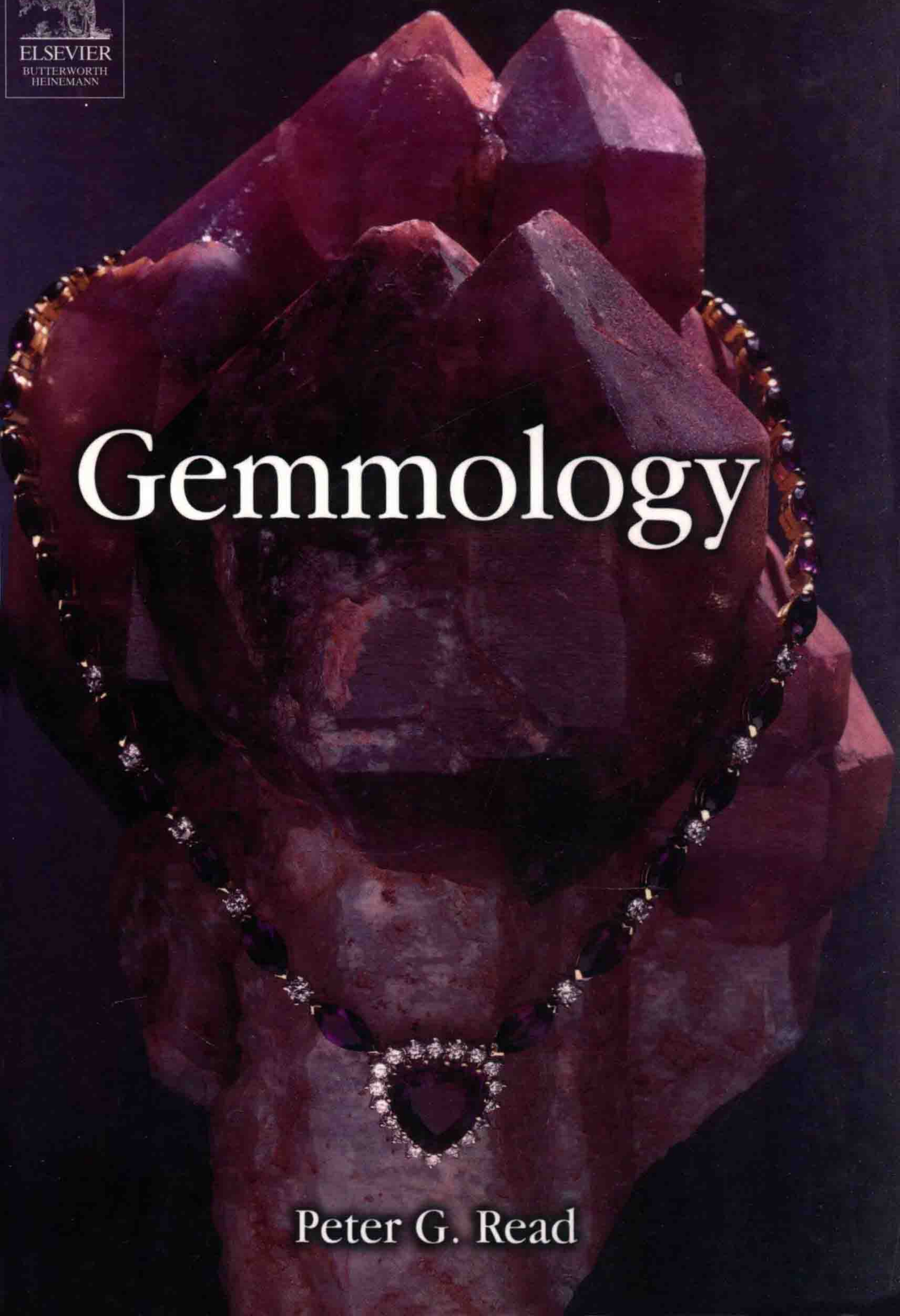
Third Edition



Gemmology

Peter G. Read

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Front cover: Amethyst and diamond necklace on amethyst crystal (Courtesy of P.J. Watson)

Preface

My *Beginner's Guide to Gemmology* was first published in 1980, and although this was only intended as an introduction to the subject, it was apparently used with some success as a textbook by many students. For several years I had acted as tutor to students taking the Gemmological Association's correspondence courses, and this experience prompted me in 1991 to produce a more expansive and up-to-date volume in the original hardback edition of *Gemmology.*

Both the first and second editions of the book were written with the aim of providing a readable account of the relatively modern science of gemstones as well as forming a text to assist students preparing for the Gemmological Association's Preliminary and Diploma examinations.

A similar format has been retained in this third edition, but more emphasis has been placed on the use of the book as a work of reference. To this end the index has been enlarged, and cross-links between chapters have been increased. The replacement of the original Preliminary course examination by the new Foundation course examination (and its associated practical endorsement requirement) is covered in Appendix E – Examination notes.

In line with the increased practical content of the Foundation course, more emphasis has been placed on the identification of natural gemstones, their simulants and their synthetic counterparts. The text in many of the chapters has been revised and updated. In particular, new HPHT diamond enhancement methods and beryllium lattice diffusion techniques for corundum are covered as is the low-pressure high-temperature CVD synthesis of thick film diamond. Finally, a new chapter has been added to provide a concise guide to practical gemstone identification.

Peter G. Read
Bournemouth, Dorset
2005

Acknowledgements

In this third edition I would again like to acknowledge my debt to those three pioneering gemmologists Basil Anderson, Alec Farn and Robert Webster all of whom I was fortunate enough to know, and whose lectures, books and articles have strongly influenced this present volume, particularly in its emphasis on practical gem identification.

I am also grateful to Vivian Watson of P.J. Watson Ltd who once again has provided the front cover illustration and some of the colour plates, to Lorne Stather who made sure I had a wide choice of digital pictures to illustrate the appropriate sections of text, and to Ian Mercer for keeping me up to date with the Gem-A's educational activities. My thanks must also go to my publishers, Elsevier Butterworth-Heinemann, who have kept me busy as an author of gemmological books since 1980.

Finally, I must thank my wife Joan for all her patience and encouragement during this project.

Contents

Chapter 1

Introduction

The evolution of the science of gemmology

The science of gemmology is concerned with the study of the technical aspects of gemstones and gem materials and the use of these aspects for identification purposes. For well over 2000 years, philosophers and scientists have been captivated by the beauty and the enigma of gems, and down the years have left records of their observations on these ornamental products of nature. One of the first gemstone books in English was written by Thomas Nichols as long ago as 1652*, but it was only in the last half of the nineteenth century that the science of gemmology began to emerge as a specialized offshoot of an already well-established branch of science, mineralogy.

Highlights of the last 170 years

In view of the important part that gemmology plays today in the identification of modern synthetic gems, it is perhaps appropriate that we go back around 170 years in time and begin this summary of the highpoints in gemmological history with the first attempt at gemstone synthesis. In 1837, the French chemist Marc Gaudin managed to grow some small crystals of ruby by melting together potassium aluminium sulphate and potassium chromate. This was in the period when there was much interest in reproducing the growth of crystalline substances, and when the first experiments were being made to dissolve the constituents in a solvent 'flux' of lower melting point.

In view of the importance of spectroscopy in present-day gemmology, it is also appropriate to mention the letter written by Sir Arthur Church in 1866 to the learned English periodical, *The Intellectual Observer.* In this he describes his experiments with an early spectroscope and his discovery of absorption bands in the spectrum of Ceylon zircons and almandine garnets. However, it was not until 1932 that a comprehensive study of gemstone spectra for identification purposes was to be undertaken by Basil Anderson.

Some five years after Church's letter appeared in print, the South African diamond rush was in full spate, and 5000 diggers were reported to be working along the banks of the Vaal, Modder and Orange rivers. In 1873, the primitive mining town that had sprung up around the site of the De Beers farm was formally named Kimberley after the British Secretary for the Colonies, the Earl of Kimberley.

In 1877, the French chemist Edmond Frémy manufactured the first synthetic rubies of commercial quality. These crystals were grown in a large porcelain crucible containing a lead oxide flux in which was dissolved alumina powder mixed with a trace

* *A Lapidary; the history of precious stones*, Cambridge University Press.

of a chromic salt. However, the resulting crystals were small and expensive to produce and were therefore no threat to natural rubies. The following year was marked by the discovery and identification of a new gem variety, green demantoid garnet.

One of many disturbing events in the jewellery trade occurred in 1885, when a quantity of relatively large 'Geneva' rubies appeared on the market. Initially, the presence of bubbles within the rubies proved them to be synthetic. Later, however, it was thought that the stones had been produced by fusing together smaller fragments of natural ruby, and for this reason they were then called 'reconstructed' rubies. More recently, analysis of surviving specimens coupled with attempts to reproduce the reconstruction process has shown that such a fusion of small stones could not possibly have produced transparent rubies, and that the Geneva ruby was probably created by the multi-step melting of a mound of ruby powder in a flame.

Meanwhile, in South Africa, Cecil Rhodes and Barney Barnato had finally agreed to amalgamate their holdings, and a controlling company, De Beers Consolidated Mines Ltd, was incorporated in 1888. The name was taken from the De Beers brothers' farm which had become the site of the famous 'Big Hole' of Kimberley. In the same year the first successful synthesis of gem quality emerald crystals was achieved by the French chemists Hautefeuille and Perrey using a flux process.

The pace of gemstone synthesis began to quicken towards the turn of the century. In 1891, the French scientist Vernueil, a former assistant to Frémy, was perfecting the furnace he had designed for the production of synthetic corundum. Over 100 years later, furnaces of this type were to be producing in excess of 1000 million carats of synthetic corundum per annum worldwide.

The year 1902 saw the discovery and documentation of the pink kunzite variety of spodumene, and three years later the 3106 carat Cullinan diamond was prised out of a sidewall in the opencast workings of the Premier mine near Pretoria in South Africa. In the same year in England, Dr Herbert Smith produced his first refractometer (Figure 1.1), providing gemmologists at last with an instrument specifically designed for measuring the refractive index of gemstones (this was followed in 1907 by a larger brass version). By 1910, the first synthetic rubies produced by the Verneuil method appeared on the market, although ironically, these could not be identified as synthetic by means of the refractometer.

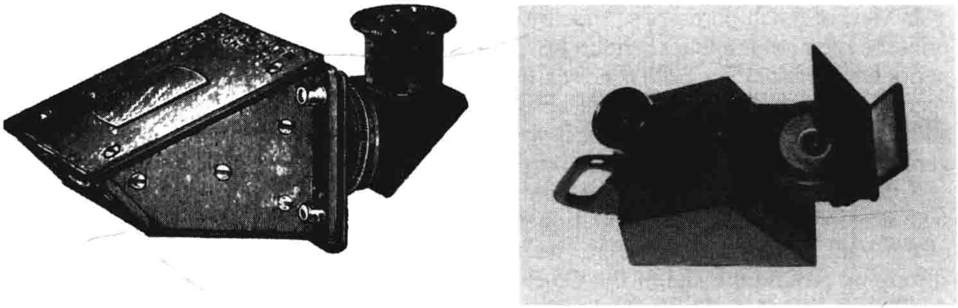

Figure 1.1 Two early gem refractometers: the Herbert Smith model (left); the Tully version (right)

One event that did more than any other to establish gemmology as a serious science was the formation of the Gemmological Association of Great Britain, which began its life in 1908 as the Education Committee of the National Association of Goldsmiths.

The Association held its first membership examinations in 1913, just three years after synthetic Verneuil rubies appeared on the market. World War I broke out in 1914, and it was not possible to reinstate the Association's examinations for another eight years.

The next milestone in the development of the young science of gemmology occurred in 1925, when Basil Anderson, fresh from university with degrees in chemistry and mineralogy, was engaged by the Diamond, Pearl and Precious Stone Section of the London Chamber of Commerce to set up a pearl testing laboratory in Hatton Garden. The urgent need for such a laboratory arose from the rapid growth of the Japanese cultured pearl industry and the problems that jewellers were experiencing in distinguishing native pearls from the cultured product. The growing importance of the refractometer to gemstone identification is indicated by the introduction in 1925 of yet another version. This new model (Figure 1.1), designed by the famous jeweller–gemmologist B.J. Tully, used a rotatable hemisphere of glass.

The following year, the first synthetic spinels were produced by the Verneuil method, and an endoscope pearl tester (Figure 1.2) was installed in Basil Anderson's new Hatton Garden Laboratory. This equipment, brought over from France, made it possible to test over 200 pearls an hour. By 1928, when C.J. Payne joined the laboratory, nearly 50 000 pearls were being examined each year. The laboratory moved to new premises in 1928, and an X-ray unit was installed so that undrilled pearls could be tested using diffraction techniques. So began gemmology's practical service to the jewellery trade, first with the identification of pearls (well over 4 million were tested in the laboratory which was merged much later with the Gemmological Association) and then with the detection of the new Verneuil synthetic rubies and spinels.

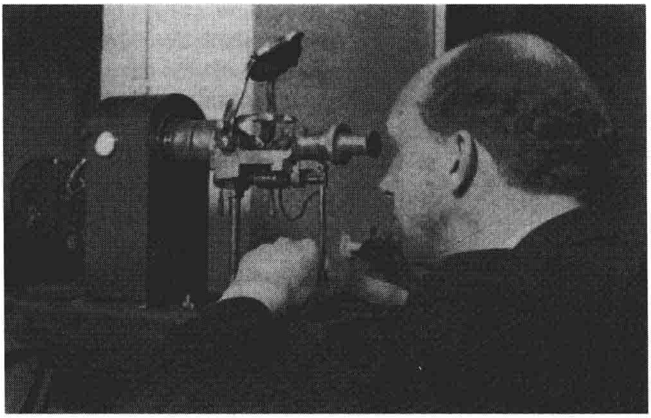

Figure 1.2 The endoscope pearl tester in use at the Chamber of Commerce's Gem Testing Laboratory in London's Hatton Garden

Another milestone event occurred in 1931. Robert Shipley, who had been awarded the British Gemmological Association's Diploma in 1929 and who had then pioneered his own gemmological correspondence course in the USA, founded the Gemological Institute of America. In the mid-1930s he was joined by his eldest son, Robert Shipley Jr, who helped develop a series of gem testing equipment which included a gem microscope, a diamond colorimeter, a refractometer and a polariscope.

In 1934, Robert Shipley Sr founded the American Gem Society as a professional body of leading jewellers. Volume 1, No. 1 of *Gems & Gemology*, the journal of the Gemological Institute of America, appeared in 1935 and in the same year the American Gem Society held its first examinations.

During the depression years of the 1930s, Basil Anderson in the UK made good use of the downturn in trade to carry out research into various gem testing/identification techniques. In particular he and C.J. Payne were able to study and record details of the absorption spectra of many gems (these were later to be published in Robert Webster's *The Gemmologist's Compendium* and in Dr Herbert Smith's 1940 edition of *Gemstones*), and to develop an experimental blende version of the Tully refractometer. During their refractometer work they also formulated a new contact liquid (a solution of sulphur and tetraiodoethylene in di-iodomethane) which until more recently was to become the accepted refractometer contact liquid and used throughout the gemmological world.

Following unsuccessful attempts by the Rayner Optical Company, manufacturer of the Tully refractometer, to fabricate the hemispherical prism in blende rather than glass, a truncated prism version was developed and fitted into a small instrument of Rayner's own design. The change from a hemisphere to a prism-shaped refractometer 'table' made it possible to make a less expensive standard glass model, and this design became the basis for all future Rayner refractometers (and for overseas 'clones'!). The blende refractometer was followed by a diamond and then a spinel version.

Other important research work by Anderson and Payne during the comparative leisure of the mid-1930s included a reassessment of the majority of gem constants. Several stable and relatively safe heavy liquids for the determination of specific gravity were also established. In 1933, Basil Anderson took over the Chelsea Polytechnic classes in gemmology. One of the students in his first Diploma class was Robert Webster. During this period, an emerald filter (called the 'Chelsea' filter) was developed jointly by the London laboratory and the gemmology students (Figure 1.3).

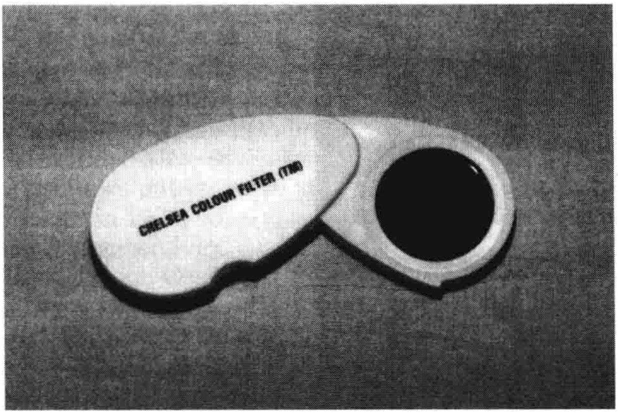

Figure 1.3 The Chelsea emerald filter designed to distinguish between emeralds and their simulants

Early in 1935, news appeared in the London press of a synthetic gemstone having 'all the qualities of diamond' and capable of 'deceiving 99 per cent of the experts'. Today the story has an all-too-familiar ring, but back in the 1930s, this new product caused quite a stir. The simulant behind the scare story was colourless synthetic spinel, which was thought to have been manufactured in Germany.

The same news caused similar consternation when it appeared in the North American press. There was further dismay in the trade on the announcement of the successful synthesis of diamond in gem qualities and sizes by a Mr Jourado, a self-styled gem expert. The Jourado stone was identified as a spinel by Anderson, and reports by him of the stone's characteristics appeared in several of the leading gemmological journals and jewellery magazines.

Another significant event that occurred in 1935 was the pilot-scale synthesis of emerald by the German firm I.G. Farbenindustrie, which had developed a new flux-melt process. Although many samples were produced, the advent of World War II interrupted the company's work. The 'Igmarald' synthetic emerald was never launched commercially, and production was finally discontinued in 1942.

Because of its high value, the synthesis of emerald became the aim of several laboratories, and in 1940 the American chemist Carroll Chatham also succeeded in growing gem-quality crystals. Although the method of manufacture was kept secret, the Chatham emeralds were close enough in character to the German Igmarald to indicate that they were grown by a flux process. (In a move to avoid the use of the word 'synthetic', Chatham finally obtained permission in 1963 from the US Federal Trade Commission to market his product as 'Chatham created emerald').

After World War II, Anderson and Payne were joined in the Hatton Garden laboratory by Robert Webster and Alec Farn, and the work of gemstone identification continued. During the following years, Robert Webster was to carry out pioneering work on the use of ultraviolet light in the identification of gem minerals, and Alec Farn was to become, among other things, the UK's leading expert on pearl testing.

Soon the Hatton Garden laboratory was working at full capacity again as parcels of rubies and sapphires containing up to 10% synthetic stones started to arrive in London. In 1946, more than 100 000 stones were tested in the laboratory, and a year later its problems were further increased by the successful production of star rubies and sapphires by the Linde Division of the Union Carbide Corporation of America.

Synthetic rutile, the first of a series of man-made diamond simulants, appeared in 1948 and was marketed under the trade names 'Rainbow Gem' and 'Titania'. In 1951, a new rare gem species was confirmed and named 'Taaffeite' after its discoverer, Count Taafe. X-ray and chemical analysis were used to verify its principal constituents as beryllium, magnesium and aluminium (except for double refraction, taaffeite closely resembles spinel). Although still a rare species, a few taaffeites have since been found in Sri Lanka.

In the 1950s, strontium titanate was introduced as yet another diamond simulant under the trade names 'Fabulite' and 'Diagem'. Unlike the earlier simulant, synthetic rutile, there appeared to be no counterpart for this material in nature. During this period, progress was also being made in the field of diamond synthesis. Although failing to have their work verified at the time by an independent investigator, the ASEA group of Sweden claimed to have developed a repeatable process in 1951. As they were unaware of any other company working on diamond synthesis, ASEA kept their process secret while they worked on improving the size and quality of their product. They were also unaware of the great industrial importance of grit-size synthetic diamonds. ASEA only revealed their earlier breakthrough after the General Electric group in the USA announced its own successful synthesis of diamond grit in 1955. Four years later, the De Beers Diamond Research Laboratories in Johannesburg also succeeded in synthesizing industrial diamonds (Figure 1.4). Since then many countries have developed this capability including Russia, Japan and the People's Republic of China.

A brown gemstone from Sri Lanka, formerly classified as a peridot, was identified in 1954 as a new mineral species and named sinhalite after its country of origin. In 1957, yet another new gem species was identified and named 'Painite' after its discoverer, A.C.D. Pain.