ruby, and it physical and optical characteristics ✤ Laboratory attempts to make artificial corundum ✤ Fremy's experiment

On account of their rarity and attractive appearance, both rubies and sapphires have been imitated in glass from the very earliest times; imitation rubies have been unearthed from the ancient Celtic graves, and even Pliny voiced a strong word of warning regarding them. These ancient glass imitations were very crude affairs indeed, and the only thing that can be said in their favour is that sometimes the colour was quite good; otherwise they would not deceive a modern child.

Today glass imitations may be freely met with everywhere, and range from a very poor cheap form of ordinary glass, which when molten has been simply pressed into a mould to give it some resemblance to a facetted stone, to those made from a carefully prepared and expensive paste of a beautiful colour and fine appearance. The ordinary poor cheap variety of a non-descript colour, which may be bought for a few pence a gross, are mostly used in the trimming of dress and other materials, or for theatrical or general decorative purposes. They can immediately be distinguished for what they are by a casual glance. Better qualities are mounted in trashy pinchbeck settings, and used for the purpose of purely sham jewellery. The higher grade ones are often mounted in good settings and sold as high-class imitations, and have not infrequently been used for the purposes of fraud; they are also often mounted as duplicates of really valuable pieces of jewellery, which are used for ordinary everyday purposes while the originals repose in the bank. The general appearance of such imitations may often be very fine indeed, and anyone other than an expert is very liable to be deceived by a mere visual examination.

The manufacture of coloured glass for the making of imitations has now reached the level of a fine art, and a considerable amount of skill and experience is necessary in its preparation. The variety used for making the better qualities is variously known as *Strass* from the name of its inventor (about 1750), and in the trade as *Mainz flux,* but more commonly as *paste* from the Italian pasta-food, in allusion to its soft plastic nature when in a molten condition. This forms the basis of all high-class modern imitations, and is in the first instance nearly always prepared in its colourless state, and afterwards remelted with various colouring agents. In this first condition it is essential that it should show the highest degree of transparency, and also be absolutely free from the slightest trace of colour of any kind. It therefore follows that all the chemical ingredients used must be in the very purest state obtainable, which means that they are not only expensive, but that extreme care must be taken in their selection and testing before use. The silica used is usually water-clear rock crystal (quartz) finely pulverised, but sometimes a very pure form of white glass entirely free from lead may be employed. Ordinary sand, being impure, is never used.

There are endless formulae for the preparation of paste, of which the following may be taken as being representative examples, No. 6 being possibly the most common formulae in general use.

1. 3 parts silica, 2 saltpetre, 1 borax, ½ white-arsenic
2. 9 silica, 3 potassium carbonate, 2 red-lead, 3 borax, ½ white arsenic
3. 8 white glass, 3 rock crystal, 3 red-lead, 3 borax, ¾ saltpetre, ⅙ white arsenic
4. 7½ silica, 10 red-lead, 1½ saltpetre
5. 33 silica, 50 red-lead, 17 potassium carbonate, 1 borax, Ä white arsenic
6. Silica 41.60%, potassium carbonate 8.40%, red lead 50.0%

The ingredients are first powdered separately, then intimately mixed, and afterwards ground to the finest state of division obtainable, and passed through a very fine sieve. The powder so produced is placed in a crucible and fused, the heat used being only just sufficient to produce complete fusion. As soon as this is attained, the heat is very gradually reduced so that the mass does not become quite cold until twenty four hours have elapsed. As it is necessary that the finished paste shall be as free from enclosed bubbles as possible, the greatest care must be taken while it is in a molten state that it does not overheat, and on no account should it be allowed to boil at any time; further while it is slowly cooling it must be absolutely

Table 17.1: The effect of adding colouring agents to glass

Colouring agent	Colour produced
Cobalt nitrate Add a tract of manganese oxide	Blue Blue tinged violet
Chromium oxide or copper oxide Add a trace of cobalt nitrate or red antimony.	Green Green tinged blue Green tinged yellow
Powdered coal Add a trace of manganese oxide	Yellow shades Golden yellow Note: Coal can only be used when the paste is entirely free from lead
Manganese oxide Add a trace of cobalt nitrate Add a larger quantity	Reddish violet Pure violet Reddish brown Note: The manganese must be entirely free from iron, the slightest trace of which will ruin the mass
Gold oxide, gold chloride or cuprous oxide.	Various shades of red
Purple of cassius (oxides of tin with metallic gold)	Fine ruby red

undisturbed the whole time. Neglect of these precautions will inevitably cause bubbles to form, but even with the greatest care it is quite impossible to prevent them altogether, and a certain number will always be formed, which are characteristic of glass being spherical in shape.

The lower the percentage of lead in the paste, the higher the abrasion hardness and the greater the lead content, and the higher the specific gravity, index of refraction and dispersion. The specific gravity may be as high as 3.80 in ordinary paste, but the hardness is seldom above 5, and may be much lower. If the potassium carbonate is replaced by a salt of thallium, the specific gravity will increase to between 4.18 and 5.60, and the dispersion will rise to about 0.049, which is higher than that of some diamonds.

Practically any desired colour may be obtained in paste by adding the right proportion of the correct colouring agent, which usually consists of some form of a metallic oxide. These colouring agents may be added prior to the original fusion, but it is found that better results are obtained by grinding a known quantity of the colourless paste to a fine powder and then intimately mixing with it the correct amount of the colouring agent, after which it is reground to the finest possible state of division obtainable.

This mixture is then fused exactly as before, but greater care must be taken that the temperature is kept perfectly even, and that it is only barely sufficiently high to keep the mass just molten, in which condition it is maintained for about thirty-six hours and then allowed another twenty-four in which to very gradually cool. Absolute freedom from movement, or the slightest shaking of any kind is of vital importance at this stage; otherwise the colour will be uneven and patchy, in addition to the formation of the tell-tale bubbles.

Only a very small quantity of the colouring agent is normally required, and great care and considerable experience is necessary in the compounding of this, as the slightest excess will completely ruin the whole mass by making it too dark; the reverse being the case if the quantity is under-estimated, but the effect may not be so marked as in the case of an excess.

The above are but a few of the agents employed, of which there are a large number of substances used in various combined forms, but the majority of the actual formulae are jealously guarded trade secrets.

The actual cost of production of first-class paste imitations is by no means low, as owing to the high degree of purity demanded the cost of the raw materials is considerable, and the skilled labour employed also commands a correspondingly high rate of wages. Add to this the fact that these glass imitations are cut and polished by a lapidary with every bit of the same care and attention as is given to a natural stone, it follows that they must always command a good price on the retail market. Gablonz, in Czecho-Slovakia, is probably now the largest centre for the manufacture of paste imitations of all kinds.

Every form of glass imitation of corundum may be at once distinguished from the natural stone by invariably being only singly refracting, and therefore monochroic in all directions, which is the exact reverse of all varieties of corundum. Their hardness is always somewhere near 5.0, as against the 9 to 9.25 of corundum. If touched with the tip of the tongue they will feel warm, while corundum will feel distinctly cold. If a fine point of aluminium be drawn across the surface of paste it will leave a silvery mark, but will leave no mark on corundum. The test for specific gravity (S.G.) is useless, as paste can be made to almost any required S.G., but it will normally be found to be under 4.180. Similarly the refractive indices are unreliable on account of their great variation, but they will usually be too low for corundum. Under the microscope, paste will always be found to contain bubbles, which are always spherical in shape, or have rounded forms, and never, under any circumstances, will they show the geometrical

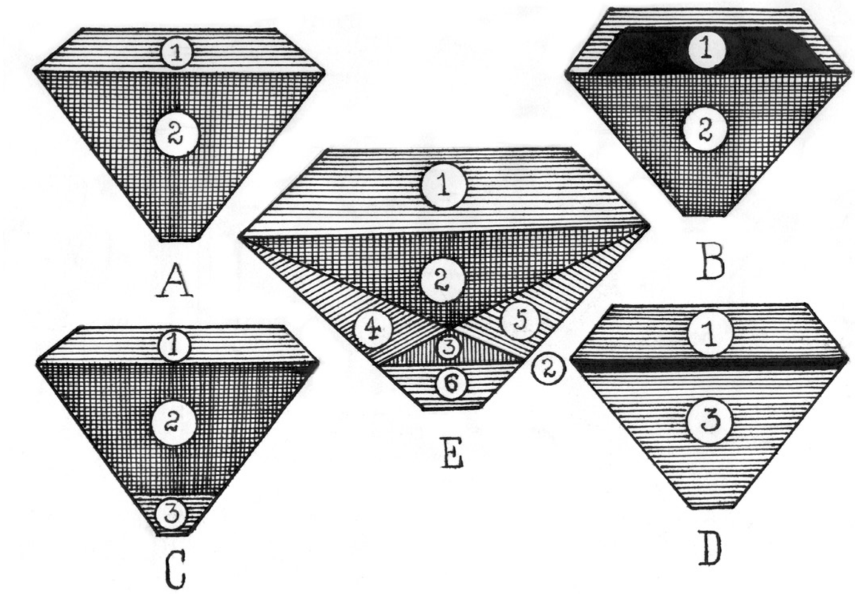

Figure 17.1
Composite stones.

shapes and angles or plane faces of the negative crystals enclosed in corundum.

When examining any form of old jewellery, always be on the alert for paste, and carefully examine each stone with a good lens, more especially the edges of the facets, noting if these appear to be much rounded or worn, and, if chipped, carefully examine these to see if they exhibit the typical conchoidal fracture of glass in a minature form. Signs of excessive wear will always indicate a soft substance, from which is reasonable to at once suspect glass, which can then be confirmed by the above tests.

A class of imitation mainly used for the purpose of deliberate swindling is to be found in the so-called *doublets* and *triplets,* which are composite stones specially prepared to trap the unwary (Figure 17.1). There is nothing new about them as they may be met with set in very old jewellery both of Western and Eastern origin, but are more common in old French and modern jewellery of Eastern manufacture. There is no doubt that they were originally introduced to combat the softness of glass, and so prevent it answering the ordinary file test of the old jewellers for hardness, and that the second use for imparting a fine colour to poor specimens was but an elaborated afterthought.

The ordinary doublet (A) was the first to be introduced, and consists of two portions, the upper of which is a thinnish crown (1) of cheap hard stone such as quartz, or topaz, or may often be cut from a poorly coloured or quite colourless piece of the stone being counterfeited, cemented to a thick base (2) of finely coloured glass or paste, and the whole facetted and polished. As it is only the crown that will defy the hardness test, such imitations are usually mounted in a completely closed setting, with the base quite concealed, and often backed with foil of various kinds.

The triplet (C) came at a later date, and as before consists of a thin crown of hard material (1) cemented to a thick layer of coloured glass (2), but with the apex of the base also consisting of another piece of hard material (3). Such stones will usually be found mounted in a high form of open setting, so arranged that while the crown and base apex are visible and may be tested for hardness, the centre portion is so concealed that it cannot be tested, or a sideways view obtained through it.

It then seems to have been realised that the triplet form could also be utilised to impart a fine colour to two colourless, or very poorly coloured pieces of a genuine stone, which was done by cutting the crown and base apex much thicker than in C 1–3, and cementing between them a thin layer of fine coloured genuine material, which when the stone was viewed directly through the table gave it the appearance of being of a fine colour throughout. But this was expensive so the form (D), which is really a doublet was evolved. This consisted of a colourless, or poorly coloured, stone slit in two at the girdle, and then cemented together with a highly coloured transparent cement, which coloured the whole stone by reflection when viewed from the top. This was subsequently improved upon by inserting a very thin film of coloured gelatine at D/2, but thin slices of glass, and even thin coloured metal foils have been found used in a similar manner. Sometimes the base (D/3) will consist of some form of glass.

A somewhat similar form to the above is known as the *hollow doublet* (B), in which the crown, of hard or genuine material is made quite thick and carefully ground out to a shell-like form (1), the interior of which is highly polished. This cavity is completely filled with a coloured liquid before being cemented to the base, which may consist of either genuine or inferior hard material, or of glass.

Another form of swindle, in the manufacture of which certain classes of Eastern jewellers are experts, is the ally of a fairly large size, but is really

Figure 17.2
The examination of a composite stone.

composed of a number of carefully matched small pieces carefully ground to shape and then cemented together, after which it is finally ground and polished as a complete facetted stone.

All of these forms of swindle, with the exception of B, are by no means so rare as most people imagine, and when examining mounted jewellery of any kind it behoves one to be well on the lookout for them. Whenever a large, and apparently valuable stone, is found to be close set so that a sideways view cannot be obtained through it, it should always be suspected, and more especially so, if the jewel is reputed to be of a Eastern origin.

The detection of doublets and similar fakes is a fairly simple matter, but it can never be done in a satisfactory or conclusive manner with the stone mounted in any form of setting. Therefore, once a stone is suspected, it should be demounted before an examination is attempted, and any refusal on the part of the vendor to permit this should be regarded as a very suspicious circumstance, and in the case of a persistent refusal the stone should be left severely alone. Place a small piece of wax, or plastacine, on the point of a pencil, and to this attach the stone by its girdle, and then in a strong transmitted light examine it with a good hand lens in a sideways direction, parallel to the table, and directly through the girdle.

In this way it is usually possible to clearly observe the cemented faces, owing to the interference of light along the planes where they occur, but it may not always be possible to do so. If these cannot be seen, carefully examine the make of the stone, and note if the crown appears to be so thin as to be out of all correct proportion to the thickness of the base; and then look for differences in colour, which will give the stone a banded, or layered, appearance. It will frequently be observed that the crown, and possibly also the point of the base, will be quite colourless, while the central portion is of a deep colour. This is of course a conclusive sign that there is something radically wrong. If any doubt still exists, grip the stone in the forceps by the table and culet and immerse it in a small beaker of a highly refracting liquid, such as monobromonapthalene, or one of the colourless oils, and repeat the examination. The cemented joints should now become very plainly visible, and any difference in colour most marked; also, owing to the differences in the refractive indices of the three substances, the cement being one, each will present a distinctly different appearance when so immersed. If this examination can be made under a microscope with a one- or two-inch objective, so much the better. Take the specific gravity and note any difference from that of the genuine stone, a considerable variation often being found. Next test for hardness, and if possible for refractive indices, in different parts of the stone, and note any differences. These tests should settle the question beyond any possibility of doubt, but should any remain, or absolute proof be demanded, there is still a remaining concrete test, but this involves the destruction of the stone. The cements used are without exception all soluble in either alcohol, chloroform, or ether, and if a composite stone is allowed to soak for a few hours in these liquids, it will fall to pieces owing to the destruction of the cement. This test may be performed in a few minutes by boiling in the liquid, but this is a very highly dangerous experiment for an inexperienced person to perform. It should, however, be noted that there is one very rare form of composite stone in which the component parts are fused together, and such stones will not answer to the alcohol test, but the other tests should always detect them.

Still another class of imitation, for as an imitation it must be regarded, was the *reconstructed ruby,* which first appeared upon the market in 1885 from Geneva, although it is very doubtful if these stones were ever really manufactured in that town. Reconstructed rubies are even today confused with the synthetic variety, and it is quite a common thing to hear a stone referred to as being reconstructed, meaning that it is synthetic, but in reality they are two entirely different and distinct things. Nowadays synthetic rubies flood almost every market; but true reconstructed rubies are very seldom to be found upon the open market, save at the sales of old pieces of jewellery, and not too often then.

Reconstructed rubies were first prepared by taking small stones and fragments of a well-matched fine colour and reducing them by grinding to an impalpable powder, and then without the addition of any colouring matter whatsoever, fusing them in a special crucible into a homogeneous mass at a very high temperature in the oxy-hydrogen furnace. Then the resulting mass was cut and polished, it would usually produce quite a fine looking stone. It was very quickly found that the raw material of the finest quality and colour was not only expensive, but was also so scarce that sufficient quantities could not be procured; thus something less expensive and more abundant had to be found. Almost or quite colourless rubies were then reduced to powder and bichromate of potash and other colouring agents added before fusion. The commoner varieties of dark stones were said to be quite unsuitable for use in this process, as they produced stones of a bad and uneven colour, although why this should be so is somewhat difficult to understand.

The substance usually produced by fusion was a curious kind of hybrid which in some ways behaved more or less like crystallised corundum, and in others like an amorphous substance, such as glass. The hardness was normally about 9, but sometimes fell to between 8 and 8.5; in other words, it was harder than topaz, but would be scratched by chrysoberyl. The specific gravity was usually within the limits of true corundum, but appeared to vary with the different colouring agents employed. The refraction was usually double, but this had the appearance of being anomalous, and was sometimes clearly single in all directions through the stone. The dichroism was very variable, in some cases being very strong, and in others the stones were monochroic in all directions. Axiality could not be definitely determined as the interference figures, when observable, were almost invariably abnormal, but some of the stones appeared to be uniaxial. The refractive indices generally conformed more to those of glass, but were on the whole very variable. Under the microscope the general structure presented the appearance of an amorphous substance. These characteristics all point to the fact that it was not a crystalline, but an amorphous, or glassy, substance which had been produced, and which was in a state of internal molecular strain, and further that the observed birefringence was in all cases anomalous.

With the exception of the stones prepared from pure ruby, without the addition of colouring matter, the colour was never quite right, and an expert could detect them at a glance. Microscopic examination revealed the interior to be full of minute cracks, which were often so numerous as to give the stone a cloudy appearance, or to impart a curious internal sheen, which was triumphantly hailed as silk, although it was really nothing like it. The characteristic spherical bubbles were always present, often in quantity and of quite appreciable size, while even microscopic bubbles were frequently so numerous as to render the stone almost opaque. In use, the majority of these stones darkened to a very appreciable extent with age, and many showed a decided tendency to fall to pieces for no apparent reason.

These imitations were freely advertised and sold as exactly what they were, and were soon in great demand. They did a certain amount of harm to the trade in genuine rubies, and were the basis of several deliberate frauds. Their popularity was, however, but very short lived, as they were quickly found to be unsatisfactory, and as soon as synthetic corundum appeared they fell into such complete disuse that it is very doubtful if one could be purchased in the ordinary way today.

True reconstructed sapphires or the other varieties of corundum were never produced on a commercial basis, although it is so often stated that they were, but a considerable amount of quite unsuccessful experimenting was carried out in this direction.

Corundum would always appear to have exercised a great fascination over the experimental chemist, who from quite early times seems to have been engaged in repeated attempts to make it artificially in gem form. From time to time they did succeed in producing substances which were said to be true rubies, but the records of these experiments are so vague, and often so contradictory that it would appear very doubtful if any of these substances were really corundum at all. It is, however, of considerable interest to glance at the general lines upon which a few of the more noteworthy attempts were made.

A. By decomposing potash alum with charcoal at a high temperature. (Gaudin)
B. By exposing to a very high temperature 1 part of pure alumina and 4 parts borax. (Ebelmen)
C. By submitting metallic aluminium in a closed carbon crucible to the action of boric acid at a very high temperature. This produced rather large rhombohedral crystals which were coloured red, blue, or green by adding chromic fluoride in varying amounts. (Deville and Curon)

D. By the action of aluminium chloride on lime at a high temperature. (Daubree)
E. By fusing alumina and red lead in a small siliceous earthen crucible a fusible lead-aluminate was first obtained, which being decomposed by the silica content of the crucible material would sometimes crystallise out as small hexagonal crystals. (Fremy and Feil)
F. By the decomposition of aluminium chloride by magnesium and water vapour at a high temperature in a sealed tube. (Meurier)

The above and numerous others were but laboratory experiments, and never went beyond that stage, but they did pave the way for the French chemist M. Fremy, who in 1888 produced something which only just missed being an artifically prepared ruby. He fused together in an earthen crucible a mixture of alumina, potassium carbonate, barium fluoride, and potassium chromate, which he kept in a state of fusion for about ten days, and then allowed to cool very gradually. When the cold mass was broken open small crystals were found embedded in it, which in most respects appeared to be corundum. The crystallisation was, however, not quite right, as the crystals, which were always tabular in form, conformed more to the rhombohedral than to the hexagonal system. The colour was often of a distinct bluish violet, and the crystals were frequently parti-coloured. This was a very big step in the right direction, and there is little reason to doubt that had death not intervened, Fremy would have eventually produced artificial corundum. As it was, the seeds of his experiments lay dormant until 1904 when his pupil, Verneuil, produced synthetic corundum.

18
SYNTHETIC CORUNDUM

Synthetic corundum essentially an imitation ✤ Trade and customs classifications ✤ The growing menace of synthetic corundum ✤ The synthesis of other species ✤ Verneuil's furnace described ✤ Preparing the mixture for fusion ✤ Growing the boule ✤ The shape and crystallographic axis of the boule ✤ Distortion of the boule ✤ Pseudo outward crystal form ✤ Early synthetic sapphires ✤ The Hope sapphire really synthetic spinel ✤ Colouring synthetic corundum ✤ Synthetic spinel only a variety of corundum ✤ The physical and other characteristics of natural and synthetic corundum and spinel compared ✤ Synthetic corundum is crystalline ✤ The examination of corundum for synthesis ✤ The use of the microscope ✤ Structure ✤ Striae and colour banding ✤ Bubbles ✤ How produced ✤ How to examine bubbles ✤ Silk and pseudo-silk ✤ Surface scratches ✤ The importance of the examination for silk ✤ Internal cracks ✤ Enclosures of foreign matter ✤ Pleochroism ✤ Colour ✤ Preliminary examination ✤ Examination by X-rays and ultra-violet light ✤ The care required in examination prior to the issue of a certificate ✤ Interference figure ✤ The splitting of the boule ✤ The arrangement of the table in cut stones ✤ Fracture ✤ Sources of origin ✤ Cutting and inferior polish ✤ Synthetic corundum in India

In the whole history of the gem trade there is probably no substance, either natural or artificial, which has received greater attention from the scientists and chemists, or has caused greater anxiety on the part of the gem merchants, than synthetic corundum in its various forms. This anxiety has to a very large extent been greatly intensified by the foolish attitude taken up by a certain section of the trade with regard to the correct classification of this substance. In recent years a considerable controversy has raged as to whether synthetic corundum should be classed as an imitation or not, and strenuous endeavours, which unfortunately have been in part successful, have been made to obtain an official decision that it is not an imitation.

In is obvious that the majority of the suggestions and attempts in this direction had their origin with the manufacturers, and that they were backed up by a minority of dealers and brokers whose business mainly lay in the selling of this class of goods. It would seem that by far the larger proportion of the trade generally were opposed to the idea.

The main argument would appear to be that synthetic corundum, although a product of the factory, is, when in cut form, in every way identical with natural corundum; which betrays either a sorry lack of knowledge of the elements of gemmology or a lamentable disregard for the truth in attempting to hood-wink the public and the more credulous members of the trade. To come to plain hard facts, synthetic corundum can only be one of two things. It must either be definitely real, or definitely imitation; there cannot possibly be any half measures about it. An imitation may be defined as something which represents itself as being a thing which it is not, but by reason of more or less close resemblance, it is able to masquerade under the name of that particular thing. There seems to be no difficulty about that, so it naturally follows that synthetic corundum cannot possibly be both real and imitation; neither can it partake partly of the nature of both, so that it must be finally classed as one or the other. To definitely settle this very stupid argument it would appear to be only necessary to ask two very obvious questions:

A. Is a cut synthetic stone a gem produced from a natural corundum as mined from the earth?
B. Does it conform in every respect to the natural article?

To both of these questions the answer can only possibly be an emphatic "NO", so therefore there seems to be no further argument, and that synthetic corundum cannot truthfully, or sensibly, be classed as anything other than as an imitation.

This view was partly adopted by the International Congress of Jewellers, held at Rome in 1933, who resolved that the term synthetic should be reserved for the products of synthesis only, and that imitation should be used for all products having only an aspect corresponding to the product from which they borrow their name. Furthermore, all synthetic and imitation stones must be offered and invoiced as such; while the terms *reconstructed*, *scientific*, *genuine*, *fine*, *pirecieux*, etc., so often prefixed to synthetic stones, must be discontinued. But this scarcely goes far enough, as it does not specificly declare synthetic stones to be imitations, and attempts to avoid a definite decision by not declaring them genuine; but at the same time their definition of an imitation very obviously also includes synthetics.

It is an important fact that practically all the world's customs authorities now officially class all synthetic stones as imitations, and that in many countries it is a criminal offence to attempt to offer them as genuine stones.

The above covers a point of far greater importance than would at first appear, as no matter whether he be an ordinary lay tourist, an experienced dealer or collector, or a man who merely wishes to buy a precious stone as a gift, one and all have nowadays to be continually on their guard against being swindled by the ever-present menace of the synthetic stone, which have in many cases now reached such a high degree of perfection that their detection has very definitely become the job of an expert specialising in such work.

On account of its simplicity of manufacture, and the initial low cost of both apparatus and raw materials, corundum is the most likely synthetic material to be encountered. The so-called synthetic spinel is common enough, but as will appear later, this is but a modified form of synthetic corundum. Under a multiplicity of names, synthetic corundum of almost every hue will be found masquerading as both synthetic and genuine stones of a variety of species other than corundum. And while it is a fact that true synthetic stones of certain of these species have been produced in the laboratory, they are most unlikely to be met with in the ordinary course of events outside a laboratory, museum, or very highly specialised collection. But should one be used as a trap for an unsuspecting gemmologist, not an unknown proceeding, the general examination for corundum will at once serve to distinguish them from natural stones, but will not isolate them to their correct species, or synthetic group.

The present commercial process of manufacture may be said to have had its real origin about 1869, when Gaudin first made a corundum-like substance by fusing potash alum and charcoal in the oxyhydrogen flame, but nothing very concrete was done to improve upon this until Verneuil invented his inverted oxyhydrogen blowpipe about 1904, and made the first form of synthetic corundum which floods the market today.

At first this blowpipe was a very heavy, crude, and clumsy affair, but it has been improved upon and elaborated into the present-day highly efficient *Verneuil furnace* (Figure 18.1) – sometimes referred to as an oven, which in all its essential principles still remains the same as the original. It consists of two stout iron tubes (A, B) of which tube A is widened out into a chamber at its upper end, while the lower and narrower end passes down inside the centre of tube B, into which it is screwed to make a perfectly gastight joint. Both of these tubes are constricted to a fine nozzle at the lower end, that of A being inside and just above that of B. Pure oxygen, under pressure, is admitted to tube A by means of the pipe (O). Within the chamber at the top of (A) is suspended a small basket (C) made of very fine

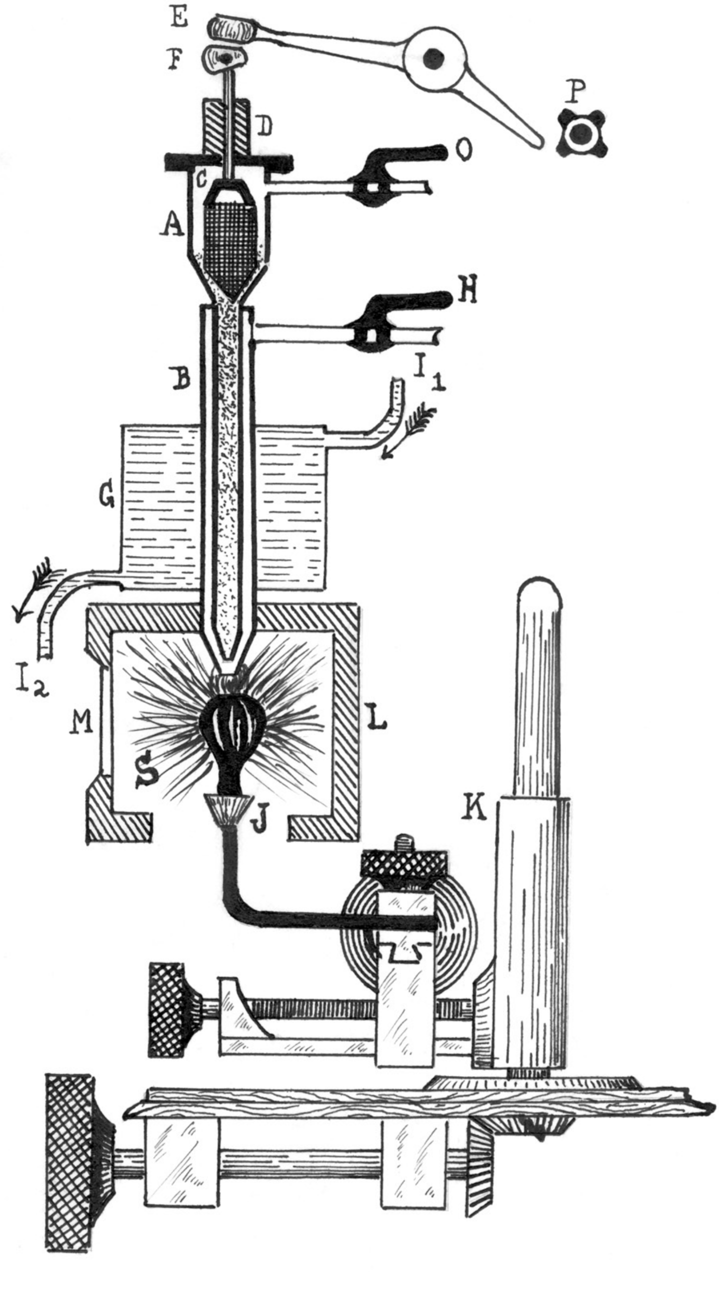

Figure 18.1
Part sectional diagram of Verneuil's furnace.

wire mesh, and rigidly fixed to a metal rod passing upwards through a block of resilient rubber (D) contained in a cylinder which forms a part of the removable, but gastight, cover to the chamber. This rod terminates in a cam shaped head (F) which can be adjusted to regulate the force with which the small hammer (E) will strike upon it. This hammer may be actuated by either an electro-magnet, or a small cam (P) revolving on a shaft, which can be so adjusted as to deliver a regular series of gentle taps at any required speed. Hydrogen – usually in the form of coal gas – is admitted into the tube (B) by means of (H); this meets and mixes with the oxygen at the lower orifice, where it is ignited. Owing to the intense heat of the flame – about 2,000°C – the iron pipes must be protected from melting, which is done by surrounding them with a water jacket (G) through which a stream of cold water is kept in circulation by means of the pipes (I_1–I_2). Below the orifice is placed a platinum, or more usually fireclay, stand fixed to the bench, and provided with screw and sliding adjustments whereby (J) can be raised or lowered and kept central under the orifice. In some of the latest models, an arrangement is fixed which allows (J) to be kept in a state of continual rotation during the growth of the boule, in order to minimise the curvature of the structural striae. To protect the growing boule (S) from cold draughts, and to maintain a more even temperature, a thick asbestos and fireclay chamber (L) is placed round it. This is provided with a mica window (M) through which progress can be watched, but to prevent injury to the eyes from the intense glare it is also necessary to use a red glass screen. A short column of alumina is fused to the stand (J) upon which to start the growth of the boule.

There are an endless number of formulae for preparing the mixture for fusion, some of which are well-guarded trade secrets, and others the subject of patent rights, but they are all more or less the same in general principle, and only differ in minor details, mostly with regard to the production of different colours. It will therefore suffice to quote here a typical formulae for the production of synthetic ruby.

Dissolve 530 grams of pure ammonia alum, which must not contain the slightest trace of potassium, in 4 litres of distilled water, and then add 150 CCs of an aqueous solution of 65 grams per litre of pure chrome alum, and boil. When boiling, add 400 CCs of pure .880 ammonia and remove the source of heat. Allow to stand for about two hours when a gelatinous precipitate will have settled to the bottom; this must be very carefully filtered through a piece of fine muslin, and the liquid thrown away. Allow the precipitate to thoroughly drain, but on no account squeeze it, and then loosely tie the muslin in the form of a bag and hang it in a large vessel full of distilled water for at least four hours, changing the water ten or more times. Again, use a piece of clean blotting paper, spreading the precipitate out well to dry. For five or more days it will be found to emit moisture. Only when this has entirely ceased may the precipitate be allowed to become quite cold; then grind it to the finest possible state of division obtainable, and screen it through a very fine mesh. It is of the utmost importance that the powder shall not only be very finely ground, but that it is also evenly screened. It is now ready for use, and will consist of about 60 grams of pure alumina containing 2.50% of oxide of chromium.

In all operations it is vitally essential that the mixture is most carefully guarded from contamination by any salt of potassium, the merest trace of which will impart an objectionable brown tint to the finished stone, and anything more than that ruin it altogether.

The prepared powder is placed in the basket C, the chamber head screwed down, and the cam and hammer finally adjusted; hydrogen is then turned on and ignited, and the whole outfit left to slowly warm up. The stand J is then centralised close up under the orifice, and oxygen slowly admitted to allow the alumina stand to partly fuse. The hammer is then started up to give gentle taps at longish intervals, and so shake a small quantity of the powder from the basket, which on passing down the tube A is blown about by the moving oxygen until when it reaches the orifice it is in the form of separate and very minute particles in a state of rapid motion and intimately mixed with the gas, in which condition it enters the flame and is instantly liquified, and falls upon the prepared alumina stand, where it again solidifies.

At first the pressure must be quite low, or the stand will be completely melted, and the boule must also be allowed to grow a little before the pressure is increased, as, if it is allowed to become too thick at the commencement, severe internal strains will be set up and a boule full of cracks will result. The pressure is then increased to give a flame sufficient to keep the alumina at the top of the boule in a molten condition, but not to allow it to boil, which must on no account be allowed to take place, or the boule will be full of bubbles. The striking rate and force of the blows from the hammer are now increased to provide a larger supply of powder, and as the boule grows it is lowered and kept central by means of the adjustments on K. The time taken to complete the growth depends upon the size of the boule, and a large one of say 250 carats in weight will take several hours to

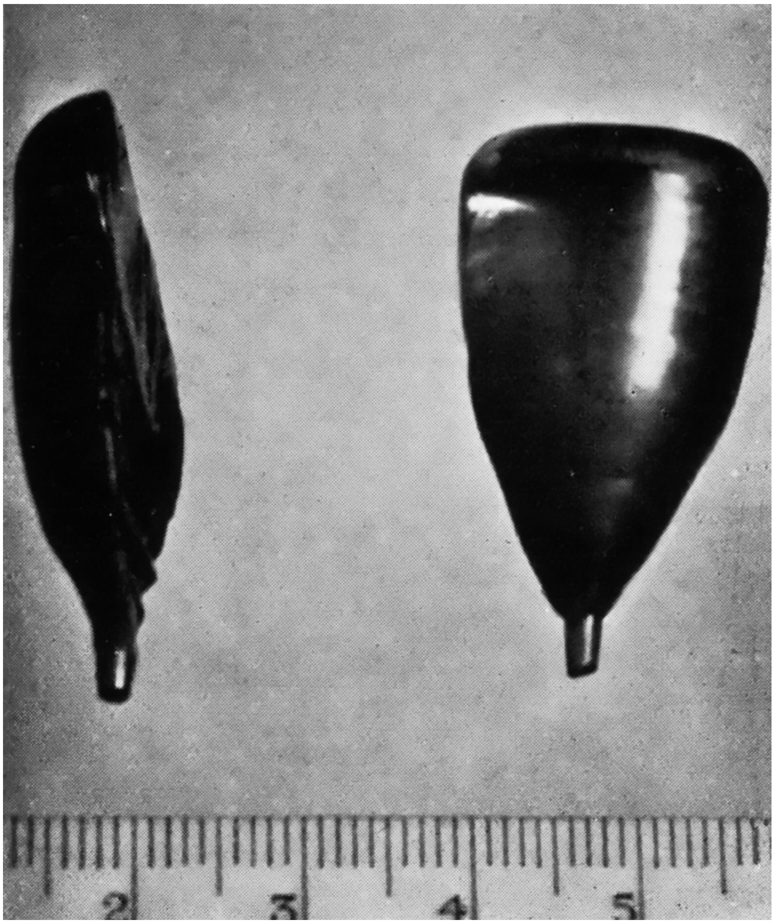

Figure 18.2
Synthetic boules. From Dollar, A.T.J. (1938) Fractures in synthetic corundum. *The Gemmologist,* Vol. 7, No. 79, pp. 553–559.

reach full size. When the desired size has been reached the hammer is stopped, and after a short interval the gasses are sharply shut off.

The finished boule is only allowed to remain in the furnace for a comparatively short time, when it is unclamped and allowed to finish cooling at room temperature, and the furnace again started up to grow a new boule. The boule already grown is not broken off its stand until it is quite cold, but it will usually split or break off on its own account during the process of cooling. The whole process is simplicity itself, and after a time becomes so mechanical that one girl can easily operate a dozen furnaces.

Normally the boule grows larger in circumference as it increases in size, so that it assumes a pear shape with the point attached to the stand. But owing to the introduction of the revolving stand, boules of very much the same shape as a drop electric light bulb, and therefore almost cylindrical in form, are becoming more common, and often they will have a distinct conic shape.

The general idea of producing the long cylindrical boule is twofold. Firstly it usually results in the production of a boule in which the crystallographic axis (A–A) lies in vertical line directly through the centre from base to apex, as opposed to the angles of 30° to 45° normally shown by the pear shaped boule. As the line of structural weakness lies in a direction directly along the crystallographic axis, the boule on cooling, or afterwards on receiving a slight blow, will normally fracture directly along this line, so that the long cylindrical shape will produce two larger pieces of a form more convenient for the lapidary to handle. As the direction of poorest colour effect lies directly along the line (B–B) the gain in size would at first appear to be of doubtful advantage when weighed against the loss in colour effect, and general appearance of the cut stone, but as will appear later there are other reasons to be considered.

The second advantage claimed is that the cylindrical form entirely eliminates the distinctive curved striae of the pear shaped boule, and produces a striae which is perfectly straight and parallel in its arrangement, and so is indistinquishable from that of natural corundum. This is not so, as the curvature of the colour banding is only slightly reduced, and is therefore always slightly regularly curved; it never shows perfectly straight parallel lines, and has moreover an utterly distinct and different appearance to that of natural corundum. Furthermore, boules of this shape would appear to be in a state of greater internal strain. Associated with the flatter curvature of the striae, the distinctive internal cracks of synthetic corundum are increased in number so that any slight advantage gained by the flatter striae is entirely nullified by the intensification of an equally distinctive fault.

The boule never shows outward crystalline form, but sometimes instead of being perfectly round in section, it will be distorted and show various forms of flattened curved faces, which is often particularly noticeable in boules of the magnesiun aluminate variety (synthetic spinel), and this has been construed into an attempt to crystallise in the correct outward form of the hexagonal and cubic systems. Likewise, the boule commonly shows a marked series of raised rings in a horizontal direction round its surface which have been held to be the same as the natural striations. Both of these

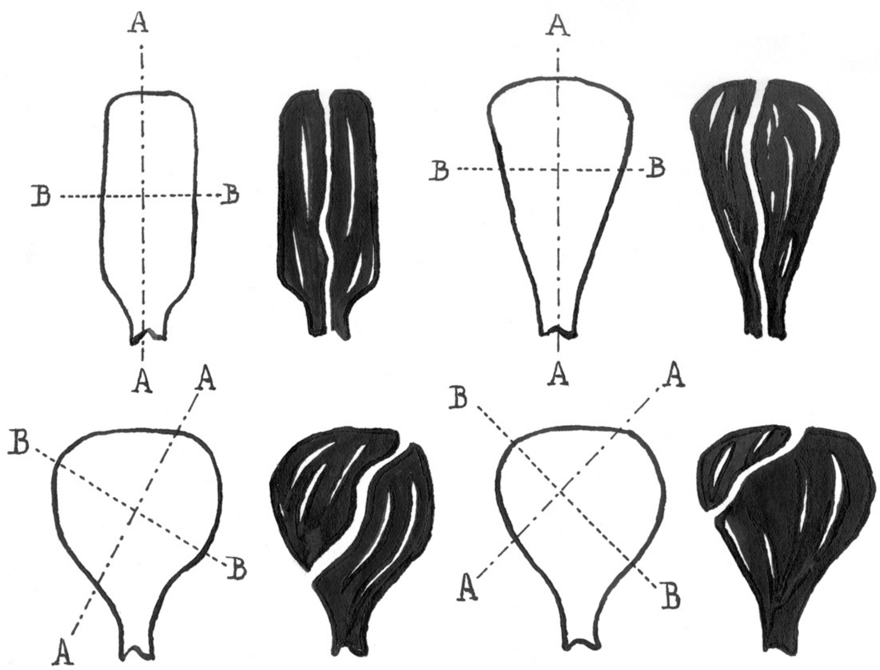

Figure 18.3
The direction of the axes in synthetic boules.

contentions are of course utter nonsense, as the distortion is purely due to mechanical causes in the process of manufacture, and the rings represent the different layers of structural material as laid on by the blowpipe. Natural striations are produced in an entirely different manner.[1]

The first synthetic stones to be placed upon the market were rubies, and for quite a long time after the other varieties had appeared these remained the only ones presenting any real difficulties in the matter of their detection, but even then many of them were so crude that their identification was a very simple thing. The sapphires that followed shortly afterwards were very miserable affairs, and their detection almost the work of a child; their colour was anything but right, and their whole general appearance was against them. In those days the main test was to observe the stone by the transmitted light of a wax match or candle, where the colour changed from blue to a distinct violet or purple. The microscope was but seldom

1 See Chapter 2, page 39.

used, and when it was, the stone was found to be full of spherical bubbles. It was a considerable time before even a decent synthetic sapphire appeared, which was mainly due to the fact that cobalt was then considered to be the colouring agent in true sapphires, so cobalt oxide was employed to colour the synthetic variety. However, this refused to mix intimately with the alumina and left the colour in blotches and patches. It was then found that if about 25% of magnesium oxide were added, it would act as a kind of flux and cause an even distribution of the colour, and this resulted in a much better looking stone being placed on the market under the name of *Hope sapphire.* These became quite popular, until it was suddenly discovered that chemically they were not true synthetic corundum at all, but a form of blue spinel, which had a considerable dampening effect in the trade in them, possibly because sapphire sounded so very much better than spinel.

About 1909, a very presentable synthetic sapphire was produced by using 0.50% of titanium oxide and 1.50% of magnetic iron oxide as pigmenting agents; but still the colour was not right, and an expert found no difficulty in identifying them by that alone. This difficulty was overcome by an accident in omitting the entire iron content from the mixture on one occasion, when it was found that stones of a much finer colour resulted, and from that day synthetic sapphires became a commercial proposition. Improvements were subsequently made, and now synthetic sapphires can be manufactured that approximate so closely to the natural stones that their detection is often a matter of great difficulty. In fact, their general appearance is often so perfect that it is in itself the first thing to arouse suspicion.

If the ingredients of the original mixture are absolutely pure, and the chrome alum is omitted altogether, a perfectly water-clear boule will be produced. These are sold as scientific or synthetic diamonds or brilliants, and have been found under the name of *Hard Masse,* which is strictly speaking a hard glass paste. Taking the formulae for various chemical colouring agents to reproduce almost any desired shade of colour, and so not only to imitate very closely coloured stones of entirely different species, but only so far as their outward appearance is concerned, as they will all answer to the physical tests for corundum, or very nearly so. For instance, if the percentage of chromic oxide is reduced, a pale pink stone will result, which is sold as scientific pink topaz. Manganese with a trace of cobalt will give a purple to violet stone, which will easily pass as amethyst. If the chromic oxide is entirely replaced by vanadium or nickel oxide, a yellow to greenish-yellow stone will be produced, which by artificial light will have a distinctly reddish appearance. These are sold as synthetic or scientific alexandrite, and have lately been somewhat plentiful in certain Eastern cities masquerading as genuine stones. So-called *synthetic emeralds* are produced with vanadium oxide as the main colouring agent, assisted by traces of chromic oxide and copper; but the colour is not right for true emerald, and approximates more to that of genuine green corundum.

There is a very considerable amount of the synthetic magnesium aluminate manufactured and sold under a large number of names including that of synthetic spinel, and many attempts have been made to classify this as a separate synthetic substance. That this has not been wholly successful is due to the fact that this substance, although chemically falling into the spinel group, must be regarded in the light of a hybrid, which in general characteristics will sometimes approximate quite closely to spinel, but on the whole bears a closer resemblance to corundum. But its behaviour is very erratic, and two stones of exactly the same appearance will often show entirely different characteristics. What happens is that, when the magnesium oxide is added to the colourless corundum in varying amounts according to the colour desired, it produces a change in the chemical composition. This, to a certain extent, upsets the optical and physical characteristics of the corundum, but does not do so in a regular manner. It has been found that, of two boules grown from the same batch of powder, one may resemble spinel, and the other incline more towards corundum, which points to the difference being due to something in connection with the fusion, rather than the original chemical composition of the mixture. The chemical formulae for true spinel is $MgAl_2O_4$, in which the alumina content is 71.8% and the magnesium 28.2%, but analysis of synthetic spinel have shown this to vary from alumina 50% and magnesia 50%, to alumina 85% and magnesia only 15%, and in certain cases it is possible that the magnesium content is much lower.

Table 18.1 gives the lowest and highest figures recorded for the chief characteristics of synthetic corundum and spinel as compared with those for the genuine stones and, as the normal tendency in the different varieties of synthetic spinel is to incline to the figures for corundum, its chemical difference should be ignored and the substance regarded as a variety of synthetic corundum.

It will be noticed that the hardness of synthetic corundum is given as 9, which is because in synthetic sapphires the hardness is lower than that of natural sapphires, and all colours of true synthetic corundum will be found

Table 18.1: Properties of natural and synthetic corundum and spinel

Property	Synthetic corundum	Genuine corundum	Synthetic spinel	Genuine spinel
Specific gravity	3.96	3.94	3.48	3.50
Hardness	9	9 9½	8 8½	8
Refraction	Double 0.0080 0.0096	Double 0.0070 0.0100	May be single or double	Single
Dichroism	Strong	Strong	Absent to distinct	Monochroic
Refractive indices	1.7594 1.7730	1.761 1.770	1.7161 1.7690	1.716 1.736

to have an almost perfectly even hardness, which is approximately 9. There are instances where a genuine ruby will scratch the synthetic variety with comparative ease, but synthetic corundum is never appreciably harder than genuine red corundum.

There are large numbers of people who still argue that from the manner of its preparation synthetic corundum must be an isotropic amorphous mass, and not a crystalline substance at all; or in other words that it is merely a form of alumina glass. Nothing could be further removed from the truth, as each boule, although without outward crystal form, is really a single crystalline individual of corundum, with a distinct crystallographic axis, which should normally run through the boule in the direction of its greatest length, but which due to strain mainly caused by uneven cooling is often considerably displaced. (A–A, Figure 18.3) And furthermore, it very closely approximates to the natural crystal in all its optical and physical characteristics.

This would appear to clearly support the often made statement that, except in the small matter of outward crystal form, synthetic corundum is in every way identical with the natural variety; which if it were true would mean that it would be quite impossible to discriminate between the two, when they were in the form of cut stones. Such a supposition is, however, entirely incorrect, as there are, fortunately, several very subtle but distinctive differences which enable us to distinguish one from the other with absolute certainty.

To search for these characteristic differences, the use of a microscope is absolutely essential; above all this must not be a trashy toy, but a really sound efficient instrument, standing on a rigid base, and provided with an efficient sub-stage condensor. It should also include some arrangement for holding the stone firmly below the objective, but permitting it to be rotated, and also with objectives of two or three different powers. A serious examination with a hand lens must never be attempted, as no matter how powerful it may be, or how expert you may consider yourself in its use, the results obtained, save in the most obvious cases, can never be absolutely relied upon, and its use is bound, sooner or later, to result in a serious mistake being made. An optical glass cell, and a highly refracting liquid, of which the best for general use are monobromonapthalene alpha, or cinnamon oil, are also necessary.

The most satisfactory method of procedure with a cut stone is to first wash it in alcohol (methylated spirit will do) to remove any surface grease or dirt, and carefully dry it. This is very important and should never be omitted. Mount the stone to the holder of the instrument and make a preliminary examination in the dry state, using a two- or even three-inch objective. It will often be found that this is all that is necessary and will reveal something conclusive; but as the magnification is on the low side, being only 16 to 25 times the size of the original, it is just as well to make quite sure by re-examining such evidence with a one- or half-inch objective, which will give magnifications of from 50 to 100 times. If nothing can be found by dry examination using a half inch objective, then place the stone in the glass cell supported on a tiny stand of fine silver wire, and completely cover it with the refracting liquid, and then examine it in succession with the following objectives using a No. 5 eyepiece:

- Half-inch (100 times)
- Quarter-inch (200)
- One eighth-inch (400)

If a No. 10 is used, the magnification will be increased about 50% in each case, but the definition will probably suffer.

In the case of rough stones, unless they are very clear, and always with waterworn stones having a dull matt surface, it is essential to rough polish them before the examination can be made, as it is absolutely necessary to be able to see right into the stone as if looking through a piece of clear glass. Never under any circumstances attempt to give an opinion on a stone with a dull surface until it has been polished, or the gravest errors may very easily arise.

In the examination of stones under the microscope there are two serious mistakes which very commonly occur, even by users of considerable experience. These are due to over confidence or gross carelessness, and should not happen. The first is imagining things, or seeing things which are not actually there, which may be obviated by verifying each observation as made. The second is to mistake an air bubble attached to the surface of an immersed stone for a spherical bubble in the interior. This is the easiest mistake in the world to make, so whenever a lone spherical bubble is encountered, remove the stone from the liquid and carefully wipe it, swill it in alcohol and replace it and again search for that particular bubble in the same spot. If you find it, you then know that it is really in the interior of the stone, but, if it is missing, then it was only an air bubble. Never take anything for granted, but always verify each point and prove it to your own complete satisfaction.

Structure

First of all, examine the general crystalline arrangement of the stone as revealed by the microscope. We know that natural corundum has a clearly observable hexagonal structural arrangement, which, from the manner of its formation, it is quite impossible for the synthetic variety to possess. In natural corundum this structural arrangement will show in the form of distinct internal striations, which are always arranged in straight lines parallel to each other, and following one or more of the faces of the original crystal, turning corners at the distinct angle of 120°, and crossing each other at definite angles of either 60° or 120°. The lines of these striae are not necessarily equidistantly spaced from each other, and may cover the whole area of the stone, or only occur in small patches, and are often situated in different parallel planes. They may take the form of fine misty white bands, of fine but very distinct black lines, or of distinct alternating lines of dark and light colour.

The structural striations due to both varieties of silk are of the utmost importance, as once they have been definitely observed there is no real necessity to proceed further with the examination; because silk of either description cannot possibly occur in synthetic corundum, and is not to be found in any other stone used for gem purposes. Its presence, therefore, proves that not only is the stone a genuine natural one, but also that it is definitely corundum.

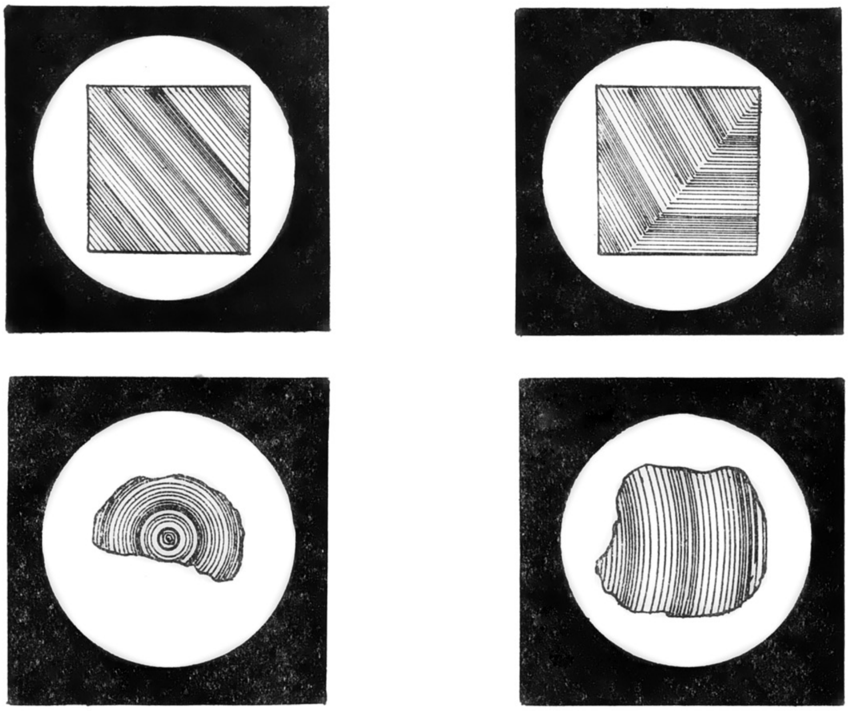

Figure 18.4
Striae. Top: In natural corundum. Bottom: In synthetic corundum. From Halford-Watkins, J.F. (1934) Synthetic corundum. *The Gemmologist,* Vol. 3, No. 34, pp. 302–313; No. 35, pp. 333–341.

In synthetic corundum the structure has no such hexagonal arrangement, but is that of a series of layers superimposed upon each other, and arranged in a lengthways direction round the crystallographic axis of the boule. Therefore if a section is across the boule, or the table of the stone is cut across the axis, the appearance of the striae will be that of a series of concentric circles of alternating light and dark bands of colour, having much the same general appearance as a slice cut across an onion.

Once these concentric circles, or more usually only arcs of them, are clearly seen, they are conclusive proof that the stone has been cut from a fused boule grown under a blowpipe. However, they do not prove that it was a boule of synthetic corundum, but only show that the stone could not possibly have been cut from either a natural stone, or an amorphous glass fused in the ordinary manner.

It is, however, only very rarely that these concentric circles, or arcs, can be seen when the stone is examined directly through the table, and it is only when it is viewed from the side, or back at an angle to the table that they will become apparent. The reason being that very few synthetic stones have the table arranged at right angles to the axis, the majority being parallel to it, or very nearly so. But owing to the shape of the boule, whichever way the striae is examined it will always show some degree of curvature, and will never be absolutely straight or quite parallel. With the advent of the elongated cylindrical boule (Figure 18.3 on page 293) stones may now be found in which the lengthways curvature is very much less marked, but will always be found if carefully searched for. From the curvilaminar structure of the boule it is, of course, impossible for the lines of striation to cross each other, or to turn corners at any regular or definite angle.

These striations are always present, and may often be seen by the unaided eye, but on the other hand they may be so exceedingly microscopic that they will require refracting liquids and considerable manipulation of the angle of light by means of the condensor, mirror, and iris

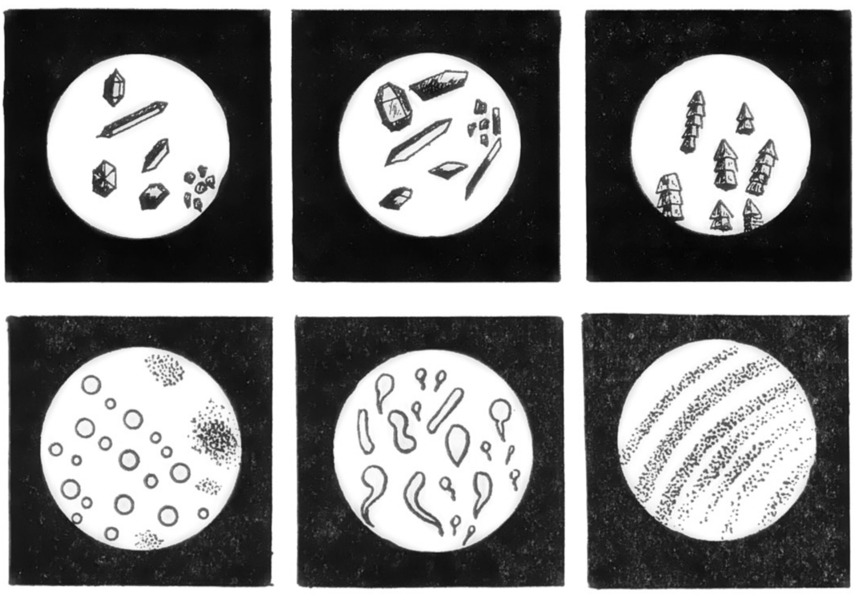

Figure 18.5
Bubbles. Top: In natural corundum and spinel. (B) In synthetic corundum. From Halford-Watkins, J.F. (1934) Synthetic corundum. *The Gemmologist,* Vol. 3, No. 34, pp. 302–313; No. 35, pp. 333–341.

diaphram, before they can be definitely observed. To the beginner the observation of obscure striae often presents difficulty, so that a certain amount of practice is necessary, but once experience has been gained it will be found that there is a regular fluid-like sweep about synthetic striae, as opposed to a hard regular stiffness of that in natural corundum, which it should be impossible to confuse.

Examination of the structure will therefore prove one of three things:

A. That the stone is a genuine natural one, and that it is definitely corundum.
B. That the stone is a genuine natural one, but not of necessity corundum, and does not prove its species.
C. That the stone is synthetic, and neither a natural stone, nor an amorphous glass; it will not even indicate the actual synthetic species.

Bubbles

There is probably no idea so firmly fixed in the lay mind than that the presence of distinctive enclosed bubbles constitutes the conclusive test for the identification of synthetic corundum, and even authorites of repute have stated such to be the case. Nothing could be more erroneous than this idea, as synthetic corundum has absolutely no distinctive bubbles peculiar to itself whatsoever. It merely encloses bubbles formed by gasses which are identical with those to be found in glass, or almost any other substance which has reached its solid state by means of fusion, or by a process of slow solidification from a plastic or semi-liquid state. For instance, precisely the same kind of bubbles may be observed on a larger scale in the amygaloidal cavities in certain rocks, in the holes in Gruyere cheese, or in cast metals which have cooled slowly; or on a smaller scale in fine paste, ordinary bottle glass, or amber.

In a similar manner the enclosed bubbles of natural corundum cannot always be held to be distinctive of that species alone, although at times they may be so, but are more generally of the kind to be met with in many other substances of a similar form of crystallisation, as instanced by the bubbles in emerald or quartz.

Therefore, it may be finally accepted that it is only when the physical characteristics of a cut stone are positive for corundum, or any other natural species, that the appearance of the bubbles are of any real use at all. And even then they will only show that the stone has been cut from a genuine natural mineral; and will not even indicate, much less definitely prove, that it is synthetic, but only that it is imitation and has been cut from some fused material.

The bubbles and other enclosures in natural corundum have been fully dealt with in Chapter 8, so it is only necessary to emphasise here that they are always geometrical, or angular in form, and show plane faces of some kind or another, and that while they may be elongated they are never completely round in section; and under no circumstances can they assume a globular or spherical form, for the simple reason that they are negative crystals. The only exceptions to this in naturally occurring substances used as gems are obsidian and amber, both of which enclose spherical bubbles; but obsidian is but a natural volcanic glass. Furthermore, the bubbles in natural stones will often be found to contain loose enclosures of foreign matter, small positive crystals, or liquids, which never occur in the bubbles of synthetic stones or glass.

Contrary to the above, the bubbles enclosed in synthetic stones are always globular, or rounded in form, and never show angles or plane faces, and they cannot possibly be geometrical in shape. The commonest form is completely spherical, but they may be elongated with either rounded or finely pointed ends. Frequently they are small and provided with little tails; in which case they may be exceedingly microscopic, black in colour, and bear a striking resemblance to a nest of certain bacteria. The occurrence of bubbles in colonies is very frequent and they will often be found arranged in bands with a very distinct curvature. Or again they may take the form of elongated drops, thick at one end and pointed at the other, when they are very often curved and twisted.

The spherical bubbles will very often show a faint pearly iridesence, as though there were several bubbles enclosed one within the other; or they may show a surface play of chromatic light, similar to the colours to be seen in a soap bubble. This is due to the interference of light at the junction of the two media at the inner surface of the bubble. Owing to the differences of the refractive indices of the stone and the interior of the bubble, it may also appear to be quite black, as though it were solid enclosure.

If carefully searched for, it is practically always possible to find bubbles in both natural and synthetic corundum. These are frequently of apprecia-ble size and very easily observed, but they may be, and often are so very microscopic that refractive liquids, and a protracted search with a high-powered objective are necessary before they can be definitely located. Bubbles may often be made to stand out very clearly by examining them at the apex of a fine point of convergent light thrown into the stone at an

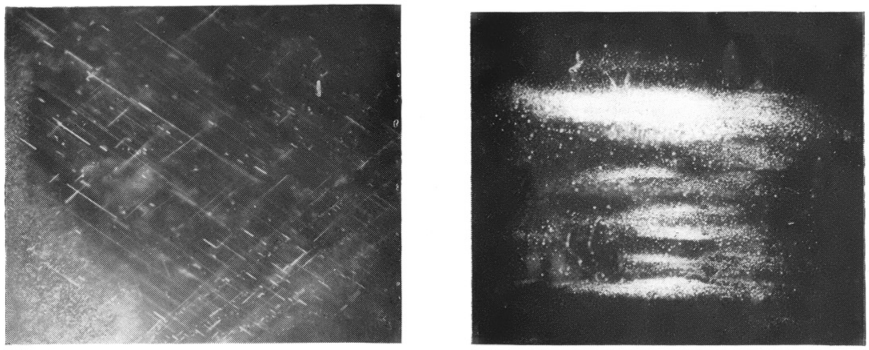

Figure 18.6
Left: Silk in natural corundum. Right: Pseudo-silk in synthetic corundum. From Heaton, N. (n.d., ca. 1912) *Rubies: Some Practical Hints on the Detection of Artificial and Imitation Stones.* London, Burma Ruby Mines Ltd., 15 pp.

angle from the condensor. Or by cutting out the bottom light altogether and examining them on a dark ground by means of a strong beam of light thrown into the stone from above.

In many modern synthetic stones, the manufacturers have almost entirely eliminated bubbles of any appreciable size, and it is only those of an extremely microscopic nature that can be found. This would appear to apply more to synthetic sapphires than rubies; and this apparently clean appearance is in itself a very suspicious sign, as natural stones are hardly, if ever, entirely free from fairly easily observed microscopic bubbles. Therefore if you cannot find any trace of bubbles, always submit the stone to the most searching tests in other directions.

The examination of the enclosed bubbles is therefore not very conclusive, as it only proves one thing:

A. That the stone is a genuine natural one; but does not always indicate its species.
B. That the stone is not a natural one; but does not distinguish between synthetic material, glass, or any other fused substance.

Silk

Despite a great deal that has been written to the contrary, there is not the slightest question that the examination for silk constitutes the conclusive and most important test for the distinction between natural and synthetic corundum, and also for the isolation of gems of the corundum group from those of other species.

The complete absence of silk of either variety will of course prove nothing either way, even if the physical characteristics show the stone to be positive for corundum. But the slightest trace of the presence of either variety is proof conclusive that the stone is genuine natural corundum, as it does not occur in any other species of gemstone, and cannot possibly occur in synthetic material, neither can it be imitated in paste, or other form of glass. Silk of both varieties is fully described in Chapter 7 (Q.V.).

Ordinary silk should first be searched for with the stone completely immersed in a solution of sulphate of copper, and here it is convenient and permissible to use a hand lens. If it cannot then be seen, continue the search under the microscope, first in copper sulfate, then dry, and then in monobromonapthalene. Black silk can only be reliably observed under the microscope, and preferably with the stone immersed in a highly refracting liquid. This examination should always be made with the greatest care, not only on account of its extreme importance, but also because there are two very dangerous snags awaiting the unwary.

Synthetic stones, and more especially the sapphires, will often show a whitish patch which, to the unaided eye or to the inexperienced or careless observer, has very much the appearance of being ordinary silk. This resemblance may be so very close that if an ordinary dry examination be made of it with a hand lens it is a very easy thing to say: "Yes that's silk right enough, so the stone must be genuine", and be perfectly convinced you are right. The writer has known this to actually occur with disasterous results. The microscope will, however, show that white patch to have none of the characteristics of ordinary silk, but to be composed of an immense number of microscopic bubbles, so closely packed together as to cause most of the light incident upon them to be totally reflected away, and so cause them to appear opaque white, or even pearly; the general appearance much resembling a fleck of foam. It will also show that the arrangement of these bubbles is usually in the form of a curve, as opposed to the perfectly straight parallel fibres of true silk. This appearance will never be found in natural corundum.

The next likely point of error is confusing the very fine lines of black silk with highly magnified surface scratches left upon the stone by the polishing lap. This is a mistake which is constantly being made, and may always be avoided by focussing sharply on any black lines, and then using the fine adjustment to very slowly focus deeper into the stone, when the first set of

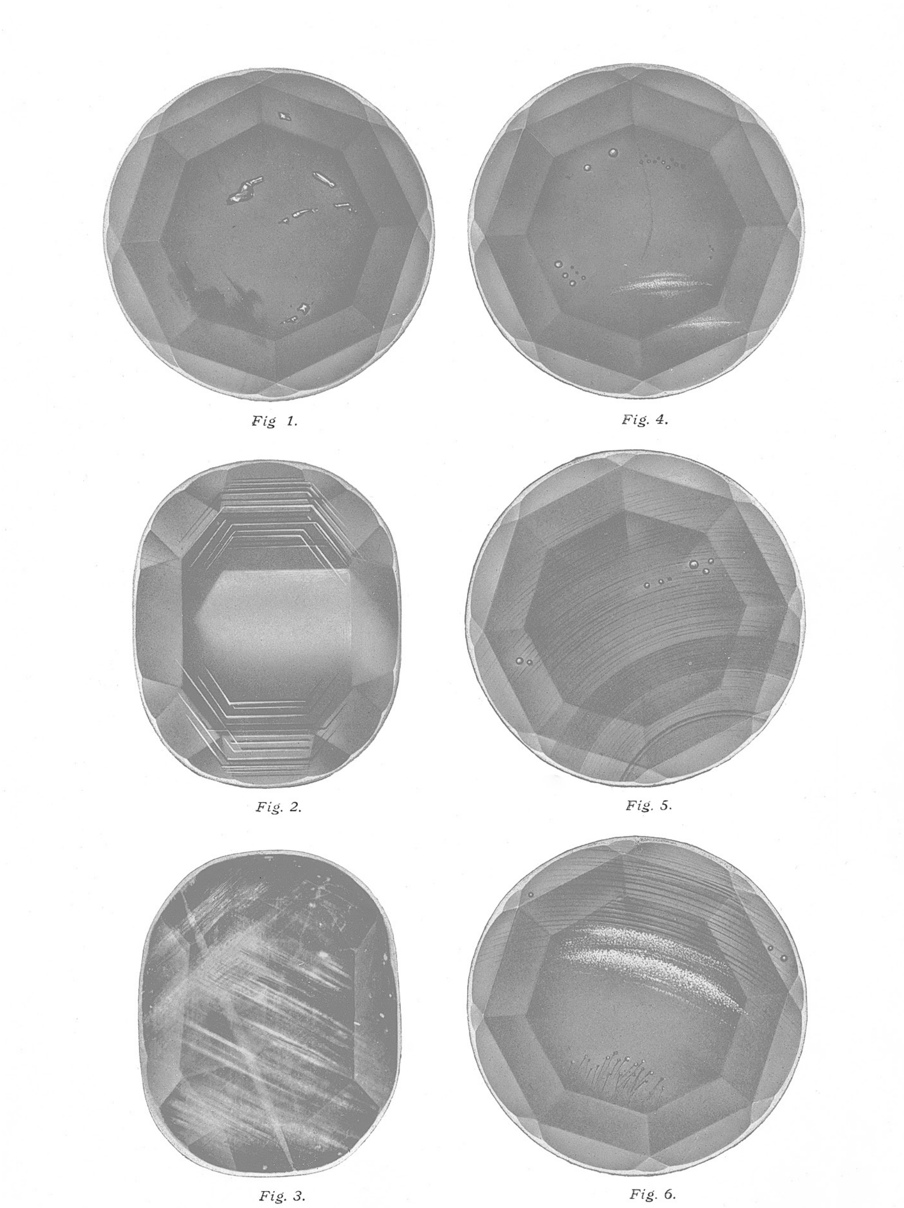

Figure 18.7
Microscopic features of natural (left) and synthetic (right) ruby compared. From Heaton, N. (n.d., ca. 1912) *Rubies: Some Practical Hints on the Detection of Artificial and Imitation Stones.* London, Burma Ruby Mines Ltd., 15 pp.

lines will fade out, and an entirely new set at a lower level slowly come into focus. This will be effective in the majority of cases, but if no second set of lines can be seen then the angles at which the original set cross each other must be very carefully examined. If they are polishing scratches, these angles will invariably be found to vary, and will never show the unfailing regularity of the definitely fixed angles of true silk.

Very few natural corundum stones will be found to be entirely free from traces of silk of one or both varieties, but they may be so microscopic and elusive that it will take a protracted examination before they can be definitely located; however, such will not normally be the case.

The examination for silk therefore indicates:

A. If found to be present, it conclusively proves that the stone is genuine natural corundum.
B. If entirely absent the test is a negative one, as it does not prove that the stone is not corundum, neither does it prove that it is synthetic. However, if the other characteristics are positive for either natural or synthetic corundum, the presumption may be regarded as being strongly in the favour of synthetic material, and the subsequent tests may be carried out with this point well in view.

Internal cracks

Under the microscope the majority of synthetic stones will show a series of irregular microscopic cracks, which are situated in the interior of the stone, but only just below the surface, and will more commonly be found lying at an angle on either side of the edges of the facets. These cracks are often present in fairly considerable quantities, and have an entirely different appearance to the cleavage cracks and feathers to be found in genuine corundum.

They would appear to indicate an incipient disruption of the stone, possibly along its structural layers, and most probably due to an alteration in the internal strain produced by the cutting operations. With age they will usually increase in size, and often spread right across the stone causing it to fracture.

These cracks must, however, only be regarded as being indicatory of synthetic material, and their presence not be taken as positive proof, as similar cracks may sometimes be observed in genuine stones, due to overheating in the cutting, but in this case there will normally be only one or two isolated cracks.

Figure 18.8
Disruption cracks in synthetic corundum.

Enclosures of foreign matter

It has frequently been stated that inclusions of foreign matter are absolute proof that the stone cannot possibly be synthetic. This idea is entirely erroneous, as inclusions of various kinds may frequently be met with in synthetic stones despite the endeavours of the manufacturers to prevent them; but cases are known where they have been deliberately introduced.

This test is therefore a negative one, as inclusions may be met with in both varieties, so should be entirely disregarded when making an examination.

Pleochroism

The dichroism of red and blue corundum of the synthetic variety is about the same in strength as in natural corundum, but in the other colours in synthetic corundum there appears to be a general tendency for the dichroism to be weak, whereas in natural corundum it is very strong indeed, and sometimes intense.

The twin colours observable in the red stones are about the same in both varieties, but synthetic sapphires will sometimes show a distinctive grey colour – almost a neutral tint – for the extraordinary ray, which has never been observed in natural sapphire.

Colour

It may at once be said that the true pigeon's blood colour of the fine genuine ruby has never been approached in synthetic stones. Even when compared with good second-grade coloured genuine rubies, the colour of the synthetic stone is never quite right. The commonest faults are a slight brownish or yellowish tinge, a hard metallic look, or a very curious, but distinctive appearance, which can only be described as a *liverish* look. These are often so very slight as to quite escape an untrained eye, but they are subtle nuances which an expert at once perceives, and are quite sufficient to cause him to lay the stone to one side for further examination. In many instances, they may be so apparent as to settle the matter out of hand, but are more usually only just sufficient to arouse suspicion. The same applies to many of the sapphires, which never by any chance exhibit the much esteemed velvety lustre, but on the contrary often have a hard, steely look. Apart from the velvety lustre, however, many of the modern synthetic sapphires are so perfect in their colour and general appearance that it is quite impossible to recognise them by the eye alone. In fact it may be said that often the first thing to arouse suspicion is that the stone looks a little too good to be true; as most natural stones will show some slight imperfection which is at once apparent to the trained eye.

The writer has often heard experts declare their ability to immediately detect by eye alone either synthetic sapphires or rubies, no matter how perfect they may be. He has also seen them invariably fail when put to the test; for it is a vain boast, and a feat impossible to perform with any degree of certainty. A man may be suspicious, but nine times out of ten he could not swear by his opinion without making a further examination.

Regarding colour, the microscope will reveal a lot of things that are not apparent to the unaided eye. It will show that in natural corundum the colour is either, evenly distributed, in the form of flakes or irregular clouds, in isolated patches, and sometimes in the form of straight parallel bands. And that in synthetic corundum it is seldom evenly distributed throughout the substance of the stone, but is arranged in the form of concentric arcs, or circles, of alternating light and dark shades, and that further these arrangements of arcs will also often show distinct additional zonal arcs of deeper and lighter general shades, which may sometimes be very distinct indeed. Under the microscope the colour of practically all synthetic sapphires will appear to be a hard steely blue, and quite unlike the softer appearance of the colour of genuine sapphires when viewed under this instrument.

From the foregoing it will be seen that in all cases it is desirable to have made a preliminary examination of the physical and optical properties to determine the native species of the stone, and when this examination gives positive results for corundum, the microscopic examination will then determine whether that corundum is natural or otherwise; but the microscope alone will not always isolate a stone to its own gemological species, synthetic or otherwise.

The examination of corundum by means of X-rays and ultra-violet light is discussed in Chapter 6, and certain differences between the behaviour of natural and synthetic corundum have been noticed, more especially in regard to the spacing of the atoms in the Laue diffraction patterns, and in regard to the appearance and duration of fluorescence. But at present both of these methods are so very much in their infancy that our real knowledge of the reactions under all conditions is too slight to render observations of any practical value as an accurate means of discriminating between the two varieties of corundum.

There is undoubtedly a great future before these methods, and with more knowledge, they are in time almost bound to become standard methods of testing; but at the present time the initial cost of the necessary apparatus places both of them beyond the reach of the average person, which has a very cramping effect upon experimentation.

In examining a stone with a view to reporting upon its being a natural stone or otherwise, always use a microscope, and never under any circumstances rely upon an examination made with a hand lens, the warning against the use of which cannot be too strongly emphasised. Even with a good microscope it often requires a very long and patient examination before anything can be discovered that can be definitely sworn to either way. It has, however, been the writer's experience, after examining hundreds of thousands of stones, never to have made an abortive examination, as there has always been something which was definitely conclusive, and often several things. But there have been many instances where for a very long time the examination appeared to be going to turn out a negative one, and it has only been by exercising extreme care and patience that the required evidence could be eventually found. Therefore never be in a hurry to jump at conclusions, or imagine that you can see things which are not really there; but make the examination in a slow methodical manner, and carefully verify each observed point immediately as it is made.

Whatever happens, never certify a stone, one way or the other, however obvious it may appear to the eye, without first of all making a microscopic examination, and then only when you are perfectly sure of your facts. It is the simplest thing in the world to make a mistake, and you will not only look, but will also feel a most perfect fool when you are afterwards proved to have been wrong. And it is just as well to bear in mind that a wrong certificate may have far-reaching effects not only upon yourself, but upon other people. The issue of certificates is a very serious thing, although it is unfortunately not always regarded as being such, and they are often far too lightly given. The writer makes it a steadfast rule never to pass even a personal private opinion on a stone without first of all having had it under a microscope.

If synthetic corundum is examined in convergent polarised light directly through the table, it is but seldom that the characteristic uniaxial interference figure of corundum will be observable. I have previously mentioned that the table of a cut synthetic stone will usually be found arranged either parallel to, or at a slight angle to the crystallographic axis, the reason for which is that during cooling the boule will usually split into two parts directly along the line of the axis (Figure 18.3 on page 293). And in doing so will leave two surfaces showing a very characteristic mixed semi-conchoidal and uneven fracture, which is quite unlike the fracture of natural corundum (Figure 4.2 on page 82). There will thus be two halves of the boule available for cutting, so that the lapidary has no option but to arrange the table in this direction, in which the interference figure will not be observable. However, if a section is cut directly across the axis, or if the table is arranged in that direction, the figure will be very clearly observable, often more clearly so than in the majority of natural stones, provided that the section is not too thick.

Apart from the splitting of the boule on cooling, the table is seldom arranged across the axis even when a complete boule is being cut, although a much better colour effect is to be obtained that way, as attempts to do so usually result in the stone breaking up during the process of cutting. Experimental stones which the writer has cut in this direction have lasted but a short time, usually splitting in the course of a few weeks; and even thin sections securely cemented to glass have quickly fractured in the same way.

The top of the boule shows an opaque white layer of scum, or dross, which is most apparent in the sapphires (Figure 18.2 on page 291) which, if examined under the microscope, will be found to be a mass of tiny bubbles; while the clear portion immediately underlaying this is also too full of bubbles to be included in a cut stone. Along the base of this layer there appears to be a second line of structural weakness, so that it is easily broken off without damaging the rest of the stone, which is usually done, leaving a second characteristic fracture, before the pieces are placed upon the market in the rough. An entire boule is somewhat difficult to purchase.

The majority of synthetic corundum is now manufactured at Annecy in France, Locarno, Biel, and Monthey in Switzerland; Butterfat and Zwickhaw in Germany; and at Terni in Italy. Possibly the largest European cutting centre is at Idar in Germany, where cut synthetic stones are turned out from factories on the mass production system, being entirely cut by machinery, with a suitable grade of diamond dust used for both cutting and polishing.

It has been noticed that no matter how great the care and attention given to the work, or what methods are used, a very large proportion of synthetic corundum will refuse to take on anything more than a very poor polish; so that either a ruby or a sapphire showing a poor polish may always be regarded with a certain amount of suspicion.

The word synthetic is derived from the Greek *sunthesis* (σύνθεση), a putting together; and *boule* is merely the French for a ball. A term sometimes also used is *birne,* which is the German for a pear.

It is impossible to form any real idea of the present output of synthetic corundum, apart from its commercial uses for pivot bearings, etc. As the gem form is now flooding the markets of the world from Alaska to the South Sea Islands, output must be assumed to be something enormous.

The following notes regarding its appearance in Southern India are, however, of more than passing interest in showing how this material obtained a firm hold upon at least one of the important markets of the world.

In 1914, the annual output for synthetic corundum was, as far as could be ascertained, about four million carats, which was even then regarded with alarm as being enormous. It grew to be such a menace to the trade in genuine rubies that in 1923 the writer had to take up the matter of its importation into India with the Government, and his investigations then led him to estimate that the consumption in Southern India alone must have been in excess of twenty million carats a year. In Trichinopoly there was a long narrow street entirely given over to the ruby cutting industry in which some five hundred cutters alone daily laboured, in addition to polishers and other assistants. In 1921, these men were all engaged in working genuine third- and fourth-grade rubies, and it was almost impossible to find a synthetic stone in the city. Two years later, these men were cutting nothing but synthetic material and it was very hard indeed to find a genuine ruby or sapphire in Trichi. Synthetic stones could be freely purchased for the equivalent of two pence a carat in the rough, and from four to eight pence a carat for the other centres. The majority of this cut stuff was disposed of locally in India, but a great deal of it was eventually shipped to Rangoon, Colombo, Singapore, and Java. The raw material entered India by post to Calcutta, Bombay, and Madras, but the majority came through Pondicherry. The following year, about two-thirds of the workmen had returned to cutting genuine stones, and the synthetic material, although still plentiful, was not nearly so prominent. Far less people are employed in this trade today, but of the total cutting done, about thirty percent of it is still synthetic material.

19
SYNTHETIC CORUNDUM AND FRAUD

Erroneous ideas regarding undetectable imitations ⚜ Their effect upon the market ⚜ Synthetic corundum and the ruby market ⚜ An international buyer swindled ⚜ An Indian official victimised ⚜ A tourist, dealer and jewellers all deceived ⚜ A faked ruby embedded in commercial corundum ⚜ Substitution at a ruby sale ⚜ A clever fake of a natural crystal ⚜ A jeweller badly swindled ⚜ Rough synthetic stones produced from the mine ⚜ Searching for a stolen stone and finding faked boules ⚜ Fraudulent practices directed against tourists

The true scientist delights to reproduce in his laboratory by purely synthetic means the exact products of nature, with no other idea save that of experiment and research and without any serious thought of financial gain. In fact, his discoveries are usually exploited by those of a more practical turn of mind. But there is another class of person possessed of a scientific brain and knowledge, who continually dreams of untold wealth flowing into his pockets, if he can only produce an absolutely undetectable imitation of one of the more valuable varieties of precious stones; and many people have used their scientific gifts, from the earliest days, to concentrate upon such a production solely with the idea of illegal gain.

It does not require a great deal of consideration to be able to realise that the efforts of such experimentors are quite futile, and simply a waste of time, as, in their greed for gold, they are quite blind to the one factor which is going to prevent the materialisation of their dreams. Not one of them would appear to realise that, apart from the physical and optic characteristics which render a stone fit to be regarded as being precious (and which are after all more or less accidental), the high prices obtainable for such stones must always depend upon their great rarity, and to a lesser extent upon an ability to maintain some sort of control over the market for that particular stone. The latter induces an artificial inflation in price, which is naturally much lower than if the stone depended entirely upon its great rarity for its high value. This is clearly demonstrated by comparing the price of a fine diamond of say ten carats with that of a fine ruby of equal weight.

It, therefore, follows that if an undetectable imitation of any stone could be made and were placed upon the market in any quantity, that particular stone would immediately cease to be rare. And even if the supply to the market were kept within moderate limits, the mere fact that it could be produced at will and in any desired quantity, would still affect its rarity and so cause the value to drop. But says the artful one "I would only place a good large stone on the market at intervals, and then no one would realise that they were imitation". That might possibly succeed twice, but the second time is doubtful, as outstanding precious stones of any variety are rare things indeed, and the appearance of a new specimen on the market immediately causes a considerable amount of comment. The places of natural occurrence for all kinds of stones being very limited, they are all well watched by the trade, so that any important stone appearing is at once traced to its point of origin. Consequently if would soon be proved that our imitation did not come from any known mining centre, as even stones stolen from such places are always clearly traceable. The only other avenue would be to represent it as an old heirloom, but the existence and even the history of all such stones are only too well known, so that the appearance of more than one from an unknown source would quickly arouse suspicion. The question would therefore soon be asked as to where they were coming from, and with suspicion thoroughly aroused, it would not be at all a difficult thing to trace them and a compete collapse of all dreams of wealth as the price would quickly fall to almost nothing at all.

Despite the fact that synthetic corundum was never by any means undetectable, this is exactly what happened to the ruby market in 1908 with the advent of the synthetic ruby, which was mainly brought about by the discovery that they were being used for the purpose of fraud. At first these swindles were confined to minor attempts of the sneak thief order, such as bilking jewellers and pawnbrokers by means of synthetic rubies in the guise of genuine stones set in old jewellery. But it quickly grew worse and synthetic stones began to appear mixed in with the stones in parcels of both cut and rough genuine rubies, which were purchased by unsuspecting jewellers and dealers, and then re-offered in perfectly good faith as genuine stones. This led to a fearful panic, and many jewellers refused to handle rubies at all, lest they should by inadvertence sell a synthetic stone as the real article, and cause their general business to suffer. Rubies in any shape or form were absolutely boycotted by the pawnbrokers, which had a curious reflex effect in Paris, as when the Mont-de-Piete (State pawnshop) refused to accept ruby jewellery as pledges, and the pretty ladies of the demi-monde also refused to accept it as a present from amorous plutocrats, as they could not turn them – the rubies, not the plutocrats – into ready cash. This had an adverse effect on the early sale of synthetic rubies, but that was a trifling matter compared to the enormous and permanent injury done to the legitimate trade in genuine rubies, the full effects of which are being felt badly today.[1]

It is impossible to form any real idea of the extent to which synthetic corundum has actually been put for the purposes of the swindler, but some vague idea may perhaps be gathered from the following few instances, selected from a large number in which the writer has been personally concerned. As this is the experience of one man alone it only serves to show that the use of synthetic corundum for fraudulent purposes throughout the world must have been considerable indeed, which, undoubtedly, it has been from the various tales which have been told to the writer, none of which are, however, quoted as their strict accuracy cannot be verified.

A personal friend, who is a buyer of vast experience and international repute, once showed me a parcel of cut rubies purchased in Burma. Pointing to a stone of about fifteen carats, I remarked: "This one looks anything but right", only to be laughed at by the others and reminded of the buyer's undoubted vast experience, which they considered would protect him from being duped into buying a spurious stone. He at once made another examination and was still of the opinion that the stone was all right, but was nervous about it and asked me to test it. Five minutes in the laboratory clearly demonstrated to him that the stone was without doubt synthetic. He had paid over £2000 for it in Mandalay and it was only under a threat of criminal proceedings that he was able to get his money back. This shows the great care that is necessary when buying fine rubies and how unsafe it is, even for an expert, to complete a purchase without making a microscopic examination.

In Trichinopoly, a wealthy Indian official once asked me to value a ring containing a fine-looking sapphire of about thirty carats. He considered this stone to be of immense value and only with the greatest difficulty was he persuaded to allow it to be removed from its setting. It turned out to be patently synthetic. This fact nearly caused the owner to faint, as he had

1 See Chapter 12, page 200.

paid the equivalent of £4500 for it entirely upon his own responsibility and without any advice from a plausible unknown seller who was never traced.

A tourist asked me to examine a second-quality cut ruby of five-and-a-half carats, which he had purchased for £200 from a well-known dealer in Calcutta and which had furthermore been examined by two firms of prominent jewellers and passed as genuine. In truth, it was one of the most obvious cases of a synthetic stone I have ever examined and the dealer immediately refunded the money against my certificate. He afterwards told me he had sold the stone in good faith and had made but a small profit on the deal. He was unable to trace the man who had swindled him in the first instance and thus, lost his money.

A local dealer once brought an unknown Burman to the laboratory and produced what appeared to be a water-worn ruby almost completely embedded in dark brown commercial corundum. The dealers suspicions had been aroused by the fact that while the surface of the stone showing was water-worn, the outer covering had a perfectly fresh uneven fracture. However, the Burman was a plausible sort of a fellow and stoutly declared that he had mined the stone himself and that is was exactly as he had dug it up. I immediately proceeded to remove a good sized chip of the outer covering with an ordinary pen-knife, which was proof number one that there was something very much wrong, but still the Burman stuck to his story. This chip was boiled in alcohol and reduced to a powder which turned out to be crushed sapphire and ordinary brick dust. The whole coating was then boiled off and revealed a completely waterworn stone of about six carats which, when rough polished, proved to be synthetic. A synthetic stone had been taken and ground to represent a water-worn stone, and then embedded in the centre of a ball of crushed corundum, brick dust, shellac and some colouring matter, from which a portion had been broken off with a hammer. Now, as rubies contained in nodules are fairly common, the swindler would probably have got away with this barefaced attempt, but for the fatal mistake of leaving a water-worn face showing where either a fractured or natural crystallised face was clearly indicated. During the test, the Burman bolted and we never saw him again.

An attempt was once made to victimise the writer during a ruby sale at which there were about a hundred buyers examining a large number of parcels of stones, amongst which was a big parcel of rough sapphires of mixed sizes, the weight of which was accurately known. This parcel was sold and on being check-weighed before being sealed, was found to be some sixty carats overweight. A quick examination showed that it now

Figure 19.1
A bogus crystal of sapphire, faked from a synthetic boule. Photo: Maha Tannous/GIA

contained a proportion of synthetic sapphire in broken pieces of from two-to-six carats each, which had obviously been added after the parcel had been put out for sale. A certain man was suspected and on being called into the office, confessed that he had brought with him to the sale two tickals (160 carats) of synthetic chips, which he had substituted for some of the best stones while examining the parcel, but had sadly misjudged the weight of the stones removed. He handed back the stolen stones and was promptly kicked out, but it is a significent fact that neither the eventual purchaser, nor his brokers, who had closely examined the stones, had detected the presence of this synthetic material. On the contrary, each had actually offered a higher price on account of the fine colour of the pieces.

A prominent Burmese merchant, who had been in the stone business from childhood, brought a rough sapphire for consignment to London. One glance was sufficient to show that the stone was synthetic. Half a large boule had been taken and ground to the form of part of a natural crystal of the pyramid habit, showing three faces of the crystal and two fractured surfaces. The faces had been ground onto the rounded side of the boule, and across each of them had been carefully engraved lines to represent the striations of the natural crystal. When viewed from the front it was an exceedingly clever fake, but the swindler had made a bad blunder in leaving the two fractured surfaces, which he evidently thought represented the ordinary everyday fracture of a sapphire, being quite ignorant of the fact that they were typical of the synthetic variety. This stone had been secretly sold by a Chinese coolie as a stolen stone for £333. The coolie had, of course, disappeared immediately after he got the money. Several other similar boules came to light, but we were never able to trace the maker.

A prominent jeweller in an Indian city once commissioned me to examine a set of ruby jewellery, with a view to issuing a certificate guaranteeing the stones to be genuine. This set, beautifully mounted in platinum, was made up from a large parcel of square-cut stones purchased through an unknown travelling broker, who provided either forged or stolen credentials of the highest order, representing him as being from Mogok. There were some four hundred stones in the set, every one of which was synthetic; here again the swindler was never traced.

An extraordinarily clever swindle came to light as follows: A local dealer of the highest reputation brought me a parcel of cut sapphires, a portion of which were synthetic. The dealer indignantly denied this, and stated that he had bought the stones direct from the mine itself, where he had actually seen them recovered from the earth in the ordinary process of washing, and that they had been cut under his own personal supervision, so that there could be no question of substitution. This argument seemed to be irrefutable, but still there was no getting away from the fact that certain of the stones were beyond a doubt synthetic. He then sent for the uncut portion of this purchase, which was found to consist of partly broken fragments, with the remainder waterworn stones. The fragments were all genuine, but when rough polished the waterworn stones were all found to be synthetic. The dealer was furious, but as the case presented too many loopholes to institute criminal proceedings, it was decided to watch events and try to catch this particular swindler. In a little while we had collected quite a number of these stones, which were all traced to a number of different mines, but all worked by members of one family. The rest was fairly easy and we discovered that an educated Burmese youth had mounted a small iron drum on spindles, which he rotated by means of a small water wheel, driven by an underground stream in a *loodwin* at some distance from his home. His procedure was to partly fill the drum with rough sharp pieces of broken ruby and sapphire refuse and water, into which was placed broken pieces of synthetic sapphire and ruby. The drum was then rotated by the water wheel for some time, with the result that the uneven pieces of synthetic material were abraded down to rounded granules which were identical in appearance with natural waterworn stones. These were then taken to one of the mines and, during the night, secretly placed in the earth waiting to be washed in the morning. This was so the dealers could actually see synthetic stones being produced from the mine itself and what better guarantee could they possibly have if the stones were afterwards questioned? It was a well-thought-out and deliberate fraud, and the perpetrators must have made a nice little haul out of it before retribution overtook them.

An informer once told me that early the following morning a certain Chinese coolie *gaung* (labour contractor) would be leaving with his family to catch the weekly steamer to Bhano [Bhamo], and that concealed on one of the party would be a large and valuable sapphire stolen from the mines. The informer had handled the stone – in fact, I strongly suspect that he had actually stolen it – and was able to furnish the most minute description, including weight and measurements. Under my special police powers I was in a position to stop, search and arrest any person or property without the necessity of obtaining a warrant. Hence, during the night I took a strong party, including female searchers, and shortly after daybreak stopped the motor bus containing the party at a lonely spot on the road. Everybody and everything, including the pots of cooked rice for food, were minutely searched, all without finding the slightest trace of the sapphire. But we did find six synthetic boules ground to represent natural crystals, the mere possession of which is no offense under the law. But to gain time to again go through everything with a tooth-comb, I made these an excuse to take the whole party back to Mogok. Here, despite the most rigid search, nothing at all was discovered. Even the handle of the Chinaman's umbrella, an imitation jade affair carved to the crude representation of a bird, was removed and found to be quite solid, so there was nothing for us to do but to let them go. A couple of days later, the Chinaman came to my office to take back his faked boules, which I had no authority to retain, and became so abusive that he was so quickly, and none too gently, hustled off the premises by the peons. After he had gone, I noticed that he had dropped his umbrella, which it appears one of the clerks sent back by a messenger. A couple of months later I received a letter from the interior of China thanking me for returning the umbrella, as the sapphire I was looking for was concealed in the handle, which the Chinaman had cast round it, and carved himself. He also informed me that he had disposed of three of the faked boules to an American traveller on the steamer for three thousand rupees (£200), which I afterwards found out from the steamer captain was the truth.

Even when buying stones at the mines themselves, great care should always be exercised, as it is by no means unknown for attempts to be made to foist off synthetic stones, and even glass, on unsuspecting visitors. The same thing may also be found in Colombo [Ceylon], or in fact in any Eastern port or city where gems are sold. Therefore it is absolutely necessary when stones are bought from itinerant vendors to have them vetted by an expert who knows his business, and not by a friend who is more often than not only a self-styled expert with little or no real knowledge. The expert will advise as to the genuine nature, or otherwise, of the stones, and also as to the correct price to pay for them. Such advice costs just a trifling sum, but it may save pounds.

The writer's advice is never to purchase from the harpies who visit ships and hotels, as this is simply asking for trouble. It is also especially necessary to beware of the ragged-looking individual who offers a stone cheap, because it has been stolen from the mines and must be disposed of secretly to a stranger who will not talk. This dodge is as old as the hills, and the writer has frequently been offered both in Rangoon and Mandalay synthetic stones, or more usually worthless bits of common glass, said to be stones stolen from his own mines.

20
THE CUTTING OF CORUNDUM

The effects of shape on appearance ✤ Factors which control final shape ✤ Arranging the table for the best colour effect ✤ Eliminating the blue in rubies ✤ Making the most of weak colour in sapphires ✤ Producing a full coloured stone from a tiny patch of colour ✤ Asymmetric shapes ✤ The importance of correct back angles ✤ Light passing through a well and badly cut brilliant, trap cut stone, and rose ✤ The use of foils ✤ The importance of correct top angles ✤ Why facets are plane surfaces ✤ Prismatic and triangular formation ✤ Point stones ✤ The brilliant analysed ✤ Correct proportions and angles ✤ The bad effects of wrong make ✤ Various groups of cutting ✤ The brilliant cut ✤ The step or trap cut ✤ The emerald cut ✤ The table cut ✤ India cut ✤ The mixed cut ✤ The rose cut ✤ The half brilliant cut ✤ The bastard cut ✤ The cabochon cut ✤ Plates ✤ Beads, drops, and allied forms ✤ Carved and engraved stones ✤ Western methods of cutting ✤ Factory methods ✤ Eastern cutting centres ✤ The Burmese lapidary and his methods of work ✤ The Indian lapidary and his methods ✤ Western and Eastern lapidaries compared ✤ The cutting of star stones

A very common statement is that because ruby and other corundum gems possess low powers of dispersion, they must depend entirely upon their colour for their beauty. Thus the lapidary is not concerned with the production of internal fire, and is, therefore, not called upon to either calculate or observe the intricate angles of a cut stone which depends upon its fire for its effect. Consequently, he may impart to the rough stone any such shape as his fancy or the demands of his customer may dictate, and at the same time obtain equally good results. This is not correct, but may be accepted as applying in a very modified form to the very highest grades of ruby, where the colour is so fine that it is only spoiled with great difficulty, or to the very poorest grades, where the colour is so bad that it does not matter much what you do to it. But with all the other grades of ruby, and all the other colour varieties of corundum, the skill and knowledge of the lapidary is often taxed to its utmost in order to produce the best possible effect.

In the case of very fine coloured rubies, with a dispersion of about 0.018, the question of internal fire may to a certain extent be disregarded, but not entirely so, as the beauty of the finished stone will always be materially enhanced by making the most of what little fire there is available. But it is at all times imperative that the back facets of the stone shall be arranged in such a manner that they will totally reflect out again through the front the maximum amount of light entering the stone.

It is therefore absurd, even in the case of the finest colour, to contend that the calculated angles of the back facets can be entirely ignored. But when we come to consider the case of sapphires and paler coloured rubies, and more especially the colourless and other coloured corundums, where the dispersion is greater (and may be as high as 0.030), it is very clear that the final shape must be so designed that it not only bring out to its fullest possible extent all the effects of fire that the stone is capable of producing, but will also, at the same time, retain to its full strength, or improve upon, the original colour of the stone, which at once places severe limitations upon the free choice of the finished form.

If a lapidary is given a rough ruby or sapphire and told to produce from it the largest possible clean stone irrespective of its final colour, he has got a very simple job on hand. He has only got to look for obvious flaws and silk, and then arrange his table so as to avoid these, and so produce the largest stone free from serious flaws that the rough is capable of giving. But such is not the work of a skilled lapidary, whose task it is to produce from a piece of rough the largest piece of clean material that it is capable of producing, which will at the same time bring out to its fullest possible extent the hidden beauties of the stone, and by so doing, produce the largest possible cut stone which will also be of the highest value. In doing this it will usually be found necessary to sacrifice size to final beauty, which is made up for by gain in value. From a single piece of rough, it is often possible to produce three or more stones that will be perfect in every way, which a is vastly different thing than producing a single large stone of a nondescript variety, which often cannot be recut to produce stones of any value.

Since it is agreed that in the case of both the ruby and sapphire, colour is the main factor, we will first consider the problems facing the lapidary in this direction. In Chapter 3 we have seen that the colour of both of these stones is deeper when it is viewed in a direction directly along the optic axis of the crystal, which is the line A–B in Figure 20.1. And we have also seen that if there is a faint trace of extraneous blue in the red of the ruby, it will be intensified if the stone is viewed in this direction, and that if the blue is very prominent it will be no more strongly marked. It is, therefore, essential with a finely coloured ruby of the pigeon's blood variety, which shows no trace of blue, that the table of the cut stone should be arranged in such a manner that the direction of the optic axis should pass through it in a

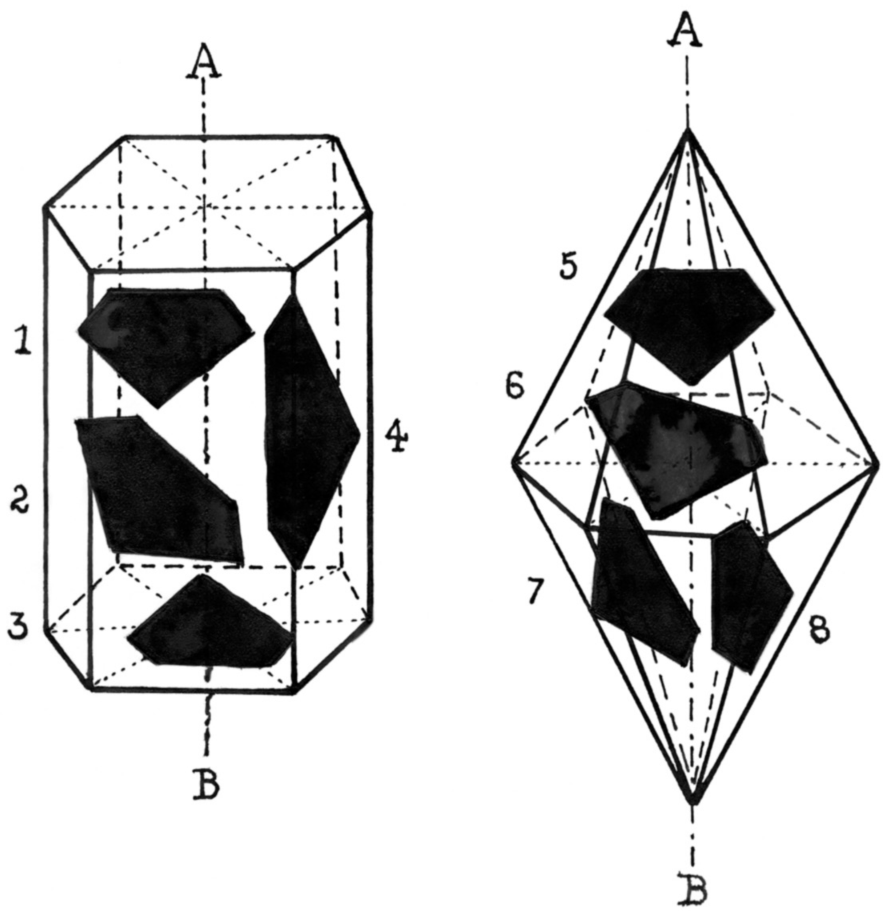

Figure 20.1
The arrangement of the table with regard to the optic axis of the crystal.

vertical direction, as shown in silhouettes 1 and 3. This does not, however, mean that a line drawn through the centre of the crystal must of necessity pass directly through the centre of the cut stone as in 3, but that the general direction of the table shall be at right angles to the axis, as in 1, but the entire cut stone may miss the central line altogether and still have the same effect. In no other direction will the deep full red of the ordinary ray be shown to its full perfection. Silhouette No. 2 is drawn with the table inclined at angle of 45° to the axis, and it is clear that if such a stone is viewed directly through the table, the colour effect will only consist of about 34% of the deep red of the ordinary ray, the remaining 66% being made up of the weaker red of the extraordinary ray, which means that it will have less than half the best colour effect procurable. By making the inclination less, the colour effect will be increased, but even so, in dealing with fine coloured stones, the slightest inclination in either direction away from the axis means a loss in the perfection of the final colour.

This is a serious business as, owing to the presence of flaws, unevenness of colour, or to avoid silk, it would often be possible to obtain a far larger stone by giving the stone a slight cant away from the axis. It is for the lapidary to decide whether the ultimate value of the cut stone will justify his going all out for colour, or to sacrifice a certain amount of colour for the sake of a larger stone, and to what extent it is permissible to carry the sacrifice.

The cutting of the famous Peace Ruby presented a problem of this kind, but it was decided to cut for colour alone, and to disregard the question of final size. This resulted in the loss of seventeen carats which at £654/15/-a carat meant that over £11,000 was being ground away to worthless powder, but the final result justified this sacrifice. It was, however, a very courageous man who made the decision.

If a fine ruby is cut as No. 4 with the table arranged parallel to the axis, only the minimum colour effect will be produced when the stone is viewed through the table, as only the weaker red of the extraordinary ray will be visible, and the fine red of the ordinary ray would only be seen when the stone was looked at sideways through the girdle, which, of course, would never do.

It will, however, be found that it is only in the small minority of cases where the colour will be so fine that the lapidary is called upon to deal with purely two shades of red, as the majority of rubies will be found to contain one colour of almost a pure red, and another shade of red containing extraneous tints of blue, the intensity of which will show considerable variation in different stones. As a decided bluish tint is a bad defect in a cut ruby, it is the task of the lapidary to eliminate as much of the blue as possible.

In their natural state such stones will be found to fall into three general classes.

A. Those in which, to the unaided eye, the blue appears to be more apparent when the stone is viewed in the direction of the optic axis. Here the blue will normally be quite small in amount, but still quite sufficient to impart a very clearly visible, although slight, bluish tint to the stone.

B. Those in which the blue appears stronger when the stone is viewed at right angles to the axis. In which case the blue is large in amount, and imparts a very marked blue tint to the stone, which may be very objectionable indeed.
C. Those in which the blue appears to be equal in whichever direction the stone is viewed. Here the blue will invariably be found to be very large in amount, frequently completely spoiling the appearance of the stone.

When cutting stones of Class A, it is often possible to entirely eliminate the blue and so produce what seems to be a pure red stone when viewed through the table, by slightly inclining the table away from the axis (as in No. 2); but of course the blue would still be visible if the stone were viewed through the girdle, which would not be so objectionable. The actual angle of inclination will vary in every stone, but will normally be round about 45°, but sometimes an angle as low as 5° will entirely get rid of the blue, and produce a fine red stone; while at other times it may be necessary to arrange the table almost parallel to the axis to obtain the best effect of red. It must, however, be fully borne in mind that, the more the table is inclined away from the axis, the weaker will be the effect of the red itself, and will, therefore, be at its weakest when the table is parallel to the axis.

This is the problem which confronts the lapidary in cutting the majority of stones which are sold as being of the true pigeon's blood colour, but which are really not so; and it may be taken as a fairly sound rule to follow that, when the dichroiscope shows no trace of blue in either of the colours, then the table must be cut at right angles to the axis, and that no cant or inclination of any kind is permissible without spoiling the best effect of the red. But when the instrument shows the presence of blue in one of the colours, then an inclination of some kind is called for.

No fixed rule can be formulated as to the actual amount of cant to be given, and each stone must be judged solely on its own merits, which in the case of a very valuable stone may mean several hours of very close study before a decision can be arrived at. Inclining the table in this manner has the advantage of often allowing a larger spread to be obtained, but the actual size of the stone must always be regarded as being subordinate to the best colour, or the final value of the stone will most certainly suffer; and on no account should the slightest cant be attempted with a pure red stone.

In dealing with a stone of Class B, it is at once evident that the best colour can only be obtained by arranging the table at right angles to the axis. If the blue then shows, as it nearly always will do, it is unfortunate, but there is nothing to be done about it, as the slightest cant will only lead to an intensification of the blue by weakening the red. If a stone of this description is cut as No 4, it will be utterly ruined, and furthermore it could not be improved by recutting, as owing to the direction of its best colour being directly through the girdle, only two comparatively small stones could be obtained from it.

With stones of Class C, very little, if anything, can be done by the lapidary to eliminate, or even lessen, the effects of the blue; but a very considerable improvement may often be made by first of all firing the stone.[1] This operation should, however, only be undertaken by one skilled in the work, and then, owing to the liability of the stone to fracture, never without the written authority of the owner, which should specifically absolve the lapidary from all liability resulting from damage to the stone. After the stone has been fired, a careful examination of its dichroism should be made, which will show the direction of the best colour, and from this the angle of the table can then be arranged to produce the best effect.

As with the ruby, the direction of the finest colour in the sapphire (or any of the other coloured corundums which crystallise in the pyramid habit), is also directly along the line of the axis (A–B). But in stones of this crystalline habit, the dichroism is usually very much more pronounced, and may often be plainly visible to the naked eye, a fine sapphire often being of magnificent blue colour when viewed along the axis, but of an objectionable bluish or yellowish green when viewed in the other direction. Therefore in cutting such stones there is only one possible direction in which to arrange the table, which is at a direct right angle to the axis. Not the slightest deviation is permissible, otherwise a certain amount of the objectionable green or yellow of the extraordinary ray is bound to be introduced which, mixing with the fine blue of the ordinary ray, will completely spoil its purity. Even the small amount of inclination shown by No. 6 would have a markedly deleterious effect, and a stone cut as No. 7 would be entirely ruined. A stone cut as No. 8 would only show through the table the nasty colour of the extraordinary, and the fine colour would only be observable through the side of the stone, which would give one the impression that the stone had been cut by a lunatic. Yet the writer has seen this mistake made by an experienced cutter.

This rule applies to all the other coloured corundums except yellow, but even there, the deepest colour is always in the direction of the axis. Still a

1 See Chapter 3, page 69

certain amount of latitude is allowable as there is no objectionable second colour to be introduced. But the greater the inclination, the poorer will the yellow colour always be, which may be the very result aimed at.

It will thus be seen that, in order to produce the best colour effects from stones of the prismatic habit, the lapidary has a considerable latitude in using his discretion as to the angle the table shall make with the axis, and that the beauty or otherwise of the finished cut stone will entirely depend upon his ability to form a correct judgement. However, in the cutting of stones of the pyramid habit, he is allowed no latitude at all.

The above remarks apply to the cutting of stones where the colour is more or less evenly distributed throughout the stone, but it frequently happens with sapphire, and more rarely in rubies, that the stone is quite colourless save for one small patch of colour, which is often very fine indeed, as indicated by the shaded portions of the diagram.

Should a lapidary be given such a stone and instructed to produce from it a large-sized stone which, when viewed through the table, would be coloured throughout, it would appear to be a task impossible to perform. Yet it can be done in a very simple manner, with quite attractive results obtained. It must be realised that, although there may only be a tiny spot of colour visible, this will have its directions of maximum and minimum intensity, which will bear precisely the same relation to the optic axis as in the case of a fully coloured stone. Now as the object of cutting a stone is to secure full reflection of the light from the back facets, all that the lapidary has to do is to so orient his cut stone in the crystal that this spot of colour, or as much of it as possible, shall be positioned at the point of the base, and also arrange the back facets at such angles that every particle of light impinging upon them where the colour lies shall be totally reflected out through the front again.

To secure this desired effect, it is usually best to make the stone of an oblong shape, and to make the base in the trap cut form, with the basal facets in the coloured portion as large as possible, and with the flattest angle that will reflect the largest amount of light, the facets in the colourless portion being narrower, and at a steeper angle. The crown should be facetted in a manner that will impart an added brilliancy; but the ordinary trap cut rectangular facets are often used, but not always with the best results. In order to get to include more colour within the stone, it is frequently necessary to arrange the back in an unsymmetrical manner, as shown at C_2, where it will be observed the culet is not central, and that the upper back facet is about a third longer than the lower one. Wherever this

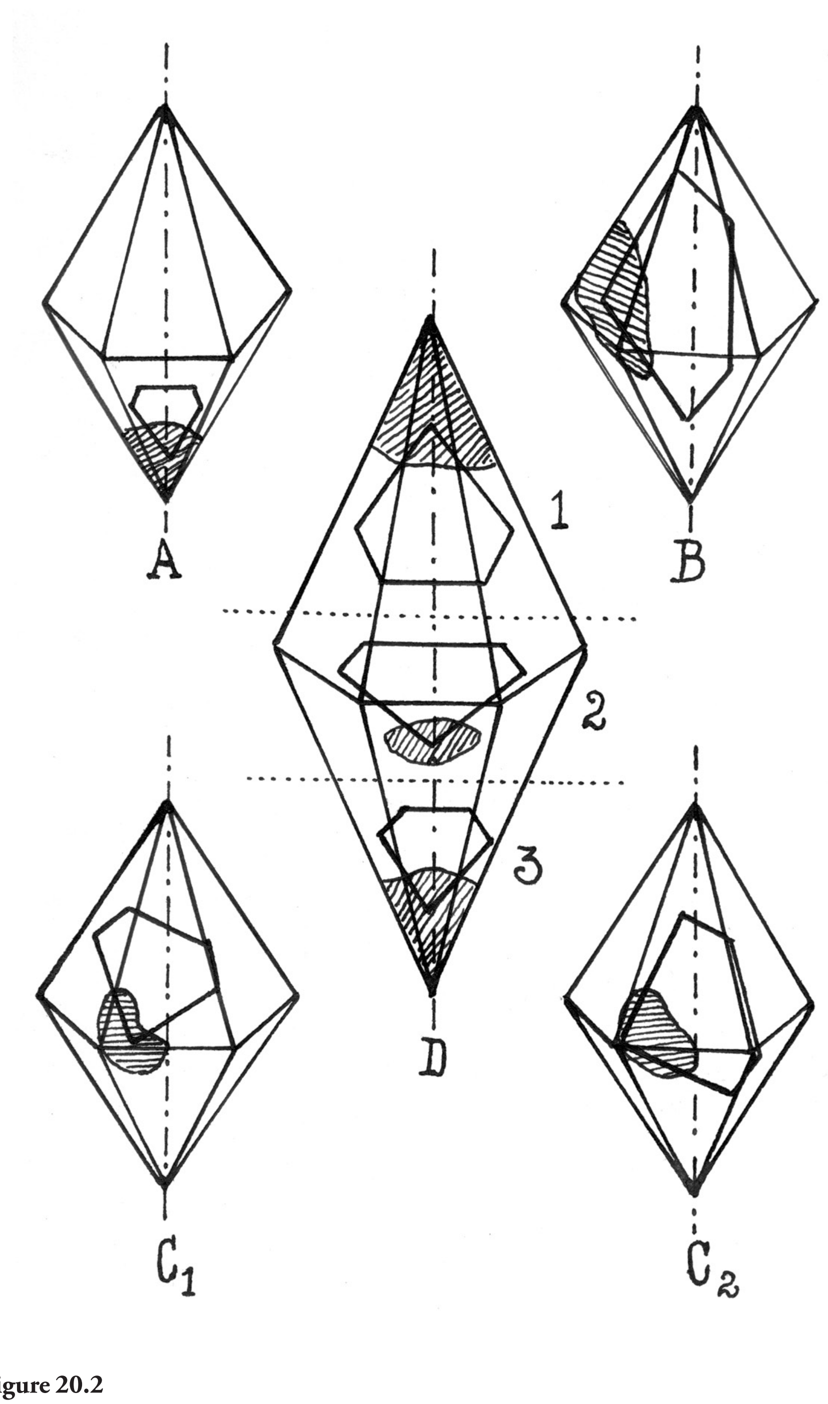

Figure 20.2
To produce a full coloured stone from a small spot of colour.

is done, particular attention must always be paid to the reflecting power of the angles; but whenever possible it should be avoided altogether. The crown of the stone must always be made symmetrical.

When due care has been exercised in cutting, the result will be that when the stone is viewed through the table it will appear to be of a good even colour throughout its entire substance, but if viewed through the girdle, it will be seen to be exactly what it is, i.e. a colourless stone with a spot of colour at the culet. The effect is produced purely by the light entering from the front of the stone being reflected from the lower portion of the back facets through this spot of colour, and becoming so saturated with colour that it really passes out again through the front in the form of reflected coloured light. In doing so, it also tints such rays as are being reflected about within the stone before finally coming out again at the front.

The actual colour effect produced will never quite equal that of a fully coloured stone, but nevertheless it can be very fine indeed, and will always be more intense when the table has been arranged as near to a right angle to the axis as possible (as in A, C_1 and D_1, D_2, D_3), and at its weakest when it is parallel to the axis (as in B). How far it is possible to arrange the table in this best direction will of course depend entirely upon the position of the colour in the crystal, and also upon its extent. If we examine A, it is at once apparent that the only possible position is at right angles to the axis, and that only a comparatively small stone can be produced. Likewise when the colour is as at B the only possible arrangement is parallel to the axis, which produces a larger stone with a weak colour effect. If the patch of colour is more or less central in the crystal, then there is a choice of producing a smaller stone with a strong colour effect (as C_1), or a larger stone with a weaker colour effect (as C_2). The shapes of the stones as drawn are merely diagrammatic, and are not intended to represent any particular form of cutting.

Sapphire crystals often occur which are of fine colour at both extremities, with a centre of poor or quite colourless material. It is obvious that such stones must be cut as D_1 and D_3, but larger stones may usually be obtained by cutting a considerable portion of the stone from the colourless portion, instead of only using the coloured part. If, as often happens, there is also a small coloured part in the centre, the crystal is slit into three pieces at the dotted lines, and three quite presentable stones may be cut from it.

Eastern cutters are particularly expert at this kind of work, and will often take a stone with but the merest speck of colour and achieve the most wonderful results with it merely by manipulating the back facets, often in quite an unorthodox manner. The writer once sold a large flat fragment of very pale blue sapphire with an exceedingly thin line of fine colour well to one side, for a thousand rupees. Within twenty-four hours this stone had been resold eight times, being finally purchased for nine thousand rupees by a man who cut it into what appeared to be a fine cornflower-blue stone. This was eventually sold in Paris for £1500, a sum far in excess of its real value.

In sapphires, the colour is very frequently unevenly distributed in patches and clouds of really fine colour intermixed with a poorer colour. In cutting such stones, it is always necessary to arrange that a portion of this fine colour is situated immediately above the culet, an operation which often calls for all the skill that the lapidary can command, not only to do this, but at the same time so arrange the table that the best colour effect can be obtained without undue loss of weight in the finished stone. This will often necessitate making the base asymmetric in shape in order to get a better spread for the symmetrically arranged crown; which often results in a somewhat ugly looking stone when unmounted, and will often detract from its value where a fastidious buyer is concerned. But if the back angles have been correctly calculated, this really amounts to very little when the stone is finally mounted. In fact, it may considerably improve the general appearance, but still, other things being equal, absolute symmetry in shape should always be aimed at wherever possible.

Simultaneously with the arrangement of the table, there is another very important point to be decided, which is the actual shape the stone is going to take, as without knowing this, it is impossible to visualise the final cut stone within the piece of rough, and unless this can be done, it is equally impossible to make a satisfactory job of the cutting. When both of these points have been decided, it then remains to definitely fix the angles at which both the back and front facets are to be placed. It has often been said that where colour is of paramount importance, once the table has been arranged to secure the best colour effect, the actual shape (or *make*, as it is called) of the stone is but a trifling matter, and that the actual make of the facets themselves is of no importance at all. Admittedly some sort of an effect can be obtained by such slipshod methods, but it can never be the best, and is often very far removed from it.

Unless due attention is paid to obtaining correct angles, all the time spent on the arrangement of the table may be regarded as wasted. Having secured the maximum colour effect, the thing is to retain it and, if possible,

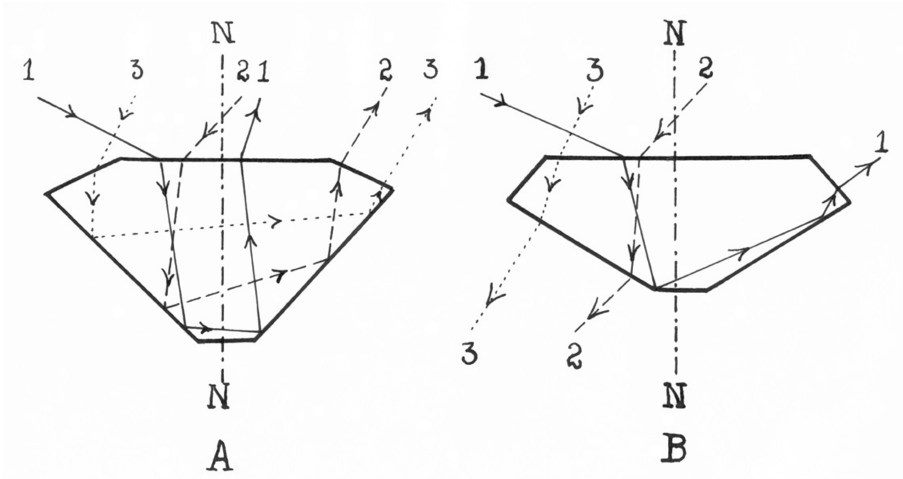

Figure 20.3
The passage of light through a brilliant.

to amplify it, which can only be done by arranging the angles in such a manner as to keep as much light as possible within the boundaries of the stone, and only allowing it to escape through the table or crown facets. The actual form the cutting shall take is, therefore, very much a matter of personal choice, but once the choice has been made, the form must be correctly angled or a poor result will be obtained.

In order to thoroughly realise the extreme importance of these angles, lets us observe the behaviour of three rays of light when passing through a correctly and badly angled example of three different forms of cutting (Figure 20.3, 20.4 and 20.5). In each instance, the rays are identical in their angle and point of incidence on the upper surface of the stone, their direction of travel being indicated by the arrow heads. It should be noted that as the table and culet are plane parallel to each other, any ray of light which is incident at a direct right angle upon the table immediately above the culet will then be in the line of the normal (N–N) to both plane surfaces, and will therefore pass directly through and out of the stone without undergoing either refraction or reflection. Hence the necessity of keeping the culet as small as possible.

Let A represent the sectional outline of a brilliant cut stone which conforms to the angles and proportions that have been calculated to give the best results; and B, a brilliant in which the crown has been made thicker and the base shallower, resulting in steeper angles to the crown facets, and flatter angles on the base. The table and crown facets may conveniently be regarded as windows through which the light enters the stone in a downward direction, and the basal facets as a series of transparent mirrors which reflect the light back again and out through the upper windows. If we now follow the direction of the Ray 1 in A, it will be seen that on entering the stone it is first refracted and then passes downward until it meets with a back facet, striking this at an angle which is greater than the *critical angle,* or the angle which is necessary to secure total reflection. It is, therefore, reflected away at an angle equal to its angle of incidence, right across the stone to a back facet on the opposite side, which it also meets at an angle greater than the critical one, and is, therefore, reflected almost directly upward to the underside of the table, and meeting this at an angle less than the critical one, it is not reflected but passes out of the stone in an upward direction, being again refracted in doing so. Therefore, it passes out again through the front of the stone carrying the full effect of the colour with it, to which it also adds the effects of dispersion. It will also be seen that Rays 2 and 3 behave in a similar manner, and although they both emerge through a crown facet, they do so in an upward direction so that they will be fully observable from the front of the stone, and will be saturated with colour, to which dispersion will add a certain amount of sparkle and brilliancy.

Now compare with this the same Ray 1 in B, which will be seen to behave in a similar manner until it reaches the first back facet, but owing to the flatter angle of the facet, the angle of reflection will now be in an upward direction to meet the opposite back facet near the top, and there to make a very wide angle of reflection, which causes it to meet the crown facet at less than a critical angle and so be refracted out of the stone in an oblique direction, which renders its colour almost unobservable from the front. But when Rays 2 and 3 meet with the first back facet their behaviour is altogether different, as owing to the flatter angle of the facet, they both meet it at less than the critical angle and are refracted out of the back of the stone in an oblique direction downwards. This means that their effects of colour, light and dispersion are entirely lost to an observer from the front; or in other words the coloured light has been made to emerge in a direction exactly opposite to the one required.

Let C represent the section of a well made trap-cut stone, and D that of a badly made one, in which it may be noted that the general shape and proportions closely conform to those of A and B, but that the back facets are now arranged as a series of rectangular steps, each one of which has a

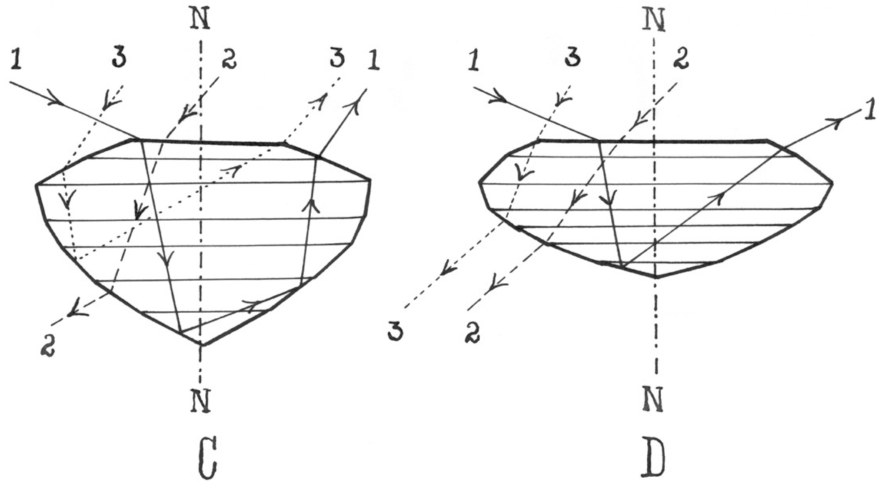

Figure 20.4
The passage of light through a trap-cut stone.

slightly flatter inclination than the one immediately above it. In C, Ray 1 behaves very much the same as in A-1, and is refracted out of the top side facet. Ray 3, however, meets the flatter third base facet at a much steeper angle and is reflected upwards to the table through which it is refracted in an oblique direction upwards. But it only just manages to do this, as the angle formed between the ray and the table is almost the critical one, and if it were the slightest degree less, would result in the ray either being refracted out of the stone at an angle only just grazing along the top of the table, or being totally reflected back again into the stone. Ray 3 meets the much flatter fourth base facet at less than the critical angle, and is refracted out of the base of the stone, with its effect totally lost.

This shows that even a well-made trap cut is not so efficient as the brilliant form for preventing back leakage. But it must be borne in mind that whatever form is adopted a certain amount of this leakage through the back is bound to take place, and that the object is not to prevent it altogether, but to minimise it as far as possible.

In D, owing to the base being made much shallower, all the back angles are correspondingly flatter than in C, which produces practically the same effects in the three rays as was observed in the flattened brilliant B. This further illustrates the bad effects of making the base too shallow, and emphasises the necessity of correct back angles.

It may be argued that in the case of coloured stones, this back leakage could be entirely overcome by mounting the stone in a closed setting and placing behind it a piece of foil, which would act as a reflector and send all these escaping rays back again into the stone, and thence out again through the front. This is to a certain extent true, but the use of foils, coloured or otherwise, is at the best only a subterfuge, and the effects obtained by their aid are never so fine as if the make of the stone had been properly designed in the first instance. Besides which it is not always convenient, or desirable, to close set the stone.

It will also be of advantage to here consider the behaviour of the same three rays when passing through a stone cut to the rosette-form, which merely consists of a crown with no base at all. There are therefore no back angles at all to consider, as the action depends entirely upon the angle at which the incident ray is refracted onto the large basal plane surface in order to secure total reflection out through the front again; and further upon the correct angles of the crown facets to refract these reflected rays outwards in the desired direction. Which proves that the crown angles must also be correctly designed.

Let E represent the section of a well-made rose-cut stone, and F that of a badly made one. In E, Ray 1 is incident upon the upper portion of one of the crown facets, and is refracted across the stone to the underside of one of the cross facets and thence reflected downwards to the basal plane, which it meets at less than the critical angle and is, therefore, refracted out of the base of the stone, and its effect entirely lost. Rays 2 and 3, however, meet the base at an angle greater than the critical one and are reflected upwards to the crown and cross facets, meeting, which at less than the critical angle they are refracted outwards and upwards in the desired direction; but in this case the effects of dispersion are not so strongly marked. In F, the whole stone has been made much thicker, resulting in a considerable steepening of all the angles, so that all three rays now meet the basal plane at less than the critical angle, and are all refracted out through the base. This shows that the total loss of light in a rose that is cut too high is going to be very great indeed.

Comparison of the two figures, therefore, shows that the rose form is not suitable for stones of any degree of thickness, but it is a suitable and very useful form for the cutting of such stones that in their rough state are too flat to permit of being fashioned into correctly proportioned stones of other forms without serious loss of raw material. They also show that even in a well-made rosette, there must always be a considerable leakage of light

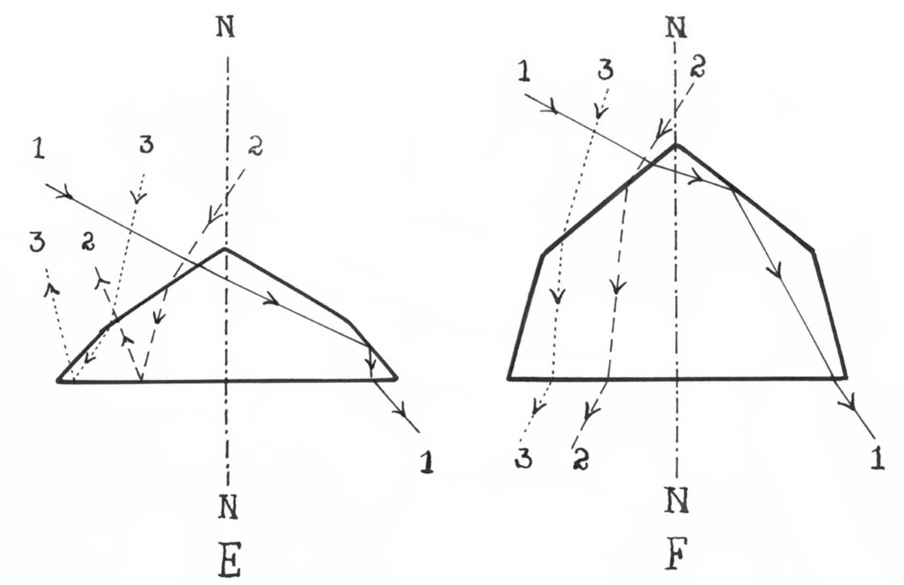

Figure 20.5
The passage of light through a rose cut stone.

through the base; with the consequence that rose cut stones will frequently be found close set, and often backed with foil.

But the most important thing indicated by the figures is that in all forms of cutting, due regard must always be paid to the correctness of the angles of the crown facets, as these angles will in all cases determine the angle at which the refracted ray will impinge upon the back facet. Therefore, a wrongly angled front facet will make all the difference between a ray being refracted out of the base of the stone, or being reflected back again into the interior.

We have only considered the case of three rays of light incident from different angles and passing from facet to facet in a single plane, but actually the same conditions apply in other planes extending right round the circumferance of the stone. So that, instead of only having three rays, there are really millions of rays entering from the front of the stone, and being internally reflected and again emerging through the front at every conceivable angle round the central point N.

When a ray of light is reflected from a curved surface, it does not behave in the same way as if the reflection took place from a plane surface, but is distorted according to the degree and form of the curvature. This behaviour is entirely unsuited to the requirements of a facetted stone, and it is due to this that, when cut stones are required to have a round form at the girdle, they are never ground to the form of a true circle, but always consist of a number of facets with plane surfaces, which become smaller and increase in number the nearer it is required for the girdle to approximate to a true circle. Another important reason is to ensure that each facet will make a portion of a prism with some other facet which is not plane parallel to it, because the colour dispersing of light when passing through a prism is greater than in the case of a parallel plate. And there are also advantageous effects upon both refraction and reflection.

It will therefore invariably be found in all forms of facetted cutting that, save in the case of the table and culet, no two facets are arranged so that they are quite plane parallel to each other, but no matter how small they may be, if their lines are sufficiently prolonged they will form a prism, not only in regard to the meeting point of the two plane surfaces, but in the relations between one facet and another at a distance, and in an entirely different direction. It therefore follows that the basis of all facets must be the triangle, and it will be found that all facets may be resolved into a series of triangles with straight sides by means of a series of diagonals, and further that these triangles are always related to each other in a triangular manner, apart from the superficial triangulation, and, if it were not so, then the universal prismatic arrangement could never be maintained. Even the table cut, which is the crudest form of modern facetting, closely follows this rule, and the most fantastic forms of bastard cut strictly adhere to it. The general principle is of course derived from the octahedral crystal of the diamond.

The earliest forms of shaping a gemstone consisted of merely polishing the natural faces of the crystal, which were known as *point stones,* a practice followed to this day in Burma with spinels. The next step was to truncate the octahedron of the diamond to about half its width in the upper half, and to a quarter in the lower, producing what is known as the *table cut.* This was a considerable improvement, and remained popular until about the middle of the seventeenth century, when Cardinal Mazarin thought of cutting extra facets onto the upper portion, and by placing sixteen triangular facets round the table, gave the stone a rounded form, and at the same time he ground twelve smaller facets onto the upper part of the base, which merged into the square portion. This was a very decided improvement and became very popular, the stones being known as *Mazarins* and later as *double-cut brilliants.* About the end of the same century, Peruzzi produced a cushion-shaped stone with thirty-two facets round the table, and a semi-hexagonal base of 28 facets and a culet, which greatly added to the fire and general brilliancy. This is known as the *triple-cut brilliant, old cut,* and diamonds so cut appear to be quite dull when compared with those of the modern cut; but where colour is the main factor this is a very satisfactory form of cutting to adopt. From this was gradually evolved the present form of the *triple-cut brilliant, modern cut,* in which the same number of facets have been more equalised in size and shape, and the angles so minutely calculated that it is the most perfect form of cutting known for bringing out the fire and brilliancy of a transparent colourless stone; and is the best to adopt for such coloured stones as are required to have an almost circular girdle section, as when the direction of best colour has been correctly arranged it will bring out in every way the very best effects the stone is capable of producing.

The modern-cut brilliant as shown in profile at D in Figure 20.6 is divided into two portions by the girdle (G), which is the portion of the stone fixed to the setting. The upper portion (X) is known as the crown, and the lower part (Y) is called the culasse, or pavilion.

The crown consists of a large central octagonal facet (T) known as the *table,* which is the largest facet on the stone, and is always parallel to the girdle, although, where modifications are concerned, not necessarily of the same shape. From the octagonal edges of the table radiate eight triangular facets (1) called the *star facets,* and between each pair of these is placed a large quadrilateral facet (2) known as a *bezel,* or *templet,* of which there are eight altogether, with their upper and lower apices respectively touching the table and the girdle. Between the lower points of the bezel facets are placed two triangular *cross facets* (3), making sixteen in all, each pair of which forms a part of the girdle. The whole thus forming a perfectly symmetrical front with thirty two small facets clustering round the large central table; the object of the smaller facets being to stimulate dispersion, and add to the chromatic effect of the emerging rays by forming numerous small prisms.

The base, or pavilion, is truncated at its apex by a small facet (Z) parallel to the table and girdle, called the *culet,* or *collet.* This is without any intentional optical function, and is merely provided to avoid having an easily splintered sharp point, but, nevertheless, it does function in a small way in preventing certain rays from leaking through the back; but as it forms a parallel sided plate with the table it should always be kept as small as possible. The principal reflecting surfaces consist of eight elongated *bezel facets* (5) extending from the culet to the girdle, at which they are separated

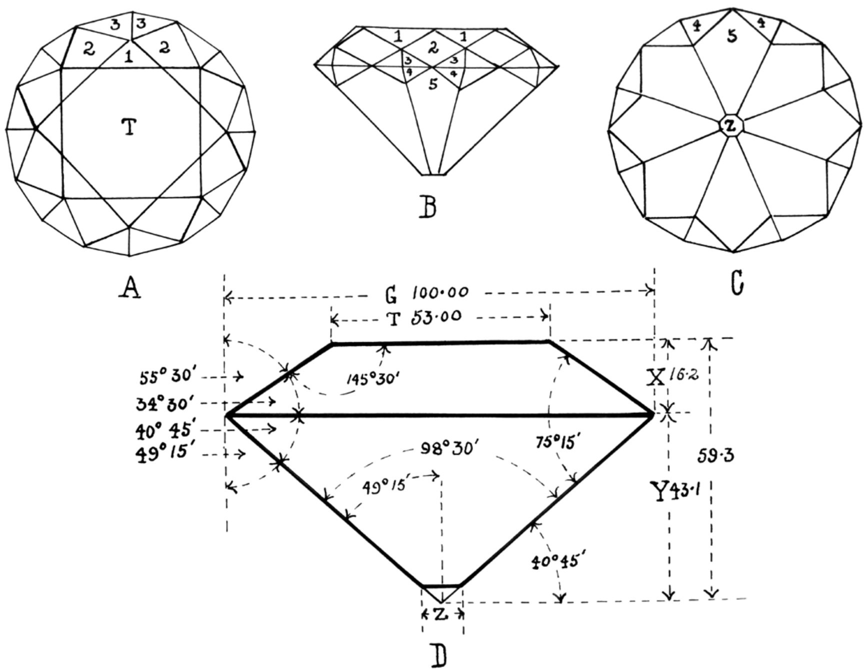

Figure 20.6
The proportions and facets of a modern triple cut brilliant.

by sixteen *cross facets* (4) which are the exact counterpart of the cross facets on the crown, and coincide with them on one edge.

In the case of very large stones, the number of the facets may be increased with advantage, and an additional set of tiny cross facets may sometimes be found added round the girdle, but these really serve no useful optical purpose.

In the old cut style of brilliant, the accepted proportions for a well cut stone were as follows. The diameter of the table (T) was made 5⁄9 that of the girdle (G), and the culet (Z) 1⁄9, the total depth of the stone from table to culet (X+Y) was usually 7⁄8 the diameter of the girdle, of which 1⁄3 was occupied by the crown (X), and 2⁄3 by the pavilion (Y), but these proportions were also often made ¼ and ¾. When these proportions adhered to both, the front and back angles would automatically adjust themselves to give a very large amount of total reflection. In cutting coloured stones to this form, a considerable amount of latitude in reducing the overall depth is permissible, and will not as a rule have any very serious consequences, but any increase in depth may have a very bad effect.

In the case of the more perfectly arranged modern-cut brilliant, these proportions have been calculated to such a nicety in order to develop to its fullest extent the play of prismatic fire, that anything more than a very slight deviation from them will have a very marked effect on the final beauty of the finished stone; and more especially so in the case of stones with a low coefficient of dispersion such as those of the corundum group. In such a brilliant, the diameter of the girdle (G) is taken as representing 100 units, the other proportions being as follows in terms of girdle units. Diameter of table (T) 53.00 units, or just over half the diameter of the girdle; overall depth (X+Y) 59.30 units, or just under six tenths the diameter of the stone; of which 16.20 units, or a trifle over a quarter forms the crown (X), and 43.10 units or a little less than three quarters being taken up by the pavilion (Y). There are no fixed proportions for the culet, which will be found to show considerable variation. The main angles for the crown facets will thus become 34° 30', and those of the base 40° 45', which are the most perfect angles for securing total reflection.

The above form of cutting results in the production of a girdle with a sharp knife edge, which if left in its original state makes a much better looking stone, but has the serious disadvantage of being liable to chip in the setting, which may easily result in a lost stone. To avoid this, it is usual to grind down the girdle a trifle after the polishing is finished, and some lapidaries will leave this slightly thickened edge in its rough unpolished state, which is bad practice as the dull surface may be reflected into the stone and so affect its brilliancy. The edge should, therefore, be carefully polished; and indeed some lapidaries will cover it with a series of minute triangular facets, which seems to be an unnecessary elaboration.

The foregoing clearly demonstrates that in cutting colourless and the paler shades of coloured stones, with the brilliant form, the strictest attention must be paid to maintaining the correct proportions if the best results are to be obtained, and the same applies in its general principles to all other forms of facetted cutting. Stones cut with too great a depth in proportion to their width at the girdle are said to be *thick* or *lumpy* and are lacking in brilliancy owing to back leakage of light. On the other hand, a stone which is cut too shallow is known as *thin* or *spread* and is often not so badly affected in this direction, provided that the thinness is not overdone; if it is, the effect known as *fish eye* will be produced in which the stone will be brilliant round its circumferance, but will have a dull and lifeless spot in the centre which will completely spoil its appearance.

In the same way, good coloured rubies and sapphires, if cut too thick, will be dull and lifeless, which is probably one of the commonest faults to be met with; and if cut too thin they will be lacking in colour. But with very deep coloured stones it is often necessary to ignore the proportional rule altogether, as a much better looking stone may often be obtained by cutting them quite thin, in fact in extreme cases the back may be made almost flat. And also with a lighter coloured stone, a deeper colour effect may often be obtained by cutting them proportionately thicker. In either case, the extent to which this is permissible must be entirely governed by the experience of the cutter; but it is an undoubted fact that a wearable stone may often be produced from a piece of rough which would otherwise be useless by means of ill-proportioned cutting. This may at first appear to contradict all that has been emphasised regarding the necessity of correct angles and proportions, but here we are dealing with abnormal stones, which sometimes call for abnormal methods.

The various forms into which corundum may be fashioned fall into four main groups:

1. Facetted stones
2. Rounded stones
3. Plates
4. Carved stones

Group 1 may be subdivided into:

A. Those made up of two pyramids in various forms, in which, although the actual arrangement of the facets and shape may show considerable variation, they all possess in common a crown, girdle, and pavilion.
B. Those composed of a single pyramid, having only a crown with a girdle at the base.
C. Facetted elongated or rounded forms, such as drops, beads etc.

Group 2 may consist of:

A. Dome shaped stones, which may be single or double, with variously shaped bases, and sometimes hollow.
B. Spherical shapes, or beads.
C. Drops of various shapes.

Group 3 may have any shape of outline, but the upper and lower surfaces must be parallel. Group 4 consists of stones carved and engraved in various ways, and includes completely sculptured figures.

The brilliant cut

The brilliant form of cutting, which is characterised by the majority of the facets being triangular or diamond shaped, and by its large octagonal table, is capable of very considerable modification in general outline without any great loss in effectiveness. Thus it is possible by merely altering the shape of the girdle to suit any abnormally shaped piece of rough to produce oval, pear shaped, triangular and many other shapes of brilliants, which is done by distorting some of the facets and, if necessary, adding a few extra ones to even things up.

For medium-sized fine coloured rubies and sapphires, the pure brilliant cut, either modern or old style, is an effective method to use and produces beautiful stones. But beyond its fine appearance and symmetrical shape, it is doubtful if it possesses any real advantage over certain forms of the mixed cut. It is excellent for the paler shades of ruby and sapphire, and also for the other coloured varieties of corundum, but it is entirely unsuited to dark rubies or sapphires, which always have a lifeless appearance when cut to this form. In the cutting of the flat tabular crystals of ruby, it will invariably lead to a severe loss of raw material if the correct proportions are to be maintained.

The step (trap) cut

This form of cutting, which derives its name from the Scandinavian *trappa* (a step), is characterised by the lower portion being composed of long rectangular facets arranged in a horizontal direction to the girdle, much after the manner of a flight of steps; the upper portion also being facetted in a similar manner. The girdle may be made to any shape having straight sides i.e. square, hexagonal, octagonal, or with twelve or more sides, and may be elongated to any extent in any one direction. On both portions the facets are so arranged that their lines of intersection are parallel with the girdle; and there may be two or more series of such facets on the crown, and four or more on the base. A culet may, or may not, be added, but if it is the table, culet, and girdle will all be the same shape.

In all cases, it is necessary to arrange the proportions of the base to meet the requirements of the stone being cut; so that if the stone is pale in colour, the base must be made deep, and more facets added. If it is deeply coloured, the base must be made shallower, as if it is too deep the stone will appear to be lifeless. By judiciously modifying the base it is possible to so regulate the colour that it will give the best effect. The stone will, however,

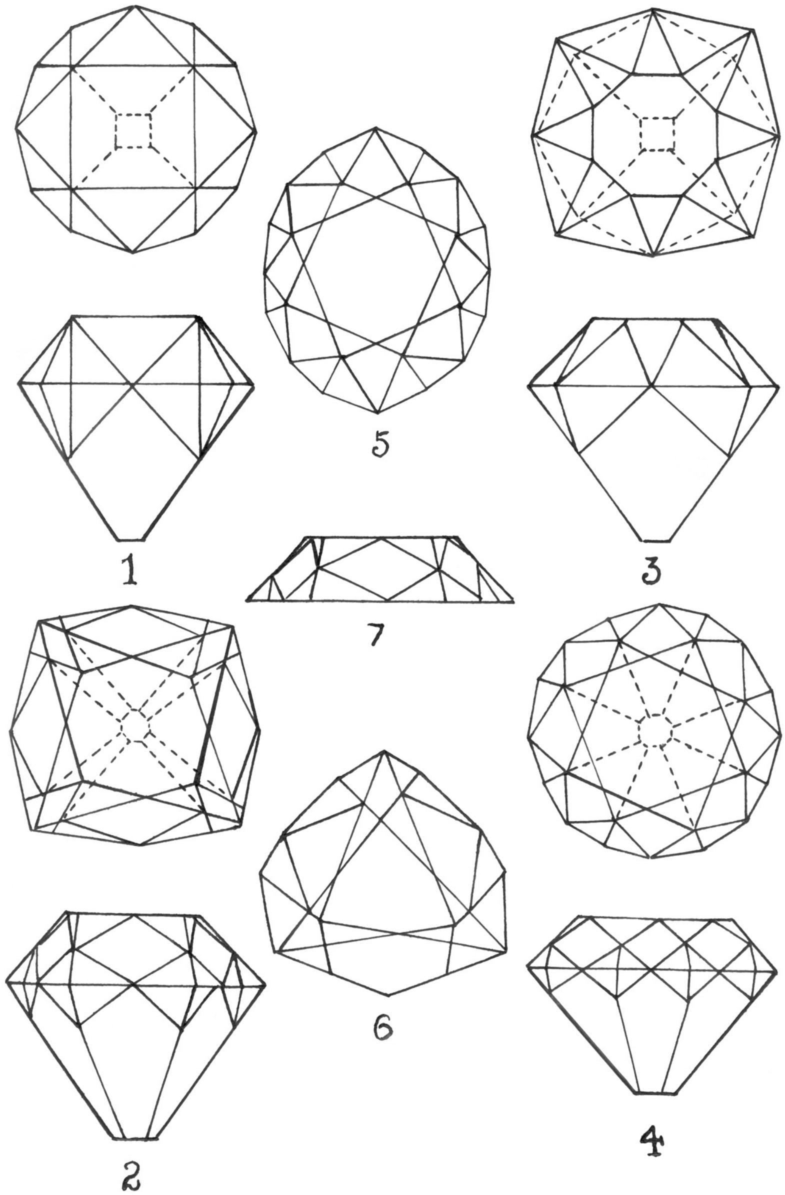

Figure 20.7
Various forms of the brilliant cut. 1. Double-cut brilliant, or Mazarin; 2.Triple-cut brilliant, old cut; 3. Double-cut brilliant, with star; 4. Triple-cut brilliant, modern cut; 5. Oval triple-cut brilliant, modern cut; 6. Triangular triple-cut brilliant, old cut; 7. Half brilliant, modern cut

Figure 20.8
Various forms of the step, or trap cut.

never attain its full beauty unless a full complement of back facets are provided, at the correct angles to secure the maximum amount of reflection, so that there should never be less than four series of them, which number may often be exceeded with considerable advantage. The facets on the crown may differ in width, and usually become narrower as they approach the table. But all those on the base should be of the same width, which is usually a trifle wider than the narrowest one on the upper portion; and each succeeding facet should be laid at a slightly flatter angle than the one immediately preceeding it.

This form of cutting is most suitable for stones which are not too deep in colour, and if properly proportioned will bring out the colour, lustre, and general beauty of the stone to a remarkable extent. But it is essentially a form for the cutting of coloured stones only, and is quite unsuitable for colourless ones. The milky Kashmir sapphires are very effective when cut to this form.

The rectangular, and square trap cut forms are now very popular for rubies and sapphires of all sizes, and are very attractive for small calibre stones. It is so popular for the cutting of emeralds that it is very frequently referred to at the *emerald cut.* It is, however, by no means an economical form, as the wastage of raw material may sometimes be very considerable. The writer's experience in the cutting of large parcels of mixed sizes from a quarter to two carats per stone in weight, when cut, has been that the average loss in weight from the parcel of rough to the finished parcel of cut stones was as high as seventy-five carats out of every hundred sent to the mill, while the loss on larger stones was not less than forty percent.

The table cut

In olden days the table cut was the first advance made towards producing an artificially shaped stone, and was practised in the East for a very long time before it became known in Europe. As already explained, it is based on the double truncation of the natural octahedron, and no matter what shape the final cut stone may have, it can always be resolved back again to the truncated octahedron.

The commonest form is the square or rectangle with right-angled corners, but as the addition of corner facets increases the brilliancy, six-, eight-, and twelve-sided figures are to be met with. In speaking of table cut stones, it is usual to refer to the whole of the upper portion above the girdle as the table, and not as the crown, and the whole of the lower portion is called the culet.

The depth of the stone may be made exactly the same on both sides of the girdle (B), which gives the stone a flattish appearance, and it is then known as a *thin stone.* Or the culet may be a trifle larger than the table portion (A) when the stone is said to be *half grounded,* and where the table is larger than the culet, as in a properly proportioned stone, it is referred to as a *thick* stone. In the East, the table portion is often made twice the thickness of the culet (C) and the stone is then known as an *India cut* stone.

The main table facet is usually the largest on the stone and is normally, but not invariably, made the same shape as the girdle. But the basal facet, which corresponds to the real culet, is always large and either square or rectangular, no matter what the shape of the girdle may be. The back facets always consist of four plane faces, and as the table cut depends entirely on these facets for its final effect of reflection, the angle at which they are brought on is really of the utmost importance, a fact which the Eastern lapidary entirely overlooks.

As the light is passed out again through the front partly by reflection from the back angled facets and also partly from the large basal facet, we have a combination of the working of the brilliant and the rose forms of cutting. But whereas, in the brilliant, the culet plays no intentional part in the reflection, its counterpart in the table cut has a most important part to play. The best angles and proportions to be observed are those which will

Figure 20.9
Various forms of the table cut. A. Half-grounded stone; B. Thin stone; C. India cut stone

approximate as closely to the brilliant cut as possible. The upper portion may be made quite plain, or may have the rectangular facets of the trap cut form; but is sometimes provided with a modified form of brilliant facetting, which is very effective, but not over popular, and is strictly speaking a bastard form of cutting.

The table cut is still very popular throughout the East, but is now only seldom to be found in Western cut stones. The Eastern lapidary will use it for any variety or colour of stone, but it is really only suitable for coloured stones, and then only when they show a very marked degree of colour. Although for want of a better form, it was once used extensively for diamonds, according to modern ideas, it must now be considered as being entirely unsuitable for any form of colourless or light coloured stone. Eastern cut table stones possess a distinct attraction for the speculative Western buyer when the are of good colour and quality, in that they can usually be recut to modern standards with but little loss in weight, and a considerable gain in both beauty and value.

The mixed cut

Although long looked down upon as a bastard cut, and thoroughly despised by all lapidaries with purist ideas, the mixed form of cutting may now be definitely regarded as a standard recognised form. As its name

Figure 20.10
Various forms of the mixed cut. 1. & 3. Maltese cross; 2. Modern triple-cut brilliant crown; 3. Maltese cross; 4. Star brilliant crown

denotes, it is a mixture of the brilliant cut crown with a trap cut pavilion, but in the East the base often has the table cut form.

The crown is often cut to the pure form of the modern triple cut brilliant (2), but this is not at all necessary as the girdle may be made to almost any shape, and the facets either double or single, and elongated or contracted to meet requirements; and will frequently produce a fine stone with far less loss of raw material than either the pure brilliant or trap cut forms. The lapidary has the greatest latitude in making his arrangements, which enables him to display individuality, and a skilled workman can produce surprisingly beautiful and effective results.

This form is suitable for the cutting of stones of all degrees of colour, being particularly effective with those of a full colour but a trifle on the light side in shade, such as cornflower-blue sapphires, or medium-red rubies, as it will bring out the colour, brilliancy, and lustre far better than any other method. The variety known as the *Maltese cross,* from the cruciform shape of its facets (1 and 3) is exceedingly effective in this respect.

In the writer's opinion, the mixed cut is the most suitable form to adopt for all varieties of coloured corundum, excepting very fine medium-sized rubies for which the pure brilliant form is the most suitable, but even then it is run very close indeed by a good mixed cut. It will, however, not usually be found so effective as the plain trap cut for deeply coloured stones.

Figure 20.11
Various forms of the rose cut. Front and side views: 1. The cross rose; 2. The round rose; 3. The Dutch, or crowned rose; 4. The double rosette; 5. The Brabant, or Antwerp rose; 6. The rose recoupee; 7. Rose with four sided cross facets; 8. Crown, or star facets. B and C. Cross facets, teeth, or dentelle

The rose cut

The rose or rosette form of cutting is so called from a fancied resemblance in the arrangement of the facets to the opening petals of a rose bud. It originated from an unknown source somewhere about the middle of the sixteenth century, and immediately superseded the table cut for the cutting of diamonds, which premier position it held until the introduction of the brilliant. Even today, so far as diamonds are concerned, it may be regarded as being the second most important form of cutting.

It is entirely different from any other form of facetted cutting, being characterised by the base consisting of a large plane surface at the level of the girdle, the facets all being placed above this in the form of a pyramid with a sharp apex. This pyramid is usually kept as high as possible, but as already explained, care should be taken not to overdo this.

The *round rose* (2), with its modifications, is the most common form to be met with, in which the facets are arranged in multiples of six and in two groups. The upper six (A) of these constitute the star, crown, or pyramid of the stone, while the lower facets (B and C) are the cross facets, also being known as *teeth,* or *dentelle.* Except in the case of the cross rose, the star facets are always triangular in shape, and the cross facets usually so, but these may also be four sided. The shape of the girdle is also subject to considerable modification, and may be almost round, square, hexagonal, octagonal, oval, or pear shaped. The actual proportions will naturally depend to a very large extent on the shape of the rough stone, but the best results will be obtained by making the angles of the cross facets to approximate as nearly as possible to 49° and the star facets to 30°.

The *cross rose* (1) is an unusual form with eight diamond-shaped star facets (A), eight triangular cross facets (B), and eight four-sided cross facets (C), the pyramid being made very high. This form is often very brilliant and effective, especially when it is backed with foil.

The double rosette (4) is really a somewhat complicated form of facetted drop, and is perhaps best described as being two rosettes joined together at the base. It is often confused with the pendeloque and briolette forms of cutting, and erroneously called by both names.

The rose cut is not much favoured for the cutting of either rubies or sapphires, but it is often used in the East with most excellent results, the stones being brilliant and full of colour, which is often enhanced by the use of foils. This much neglected form of cutting is thoroughly deserving of a greater popularity for the corundum gems, as, besides its beautiful appearance, it is far less wasteful in raw material than when cutting flattish stones to the square trap cut form. It is also very useful for using up tiny scraps and fragments from the mill, as very tiny rosettes can be cut. The writer once possessed some rose cut rubies of which a thousand stones were required to weigh one carat, each facet on the stone being perfectly formed, but rose-cut diamonds are cut a much smaller size than this. Dark rubies look quite nice when rose cut, but dark sapphires are not so attractive.

The half-brilliant cut

This form of cutting shown in Figure 20.7, Part 7, is somewhat similar to the rose cut, but consists of only the crown portion of the brilliant, with no pavilion at all, as the stone ends in a plain base at the girdle. It is sometimes used for cutting very flat rubies and sapphires, with but only moderate success, and is on the whole not a form of cutting to be recommended for any of the corundum gems.

The bastard cut

Any form of cutting or shaping a stone which does not conform, or very closely approximate to one of the standard types is known as the bastard cut; and although stigmatised by this very ugly name, some of these

Figure 20.12
Examples of bastard cut. 1. Front view; 2. Base view; 3. Side view; A. Gaires star cut; B.–D. Modern unconventional forms

unconventional forms are often very beautiful and remarkably effective in bringing out all that is fine in a coloured stone.

Cutting to novel shapes affords the lapidary an opportunity to show individuality and to display artistic talent. But experiments in the production of such forms were, however, not encouraged by the master cutters in the early days, owing to the high cost of raw material and the great risk of spoiling it. But now that synthetic material is so cheap and plentiful, there is not the slightest reason why young cutters should not be encouraged to experiment freely in this direction, so that entirely new and beautiful forms may be evolved. As modern ideas in the design of jewellery show a decided tendency towards the unconventional, and often bizarre, forms of outline and grouping of the stones, it is becoming more and more necessary to also make the gems themselves to unconventional shapes. This is unfortunately only too often done in a clumsy inartistic manner, which results in not only spoiling the optical beauties of the gem, but also in the production of an ugly and objectionable form of outline. Here then is a vast new field opening out for the scientific lapidary with an eye for artistic design, which incidentally might prove to be a fascinating and profitable hobby for an amateur.

The term bastard cut does not apply to gemstones on which the facets are arranged in an irregular or haphazard manner, as such stones are termed to be *cap cut.*

The cabochon cut

This form of cutting is characterised by its dome shape and plainly polished surface, as, save for the purpose of useless ornamentation (as shown in Figure 20.13, Part 8), facets are entirely absent. The dome may be made to any height from a pure hemisphere, or very much less, to a long blunt point; and the base may be either circular or oval in section, and sometimes has quite sharp points. The underside may be flat, rounded, or hollowed out, and is frequently left unpolished, which is bad practice. When deeply hollowed out (Part 11), the stones are known as *shells,* and when the finished stone has a very low degree of curvature (Part 3), it is said to be *tallow topped.*

It is a form of cutting eminently suited to both dark rubies and sapphires, but fine transparent stones are also to be found cut in this manner; while all asteriated stones must of necessity be so cut, otherwise the phenomenon could not be produced. For colourless, or very pale coloured transparent stones, the cabochon cut should never be used, as the effect is distinctly unpleasing; but it is a most useful form for obtaining quite attractive results from opaque and translucent stones of any colour, which would often be quite useless if cut in any other manner.

In southern India, a low grade of cracked ruby *(sayo)* is cut into shells and the hollowed-out portion filled with pure gold leaf, which gives a most effective result both as regards colour and brilliancy. It is noteworthy that these stones are cut without impregnating them with any kind of binding material and that nowhere else in the world are they able to cut this cracked material into stones of any appreciable size except as plain cabochons, or beads, and then only with the greatest difficulty.

Plates

Both ruby and sapphire of all grades, and often showing a considerable amount of visible silk, are to be found cut into plates of varying degrees of thickness, with perfectly parallel surfaces. They may be of any shape, with edges bevelled, rounded, indented, or facetted in various ways.

These plates are frequently engraved with monograms or crests for use as seals, and are not at all uncommon in the form of deeply cut intaglios of intricate design.

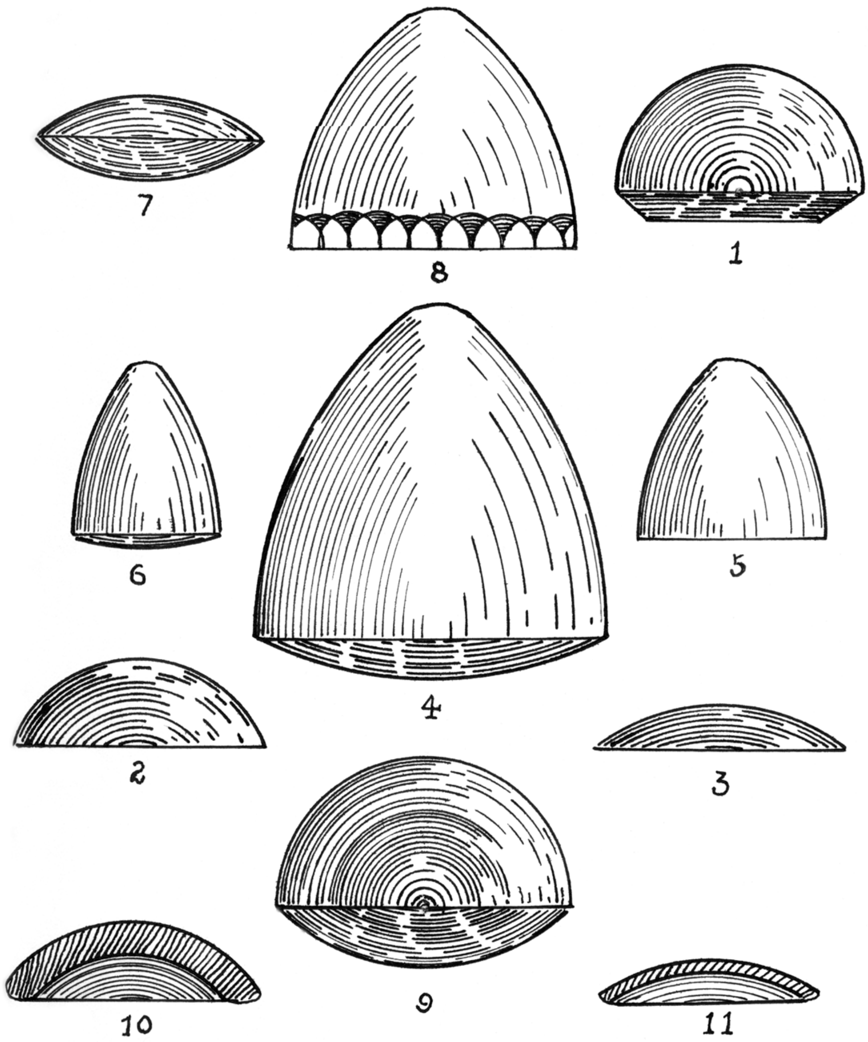

Figure 20.13
Types of cabochon cut. 1. Medium low, with bevelled base; 2. Low, with flat base; 3. Very low (*tallow topped*); 4. Medium low, with deeply rounded base; 5. High, with flat base; 6. Very high, with lightly rounded base; 7. Double low cabochon (*lentil cut* or *coffee bean*); 8. Facetted cabochon; 9. Double high cabochon; 10. Section through hollow cabochon; 11. Section through shell cabochon

Beads, drops and allied forms

Corundum of all colours and every degree of diaphanity is common in the form of beads, which are often facetted in various ways, and frequently very elaborately carved or engraved. In olden days, really fine rubies and sapphires were fashioned into plain polished beads, but now these are very seldom to be met with, the usual forms being silky to quite opaque stones. Plain and facetted drops in endless variety, and also perfect spheres, are quite common.

Carved and engraved stones

There is a considerable quantity of rubies and sapphires carved in the form of leaves and other conventional figures, many of which are very attractive indeed. It is, however, only the poorer qualities that are treated in this way, and if they are of a good colour, will usually be found to be either cracked, full of internal silk or other inclusions, or defective in some other way.

Both the Burmese and Indians are experts in fashioning these stones into completely sculptured figures, mostly quite small, but sometimes of appreciable size. Birds, animals, images and other figures of a religious significence are the favourite subjects.

The Western methods of cutting are too well known to need description here, save to mention that even today the finest work upon really valuable stones is all done upon a mill operated by hand, and entirely by eye, upon an iron, brass or copper lap, with diamond dust as an abrasive; and are polished upon a brass or copper lap with tripolite. On the other hand, the cheaper grades and vast amounts of synthetic material now flooding the markets from Continental cutting factories are all cut on electrically driven laps running at an enormous speed, and are held in clamps with graduated arcs for obtaining the angles of the facets, which being almost automatic in their use and adjustments can be operated by comparatively slightly skilled labour. Diamond dust is used as an abrasive, and very finely levigated diamond dust is also used for polishing purposes. The work is thus done very rapidly and at a cost which is estimated as being about only one ninetieth of that by any other method. But speed, cheapness and mechanical accuracy do not appear to be the essential factors in the production of a pleasing result, as the facets and angles are so deadly accurate and regular that the stone possesses no individuality, and has a hard, unpleasing appearance. Moreover in its extreme accuracy, this method of cutting is decidedly wasteful in raw material.

By far the largest proportion of the total production of the corundum gems are in the first instance cut somewhere East of Suez. The principal cutting centres in India are Bombay, Calcutta, Delhi, Jaipur, Madras, Trichinopoly, Madura, and Vellore. In Burma, Mogok, Mandalay and Rangoon. In Siam, Bankok and Chantabun. In Ceylon, Colombo and Galle. On the whole the cutting is pleasing, but cannot be considered good, and in many cases is downright bad, so much so that the majority of the stones need to be recut before they can be used on the Western markets.

The Burman is perhaps the most civilised workman, but even so his methods are so very much his own that they are worthy of description.

The Burmese cutting mill carries a horizontal lap, but it is altogether much more crude in design than the European mill, which is not saying a great deal. It is operated at a high speed by being turned by hand by a separate coolie, who works a belt, the gearing of which is often of such an original and fantastic design that it might have emanated from the fertile brain of Heath Robinson himself.

Cutting laps are usually made of brass or copper, but sometimes of iron or zinc. Copper or wooden laps are used for polishing, but other materials are also used, and the writer once saw one made of jadeite. The abrasive is usually crushed inferior sapphire or ruby, to which may be added a little diamond dust to give it an extra bite; a very few cutters will, however, use pure diamond dust on the wheel only. The stone to be cut is mounted to a wooden or stick *(kyauktan)* with a cement made from shellac and burnt clay crushed to a fine powder; which for a portion of the operations is merely held in the hand, and for the remainder fixed into a holder made of buffalo horn called a *hnyat.* This permits the stone to be clamped at any desired angle, and is much the same in general principle as the diamond dop arm; it is, however, not fixed to the bench in any way, being merely held and the stone pressed onto the lap by hand. Each individual cutter only works on one stone at a time, but two or three cutters may use the same lap simultaneously. But the Burman only uses the lap for the final touching up of the facets and for polishing, all the preliminary grinding on and shaping of the facets being done by eye and hand alone, the use of templates or gauges of any kind being entirely unknown.

For the preliminary grinding, a series of boards about eighteen inches long by six wide known as *hmat* are employed; these are coated on one side with a thick layer of crushed corundum refuse mixed with shellac, to which if times are good, a very little diamond dust is added, but is more often than not omitted altogether. These vary in grain through four or more

Figure 20.14
The preliminary grinding on the coarse *hmat.* From Scott O'Connor, V.C. (1904) *The Silken East.* London, Hutchinson & Co., 2 Vols., American edition 1905, 842 pp.

grades, from very coarse to almost glass smooth; and when they become grooved through use they are warmed and made flat and smooth again by passing over them an ordinary flat iron. The first step is to take the stone mounted to the end of a fairly thin kyauktan, and to hold the coarsest grained hmat in the left hand, with its lower end submerged in a bowl of water, and then to vigorously rub the stone up and down the hmat, using considerable pressure and letting the stone dip into the water at the end of each downstroke. This is continued until the whole of the crown has been very roughly ground to its final shape. It is then melted off the kyauktan by means of a tiny charcoal fire, and reset so that the same operation can be repeated on the base.

The stone is then mounted crown uppermost onto a much thicker kyauytan, which is fixed to the arm of the hnyat into which it is a very tight taper fit into a hole in a peg, which in turn fits into the arm very much in the manner of a violin tuning peg, so that by merely twisting the peg and kyauktan about any portion of the surface of the stone can be brought to bear on the lap or hmat, and at any required angle. The cutter now takes the

Figure 20.15
Grinding on the facets, using the *hnyat.*

second coarsest hmat and lays it flat upon a small platform standing but a few inches above the level of the floor, and then squats at one end of it with the legs of the hnyat resting on the platform, and the stone on the hmat.

The stone is adjusted to the proper angle for grinding on the flat table, and a little powdered abrasive and water placed on the hmat, and the cutter then proceeds to slide the stone up and down the hmat using both hands and considerable pressure in doing so. From time to time he will lift the hnyat and after wiping the stone on his cheek or forearm will inspect the growth of the facet, and will then place the end of the hmat in a bowl of water and lave off the accumulated powder, which is carefully dried and the screened to different sizes for use in making new hmats. This process is continued until the table has been ground to its full size, when the angle of the stone is altered and the remainder of the crown facets ground on, one after another. The whole process is then repeated twice on hmats of increasing degrees of fineness, but some cutters will use six altogether, the last being almost like a piece of glass. By this time all the facets are quite perfectly formed and there is very little actual grinding left for the mill to do; and in point of fact, many cutters will at once proceed to the polishing, and

Figure 20.16
Polishing the stone. From Anonymous (1905) A city built on rubies: The marvelous mines of Mogok. *Booklovers Magazine,* Philadelphia, Vol. 5, No. 1, January, pp. 15–26.

if the stone is placed on the grinding mill this operation has to be very lightly performed with one hand only, more guiding the stone than exerting any pressure to avoid distorting the facets already formed by the hmat. When the crown is completely finished the stone is reversed in its cement setting, and the base is ground in exactly the same manner.

On the whole the work of the Burmese lapidary is superior to that produced by the native of India, but it is never really first class. He charges quite moderately for his work on the basis of the weight of the finished

Figure 20.17
A Burmese ruby carver at work.

stone, but will increase the rate per rati according to the value of the stone itself. His great fault is that he will always cut to produce the largest stone possible, and to do so will ignore all conventions regarding symmetry of make, and set at defiance all rules regarding angles or proportions; and what is worse will often leave unsightly surface blemishes in the shape of uneven holes etched on the back of the stone. Weight seems to be his inherent vice, and he seems to understand nothing else, for even if given implicit instructions regarding the proportions and shape, and one stands over him while working the stone, he will then do his utmost to defy your instructions in order to sneak in an extra quarter of a rati.

The appliances of the Indian lapidary are of the crudest possible form imaginable, and those in use today conform in almost every detail with those described by Tavernier in 1665. The lap revolves in a vertical direction and consists of a moderately thin disc of iron or copper into the surface of which has been hammered an abrasive of diamond dust, or more often crushed corundum; but frequently the abrasive is merely plastered onto the surface of the metal by means of hot shellac. This lap revolves in two rickety uprights which are simply pushed into holes in a block of wood, and is rotated by means of a long bow which the cutter works with his right hand; the rotation is therefore backwards and then forwards in alternate directions, and it makes a most curious and distinct noise when cutting is in progress.

Figure 20.18
An Indian lapidary using the vertical bow lap.

The stone is mounted with a lace cement to any old piece of stick and is simply pressed against the lap by the left hand. There is no support of any kind except that afforded by the cutter's left knee, and the facets are formed and their positions determined purely by the eye and hand working together. All the facets are ground onto the one portion of the stone at a single setting, there being no preliminary shaping of any kind.

The polishing is done on a brass or copper disc in exactly the same way, and the majority of Indian cutters will lay claim to their polishing paste being their own particular secret preparation, but will in fact almost invariably be found to consist of a species of tripolite, or locally found bole, mixed with cow's urine.

The slitter is often a piece of tin worked in the same way, but is more usually a piece of thin wire stretched between the ends of a bent cane, smeared with diamond dust or crushed corundum mixed with butter or cooking oil, and worked like a saw.

Figure 20.19
An Indian lapidary drilling a stone.

The drill is an ordinary needle pushed into a crude holder and rotated by means of a bow; but is very often merely driven into the end of a round piece of wood and twirled between the palms of the hands. The stone is held between two pieces of wood lashed together with string, and is cooled by a small stream of water let onto it from an earthen water pot.

The work is always more or less crude, but when one considers the primitive nature of his appliances and the miserable conditions under which he normally works, it is really surprising the delicate work these men will turn out. The writer has often employed Indian lapidaries who will work on the hotel verandah from daylight to dark for the equivalent of ten pence. As he always cuts for the greatest size, the work of the Indian lapidary has the advantage that it can usually be improved by recutting.

London has long held the reputation of possessing the most highly skilled cutters in the world, and in this is run very close by New York; but in both cities, beyond the production of the very finest class of work, comparatively little serious cutting is really done. So far as the corundum gems are concerned, the art of the highly skilled men would appear to be developed more along the lines of refashioning stones which have already been cut, than in the production of fine cut stones direct from the rough. If they are given a stone which has been fashioned by the crude methods of an Eastern lapidary, or the inferior cutters of bygone days, they will usually recut it with but a trifling loss in weight into a very beautiful stone in which every good point is brought out to its fullest extent. On the other hand, if given a rough stone they are not always so successful in getting the best out of the stone that it is capable of producing; although for fine effect, what they do produce cannot be beaten.

The writer is aware of quite a number of instances where stones obtained direct from the rough have only been produced at the expense of a considerable amount of raw material which might have been cut into the stone. Or, in other words, had the stone first been cut by a native cutter and then recut by the European, an equally beautiful but larger stone would have been produced.

There is a very sound reason for this which is not far to seek as it really amounts to the application of practical experience. In spite of his crude methods, the native is usually a very highly skilled cutter in his own way, and his raw material being almost invariably in the rough, he is naturally a past master in judging its possibilities, as he has been doing nothing else all his life, and his forefathers have been doing the same for countless generations, stone cutting being a trade which descends from father to son.

This, combined with his invariable practice of always cutting for size, enables him to visualise in the rough stone the largest piece that can possibly be obtained from it, which he proceeds to cut out, and includes not only all that is fine in the stone, but also a large amount of useless material which has to be removed by subsequent recutting.

The European is also able to visualise the finest piece of colour in the stone, but not necessarily the largest piece, and he sees it. But he has not the advantage of the vast experience of the native in handling the rough, and the dull exterior of the stone, to which he is not so well accustomed, will probably mask to his eye an extension of this fine colour which he cuts to waste. With the native method, this would have been included in the stone, and when recutting, would also have been retained. But given a clean stone, in which he can see the full extent of the fine parts, there is no one to equal the European cutters in the fine work he will produce.

In view of the foregoing, it is obvious that in dealing with coloured stones in the rough, unless one has a very great experience of them, it is of considerable advantage to first of all rough polish the stone all over, so that a clear unobstructed view can be obtained into the interior, and all its beauties as well as its defects clearly seen. It is then a fairly simple proposition to visualise the final cut stone and to estimate its exact size and position. This may take a little more time, but the results obtained will usually amply justify this.

When cutting stars, this preliminary polishing is of the greatest advantage, and the stone should always be given a rough spherical or ovoid shape. The star should then be plainly visible, and if it is examined in the asteriascope, the cutter will be able to fix the exact spot at which to make the apex, so that the star will be quite central, and also to calculate the exact proportions and final shape in order to secure the finest appearance.

21
THE MOUNTING OF CORUNDUM GEMS

Why a cut stone requires mounting ✤ The difference between a gem and a jewel ✤ The two classes of mountings ✤ The stone is more important than the mounting: Apparent increase, or decrease in the size of the stone ✤ Carmonising ✤ Metals used for mounting ✤ Platinum, silver, gold, white gold ✤ Fraudulent substitutes ✤ Gold not the ideal metal for use ✤ How gold affects colour ✤ Rubies and sapphires spoilt by gold ✤ How the stone is attached to the mounting ✤ The open setting ✤ The closed setting ✤ Chicanery hidden by close setting ✤ Eastern jewellers and tricks in mounting ✤ The bad effects of carelessly associating stones of different colours ✤ Mounting stones upside down ✤ Methods of mounting stones in collections ✤ Cleanliness is essential for the appearance of cut and mounted stones

A stone in its final cut and polished state direct from the hands of the lapidary is commonly referred to as a *gem.* In this state it is of no use as an article of adornment, as it cannot be attached to the person, and can only be somewhat poorly exhibited upon a pad of satin or velvet. To render them available for everyday use, they require to be provided with some sort of support which will enable them to be freely worn upon the person, or effectively displayed in other ways; and which at the same time will act as permanent base sufficiently solid to prevent the gem being lost or mislaid.

In the great majority of cases this base takes the form of some arrangement in metal, and is known as the *mounting* or *setting,* and the complete assembly of the stone and its mounting is then commonly referred to as a *jewel.* Although metal in some form or other is by far the commonest thing used, there are many other substances to be found acting as supports for cut gemstones; and even the string of a necklace may strictly be regarded as a form of mounting. Such supports are, however, only freak mountings and require no further consideration here.

Mountings may be said to fall into two general, but very distinct classes:

A. Where the stones themselves are entirely subordinate to the mounting, and are only added to impart extra beauty and value to a mass of metal, which may be arranged in a purely ornamental or useful manner. This form of mounting is exemplified in Royal regalia, jewelled church plate, and in a thousand ways as fancy articles in daily use.

B. Where the stone is of primary importance, and the setting is, or should be, entirely subordinate to it; as shown in the mounting of high-class modern personal jewellery.

But in practice there is a very bad overlapping between the two. It is common to meet with really fine and valuable stones that have had their beauty completely spoilt by being made subordinate to the setting through being surrounded by an elaborate display of the goldsmith's art. Beautiful though it may be, it can detract from the general appearance and beauty of the stone.

This was particularly the case with old fashioned jewellery, but there seems to be a growing tendency today to revert to this, and to set stones in barbaric masses of metal, often of inartistic, bizarre design. The mountings used in the East commonly err in this respect, but there a lavish display of gold is always regarded as a sign of wealth. The Eastern tendency today is to use far lighter settings, but whether this is due to economic reasons, or to an awakening artistic sense, it is difficult to say.

In the case of all fine stones, the mounting should invariably be light and dainty, so that it will not only add to the beauty and general appearance of the stone, but will also have the effect of making it appear to be larger than it really is. It must in all cases be unobtrusive, so that, although the observer is fully aware of its presence, it does not actually hit him in the eye. In no case should it be so fashioned that it is the first thing to be noticed, and cause people to remark, "what a pretty setting", which simply means that the stone has been subordinated to the setting. This effect may very easily arise with the lightest and most dainty mounting if there is too much of it.

The effect of increasing the apparent size of the stone is of very considerable importance, not only as regards appearance, but also from a sales point of view, as a stone so set will usually sell far quicker and better than a precisely similar stone which is so set as to appear only its natural size or even smaller. A heavy mounting will always have the effect of decreasing the apparent size of a stone, while a light one will have a tendency to increase it.

The best effect will usually be obtained when the stone is held in simple claws with no metal showing either above or around the girdle, so that the stone would appear to be invisibly suspended above the band of a ring, bar of a pin, or other method of attachment. An apparent increase in size may often be obtained by correctly surrounding the main stone with a border of tiny stones of a contrasting colour, and often of a contrasting form of cutting. This is known as *carmonising* and, if well done, can be very beautiful indeed. But if badly done, as it most frequently is, it can be the most dreadful thing imaginable and utterly ruin the appearance of the main stone.

In all good-class work, the metals used for mounting are platinum, gold, silver, or white gold, the first three of which may be in their pure state, or alloyed with other metals in various ways. For fraudulent purposes, or in very cheap jewellery, such things as gilded brass and a form of stainless steel are often used.

Platinum is expensive but is daily becoming cheaper. It works well, is durable and hard, and neither tarnishes or turns black; thus it does not need to be frequently cleaned or polished, save to remove traces of everyday dirt. In appearance it closely resembles silver, but has a somewhat duller and more steely lustre. At present there is no compulsory hallmark for platinum, but it may be distinguished by its very high specific gravity of 21.531, as compared to 10.474 of silver, and about 7.90 of stainless steel. The specific gravity of white gold is variable according to the percentage of silver present, but it will always be higher than pure silver, that of a 50% mixture being 14.59. The S.G. of 22 karat gold is 18.68. If a drop of a saturated solution of ferric chloride ($FeCl_3$) be applied to platinum, it will leave no stain, but will stain a good quality white gold a biscuit colour, and a poor quality dark brown. Chromium steel is instantly stained grey, which stain is very difficult to remove. Silver is blackened by a solution of sulphur dioxide, or by nitric acid. A considerable amount of fraud has been perpetrated by substituting stainless steel for both platinum and white gold.

Silver is a cheap and attractive looking metal which works well. It is, however, not a suitable metal for jewellery, owing to its habit of easily tarnishing, and of turning quite black through absorbing sulphur from the atmosphere or the perspiration from the skin, and so forming silver sulphide. In any case, it always requires to be frequently cleaned and polished.

In order to secure a white metal which will overcome the high cost of platinum and the bad behaviour of silver, an alloy known as *white gold* has been introduced. This, when of a high standard, consists of equal parts 22 karat gold and pure silver, but the gold content is often very much lower. It appears to be in every way satisfactory, as it is almost indistinguishable from platinum, and is comparatively hard, easily worked, and cheap. As it neither tarnishes nor turns black, it does not require frequent cleaning or polishing.

In spite of the fact of its almost universal use, gold is very definitely not the ideal metal for mounting colourless stones, as by reflecting its colour into the stone it will impart to a perfectly water-white colour a decidedly yellow tinge. And if the stone is at all yellow in itself, this colour will be greatly intensified not only by reflection, but also by direct comparison with the deeper yellow of the gold itself. Neither is it at all suitable for blue or pure red stones, as its yellow colour mixing with the blue will usually impart a very objectionable greenish tint; and in the same way mixing with the red will give a fine ruby such a liverish look that it will make an expert at once suspect synthetic material. Therefore it should never be used for the purpose of mounting either fine rubies or sapphires, as such stones most decidedly call for the use of a white metal; and the writer has seen many instances where the colour effect of both very fine rubies and sapphires has been completely spoilt by mounting them in gold. If the use of gold is essential for the purposes of design, or for other reasons, then the inside of the setting and the whole of the fine claws should be covered with a wash of either platinum or white gold so as to eliminate as far as possible the colour reflection from the back.

There are two basic methods of actually attaching the stone to the mounting:

A. The open, or claw setting, which is also known by the French term *a-jour,* meaning daylight.
B. The closed form of setting, which is also known as *close up,* or *close set,* and also by several other names.

There are, however, endless methods of setting known under a very large number of names, but the principles of every one of them will be found to be based upon one or the other of the above two forms, or sometimes a combination of the two.

The most effective way of mounting all facetted stones is undoubtedly some form of the open setting, which has the advantage of permitting the stone to be seen from all sides, as it is held suspended away from the main setting by a series of tiny claws. It also has a tendency to make the stone appear to be much larger than it actually is, and being unobtrusive allows the full attention to be concentrated upon the stone itself. But it has the disadvantage of being somewhat fragile as there is but little thickness of metal in the claws, which in the course of time are apt to wear thin and snap off, which may easily result in a lost stone.

The closed form, in which the base of the stone is sunk into a cavity in the mounting and a rim of metal then clenched over right round the girdle, is a distinctly stronger and safer method. It is, however, obtrusive to the eye, and has the disadvantage of making the stone appear smaller than it really is; and in the case of facetted stones, other than the rose cut, as the base is entirely hidden, it never shows off the stone to its best advantage. It is an ideal method for mounting large cabochon cut stones, plates, or opaque stones cut to any form; and where it is desired to resort to the use of foils or similar forms of chicanery its use is almost a necessity.

The closed setting, or some adaptation of it, is often employed for the purpose of concealing bad cracks or other defects in a stone. For instance, if a stone contains dark patches of colour, the inside of the mounting may be painted a dead black and so hide the patchy appearance. Or a poor colour may be improved by placing coloured foils in the base of the setting, or the base of the stone may be coated with a pigment. Fire and brilliancy may be stimulated by setting a second stone, or even a tiny piece of mirror, below the main stone; while it is by no means unknown for the base of the stone itself to be silvered to form a mirror.

When it is desired to set a number of stones *en pavé,* or like tiles in a pavement, difficulty is often encountered in securing even an approximate match. This trouble is overcome by separately treating the base of each stone with a pigment, until when viewed from the front they all appear to be of the same colour, and then setting them close-up over a dead black background. Doublets and other forms of built-up stones will nearly always be found close set.

The open form does not permit so many of these little tricks being played; but even here attempts may be made to improve the colour of a stone by placing a band of a deeply coloured transparent pigment round the inside of the setting below the girdle. Native Eastern jewellers are experts in all of these artifices for concealing defects, and very great care is necessary in examining all jewellery of an Eastern origin, more especially if it is close set.

A very common fault in mounting which quite spoils the appearance of a fine stone is due to either carelessness or ignorance when setting it in conjunction with stones of a different colour. This is very especially to be noticed in the carmonising of sapphires with diamonds, as it is quite usual to find a sapphire set round with diamonds which present the appearance of being dirty, and so give the whole jewel a slipshod second-rate appearance. This is caused by using diamonds which are not quite pure white, but have a very slight yellow tint, and as blue and yellow are complementary colours, they will contrast very strongly, with the consequence that the fine blue of the sapphire will make anything but the very purest white melee appear to be quite dingy. Even fine blue-white melee should not be used for this purpose, as the darker blue of the sapphire will entirely override the fainter blue of the diamonds and make them appear grayish by comparison. For the same reason a sapphire should never be set as a twin alongside anything but a pure white diamond, otherwise the general effect is bound to suffer.

The same remarks may be taken to apply in only a slightly lesser degree to the association of rubies with diamonds; and in this case the ruby will also probably suffer by the yellow tint making it appear liverish. How exceedingly common this mistake is will be clearly shown if a critical examination is made of the showcases of any large jeweller. On the other hand, if a fine yellow corundum is associated with a diamond with a slight yellow tint, it will by comparison make the diamond appear to be quite white, and both stones will materially gain in effect by the partnership. The carmonising, or otherwise setting of either rubies or sapphires in association with colourless or yellow corundum is an outrage and the general effect abominable, yet it is very often done.

A curious method of mounting large facetted rubies, sapphires, yellow corundum, and even diamonds, is quite common in the East, which consists of mounting the stone in either an open or closed setting with the culet uppermost, so that the crown is entirely hidden in the setting. This is done merely to pander to the oriental's love of making an ostentatious display of what a very large stone he possesses, and which, if correctly set, should be more than half hidden in the setting. That nine-tenths of the beauty, and all the calculated effects of the cutter, are entirely lost does not concern him; all that matters is that the world shall be able to see the outstanding size of the stone. Against this they also set fine cabochon rubies in a closed setting with the apex downwards, and only the surface of the polished base showing, which has a remarkably fine effect of both brilliancy and colour.

A word of protest may here be said regarding the very unsatisfactory and ugly manner in which fine specimen gems are often mounted in museums and collections, by using clumsy wire clips ending in a spike for sticking into a shelf. These would appear to be all of one standard size, which is used indiscriminately for large or small stones, and is usually about ten sizes too large and of far too thick a gauge of wire. The methods of mounting gems to small white blocks, or showing them in hollows in pads of velvet, are both equally objectionable, as neither permit the stone to be seen clearly, much less to its best advantage. What is wanted is a light delicate clip of wire which will hold the gem well away from the stand, and at the same time be almost invisible. The writer uses a small square of glass, to the centre of which is cemented about half an inch of one-sixteenth or smaller glass tube, the gem being cemented to this by a touch of Canada balsam on the culet. These are shown in the case of glass shelves and look quite effective, and the little stands permit the stones to be freely handled while preventing them being lost or mislaid, and should they require to be demounted, they are quite easily snapped off and cleaned with a little methylated spirit or xylol.

All the care that is taken in cutting and mounting will be completely nullified if during use the stone is allowed to become dirty at the back. The thick accumulation of soap, grease and other filth so often to be found completely filling the back of the setting has a very bad effect on the total reflection, and will absorb a large amount of the light which would otherwise be reflected, with the consequence that the stone appears to have lost its life and sparkle. This frequently leads to it being sent to the lapidary to be repolished, a somewhat expensive business, when all that is required is washing in a little methylated spirit and the back gone carefully over with a small brush. To obtain the best appearance from a cut stone, scrupulous cleanliness is essential, which can only be attained by an occasional washing in alcohol.

22
ON JUDGING A RUBY

Practical experience a necessity ⚜ The purposes of expert examinations ⚜ Valuation for insurance, probate, purchase by a client, or for personal business purposes ⚜ Purchasing for a friend ⚜ Purchasing on commission or for resale ⚜ Afternoon light not suitable ⚜ Avoid the presence of coloured objects ⚜ Examine by both daylight and artificial light ⚜ Judgment by direct comparison ⚜ Never examine when unwell or tired ⚜ Never examine stones in bulk ⚜ Examine stones when unset ⚜ Forceps ⚜ Judging the basic colour ⚜ Dimming the stone ⚜ Examination in ordinary daylight ⚜ Examination in artificial light ⚜ Examination in bright sunlight ⚜ Examination in refractive liquids ⚜ Examination with a spotlight ⚜ Feathers ⚜ Sleepy stones ⚜ Clouds ⚜ Chalcedony patches ⚜ Dull surface patches ⚜ Icy flakes ⚜ Bad polish ⚜ Spangles ⚜ Enclosed bubbles ⚜ Foreign matter ⚜ Cavities ⚜ The hand lens and microscope ⚜ Colour ⚜ Visible silk ⚜ Judging rough stones ⚜ Special points to be considered when judging rough stones ⚜ Synthetic and other substitutions

It is just as well it should be realised that there is no easy way to become an expert judge of rubies, or for a matter of that of any other gemstone. It is purely a matter of correctly applied experience, and cannot possibly be learnt from books, as they can only explain the most obvious things to look for, and how to look for them, and the remainder must depend entirely upon the learner's own industry, coupled with his powers of observation and an ability to apply these observations in actual practice. But as the different conditions which go to make up either a good or a bad stone will be found to occur in such a variety of ways this ability will depend to an enormous extent upon the students facilities for handling the material itself, and being able to study the various points by direct observation. This cannot be done by merely examining the stones reposing in a museum or jeweller's show case; the material must actually be handled and critically examined. Therefore before anyone can be in a position to express an opinion which is of the slightest value, it is necessary for that person to have served a fairly long apprenticeship and to have handled a large amount of material, and so built up a considerable experience.

An expert is called upon to examine a stone for a variety of purposes, all of which are directly connected with three main things:

A. That the stone is, or is not, a genuine example of the species stated.
B. Its condition, or quality.
C. Its value.

It may also sometimes be necessary to make an examination for the purpose of identifying a stone for legal, or other purposes, as in the case of stolen property; but this is a specialist expert's work of the very highest order, and more especially so if the stone has been recut, or in any other way altered from its original known state.

A and B will after a time become a matter of scientific routine, and will normally present little difficulty. The assessment of value, however, calls for a very special knowledge, and the ability to properly apply it. This is made more difficult still by the fact that valuations require to be made for different purposes, and have to be based upon entirely different factors in each case, upon which there are no rigid standards to act as a guide.

We will assume that a valuable piece of jewellery has to be valued for the purpose of insurance, in which case the value must be calculated upon the basic figure at which the jewel could be replaced by the insurance company, which is naturally the retail selling price at the time of the valuation. That seems simple enough, and so it is when you are dealing with an ordinary straightforward stone or jewel, but when it comes to exceptional stones, or jewels of historic value, then the artistic value of the workmanship, rarity of the specimen, difficulties attendant upon replacement, and numerous other factors all have to be taken into consideration. Mere sentimental value placed upon a gem or jewel by its owner has nothing to do with the professional valuer, and must be entirely ignored. All that he is concerned with is the hard fact of its market value, the remainder being purely a business matter between the parties. Further, it by no means follows that because a stone or jewel was bought for, say, a hundred pounds twenty years ago, it will be worth anything near that sum today; and on the other hand it may be worth a great deal more.

Should it be necessary to value the same piece for probate, the valuation would then have to be based upon its probable realisable value on a forced sale, in the open market either in the sale-room or to a private collector, which is a vastly different thing to its retail selling price in a shop. The stones would have to be valued at the current wholesale rate, and a percentage deducted for a forced sale, and any historic value may, but normally would not, be taken into consideration. The value of the mounting would only be estimated on the prevailing market rate for the metal, at so much per ounce, completely ignoring any value attached to the workmanship, no matter how fine it may be, unless it were of unique historic value.

If the valuation had to be made to assist a client with a view to purchase, it would have to be made with a view to seeing that the client secured a fair deal for his money, and also that the seller was making a reasonable profit; while counteracting the energies of a possibly clever salesman who was simply out for blood, and to secure the utmost farthing he possibly could.

But if the valuation were being made with a view to purchasing the piece on your own account as a business proposition, you would only then be concerned with the purely wholesale value of the piece, which represents the price that you are prepared to pay knowing that it will leave you a fair margin of profit on the resale. This will usually involve an intimate knowledge of both the open and private markets.

It will thus be seen that the business of valuation for various purposes is by no means the simple thing that so many people appear to think. It is no use making a wild guess, or of giving an unconsidered opinion. In every case you must be absolutely sure of both your position and facts, and be prepared to stand by your opinion, and if necessary to fully and clearly explain it in a court of law, which is often a very serious business indeed.

When an expert has occasion to purchase a ruby as a personal gift for a lady friend, the temptation is almost irresistible to make a personal selection in a scientific manner, and to present her with the finest stone you can possibly obtain at your price. But the writer's advice is to take the lady with you and let her select the stone for herself, as she will usually be far more pleased with a stone of her own choosing than with the perfect specimen you have been able to obtain with difficulty. Your expert knowledge will here only be used in an advisory capacity, and to see that the price paid is reasonable compared to the actual quality of the stone. But when buying on commission, or for one's business, an entirely different procedure must be followed and every stone critically and scientifically examined, and every little detail good or bad carefully noted, and placed to the credit or debit side to be weighed when the final decision and estimate of price comes to be made.

In judging stones of all kinds, there is one golden rule to be observed, which is that, while the afternoon light is an excellent thing for the seller, it is very bad indeed for the buyer. This is very particularly applicable to rubies, so never under any circumstances attempt to examine them outside the limits of 10 AM and 1 PM.[1]

For the examination in ordinary daylight select a good North light which is unobstructed by buildings, trees, or other objects; and above all take particular care that there is no brightly coloured surface, or object, nearby to reflect tinted light, or as it is termed, put *colour in your eye.* A well known dealer in Colombo once told the writer that whenever he had an important ruby sale pending, he made it a practice to have several assistants hovering about, each of whom would be wearing some article of clothing of a fine ruby red colour, and that he also laid a special red carpet on such occasions. These precautions are of the utmost importance, and many grave and expensive mistakes have been made by neglecting them.

It is quite impossible to examine either rubies or sapphires solely by artificial light, so never attempt it. But an examination of both stones by artificial light is always necessary in order that their night appearance may be correctly judged. For this purpose, an electric light of between 60- and 100-watt power should be used; but it is absolutely essential that the main examination should be made by daylight.

Unless you are very expert, it is a good thing to have an *aide-mémoire* in the form of a properly classified set of stones with you, so that the final judgment may be made by direct comparison. Also never attempt to seriously examine stones if you are feeling at all below par, as at such times the eye may not correctly respond to colour effects, and mistakes are apt to occur. The same rule applies when the eye is tired by examining large quantities of stones of varying colour graduations. It is then an absolute impossibility to judge colour correctly; and it is a favourite trick of sellers to produce parcels of poorly coloured stuff first, and to make every effort to get you to examine it, solely with the object of thoroughly tiring the eye and so confusing it for colour when the higher-class material is being examined, which may then look finer than it really is. Therefore, if you are in the market for really fine stones, always insist upon their being produced at

1 Editor's Note: When viewing rubies or sapphires in daylight, it is the colour of the skylight, rather than direct sunlight, that is critical. Skylight is most neutral at midday, while it takes on a stronger bluish cast in early morning and late afternoon. The opposite is true for direct sunlight. Thus rubies will look their best in skylight around midday, while sapphires improve in early morning and late afternoon. As a result, the careful buyer purchases sapphires at midday, and rubies in early morning or late afternoon.

once, and when inferior parcels are brought out, merely glance at them and immediately reject them, but never be tempted to do more than this, as it is exactly what the dealer wants you to do.

When examining large parcels, never attempt to look closely at them with the stones *en masse,* but divide them up into small groups of about six stones each on a separate piece of paper, and then examine them. Large parcels in bulk will always appear to be of a deeper colour than when the stones are fewer in number, and consequently they are said to *draw colour,* which really means that more light has been absorbed in passing through the larger bulk of stones, thus causing them to appear to the eye to be of a deeper colour than they actually are.

If possible, all stones should be examined in an unset state, as it is impossible to make a thorough examination, or to be able to see into a stone from all angles when it is in an open setting, and quite impossible to make any examination at all when it is close set. Therefore, unless there is some very sound reason why the stone should not be demounted, always insist upon this being done, and in the case of a determined refusal, regard it as indicating that there is something to be hidden, and act accordingly.

Fine forceps should always be employed for holding the stone, as the fingers interfere with the light entering and the proper illumination of the interior. The forceps should never be of brass (or gold plated), as they will reflect yellow light, but should be of steel or silver plated, while black forceps are ideal for all purposes.

In the ruby, the main thing to be judged is the basic colour of the stone, and this cannot be done correctly with a facetted stone in a highly polished state. Although the ruby has a very low dispersion and but little internal fire, what little there is will often be quite sufficient to interfere with the basic colour of the stone, so it must be eliminated or subdued as much as possible. This is very simply done by merely breathing on the stone so that it becomes covered with a thin misty film of condensed moisture, in which state the true colour can be very easily seen, and if necessary the process may be repeated several times. This is known as *dimming the stone* and is such a simple but highly efficient, and easily applied method that it is astonishing how little one sees it used in actual practice. The examination for colour should not only be made through the table alone, but from every possible angle through the stone, including directly through the girdle, as it is only in this way that errors in colour direction due to faulty cutting can be detected, and the actual direction of the best colour ascertained.

When making the examination, hold the stone in the forceps and then examine it by eye alone in ordinary daylight away from the sun. After noting its general appearance, colour, freedom from obvious flaws, surface or other blemishes, clouds, and any other peculiarities, take it into the direct sunlight, and keeping yourself in the shade examine it by both reflected and transmitted light. Then repeat the examination in artificial light, here taking particular notice of any apparent change in either colour or general appearance. In this way a very good idea will be gained of the appearance of the stone under all conditions, and what is more the eye will have been gradually accustomed to the task before it, and any very obvious faults will have been observed. Up to now, a hand lens should not be employed, as it has a tendency to tire the eye, is apt to obscure large and obvious faults and does not permit of a good idea being formed of what the stone will look like when mounted.

If, after this examination with the unaided eye, the stone appears to be either yellowish or brownish, if it has a liverish look, and more especially if it appears too fine to be true, make a mental note of the possibility of synthetic material and the necessity of making a careful microscopic examination.

Now take it into the direct sunlight again and make a thorough examination of both the exterior and the interior by both reflected and transmitted light; but this time use a good hand lens, which should not be of a lower power than plus eight magnifications, or higher than plus twelve. Shade the stone in different positions by means of the free hand and tips of the fingers, so as to let the light into it at different angles, or blocking it out in any desired portion. Some people will use an auxiliary lens to throw a strong beam of light into the stone, which may be very useful, but is an exceedingly senseless and dangerous practice, as it is very liable to overheat the stone, and so set up a feather, which will completely ruin a possibly very valuable stone which is not your own property. This is no idle warning, as the writer has actually had it happen to one of his own stones. Any internal faults in the shape of cracks, feathers, inclusions, or obvious bubbles should now show up quite plainly, usually in the form of distinct bright patches in the interior of the stone.

But it is not always advisable to trust to the examination in the dry state alone, but to completely immerse the stone in a small cell – a small liquor glass will do nicely – filled with a highly refractive liquid such as monobromonapthalene alpha, cinnamon oil, calol, 3-in-1 oil, or even clean water is better than nothing. When this is done, the most minute imperfection, as well as any patchiness in colour, will usually show up very clearly indeed. Silk should be looked for with the stone immersed in a solution of copper sulphate.

Many buyers will go a step further than this and repeat the examination in a dark room with the aid of a very narrow but strong beam of light thrown into the stone by a specially arranged electric spotlight. This is a most excellent way of searching for internal imperfections, but it is most important that no notice be taken of any actual change of colour effects noticed, as the strong light will play all sorts of tricks with the colour, and usually has the effect of making it appear to be very pale and washy; but at the same time it will usually show up any banding or dark patches that may happen to be present.

Feathers should be most carefully searched for,[2] as they are the most dangerous fault that a ruby can possibly contain. And any stone found to hold a feather, no matter how minute it may be, should be immediately rejected as being comparatively worthless.

A most common fault which detracts from the appearance of a ruby is a slightly dull lifeless appearance, which may sometimes even be cloudy. Such stones are said to be *sleepy* and the commonest cause is microscopic silk scattered throughout the substance of the stone. There is no way of curing this, or even of improving the appearance of the stone. A sleepy look may also be imparted by faulty cutting, that is by making the stone too deep; this may usually be remedied by recutting the stone to more suitable proportions. Uneven distribution of colour may also give a stone a slightly sleepy appearance, which may often be cured by judicious heating.

The semi-translucent patches known as *clouds* are due to internal silk, nests of microscopic bubbles, or to a distinct difference in colour. This is a bad fault for which there is no remedy, save in a minority of cases by recutting the stone. The so-called *chalcedony patches* are semi-transparent milky patches which are due to internal silk, and for which there is no cure. The presence of a marked metallic or pearly sheen is due to visible silk, which it is sometimes possible to rectify by recutting.

Dull patches on the surface or in the interior of the stone may be caused by masses of black silk, and when on the surface can often be removed by recutting, but when in the interior they are incurable. The same appearance can also be brought about by a number of very minute cracks which have

2 See Chapter 8, page 126

been known as *icy flakes* and prevent the stone taking on a proper polish; there is no remedy for them, and the stone is absolutely ruined. Dull surface patches may, however, merely be due to inferior polishing, the cure for which is obvious.

Enclosed bubbles are usually bad faults, as they often interfere with the correct passage of light through the stone, and in artificial light produce the bright metallic spots of light in the interior known as *spangles.* If the bubbles are small and few in number, they will not as a rule matter much, but if they are numerous enough to form clouds, or are distinctly visible to the unaided eye they must be regarded as being serious defects. Large enclosures of foreign matter, or cavities containing liquids or other substances, should always be looked upon as very bad faults.

Unless the bubbles are of an appreciable size and the black silk very prominent, it is quite impossible to examine them, or even to search for them, with a hand lens, no matter how powerful it may be. For the proper examination of such minute detail, the use of the microscope is essential, and even with its assistance it is frequently a matter of great difficulty. The hand lens is very useful indeed for detecting and examining very obvious faults, but it is impossible to hold either the lens or the stone sufficiently steady in the hand alone to permit of an accurate observation of very small objects being made. This minute examination is of the utmost importance, as it is often solely upon the appearance of this microscopic detail that the final detection of a spurious gem may depend.

The colour should be of a fine carmine red with no trace of blue in the finest qualities, but a slight trace of blue is inevitable in the ordinary grades, which may still be regarded as being very high class. The quality and value will decrease as the blue becomes more prominent, and also as the quality of the red degenerates towards pink. Perfect transparency and a fine polish are essential, while the stone should have a sparkle and a lively appearance. It is most important that there should be no change of colour, at least for the worst, when the stone is viewed in artificial light.

The presence of visible silk is a debatable point, and the majority of connoisseurs hold that the slightest trace of it at once puts the stone beyond the pale of even being worthy of consideration. But as before mentioned,[3] a very slight trace of it has the very decided advantage of definitely marking the stone as genuine. Therefore, provided that it is

3 See Chapter 7, page 114

situated in an inconspicuous place, and does not interfere with the general appearance of the stone in any way, a very slight trace of silk may be regarded more in the light of an asset than as a defect.

The process of judging a rough stone as far as searching for faults is concerned is precisely the same as for a cut stone, but there are many more things to be taken into consideration which only practice and long experience can teach. By this is meant, *inter alia,* an ability to judge the colour in the rough as compared to what it will be when the stone is cut and polished, which is not at all an easy thing to do. And of being able to visualise in the rough stone the finest cut stone that can be obtained from it, and of being able to mentally calculate the weight of that cut stone to a fraction of a carats. Also of which are important points to be considered when purchasing rubies in the rough, as a misjudgment once made cannot afterwards be rectified, and may result in a very severe loss. A rough stone should always first of all be examined in the dry state, and then dipped in a clear oil and critically examined when wet; the examination may with great advantage be continued with the stone completely immersed in a high refractive-index liquid.

When purchasing rubies either as mounted stones, as cut stones in parcels, or as rough stones offered singly or in parcels, the possibilities of synthetic substitution must always receive full consideration. Also, unless the buyer is an expert, the physical and optical tests for corundum should always be applied in view of the possible substitution of stones of a similar appearance but entirely different species of a lower value. In this connection, it must be remembered that while such substitutions are most frequently made by swindlers, the same misrepresentation may be made and stones of another species accidentally offered in quite good faith, so that substitution may be met with in the most unlikely places.

23
ON JUDGING A SAPPHIRE

The examination for colour ⚜ What is the best colour ⚜ Velvety lustre ⚜ Uneven colour ⚜ Extraneous tints of colour ⚜ Examination in artificial light ⚜ Examination in yellow light ⚜ Alterations in colour ⚜ Sleepy stones ⚜ Green, yellow and red tints ⚜ Clouds ⚜ Inclusions ⚜ Feathers ⚜ Bubbles ⚜ Silk ⚜ Synthetic material ⚜ Confusion with other species ⚜ Judging rough sapphires ⚜ The care required in judging sapphires

The general procedure for the examination of sapphire is exactly the same as that for a ruby and precisely the same faults may be looked for, but in many cases, owing to the deeper colour of the stone, some of these will be found to be much intensified, and others minimised.

The main thing to be judged is the colour and general appearance of the stone, with very special reference to its stability under all conditions and varieties of light. The basic colour of a sapphire should always be judged by its appearance when viewed directly through the table of the stone, for which purpose it is essential that the stone should be dimmed. It is of prime importance that there should be no appreciable change in the colour between daylight and artificial light, or between ordinary daylight and sunlight.

The actual colour itself will be found to show considerable variation, and what may be considered to be the finest colour is often but a matter of personal opinion, or the demand of the prevailing fashion. But as a general rule, it may be taken that in the finest grades the colour should be either a fine darkish royal blue, or an intense cornflower-blue, but both must be accompanied by a sparkle and lively appearance.

Those stones which possess in addition the rare rich velvety lustre are of a far higher grade than stones of exactly the same colour and general quality but without the lustre. This peculiar lustre is very much esteemed, and should always be carefully watched for.

As the colour decreases in intensity, so does the quality of the stone become poorer; and the same applies as the colour increases towards a black appearance, and stones of a very dark, indigo blue should be regarded as being of the very lowest quality, and practically valueless save for use in the very cheapest forms of jewellery. Similarly, when the colour shows extraneous tints of green or yellow, the stones are of a very poor quality. From the point of view of a pure sapphire, a tint of red is a decided defect, but at the same time may have a certain saving grace. Above all, when a fine stone is viewed through the table, the colour must appear to be perfectly evenly distributed, although such may not actually be the case, but any apparent patchiness in this direction must be looked upon as being one of the gravest faults.

Although the colour should be judged solely through the table, it is also necessary, for the same reasons as with a ruby, that it should be examined from every other angle, and particular attention paid to the view obtained through the girdle. Should the colour here be found to be entirely different, or even objectionable, there is not the slightest reason for alarm, as things are exactly as they should be.[1] But should the colour be finer when viewed in this direction, you know at once that the table has been arranged in the wrong direction to the optic axis. And should the stone appear to be almost, or quite, colourless with a small spot of colour near the base, it is only a parti-coloured stone, and of comparatively little value despite its possibly very fine colour when viewed through the table. Sapphires should always be examined for colour when immersed in a refractive liquid, which at once shows up any patchiness or colour banding.

Very careful note must be taken of the colour and general appearance in ordinary daylight, and then in sunlight, and the stone immediately re-examined by artificial light. Then, if there is any loss in lustre or alteration in the general appearance, and especially if the colour should show any marked sign of becoming darker – in some cases the stone will become dull and lifeless, and almost black in colour – the stone should be rejected as worthless. For this purpose, the stone should be scrutinised at a normal distance from the eye, and then from about ten feet away. On the other hand, some stones will greatly improve both in colour and general appearance, which is a very good point in their favour, if they are presentable in daylight, but on the whole those which show no change at all should be regarded as being the better quality stones.

It must not be overlooked that jewels are mostly worn at night, and in public places, which although they are illuminated by more or less white

1 See Chapter 3, page 63, Chapter 5, page 91 and Chapter 20, page 325.

electric light, these will also reflect a certain amount of yellow light from gilded mural decorations, etc., which sometimes may be very considerable in amount. So that when making the artificial-light test for colour, it should always be made by ordinary electric light and then repeated with the light arranged to carry a certain proportion of yellow. Too great a stress cannot possibly be laid upon the importance of this comparative examination for colour under all conditions of lighting when dealing with sapphires.

The most common fault in a sapphire is a sleepy appearance, which may be caused by silk, an uneven distribution of colour, or by the fact that the colour is too dark, all of which are quite incurable. It may also be produced by making the stone too thick, the remedy for which is obvious. It should, however, be noted that the milky appearance in Kashmir sapphires, which often gives the stones a very sleepy appearance, is considered to be an asset.

The next most frequent fault is a greenish or yellowish tinge of colour, which is very often caused by faulty cutting, but may be the basic colour of the stone itself. This is also incurable. A red tinge looks bad by daylight, but by artificial light may have an extraordinarily beautiful effect; such stones may, however, be regarded as freaks. Extreme depth of colour is always a grave fault, as the stones appear to be black and lifeless by artificial light.

Internal clouds are very common, and are mostly due to an uneven distribution of colour, in which case if they are not observable through the table they may be disregarded. But if they are caused by black silk or nests of microscopic bubbles, they are then grave faults.

Enclosures of foreign matter and cavities containing liquids and other things are very common, and constitute serious faults.

Icy flakes may frequently be met with, and so may the dangerous feathers, and a stone showing either should be immediately rejected.

Enclosed bubbles are very usual, but on the whole sapphires do not contain them to quite the same extent as rubies, and the generality of them are smaller. As with rubies, they may, or may not, constitute faults; but if they produce spangles, or obtrude upon the eye, they are grave faults.

Black silk is usually more prominent in sapphires than in rubies, and may often cause dark patches in the interior of the stone which are quite incurable.

Ordinary silk at, or near, the surface of a sapphire is extremely common, and constitutes a most unsightly blemish. But as with ruby a small inconspicuous trace should be regarded as an asset. Silk should always be searched for in a solution of copper sulphate, when it shows up very clearly indeed in sapphires.

If the stone has a hard steely look, or appears too perfect to be true, at once suspect synthetic material. And if any of the colour banding takes the form of regular curving arcs, then synthesis is practically a certainty.

The physical and optical tests for corundum should always be applied, as there are several stones of very similar appearance, but of inferior species, which are easily confused with sapphire.

The judging of rough sapphires is a very tricky business, and it requires a considerable experience to be able to estimate their colour correctly, and more especially to visualise the cut stone in a piece of rough. It is decidedly the work of an expert well versed in the technicalities of judging rough sapphires, and should never be undertaken single handed unless you have a very great experience in handling such stones.

The judgment of sapphires of any kind at all times calls for the greatest care, as once a mistake has been made and a defective stone purchased, it is very seldom indeed that anything can be made of it, save in a very few instances by drastic recutting with its consequent loss of weight.

24
COMMERCIAL AND NON-GEM USES OF CORUNDUM

Supply not equal to demand ⚜ High grade abrasives ⚜ Mine rejections ⚜ Commercial corundum ⚜ Lapidaries abrasives ⚜ Carborundum ⚜ Sapphire the hardest corundum abrasive ⚜ High-class emery wheels ⚜ Dentists drills ⚜ Engravers discs ⚜ Lining steel furnaces ⚜ Commercial emery wheels ⚜ Emery cloths ⚜ Vitrified wheels ⚜ Chemical wheels ⚜ Cemented wheels ⚜ As an ore of aluminium ⚜ Watch pivots ⚜ Wire draw plates ⚜ Band and chain saws ⚜ Gramophone needles ⚜ Microscope lenses

We have already seen that at least three quarters of the actual corundum recovered in the process of mining for precious corundum is either too small, too cracked or lacking the cohesion, too impure in either colour or substance, or so deficient in transparency as to be quite useless for gem purposes; yet it is still good hard crystallised corundum, which ranks as the next hardest natural substance to the diamond. Beyond this, there are large deposits of the variety known as commercial corundum, or emery, situated in various parts of the world, but which usually contains haematite or magnetite and sometimes other impurities, in consequence of which it has a slightly lower degree of general hardness.

All of these have a fairly extensive commercial use and the supply of the finer grades is often nothing like equal to the demand. The main use to which both varieties are put is in the manufacture of abrasive materials of various kinds, which are placed upon the market in some variety of the following general forms: grinding wheels, abrasive blocks and hones, emery papers and powders of varying grades, and in various other forms adapted for special purposes. The highest grades of abrasives are those in which the fragments will retain their sharp edges, known as the cutting edges, for a long time and do not permit them to grind down or round off in use. This form is naturally supplied by the more solid crystallised rejections from the gem mines, and are therefore used for the most important and highest classes of work.

The mine rejections are first sorted into three classes, ruby, sapphire, and mixed rejections, the later consisting of a mixture of stones such as spinel, chrysoberyl, topaz, tourmaline, garnet, etc., and each grade is then hand pounded to varying degrees of fineness in cast iron or brass pots. Of the powders so produced, sapphire forms by far the largest proportion, and is certainly the hardest and most durable in use; but the powdered ruby, which is appreciably less hard but very durable, realises the highest price, possibly because there is less of it. Consequently, it is used for special purposes. But in any case, the production of both varieties is quite small, and it is doubtful if the whole world's output exceeds the modest total of ten tons of fine abrasive in any one year. The commercial variety is mined and reduced to powder by mechanical means, and considerable quantities are produced.

It forms a high-class abrasive for the less important kinds of work, and has been more or less standardised for hardness, mainly by a very careful selection of the raw material. It will, however, not stand up to the same amount of hard work as the higher grades and has a tendency for the cutting edges to become dull in use.

High-class abrasives of the finest quality are in constant demand by lapidaries for the purpose of grinding gemstones to shape; and of these, powdered diamond with an abrasion hardness graded at 10 is the hardest known substance, and is far harder than crushed sapphire, with a hardness of well over 9, which ranks second; crushed ruby, graded as 9, is third.

Between diamond and sapphire there is a manufactured substance known as *carborundum* – silicon carbide (SiC) – which is prepared by fusing together quartz sand and coke at a very high temperature in the electric furnace. This has an abrasion hardness considerably higher than that of sapphire, but it is very brittle, and the cutting edges soon round off, while the whole quickly becomes reduced to a fine powder which has very little abrasive power. It is, therefore, not much used by the lapidary, except for the softer stones, for which purpose it is often made into solid laps. The similarity of its name to corundum has often led to confusion, and sometimes to deliberate misrepresentation.

Next to diamond dust, crushed sapphire is the commonest form of lapidary abrasive, for which purpose it is often mixed with a little diamond dust to give an added tooth, but it is also used in its pure state. It is also employed for making the very highest grade of emery wheels, which are used for special purposes by engineers and others, and for solid laps for the lapidary.

Crushed ruby is also used by the lapidary, but is more in demand for the manufacture of the very delicate emery wheels, discs, and points used by dentists, high-class glass engravers and cutters, gem engravers, and similar delicate work. It is also used for making emery cloth and small hones for very delicate and high-class polishing work, in which state it is often of an almost impalpable degree of fineness.

The black and brown commercial variety is used for making emery wheels, and an endless assortment of grinding tools for the engineering and other trades. It is the abrasive on all good quality emery cloths and papers, and is used in powdered form by lapidaries for cutting the softer species of gemstones. It is much used as a knife polish, and for similar purposes. Mixed with grease, it is the basis of the better class of motor grinding compounds, but carborundum is most frequently used for this purpose. Large quantities of the massive commercial variety are now being used in Germany for lining furnaces for melting steel.

In the manufacture of emery wheels and solid blocks, the crushed corundum requires to be mixed with some form of bonding material, and then treated in such a manner that it will become a hard solid compact mass. There are three main ways of doing this, each of which may be subject to considerable modification. But in all cases, the corundum powder is in grains of an even size, which will vary with the grade of the wheel that is being made. And since it is necessary for the wheels to be run at enormous speeds to secure efficiency in cutting, great care must be taken in the manufacture to secure a temper, or degree of cohesion, which will withstand the strain, and prevent the wheel flying to pieces.

For medium-sized wheels and blocks, the most common is the vitrified, or fired, type, in which the corundum is made into a paste with suitable clays and other fluxes, and then poured into a mould and allowed to partly dry, after which it is trued up on an ordinary potters wheel, and then fired in a kiln at white heat for several days. It is then turned up to correct size, finally trued, bored, and balanced, and is ready for use.

For large wheels, the chemical, or silicate, process is used, in which the corundum is mixed with sodium silicate (water glass) and fireclay, pressed into moulds and then strongly heated in an oven for twenty-four hours. Wheels of over two thousand pounds in weight have been made by this process.

A softer and often very thin emery wheel is made by the cement process, in which the corundum is bonded with shellac, rubber, linseed oil, and other substances, moulded and then lightly baked. Many Eastern lapidaries make their laps in quite an efficient manner in this way.

Many attempts have been made to utilise the enormous deposits of low-grade commercial corundum as an ore of the metal aluminium, but owing to its refractory nature and contained impurities, this has not been a commercial success.

The lower classes of the gem qualities are also in considerable demand for commercial purposes, the chief of which is as pivot bearings for watches and delicate scientific instruments, where it is necessary to reduce both wear and friction to a minimum. For the same reason it is also used for the bearing knife edges on very delicate balances.

For watch jewels, the general trade term is *watch rubies,* but these will usually be found to consist of a mixed variety of stones with a hardness of 7 and over. There is, however, a very considerable trade done in very tiny rubies for this purpose in Mogok; which is entirely in the hands of women traders who wander from mine to mine and purchase the stones from the kanase women at the rate of between twenty and forty for about a penny, and the women working in the streams, and amongst the rejected gravels and sands for such stones are indeed lucky if they manage to earn fourpence a day. Owing to the great demand, (the requirements being estimated at about two hundred million jewels a year), and the scarcity of natural material, a great deal of synthetic corundum is now used as jewels in the cheaper watch movements, but it is not generally popular and genuine stones are preferred when obtainable at a reasonable price, which is sometimes a matter of difficulty. From the manufacturer's point of view, the synthetic material has the advantage of being of a good clear red colour, which is not always the case with the natural stones.

Ruby is extensively used in making the draw plates used in the manufacture of very fine gold and silver wire; a tiny hole being drilled in the stone and the wired pulled through decreasing sizes of these holes until it reaches a state of extreme fineness. In the case of gold wire, which commences as a piece of fairly thick silver wire very thinly covered with a layer of pure gold, which spreads along the wire as it is pulled through the smooth holes, ruby has been found to be the most suitable stone for the purpose; it being essential to use a hard stone, as steel is far too soft, and the holes enlarge almost immediately. Many other stones have been tried, but none of them will spread the gold so well as the ruby. Synthetic corundum has been tried for this purpose and works very well, but only for a short time, as it appears to be unable to stand up to the strain, and the stones quickly fracture.

Ruby is also used to a certain extent for mounting in band and chain saws for rock and metal cutting, and other tools of a similar nature, but for this purpose it is by no means so satisfactory as diamond; while for mounting in rock drills it was found to be a complete failure.

Sapphire is employed as an everlasting gramophone needle, but on account of its extreme hardness it quickly wears the records; it is, however, used as the cutting stylus when records are being made in the studio.

On account of its hardness, it was thought that pure water-white corundum would make excellent material for the manufacture of delicate microscope objective lenses, and a certain number of them were actually made, but they were not altogether satisfactory.

25
SOME NOTABLE RUBIES AND SAPPHIRES

The fabulous rubies of the Burmese Kings ✤ Two wrongly-named famous rubies ✤ Descriptions and values of some notable rubies ✤ The scarcity of notable sapphires ✤ The Kashmir collection of sapphires ✤ Descriptions and values of some notable sapphires

The greed of the old Burmese Kings in taking the largest and best stones from the miners, has been the basis of a vast amount of fiction being written regarding the rubies of immense size and fabulous value accumulated by them. Much of this is purely of the fairy tale order, but such a great deal of it has filtered into really scientific works and serious historical books that it has become to be regarded as having been an actual fact. Indeed there are vivid descriptions of the beautiful and valuable jewels used to decorate the persons of the kings and their consorts on their various state appearances, made by persons who actually profess to have seen them. But it is noteworthy that we have not a single description of these jewels from anyone who has actually examined them, or was in any way capable of writing with a first-hand knowledge of them.

There is not the slightest doubt that these royal personages were very lavishly decorated with gems, both in their private lives and when they appeared in state; but it must not be overlooked that they were really very simple-minded Orientals with a natural propensity for outward show and tawdry finery, to gratify which the use of glass imitations was by no means unknown. Further, their persons were regarded as being so very sacred that such regalia had to be viewed from a very respectful distance, so that it was quite impossible for anyone even to judge of the genuine nature of the stones, much less to estimate their value. The writer has talked with several of the old officials and habitues of the palace of the times of both King Mindoon Min and Thebaw, and has been assured that the majority of these tales are pure invention, and that most of the stones worn were of quite ordinary, and sometimes very poor, quality; while many of the large gems

Figure 25.1
U Hmat, the Ruby King, and his family. According to Thatcher, his daughter wears "$100,000 worth of gems." This is likely a gross exaggeration. From Thatcher, F. (1908) Where rubies are pebbles. *The World To-Day,* Vol. 15, No. 5, November, pp. 1142–1148.

attached to the robes and other regal paraphernalia were merely coloured glass.

This rather calls to mind the stories of the valuable ruby trousers buttons worn by my friend the Sawbwa of Momeit during his visit to London, which were made so much of at the time by a certain section of the press. The Sawbwa invariably wears his native costume, in which his trousers do not posses a single button of any kind, much less ruby ones.

The fact that only a comparatively few gems of any importance were found in the possession of King Thebaw at the taking of Mandalay confirms the statements made by these old officials. And it is a known fact that when Queen Supyalat left, she carried with her all her personal gems wrapped in a handkerchief which was so small that she dropped it as she was boarding the steamer, and did not miss it until it was returned by a soldier who had picked it up. Of course it was said that the majority of the treasure had been buried as the British advanced, and there has since been such excavating and searching done in and around the square mile of Fort Dufferin, in some of which the writer has taken an active part. But so far the result has been a total blank, as the old officials always said that it would be, owing to nothing having been buried, and but comparatively little stolen, for the simple reason that it was not there to be made away with.

There are two well-known stones which are commonly referred to as rubies, but which are really nothing of the kind.

The Black Prince's ruby

This fine red cabochon cut stone known by the above name is really a very fine spinel, and is set in the British Imperial Crown. It was presented, as a ruby, to the Black Prince by Don Pedro ('The Cruel'), King of Castile, and was worn by Henry V at the Battle of Agincourt. It originally had a hole drilled through it, but this has been plugged with another piece of spinel, and so perfectly matched that it can only be detected on the closest inspection.

Caesaris Rubinus

This stone is mentioned by Boetius de Boodt in 1609, and at one time belonged to Kaiser Rudolf II of Germany. It was taken by the Swedes when Praha was sacked in 1648, and went into the possession of the Swedish Queen Kristinia. In 1777 it was given by Gustaf III of Sweden to the

Figure 25.2
The *Peace ruby.* Natural size.

Empress Katharine of Russia. According to A.E. Fersman,[1] this stone is really a pink tourmaline (rubellite) weighing 250 metric carats, and which most probably came from Burma in the first instance.

RUBIES

The Nga Mouk and Kalla Pyan rubies

These were originally one stone weighing 560 carats, found during the rein of Mindoon Min (1853–1878), by an ignorant man while cultivating a rice field, and bartered to a Mogok hawker for a rupees worth of putrid fish paste. The stone was broken into two, and one half surrendered to the king, the other portion being sent to Calcutta for sale. The king discovered the fraud and all concerned were tortured until it was revealed that the second part was in India, from where the king eventually purchased it at a high price. Both pieces were cut in Mandalay and yielded fine stones, one called *Nga Mouk* after the man who found it, weighed 98 carats, and the other named the *Kalla Pyan,* signifying that it had come back from the foreigners, weighed 74 carats. Both of these stones are reputed to have been lost at

1 Fersman, A.E. (1932) [Caesaris Rubinus]. *Mineralogical Magazine,* Vol. 22, No. 137, June, p. 53.

the taking of Mandalay, but were more probably sold by the king at a far earlier date.

The Maung Lin ruby

As some coolies were repairing a road, in the time of Mindoon Min, they came across a ruby weighing 400 carats, which they secretly disposed of to a trader named Maung Lin for three thousand rupees (about £200). The stone was broken into three pieces, one selling in Mandalay for an unknown sum, another was sold in London for a very large sum, and the third was sold in Calcutta for Rs70,000/- (about £4,666).

The Nga Boh ('Dragon Lord') ruby

This stone, for long reputed to be the finest cut ruby ever seen, was mined at Bawbedan near Mogok, weighing 44 carats in the rough, and 20 when cut. It was presented to King Tharriwadi (1837–1846), and was later known to have been in the possession of Thebaw, but was missing at the taking of Mandalay.

The J.N. Forster rubies

In 1875, King Mindoon Min, in order to realise funds, sent to London two cut rubies weighing 47 and 37 carats respectively. These were recut by J.N. Forster, of London, and yielded two magnificent stones of 38 9⁄16 and 32 5⁄16 carats, both of which were sold abroad, the larger for £20,000, and the smaller for £10,000.

The Peace ruby

This magnificent stone, by far the finest ruby the world has ever seen, was mined in the Mogok Valley on the 30th June 1919 (the day that Peace was signed). In shape it had the form of an irregular hexagonal prism with a flattened apex, the weight being exactly 42 old carats. The colour was a perfect pigeon's blood, and when in the writer's possession he likened it to a piece of red currant jelly, and used to exhibit it on a small plain white china plate to heighten the illusion. With the exception of a tiny crack near the base, which was removed in the cutting, the stone was entirely without a blemish of any kind. It was purchased in the rough by Chhotalal Nanalal, an Indian gem merchant of Mogok, for £27,500, or £654/15/-per carat, which is the highest price per carat ever realised for a rough ruby of any size. It was cut in Bombay into a round brilliant weighing 25 carats, of perfect colour, and absolutely flawless. This brought the actual cost of the material in the finished stone up to £1,100 a carat. The cut stone was disposed of in Paris, and afterwards went to America, the prices realised at the resales being very considerable, but the actual figures are not available for publication.

The Tagaungnandaing ruby

Mined in the Tagaungnandaing Valley at Kyatpyin in 1895, this stone weighed 18 7⁄16 carats, and was of a fine colour, but held a slight trace of blue. It was sold in the rough in London for £7,000, or just about half the price per carat realised for the Peace Ruby.

The Lady Craddock ruby

Mined in the Mogok Valley in 1922, this fine ruby weighed 22 ¾ carats, was quite flawless and of a perfect colour, but was of a long narrow shape which made it a very bad stone for cutting purposes. As a rough stone, it realised £4,000 in London, which is only about £175 a carat.

The Enjouk ruby

This stone, not quite of the best colour, was mined in the Mogok Valley in 1927, and weighed 22 ⅝ carats. It was sold uncut in London for £2,447, nearly £109 per carat.

The Chaungzone ruby

In 1903, this ruby of second-rate colour, and weighing 23 ½ carats, was mined in the Mogok Valley, selling in London as a rough stone for £2,005, or £85 per carat.

The Pingu Taung ruby

This very fine quality stone was mined while exploring a loodwin high upon, and far in the interior of, Pingu Taung (Spider Mountain) at Kyatpyin in 1893. It only weighed 8 7⁄16 carats, but was sold in London as a rough stone for £1,762, or £207 a carat.

The Kathe ruby (No. 2)

This ruby of a decidedly bluish tint was mined at Kathe in 1924. It weighed 21 ½ carats, and was sold on the London market as a rough stone for £1,667, which is over £77 per carat.

The Kathe ruby (No. 1)

A very similar stone to the above, weighing 22 ½ carats was mined at Kathe in 1915, and sold in London, in the rough for £1,600, or £71 per carat.

The Padansho ruby

Mined in the Mogok Valley in 1901, this bluish stone of a very secondary colour, and of a flat elongated shape, weighed 13 carats, and was sold as a rough stone in London for £1,514, or over £116 per carat.

The Shwebontha ruby (No. 1)

This fine stone weighing 15 ½ carats, was mined in the Mogok Valley in 1901, and was sold uncut in London for £1,500, or £96 per carat.

The Shwebontha ruby (No. 2)

This very fine stone, of outstanding colour and quality, only weighed 9 ½ carats, and was mined in the Mogok Valley in 1902. As a rough stone it sold in London for £1,444, or £152 per carat.

The Red Hill ruby

This fine ruby of 7 carats in weight was mined in the Mogok Valley in 1904, and sold in London as a rough stone for £534, or £76 per carat.

The Taroktan ruby (No. 1)

Mined in the Mogok Valley in 1904, this very fine ruby weighed 9 carats, and was sold as a rough stone in London for £635, or just over £70 per carat.

The Taroktan ruby (No. 2)

Mined in 1906, this companion stone to the above weighed 7 carats, and was sold in London in the rough for £490, or £70 per carat.

The Pama ruby

This ruby of a remarkably fine colour was mined at Kyatpyin in 1931, and weighed in the rough 32.90 carats, measuring 18.5 millimetres long, by 15.0 wide and 11.5 deep. Only a little less than half the stone was available for cutting, the remainder being badly cracked and containing much visible silk. It was sold in Mogok for £3,270, or £99 per carat, and sent to Paris, where it was cut into a square trap-cut stone of perfect colour and

Figure 25.3
The *Gem of the Jungle sapphire.* Natural size.

quality, weighing 9 ¼ carats; thus making the cost of the material in the finished stone well over £350 per carat.

SAPPHIRES

Many stories regarding sapphires have been passed into history, but the majority of these must be regarded as so much moonshine. It is a somewhat curious fact that, although sapphires frequently run to outstanding sizes and have always been popular gemstones, there are hardly any of either historic or other interest. In fact, remarkably few individual sapphires are known regarding which accurate details are available.

The tales which have been circulated in the trade regarding the accumulation of magnificent sapphires secretly kept in the treasure chambers of the ruler of Kashmir have often been classed as being fabulous. Nevertheless they are perfectly true[2] and should this remarkable collection ever be placed upon the market it will cause one of the biggest sensations the jewellery trade has ever known. Not only as regards the remarkable beauty, size, and value, of the stones, but also on account of their immense number.

2 See Chapter 11, page 177

The Raspoli sapphire

This magnificent sapphire of unknown origin is also known by the curious name of the *Wooden Spoon Seller's sapphire* as it is said to have originally been found by a very poor man who earned his living by selling wooden spoons in Bengal, but this story may be regarded as being entirely fictitious. It has for some unaccountable reason been described by at least two writers as a brown sapphire, whatever that may mean, whereas it actually is of a fine blue colour, and free from cracks or other flaws. It is still in its rough state, and weighs 132 1⁄16 carats, being preserved in the mineral collection in the Jardin des Plantes in Paris.

The Loop sapphires

These two famous sapphires were exhibited at the London Exhibition of 1862, and the Paris Exhibition of 1867, being classed together as the *Loop sapphires,* after the name of the supposed cutter in London. The larger, a stone of unknown origin, was of a dark indigo colour, but free from flaws. Loop cut this from the rough in London in 1840 into an oval stone weighing 252 carats. The other was brought from India as a table-cut stone weighing 225 carats, in 1856. It was then a very badly-shaped stone with a large yellow patch at the base, which imparted an objectionable greenish tint to the whole stone. J.N. Forster, who succeeded Loop at his death, recut it and removed the yellow, producing a magnificent blue stone which sold in Paris for nearly £8,000.

The Gem of the Jungle ('Great Burma') sapphire

This stone was scratched up from within a few inches of the surface in 1929, by some native miners who were preparing a site for mining in the jungle, near Gwebin, some twenty miles to the West of Mogok. It weighed in the rough 958 carats, and was of a fine royal blue colour, but showed distinct traces of visible silk. Sold in Mogok for £13,300, and subsequently cut in New York, it yielded nine magnificent stones of the following weights; 66.53; 20.11; 19.91; 13.15; 12.29; 11.39; 11.18; 5.57; and 4.39 carats.[3]

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3 Editor's Note: It is possible that the largest of these stones is identical to the so-called *Rockefeller Sapphire.* Recut from 66.03 to 62.02 ct in the early 1970s, it once held the world record for the sale of a sapphire at auction, when it sold for $3,031,000 ($48,871/ct) at Christie's New York on 11 April, 2001 (Lot 435).

Other notable sapphires

The following notable sapphires have been produced in Mogok and neighbourhood, and were all sold in Mogok as rough stones.

Table 25.1: Notable Mogok sapphires.

Year Mined	Weight in Carats	Price Realised in £
1934	390	2,770
1919	200	2,686
1917	140	1,876
1927	30	1,343
1919	46	1,343
1910	35	1,000
1920	51½	1,000
1919	50	738
1918	41	333

Appendix A

NOMENCLATURE

A List of Names Used in Connection with Corundum, Natural and Synthetic, Which are Likely to Cause Confusion, with their True Meaning, or Species

Adamantine Spar	Brownish variety of chatoyant, or asteriated commercial corundum; sometimes used as a gemstone
Adelaide Ruby	Almandine garnet
Alexandrite, Blue	Genuine blue sapphires which appear reddish by artificial light
Alexandrite, Sapphire	As above
Alexandrite, Scientific	Synthetic corundum containing vanadium or nickel oxide
Alexandrite, Synthetic	As above
Almandine Sapphire	Brownish red corundum
Almandite	Violet-red synthetic corundum
Aloxite	American trade term for synthetic corundum
Alundum	As above
Amaryl	Yellowish green synthetic corundum
American Ruby	Red garnets (various species)
Amethyst, Oriental	Purple corundum
Amethyst, Sapphire	As above
Amethystine	Blue sapphires which appear purple or reddish by artificial light
Ancona Ruby	Reddish quartz
Aquagem	American trade term for bluish green synthetic corundum

Aquamarine, Oriental	Bluish, or yellowish green corundum
Arabian Magic Diamond	Colourless, yellow, or pale green synthetic corundum
Arizona Ruby	Pyrope garnet
Art Ruby	1. Red synthetic corundum 2. Red glass, or paste
Art Sapphire	As above, but blue
Asteria	1. Any variety of corundum when asteriated 2. Asteriated stones of other species
Australian Sapphire	An American trade term for very dark inky sapphires independent of their place of origin
Balas Ruby	Spinel
Beef Blood Ruby	Genuine rubies of a dark red shade with a distinct tinge of blue
Berylite	Pink synthetic corundum
Birne	Term sometimes applied to rough form of synthetic corundum; German for *pear*
Bohemian Ruby	Rose quartz
Boule	Term for the rough form of synthetic corundum; French for *ball*
Brazilian Ruby	Deep red fired topaz
Brazilian Sapphire	1. Blue topaz 2. Blue tourmaline
Cape Ruby	Pyrope garnet
Carborundum	A hard artificial abrasive
Carbuncle	Any red stone when cut cabochon, but usually garnet or spinel
Cat Sapphire	The very darkest shades of genuine sapphires
Cat's Eye Ruby	Chatoyant red corundum
Cat's Eye Sapphire	Chatoyant blue corundum, but may be applied to other colours
Cat's Eye Topaz	Chatoyant yellow corundum
Ceylon Sapphire	1. Genuine sapphire 2. Pale blue synthetic corundum

Ceylonese Ruby	1. Genuine rubies from Ceylon 2. A fraudulent term applied to almandine garnet
Chemical Diamond	Colourless, or pale yellow synthetic corundum
Chemical Emerald	Green synthetic corundum
Chemical Ruby	Synthetic corundum
Chemical Sapphire	As above
Chemical Topaz	As above
Chrysolite, Oriental	1. Yellowish green corundum 2. Chrysoberyl
Chrysolite, Sapphire	Yellowish green corundum
Colorado Ruby	Pyrope garnet
Corundolite	Synthetic white spinel
Diamond, Spar	Colourless corundum
Elie Ruby	Pyrope Garnet
Emerada	Yellowish green synthetic corundum
Emerald, Brazilian	1. Tourmaline 2. Synthetic corundum
Emerald, Chemical	Synthetic corundum
Emerald, Oriental	Green corundum
Emerald, Reconstructed	Synthetic corundum
Emerald, Scientific	Synthetic corundum
Emerald, Synthetic	Synthetic corundum
Erinide	Light green synthetic corundum
False Ruby	Fluor-spar
False Sapphire	Flour-spar
Fashoda Ruby	Almandine, or pyrope garnet
French-Coloured Ruby	Genuine rubies of pale red colour, but a deeper shade than pink
French, Ruby	Synthetic red corundum
French, Sapphire	Synthetic blue corundum

Girasol	Pale blue, or bluish white corundum
Girasol, Oriental	Chatoyant yellow corundum
Golden Sapphire	A Ceylon term for golden yellow corundum
Hope Sapphire	Blue synthetic corundum (spinel)
Hyacinth, Oriental	Yellowish red corundum.
Hyacinth, Sapphire	As above
Hyaline	Pale blue; or bluish white corundum
Indigo Sapphire	Very dark, indigo blue, corundum
Inky Sapphire	Very dark blue, almost black, corundum
King Sapphire	A Ceylon term for deep yellow corundum
King Topaz	Yellow corundum, mainly from Ceylon
Leuco Sapphire	Colourless corundum
Lynx Sapphire	1. Very dark blue sapphire 2. Cordierite
Mogok Diamond	1. Colourless corundum 2. Other colourless stones
Montana Sapphires	Genuine sapphires from Montana
Noble Corundum	Gem quality corundum of any colour
Oriental Amethyst	Purple corundum
Oriental Aquamarine	Yellowish or bluish green corundum
Oriental Chrysolite	Yellowish green corundum
Oriental Emerald	Green corundum
Oriental Girasol	Chatoyant yellow corundum
Oriental Hyacinth	Yellowish red corundum.
Oriental Ruby	Finest grades of genuine rubies
Oriental Sapphire	Finest grades of sapphires from the East
Oriental Topaz	Yellow corundum
Opaline	Pale blue, or bluish white corundum
Padparadscha	Bright orange corundum

Parisian Ruby	Paste imitation
Parisian Sapphire	Paste imitation
Pearl Corundum	An asteriated or chatoyant corundum of a bronze or brown shade from America, a variety of adamantine spar
Perigem	Yellowish green synthetic corundum
Pink Sapphire	1. Pink corundum, too pale to be classed as ruby 2. Synthetic pink corundum
Purple Ruby	Rubies of a purplish colour, but not amethystine
Purple Sapphire	1. Sapphires with a reddish tinge 2. Purple corundum
Reconstructed Ruby	An old form of manufactured ruby made by fusing together fragments of genuine ruby
Rose Kunzite	Synthetic pink corundum
Rose Sapphire	1. Deep pink corundum 2. Synthetic pink corundum
Rozicon	Synthetic pink corundum
Rubellite	1. Red tourmaline 2. Fluor-spar
Rubicelle	Spinel
Ruby Spinel	Spinel
Safira	Blue topaz
Sappare	Kyanite
Sapphir D'eau	Cordierite
Sapphirine	Blue carnelian (quartz)
Scientific Alexandrite	Synthetic corundum
Scientific Brilliant	Colourless synthetic corundum
Scientific Diamond	Colourless or yellow synthetic corundum
Scientific Emerald	Green synthetic corundum
Scientific Padparadscha	Orange, or orange-red synthetic corundum
Scientific Ruby	Red synthetic corundum

Scientific Sapphire	Blue synthetic corundum
Scientific Topaz	Yellow synthetic corundum
Star Amethyst	Asteriated purple corundum
Star Ruby	Asteriated red corundum
Star Sapphire	Asteriated blue corundum
Star Stone	1. Any colour variety of asteriated corundum 2. Asteriated stones of other species
Star Topaz	Asteriated yellow corundum
Starolite	Asteriated quartz
Synthetic Alexandrite	Synthetic corundum
Synthetic Ceylon Sapphire	Synthetic pale blue corundum
Synthetic Chrysolite	Yellowish green synthetic corundum
Synthetic Emerald	Green synthetic corundum
Synthetic Padparadscha	Synthetic corundum
Synthetic Zircon	Pale blue synthetic corundum
Syntholite	Synthetic corundum, greyish green by day and reddish by artificial light
Topaz Cat's Eye	Chatoyant yellow corundum
Topaz, Chemical	Synthetic yellow corundum
Topaz, Oriental	Yellow corundum
Topaz, Sapphire	Yellow corundum
Topaz, Scientific	Synthetic yellow corundum
Topaz, Star	Asteriated yellow corundum
Topaz, Synthetic	Synthetic yellow corundum
Ultralite	Synthetic violet corundum
Uralite	Synthetic corundum
Vermeille Orientalle	Yellowish red corundum
Violet Ruby	Violet corundum
Violite	Synthetic violet corundum

Water Sapphire	1. Colourless corundum 2. Very pale blue corundum 3. Cordierite 4. Fibrolite 5. Colourless topaz
White Sapphire	Colourless corundum
Yellow Sapphire	Yellow corundum
Yogo Sapphire	Genuine sapphires from Yogo Gulch, U.S.A.
Zircolite	Colourless synthetic corundum
Zirctone	Pale blue synthetic corundum

Appendix B

IDENTIFICATION TABLE

A table of the physical and other properties of the gemstones of the corundum group, and other species of a similar appearance with which they may be confused. Arranged in order of specific gravity.

ABBREVIATIONS USED IN THE TABLE

For colours, all shades being represented by one colour

Number	Colour
1.	Colourless and white
2.	Red
3.	Blue
4.	Green
5.	Yellow
6.	Purple and violet
7.	Brown
8.	Grey
9.	Black
10.	Multicoloured
11.	Asteriated
12.	Chatoyant

Other abbreviations

Abbreviation	Definition	Abbreviation	Definition
ABS	Absent	ORB	Orthorhombic
ADMT	Adamantine	P	Parting
AMPH	Amorphous	PFT	Perfect
BI	Biaxial	PLY	Pearly
BLT	Brilliant	PSOL	Partly soluble in
BTL	Brittle	RES	Resinous
CON	Conchoidal	SR	Singly refractive
CUB	Cubic	SKY	Silky
CRYPT	Cryptocrystalline	SLT	Slight
DR	Doubly refractive	SOL	Soluble in
DI	Dichroic	SPDT	Splendant
DIF	With difficulty	SPTY	Splintery
DIS	Distinct	ST	Strong
FGL	Fragile	TCL	Triclinic
FUS	Fusible	TET	Tetragonal
GSY	Greasy	TGH	Tough
HACK	Hackly	TRI	Trichroic
HCl	Concentrated hydrochloric acid	UNI	Uniaxial
H_2SO_4	Concentrated sulphuric acid	UNVN	Uneven
HEX	Hexagonal	V	Variable
HF	Hydrofluoric acid	VIT	Vitreous
IMP	Imperfect	VV	Very variable
INFUS	Infusible	VTY	Velvety
IND	Indistinct	WK	Weak
INT	Intense	+	Positive
ISOL	Insoluble	-	Negative
MASS	Massive	-:-	As above entry
MCL	Monoclinic	*	Not applicable, or so variable as not to be reliable
MONO	Monochroic		

Table B-1: Identification table of corundum and other gems

Name & Colour	SG	Hardness	Optic Char. & Sign	RI's	Bire.	Pleochroism	Dispersion	Lustre	Crystal System	Cleavage	Fracture	Frangibility	Blowpipe Fusibility	Action of Acids
CORUNDUM 1 to 12	5.00 3.95	9¼ 9	DR UNI –	1.775 1.757	0.010 0.004	DI	LOW 0.030 0.018	VIT	HEX	ABS P	CON	BTL	IFUS	ISOL
IMPURE CORUNDUM YELLOWISH RED AND OPAQUE 11 - 12	5.00 3.93	9	-:-	*	0.009 0.008	ABS	ABS	-:-	-:-	-:-	-:-	-:-	-:-	-:-
ADAMANTINE SPAR OPAQUE 7 - 11 - 12	4.20 3.90	9	-:-	*	*	-:-	-:-	-:-	HEX MASS	ABS	UNVN	-:-	-:-	-:-
GREEN CORUNDUM 4 - 12	4.10 3.98	9	-:-	1.767 1.758	0.009	DI INT	0.018	-:-	HEX	ABS P	CON	-:-	-:-	-:-
PURPLE CORUNDUM 6 - 11 - 12	4.10 3.94	9	-:-	1.775 1.767	0.008	DI INT V	0.025 0.018 V.V	-:-	-:-	-:-	-:-	-:--	-:-	-:-
BLUE CORUNDUM 3 - 11 - 12	4.10 3.95	9¼	-:-	1.768 1.757	0.009	DI SI	0.025 0.018 V	VIT VTY	-:-	-:-	-:-	-:-	-:-	-:-
YELLOW CORUNDUM 5 - 11 - 12	4.10 3.95	9	-:-	1.769 1.759	0.010	DI INT V	0.030 0.018 V.V	VIT	-:-	-:-	-:-	-:-	-:-	-:-
COLOURLESS CORUNDUM 1 - 11 - 12	4.10 3.95	9	-:-	1.767 1.759	0.008	ABS IND	0.025 0.018 V.V	-:-	-:-	-:-	-:-	-:-	-:-	-:-
RED CORUNDUM 2 - 11 - 12	4.10 3.40	9	-:-	1.770 1.759	0.009 0.007	DI ST V	0.018	-:-	-:-	-:-	-:-	-:-	-:-	-:-
CASSITERITE (TIN STONE) 1 - 2 - 5 - 9	7.10 6.80	7 6	DR UNI +	2.093 1.997	0.096	DI	HIGH V	ADMT SPDT	TET	IMP	SUBCON to UNVN	BTL	IFUS	PSOL HCl
ZIRCON GROUP 1 - 2 - 3 - 4 - 5 - 6 - 7	4.71 4.00	7½ 7¼	DR UNI +	1.995 1.790 VV	0.205 V	DI to ABS V	VV	ADMT VIT RES GSY	TET	IMP	CON	BTL	IFUS	PSOL H2SO4

Table B-1: Identification table of corundum and other gems

Name & Colour	SG	Hardness	Optic Char. & Sign	RI's	Bire.	Pleochro-ism	Dispersion	Lustre	Crystal System	Cleavage	Fracture	Frangibility	Blowpipe Fusibility	Action of Acids
ALMANDINE GARNET 2 - 6 - 7 - 11 - 12	4.20 3.90	7 6	SR UNI *	1.810 1.770	*	MONO	LOW	VIT to GSY	CUB	IMP	CON to UNVN	BTL to TGH	FUS 3	PSOL HCl
ANDRADITE GARNET 1 - 2 - 4 - 5 - 7 - 9	3.90 3.80	6½	SR UNI *	1.890 1.880	*	MONO	HIGH	VIT BLT	CUB	IMP	UNVN	BTL	FUS 3	SOL HCl
RHODOLITE GARNET 2 - 6	3.84	7¼	SR UNI *	1.760	*	MONO	LOW	VIT SPDT	CUB	IMP	UNVN	BTL	FUS 3½	PSOL HCl
PYROPE GARNET 3	3.80 3.70 V.V	7¼	SR UNI *	1.740 and up V.V	*	MONO	LOW	VIT	CUB	IMP	CON	TGH V	FUS 3½	PSOL HCl
AXINITE 3 - 5 - 6 - 8	3.80	7 6½	DR BI –	1.684 1.674	0.009	DI INT	LOW	VIT SPDT	TCL	DIS	CON	BTL	FUS 2	ISOL
ALEXANDRITE (CHRYSOBERYL) 4 Daylight 2 Artificial light	3.78 3.68	8½	DR BI +	1.757 1.742	0.015	TRI STR	LOW	VIT	ORB	ABS	CON to UNVN	BTL	IFUS	ISOL
CYMOPHANE (TRUE CAT'S EYE) 4 - 5- 7 - 9 - 12	-:-	-:-	-:-	-:-	-:-	DI WK	-:-	-:-	-:-	-:-	-:-	-:-	-:-	-:-
CHRYSOBERYL 1 - 4 - 5 - 7 - 9 - 12	-:-	-:-	-:-	-:-	-:-	DI V	-:-	-:-	-:-	-:-	-:-	-:-	-:-	-:-
SPINEL 1 - 2 - 3 - 4 - 5 - 6 - 7 - 9 - 11	3.70 3.50	8	SR UNI *	1.736 1.716	*	MONO	LOW	VIT SPDT	CUB	IMP	CON	BTL	IFUS	DIF SOL HOI H2SO4
GROSSULAR GARNET 1 - 2 - 4 - 5 - 7	3.66 3.55	6 3/4	SR UNI *	1.748 1.742	*	MONO	LOW	VIT to RES	CUB	ABS	SUBCON to UNVN	BTL to TGH	FUS 3½	PSOL HCl
BENITOITE 3	3.65	6½	DR UNI +	1.804 1.757	0.044	DI INT	HIGH	VIT	HEX	DIS	CON	BTL	FUS 3	PSOL HCl
KYANITE 1 - 3 - 4 - 5 - 8 - 9 - 12	3.61	7 5 VV	DR BI –	1.730 1.720	0.010	DI WK	LOW	VIT to PLY	TCL	PFT	SPTY to HACK	BTL	IFUS	ISOL
TOPAZ 1 - 2 - 3 - 4 - 5 - 7	3.60 3.50	8	DR BI +	1.629 1.615	0.004	DI WK	FAIR	VIT SPDT to PLY	ORB	PFT	CON	BTL	IFUS	PSOL H2SO4

Table B-1: Identification table of corundum and other gems

Name & Colour	SG	Hardness	Optic Char. & Sign	RI's	Bire.	Pleochroism	Dispersion	Lustre	Crystal System	Cleavage	Fracture	Frangibility	Blowpipe Fusibility	Action of Acids
TOPAZ (AFTER BEING FIRED) 2	-:-	-:-	-:-	1.634 1.625	0.012	DI STR	FAIR	VIT	-:-	-:-	-:-	-:-	-:-	-:-
UVAROVITE GARNET 4	3.52 3.41	7½	SR UNI *	1.838	*	MONO	HIGH	VIT to RES	CUB	IND	UNVN	BTL	IFUS	PSOL HCl
DIAMOND 1 - 2 - 3 - 4 - 5 - 7 - 8 - 9	3.52	10	SR UNI *	2.417	*	MONO	HIGH	ADMT SPDT	CUB	PFT	CON	BTL	IFUS IGNITES	ISOL
CHRYSOLITE (OLIVINE, PERIDOT) 4	3.50 3.30	7 6½	DR BI +	1.701 1.650	0.049	DI to TRI	FAIR	VIT to GSY	ORB	IMP	CON	BTL	IFUS	SOL HCl H2SO4
EPIDOTE 1 - 2 - 4 - 5 - 7 - 8 - 9 - 12	3.50 3.25	7 6	DR BI –	1.766 1.735	0.031	TRI ST	HIGH	VIT to PLY or RES	MCL	DIS	UNVN	FGL	FUS 3½	PSOL HCl
SPHENE 2 - 4 - 5 - 7	3.45 3.35	5½	DR BI +	2.053 1.888	0.140	TRI	HIGH	ADMT	MCL	IMP	SUBCON	BTL	FUS 3	SOL HOT HCl
DIOPSIDE 3 - 4 - 5 - 8	3.38 3.20	6 5	DR BI +	1.750 1.671 VV	0.030	DI WK	LOW	VIT	MCL	IMP	CON	BTL	FUS 3 to 4	ISOL
DIOPTASE 4	3.28	5	DR UNI +	1.723 1.667	0.056	DI	LOW	VIT WK	HEX	DIS	CON	BTL	IFUS	SOL HCl
FIBROLITE 1 - 3 - 8	3.25 3.23	7½ 6	DR BI +	1.659 1.657	0.002	DI INT	HIGH	VIT to PLY	ORB	PFT	UNVN to SPTY	FGL	IFUS	ISOL
APATITE 1- 2 - 3 - 5 - 6	3.25 3.17	5	DR UNI –	1.646 1.642	0.004	DI VV	LOW	VIT to SUBRES WK	HEX	IMP	SUBCON	BTL	FUS 5	SOL HCl
TOURMALINE – BLUE 3	3.20 3.16	7½ 7	DR UNI –	1.635 1.634	0.019	DI ST	LOW	VIT to RES	HEX	IMP	SUBCON to UNVN	BTL	FUS 6	ISOL
SPODUMENE 2 - 4 - 5 - 6	3.18	7 6½	DR BI +	1.675 1.660	0.015	DI V	LOW	VIT	MCL	DIS	CON to UNVN	BTL	FUS 3½	ISOL
FLUOR-SPAR 1 - 2 - 3 - 4 - 5 - 6 - 7 - 9 - 10	3.18	4	SR UNI *	1.433 VV	*	MONO	LOW	VIT	CUB	PFT	SUBCON to SPTY	BTL	FUS 2	SOL H2SO4 EVOLV- ING HF

Table B-1: Identification table of corundum and other gems

Name & Colour	SG	Hardness	Optic Char. & Sign	RI's	Bire.	Pleochro-ism	Dispersion	Lustre	Crystal System	Cleavage	Fracture	Frangibility	Blowpipe Fusibility	Action of Acids
TOURMALINE – GREEN 4	3.10 3.08	7½ 7	DR UNI –	1.640 1.620	0.020	DI ST	LOW	VIT to RES	HEX	IMP	SUBCON to UNVN	BTL	FUS 6	ISOL
EUCLASE 1 - 3 - 4	3.10 3.05	7½	DR BI +	1.670 1.651	0.019	DI ST	LOW	VIT to PLY	MCL	PFT	CON to UNVN	FCL	FUS 2	SOL HCl
TOURMALINE – RED 2	3.08	7½ 7	DR UNI –	1.627 1.611	0.016	DI WK	LOW	VIT to RES	HEX	IMP	SUBCON to UNVN	BTL	FUS 6	ISOL
TOURMALINE – COLOURLESS 1	3.04 3.00	-:-	-:-	1.636 1.619	0.017	ABS	-:-	-:-	-:-	-:-	-:-	-:-	-:-	-:-
DANBURITE 1 - 5	3.02 2.97	7½ 7	DR BI +	1.639 1.637	0.002	DI	HIGH	VIT to GSY	ORB	IMP to ABS	CON to UNVN	BTL	FUS 3½	DIF PSOL HCl
PHENACITE 1 - 2 - 5 - 7	2.99	8 7½	DR UNI +	1.667 1.652	0.015	DI WK	LOW	VIT	HEX	DIS	CON	BTL	IFUS	ISOL
BERYLLONITE 1 - 5	2.84	6 5½	DR BI –	1.565 1.553	0.012	ABS	LOW	VIT WK	ORB	PFT	SUBCON to UNVN	BTL	FUS 2	SOL HCl
EMERALD 4 - 9 - 11	2.79 2.69	7½ 7	DR UNI –	1.653 1.634	0.019	DI	LOW	VIT VTY	HEX	IMP	CON	BTL	FUS 5½	SOL HF
BERYL GROUP 1 - 2 - 4 - 5 - 9 - 11	2.79 2.67	8 7½	-:-	1.653 1.567	VV	DI V	-:-	VIT	-:-	-:-	CON to UNVN	-:-	-:-	-:-
BERYL–GOLDEN 5	2.75 2.68	7½	-:-	1.590 1.567	0.023	DI	-:-	-:-	-:-	-:-	-:-	-:-	-:-	-:-
QUARTZ – TRANSPARENT 1 to 12	2.70 2.65	7	DR UNI +	1.553 1.544	0.009	DI V	LOW	VIT to GSY	HEX	IMP	CON to UNVN	BTL	IFUS	ISOL
AMETHYST – QUARTZ 6	2.66 2.65	7	-:-	-:-	-:-	DI VV	-:-	VIT	-:-	-:-	-:-	-:-	-:-	-:-
CORDIERITE (IOLITE) 1 - 3 - 4 - 5 - 7	2.66 2.60	7¼ 7	DR BI –	1.551 1.543	0.008	TRI INT	LOW	VIT to GSY	ORB	IMP	SUBCON to SPTY	FGL	FUS 5½	PSOL HCl
QUARTZ – MASSIVE 1 to 10 and 12	2.60 VV	7 6½	DR *	*	*	DI VV	*	VV	CYPT to MASS	ABS	CON UNVN SPTY	PTL to TGH VV	IFUS	ISOL

Table B-1: Identification table of corundum and other gems

Name & Colour	SG	Hardness	Optic Char. & Sign	RI's	Bire.	Pleochro-ism	Dispersion	Lustre	Crystal System	Cleavage	Fracture	Frangibility	Blowpipe Fusibility	Action of Acids
HAUYNITE 1 - 2 - 3 - 4 - 5	2.50 2.40	6 5½	SR UNI *	1.495 1.483	*	MONO	LOW	VIT to GSY	CUB	DIS	CON to UNVN	BTL	FUS 4½	SOL HCl
OBSIDIAN 2 - 3 - 4 - 5 - 7 - 8 - 9 - 10	2.50 2.30	5	SR UNI *	1.550 V	*	MONO	LOW	VIT to SKY	AMPH	ABS	CON	BTL	FUS 2	SOL HF
ROSE OPAL 2	2.50 2.10	6½ 5	SR UNI *	1.464 1.444	*	MONO	HIGH	VIT RES PLY	AMPH	ABS	CON	BTL	IFUS	SOL HCl
MOLDAVITE 4	2.50	6 5 V	SR UNI *	1.510	*	MONO	LOW	VIT	AMPH	ABS	CON	BTL	FUS 2	SOL HF
LAPIS LAZULI OPAQUE 2 - 3 - 4 - 6 - 10	2.45 2.38	6 5 V	*	*	*	*	*	VIT WK	MASS	ABS	CON to UNVN	BTL to TGH VV	FUS 3 to 4	SOL HCl VV

Appendix C

THE STREETER DIARIES

An extract from the diary of George Streeter covering the period when he accompanied the military expedition to the Ruby Mines at Mogok from December 1886 to March 1887. With notes by his grandson, Patrick Streeter.

Biographical Note: George Skelton Streeter was born in 1863, the second son of the Bond Street jeweller Edwin Streeter. He was educated at University College School, London and London University. Also he studied mineralogy under Professor Rudler at the Museum of Practical Geology, Jermyn Street. He travelled to Ceylon, India, Australia and South Africa to gain practical knowledge of mining. After the Burma Ruby Company was launched, for ten years, he managed the family pearl fishing interests at Broome, Western Australia. In 1898 he married and retired to a sporting estate in Hertfordshire, England. He died aged 63 in 1929.

Mandalay, 10 December

Packing up. Drew rations for ten days for self, Ben, four servants and eight ponies. Wired to Gordon[1] to come up. Wrote to Gordon, Patton[2] and Atlay.[3]

11 December

Left Kyan-Nyat with five carts, nine ponies. Three syces, Ibrahim and Ben. Arrived at Tongive about 3 PM. Found Bill[4] and General Stewart[5] there. We dined all together. Attacked with dysentery, bad night.

Sunday, 12 December 1886.

Left Tongive about 8 AM. As a band of dacoits had been seen along the road we all had to keep together. We arrived at the second stockade at about noon after a ten-mile march. We got the camp fixed by about 3 PM and found Cowley en route for Tongive. We heard that the Mogok people were under pressure from Main-Loung and were going to resist us. Wrote to E.W.S.[6] Feeling rather shaky.

13 December

Left Second or 'New Stockade' at 7 AM and a twelve-mile march brought us to Webong. Put up in a Phongee Kyoung.[7] 200 mules and thirteen commissariat carts camping with us. Took two photos in the afternoon. Charles Bill shot a Jungle Fowl for dinner.

1 Captain Gordon, a military engineer. He later authored two papers on Mogok, including: Gordon, R. (1888) On the ruby mines near Mogok, Burma. *Proceedings of the Royal Geographical Society,* New Series, Vol. 10, No. 5, May, pp. 261–275; map, p. 324.

2 Major Aubrey Patton (later Patton-Bethune) a member of the syndicate that gained the ruby mine concession; subsequently a director of the Burma Ruby Mines, Ltd.

3 H.F. Atlay; subsequently manager of the Ruby Mine Company at Mogok.

4 A colonel in the Stafford Militia. Also a barrister and MP for Stafford from 1892 to 1906. He was also one of the members of the syndicate that was gain the ruby mines concession.

5 The Commander of the expedition to Mogok.

6 Edwin Streeter, George's father, the famous London jeweller.

7 A Buddhist monastery

14 December

Left Webong at daybreak – having heard that the Shans[8] were about I thought it advisable to go with the convoy. We arrived at Sagadun at 9 PM after a ten-mile march where we found Reginald Beech.[9] I had another go of fever.

15 December

I tried to arrange with the Panthe[10] headman to go up to the hills and communicate with the Mogok people but this was not considered safe after the engagement that took place on the 11th. Dak[11] arrived. Letters from Dr. Coulter for Patton,[12] Piggott[13] and Scott. Walked over the old fields around Sagadun with my gun and shot a partridge.

16 December

The head Panthe arrived with followers bringing me a letter from Mogok, which, so that he could send it back by return, he asked me to answer. I did so. Took two photos. Feeling seedy with headache.

17 December

The General, Colonel Cubitt and the Headquarters of the 43rd arrived with Carter and the elephants. The Shans were firing volleys on the hills yesterday. Packed our kit for transport on the ponies. Wrote to my mother, E.M.T. and Thompson, sending four negatives. Down with fever in the evening, temperature 103 degrees. Bill shot his first deer.

18 December

My ague and fever were very bad in the morning, temperature 104. The General order issued for Colonel Cubitt[14], 100 Riflemen, 50 K.O.L.I[15] and

8 The Shans were one of the national groups that lived in Upper Burma.

9 Another member of the syndicate.

10 The Panthe (Panthay) were Mohammedan Chinese traders.

11 Native word for *post.*

12 Major Aubrey Patton (later Patton-Bethune) also a member of the syndicate and subsequently a director of the Burma Ruby Mines, Ltd.

13 Reuter's correspondent.

14 Colonel George Cubitt won his VC in the Indian Mutiny. He was commanding the 43rd Gurkha's.

15 King's Own Light Infantry.

guns to start up the hills for Suikor at 4:30 AM on the 19th, the rest of us for Marnett's camp at 2 PM. Major White to be left in command of Sagadun

Sunday, 19 December

Padre Adams[16] VC held a service in camp at 10 AM. My fever still bad so did not get up till noon. We started at 2 PM and got into camp by 4 PM. I was bad with fever as well as dysentery.

20 December

Started at 4:30 AM – quite dark, feeling awfully bad. We reached Suikor at 8 AM. I lay down in my coat and went off my head for about an hour. The force went forward, leaving the transport behind, expecting to meet the enemy stockaded. Nothing, however, was seen so they sent back for transport with whom I went forward and camped on the side of a hill, 2,800 feet above sea level.

21 December

Heavy rain came down about 7 AM and the camp was enveloped in a thick mist. The Sappers went out to improve the road but the wet stopped all work. I walked over to the Yorkshire camp and had a chat with the General. Weather cleared up towards the evening. A reconnaissance party went out but saw nothing.

16 The Revd James Adams was an Irishman. He won his VC in the Afgan wars in 1879.

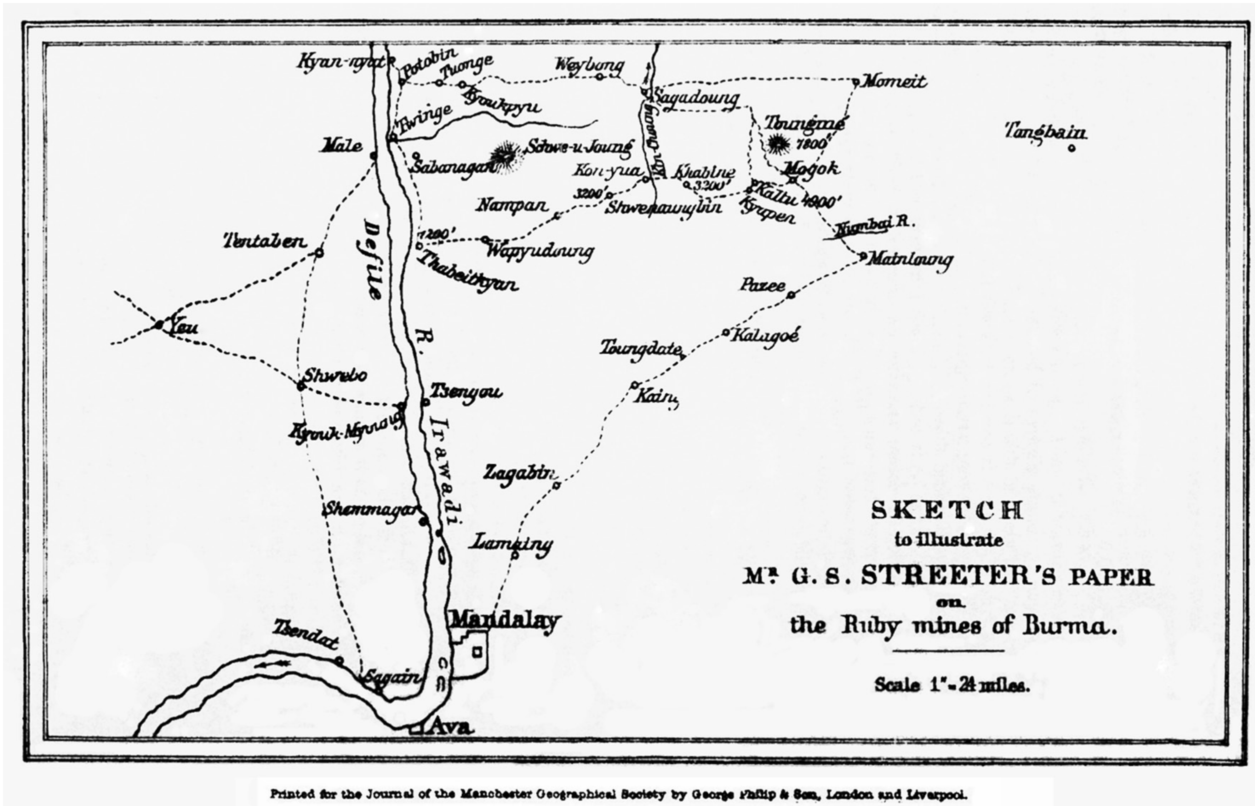

Figure C.1
Map of GS. Streeter's route to Burma's ruby mines. From Streeter, G.S. (1887) The ruby mines of Burma. *Journal of the Manchester Geographic Society,* No. 3, pp. 216–220, map.

22 December

We struck camp at 9 am and marched forward, reaching Nanport about 11 am. The advanced party was fired upon. The village strongly fortified but deserted and the road enfiladed by bamboo and earth breastworks. The Force pushed along the road with guns and a mile further along came upon a very strong stockade, but the Shans would not stand. We put two volleys into them at 1,500 yards as they ran away. From the camp in the village we had a splendid view of the country to the north, with a high range of mountains on the horizon. I could trace the Sweli River for about 50 miles running by us to the north, north, west. Looted a set of three gongs from a Kyoung. All about were small hollow bamboos with sharpened ends, stuck into the ground, containing flowers. They were offerings to the Zats or wood spirits. We captured a cross bow which had a shave of poison arrows. Our elevation was about 4,000 feet.

Ben went back with two ponies, which were going for more provisions. He forgot himself yesterday. I must send him back or make some arrangements with Bill. He has been utterly useless to me.

23 December

Started from Nanpoot with the advanced guard under Colonel Cubitt. We had 100 Gurkhas, 50 K.O.L.I with Earle,[17] and Mule and Gardiner guns. We had a big climb and the path was at times bad. The highest point reached was about 5,800 feet, you could see Kyan-Nyat, with Swee-ou-Toung due west. On descending the advanced party came on a band of about 40 dacoits or perhaps just armed villagers. We fired a volley and the Yorkshires flanked them. The General and staff came up and I went on with them. After a big hunt through the jungle side of the hill the Gurkhas caught five and a woman and a boy, and killed one, bringing his head to us. We camped on a stubble of paddy fields and as we were having breakfast a man came within a couple of hundred yards of us and loosed off. Sent off two parties to burn village, opposition met with on both sides, then all-quiet. Took a rough photo of the prisoner with a view lens. Awfully cold in the evening. The camp was called Pyouk Gyoung.

17 Henry Earle, son of Sir Thomas Earle, 2nd Bart. Succeeded as 3rd Bart 1900.

24 December

Up at reveille. Thick while frost on the ground. Half an inch of ice in the Chilam-Chi thermometer, 8 degrees below freezing. Left with staff at 8:30 AM and overtook advance guard at 9:30 AM. The enemy were reported to be in force in the front. Flanking parties were sent out to scout over the hills on each side of the path. I went with the General and staff with guns over the hills on the left and finally took up position on a commanding eminence about noon a little before the Sappers under Pietri got touch of the enemy. The guns and Gardiner's unlimbered and began shelling the stockade at 1.50 range from 1,600 yards. The only signs indicating the position of the stockade were the smoke and answering shots. We heard that they all went too high except the last, which killed three men. Barrett with 50 Riflemen and Earle with 40 Yorkshires, with Major Skeene in reserve, were ordered to storm the stockade. In the meantime fire was opened on us from another stockade on the left, one man being hit and several bullets going over our heads. We replied to this with the Gardner's and shrapnel. A little after 2 PM Barrett reached the stockade, attacking it at the front. Earle made a flanking attack on the left. After ten minutes they took it. One Yorkshire being hit badly in the leg and Barrett having his field glasses broken by a bullet. The Shans, carrying their dead and wounded, bolted off. We could see them very slowly clambering up the hills to the left at a distance of about 2,000 yards. Probably they spent a pleasant night in the jungle. One prisoner was taken who gave important information. In the meantime desultory fire was kept upon us from the jungle and stockade to the left. We answered occasionally with the Gardiner's. At 4 PM it was considered too late to attack the stockade on the left, so the guns were lumbered up and we got back to our new camp, about half a mile distant a little after 5 PM. Dead tired.

25 December. Christmas Day

Force halted today. A patrol of twenty men went out to watch the Mogok road and two scouting parties of three men each went off to the left to check the stockade. Went to a service held by the Revd. H. Adams. Clay and Chamberlain[18] returned with the patrol reporting that they found two stockades carefully masked but they did not ascertain if they were occu-

18 N.F.F.Chamberlain, later Colonel Sir Neville Chamberlain, reputedly the inventor of snooker.

pied. But they heard men moving around and felling trees in the jungle above. The piquet returned with two prisoners and an old Snider gun. When separated they gave most contradictory reports. One of them had a quantity of rubies on him. Walked back to where they were building a stockade and sampled the gravel of a small stream close by, finding traces of mica and spinel crystals. Dined with the officers of the 43rd, fourteen of us sitting down to dinner. Sent a letter to E.W.S by the dak that left in the morning.

26 December. Sunday.

Started with the General and staff at 8 am. Chamberlain asked me to act as extra aide-de-camps if the necessity arose. We reached the stockades that had been discovered the day before. They were deserted and destroyed. A little further along we came to another stockade and a large camp behind a most wonderful rock, which rose up about 60 feet and, except in the centre, was only about a foot thick, with doors and windows cut into it for the use of the camp behind, which was also deserted. We climbed up to the top of the gorge known as the Toung-Mee-Dyak, elevation 6,200 feet, and found on the summit another strong stockade, which was also deserted. The descent was very steep and after about a mile through the jungle we suddenly came out in the open and had the most magnificent view of the Mogok valley and another long clear valley beyond, then range after range of hills and mountains until it all ended in an immense mountain running due south from our position. After a very hard march of about eight miles and having descended 2,000 feet we camped on the side of a hill just above Yebu. The Tommies discovered and looted a quantity of little rubies in the village. The baggage did not arrive until after dark and several mules and ponies fell into a deep ditch. We had a lot of trouble getting them out.

27 December

Sent a note by Williams to Gordon and also a telegram to Pigott at Mandalay describing the march and engagement. Struck camp at 11 am. After going one and a half miles over the spur of the hills we entered the cart road to Mogok. The General lined the hill with skirmishers and he sent out the Panthe chief with three of his followers to bring back to us the headman of the village. We could see some villagers, like disturbed black beetles, scuttling off with their household Gods.[19] The chief shortly returned with a few men but they were only traders. All the headmen had fled. The General then ordered that they should tell all their fellow villagers to come back in and look after their own property. Also that the camp should be pitched on the hill on which we stood and that a strong guard should be placed around Mogok and that no one except Panthe and Burmans be allowed to enter, under penalty of being shot. I went with the General around some fine pagodas and kyoungs and also into a poor house where we found three men, one blind, one dying and the third very bad with fever.

Mogok lies in a hollow, mostly devoted to paddy fields, with a stream running through them. Towards the north end of the valley runs the road to Momeit, to the east the road to Mainloung and to the south the road to Kyat-Pien[20] and Thabeitkyen. To the west is the mountain path over which we came, via Toun-Mee-Dyak. It is at an elevation of 4,000 feet and the hills surrounding it average about 6,000 feet, running down in several spurs to the paddy fields. Most of the spurs nearest the village are dotted with pagodas. At first sight there are not many signs of ruby working except pits sunk into the red earth here and there. I learnt from Nuur Mahommed that he came up here with five Frenchmen who spent some time in making maps but they were unable to buy any rubies.

28 December

The General has advised us not to go into the town for the present as he has been advised that the people are treacherous. A party of Sappers has discovered three or four rifles and eighteen daks hidden in the jungle. I passed a quiet day watching the people coming in from the jungle. None of the Headmen have given themselves up.

29 December

Went with the Panthes and Barrett, with six Gurkhas as a guard, into Mogok to look for a house or office, but found nothing satisfactory. We visited the Thoogyi's house, now occupied by the Woon and Carter's Burmans and also the Suigi's house. He is said to be the boss of the mines. We found everything in a state of confusion. It had evidently been looted by the dacoits. There were any amount of papers knocking about. We took

19 George has written gods with a small g, but he may have meant 'goods'.
20 Spelled *Kyapen* on Streeter's hand-drawn map and *Kyupen* on that printed by the Manchester Geographical Society.

a few of them. Carter, the Deputy Commissioner, has been very seedy for the last four days. I went down with Bill and inspected the recent workings to the right of the town, which were an old riverbed.

30 December

Bill went with Major Skeene and thirty Riflemen, together with Abercrombie and twenty-five Tommies, to Kyat-Pien. The General and staff following later and returning together to report that Kathe was six miles distant and Kyat-Pien one mile beyond. Both villages were deserted. Parkyns came having ridden up from Kyan-Nyat in four days. He told me Gordon was on his way up but delayed for want of transport. I went out shooting with Beech. The bag was two Jungle Fowl and one Snipe but we lost them all for want of a dog.

31 December

Very cold in the night. I was seedy in the morning. I went down to the village and found them working a pit in the middle of the maidan. The site was surrounded by huts and about twelve men were working on a shaft twenty feet deep. Three were at the bottom filling small buckets, two others were scooping out the water and others were carrying the mud and gravel and placing it in a heap to be washed. The villagers seem to be in three classes, Burmans, Shans and Sooshais, who are the lowest class of miners, doing all the hard and dirty work. The people are very unhealthy; whether from opium eating or interbreeding I can't say, anyhow they are the most wretched looking lot. There are also a few Chinamen around. The General brought me six stones to look at. Four were spinels and two rubies. The owner, a Burman, asked a most exorbitant price for them. The General granted him a pass to go down to Mandalay. I think I ought to object to this. I went round to see Hume who showed me a bullet he had picked up with a small ruby fixed in it for luck. In the evening there was a great campfire and sing-song, 'Lights Out' being half an hour later than usual. I did not feel fit enough to go so turned in early.

1887

1 January

I had arranged with Beech to ride out early to Kyat-Pien to bring Bill back. We were to take our rifles as there were some wild cattle reported to be on the road. However the General got wind of the arrangement and stopped us going without an escort. As there were no men available we had to give up the idea at the last minute, so instead I sent out Muza and Achum with a pack-saddle and letter. I went to see Padre Adams who has been very seedy.

I set off with the General at noon to explore the north or Momeit end of the valley. We rode out about three of four miles finding it mostly paddy ground with ruby workings and water channels interspersed here and there; these workings grew less frequent as we reached the end of the valley where there were just two, and a small village. We interviewed the Headman there who showed us two roads to Momeit, both pony tracks; the first which went up the north west end of the valley and ran to Padan was reported to be very difficult climbing and little used. The second ran out of Mogok at the north east end of the town, skirting the eastern side of the valley and is said to be a very fair path for ponies and mules. Riding back to the camp we passed through a small deserted mining village. As we neared Mogok we saw several hillside and river workings. We entered a Kyoung and interviewed the Phoongys.[21]

Sunday, 2 January

I was feverish all-night and seedy in the morning. Bill arrived from Kathe at 10 AM and Gordon arrived from Sagadun shortly afterwards with four ponies, two of his own and six transport mules. Had a talk about the Proclamation,[22] which Carter showed us. The third clause had been quite altered; the Deputy Commissioner's name had been inserted for ours throughout. Carter also told us of another hitch in the arrangements, the business was to be referred to England. Also whether the concession would be granted to us or not would almost entirely depend upon his report. I sent a telegram to Sir Charles Bernard asking if this was so and if he could advise us, also one to Patton asking if there was a hitch anywhere. I dispatched letter written on the 1st to E.W.S.

3 January

I went with Gordon, Carter and some ruby miners and merchants to visit the principal mines of Mogok. We saw three different kinds of workings – Working on the hillside gravel by bringing water from a higher level and washing the gravels down into the valley.

21 A Buddhist monk
22 This concerned the legal arrangements for the Ruby Mines.

Working veins or leads of earth between the rocks on the hillside, which are made of gneiss and are of volcanic formation. I saw one lead said to run in some hundreds of feet. At certain times of the year it is unworkable on account of gas.

The old riverbed workings in the valley. The first ruby-bearing strata being at a depth of four feet and the second about eighteen feet. I saw the gravels of both these different depths being washed. They were very rich in different kind of gems. This seems the favourite way of working. I suppose because the miners and owners get returns with the minimum of trouble.

Gordon told the merchant who was our guide that if he wanted to sell his rubies he should bring them to me. He asked Carter for a permit. Carter replied that he had nothing to do with permits and that he could sell them to whom he liked. In my opinion establishing a very bad precedent. I also made enquiries about water and other rights. I consider Carter's opinion on these unsatisfactory. I had a long chat with the General on my return and he gave us permission to go into a Kyoung and that he would provide a guard. He also requested me to ask Gordon quietly to obtain information from the Panthe about the movements of the dacoits and villagers. He told me that an expedition would shortly be going from here to Mainloung and that one had already started for there from Mandalay. I heard that the Transport department had been commissioned to buy up as many ponies as possible.

4 January

I went with Bill to look at Kyoungs and also at Tyats to choose a place for an office. We settled on a Tyat close to the Hospital Kyoung. I was obliged to come back feeling sick and with a bad headache. Gordon went surveying at the top end of the valley.

5 January

I had a long talk with Carter in the morning and arranged that he should, in a day or two, issue an order that no rubies should be sold except at my office and that I should deduct 25% and pay it to the government. I went to the Siugi to meet Paya-Taga-Mat (Meaning Ma, the supporter of the Pagoda) and several of the principal ruby merchants. I bought one lot of rough rubies for 800 Rupees and sealed up another for 1,200 Rupees. Ben arrived from Sagadun with eight pony loads of stores. Beech decided to leave us next day – busy packing.

6 January

Beech left at 11 am. I went down with Bill to So-Thuugyis' house with Carter to meet ruby merchants. I offered one 1,000 Rupees for a parcel when he asked 1,600 Rupees. He would not come down to my price so I levied 25% duty on his valuation. We had a long talk about regulations.

7 January

I went down early with Gordon to Paya-Taga-Mat's house to tell him to bring all the merchants to the office at 11 am. I bought a parcel of rough stones from him for 1,400 Rupees. After breakfast bought several small parcels. Returned at 3 pm and found mail of November 18 and 26. There were letters from E.W.S., Mother, F.J.S., V.M.S.,[23] L.R.Russell and the Doctor about Patton. I packed up the stores and asked the Revd Adams to take the parcel down to Kyan-Nyat as he was going on Monday. I had a long talk with the General who asked me to go out to Mainloung with him and he promised to get my 6,000 Rupees up from Sugadun.

8 January

I wrote and posted the report to E.W.S. I took two photos of a group of the officers that came up with the expedition, and another of the native officers. Wired to Atlay. Then I rode out to Kathe, Bill came with me as far as Yebu, and then I went on alone. It was rather a risky thing to do but I met no one on the road, which winds up a pass 5,300 feet high and then descends into the Kathe and Kyat-Pien valley, which is 800 feet higher than Mogok. I found the people only just returning. Moung Gyin was the Thoogyi here. I stayed in a Kyoung with Skeene and Abercrombie.

Sunday, 9 January

I found a beautiful site for a house on a plateau about fifty feet above Kyoung. I walked into Kyat-Pien about a mile distant, a fair road with some good Burmese bridges; about half way I passed on the right the village of Bama, containing a good Kyong and many pagodas. Bama is situated at the foot of Pagoda Hill, known to the Burmese as Ping-oo-Toun, which rises 900 feet above the village. Hain-Moung is the Headman and it is inhabited by Paloungs. The finest rubies are said to come from Pagoda Hill. It is worked by extracting the ruby-bearing soil from the

23 Probably George's sisters Florence and Violet, although Florence's initials were F.R.S.

fissures in the rocks. But a landslip occurred a little while back killing four men and so the workings are deserted.[24] Kyoung has a small pagoda at the summit. I found Kyat-Pien almost deserted. It contained over one hundred houses, an immense Kyoung and a god market place. There was a double-storied house where Oo-Twee-Gee's principal wife lived. Moung-Gok was the So-Thoogyi here. It was cold and cloudy, in fact quite wintry. The people of Kathe say they have seven months rain a year and that it is never warm.

10 January

Kathe is said to have derived its name from the tribe of Kathays in Mannipur, many of whom were brought down as prisoners during one of the late Burmese wars. They were Brahmins and, as such, used to wear the cord; but they have so intermarried with the Burmese and embraced the creed of Buddhism that they are now scarcely recognisable from the pukka Burman. About twenty families passed through Kathe in the morning on their way back to Kyat-Pien. I noticed one old lady riding in a wicker-work cage on a pony's back, who said she was over one hundred years old. I interviewed a Shan goldsmith who seemed much respected. It struck me that there were more rich men in Mogok than Kathe and Kyat-Pien. The General and staff came out at noon so I went back to Mogok with them where I found Bill had moved down that morning to the Tyat.

11 January

I posted letters to E.W.S and Lennie Routledge.[25] It was Ruby Hall day and a good many dealers turned up but they brought no good stones. I bought about 450 Rupees worth. Then I had a long talk with Carter and told him that without the enforcement of the most stringent regulations the district could never pay. He agreed and said he had written a memo to that effect.

12 January

I had a return of my headache. I spent the day on accounts and writing. Gordon returned from Kathe at 2 PM by the lower road, which he said was shorter. I had a walk with the General in the evening. I paid Carter a

24 The miners considered a working cursed if a death occurred and they would not work it again.

25 L.A. Routledge, a businessman and Captain in the Royal Fusiliers. One of George's oldest friends.

cheque for the 25% duty on stones bought or valued to date. I heard that Paya-Taga-Mat had bolted early in the morning. His excuse being that I had frightened him because he had not brought good stones.

13 January

Bill received his mails of 3 December. I only got newspapers. I wrote a long letter to Sir Charles Bernard, copying E.W.S and Patton. I went round the village with Gordon talking to the people. Twenty Mengthas came in from Mormeit. They are Chinese Shans and are employed as carpenters etc. 'Meing' or 'Main' is the Shan word for district. News came in that the column under Earle had taken Mainloung, killing four and taking some important prisoners. Went out shooting in the evening. Barnett of the Royal Engineers dined with us.

14 January

Ruby Hall day. A few men came in but they said they had no rubies. It was reported that Moung-Mat had gone down to Mandalay. I went to see his brother, Poo-Lein-Sein, with Gordon. He said Moung-Mat had been frightened by something he heard at his own house. Carter was very annoyed at this disappearance, as it seems he had written to Mandalay saying he could produce him. He thinks the Commissioner will want him for the part he took against us in our advance. I received a curious letter from Major White of the K.O.L.I., the Commander at Sagadun, saying that the 2,000 Rupees left in his charge by Gordon had disappeared. I showed it to Chamberlain who took it to the General and he ordered a strict enquiry to be made.

15 January

Gordon, having completed his investigations and survey, left for Mandalay. I instructed him to make full enquiries about the missing money at Sagadun and he took a letter to White from me. He also took a letter for Bernard and two registered packets containing consignments 3 and 4. He promised to send me his report as quickly as possible. I wrote to Mother and E.W.S. then went round the valley at the back of the camp and noticed some very extensive workings. I went under an immense aqueduct constructed of timber and bamboo, about 200 feet high, and noticed two or three villages to the north east corner of the valley.

Sunday 16 January

I attended the service held at Kyoung by the Revd Adams. Rode out around Yebu in the evening. The Padre and the General came to dinner afterwards. They had ridden out to the tops of the hills on the south side of the valley, which they said was 1,200 feet above our camp.

17 January

I walked down before breakfast to the maidan to look at the new works that had been opened in the Thoogyi's special ground. About one hundred men were working at different shafts most energetically and they were producing some good coloured rubies, though small. Carter informed Bill that he was sending his report off that afternoon and it pointed out most strongly that without the regulations being in our favour we would not be able to pay the rent. Bill wrote to Patton to the same affect and enclosing a copy of my letter to the Chief Commissioner. I went out shooting in the evening. Judy[26] was chased by a pig or a deer and would not work. I saw several Jungle Mungi and Partridges.

18 January

At 9:30 AM set off for Kathe with Bill who rode Theebaw. We went as far as the In-Gyouk road with the Padre and Barnett, then said good-by the Padre who was going down to Kyan-Nyat, en route to Bhama. After passing a little village on the top of a hill beyond Yebu, while going up a rather bad pass, Bill's pony kicked him off. I dismounted to try and catch the pony but as he passed me he sent me flying also. I picked up Bill who was badly shaken, and put him on my pony and went back to Mogok. Sent the Panthe Muzor out to Yebu to make enquiries but he had no success. Received a note from Gordon about the missing money. It is most unsatisfactory; he has taken very little trouble about it. Nor about sending up the stores, only three out of the five ponies I lent him have returned loaded. I made over six ponies to the Transport for 590 Rupees. I fetched Doctor Sykes to look at Bill, no bones broken. Colonel Cubitt and Carter dined with us.

26 George's dog.

19 January

Went up early to the 43rd's Quarter Guard and fetched down the box of treasure, and counted it – 1,975 Rupees, probably the bag from which the 25 Rupees discount had been deducted. It was market day, which was very busy. Afterwards I was warned that it was dangerous to go alone, as several dacoits had come in and mixed with the people. I saw several small stones of a very good colour that the General had bought from the new mine in the maidan. The General and Chamberlain came down to see us at noon and showed me a letter from Major White about the missing Rupees. Bill and I replied to it saying that sufficient care had not been taken of the treasure and that we must hold him responsible. I met Hobday who had come up with the Mandalay and Mainloung column and then over to Mogok with Earle and Barnett.

20 January

Started at 8 AM with Barnet of the Royal Engineers, and Hobday by the lower or new road to Kathe and Kyat-Pien. We worked right up to the end of the valley and then ascended several spurs enclosing small valleys, which showed neither signs of mining or cultivation. I consider this road better than the higher one. Hobday went up Pagoda Hill. I went with Skeene and Barnett to Kyat-Pien, where only a few of the people had returned, and then on the Bama where they were repairing their viaduct. I was not offered any rubies but heard that most of the people were hard up and wanted advances. Left at 3 PM to get back at 5 PM and found most of my missing letters and papers had arrived by dak. Lloyd of the Royal Artillery and Barnett dined with us.

21 January

Bill is better and able to go out. I received a cable from Patton. I wrote a memo of the requirements of the district concerning mining in case the Commander in Chief asked for it. Sir Frederick Roberts,[27] Sir George White,[28] Colonel Potheroe, Major Hamilton[29] and Staff arrived at 4 PM.

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27 Later Earl Roberts of Kandahar, the Commander in Chief of the Indian Army.

28 Later Field Marshal Sir George White. He won the VC in Afganistan. At this time a Brigadier General.

29 Then Roberts' ADC. Later Sir Ian Hamilton, Commander at Gallipoli. Hamilton had just got engaged and spent some time digging for rubies for his fiancé but found none.

Gave our tent over for the Chief. It has been cloudy all day and a heavy thunderstorm broke just after nightfall.

22 January

Last nights rain continued right throughout the day. A council of war was held in the morning and Ing-Gyouk was decided upon for the sanatorium. I gave my memo to Pole-Carew,[30] the Military Secretary who promised to show it to the Chief. I wrote to Blackwood and Ethel.[31] Carter has moved down to So-Thoogyi's house in town. Kather of the Royal Engineers visited in the afternoon. Pole-Carew and Hume dined with us. I received a telegram from Atlay saying he was leaving Calcutta on the 27th.

Sunday, 23 January

I wrote to Patton with the memo urging the extension of the term of the lease, and also to Gordon about the report. Sir Frederick held an inspection of troops at 8 AM and then left for Sagadun at 9 AM. The road was very bad and he was pipped before he had got 200 yards from the camp. Richards and Hobday came down to see us. The latter thinks a railway might be run from Mandalay along the Maddea valley, tapping this region about 12 miles from Kyat-Pien. I went out shooting with Lloyd at the west end of the valley and saw a great quantity of Jungle Fowl. There was a big convoy of pack bullocks staying at a small village.

January 24

Out early and had a talk with General Stewart. He said a formal enquiry should be held about my missing treasure. Also he did not consider it safe for us to remain in our present Zyat[32] after the main body of troops took up their quarters at Ingyouk. The mail arrived for December 10 and 17 and a letter from the office of October 19 and also letters from Mother, Beatrice,[33] Hoole and Patton. Market day was very well attended. I heard that Bill's pony was at a village called Tuan-Bic and so sent for it. Ever since leaving Tongive I've been suffering from chronic diarrhoea so the Doctor has put me on 'soft tuck'. Chamberlain and Parkyns came to dinner.

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30 Another ADC to Roberts. Later Major-General Sir Reginald Pole-Carew.

31 One of George's sisters.

32 A guest house.

33 Another of George's sisters.

25 January

Spent a bad night and so I did not get up until 2 PM. I wrote a long letter to E.W.S, the General, Carter and Barnett. We started for Mgyouk to fix on a spot for a site. Eyre and the Screwguns left us for Mandalay. Bill was shooting with Lloyd at the end of the valley but they had no luck.

26 January

Took three photos this morning. Woon came round bringing a man from Morneit from whom I bought 1,500 Rupees worth with a cheque on Mandalay. I finished and posted letter to E.W.S asking him to cable on my proposed plans. I went and inspected the proposed site of the stockade and grounds for our house. Arbuthnot and Sykes came to dinner.

27 January

A wet day. I went through my papers and packed up a dozen films and sent them to Thompson with a letter and a list. I wrote to Sydney Smith in Madras and Billy Robinson in Australia. I saw Kosein, the Mainloung pretender arrive with thirty followers at 2 PM. The General and the District Commissioner returned from Mgyouk, having selected a site for the Sanitarium at Pyouk-Gyoung. Moung Mat came round in the afternoon and I made an appointment with him for tomorrow morning.

28 January

Carter came round with a telegram from Sir Charles Bernard asking for a copy of my letter of January 13. I showed him a rough draft. I took two views from our window of the Mogok valley. Moung Mat came at noon and I paid him his account in Rupees, and tried to make arrangements with him but I could not fix him to any proposition. I bought stones valued 200 Rupees from him. Posted my letters including one to Cecil,[34] I had a talk with the General about our position. Hathaway and Williams dined with us.

29 January

Market day – there was a large attendance; the Meinthas were selling Chinese produce. Rode with the General to Kathe by the lower road. We saw the column going to Thabeitkyan, made up of Gurkhas under Colonel

34 George's brother.

Skeene and Lieut. Williams, twenty five K.O.L.I. under Abercrombie, a few Sappers and over one hundred mules. Hobday and Richards were accompanying it as far as Mandalay. We returned by the upper road and I noticed that the half dozen villages that we passed were all inhabited again. We met a great many villagers returning from market. I found letters from E.W.S., Florrie[35] and the papers. Bill had a letter from Scoble,[36] a Legal Member of the Council. News came in that Main-Ga-Moung, the Mainloung Swabar had attacked the Mainloung column two miles from his town, on its return march. He was beaten back. Six prisoners were taken and shot. They attacked again and were beaten back with severe loss. The General and Chamberlain came to dinner and we had a rubber. I had a bad go of tooth ache.

Sunday, 30 January

I went round to see Carter who was bad with fever. I wrote to F.J.S. Moung Mat came and reported that everybody informed him that there were no rubies for sale. I told him that if he could not exert his influence I would get a Suigi from Mandalay to help me. I had a serious talk with Bill about returning to Mandalay to see Sir Charles Bernard. I strolled around the camp in the afternoon and found nearly everyone on the sick list. I had attacks of neuralgia all day.

31 January

I had a long talk with Carter who advised us to stay here for the present. He showed us a telegram from the Chief Commissioner[37] asking for a further report in answer to the eight questions. I impressed on him the necessity of backing us up on the question of having the rubies shown to us. I had a talk with the General about the missing treasure. He gave me the report of the enquiry to look at and I returned it with comments. Lloyd and Earle came to dinner and Chamberlain called in afterwards for a rubber.

35 George's sister.

36 Later Sir Andrew Scoble and MP for Hackney.

37 Sir Charles Bernard.

1 February

I received a cable from Pigott referring to the question asked in the House of Commons[38] about the concession. I sent a reply, with Carter's sanction, for publication in the home papers. I showed Woon the proposed site for the house and got his agreement for it. I rode out with Bill to the north end of the valley but saw few recent workings. I heard that the Mandaday column was returning to Mainloung. Dined with the General.

2 February

Clay left for Calcutta with a roll of films for dispatch. I received letters from Sir Charles Bernard, Gordon and E.W.S., dated October 16. I selected with Moung Mat a piece of ground on which to commence small mining operations, but did not receive Carter's sanction as he was waiting to see the plot. The owner is said to be Ui-Bu-Yar. I wrote to E.W.S with several enclosures and authorised Chamberlain, who is proceeding to Sagadun, to offer a reward up to 250 Rupees for the missing treasure.

3 February

I started the Meintha on building the stockade and advanced Moung Mat 100 Rupees for the mining operations; then rode out with Bill to Toun-Mee. Dined with Barnett, Pietri and Bonham Carter of the Royal Engineers. Finally I wrote a letter to Patton.

4 February

We started the opening of the mine. I heard from Gordon. Moung Mat informed us that our site for a house was bad because of nats.[39] I rode out with Bill and Earle to Oon-Gein, a village to the north west of the valley – a bad road. We noticed smoke on top of Toun-Mee. The villagers seem more cultivated than the miners. The three Royal Engineers dined with us.

5 February

I inspected the mine and stockade then went to see the goods brought be the Panthes. I bought a dagger said to have belonged to the Swabar of

38 In fact at least 37 questions were asked in the House of Commons about the Ruby Mines, most of them by the Radical, Charles Bradlaugh.

39 Native spirits

Thubaw, the hilt of which had four tickals of gold on it. Bill and I rode out in the afternoon to the west of the valley.

Sunday, 6 February

I went round with Carter and Bill to see a site for Carter's house. There was a third case of dacoitary reported between Webong and Sagadoun. I rode with Lloyd and Bill to the east end of the valley and then walked along another valley at right angles to Yebu – a few small signs of working about. The Colonel and Cowley dined with us.

February 7

I inspected the washing of the gravel, which was done two or three times. Bill had a touch of fever. Chamberlain returned from Sagadoun – no news of the missing rubies. The Mainloung column, which was to have left today, was postponed. The General rode up to the tops of the hills on the south of the valley, within a mile of a big village called A-Shee-U-A. He noticed several workings on the way. I went out shooting in the evening but a bad go of neuralgia made me return. Shewan and Parkyns arrived.

8 February

Bill is better. I went up to the Gurkha camp and was shocked to hear that Vaughn of the Punjab Infantry, who I met at Kyouk-Myoung, and who was in command at Kyan-Nyat, had been murdered there within 400 yards of the stockade. Moung Mee came with two men and a quantity of bad rubies. The price was too high so I did not buy. Moung Mat brought the first results from the mine. We have expended 23 Rupees.

9 February

The General left at 10 AM for Mainloung with the Gardner guns and a mixed force of 125 men. I sent Moung-Ku-Gin and Moung-Sa, who brought the bad rubies yesterday, round to Carter, as they wanted a permit to go to Mandalay. It was reported to me that they had some fine ones and were just using the others as a cover. Gave Moung-Gwee a permit, which Carter stopped. I shot a fine Jungle Cock and Ben stuffed it for Bill. Shewan dined with us.

10 February

We left at 8:30 wilt Bill and three Sowars[40] to ride halfway to Mainloung. In the villages along the way there was just cultivation and no mining, although the soil was the same as at Mogok, but with more limestone. At eight miles along we took the wrong path and did not find our mistake for another two miles. We cut across to a village where the people politely shut the gate in our face. Our Sergeant cut it open again and after a long talk, we got one of the villagers to put us onto the right road. There was a most marvellous banyan tree outside the village, the main stem being 32 yards in circumference. At the top of the pass there was a good view of the Mainloung valley. On the way back I noticed numerous orchards and different kinds of ferns. The road was steep and bad. I wonder how laden mules ever get along it. We crossed several tributaries of the Mogok stream that goes on to Mainloung, the flow must be torrential in the rainy weather. Colonel Skeene's column returned from Thabut-Kyen, forty miles away, and they reported very favourably of the roads. The mail came in late, letters from E.W.S, W.M.S., Haynes,[41] and Patton, enclosing a note from Alexander. I arranged to send a dozen coolies to bring up Atlay's belongings. Moung Mat brought up rubies, which were the entire washing from one big pit, which he valued at 30 Rupees. The name of the village visited today was Noung-Gyvung.

11 February

I visited the mine workings where about 60 men were engaged. Carter sent me the draft of the Ruby mining regulations. I went through them carefully and made a not of suggested alterations and additions. Ibrahim is ill so I have no cook. I telegraphed to Patton, and also to Gelbanks, asking him to send an interpreter.

12 February

I sent three ponies and a bullock trunk down Sagadun with Bill's and my curios. I wrote to E.W.S and Haynes and Bill wrote to Bernard and Patton. We dined with Earle and Abercrombie and received a telegram from Beech saying Patton had had no information from us, sent a reply to leave by dak in the morning. I was awake a good part of the night with neuralgia.

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40 A mounted native soldier.

41 Thomas Haynes, the manager of E.W.Streeter's pearl fishing ventures in Australia.

Sunday, 13 February

Seedy with a slight go of fever so kept quiet today. Twelve coolies left early for Atlay's things.

14 February

I started a working party of Gurkhas to clear the ground in the stockade then bought 450 pieces of timber from Yebu. I watched the miners finish washing in one pit and then started them in another. Moung Mat presented me with a rare orchid, which he said was always claimed by the king. I gave it to Bill. The mail came in late, letters from E.W.S, Ethel and others, and a disquieting and abusive telegram from Patton.

15 February

I marked out the dimensions for the temporary house with Colonel Skeene and the Subadar Major. I had a long talk with Moung Mat and other ruby men. I withdrew the 25% tax and they promised to bring 1,000 Rupees worth of rubies in. I spoke to Carter about Patton's wire and he strongly advised me to stop saying we had a government promise. He did not think the matter would be raised again. The General returned from Nyouk with Captain Airey[42] of the New South Wales Artillery and Green an Assistant Commissioner. Atlay turned up just after dusk, having left all his effects with Bear at Ingyouk. Chamberlain and Skeene dined with us.

16 February

I received a wire from someone called T. Bennett in Mandalay who said he had just come from the diamond mines. Carter left for Mianloung. I showed Airey over the mine. We celebrated the Queen's jubilee by dining with Lloyd, Parker and some men from the Gunners. The General came down in the afternoon and I gave him some rubies and spinels.

17 February

The Gurkhas left for Pyouk-Gyoung. We moved out of our Zyat into the stockade. I received a telegram from Jackson saying he was leaving for Kyan-Nyat. I wrote telling him it was no good coming here at the moment and also wrote to Ward about him.

42 Henry Airey, later Lt.Col. He was attached to Sir George White's staff and was severely wounded at the attack on Hwai-Hwaing.

18 February

The General and Staff left for Pyouk-Gyoung and Rangoon. He advised me to offer a reward of 400 Rupees for the lost treasure and he said he would carefully look into the matter at Sagadoun. He advised me to be very careful and not to run any risks while up here. Also he said we deserved a campaign medal for our work as Orderly Officers on the way up and that he would apply for it. We moved our camp down to our own stockade. Bear arrived with the rest of Atlay's kit on two elephants. We pitched three tents. One is for Bill and I to sleep in, the bath section reserved as a store-house, the second as an office and sitting room and the third for Atlay and Bear. I went down to the Zyat, which I converted to a kind of office. Moung Mat showed me a lot of rubies but we could not agree a price. While we were dining the Phonges handed over to Skeene two ruffians who they said we dacoits. I gave the Gordon report to Chamberlain asking him to post it in Rangoon.

19 February

Earle, the Yorkshires, the Commissariat, and the rest of the departments left for Pyouk-Gyoung. We started for Kathe at 8 AM taking with us Micalder, Moung Mat and, as guard, two mounted infantry. Moung Mat showed us the old haunts of the dacoits who used to come from Mainloung and Tubaw by a jungle path. The gorge they attacked from was just below the eight Pagodas, the site of the old village destroyed ten years ago; the villagers worked the mines in the valley below. We went on to Bama to Hein-Moung's house where I bought four rubies for one hundred Rupees. I could not get any in Kathe because, I think, Micalder buys there himself. After lunching with Pietri we came back on the high road, passing two swarms of bees. Moung Mat pointed out several small mining villages, the best of which was Gon-Bein. One village of ten houses dug 5,000 Rupees worth of rubies in one month, nearly all of which they spent on gambling. On our return I posted three copies of the Notice of Reward, written in both English and Hindustani to White at Sugadoun, Parkyns at Pyouk-Gyoung and Ward at Kyan-Nyat, requesting them to post it prominently.

Sunday, 20 February

I settled the accounts for Bill and Gordon, and then wrote to E.W.S. In the afternoon I went with Bill, Skeene and Sykes to scale the rocky hill at the north end of the valley. It was rough climbing and we passed many ruby mines, large caves, galleries and shafts. At the summit we found a small Pagoda. There was a fine view; you could see a large Kyoung and the Padan-Moneit road and a good aqueduct joining the two hills to the north. Our elevation above Mogok was 400 feet. On our return we learnt that our old zyat had been broken into and the contents looted. Pawkay, who came yesterday, had a long interview with Colonel Skeene. I paid the Meinthu coolies up to date.

21 February

I took photos of the front and back of the camp, and then I tried to balance my accounts. Bill counted and sealed three boxes of treasure to the value 6,000 Rupees and placed it in the Gurkha quarters for guarding. I went down and visited one or two ruby men and then sent for the Siugi to account for the Zyat being broken into and looted.

22 February

I wrote home for the last time then rode out wilh Bill before breakfast. I handed over 7,274 Rupees over to Atlay and then took a photo of Bill and his horse and he did the same for me. I bought rubies worth 1,200 Rupees from Moung Mat and then went out with Atlay and Skeene to examine hill workings. We saw the remains of a Sapper Seik that had been burnt a few days ago. The Gardner guns returned with Lloyd and Parker. I heard that White and his company had left Sagadoun. Sykes and Skeene dined with us and we played a rubber afterwards.

23 February

Bill's baggage left for Kyat-Nyat including twelve photo negatives, six glass and six paper films. Ibrahim left going with the ponies. I paid him to date, 83 Rupees. After breakfast I walked down to the mine on the maidan and visited the market. Carter returned from Mainloung suffering from fever with Green, the Civil Officer. I went out shooting, attacked with diarrhoea. Lloyd and Parker dined with us.

24 February

I was feeling off colour. No mail arrived but a wire from Jackson. Bill heard from George Porter. I had a talk with Carter but he could not report any progress and he advised me to stay in Mogok. Moung Mat called and I paid him 1,000 Rupees on account, and also 130 Rupees to Heing Moung.

Skeene and I went out in the afternoon to do some amateur mining. We met an English speaking Burman in out Zyat. I wonder if he is an agent for Gillanders, Arbuthnot.[43]

25 February

I rode around the Yebu valley with Bill before breakfast and noticed some new workings. The pony got in a bog and I fell off, but on soft ground. The English mail arrived, letters from E.W.S and Beatrice.[44] I wrote to E.W.S enclosing the consignment invoice and a note for Fergano and Co. Bill had a parting interview with Carter and they were unable to settle the question of the duty. We had a farewell dinner with Lloyd and Parker.

26 February

Bill, Ben and I started at 7 AM for Pyouk-Gyoung via the Toaun-me-Diak. We found the road much improved and arrived at the Gurkha camp a little after 10 AM, where we had breakfast. Bill and Green then left for Sagadoun at noon en route for Mandalay. A storm came in from the north-east and it was bitterly cold. About two hundred people came up from Mogok on the way to visit the Mandalay pagodas. Smallpox has broken out among the Seeshaws. I went for a walk with Barrett in the evening and made arrangements with him about the mails. I dined with the Gurkhas and slept in Barratt's hut.

Sunday, 27 February

Up at 6 AM and started back with the dak to Mokok where I arrive at 10 AM. I saw Carter after breakfast and found him interviewing the head ruby men. I visited the mine and watched them washing. I noticed they had found one or two nice little stones. There are rain clouds blowing about. I'm missing Bill considerably. Skeene and I investigated the rock in the middle of the plain. It was worked in years gone by. There was a big fire on the Momeit side of the hill and the valley filled with smoke.

28 February

I visited Carter in the morning. The mail arrived at 2 PM with letters from E.W.S and Violet. I wrote to the Map Curator at the Royal Geographical

43 The rival firm seeking the Ruby Mine concession.

44 One of George's sisters.

Society enclosing a rough map of the district. Carter came in the afternoon to see how the house was progressing. He read me part of a letter from Sir Charles Bernard, which said that he had forwarded his reply to the Government of India and that he hoped soon to have permission to put us in permission. He also mentioned he was going on a years home leave. I walked down with Carter to his house and read the papers. Atlay is feeling seedy.

1 March

I started with Lloyd and the Gardner guns along the rainy-weather path to Momet. We climbed about five miles to the top of the range of hills. Breakfasted at a Kyoung on a top of a ridge and returned to Mogok about noon. Letters arrived from Bill and Alexander. In the afternoon I looked at the big, well made, sold timber aqueduct at the right of the On-Bein road. I came back by another path and saw extensive workings. Lloyd and Parker came to dinner and then the Colonel joined us for a rubber.

2 March

I visited the mines before breakfast and collected stones from Moung Mat. One hundred and fifty Munthas came in. I understand their ancestors were camp followers of a big army with which the old King of Pagan invaded Yunnan two to three hundred years ago. Visited Carter and had a walk with Skeene in the evening.

3 March

I rode out before breakfast and then spent the day with Carter buying and valuing rubies, spending 940 Rupees. In the evening accompanied Skeene to the valley between Oon-Gein and here and found some very rich ruby earth. Skeene and Sykes dined with us. Atlay is down with fever.

4 March

I wrote to E.W.S and home asking them to direst letters to C/0 G and S, Rangoon. The weather is showery. I visited the mines and called on Carter, then sent down to Sagadoun for the remainder of Atlay's kit. In the evening Skeene and I visited a large working on the other side of the river,

5 March

I rode out early with Parker to the Kyoung on the Momeit road. We met some Paloungs coming to market who stampeded at the sight of us. Letters arrived from E.W.S., Florrie and E.A.Arnold.[45] I started an article for *Murray's Magazine.* Lloyd showed me one he had written for *Blackwood's.* I shot a brace of pigeon in the evening. Atlay is still down with fever.

Sunday, March 6

I paid for the rubies purchased on Thursday. A letter arrived from Bill written at Kyan-Nyat. I did some hard work on the article for Murray's and then rode out with Parker to Oon-Gein and Ingyouk. The nights are getting colder. Atlay is no better.

7 March

I continued working on the article for Murray's. Pietri came and had tiffin with us. He spoke unfavourably of the Thabeit-Kyan road. Lloyd, Butcher and I wet out in the evening. It was stormy and blowing half a gale. Lloyd dined with me.

8 March

I was up at sunrise and went with the Gunners to a village on the Mainloung road called Foun-Yua. I finished the article for Murray's and posted it to Arnold at 50 Albermarle Street. A letter arrived from Bill at Kyan-Nyat about Jackson. I had a long talk with Carter. He considers that the Thabeit-Kyan road will not be opened before the rains.

9 March

All the servants are down with fever. I wrote a letter to Bill and then called at the mines. I visited the Head Phongy who gave me a gold book. Skeene and I went for a walk. There was a heavy thunderstorm over Pyouk-Gyoung. Atlay is still bad with fever.

10 March

I rode out with Parker at 7 AM along the summer road to Momeit to the end of the valley. We went in a forest and followed the path for some distance. Carter is down with fever. It is ruby buying day. In conjunction

45 A publisher.

with Woon I spent about 920 Rupees. A letter arrived from Ko Sein saying six hundred men were attacking him and asking for help. Skeene and I walked around the valley at the back of the stockade in the evening.

11 March

I went down to the village early to see the mines and Moung Mat and was buying and sorting rubies until 2 PM. A telegram arrived from Gilbanks about Patton. I wrote to E.W.S in the afternoon and then rode out with Lloyd, Parker and Butcher along the new path to Oo-Bein; there was a great quantity of wood stacked there. I had a bad night with neuralgia.

12 March

Dr Sykes lanced the spot on the inside of my cheek. The column, commanded by Earle and with Abercrombie and Cowley, arrived from Pyouk-Gyoung on its way to Mainloung. I telegraphed Bill at Calcutta and then went to see Carter to find him seedy and packing also for Mainloung. Atlay's temperature is a little higher again. My face has been bad all day.

Sunday 13 March

The Mainloung column left at 7 AM. I went for a walk with the Colonel before breakfast and inspected the hospital. The dak arrived at 11:30 AM. There was a certificate from Chamberlain concerning the medal and a telegram from Bill at Rangoon asking me to meet him and Patton in Mandalay on Friday. I consulted with Skeene to see if this was possible and the packed up my kit and sent it on ahead on two ponies with a bearer and a syce. I then sent for Moung Mat and left instruction and accounts with Bear. I packed all the rubies to carry in my saddlebag. I was kept awake all night with toothache.

14 March

I was up at daybreak and left Mogok on Prince at 6 AM with Butcher of the Royal Artillery. We arrived at Pyouk-Fyoung at 10 AM where we found Barratt seedy and breakfasted with Colonel Cubitt. At noon I rode on to Suicor by myself, rested for half an hour and met up with a relief of Gunners joining the Gardiner guns under an officer of the 13th. I continued on with a dak Sowar. The sun was frightfully hot and my toothache bad, although Downey had lanced the cheek at Pyouk-Gyoung. I reached Sagadoun at 4 PM, both the pony and I exhausted. Dr Morris, in charge of the Bearer Corps, lanced my cheek twice to give some relief. I dined with Stewart of the 103rd, the acting Transport Officer, and Dr Morris. I received another wire from Bill urging me to come quickly. I telegraphed him at the Irrawaddy Flotilla Co., Prome. There were also communications from Ward at Kyan-Nyat and the Post Masters at Kyan-Nyat and Mandalay. I slept in Stewart's tent. Dr Morris offered to run me down to the second stockade in a dandy with eighteen bearers but I foolishly refused.

15 March

I was up at 5:30 AM and left with my kit at 6:30 PM. It was a hot march to Webong where I rested, had breakfast and fed the ponies. There was another long hot march to the second stockade. There were bush fires burning on both sides of the road. I camped in a rest house for the night. No one was around except a few Gurkhas and mules. I had a little rice and curry for diner and turned in about 7 PM. A thunderstorm passed over but there was not much rain.

16 March

I was up at 4 AM and had a cup of cocoa and started before 5 AM, doing the first hour and a half my moonlight. I met a party of Burmans with guns but I was not molested. A little after daybreak I came across Capel Cure who had left Kyan-Nyat at 2 AM. I reached Tongive at 7 AM, putting up a flock of Jungle Fowl by a stream. I had breakfast and then went off again with a Police Sowar. I cantered all the way to Kyan-Nyat, arriving at 9:15 AM and breakfasting with Ward and two officers of the police. The ponies came in with the kit at 2 PM. The ferry from Mandalay arrived at 4 PM but she brought no mails. I gave an 84 Rupee cheque to settle the Kyan-Nyat commissariat account. I dined with Ward and then slept on the ferry, leaving the three ponies and the syce to come on the next steamer.

March 17

The steamer started at 7 AM and we reached Male at 9 AM and Thabeit-Kyan at 11 AM, where we took Schon of the Royal Engineers on board. We arrived at Kyouk-Myoung at 1 PM. I went for a walk with Surgeon-Major Beattie and I was surprised to find the villages so well populated. Kyouk-Myoung used to be the summer residence of the Burman kings when the capital was at Savebo. Some fine gold coins and godamas were found here last week when they were demolishing old pagodas. Dacoits are still active here. Barton of the K.O.L.I is in command and the post has been greatly fortified and improved since I was last here.

18 March

We left Kyouk-Moung at 6:30 AM and we passed the Mindoon Pagoda at noon. The skipper pointed out to me the great bell, which is supposed to weigh over one hundred tons. Disembarked at Mandadlay at 1 PM and found that the mail had arrived four hours before. As Kather was at Woontho, I borrowed a transport pony from Ranken and rode up to the house. I found Patton there but Sir Charles had, at the last minute, gone to Calcutta. He left me a long letter explaining how things were. I talked the whole thing over with Patton and found that the Indian Government could not agree with Sir Charles's suggestions and so had handed the whole matter over to Crosthwaite.[46] Piggot was still staying in the house but Gordon had gone to Kanske. I'm greatly inconvenienced by passing the last two mails on my way down.

46 Sir Charles Crosthwaite. He took over as Chief Commissioner from Sir Charles Bernard in 1887.

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