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GEMMOLOGICAL PROPERTIES OF SYNTHETIC CORUNDUMS COATED BY LECHLEITNER

By *MAHINDA GUNAWARDENE, F.G.A., D.Gem.G.,*
Im Sierling 2, 6581 Hettenrodt, W. Germany

INTRODUCTION

Lechleitner is not a new name in gemmology. He became famous in our science of gems giving an 'emerald coating' to colourless natural beryl. His seeding technique (Figure 1) covered not only beryl seeds, but also quartz and topaz seeds — still, however, providing an emerald appearance (Bank 1976 and 1979). Recently this Austrian manufacturer succeeded in giving a corundum skin to ruby and sapphire seeds.

The initial trials in this new process have been carried out so far only on Verneuil synthetic corundum seeds. The technique is still in the experimental stage. The author was informed by the manufacturer on his achievements about a year ago. However, the author had to endure a great deal of patient waiting before obtaining suitable material for an investigation. The reason is most probably due to the fact that a very few traders are attempting to control the sales of the new product. This was further evident

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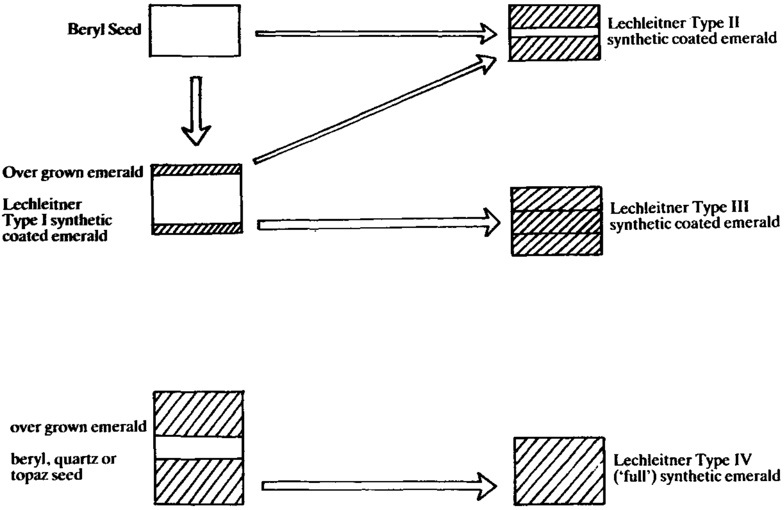

FIG. 1. The famous seeding techniques employed by Lechleitner in emerald.

through the large collection of the material just shown to the author by Mr Lechleitner. Further, the dealers are looking forward to obtaining natural light-coloured sapphires to be used in the process so soon as the manufacturer achieves a considerable success.

The coating is done on all coloured varieties of corundum made by the flame fusion method (Figure 2). The identifications are still easy under gemmological microscopy, with the typical inclusions of Verneuil synthetic corundum. However, if natural seeds are involved, the gemmologist may have to undergo difficulties in determining whether coated or not. Therefore it seemed important to present in detail the characteristics of the material made by Lechleitner. During his studies of the Lechleitner coated synthetic corundums the author observed the importance of the various techniques involved in gem microscopy; and therefore this article aims at describing:

a. different techniques used in gem microscopy, and
b. microgemmology of the material available from the manufacturer.

FIG. 2. These coloured stones are the Lechleitner coated corundums discussed in this article. Weights 1.80 ct to 12.30 ct.

THE MICROSCOPE AND ILLUMINATION TECHNIQUES

In the course of microgemmological studies two main types of microscope are in use, namely *horizontal* and *vertical*. The illumination techniques used in both these kinds of microscope are basically the same and are known as

a. transmitted illumination,
b. dark field illumination,
c. reflected illumination.

TRANSMITTED ILLUMINATION

Figure 3 illustrates typical illumination by transmitted light. In the majority of cases a great deal of the detail of the gem's interior is lost through the transmitted system, especially in corundum gems where the refractive indices of the host gem and air are far different from each other. The light rays passing through the object are mostly lost, and only very few can pass into the microscope system (Figure 4). To avoid such leakage of light the gem must be included in an environment of higher refractive index than that of air. The most suitable for such studies is the immersion technique (Figure 5).

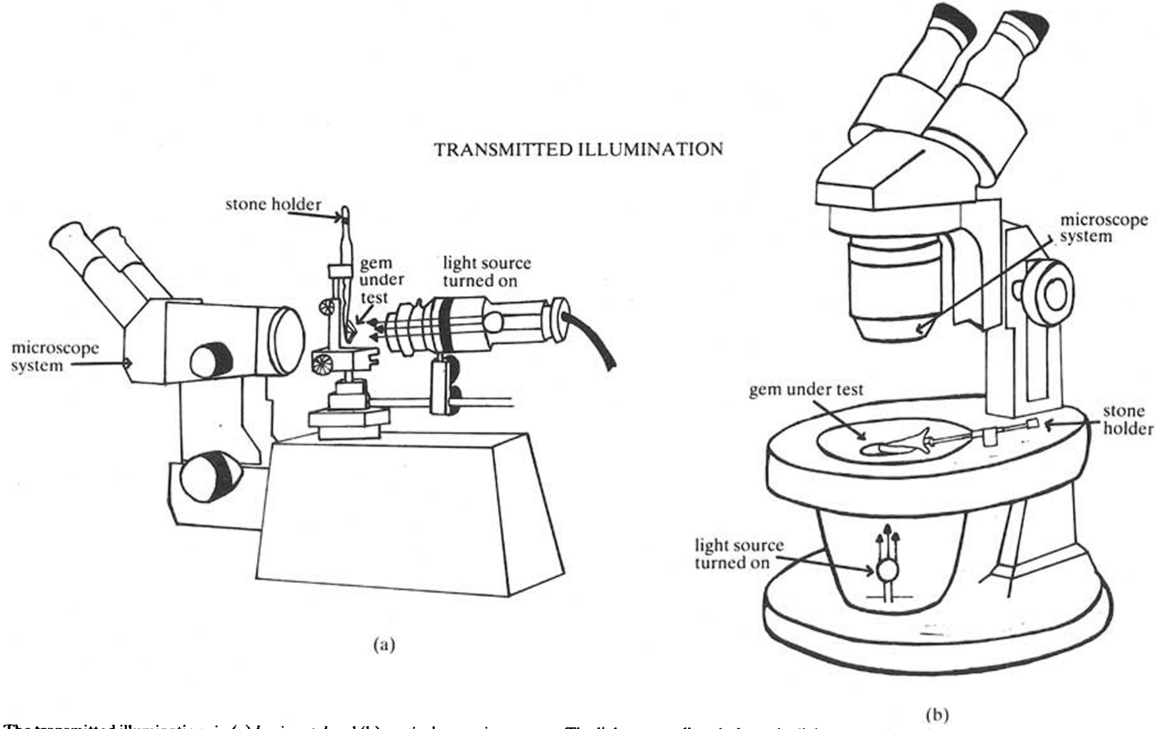

FIG. 3. The transmitted illuminations in (a) *horizontal* and (b) *vertical* gem microscopes. The light passes directly from the light source through the gem to the microscope system. Addition of two polarizers, the polarizer and the analyser, converts the field between to a crossed polarized zone.

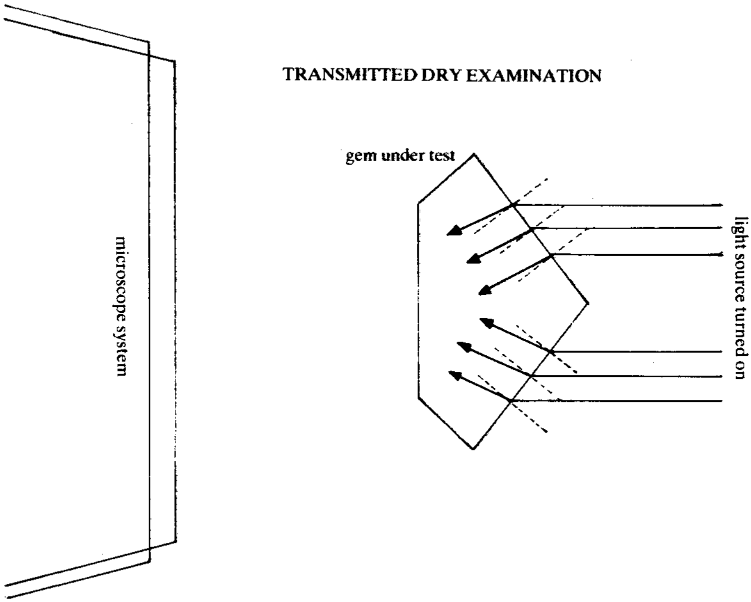

FIG. 4. The velocity of light in air is considerably reduced by the high refractive gem allowing light beams to converge to a limited zone. Only a portion of the gem becomes visible in microscope.

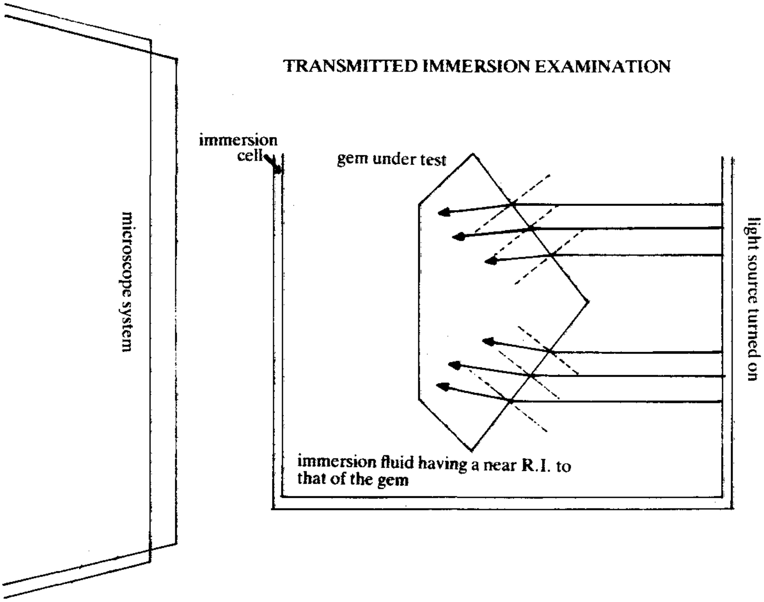

FIG. 5. An alternative method to overcome the problem discussed in Fig. 4. Since the 'optical densities' of two media are similar the velocity of light is not altered considerably. The whole gem is visible.

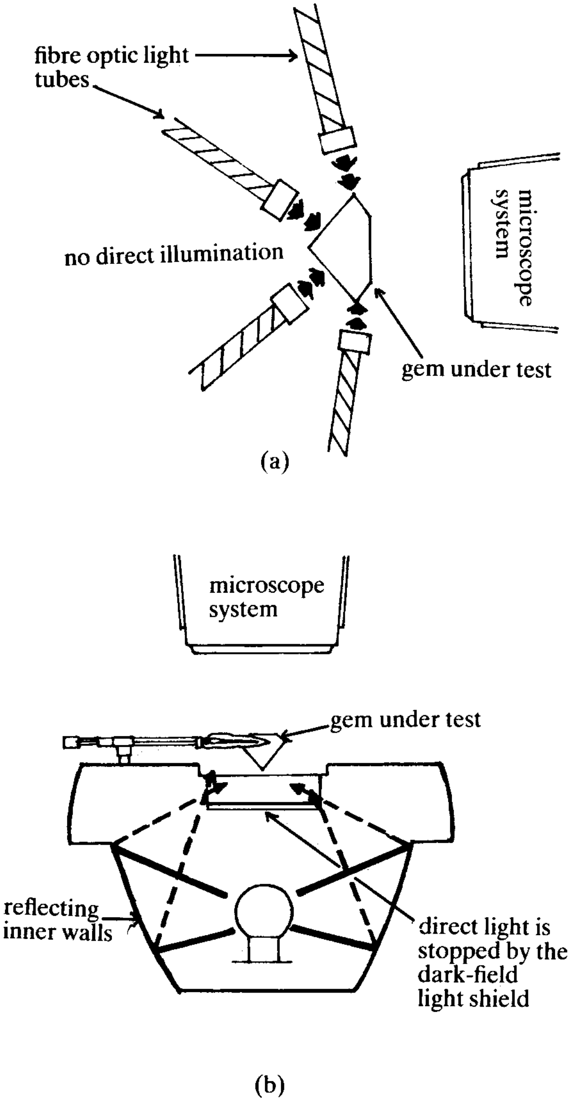

FIG. 6. The dark-field illuminations in (a) *horizontal* and (b) *veritcal* gem microscopes. No direct light is allowed to pass into the microscope system

REFLECTED ILLUMINATION

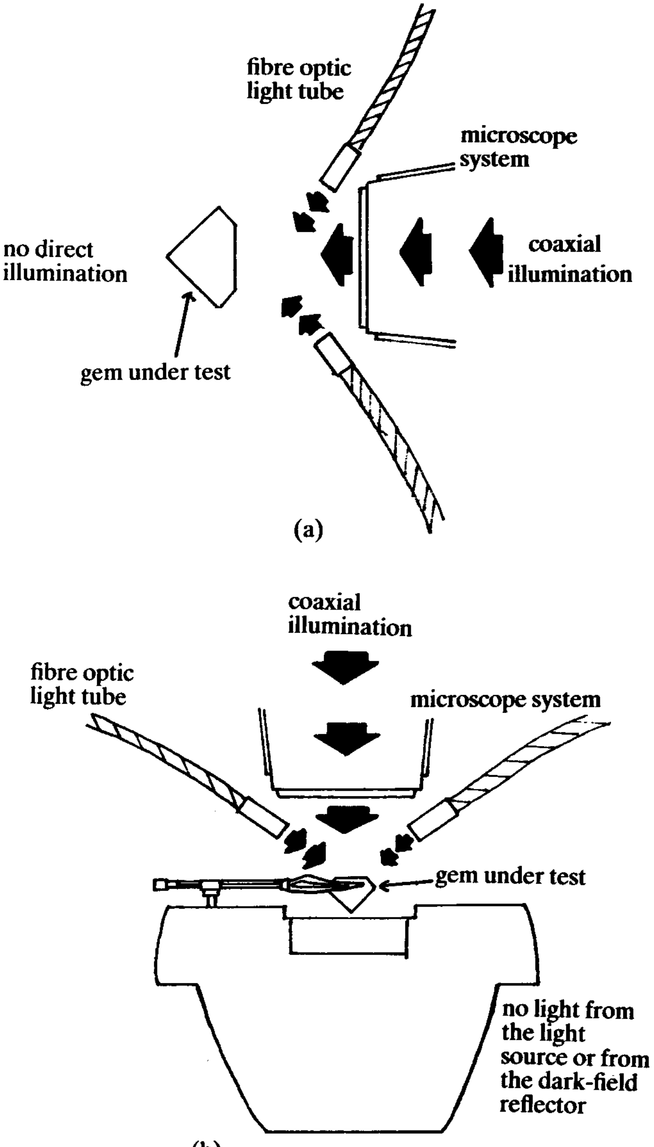

FIG. 7. The reflected illuminations in (a) *horizontal* and (b) *vertical* gem microscopes. The use of vertical or coaxial illumination provides better surface examination possibilities.

This method provided a number of details in new Lechleitner coatings, such as coated contour and various feathers formed in the synthetic (see Figure 8).

DARK FIELD ILLUMINATION

Study of the overall inclusion portrait of the gem under dark field illumination can be informative (Figure 6). In a *horizontal* microscope the dark field lighting can be obtained by the use of a fibre optic illuminator (Figure 6a). The internal characteristics apparent in new coated corundums under similar illumination are illustrated in Figures 14, 15 and 18-24.

REFLECTED ILLUMINATION

Although this method is seldom employed in identification of transparent objects in microgemmology, reflected light was extensively used in studying Lechleitner products. Further deviations such as oblique and/or coaxial illumination are often used in relation to the reflected light method (Figure 7). This light provides ideal conditions for surface examinations, and such observation of new products is shown in Figure 10.

MICROGEMMOLOGY OF NEW COATED LECHLEITNER SYNTHETIC CORUNDUMS

In the course of this study, several characteristics were observed to play a key role in establishing whether the stone in question was coated or not: (a) appearance under immersion, (b) corundum-corundum contact zone, (c) surface appearance and (d) inclusions were of prime importance. The techniques discussed on the use of the gem microscope contribute on a large scale in recognitions.

(*a*) *Appearance Under Immersion*

The close refractive indices of methylene iodide ($n=1.74$) and corundum ($n_\omega=1.77-n_\varepsilon=1.76$) provide a clear picture of the coated layer of the Lechleitner corundum (Figure 8). The manufacturer has 'skinned' his product with a thin corundum layer. If precautions are not taken in gem microscopy the observer may miss such features. Practically valuable information is readily obtained by the use of diffused transmitted light with immersion of the stone.

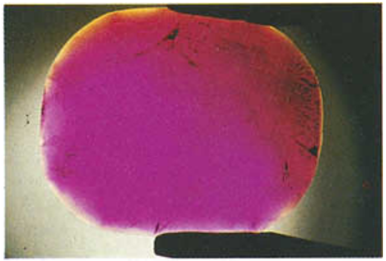

FIG. 8. A coated Lechleitner synthetic ruby seen in immersion microscope with *diffused transmitted light*. The colourless rim visible is the overgrowth. Magnified 20×.

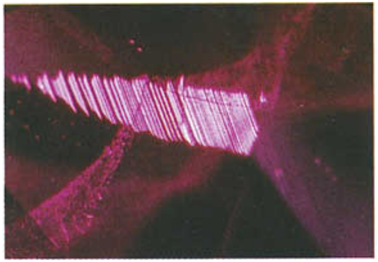

FIG. 9. Often visible unpolished facet plane in Lechleitner coated synthetic corundums. *Reflected illumination*. Magnified 50×.

FIG. 10. Surface cavities on the host corundum during the overgrowth procedure in Lechleitner coated synthetic corundums. *Reflected illumination*. Magnified 22×.

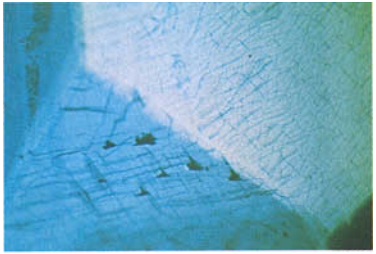

FIG. 11. Typical inclusion portrait of Lechleitner coated Type I synthetic emerald showing the 'net-like' cracks on the coating (see also Fig. 1). *Transmitted illumination*. Magnified 25×.

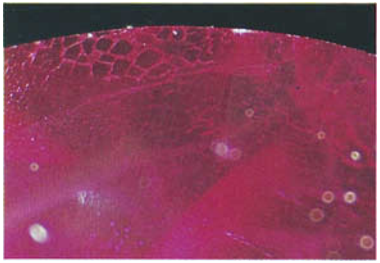

FIG. 12. Very fine 'nets' revealed in Lechleitner coated synthetic ruby. *Dark-field illumination.* Magnified 32×.

FIG. 13. Another ruby exhibiting the typical 'net-like' cracks on the coating. *Dark-field illumination.* Magnified 22×.

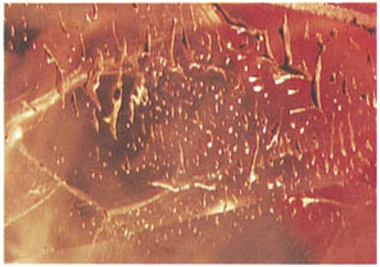

FIG. 14. A coated synthetic yellow sapphire with healed feather giving the stone a natural appearance. *Dark-field illumination.* Magnified 45×.

FIG. 15. The healed voids now containing a solid substance in a coated Lechleitner ruby. *Dark-field illumination.* Magnified 25×.

FIG. 16. Healed feathers, similar to those seen in Fig. 15, with included solid substance in a Lechleitner coated synthetic yellow sapphire. *Transmitted illumination.* Magnified 22×.

FIG. 17. The fingerprint cavities clearly exhibiting the dark fillings in synthetic yellow sapphire coated by Lechleitner. *Transmitted illumination.* Magnified 20×.

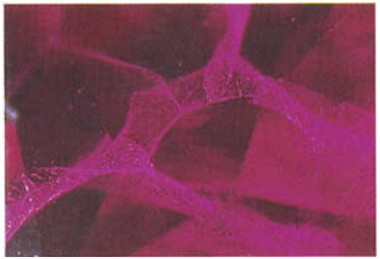

FIG. 18. Feathers resulting under high temperature in coated synthetic ruby appear almost similar to those seen in synthetic flux rubies. *Dark-field illumination.* Magnified 40×.

FIG. 19. Feathers (resembling those seen in heated natural rubies) observed in Lechleitner coated synthetic ruby. *Dark-field illumination.* Magnified 35×.

FIG. 20. Fine 'lace-like' feathers bunched in the central portion of a synthetic ruby 'skinned' by Lechleitner. *Dark-field illumination.* Magnified 38×.

FIG. 21. 'Padparadschah' colour Verneuil synthetic sapphire experimentally coated by Lechleitner reveals fine fingerprint feathers, almost similar in appearance to those observed in Chatham synthetic orange sapphires. *Dark-field illumination.* Magnified 40×.

FIG. 22. Very fine cracks resulting in a Verneuil 'padparadschah' sapphire during the process of coating by Lechleitner *Dark-field* illumination. Magnified 35×.

FIG. 23. Fingerprint feathers resembling those seen in natural 'padparadschahs' from Sri Lanka included within a coated Lechleitner corundum sample. *Dark-field illumination.* Magnified 20×.

FIG. 24. All colours of Verneuil synthetic corundums are 'skinned' by Lechleitner — here a colour-changing type synthetic sapphire exhibiting many feathers internally after seeding techique. *Dark-field illumination.* Magnified 30×.

(*b*) *Corundum-corundum Contact Zone*

The coating of a corundum layer on a corundum base (preform) is done only for faceted stones. However, a good polished surface would not provide a suitable contact zone. Therefore in the majority of cases the facets are left unpolished for successful coating (Figure 9).

(*c*) *Surface Appearance*

It can be established that 'skinning' is done in a high temperature environment. During the process, the secondary corundum layer penetrates somewhat into the host (estimated 3μm deep). By re-polishing the coating can be removed. Such a surface, specially re-polished during this study, is shown in Figure 10; this shows, under reflected light, the surface cavities formed during the coating procedure on the corundum seed.

(*d*) *Inclusions in Coated Synthetic Corundum*

One of the most characteristic inclusions seen in Lechleitner coated emerald is fine *net like* cracks on the coating (Figure 11). However similar quite thin and very fine 'nets' were apparent in some coated rubies (Figures 12 & 13). These inclusions were not distributed in a regular manner over the whole coating in many samples.

Similar in appearance to healed fingerprints, voids were visible just below the surface of coated stones (Figure 14). It is probable that these voids may have resulted during the high temperature evironments of the coating procedure. These are the surface cavities (Figure 10) which may be exposed to the surface by polishing the coating away. In many instances these voids contained a solid substance which exhibited a similar appearance to the over-all heated cavity or fingerprint-like effect (Figures 15, 16 & 17) usually seen in natural gem corundums.

The new Lechleitner coated synthetic corundum revealed fine flags or feathers similar in appearance to those seen in rubies grown by Chatham, Kashan, Knischka and Ramaura and sapphires by Chatham (also Gunawardene, 1983 a; Gübelin, 1983 a & b; Kane, 1983; Gunawardene, 1984 and Kane, 1982; Gunawardene, 1983 b). These may have resulted during the heat inducement in giving corundum skin to the host synthetic. Similar fingerprint inducement was described by Koivula (1983). The observations made by the author on many coloured sapphires coated by Lechleitner are illustrated in Figures 18 to 24 respectively.

CONCLUSION

The coloured gemstone industry is again being invaded by a new technique of modifying ruby and sapphire. Although it is not known at this time how far the manufacturer has gained success and how widespread such coated materials are, the ruby and sapphire dealer has to undergo a difficult time in dealing with corundum gems. Recent publications on the subject have reported the heat-treatment, synthesising, glass filling of corundum and its surface cavities and now surface coating is added. The gemmologist, jeweller and others who deal with ruby and sapphire should obtain a great amount of practice in detecting such altered stones. Therefore it is author's suggestion that every gem must be viewed through a magnifier. Microgemmology has now taken a vital position in the science as well as in the trade.

This article deals with the first synthetic coated corundum from Lechleitner. It was not possible to gather all details of recognition, especially where natural seeds are involved, due to the absence of such samples to date. On the other hand the nomenclature of this new product still leaves a question. Whether they can be called synthetics or coated material or doublets is still left for discussion.

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THE COMPOSITION OF THE LAPIS LAZULI IMITATION OF GILSON

By Dr K. SCHMETZER

Institute of Mineralogy and Petrography, University of Heidelberg, West Germany
and Deutsche Stiftung Edelsteinforschung, Idar-Oberstein, West Germany

ABSTRACT

The product, which is manufactured by Gilson and sold as synthetic lapis lazuli, consists of ultramarine and hydrous zinc-phosphates as main components as well as small pyrite crystals as an accessory constituent. The product does not deserve the synthetic label and has to be called an imitation. The declaration of the producer is incomplete and misleading.

INTRODUCTION

Lazurite, as a mineral species with the general formula $(Na,Ca)_8[(SO_4,S,Cl)_2/(AlSiO_4)_6]$, may be regarded as a natural solid solution consisting of the minerals sodalite $Na_8[Cl_2/(AlSiO_4)_6]$, haüyne $(Na,Ca)_{8-4}[(SO_4)_{1-2}/(AlSiO_4)_6]$ and a component similar to synthetic ultramarine $Na_8[S_{2-4}/(AlSiO_4)_6]$ (Deer *et al.*, 1963; Taylor, 1967; Leithner, 1975). A detailed mineralogical investigation of lazurite was recently published by Hogarth & Griffin (1976). The lazurite-bearing rocks of different localities are given the general name lapis lazuli, though showing often a great variation in their mineralogical composition. The colour in synthetic ultramarine and natural lazurite is assumed to be due to the presence of the radical anion S_3^-. Spectroscopic investigations of lazurite and ultramarine show a strong absorption in the red to yellow area of visible light (broad absorption with maximum at about 600 nm). This absorption is generally accepted to be caused by the S_3^- ion in both crystalline phases, i.e., the intensity of the blue is due to the amount of sulphur which is present as S_3^- (Hofmann *et al.*, 1969; Schwarz & Hofmann, 1970; Wieckowski, 1970; McLaughlin & Marshall, 1970; Seel & Simon, 1972; Chivers, 1974). The mechanism of absorption caused by the S_3^- ion in the visible area, however, is still a subject of scientific investigations (Galimov *et al.*, 1981).

At present, various man-made lapis lazuli substitutes are found on the market. Most of them have to be called imitations due to their chemical composition, e.g., Co-containing synthetic spinel, which was produced by Degussa in Germany. The only man-made

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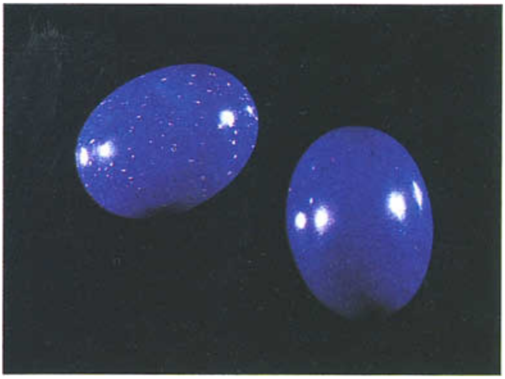

FIG. 1. Lapis lazuli imitations of Gilson; size of the samples approx. 8×6 mm.
(*Photo by O. Medenbach, Bochum.*)

product which has been claimed to deserve the synthetic label is said to be the lapis lazuli substitute manufactured by Gilson (Figure 1). For natural and synthetic lazurite an identical formula of $Na_8(AlSiO_4)_6S_2$ is given by the producer, which corresponds to the formula of synthetic blue ultramarine. Small crystals of pyrite are quoted by Gilson to be the only additional admixtures in this "synthetic" lapis (advertisement brochure of P. Gilson). Though some uncertainty in the nature of the man-made lapis substitute of Gilson is mentioned by Nassau (1976, 1977), no detailed investigation of this product is available, which has been sold since about 1975 as true synthetic lapis. In the trade and in some new monographs on synthetic gem materials (Nassau, 1980; Nassau & Nassau, 1980; Sunagawa, 1982) the substitute of Gilson is accepted as synthetic lapis lazuli. The gemmological properties of the lapis substitute of Gilson were described by various authors (Schiffmann, 1976; Andersen, 1976; Mitchell, 1982). In the paper of Andersen an amorphous phase is mentioned, which was found in addition to a crystalline member of the sodalite group. This remarkable observation, however, was only noted in the paper of Gübelin (1981).

Recently, in some of the man-made products of Gilson (turquoise and opal imitations) contrary to the specification of the producer, various additional admixtures were observed. Due to these observations, neither the man-made turquoise nor the man-made opal of Gilson deserve the synthetic label (Schmetzer & Bank, 1981; Schmetzer, 1984). Therefore, a detailed investigation of the lapis lazuli substitute of Gilson was highly desirable in order to clarify the nature of this product.

RESULTS

The strongest lines in the x-ray powder pattern of the lapis substitute of Gilson are identical within the limits of error with the pattern of natural lazurite (JCPDS Powder Diffraction File # 17-749; Hogarth & Griffin, 1976); some weak lines of pyrite were also observed. Assuming a cubic unit cell with Z=1, the unit cell dimension of the synthetic ultramarine component in the product of Gilson was calculated as $a_o = 9.100(2)$ Å. At the beginning of the investigation some weak diffraction lines, which could not be assigned to ultramarine or pyrite, could not be interpreted without chemical information.

By scanning electron microscope only irregularly shaped particles 5-10 μm in diameter were observed (Figure 2). From this information, however, no information about the number of phases present in the product of Gilson could be deduced.

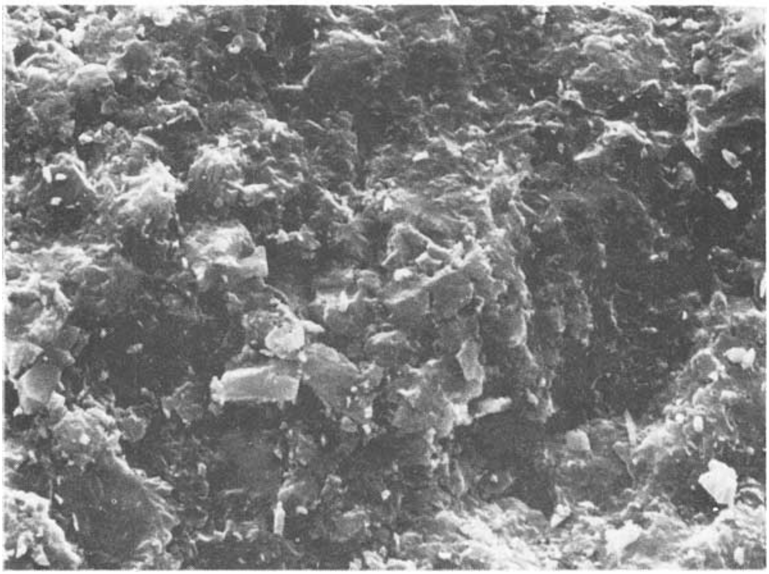

FIG. 2. Lapis lazuli imitation of Gilson; SEM micrograph, 2 300×. (*Photo by H.-G. Röpert, Cologne.*)

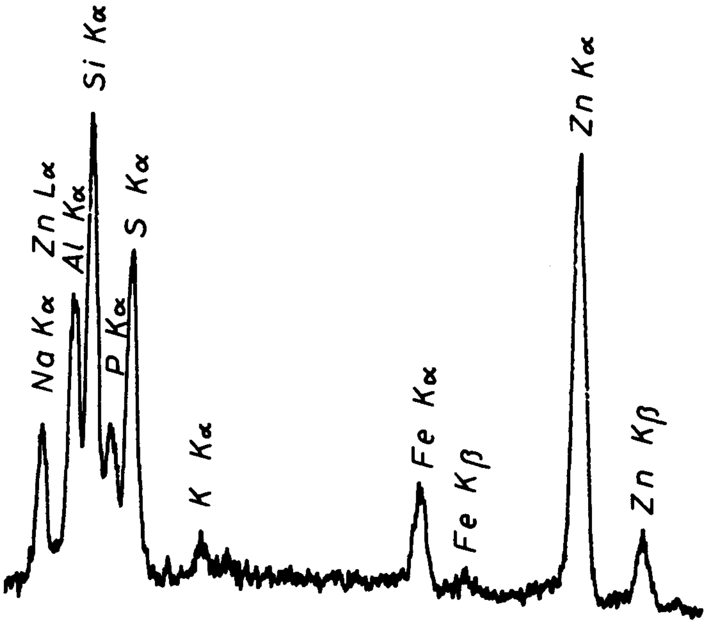

FIG. 3. Energy dispersive x-ray spectrum of lapis lazuli imitation of Gilson.

A qualitative chemical investigation of the lapis substitute by electron microprobe (Figure 3) showed the major elements typical for lazurite (Si, Al, Na, K, S) to be present in the blue areas of the product. In addition, substantial quantities of P, Zn and Fe were found, which are not known to occur in natural lazurite. By investigation of the yellow pyrite crystals in the lapis substitute only Fe and S were found as main elements. A quantitative chemical analysis of a rough piece of the lapis substitute by classical chemical methods is given in Table 1. As a significant result, the percentages of Zn and P were found to fall in the range of the main constituents of the synthetic ultramarine (Si, Al, Na, S). By the analytical method used, the blue matrix and the yellow pyrite crystals were not analysed individually. Therefore, in the analysis given, the value of 1.2 weight % Fe has to be interpreted as sum of the iron content in pyrite and in the other phases of the whole product; sulphur is assumed to be present in both phases, ultramarine and pyrite.

TABLE 1: Chemical data of the lapis lazuli imitation of Gilson

	Chemical composition in weight %
Na_2O	10.8
K_2O	0.7
SiO_2	19.9
Al_2O_3	13.4
SO_3*	17.0
S*	1.4
Fe	1.2
ZnO	20.5
P_2O_5	11.5
H_2O	5.0
Total	100.9

*S and SO_3 calculated from $S_{total} = 8.2\%$

	Ionic ratios calculated to Si+Al = 12		
Na	7.04	7.34	ultramarine
K	0.30		
Si	6.69	12	
Al	5.31		
S*	4.31		
S	0.86	pyrite	
Fe	0.43		
Zn	5.09	$Zn_3(PO_4)_2.4H_2O$ and $Zn_3(PO_4)_2.2H_2O$	
P	3.27		
H_2O	5.61		

*S and SO_4 in ultramarine

By thermogravimetric analysis (Figure 4) a continuous loss of weight was observed between 20 and 350 °C, no additional loss of weight was found between 350 and 750°C. A chemical water determination using titration by the Karl-Fischer method after thermal decomposition of the sample resulted in a water content of 5.0% H_2O.

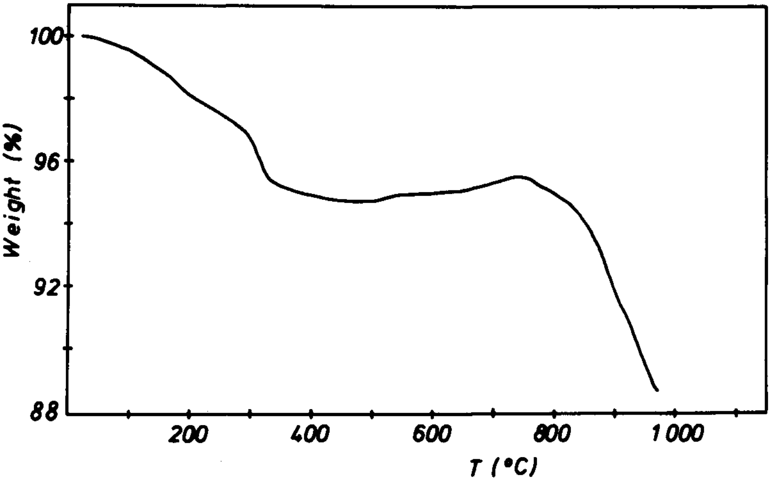

FIG. 4. TG curve of lapis lazuli imitation of Gilson.

In order to characterize the product manufactured by Gilson sufficiently, it had to be determined whether Zn and P could be present in independent crystalline phases. The loss of weight by heating up to 350 °C, as determined by TGA, and the water content of 5.0% present in the sample, as determined by titration, were possibly interpreted as dehydration of a zinc phosphate.

After heat treatment at 300°C for 30 minutes additional information was obtained by the x-ray powder diffraction pattern of the sample. The powder diagram of the heat-treated sample consists of the diffraction pattern of ultramarine and of some weak pyrite lines. The lines in the powder diagram of the untreated sample, which were not yet assigned to a crystalline phase, were not observed in the pattern of the heat-treated sample. However, some new lines were observed in the powder diagram after heat treatment, which were easily assigned to α-$Zn_3(PO_4)_2$. After dehydration of one or even more hydrous zinc phosphates caused by heat treatment a formation of crystalline α-$Zn_3(PO_4)_2$ was observed. The atomic ratio of Zn:P, as determined by the chemical analysis, was found to be close to 1.5; the ratio of water and zinc is calculated as $H_2O:Zn = 1.10$ (Table 1). Using all this information, the additional weak diffraction lines in the powder pattern of the untreated sample were assigned to two hydrous zinc phosphates, $Zn_3(PO_4)_2.4H_2O$ and $Zn_3(PO_4)_2.2H_2O$. Consequently, the product of Gilson is considered to consist of ultramarine, pyrite, and two crystalline hydrous zinc phosphates. Supposedly, the amorphous phase mentioned by Andersen (1976) is identical with the hydrous zinc phosphates mentioned above.

Though small amounts of iron and zinc may also be present on Na sites in synthetic ultramarine – synthetic Zn-containing ultramarine was described by Jaeger (1929) – most of the zinc and iron determined by chemical analysis are thought to be present in the form of pyrite and hydrous zinc phosphates. Under this precondition, the formula of the synthetic ultramarine is given as $Na_{7.04}K_{0.30}[(S,SO_4)_{4.31}/Si_{6.69}Al_{5.31}O_{24}]$.

By spectroscopic investigations an absorption band at 17 100 cm^{-1} (585 nm) was determined. Therefore, the colour of the lapis substitute of Gilson, i.e., the colour of the ultramarine component of this product, is thought to be caused by the S_3^- ion.

CONCLUSION

The lapis lazuli substitute of Gilson consists of three main components, synthetic ultramarine and two hydrous zinc phosphates; small pyrite crystals may also be present. The process of manufacture of this product is unknown, but, for the purpose of this paper, it is not necessary to discuss this process in detail. Due to the presence of crystalline hydrous zinc phosphates as main components, which are not at all associated with natural lazurite or natural lapis lazuli, the lapis substitute of Gilson has to be described as imitation.

ACKNOWLEDGEMENTS

The investigation of the lapis lazuli imitation of Gilson was initiated by Prof. Dr H. Bank, of Idar-Oberstein. The firms R. Litzenberger and Gebr. Bank of Idar-Oberstein kindly supplied the samples for investigation.

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FRACTURING IN CANADIAN HESSONITES

By JOHN ILMARII KOIVULA, B.A., B.Sc., C.G., G.G.

Senior Gemologist, Department of Applied Gemology, Gemological Institute of America,
Santa Monica, California

ABSTRACT

Repeated oscillatory growth between the rhombic dodecahedral and the trapezohedral crystal habits in hessonite garnets from Québec, Canada, results in considerable internal strain and fracturing. The intensity of this strain is revealed in the microscope by using polarized light and/or the author's shadowing technique.

INTRODUCTION

The Jeffrey mine, at Asbestos, Québec, Canada, has long been known for the splendid pale orange to deep brownish-orange grossular garnets it produces. Externally, the rhombic dodecahedral and trapezohedral habits displayed by these garnets are quite pleasing in their geometric perfection (Figure 1). Yet upon closer inspection these garnets, even in the very finest qualities, are commonly interspersed with numerous small fractures.

While a few of these fractures show distinct signs of secondary healing, trapping small volumes of fluid in the process, as shown in Figure 2, the vast majority appear to be epigenetic in origin showing no evidence of fracture repair whatsoever. Why would these hessonites from the Jeffrey mine contain so many fractures while those from other localitites, such as Sri Lanka and East Africa, are, on a comparative basis, essentially free from similar defects?

PRELIMINARY OBSERVATIONS AND SAMPLE PREPARATION

To investigate the inherent cause of fracturing in the Canadian hessonites, 41 rough crystals and broken crystal sections and seven faceted stones were obtained for this study. When initially examined, it was observed that all 48 specimens, both rough and cut, contained at least a few fractures. Since all of the rough garnets contained fractures, the idea that the fracturing might in some way be caused by heat generated during the lapidary process was ruled out. Ten of the 41 rough crystals and crystal sections were then selected at random, and windows were polished on them so the internal characteristics might be more easily studied.

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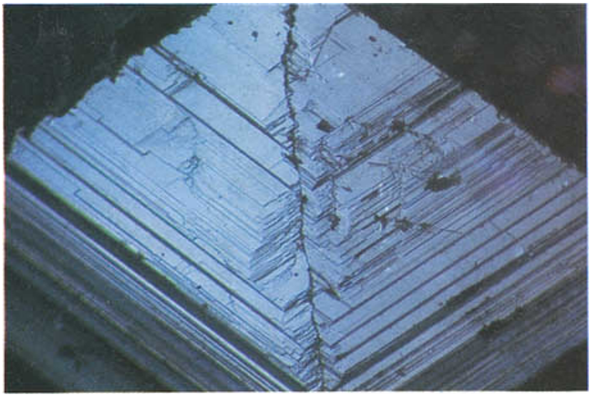

FIG. 1. The surface of this Canadian hessonite grossular garnet displays growth features resulting from oscillation between the rhombic dodecahedral form (dominant) and the trapezohedral form (subordinate). A dislocation that has influenced the crystal's growth runs through the centre. Oblique illumination and shadowing. 35×.

FIG. 2. A somewhat planar secondary partially healed fracture composed of numerous microscopic one-and two-phased inclusions. Transmitted light and shadowing. 110×.

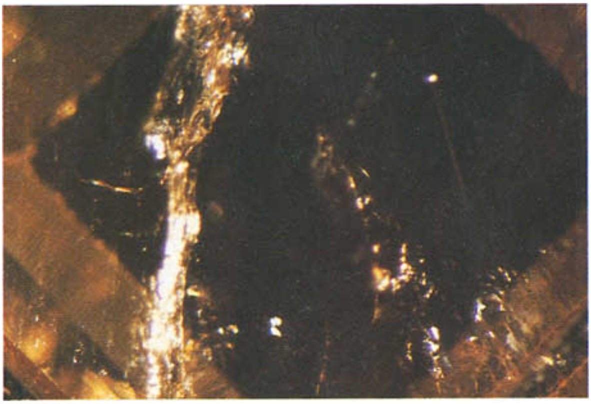

FIG. 3. Fracture system in a Canadian hessonite using partial immersion and darkfield illumination. 40×.

FIG. 4. The same fracture system using partial immersion and transmitted light. Notice the single tiny acicular diopside inclusion. 40 ×.

FIG. 5. Shadowing is now used and the garnet's rhombic dodecahedral-trapezohedral structure becomes visible. 40 ×.

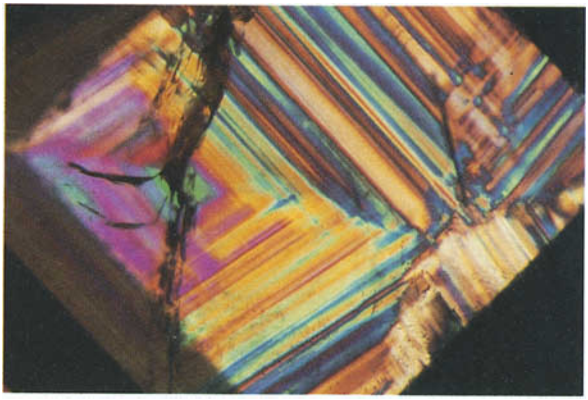

FIG. 6. Under polarized light, strain colours delineate the hessonite's form. 40 ×.

DETAILED MICROSCOPIC INVESTIGATION

Then the ten polished roughs and the seven faceted gems were studied very carefully under the Gemolite microscope using both darkfield and transmitted light to see if perhaps the fractures were the result of thermal expansion of either primary or secondary fluid inclusions. The fractures ran randomly throughout the gems and no such fluid inclusion-to-fracture relationship could be established. The acicular diopside crystals also observed crisscrossing through some of the hessonites (Grice and Williams, 1979; Wight and Grice, 1981) were in no way responsible for the fracturing, as no fractures were directly related to any of these inclusions. It was thought that perhaps shadowing (Koivula, 1982) might reveal some internal features that were not resolved by either darkfield or transmitted light microscopy. A rough crystal section was placed under the microscope and when shadowing was employed the entire original rhombic dodecahdral structure of the garnet became visible just as if the surface features had never been ground and polished away. It was quite obvious at this point that a great deal of strain must be present within these crystals. It was decided that polarized light be used in conjunction with shadowing to see if the strain would produce a polarized light reaction somewhat similar to that observed in synthetic flame-fusion spinels and some diamonds. When polarized light was used, not only was there a reaction, but the strain colours traced the original growth features of the parent crystal. The series of photomicrographs, Figures 3, 4, 5 and 6, illustrate the same hessonite in identical position in darkfield illumination, transmitted light, shadowing, and polarized light. Although hessonites from other localities do show signs of strain in polarised light, no reaction of the strength, vibrant colouration, and clarity shown by these Canadian hessonites had ever before been observed by this author or reported in any of the literature. All of the polished hessonites were studied by shadowing and polarized light, and all showed the same reaction. Even the rough unpolished crystals and crystal sections showed brilliant strain colours in polarized light that delineated the external crystal form. It was now apparent that internal strain was responsible for the fractures commonly observed in the Canadian hessonites from the Jeffrey mine in Québec.

CONCLUSION

Before cutting, the surfaces of these hessonite crystals show a distinctive continuous growth oscillation between both the rhombic dodecahedral and the trapezohedral habits. This intermixing of structural forms results in zoned strain throughout the crystals, which is resolvable even after faceting using shadowing and/or polarized light. In such intensely strained crystals it is not at all surprising to find stress-related fractures.

Gemmologically, it is generally not considered common practice to study singly refractive gem materials, such as garnets, under the microscope using polarized light, but at least in this instance unconventionality proved worthwhile.

ACKNOWLEDGEMENT

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'ARTERIES' IN OPAL?

By R. KEITH MITCHELL, F.G.A.

We are accustomed to thinking of Mexican opal as a gem which, unlike precious opal, owes its appeal to a fundamental slightly milky body colour, usually in shades of orange or red, without play of colour.

But this describes only part of the colour range, and it is found almost colourless and transparent, through a butter-milk colour to pale yellow, and on through the familiar orange and red shades. In the finest examples from the Querétaro mines the 'missing' play of colour may occur in quite amazing profusion of greens, blues, reds, yellows and other shades emphasized by their contrast with the saturated body colour of the opal.

FIG. 1. Veining in fire opal.

The opal masses occur enclosed in random and usually rough-surfaced cavities in such rocks as lavas, porphyries and rhyolites, and there is usually considerable wastage when local cutters need to produce clean cabochon gems. Occasionally inclusions may be left in the finished gems, and interesting stones containing a variety of included minerals are known. These can be of goethite, hornblende, quartz, cristobalite, kaolinite, haematite or other associated minerals and may give clues to the original formation of the opal concerned.

Some stones show what appear to be trail or flow markings in their colour structure, which would seem strange in material which has been enclosed totally in cavities of the volcanic rock. One such

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stone is the rather magnificently marked flat cabochon, which I illustrate (Figure 1). Here the blood-red colour is in a reticulated pattern, almost like a medical picture of a circulatory system. The usual assumption is that such colours in a porous gem are due to iron contamination, but it is difficult to envisage just how such a formation could have occurred in this stone. Opal in its early stages may have been a somewhat wet and plastic gel, and I suppose that colorant solutions could penetrate and flow in wisps to form cellular patterns in this way.

Regrettably the stone was not mine, and I no longer recall from whom I begged permission to make this photographic record some ten years ago. If the owner recognizes the stone, I am grateful to him and apologize for my inability to name him.

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A RE-EXAMINATION OF SLOCUM STONE - WITH PARTICULAR EMPHASIS ON INCLUSIONS

By C.R. BURCH, B.Sc., F.G.S.
Senior Lecturer in Gemmology and Geology, Sunderland Polytechnic

ABSTRACT

The properties of Slocum Stone are reviewed. Six stones were examined microscopically, and their inclusions and optical effects are described and discussed. The commonest inclusions are tinsel-like flakes, which are evidently responsible for the play of colour. No swirl marks were observed, but gas bubbles, many of which display very unusual shapes, are abundant. Evidence is presented to show that at least some of the flakes are the disrupted remnants of what were probably originally continuous sheets produced by a sedimentation process. The distortion of the gas bubbles can probably be attributed to mixing and agitation in a viscous liquid medium (the glass matrix).

INTRODUCTION

Slocum Stone, a beautiful glass imitation of opal, is now well known in gemmological circles. Although not perhaps as convincing as the Japanese latex simulant, it is undoubtedly one of the best opal imitations which has yet appeared. Few experienced observers would be deceived by Slocum Stone, but the general public could easily confuse it with genuine opal.

The manufacturer of this material, Mr John S. Slocum, of Michigan, U.S.A., introduced Slocum Stone in the late 1970s. After several years of experimentation Slocum eventually succeeded in producing a true synthetic opal but was dissatisfied with the result. Although his synthetic material showed the play of colour so desirable in natural opal, it also suffered from the same drawbacks – namely high porosity, sensitivity to moderate heat, susceptibility to cracking and tendency to chip when knocked. Because of the undesirable properties of his synthetic product Slocum embarked on a series of experiments designed to produce an imitation which was tougher and more durable than natural or synthetic opal but which still retained the prized colour flashes. Slocum Stone was the successful outcome of this work and is a tribute to the patience, ingenuity and skill of its originator.

As one would expect, details of the manufacturing process are still secret but the structure, composition and properties of Slocum Stone have been investigated by several workers, including Schowalter (1976), Gübelin (1976), Dunn (1977), Darragh and Sanders (1978), Ball (1978), Farn (1979) and others. Slocum Stone

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is also discussed in the three most recent texts on man-made gemstones — Elwell (1979), Nassau (1980) and O'Donoghue (1983).

Slocum Stone is essentially a silicate glass containing calcium, sodium and magnesium. The water content is negligible compared to that of natural or synthetic opal. The material is made in a range of colours including black, white, amber and green. The specific gravity is between 2.4 and 2.5 and is slightly higher than that of natural opal (2.0 – 2.1). Refractive index is also somewhat higher – 1.49 to 1.51 for Slocum Stone as compared with 1.45 for natural opal. Slocum Stone is inert under all UV wavelengths and x-rays. It is very tough, reasonably hard (H 5½), is resistant to chipping and is unaffected by moderate heating. It is non-porous, does not shrink or expand, and is easily worked by the lapidary. Three types of inclusions have been reported – very thin flakes resembling tinsel or foil, swirl marks and bubbles. Although their precise nature is still uncertain the tinsel-like flakes are evidently responsible for the play of colour, and electron microscope studies (Darragh and Sanders) show that they are composed of a laminated material. Swirl marks and bubbles are to be expected in glass, but, as will be shown later, many of the bubble shapes are very unusual and completely atypical.

The purpose of this paper is to extend previous discussions of Slocum Stone particularly in respect of the inclusions.

A parcel of nine polished Slocum Stones in various colours was kindly loaned to the author by the Gemmological Association of Great Britain. Six of the stones were subjected to detailed microscopic study and the results of that investigation are summarized in this paper. Colour photographs are used extensively to illustrate the article.

DESCRIPTION

The six stones examined are illustrated in Figure 1. Two black, two amber (fire opal imitations) and two white opal simulants are shown. The fire opal simulants have a rather stronger play of colour than is normally associated with that variety of natural opal, but, apart from this slight discrepancy, all of the stones are quite convincing imitations and are undeniably attractive.

FIG. 1. Six Slocum Stones: 1 and 2, black opal simulants; 3 and 4, fire opal simulants; 5 and 6, white opal simulants.

FIG. 2. Blue or purple tinsel-like flakes, some with drawn out gas bubbles adhering to their edges. Black opal simulant. 42×.

(A) INCLUSIONS

According to the literature three types of inclusions occur in Slocum Stone. These are tinsel-like flakes, swirl marks and gas bubbles. Flake inclusions and bubbles are abundant in all of the specimens but typical swirl marks were not observed.

Tinsel-like flakes

These are the most conspicuous inclusions in all of the stones examined; their presence in fact is essential as without them the play of colour is not seen.

Essentially the flakes are flat, extremely thin fragments of widely varying dimensions. Actual sizes range from those which are easily visible to the naked eye (up to several millimetres across the largest diameter) to examples which can just about be seen at a magnification of ×100. Most of the flakes show angular outlines but some are partially rounded. In one of the black opal simulants (No. 1 in Figure 1) the edges of some flakes are accentuated by the presence of drawn out, high relief structures; the latter are assumed to be elongated bubbles adhering to the flake margins (see Figure 2).

The colour of the flakes, as seen in transmitted light, varies according to the simulant. In the black and white imitations they are either bluish or purple (Figures 2 and 3), while green, yellow and orange are the dominant flake colours in the fire opal simulants (Figure 4).

Most of the flakes have featureless surfaces, but one or two show a pattern somewhat resembling lunar cratering (Figure 5).

Under crossed polarized light the flake inclusions show spectacular interference colours (Figure 6).

Close examination of these interesting inclusions suggests that many of them were once part of larger structures; this is evident because boundaries between adjacent flakes are often shaped such that they clearly once fitted together, rather like the pieces of a jig-saw (Figure 5).

Bubbles

Bubble inclusions, presumably air-filled, are common in all specimens. Whilst many of the bubble shapes are perfectly normal for glass (spherical, torpedo shaped, etc.) a considerable number are completely atypical and quite unlike anything the author had previously recorded in glass. The shapes of these unusual bubbles are often so bizarre that it is difficult to describe them adequately in words.

FIG. 3. Blue and purple tinsel-like flakes. White opal simulant. 10×.

FIG. 4. Yellow, green and orange tinsel-like flakes. Fire opal simulant. 10×.

FIG. 5. Tinsel-like flakes with surface pattern resembling lunar cratering. Note the jig-saw like relationship between some of the flake margins. Fire opal simulant. 16×.

FIG. 6. Tinsel-like flakes showing spectacular interference colours separated by isotropic (black) glass. Fire opal simulant. Cross polarized light. 10×.

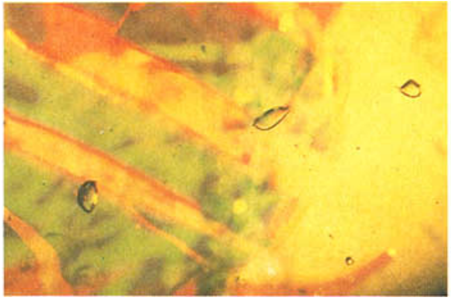

FIG. 7. Three normal bubble shapes showing high relief. Green flakes in background. Fire opal simulant. 10×.

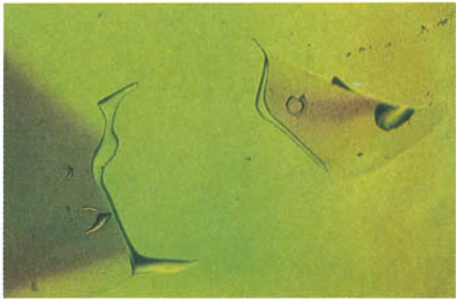

FIG. 8. Unusual bubble shapes associated with tinsel-like flakes. Fire opal simulant. 42×.

FIG. 9. Bizarre 'two-pronged' bubble (bottom right), elliptical bubbles and tinsel-like flakes. Fire opal simulant. 10×.

FIG. 10. High relief crescent-shaped bubbles and tinsel-like flakes. Fire opal simulant. 10×.

The fire opal simulants (Nos. 3 and 4 in Figure 1) provided the most interesting gas bubbles. Figures 7, 8 and 9 are enlarged views of the stone numbered 4 in Figure 1. In Figure 7, three drawn out, approximately elliptical, high relief bubbles are shown. These are normal shapes for glass. Figure 8, however, illustrates a number of extremely unusual bubbles. The bubbles have the typical high relief (black outlines) but quite atypical shapes.

The two largest bubbles are markedly elongated and taper at their terminations. One of the smaller bubbles (right) resembles a ring while others are crescent shaped. A few minute bubbles are spherical. It is interesting to note the close association between the larger bubbles and the flake inclusions, two of which are shown in the photograph. A variety of bubble shapes are shown in Figure 9 together with flake inclusions (the latter producing colour flashes). The astonishing 'two-pronged' bubble (lower right) is particularly noteworthy. In the other fire opal simulant (No. 3 in Figure 1) crescent, shield or cusp-shaped bubbles are fairly common. Some of these shapes resemble miniature 'Barkhan type' sand dunes which are a feature of certain deserts. Examples are shown in Figures 10, 11 and 12. Flake inclusions are also prominent in Figures 10 and 11.

Bubbles with spikey terminations occur in one of the black opal simulants (No. 1 in Figure 1). These are shown in Figures 13 and 14.

(B) OPTICAL EFFECTS

Although Figure 1 may not suggest it each of the stones studied is transparent to some degree. If transmitted light only is used to illuminate the specimens, they are quite dull and lifeless and show few if any colour flashes. Using overhead reflected lighting, however, the appearance of the stones alters dramatically and a beautiful play of colour, which changes with the viewing angle, appears. The colour flashes are seen at their best when the observer is directly above the specimen but are considerably reduced when the stone is examined from the side.

The optical effects are illustrated in Figures 15-18. These photographs are of the black opal simulant shown as No. 1 in Figure 1. All pictures show an identical field of view but the lighting conditions vary. In Figure 15, photographed in transmitted light only, the body colour of the glass is revealed as a purplish or yellow-orange in which blue or purple tinsel-like flakes are suspended; colour flashes are non-existent. For Figure 16 overhead reflected light (supplied from a fibre optic light guide) was employed as well as transmitted light, and pure spectral colour flashes, evidently associated with the flake inclusions, can be seen. In Figure 17 the reflected light was retained while the intensity of the transmitted light was markedly reduced resulting in a more pronounced play of colour. Reflected light alone was used to illuminate Figure 18, and the colour flashes are now spectacularly developed against a totally black background.

DISCUSSION

The findings of various workers who have examined Slocum Stone suggest that the production of the material involves a controlled sedimentation process followed by heating in the presence of powdered glass. The fact that some 20 gallons of water are required to produce every carat of Slocum Stone tends to support the view that precipitation is involved.

The purpose of the sedimentation process seems to be to produce a number of multi-layer films. These films, at some stage in the manufacturing process, are apparently disrupted and form the tinsel-like flakes. That many of the flakes are remnants of larger structures, perhaps originally continuous layers, is indisputable (see Figure 5), and it is very likely that all of the flakes were once parts of continuous sheets. The mechanism by which the multi-layer films become fragmented, and their subsequent incorporation as flakes in the glass matrix of Slocum Stone is speculative, but clearly some type of agitation and mixing is involved. The bizarre bubble shapes may well be another manifestation of the mixing process. The high degree of distortion of the bubbles is certainly suggestive of movement of trapped gas (air?) in a viscous liquid medium during agitation. Strangely, clear evidence of mixing of the components, in the form of swirl marks, is lacking in the stones examined. Other workers, however, have recorded swirl marks in Slocum Stone.

Although their exact nature is still conjectural, transmission electron microscope studies by Darragh and Sanders (1978) have shown that the tinsel-like flakes are composed of a laminated or layered material. It has been suggested that the flakes consist of extremely thin layers (about 0.5 μm thick) alternately silica rich and alumina rich. Ball (1978), however, using a scanning electron microscope asserts that the layers are possibly of uniform

FIG. 11. Detail of crescent-shaped bubble resembling a 'barkhan' sand dune. Tinsel-like flakes in background. Fire opal simulant. 42×.

FIG. 12. Detail of two crescent-shaped bubbles. Fire opal simulant. 42×.

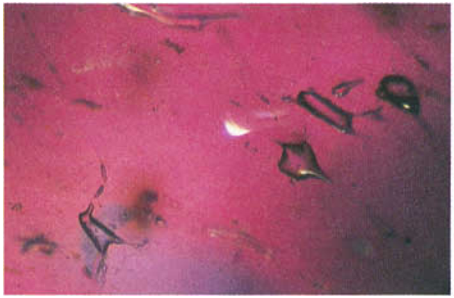

FIG. 13. High relief bubbles with spikey terminations. Black opal simulant. 42×.

FIG. 14. High relief bubbles with spikey terminations. Black opal simulant. 42×.

FIG. 15. Black opal simulant without colour flashes. Transmitted light. 10×.

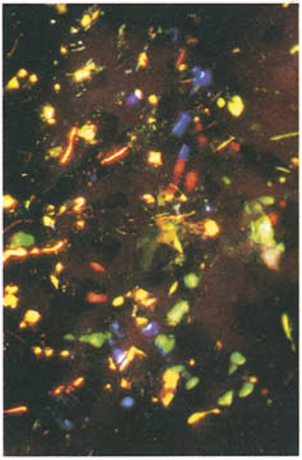

FIG. 16. Black opal simulant showing colour flashes. Transmitted and reflected light. 10×.

FIG. 17. Black opal simulant showing colour flashes. Reflected light and reduced transmitted light. 10×.

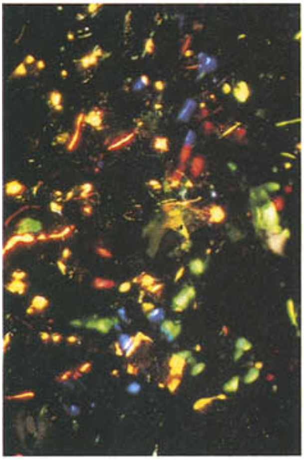

FIG. 18. Black opal simulant showing spectacular colour flashes against a black background. Reflected light only. 10×.

composition. The 0.5 μm thickness of each layer appears to be critical and is sufficient to cause diffraction of reflected light, giving rise to the play of colour in a manner similar to that produced by the silica spheres in natural or synthetic opal. That the flake inclusions are responsible for the colour flashes in Slocum Stone is evident from Figures 15-18. Slocum Stone tends to be fashioned in the cabochon style and normally the material is cut so that the largest surfaces of the majority of the flake inclusions are oriented parallel to the cabochon base. This probably explains why the play of colour is seen at its best from directly above the top of the cabochon. In this position the observer is looking directly down on to the flake surfaces and the effects of diffraction are seen at their best; when they are examined from the side, the viewer sees most of the flakes approximately edge-on, and much of the diffracted light never reaches the eye.

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I should like to thank Mr J.P. Brown, of the Gemmological Association of Great Britain, who kindly loaned me, from the Association's collection, the parcel of Slocum Stones discussed in this paper.

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COLOUR FILTERS AND GEMMOLOGICAL COLORIMETRY

By JAMES B. NELSON, Ph.D., F.G.S., F.Inst.P., F.G.A.
McCrone Research Associates Ltd, 2 McCrone Mews, Belsize Lane, London, NW3 5BG

INTRODUCTION

Colour science is now beginning to assume considerable importance in gemmology. The science is a complex one, because it is a mixture of purely physical and psychophysical components. The attainment of even a minimally useful grasp of the subject for gemmological purposes is not easy, and as much help as possible is needed to assist the learning process.

In a previous article(1) a new spectroscope unit was described which, with a few accessories, enables other kinds of characterizations to be made. A set of colour-filter slides has now been produced for use with this unit. It is felt that this additional combination will help to fill a gap in the practical process of understanding the principles of colour production, perception and measurement.

This article is an attempt to persuade fellow gemmologists that systematically based instruction in colour science is fast becoming a necessary part of their training.

ATTITUDES TO GEMSTONE COLOUR MEASUREMENTS

There is now a strong ground-swell of interest in the internationally accepted method of quantitative colour assessment known as the CIE Tristimulus Colour System.* The interest springs mainly from those research laboratories and teaching institutes which are concerned with gemmological science.

There is, however, also a world-wide awakening of interest in the jewellery, diamond and coloured stone trade. Its collective response covers a range of awareness from a sympathetic but cautious interest to one of declared hostility. The latter stance probably arises from the prevailing and strongly-held belief that it will never be possible to measure quantitatively the body colour of a faceted gemstone.

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* CIE is the acronym for the 'Commission Internationale de l'Eclairage', the international governing body for colour science.(2) In the U.S.A., it is sometimes referred to as the ICI System ('International Commission on Illumination').

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At the CIBJO* 1983 executive meeting in Rome, the delegates representing the coloured stone trade of fourteen countries unanimously passed a resolution with the following wording: '*The Coloured Stone Commission of the CIBJO definitely rejects the use of mechanical graduation systems for coloured stones in order to stimulate public sales. The Commission holds that these systems are to the consumer's and to the retail trade's disadvantage*'.(3,4)

This resolution was an answer to the activities of investment firms using coloured stone certificates in order to sell single coloured stones or whole sets for investment purposes. The Commission stated that the trade was aware of several methods for determining the colour of gemstones such as the use of electronic measuring instruments and tables. It had no objection to their development and use, provided that none of the resulting colour measurements were used to ascribe certain commercial values to the measured stones. It believed that such practices would open the way for investment firms to mislead the public into thinking that coloured stones were suitable objects for investment. Reference was made to the fate which faceted gem diamonds have suffered in the last three years. This was in consequence of the issuing by such firms of quantitative colour certificates with their direct linkage to prices.

It might well be thought that those outside the gemstone trade could misconstrue the meaning of the last sentence in the resolution. From the reported general discussion at the Congress, it is abundantly clear that the Commission has no wish to inhibit progress in research studies aimed at the full characterization of coloured gemstones. This included the development of accurate and practical methods of colour measurement.

TRADE PROBLEMS IN THE DESCRIPTION OF GEMSTONE COLOUR

Of the many problems of faceted stone characterization which confront the trade, there are three in particular which spring to mind. They all relate to the now pressing need for an accurate, practical and inexpensive assessment of body colour.

The first is the difficulty experienced by those gemstone miners and merchants who form such an important international coterie

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* CIBJO is the acronym for 'Confedération internationale de la bijouterie, joaillerie, orfèvrerie des diamants, perles, et pierres'.

dealing in the highest quality coloured stones. Like diamonds, relatively small colour differences are usually linked to breath-taking price differences. With aquamarines, for example, Ramsey(5) mentions that there is almost an 8000 per cent difference from the cheapest stone to that showing the 'top' colour. The sellers are continually frustrated and baffled by the inability of their buying public to recognize the fine nuances of colour in their own specialist stones. For their part, the buyers are prone to dispute the seller's judgement of colour differences. An internationally-agreed colour standardizing procedure would do much to remove this trading obstacle.

The second is concerned with the widely felt, but largely unexpressed, need to monitor the colour constancy of certain gemstones. These are the stones which are known to have received, or are suspected of having received, laboratory-type treatments to improve their colour appearance. The enhancements could involve irradiation, thermal or chemical operations of a kind which Goethe* could not have imagined. There even exist some natural stones, known to be untreated, which are also subject to colour changes when exposed to white light. Some examples of these are Maxixe beryl, much brown topaz, kunzite from certain localities and zircon.

In current practice, such changes can only be followed by visually comparing the colour appearance of the treated stone with that of a stone of much the same shape and size cut from the untreated homogeneous material. Such comparisons would be made at chosen time intervals, to ensure that the colour was not fugitive over long periods. Intermittent or constant exposure to an intense white light source during these intervals would probably be a requirement of a stringent test for colour stability, or for a check on the absence of tenebrescence.†

When testing a single gemstone of unknown history for light-fastness, by the very nature of the experiment the observer has

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* '. . . Colours fixed in glass by fusion, and by nature in gems, defy all time and reaction . . .'. Goethe. *Theory of Colours*, 1810.

† Tenebrescence is a type of reversible photosensitivity. There are certain transparent minerals which darken or beome more deeply coloured on exposure to shortwave UV light (or electrons, neutrons, x-rays, gamma rays). When exposed to white light (e.g. daylight), the irradiated material is bleached or reverts to its previous colour. The process cycle can be repeated endlessly. Hackmanite, a pink sodalite, is the classical model for tenebrescence. Its curious behaviour has been studied by Lee(6) and Medved.(7) Pough and Rogers(8) carried out many experiments on the 'soft' x-ray irradiation of various gemstones and showed that all radiation-treated sapphires exhibited tenebrescence. More recently, Scarratt(9) has reported on the existence of this phenomenon in the so-called 'chameleon' diamonds and in yellow sapphires.

deprived himself of any reliable comparison colour with which to gauge a possible colour shift. Recourse must then be made to some other colour standard with which to match the stone before commencing the light-fastness experiments. This could be chosen from, say, a comprehensive set of similarly coloured pastes, or other standards known to be colour-fast or intrinsically non-fading.

With a system of quantitative colour measurement, this troublesome visual comparison method would be unnecessary. Instead, the colour co-ordinates of the untreated or suspect stone would first be measured by means of a suitable instrument. When the planned treatment of any kind had been carried out on the same stone, the identical measuring procedures would be followed, again at chosen time intervals.

The colour attributes measured would be recorded as three numbers. They would be characteristic of the actual instrument and procedures used; they would probably have little direct meaning to those unfamiliar with the device and its use. If, however, the nature of the device was such as to allow its own particular numbers to be easily converted into those of the CIE System, then a formidable new tool for the gemmologist becomes available. The three derived CIE co-ordinate numbers would serve as a universally-understood international colour description of the stone. They would render quite unnecessary the totally imprecise and crude colour language terms in present use.

Those CIE colour co-ordinate numbers which convey the most meaning in a colour sense are the objective psychophysical terms of dominant wavelenth (λ_d), excitation purity (p_e) and relative luminance Y/Y_o. The more familiar colour terms are the closely-connected perceptual or subjective attributes of hue, colourfulness and lightness, respectively.

The third problem seeking a solution relates to the curious colour change effects seen with some chrysoberyls, corundums, spinels, garnets, monazites, kyanites and fluorites.(10) The higher commercial values, which such alexandrite-effect stones command, no doubt encourages a desire to know more about the fundamental nature of this intriguing phenomenon, and to measure precisely the intensity of the effect to which the value is linked. Here again, the use of a colour measuring device capable of producing CIE co-ordinates for any of the standard light sources could easily dispose of this problem.

GEMSTONE COLORIMETRY

It must be said that so far there appears to be little real understanding in gemmology of the general aspects of colour science. This is rather puzzling. Particularly so, when considering the dominant role that colour plays in the over-all attractiveness and value of a gemstone.

Should teachers now be starting to ask their students certain questions? For example: What are the psychophysical mechanisms of colour vision and colour perception? What does the phrase mean . . . 'Colour exists only in the eye of the beholder'? What is subjective dichroism? How can an absorption or transmission spectrum be qualitatively related to a perceived colour? How can the measured transmittance spectrum of a gemstone be mathematically manipulated so that even a colour-blind person can produce a universally-accepted numerical and objective statement of its colour? How can this same process objectively predict what colour appearance a gemstone will present when viewed with any illuminant of a specified type? What is meant by the rigorous terms 'dominant wavelength', 'excitation purity', 'metric lightness', 'brightness', 'relative luminance', 'metamerism', 'saturation', 'chroma', 'chromaticity', 'colour temperature'? These, some of the terms and concepts used in colour science, would be viewed as unnecessarily arcane matters of little value to practising gemmologists.

At one point the author felt that the greatest obstacle to an eager acceptance by gemmologists of the CIE System was its almost unintelligible profundity. The available literature was written entirely by the same scientists who had invented or developed it. They conceded few departures from the hard road of scientific rigour to simpler pathways which would have helped those who did not have so advanced a technical background. It was, and still is, hard to explain why it is necessary to introduce awkward conceptions such as negative colours. Or to invoke such bizarre quantities as 'supersaturated' or imaginary colour stimuli, which are the X, Y and Z of the CIE Tristimulus Colour System. Such notions are very discouraging to anyone wishing to comprehend the intricacies of colour perception and measurement.

It was therefore the most pleasant surprise to discover, somewhat belatedly, a series of three articles which gave a masterly and lucid treatment of just these two subjects.(11,12,13) Published in this *Journal* more than 30 years ago, they were a plea by the author, M.D.S. Lewis, to the diamond and coloured gemstone trade, to consider urgently this 'universally adopted system of colour specification and measurement as the basis of a gemmological colorimetry'.

In the last article, the last paragraph is also worth quoting. His last sentence is worth remembering:

'. . . Very recently the writer's attention has been drawn to a remarkable article which appeared in *The Gemmologist* of September 1933 (Vol. 3, No. 26) on the 'Measurement of the Colours of Precious Stones'. A description is given of the Guild Trichromatic Colorimeter (now superseded by the Donaldson instrument) and of the calculations determining the colour quality of a stone. A fascinating and ingenious technique of measuring the light path in a gemstone is also described. It is astonishing to find that even 20 years ago – within two years of the (1931) inauguration of the CIE System – a London firm of scientific instrument makers was ready with an apparatus for the measurement of gemmological colour. Unfortunately the ground was not sufficiently fertile for the idea to take root.'

For the prevailing views on gemmological colorimetry to begin to be changed, at least two things must happen. One is a recognition by examining bodies and teachers to take action soon. It is also necessary for these same individuals to stimulate members of the trade into an awareness of the considerable benefits which can accrue.

Of course, it is equally necessary for the trade itself to deal firmly with retail traders who follow policies of openly encouraging the public to purchase 'colour-certified' stones for investment purposes.

The other matter is the provision of inexpensive teaching material, to allow beginners and mature students to be gradually eased into this new and quite complex subject. The development of the new spectroscope unit has prompted the author to take this latter step.

COLOUR FILTER SLIDES

Clearly, the simplest and most effective way to begin to do this is to provide a comprehensive series of durable, low-cost, mounted, colour filters. This has now been done. Each of these is relatable to

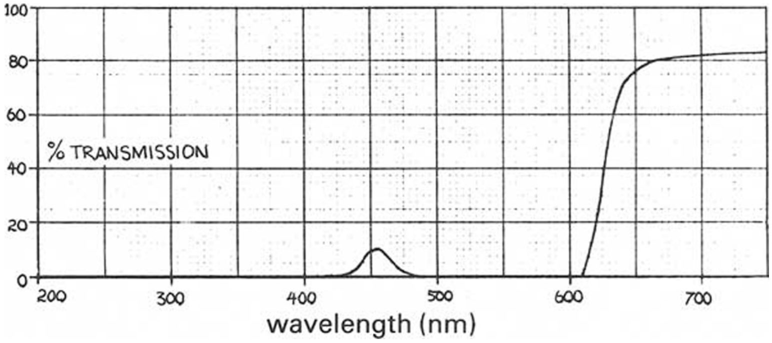


FIG. 1. Example of the spectral transmission graph of a gelatine colour filter. 'Ruby Red' (Filter No. 19, Table I). Percentage transmission versus wavelength (nm).

its own spectral transmission graph provided with the filter set. A typical graph is shown in Figure 1.

Each filter is viewed with the spectroscope unit, either by holding it in front of the spectroscope slit or directly over its eyepiece, whichever is the most convenient. A glance at its corresponding spectral transmission curve allows the student, moving at his or her own pace, to follow the quite complex interactions of white light and coloured filter.

As a rule, in teaching colour science, the lecturer's projection slide explanations are much too fast to permit convincing relationships to be grasped between observation and theory. Although the colour effects on the classroom projector screen can, of course, be seen, the student is often unclear as to exactly what filter or filter combination is being projected.

With each of the new mounted filters, the student's hand and not the lecturer's, is virtually on the projector. The student can follow step-by-step, personally, and at a chosen pace, the direct connexions between the labelled filter, its perceived spectrum, the characteristics of its spectral transmission curve and its perceived colour.

The student then becomes aware that it is the spectral energy *transmitted* by the filter (or stone) that produces the distinctive colour observed. In gemmology, the student has been taught, quite properly, to regard the absorption peaks, rather than the absorption 'valleys', as the important diagnostic features, simply because they are sharper and more distinctive. It is, however, the shallower absorption valleys (i.e. the transmission bands) that hold the key to an understanding of the production of the resultant colours.

Because of their well-known colour constancy and durability, coloured glasses would be the favoured choice for such a slide collection. However, apart from their high cost, the commercially-available glass colour filters do not embrace a colour range, or colour gamut, as it is called, which is large enough for the present purposes. Coloured gelatine filters are available which do provide an adequate gamut.

The traditional commercially-available gelatine-film filters are usually required for uses which involve frequent handling, as in photography, or for the filtration of strong light sources. They are offered in relatively large standard sizes, varying from a minimum usable diameter of 25 mm to a maximum aperture of 110 mm square. In order to minimize scratching, finger-staining or the buckling arising from changing humidity, it is the practice to sandwich them between optically-flat glass plates. In addition to this, the three components are invariably cemented together with Canada Balsam. This further both improves heat transfer and inhibits humidity-change buckling. However, its main purpose is to reduce the number of parasitically-reflecting air/filter/glass interfaces from six to two, thus increasing the overall light transmission.

The collection of filter slides intended as an accessory to the basic spectroscope unit has been produced with cost very much in mind. They are thin-film (0.1 mm thick) gelatine filters with a protective lacquer overcoating on both sides: they possess sufficiently good colour-fastness. The low cost has been achieved:

(1) By limiting the holder aperture to the smallest diameter which can be conveniently viewed. This reduces humidity buckling and uses less filter material.

(2) By using 'bare' filters. The operations involved in preparing and securing cemented glass sandwiches require costly manipulative time and skills.

(3) By placing the filters in relatively deep recesses in their holders. This decreases the possibilities of scratching or of finger-soiling the surfaces.

TABLE 1. FILTERS MAINLY OF GEMMOLOGICAL INTEREST

Filter No.	Filter name	Purpose
		Crossed filters
1	Fluorescence Exciter* (glass)	Excites chromium fluorescence; absorbs all wavelengths (λ) above 620 nm.
2	High Barrier	Absorbs all wavelengths below 620 nm. Used as a crossed filter to exclude all exciter light.
3	Low Barrier	Absorbs all wavelengths below 530 nm. Used as a less restrictive crossed filter.
		Miscellaneous filters
4	White Diffuser* (glass)	Produces a uniform light source for examinations with 10X loupe and glass immersion cell and for dichroscope observations.
5	Red-End Attenuator	Eliminates the purple glare seen in the spectroscope's blue-violet region.
6	Chelsea	Shows colour effects identical to the Chelsea filter.(17, 18)
7	Colourless Polariser	Colourless filter for use with spectroscope, visual optics, and refractometer.
8	Sodium I	Converts white light to effective 'sodium' light for refractometry.
9	Sodium II	As above, but of higher luminosity for use with the barrel light source.
10	Neodymium (glass)	Shows strong doublet peaking at 744 nm in the far red.
		Filters for demonstrating alexandrite-type colour change effects
11	Standard Daylight	Simulates daylight. Equivalent to CIE Illuminant 'C' (6775K).
12	Standard Tungsten Light	Produces tungsten light equivalent to CIE Illuminant 'A' (2855K).
13	Standard Candle Light	Simulates standard candlelight. Equivalent to a colour temperature of 1950K.
14	Red-Purple Colour Change	Produces large λ_d change. R-P with 'A'; V-P with 'C'.
15	Mid-Purple Colour Change	Produces large λ_d change. M-P with 'A'; V-P with 'C'.
16	Violet-Purple Colour Change	Produces large λ_d change. V-P with 'A'; V with 'C'.
17	Saturation Colour Change	Produces zero λ_d and L* changes. Large p_e change ('A' to 'C').
18	Zero colour Change	Produces zero λ_d,p_e and L* changes ('A' to 'C').
		Colour simulants for some gemstones
19	Ruby Red	Simulates the hue of Sri Lankan and Thai rubies.
20	Spinel Red	Simulates the hue of Burmese spinel and ruby.
21	Imperial Topaz Orange	Simulates the hue of Brazilian 'Sherry-brown' topaz.
22	Heliodor Yellow	Simulates the hue of Namibian heliodor.
23	Peridot Green	Simulates the hue of Zabargad peridot.
24	Emerald Green	Simulates the hue of Colombian emerald.
25	Sapphire Blue	Simulates the hue of Kashmir sapphire.
26	Alexandrite Red	Simulates the hue *changes* of Urals alexandrite.

*This is a thick glass filter enclosed in a metal tube cap which fits on the light source barrel.

TABLE 2. FILTERS MAINLY OF COLOUR SCIENCE INTEREST

Filter No.	Filter name	Purpose
		Additive primary colours
27	Red	These filters are used to produce most colours by simultaneously projecting white light through each. Means have to be provided to vary the relative proportions of coloured light passing through each filter, and to direct each beam on to the same patch of white diffusing mixing screen. The filters yield the same colours that are produced by the three phosphors used in American television receivers. The additive mixing of coloured lights is the principle upon which is based colour printing (half-tone screen letterpress and lithographic process), mosaic art, Impressionist painting, stage lighting and colour television. This principle is also used in the GIA ColorMaster visual colorimeter(27, 28) for the colour measurements of gemstones.
28	Green	
29	Blue	
		Also known as:– *Subtractive primary colours*
30	Cyan	(minus-red) By viewing a single white light beam through a pair of these filters at a time, the above red, green and blue colours can be substractively obtained. If the three are used together, no light passes. In principle, by using methods for decreasing each filter's CIE saturation (p_e), most colours can be produced. The subtractive filtration of white light is the principle upon which is based colour photography, oil-pigment painting, textile dyeing, gravure printing and the Nelson-Lovibond visual colorimeter(29) for the CIE colour measurement of gemstones.
31	Magenta	(minus-green)
32	Yellow	(minus-blue)
		Narrow-band ('Spectral') monochromatizing filters
33	λ_d = 675 nm	These filters demonstrate how the band-peak wavelength, as shown on the charts, or the CIE dominant wavelength (λ_d), is related to the perceived colour. Spectral observation of each filter should be made using the barrel light source:– (1) alone; (2) with the Standard Tungsten Light filter (CIE Source 'A'), and (3) with the Standard Daylight filter (CIE Source 'C'). They can also be used to obtain values of the dispersion of faceted stones. This is accomplished with any gemstone refractometer following the method of Suhner.(30)
34	λ_d = 606 nm	
35	λ_d = 576 nm	
36	λ_d = 538 nm	
37	λ_d = 490 nm	
38	λ_d = 452 nm	

(4) By using a single rubber grommet to hold the filter in its cell. Again, this further reduces thermal- or humidity-buckling by permitting small elastic movements of the filter. Should the filter surfaces become soiled or dust-coated, the grommet can be easily removed. The released filter can then be gently wiped with a soft, clean, dry cotton handkerchief and replaced.

(5) By designing easily-machined slide-type filter holders. These are of black Perspex, and are 40 mm in length, 19 mm in width, 6 mm in thickness, and with a viewing aperture of 9.5 mm diameter.

The set contains 38 filters, and except for 3, which are of glass, are of dyed gelatine films. Two of the glass filters are mounted inside metal tube caps; these slide on to the light source barrel. Of the 38 filters, 26 are of direct application to practical gemmology. The remaining 12 are intended to acquaint the student with the elementary principles of colour production, and with the linking of the filter's perceived colour to its observed spectrum and to the corresponding spectral colour transmission curve. They should also help to familiarize the student with the conceptions of dominant wavelength (λ_d), excitation purity (p_e) and metric luminance (L^*). These values are listed for each filter and correspond to the use of the white light of the barrel light source when run at the highest voltage setting and when viewed through the standard Tungsten light filter. This source-plus-filter has been measured experimentally to conform closely to the CIE illuminant A (of colour temperature 2855 Kelvin). This information, together with all the filters, should allow the student, with some practice, to assign numbers, albeit approximately, to the values λ_d, p_e and L^* for an 'unknown' filter.

Brief details of the set of filters are listed in Tables 1 and 2.

A spectrum is viewed by placing the filter over the spectroscope eyepiece. Light from the barrel light source is directed on to the mirror side of the black velvet/mirror sub-base. In this way, light is specularly reflected at 45° into the spectroscope slit, just as it is when reflected from the internal table surface of a gemstone lying on the black velvet side of the stone rest (see Figure 2).

Alternatively, a spectrum can be viewed in a direct transmission mode. This is done by clamping the filter slide on to a fixture attached to the vertical slot of the basic stand. This attachment, with a filter slide in place, can be seen in Figure 3.

The filter storage box and slides are seen in Figure 4.

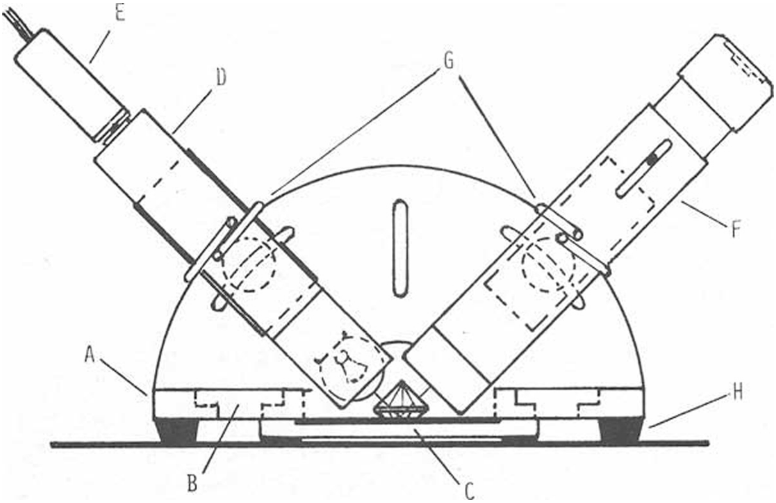


FIG. 2. Sketch of the spectroscope unit.
A. Base. B. Recessed hole for pinhole disc.
C. Gemstone rest; black velvet topside, mirror underside.
D. Barrel light source. E. Jackplug.
F. Fixed slit prism spectroscope.
G. Vee-blocks with wire clamps.
H. Rubber supporting feet.

COMPARISON PRISM SPECTROSCOPE

In addition to the five spectroscopes already described,$^{(1)}$ there is now a sixth which has novel features. This is the McCrone comparison spectroscope for viewing two juxtaposed spectra.

It consists of a compound-Amici prism spectroscope, a light source, a standard filter slide holder and an optical arrangement for presenting two spectra side-by-side in the same field of view. It can be mounted on the basic stand in the same manner as the other five instruments. The slit is continuously variable and the eyepiece is focusable.

The advantages of this device over those prism spectroscopes which have externally injected wavelength scales are considerable. There is a complete absence of parallax shift between the two images; this shift is the most troublesome aspect of wavelength scale instruments. Direct spectral comparisons can be made between the faceted test gemstone and a plane-parallel polished section of a chosen orientation of any transparent gemstone material. Such sections, mounted in the standard filter slides, serve as permanent

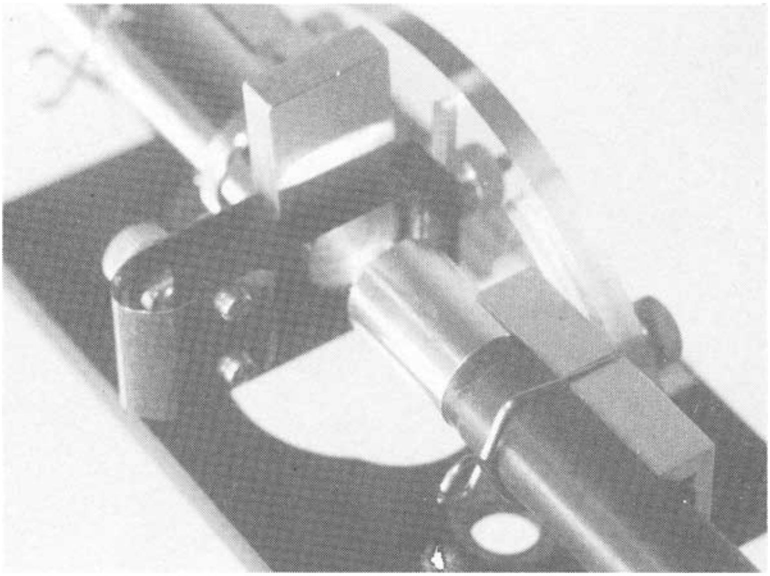


FIG. 3. Prism spectroscope and light source mounted in the direct transmission viewing mode.

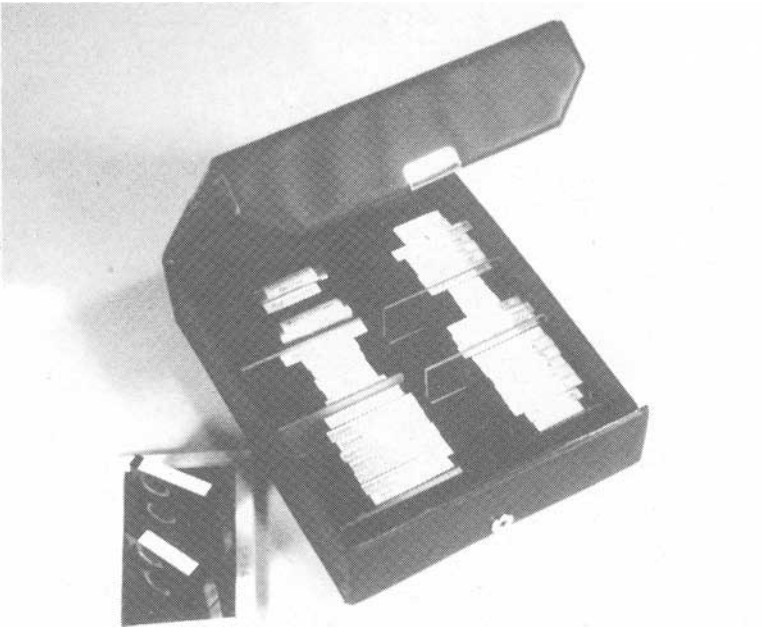


FIG. 4. Filter storage box with filter slides.
Two of the filter slides are shown resting on the mirror side of the gemstone rest.

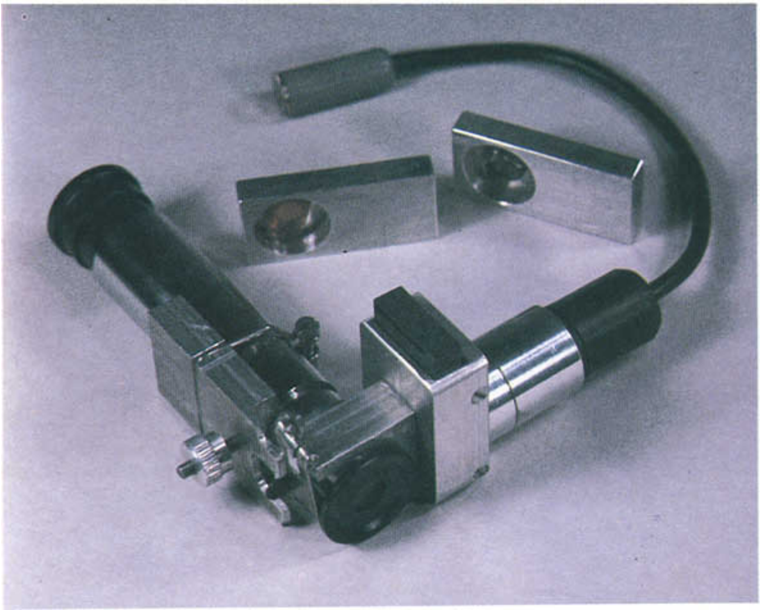


FIG. 5. Comparison prism spectroscope.
Three filter slides are shown; one is in place on the holder. The other two slides contain thick, plane-parallel, polished sections of transparent gemstones. This type of slide serves as a permanent comparison standard for gemstone spectra.

FIG. 6. The comparison prism spectroscope mounted on the basic spectroscope stand.
A black Perspex annulus confining the gemstone can be seen on the gemstone rest. This enables the gemstone's movements to be more readily controlled to obtain the optimum brilliance and uniformity of the spectrum.

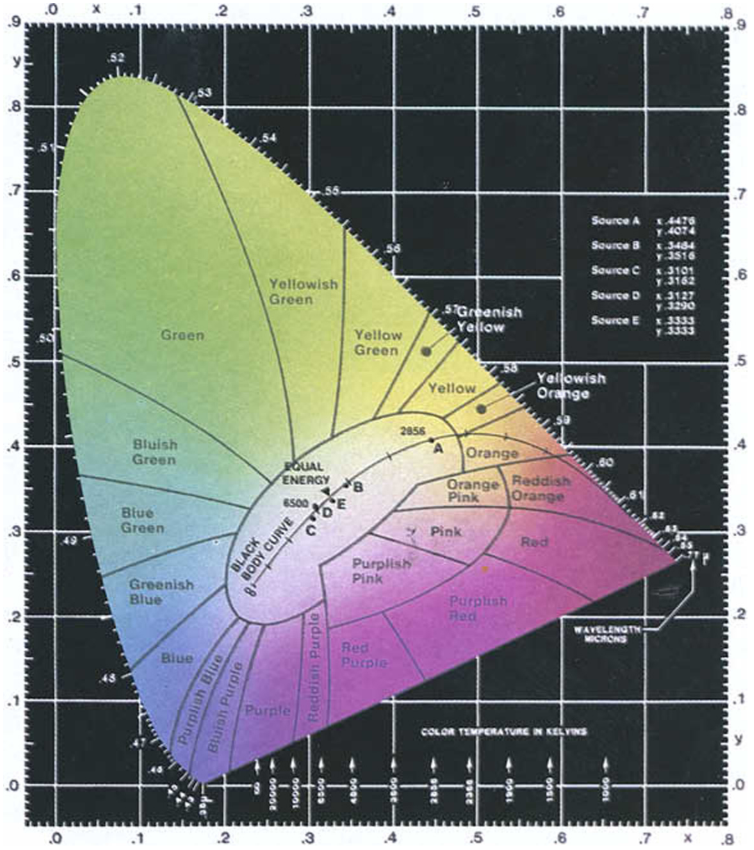


FIG. 7. The CIE (1931) x,y chromaticity diagram.
The chromaticity names allocated to the various zones are those defined for the discriminatory 'Level 1' of the Universal Colour Language System(22) when using the CIE Illuminant 'C' (6775K). The Planckian 'black body' curve and the plots of the various CIE Standard Illuminants (A, B, C, D and E) are also shown.

spectrum references. By suitable choice of materials with known absorption line wavelengths, fairly accurate measurements of the line and band peaks of the test gemstone can be made. Finally any pair of filters, chosen from the collection of gelatine filter slides, can be examined.

The spectroscope is shown in Figure 5. Figure 6 shows it mounted ready for use on the basic spectroscope stand, together with a new type of stone support. This support has been designed so as to permit the stone to be moved about freely on its table surface, both translationally and rotationally. It enables the stand itself to remain stationary; this can even be bolted to a firmer base.

Several experiments with the comparison spectroscope using this device have persuaded the author that with certain faceted stones, particularly with natural and synthetic emeralds, small but detectable wavelength shifts of the sharp absorption lines in the red do exist. This could of course, be accounted for by crystal axis orientation effects, which only a systematic study could settle. If it proves to be a real effect, it might well have diagnostic significance.

COLORIMETRIC PROPERTIES OF THE Filters

The relevant colorimetric properties of each filter accompany the set. In addition to the spectral transmission graphs which cover the wavelength range from 200 to 750 nanometres, they include the tabulated values of the CIE Tristimulus Colour co-ordinates for each of the three standard illuminants, CIE Illuminant A (colour temperature = 2855K), CIE Illuminant C (= 6770K) and CIE Illuminant D65 (= 6500K). The chromaticity values of the filter for each of the three illuminants are also plotted on two different CIE diagrams. These are the original CIE (1931) x,y diagram and the more recent CIELUV (1976) u′, v′ diagram. The latter yields a more uniform scale of colour differences.

A coloured representation of the CIE (1931) x,y chromaticity diagram is shown in Figure 7, showing the black body (Planckian locus) curve and the plots of the various CIE Standard Illuminants associated with that curve. Examples of two of the six diagrams are shown in Figures 8 and 9. They are the (1931) x,y diagram for Illuminant A and the (1976) u′, v′ diagram for Illuminant D65. The symbols shown against each of the 38 filter plots correspond to the filter name symbols listed in Tables 1 and 2.

It is not appropriate here to give even a short description of the CIE Tristimulus System and its many applications in commerce and industry. For those who seek further information, there are two recent publications,(14,15) which the author believes are among the clearest treatments yet given. An article by Yu,(16) dealing specifically with gemmological colorimetry, retraces some of the paths first blazed by Lewis. Following a brief account of the fundamentals of the CIE System, he proposes the use of any of the well-established collections of standardized colour-graded paint

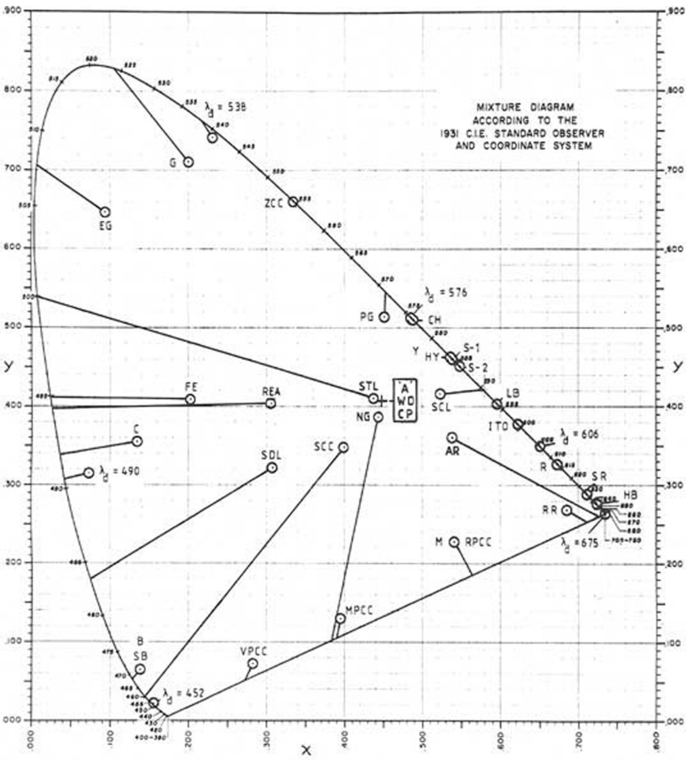


FIG. 8. The CIE (1931) x,y chromaticity diagram.
The chromaticity plots of all 38 colour filters are shown with respect to the CIE Illuminant 'A' (2855K). The filter symbols are given for each plot. The cross corresponds to the identical plots for Illuminant 'A', the white diffuser filter (WD) and the colourless polarizing filter (CP).

chips to match transparent cabochons of ruby, sapphire and other stones. In particular, he mentions the Colour Systems of Munsell, DIN 6164 and others, but neither describes them nor cites actual measurements. A plea is also made for the speedy development of CIE-based techniques to cope with the measurement of transparent faceted stones.

Because of their special interest to gemmologists, the three articles by Lewis have been reproduced and accompany the set of filter slides. Echoing his gentle rebuke, it is to be hoped that the ground has at long last been sufficiently fertilized.

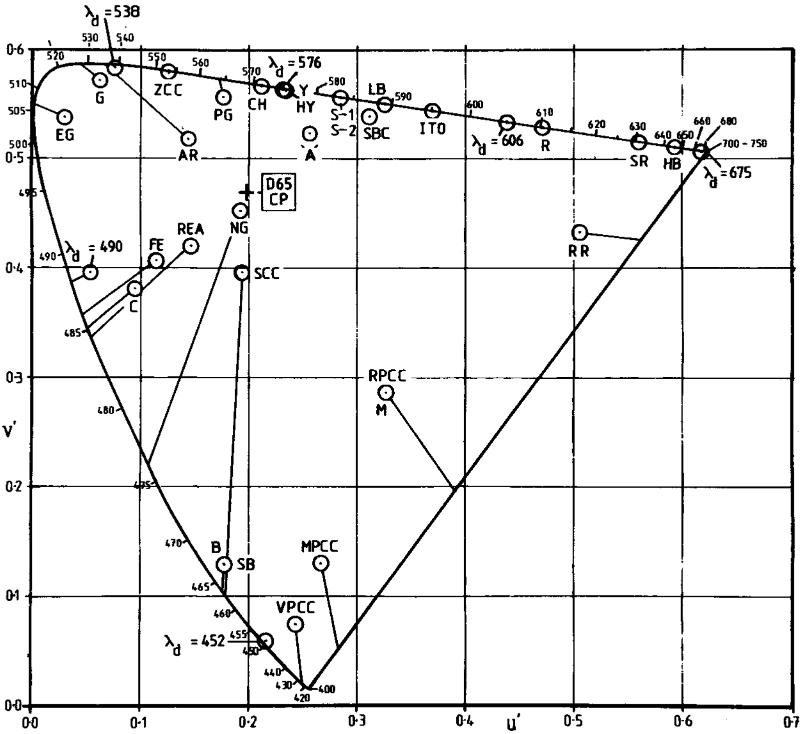


FIG. 9. The CIE (1976) u′, v′ chromaticity diagram.
The chromaticity plots of all 38 colour filters are shown with respect to the CIE Illuminant 'D65' (6500K). The filter name symbols are given for each plot. The plot for CP is identical to that for D65. Two other illuminants are plotted. They are the CIE Illuminant 'A' and the (non-CIE) illuminant 'SBC', the Standard British Candle (1950K).

FILTER APPLICATIONS

Tables 1 and 2 are more or less self-explanatory, although some amplification is needed for certain filters. The comparison prism spectroscope is an essential device when comparing the spectra of two filters.

While the use of the barrel light source, together with the Standard Tungsten Light filter, is required to render the correct colour appearance of the filters in the set (i.e. with CIE Illuminant A), there are occasions when another, more intense illuminant can be substituted. This is the ordinary unfiltered 100 watt household pearl lamp. It has almost the same colour temperature as the CIE Illuminant A. It is especially useful when viewing the dense filters such as the Chelsea, Sodium I, Alexandrite Red and the Narrow-band ('Spectral') filters.

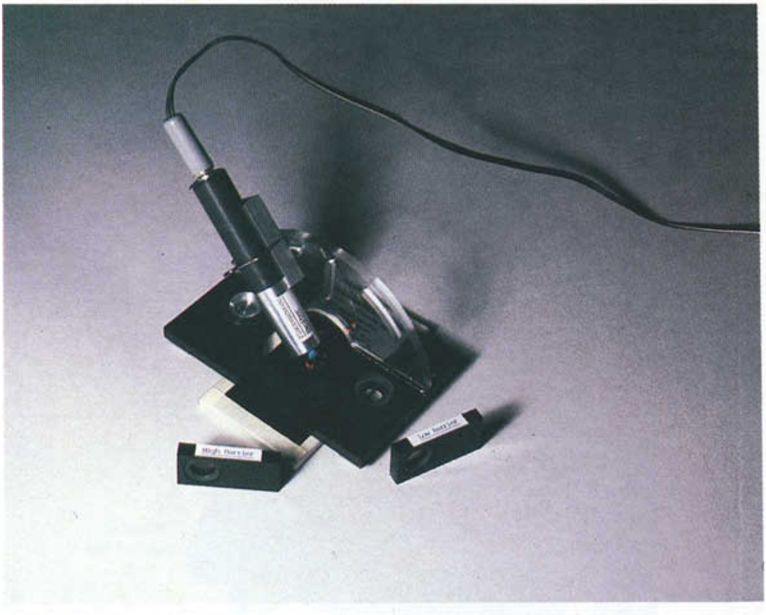


FIG. 10. The 'crossed filters' technique.
The barrel light source is fitted with the glass Fluorescence Exciter filter (No. 1, Table I) to illuminate the ruby gemstone.

In Figure 10, the barrel light source is shown on its stand with one of the cap-mounted glass filters in position. This is the 'Fluorescence Exciter' filter (Table I, No. 1) which transmits all but the red wavelengths. The light emitted from the ruby lying on a velvet-surfaced stone support is seen to be a mixture of two lights. The blue-green light is that specularly reflected from the stone's pavilion facets. The red light is fluorescent light emanating only from the body of the stone. The 'High Barrier' filter (No. 2) completes the crossed filter combination. Placed close to the viewing eye, it behaves as a barrier to the unwanted residual blue-green fluorescence excitation light, but passes all the red fluorescent light.

The Red-End Attenuator filter (No. 5) is useful for detecting faint lines or weak bands in the blue-green, blue and violet regions, particularly when using diffraction grating spectroscopes.

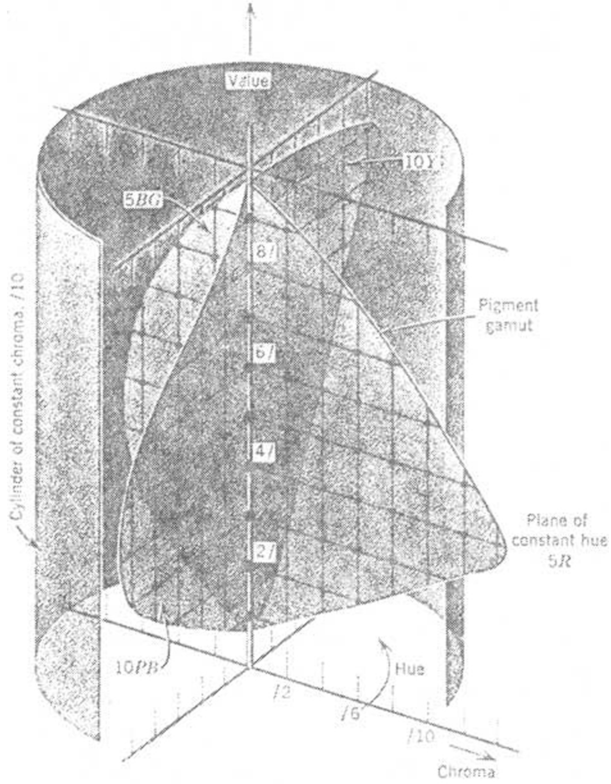
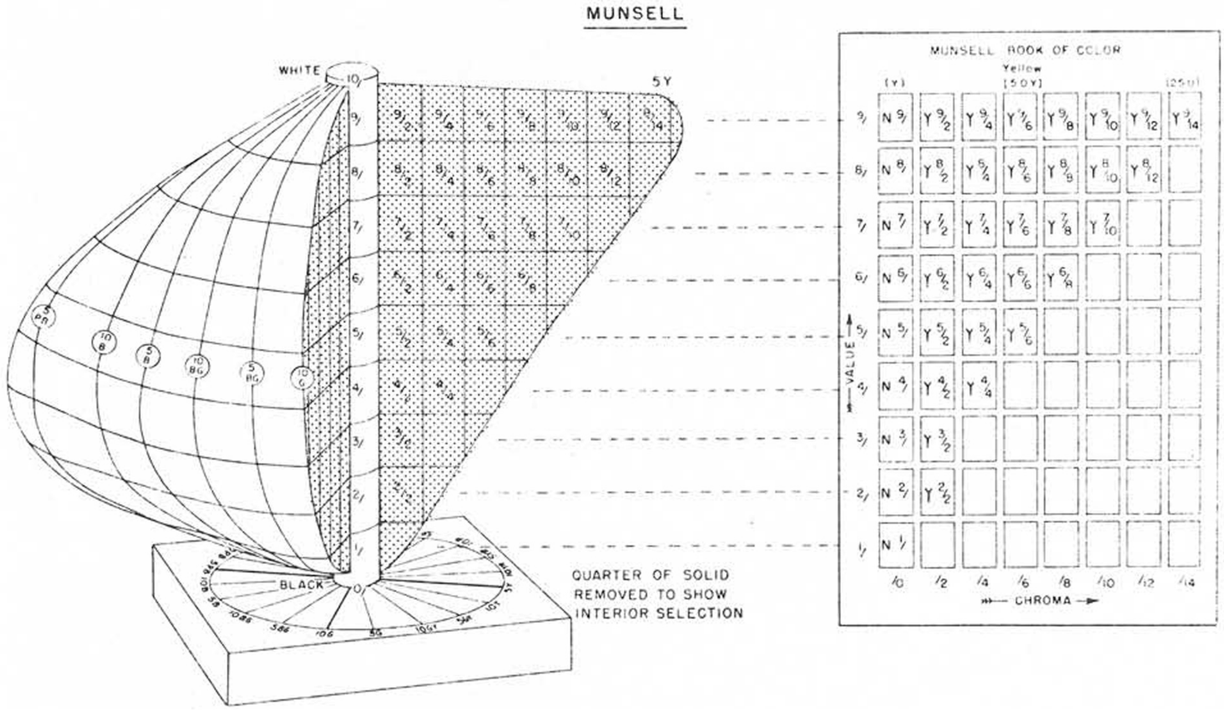


FIG. 11. Schematic diagram of Munsell Colour Space.
This arrangement of a large number of calibrated colour-related surfaces is based on a cylindrical co-ordinate framework. The three attributes of a colour can be represented as a co-ordinate point lying within this space. The attributes are known in the Munsell System as *Hue* (equivalent to the dominant wavelength, λ_d), *Value* (equivalent to the metric lightness, L^*), and *Chroma* (equivalent to saturation, 'colourfulness' or excitation purity, p_e).
The actual colour standards consist of opaque, pigmented films bonded to stiff paper rectangles. They are arranged in a three-dimensional array of orderly scales having visually equal steps. For the sake of clarity, only four vertical planes of constant hue are shown. These are red, yellow, blue-green and purple-blue.

The Chelsea filter (No. 6) has been well documented(17,18) and needs no further comments.

The Alexandrite Red filter (No. 26) gives exactly the same colour response as the new Sterek A filter(19) and indeed performs better in some respects than the Chelsea one. A table listing the observed colour changes for some 26 different stones is supplied with the set.



	/0	/2	/4	/6	/8	/10	/12	/14
9/	N 9/	Y 9/2	Y 9/4	Y 9/6	Y 9/8	Y 9/10	Y 9/12	Y 9/14
8/	N 8/	Y 8/2	Y 8/4	Y 8/6	Y 8/8	Y 8/10	Y 8/12	
7/	N 7/	Y 7/2	Y 7/4	Y 7/6	Y 7/8	Y 7/10		
6/	N 6/	Y 6/2	Y 6/4	Y 6/6	Y 6/8			
5/	N 5/	Y 5/2	Y 5/4	Y 5/6				
4/	N 4/	Y 4/2	Y 4/4					
3/	N 3/	Y 3/2						
2/	N 2/	Y 2/2						
1/	N 1/							

FIG. 12. Munsell Scales of Hue, Value and Chroma.

The Hue (symbol H) circle of this colour space has 20 major hues. It can be expanded to 100 hues, each with its own hue notation. The Value (symbol V) varies from 0 (black) to 10 (white) in relation to the neutral (achromatic) vertical central axis. The Chroma (symbol C) increases radially outwards from the axis. The greater the C, the greater is the colourfulness.

The full notation for each of the 38 yellows of the Hue symbol '5.OY' is shown alongside. This page has been taken from the Munsell Colour Atlas. The basic collection of the 'Munsell Book of Colour' has a total of over 1500 painted, detachable colour 'chips'.

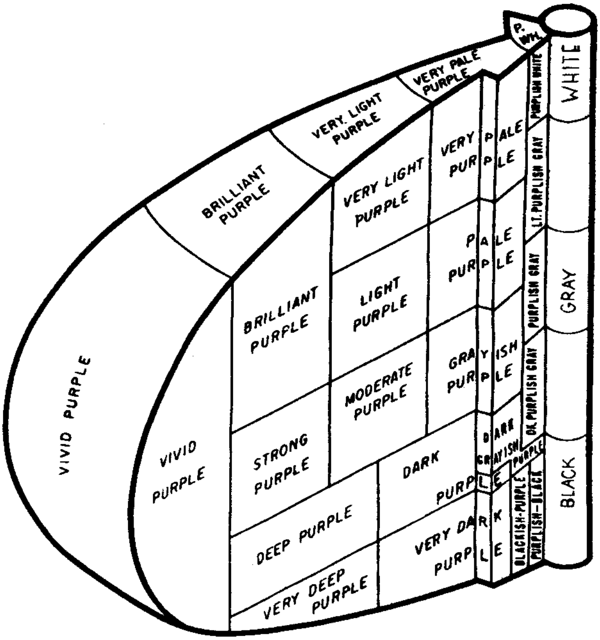


FIG. 13. The purple section of the Universal Colour Language colour space.(22)
This illustrates the colour-name block structure at the discriminatory 'Level 3'. The colour space is identical to that of the Munsell System.

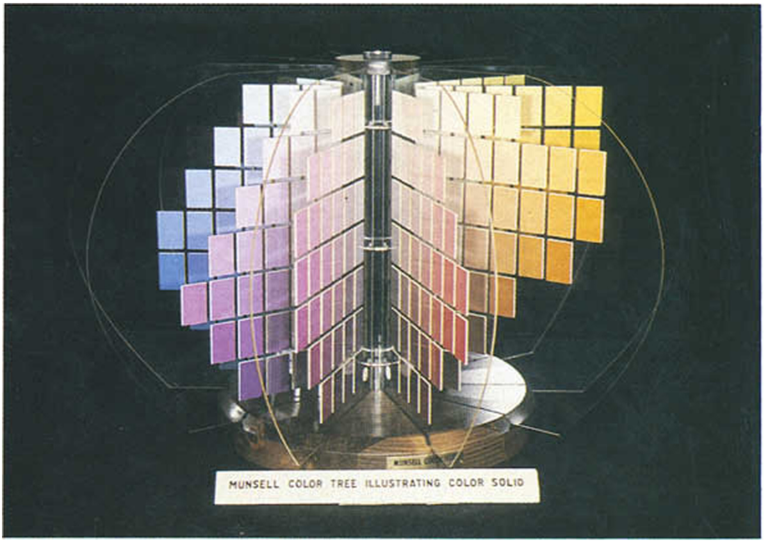


FIG. 14. Munsell 'Colour Tree'.
This is an assembly of standard Munsell colour chips mounted on transparent Hue planes. To prevent visual overcrowding, only 10 of the standard 40 major Hue planes are shown.

In routine refractometry, when a sodium vapour lamp is not available, a convenient substitute consists of a free-standing, condensing, tungsten light source of about 10 watts in conjunction with a Gemmological Instruments Ltd (1157) Sodium-I filter (No. 8). However, this is too dark a filter to be usable with the barrel light source, particularly when the colourless Polariser filter (No. 7) is also employed. A more luminous filter, Sodium-II (No. 9) is a good substitute, but other monochromatizing filters such as $\lambda_d = 606$ (No. 34) and $\lambda_d = 576$ (No. 35), although darker, can also be used. In operation, the light shield of the mechanically adjustable barrel light source is placed directly and centrally against the light entrance port of the refractometer. The selected filter fits centrally in the flange of the eyepiece. As before, either the mains transformer or a 6-volt battery power supply can be used. The properties and performances of the various monochromatizing light sources are listed in Table 3.

The Neodymium filter (No. 10) serves as a good test of the red sensitivity of normal colour vision. When used with a prism spectroscope and the High Barrier filter (No. 2), a strong doublet peaking at 744 nm in the far red should be discernible. The 'N3' line at 415.5 nm, seen with a yellowish Cape series diamond, is a fair test for visual sensitivity in the far violet if the Red-End Attenuator filter (No. 5) or the Fluorescent Exciter (No. 1) is used with a diffraction instrument.

When exploring the alexandrite-effect colour changes, the three colour temperature filters (Nos 11, 12, 13) should be held together fan-wise in front of a 100 watt pearl lamp. In this way, swift comparisons can be made of the behaviour of any one of the six filters (Nos 14, 15, 16, 17, 18, 26) or indeed of any of the set's other filters interposed in the light path.

THE DESCRIPTION OF COLOUR

The colour simulant filters (Nos 19 to 26), named for some of the more important gemstones, are not meant to represent faithfully the commercially- or aesthetically-preferred colour appearance of such stones. As an analogy they are intended simply as colour 'hitching-posts' to which gemstone colours can be tied with different lengths of rein, not just in the two dimensions of

TABLE 3

Monochromatizing light sources obtainable with barrel light source

Filter properties					Performance with refractometer		
Filter name	No. in set	Effective peak λ (nm)	Peak band-width (nm)	Peak transmission (%)	Relative signal sharpness	Relative image intensity	Required correction to instrument reading
$\lambda_d = 606$	34	604	27	6.0	Medium	Moderate	Add 0.0006
(Sodium vapour lamp)	–	589	1	–	Maximum	Intense	Zero
Sodium-I	8	581	20	2.2	Good	Weak	Subtract 0.0004
Sodium-II	9	576	35	36	Fair	Strong	Subtract 0.0007
$\lambda_d = 576$	35	573	25	6.0	Medium	Moderate	Subtract 0.0008

chromaticity (hue and saturation), but in the three complete colour dimensions of hue, saturation and lightness. No one can describe exactly in words how green, grey or dark a particular colour of emerald or peridot appears. The kind of greenness can only be stated as a greater or lesser shift of hue from a given perceived green towards either the blueness of the emerald or the yellowness of the peridot. Or by how much or how little a hue is more colourful or more grey; this is termed its degree of saturation. A shift towards either a lighter or a darker sensation would be described as a lightness difference. In this manner, the filters serve as helpful colour reference points when any of the three light sources (Nos 11, 12, 13) are specified.

In the distant past, gemstones with favoured colours were given biologically poetic names that did little to inform. Nature is ungenerous with her supply of reliably constant colours and Nikon Cooper(20) rightly scorns the continued use of such terms as 'pigeon's blood red' to describe the finest ruby colour. However, many of these optimistically associative and bizarre names are still with us.

In an attempt to seek a more quantitative description for this mysterious red colour known only to hunters and the few fortunate owners of the best Burmese rubies, the author sought the help of the London Zoo. Their Research Department were quick to oblige and sent a specimen of fresh, lysed, aerated, pigeon's blood. A sample of this was promptly spectrophotometered. It yielded a spectral transmission graph which was found to be virtually identical to that for the Spinel Red filter (No. 20). This means that for the first time, good CIE colour co-ordinates for three different light sources now exist for at least one classical gemstone colour. The Burmese bird can at last be safely removed from the realms of gemmology and consigned back to ornithology. The eggshell colour of another bird, the robin, may well be the next one to succumb to CIE scrutiny in the quest for a more acceptable turquoise standard. As the American robin has chosen a different colour scheme for her eggs from that of Britain's national bird, this may present difficulties. The American robin is actually a red-breasted thrush.

While such august bodies as the U.S. National Bureau of Standards has sponsored the development of colour vocabularies,(21) giving sensible English names to specific wedge-shaped zones in colour space, the scheme appears to be too elaborate and imprecise for widespread acceptance. For example, there are 173 names for the 'light blue' zone. An article by Styne(22) outlines the principles of an extension to this Munsell-System-based method. It is known as the Universal Color Language.

The scheme of the Munsell colour space with its own nomenclature is illustrated in Figures 11 and 12. The Munsell numbers can be converted by computer into CIE co-ordinates corresponding to daylight viewing (equivalent to CIE Illuminant D65). The purple slice of this space is shown in Figure 13, but here the Munsell code-numbers have been replaced by the colour-name blocks of the Universal Color Language. This slice represents a portion of the discriminatory 'Level 3'. The whole colour space at this Level contains 267 colour-name blocks. Coarser divisions are given at Level 1 (see Figure 7) and at Level 2. Tighter descriptions are provided for at Levels 4, 5 and 6. For example, Level 5 yields 100,000 colours by visual matching. Level 6 is divided into 5,000,000 parts, but only a spectrophotometric procedure could hope to attain this kind of accuracy. A Munsell 'Colour Tree' is shown in Figure 14.

It appears to the author (J.B.N.) that the assignment of three CIE numbers per colour has one increasingly important advantage over this method; that of being 'computer-user friendly'. Another is the ease which plus-and-minus tolerances can be assigned to each of the three numbers. This automatically defines the location of a specific volume or zone within any one of the several CIE colour spaces, preferably the uniform and orthogonal colour space, CIE 1976 ($L^*u^*v^*$).(23,24) Thus, colour co-ordinates plotted as points and falling within these boundaries can represent the most favoured gemstone body colours, based either on commercial or aesthetical judgements. There is a further valuable feature. It is the manner by which a consideration of only three numbers allows the gemmologist to conjure up in the mind's eye a fair mental picture of what the unseen colour of a stone will look like. Or conversely, describe a perceived colour with three numbers.

The author fears that the instinctive desire to employ words rather than numbers may sway gemmological colorimetry in this direction. He hopes that Lord Kelvin's view* will prevail.

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* '. . . when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of science, whatever the matter may be'.

COLOUR SCIENCE EXPERIMENTS

All the filter slides listed in Table 2 and several in Table 1 are components of demonstration material intended as learning aids in the subjects of colour production and colour perception. Both subjects form a necessary preparation for the understanding of practical gemmological colorimetry. Of the systematic experiments which have been brought together, most require detailed explanations. Several other experiments considered important enough to be included require a few simple, low-cost ancillary items. These are large quarter-wave and full-wave retardation filters;(25) 'Dayglo' and UV fluorescent specimens, a pair of wavelength calibration slides, a set of diffusely-reflecting international ceramic colour standards(26) and both ultraviolet- and infrared-transmitting filters.

Descriptions of the experiments and their background explanations are much too lengthy to be included in this article. They will be published in a future paper in this *Journal* under the title 'Some experiments in colour science'. It is also hoped to follow this with an account of the development of a visual gemstone colorimeter.(29)

ACKNOWLEDGEMENT

The Author wishes to express his thanks to Dr Christine Hawkey of the Haematology Department of the Nuffield Laboratories of Comparative Medicine at the London Zoo, for providing samples of pigeons' blood.

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[*Manuscript received 25th January 1985*]

REFRACTOMETERS WITH BUILT-IN LED ILLUMINATION

By PETER READ, C.Eng., F.G.A.

The use of yellow light-emitting diodes (LEDs) as a convenient and relatively cheap source of refractometer illumination was first proposed by D. Minster(1) in 1979. These miniature solid-state lamps have a peak emission in the region of 585 nm, a wavelength that is sufficiently close to that of the sodium lamp (589.3 nm) to make the yellow LED a useful alternative light source.

The first commercially produced LED unit for refractometer illumination was marketed by the Rayner Optical Company in 1982

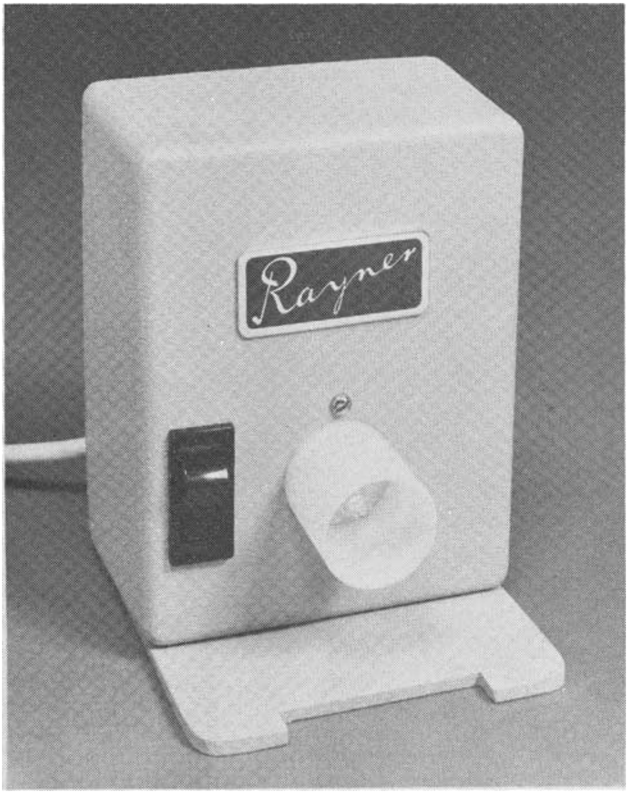

FIG. 1. The Rayner Raylight uses six light-emitting diodes.

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(Figure 1), and this was followed by versions from several other gem instrument manufacturers. The LED illuminator proved to be very popular because of its relatively low cost coupled with the long life of the light-emitting diodes (around 50 000 hours) and the fact that, unlike the sodium lamp, it produced its maximum light output immediately on being switched on. However, in contrast to the sodium lamp, its light is not monochromatic, but includes some green and red wavelengths. As can be seen in Figure 2, the emission bandwidth of the yellow LED (measured at the 50% relative emission points) is 35 nm. In comparison, a medium-quality interference filter (as fitted to high-intensity white light refractometer illuminators) has a bandwidth of between 5 and 20 nm, while the sodium lamp emits the bulk of its energy at the D_1 and D_2 Fraunhofer lines of 589 and 589.6 nm (i.e., it has an effective bandwidth of 0.6nm).

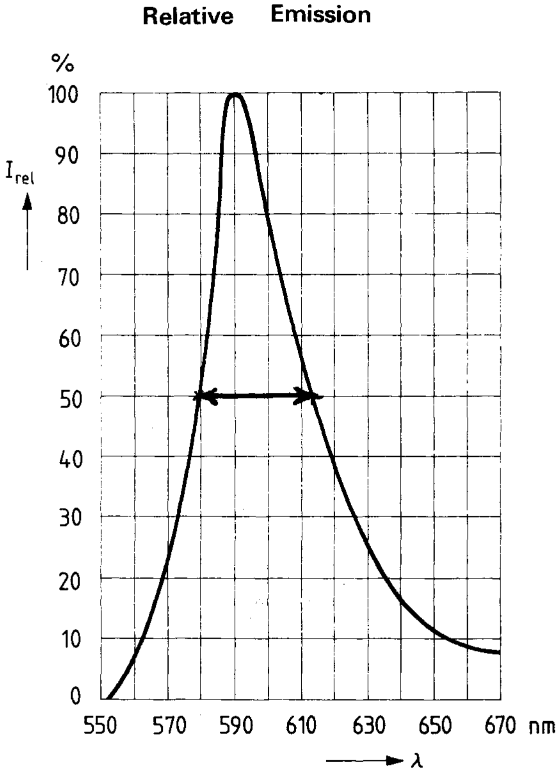

FIG. 2. Relative spectral emission of a yellow LED. The bandwidth at 50%: relative intensity is 35 nm.

In 1983, the Eickhorst company introduced the GemLED refractometer which contained a built-in source of LED illumination.⁽²⁾ By placing three LEDs in close proximity to the refractometer prism (Figure 3), a sufficiently high level of light was available to enable the refractometer to be used with a polarizing eyepiece filter (with external-LED units the light level is often too low to allow the use of such a filter).

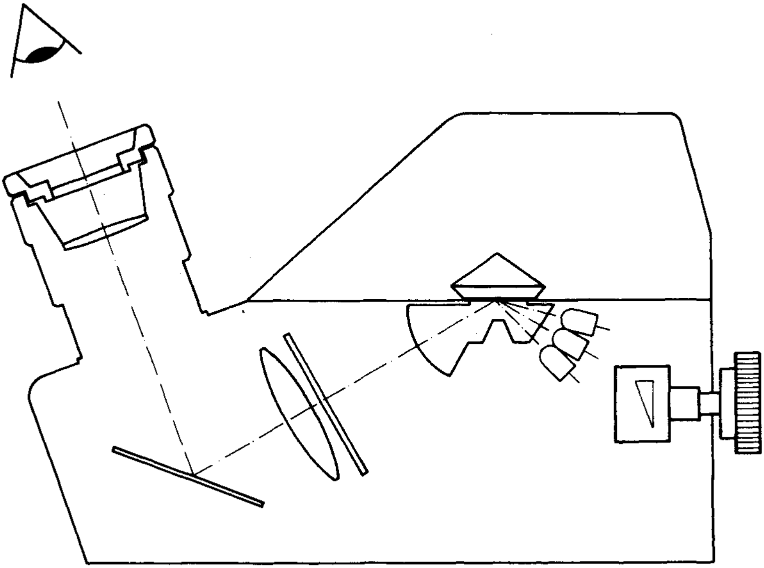

FIG. 3. Diagram showing the position of the three yellow LEDs against the prism in the Eickhorst GemLED refractometer.

The Eickhorst GemLED refractometer (Figure 4) is fitted with a rotary light-level control and because of the low current consumption of the LEDs (around 30mA) can be operated both from a battery supply and, via a 120/240-volt adaptor, from an A.C. mains supply. The battery holder, which can be fitted with either dry batteries or a rechargeable unit, also serves as an operating plinth for the refractometer.

More recently, the Rayner Optical Company has developed a similar LED refractometer (Figure 5). With this unit, the operating plinth contains the mains supply unit, a light-level control and a battery/off/mains switch as well as a PP3-type dry battery. Like the Eickhorst refractometer, the LED illuminator in the Rayner

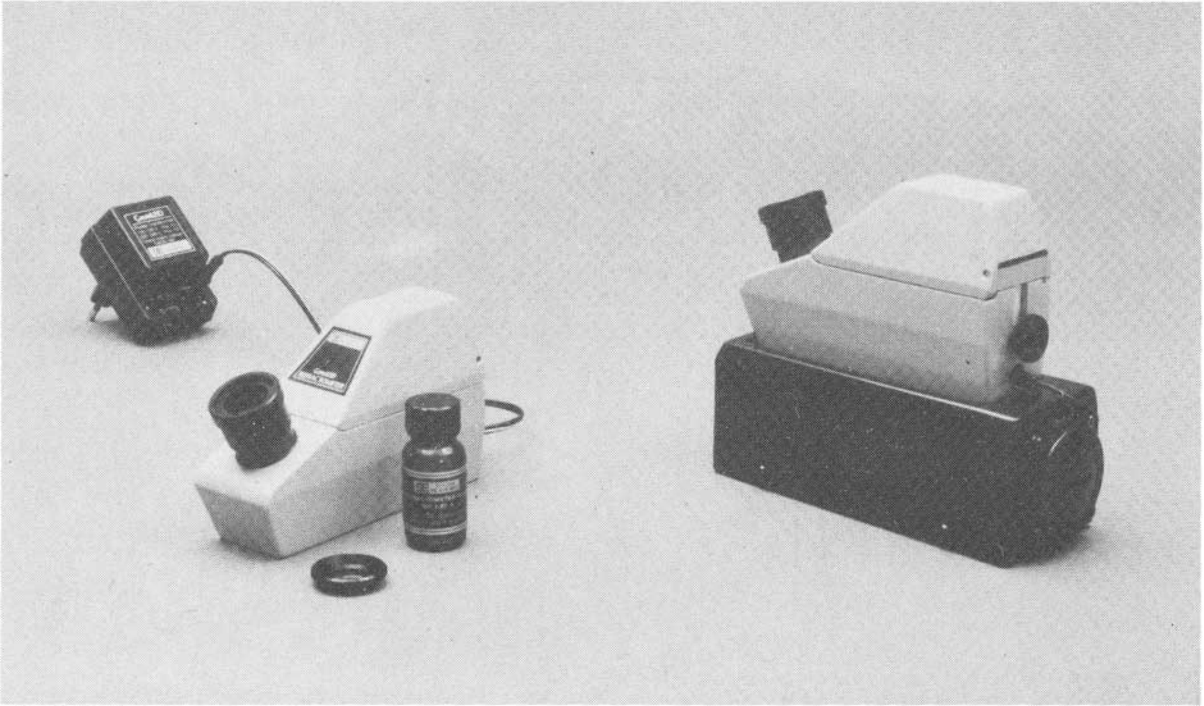

FIG. 4. The Eickhorst GemLED refractometer with a mains adaptor (left) and a battery plinth (right).

FIG. 5. The Rayner LED refractometer uses a 2-LED illuminator which can be withdrawn through the rear of the unit.

model is sufficiently bright to allow for the use of a polarizing eyepiece filter.

In the case of the Rayner model, however, the twin-LED illuminator element can be withdrawn through the rear of the refractometer. This added feature enables the Rayner refractometer to operate with external light sources such as the sodium lamp, which can then be used to provide a truly monochromatic light source when the need arises for very precise RI readings.

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[*Manuscript received 25th November, 1984*]

GEMMOLOGICAL ABSTRACTS

Abbott (R.N., Jr). *$KAlSiO_4$ stuffed derivatives of tridymite: phase relationships.* Am.Mineral., **69**, 5-6, 449-57, 8 figs, 2 photos, 1984.

The system (K, Na)$AlSiO_4$ includes several stuffed derivatives of tridymite, among them, nepheline, kalsilite and kaliophilite. The phase relations for the potassic side of this system are reassessed in light of (1) theoretical considerations regarding Al/Si order/disorder and displacive transformations, and (2) new analyses of the XRD patterns of some of the polymorphs. J.A.Z.

Balfour (I.). *Famous diamonds of the world, XXI. The 'Star of the South'.* Indiaqua, 40 (1985/1), 113-18, illus., 1985.

The author provides a brief survey of the part that three women have played in the history of diamond discoveries; Russian geologist Larisa Popugayeva who was responsible for opening up the U.S.S.R.'s Yakutia diamond field, the diamond geologist Maureen Towie who, with her husband, was the first to find diamonds in the Australian Kimberley Ranges, and a negress slave in Brazil who in 1853 picked up a diamond weighing 268.82 metric carats in the Bugagem diggings in Minas Gerais. The name of the nearby town Bugagem was subsequently changed to 'Estrala do Sul' (Star of the South) in honour of the find.

The negress who found the stone was rewarded with her freedom and a pension for life. Surprisingly, the value of the Brazilian diamond was not immediately recognised, and it was sold for a mere £3000. The fortunate buyer, however, deposited the gem in the Bank of Rio de Janeiro and received an advance of £30000 in lieu of its potential value.

After being the subject of several deals, the diamond was eventually sent to Amsterdam for cutting by Mr Voorzanger of the firm of Coster (who had previously recut the 'Koh-i-Noor'). The Brazilian stone was fashioned into an oval weighing 128.8 metric carats, and because of the stone's 'peculiar prismatic form' this had a rose tint.

The polished gem was bought by a Paris syndicate of dealers who named the stone 'Star of the South', and it was displayed at the London Exhibition of 1862 and at the Paris Exhibition of 1867. The stone was eventually purchased by Mulhar Rao, the Gaekwar of Baroda, for £80000. Following a trial of the Gaekwar for complicity in the attempted poisoning of the British Political Resident at Baroda, the 10-year old son of the Viceroy was placed on the throne. In 1934, the new Gaekwar of Baroda, now an elderly and respected ruler, revealed that the 'Star of the South' was mounted in a necklace among his family's jewels. In recent years it has been reported that the diamond is owned by Rustomjee Jamsetjee of Bombay, but there has been no confirmation of this fact. P.G.R.

BALL (R.A.). *Black opal: a brief review.* Aust.Gemmol., **15**, 9, 310-14, 3 figs, 1985.

Summarizes known facts on this rarest of opals including efforts to define the type more exactly. Carbon from bush fires is suggested as the cause of the black base-colour, but more research is needed on this. R.K.M.

BANK (H.). *Fast farbloser Olivin aus Sri Lanka.* (Nearly colourless olivine from Sri Lanka.) Z.Dt.Gemmol.Ges., **33**, 3/4, 139-40, 2 tables, bibl., 1984.

The author describes a nearly colourless olivine with very low RI 1.640-1.675, SG 3.2, and Fe content only 3.6% of the weight. The author was offered the stone as painite from Sri Lanka and is not absolutely sure of the correctness of the origin. E.S.

BENNETT (J.M.). *A guide to choosing facet rough.* Lapidary J., **38**, 11, 1472-5, 1985.

Advice is given to prospective purchasers of rough gem material. M.O'D.

BREITHAUPT (B.H.). *Goniobasis agate.* Rocks & Minerals, **58**, 5, 247, 1 fig., 1983.

In SW. Wyoming and NW. Colorado, layers of calcareous sediments rich in *Goniobasis* gastropods have been replaced by silica to form an attractive agate. The resulting dark brown to black rock with white fossiliferous markings is popular with lapidaries. The rock is commonly erroneously named turritella agate for its resemblance to the marine-dwelling *Turritella* gastropod. R.S.M.

BRIDGES (C.R.), GRAZIANI (G.), GÜBELIN (E.). *Ein neuer Edelstein aus der Feldspat-Familie.* (A new gemstone of the feldspar family.) Z.Dt.Gemmol.Ges., **33**, 3/4, 104-13, 8 figs in colour, 4 diagrams, 2 tables, bibl., 1984.

The new gem quality feldspar comes from Kioo Hill in Kenya. It occupies central parts of larger common feldspar crystals in a kyanite bearing pegmatite besides vermiculite and quartz. The new gem was found to be a low temperature albite with peristerite structure. RI 1.531-1.539, DR 0.008, SG 2.623 ± 0.002. E.S.

BROWN (G.). *Recording gemstone absorption spectra.* Aust.Gemmol., **15**, 9, 308-9, 2 figs, (1 in colour), 1985.

A brief account of the Snow photographic system for recording colour pictures of absorption spectra. It takes no account of the uneven spectral sensitivity of photographic film or of the inherent absorption of the emulsions. Thirteen spectra are illustrated, but some colours are entirely missing and the built-in scale seems to have a will of its own and wanders some 30nm up or down the spectrum. R.K.M.

BROWN (G.). *Synthetic or imitation: that is the question.* Aust.Gemmol., **15**, 9, 319-21, 1985.

An attempt to sort out the hair-splitting situation in the use of these terms. R.K.M.

CASSEDANNE (J.). *Au pays des émeraudes.* (In the emerald country.) Monde et Minéraux, 66, 16-20, 4 figs (2 in colour), 1985.

The emerald-producing areas of Brazil are reviewed and details given of locations and mining methods. M.O'D.

CHIKAYAMA (A.). *Gem occurrences in India.* Gemmological Review, **6**, 1, 2-7, 9 figs, 1984.

Chrysoberyl cat's-eye is found in the Trivandrum area in Kerala, most specimens being fairly small. Apatite cat's-eye is produced in small quantities from the Kangayam-Karur region, the stones being honey-yellow. Diopside cat's-eye comes from the same area; the stones are black tinged with green. Enstatite cat's-eye from the same area is brown-tinged black. Agate and jasper localities are also quoted. M.O'D.

CHIKAYAMA (A.). *New synthetic vanadium-doped emerald, Biron emerald.* Gemmological Review, **6**, 1, 10-12, 5 figs, 1984.

A synthetic emerald doped with vanadium as well as chromium and with RI 1.577, 1.570, DR 0.007, turned out to be a Biron emerald. SG was 2.72 and the stone displayed straight growth lines and liquid inclusions similar to those already seen in hydrothermal emeralds. M.O'D.

CHIKAYAMA (A.). *Seeking out the sources of some of the newer synthetic gems.* Gemmological Review, **6**, 2/3, 10-12, 1984.

The author discusses Ramaura ruby, C-Ox, Kashan ruby and some new Chatham material. Pink cubic hafnia is being made in the U.S.S.R. and sold as cut stones in the U.S.A. M.O'D.

CHIKAYAMA (A.). *Gem occurrences in India.* Gemmological Review, **6**, 4, 2-4, 7 figs, 1984.

The author discusses cornelian from Jhangadia, Gujarat, calcite from Aurangabad, Maharashtra state, a reported alexandrite occurrence in the Kangayam-Karur gem field in central-southern India. Some tourmaline, kyanite and apophyllite deposits are also quoted. M.O'D.

CHIKAYAMA (A.). *Gem occurrences in India.* Gemmological Review, **6**, 5, 2-5, 4 figs, 1984.

Yellow and brown sphene of gem quality comes from Mettur in Tamil Nadu; no green material has yet been found there. Sillimanite cat's-eye comes from the Bhandada area of Madhya Pradesh which also produces lazulite crystals. Analcime comes from the Poona area and samarskite from Tamil Nadu. Pearl localities are also given. M.O'D.

CHIKAYAMA (A.). *Boulder opal doublets.* Gemmological Review, **6**, 5, 12, 1984.

A boulder opal doublet is made from a white opal on a limonite base with a jagged join. Traces of a dark film of adhesive may be seen on magnification. The opal will show a characteristic bright bluish-white fluorescence under LWUV; this is rarely seen with true boulder opal. M.O'D.

CHIKAYAMA (A.). *Gem occurrences in Sri Lanka.* Gemmological Review: (a) **6**, 6, 2-5, 4 figs; (b) **6**, 7, 2-4, 2 figs; (c) **6**, 8, 2-6, 4 figs; (d) **6**, 9, 2-7, 8 figs; 1984.

(a) A short history of Sri Lanka is given. (b) and (c) The geology is described with a classification of the rock types. (d) The chief mining areas of Ratnapura, Buttala, Meetiyagoda, Pallegama and Kataragama are described. M.O'D.

CONNELLAN (M.), POZZEBON (L.). *Asterism – the great enigma: a study of Austrlian star sapphires.* Aust.Gemmol., **15**, 9, 295-9, 301-6, 9 figs (2 in colour), 1985.

A somewhat aggressive appraisal of asterism which, although extensively illustrated, is neither easy to follow nor completely rational. It seems to be suggested that the arms of a star run parallel with the length of the reflecting crystals, and that star stones are multi-crystalline. A diagram indicates 'Parallel bands of inclusions which act as condensers and store the electric field from incident light-rays which are annulled as they lose photons.' [This may make sense to the writers, but it does not do so to this abstracter.] R.K.M.

DEINES (P.), GURNEY (J.J), HARRIS (J.W.). *Associated chemical and carbon isotopic composition variations in diamonds from Finsch and Premier kimberlite, South Africa.* Geochimica et Cosmochimica Acta, **48**, 2, 325-42, 9 figs, 1984.

The carbon isotopic composition of 66 inclusion-containing diamonds from the Premier kimberlite, S. Africa, 93 inclusion-containing diamonds and four diamonds of two diamond-bearing peridotite xenoliths from the Finsch kimberlite, S. Africa, was measured. The data suggest a relationship between the carbon isotopic composition of the diamonds and the chemical composition of the associated silicates. For both kimberlites, similar trends are noted for diamonds containing peridotite-suite inclusions (P-type) and for diamonds containing eclogite-suite inclusions (E-type): higher $\delta^{13}C$ P-type diamonds tend to have inclusions lower in SiO_2 (ol), Al_2O_3 (opx, gt), Cr_2O_3, MgO, Mg/(Mg + Fe) (ol, opx, gt) and higher in FeO (ol, opx, gt) and CaO (gt). Higher $\delta^{13}C$ E-type diamonds tend to have inclusions lower in SiO_2, Al_2O_3 (gt, cpx), MgO, Mg/(Mg + Fe) (gt), Na_2O, K_2O, TiO_2 (cpx) and higher in CaO, Ca/(Ca + Mg) (gt, cpx). Consideration of a number of different models that have been proposed for the genesis of kimberlites, their xenoliths and diamonds shows that they are all consistent with the conclusion that in the mantle, regions exist that are characterized by different mean carbon isotopic compositions. R.A.H.

DEVRIES (R.C.), FLEISCHER (J.F.). *Synthesis of jadeite for jewelry.* General Electric Technical Information series report (class 1) 84CRD282, 15 pp, 1984.

Different colours of jadeite have been made both by high-pressure synthesis and by a method of reconstitution from natural jadeite powder. Pressures used were about 30-50kb, temperatures 1200-1400°C and the time taken for completion of growth ½ to 24h. M.O'D.

DIETRICH (R.V.). *Michigan's state stone and state gemstone.* Rocks and Minerals, **58**, 3, 97-8, 2 figs, 1983.

'Petoskey stone' is a coral (*Hexagonaria percarinata*) limestone that takes a high polish and is prized by lapidaries for making gems and ornaments. It consists of solid material showing roughly hexagonal-walled units, each with a central dark area from which radial lines extend outward to the walls. This rock was declared the official state stone of Michigan in 1965. The state gemstone (since 1972) is chlorastrolite, an attractive green, chatoyant variety of pumpellyite. R.S.M.

DORLING (M.), ZUSSMAN (J.). *An investigation of nephrite jade by electron microscopy.* Mineralog.Mag., **49**, 1, 31-6, 8 figs, 1985.

Specimens of tremolite and richterite were examined by TEM, the specimens having been ion-thinned. They contained clusters of very small lath-like crystallites with the z-axes roughly parallel but having a range of azimuthal orientations. The clusters may arise from post-tectonic recrystallization of strained amphibole crystals where the new crystals have their z-axes following those of the old. The toughness of nephrite is a function of a variety of submicroscopic features including the sizes and orientations of the crystallites and the nature of the grain boundaries. M.O'D.

EMMETT (J.L.). *Lapis lazuli, the gem of Afghanistan.* Lapidary J., **38**, 11, 1416-19, 2 figs (1 in colour), 1985.

A general survey of the occurrence and use of lapis lazuli with particular reference to the Afghanistan deposits and a note on its colour. M.O'D.

FRYER (C.W.), ed., CROWNINGSHIELD (R.), HURWIT (K.N.), KANE (R.E.). *Gem Trade Lab Notes.* Gems & Gemology, **XXI**, 1, 43-8, 17 figs in colour, 1985.

An amethyst, heated to lighten colour, was left too long and turned brownish-yellow; an almandine star stone had been cut as a cat's-eye by placing the star on the end of the cabochon; a large grossularite carving was identified by RI 1.72 and sinking in methylene iodide [Why not a hydrostatic weighing?]; damaged Mabe pearls evoke warnings of their extreme fragility; 'pearls' cut from hinges of bivalve shells incorrectly offered as 'hinge pearls' (they are shell); a multi-star quartz from Alabama is similar to Sri Lankan stars; Thai ruby had bubble inclusions superficially like those in a glass-filled ruby; a dark-blue doublet consisted of green synthetic spinel top and blue synthetic sapphire base, apparently cemented with super-glue [Difficult to know why such a fake was made]; finally a necklace sold as 'untreated turquoise' was found to be dyed magnesite. All are described and illustrated.

R.K.M.

GRUNDMANN (G.). *Die Mineralien des Smaragdvorkommens im Habachtal.* (Minerals of the emerald deposit in the Habachtal.) Lapis, **10**, 2, 13-33, 22 figs (19 in colour), 1985.

The minerals occurring with emerald, and emerald itself, are described in this exhaustive paper which is also well illustrated. M.O'D.

GUNAWARDENE (M.). *Die innere Paragenese von Taaffeiten aus Sri Lanka.* (The inner paragenesis of taaffeites from Sri Lanka.) Z.Dt.Gemmol.Ges., **33**, 3/4, 91-5, 6 figs in colour, 1 table, 1 map, bibl., 1984.

Taaffeites from eight different localities in Sri Lanka and their typical inclusions are described and shown in photographs. The varying localities produce taaffeites with characteristic inclusions of apatite, phlogopite, spinel, muscovite (?), zircon (?) and garnet (?). The taaffeites in Sri Lanka are found in regional metamorphic rocks together with spinels, corundums and chrysoberyls. E.S.

Heylman (E.B.). *Gem quality spinel in Nayarit, Mexico.* Lapidary J., **38**, 9, 1232, 1984.

A black spinel of gem quality is found in Mexico in the state of Nayarit. The spinel occurs in stream gravels, thought by the author to be in tributaries of the Rio Ameca. M.O'D.

Hoffmann (K.). *Aufnahme spektraler Remissionskurven von Brillanten und ihre farbmetrische Auswertung.* (Spectral remission curves of brilliant-cut diamonds and their usefulness in determining colour.) Z.Dt.Gemmol.Ges., **33**, 3/4, 96-103, 2 diagrams, 1 table, bibl., 1984.

Reflectance spectra of mounted and unmounted brilliant cut diamonds are obtained using a suitably modified double beam reflectance spectrophotometer interfaced with a computer for colorimetric evaluation. Beside the well-known Cape spectrum, many stones show a broader absorption band in the blue region by which the colour can be graded. For objective grading a colorimetric Yellowness Index is proposed, which is very concise and takes very little time. E.S.

Howie (R.A.). *Gemstones.* Transactions of the Leicester Library & Philosophical Society, **78**, 1, 22-7, 1 fig, 1984.

Notes for the author's peripatetic lecture, containing some philosophical (if not literary) musings on gemstones and their simulation, faking and 'value'.

(Author's abstract.) R.A.H.

Howie (R.A.), Pegram (E.), Walsh (J.N.). *The content of rare earth elements in English fluorites: a preliminary study.* Journal of the Russell Society, **1**, 1, 22-5, 1982.

Ten times more rare earth elements are found in fluorescent fluorites from the Weardale area of north-east England than in non-fluorescent material from Derbyshire. The distribution pattern of the REE also differs between localities. Eleven rare earths and yttrium were checked in eleven fluorites from different English localities and the results tabulated. M.O'D.

Hübner (G.). *Ein Kapitel Opalforschung aus dem 18.Jahrhundert.* (Research into opals in the 18th century.) Z.Dt.Gemmol.Ges., **33**, 3/4, 126-7, bibl., 1984.

An early publication by G.Ch. Beireis in the year 1791 on opal and the phenomenon of play of colours is discussed; the scientific content is considered outstanding for its time. The original publication, which took up only four pages of 30 lines each, dealt with the finds in the Carpathian mountains; the chemical composition was unknown at the time, but the author thought the play of colour to derive from a fine lamellar structure reflecting the light in such a way that the colour play is caused. He even spoke of recreating opals artificially. E.S.

Javoy (M.), Pineau (F.), Demaiffe (D.). *Nitrogen and carbon isotopic composition in the diamonds of Mbuji Mayi (Zaire).* Earth and Planetary Science Letters, **68**, 3, 399-412, 6 figs, 1 map, 1984.

The concentration and isotopic composition of N, measured in large diamonds (g size) from this kimberlite district of Zaire shows a large range of variation ($100 < N < 2100$ ppm; $-11.2 < \delta^{13}N < +6.0$). The ^{15}N-depleted N is associated with the higher N concentrations. The larger diamonds are individually rather homogeneous in ^{13}C (range of $\delta^{13}C < 0.9\%$) while variations occur within small octahedral diamonds from the same district (range $\leqslant 5.8\%$). The total range of $\delta^{13}C$ variations is about the same for the larger diamonds ($-10.5 < \delta^{13}C < -5.5$), the small octahedral diamonds ($-10 < \delta^{13}C < -4.6$) and the carbonates from local kimberlites ($-11.8 < \delta^{13}C < -5.5$). The diamond carbon isotope data could indicate a complex story of crystallization within a deep-seated system fractionating its carbon isotopes. The N results indicate that N in diamonds is, on average, markedly depleted in ^{15}N (weighted average -5.15%) relative to atmosphere, sediments and upper mantle.

P.Br.

Kane (R.E.). *A preliminary report on the new Lechleitner synthetic ruby and synthetic blue sapphire.* Gems & Gemology, **XXI**, 1, 35-9, 5 figs in colour, 1985.

Two specimens examined and appear to be either flux overgrowth on Verneuil seeds or a larger Verneuil synthetic encased in flux synthetic material and partially altered by the process. No divisions between the Verneuil and flux material were discerned. Process seems entirely different from that used by Lechleitner for emerald overgrowth. Both stones showed very marked wisp-like veil inclusions expected in most flux-grown synthetics. R.K.M.

Keller (P.C.), Koivula (J.I.), Gonzalo (J.). *Sapphire from the Mercaderes-Río Mayo area, Cauca, Colombia.* Gems & Gemology, **XXI**, 1, 20-25, 8 figs in colour, 1985.

A new source of gem sapphire visited in 1984. Further visit impossible due to political situation. Crystals are simple hexagonal prisms terminated by parting on (1000), mostly water-worn. Pastel shades; RI and SG normal for corundum; 457nm absorption line in most stones. Boehmite, rutile and apatite inclusions, colour- and growth-zoning and colour changes were found. R.K.M.

Koivula (J.I.), Fryer (C.W.). *Interesting red tourmaline from Zambia.* Gems & Gemology, **XXI**, 1, 40-2, 4 figs in colour, 1985.

Strongly birefringent, deep red crystals of tourmaline were found to be very similar to the rare deep red dravite tourmaline reported (1974) from Kenya, despite the two sites in the Great Rift Valley being 1000 km apart. R.K.M.

Koivula (J.I.), ed., Misiorowski (E.). *Gem News.* Gems & Gemology, **XXI**, 1, 57-60, 2 figs in colour, 1985.

Diamonds.

Australia – a new, potentially major find near Coanjula, Northern Territory.

Ontario Geological Survey encouraging diamond prospecting following find of Kimberlite boulders near Hearst.

Israel exported 2.3 million carats, mostly small cuts, in 1984.

Sierra Leone buys out B.P. share in National Diamond Mining Co. and gains total control.

Coloured stones.

Australia. New opal locality in northern N.S.W. has yielded a 574.09 carat rough which is known as the 'Big Black'.

Sri Lanka. Australian Haoma North West Group propose to mechanize gem mining on the island.

Turkey. C.A. Schiffmann reports a 157.66 carat gem quality diaspore from Mamaris in Mulga Province.

Precious Metals.

Reports quoted on gold from Colombia, Nova Scotia, Finland, Mali and China, while C.S.I.R.O. in N.S.W. has developed an ultra sensitive test for trace amounts of gold in water. Neutron activation analysis is claimed to detect 1 part in 3 trillion.

Synthetics.

The National Institute for Research in Inorganic Materials in Japan have announced growth of a 3.5 carat gem diamond in 200 hours. De Beers have also grown more large crystals.

Russian hydrothermal synthetic emeralds reported by F.H. Pough had RI 1.574-1.580, SG 2.67+ and unique chevron-shaped internal growth pattern. Iron doping suppresses fluorescence completely [so no response to UV wavelengths or through emerald filter].

Reports on Tucson 1985 Gem Convention, The World Congress of Jewelry Convention, and Hong Kong Jewelry and Watch Fair are printed. R.K.M.

LIND (Th.), SCHMETZER (K.), BANK (H.). *Schleifwürdige blaue und grüne Berylle (Aquamarine und Smaragde) aus Nigeria.* (Cuttable blue and green beryls (aquamarines and emeralds) from Nigeria.) Z.Dt.Gemmol.Ges., **33**, 3/4, 128-37, 13 figs (1 in colour), 2 tables, 2 graphs, bibl., 1984.

The gem quality beryls come from a newly discovered area near Jos in Nigeria. RI 1.570-1.574 to 1.564-1.568, SG 2.66-2.68. Colour zoning. Variable colours and colour intensities are caused by varying concentrations of V, Cr and Fe. Absorption spectra typical for blue beryl aquamarine (coloured by iron) and green beryl emerald (chromium and vanadium). Growth zoning is parallel to the basal pinacoid, the hexagonal dipyramid and parallel to the prism of the first order. Some two-phase inclusions were found. E.S.

MACFALL (R.P.). *Michigan and the Lapidary.* Rocks & Minerals, **58**, 3, 135-6, 5 figs, 1983.

The major gem materials found in Michigan include coral limestone ('Petoskey stone'), pumpellyite (the variety chlorastrolite), datolite (porcelain-like nodules), agates, thomsonite, prehnite, dolomite (pink, brecciated variety), verd antique, conglomerate, and jaspilite (alternating bands of red jasper and haematite). These and their localities are described. R.S.M.

MADSON (M.E.). *Wyoming Jade.* Rocks & Minerals, **58**, 5, 218-22, 5 figs, 1 map, 1983.

The jade (nephrite) fields of central Wyoming include the following areas: Crooks Mountain, Bull Canyon, Pathfinder Reservoir, Horse Creek, and Granite Mountains. The major colours are apple-green, black, olive-green, and snowflake. The latter variety consists of nephrite with coarse-grained tremolite, quartz, epidote or zoisite, and albite. A pink jade owes its colour to zoisite (thulite) and a white jade-like rock is composed primarily of quartz and albite. Three important modes of

occurrence of jade in this area include float, vein and fissure fillings, and ellipsoidal pods. Comments are given on the history and modern development of the deposits.
R.S.M.

MIZOHATA (K.). *Gemmological excursion to Tono.* Gemmological Review, **6**, 7, 5-12, 7 figs, 1984.

This area in Japan is particularly celebrated for topaz crystals which are found in pegmatites. Supplies are now scarce. M.O'D.

NASSAU (K.). *Altering the colour of topaz.* Gems & Gemology, **XXI**, 1, 26-34, 7 figs in colour, 1985.

The past decade has seen the production of deep blue topaz in great quantity. Obviously a treated colour and not a new source. The author and others have established that this colour is the result of irradiation by various sub-atomic particles, followed by heating. Heat treatment of yellow and brown topaz to pink and red is also discussed. R.K.M.

NASSAU (K.). *The early history of gemstone treatment – 1.* Lapidary J., **38**, 11, 1406-12, 9 figs (7 in colour), 1985.

The origins of gemstone treatment are discussed, the text of the article being taken from the author's *Gemstone Enhancement* (Butterworths, London 1984).
M.O'D.

NAZELROD (E.). *Turquoise, inside and out.* Lapidary J., **38**, 9, 1152-90, 1984; **38**, 10, 1304-19, 1985; 24 figs.

A useful survey of turquoise with particular reference to American material and with notes on marketing. M.O'D.

O'DONOGHUE (M.). *The literature of mineralogy – 10.* Gems & Mineral Realm, **16**, 3, 37-9, 3 figs, 1985.

The large illustrated work by Victor Goldschmidt, *Atlas der Krystallformen*, Heidelberg, 1913-1923, 9 vols, is discussed with reproductions and access to large libraries reviewed. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *New light on some old gem friends – spinel.* Gems & Mineral Realm, **16**, 3, 41, 1985.

An overview of the spinel group of gemstones. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *Some beryl minerals – 3.* Gems & Mineral Realm, **16**, 3, 42, 1985.

The minerals herderite, vayrynenite and roscherite are described.
(Author's abstract.) M.O'D.

O'DONOGHUE (M.). *Man-made gemstones.* Gems & Mineral Realm, **16**, 3, 43, 1985.

The Ramaura synthetic ruby is described, followed by a note on the absorption spectrum of treated diamonds and of treated yellow sapphire.
(Author's abstract.) M.O'D.

O'DONOGHUE (M.). *The dealer looks at gemstones – 14.* Gems & Mineral Realm, **16**, 3, 44-8, 1985.

The work and writing of Louis Kornitzer are discussed with notes on David Jeffries' *Treatise on diamonds and pearls* (4th edition, 1871), parts of which, dealing with the method then in operation of pricing diamonds, are reproduced.

(Author's abstract.) M.O'D.

PETERSEN (V.), SECHER (K.). *Grönland.* (Greenland.) Magma, 6/84, 3-80, 48 figs in colour, 1984.

A general survey of the mineralogy of Greenland in which several gem species make their appearance. They include tugtupite, ruby, moonstone, lapis lazuli, kornerupine and a fuchsite-bearing quartz, locally known as 'greenlandite' and darkish-green in colour. M.O'D.

PROCTOR (K.). *Gem pegmatites of Minas Gerais, Brazil: The tourmalines of the Araçuaí Districts.* Gems & Gemology, **XXI**, 1, 3-19, 16 figs in colour, 1985.

The second of a series, this deals with mines in the Araçuaí-Salinas districts. Gem crystals found in green, blue, red and other colours, often particoloured, in pegmatite lenses in different localities with topaz, beryl and other minerals. Some pegmatite is hard and unaltered, others in various states of decomposition down to kaolin. R.K.M.

RAMSEY (J.L.). *Pink and precious.* Lapidary J., **38**, 10, 1298-302, 9 figs in colour, 1985.

Red and pink tourmaline, kunzite, pink diamond and pink sapphire are discussed. M.O'D.

SEGNIT (E.R.). *Australian gemstone deposits.* Z.Dt.Gemmol.Ges., **33**, 3/4, 114-25, bibl., 1984.

A general survey of Australian gemstone deposits including history, formation and occurrence, types of gem materials and resources. The more important Australian gems are described and these include opal, sapphire, diamond, emerald, ruby, aquamarine, topaz, zircon, iolite, nephrite, andalusite, tourmaline, garnet, rhodonite, bustamite and a number of quartz varieties such as rock crystal, smoky quartz, amethyst, chrysoprase, tiger's-eye and petrified wood. Many other gemstones have been found in small quantities and the author believes that the future will discover many more and bigger finds. E.S.

SNOW (J.), BROWN (G.). *A red Hi-Superbright LED refractometer light source.* Aust.Gemmol., **15**, 9, 322-4, 1 fig, 1985.

R.L. Burns has suggested the use of a Hi-Superbright ESBR 5001 (Stanley) LED for refractometer readings. This gives about four times more light than a six unit sodium range LED, but is spread from 620 to 690nm. This use of longer wavelengths actually raises the RI readings by about one in the third (estimated) place of decimals. This is not explained although it is known that longer wavelengths are refracted less. The use of such a light-source seems to be acceptable, since trial tests by gemmologists showed that the red readings were only 0.001 too high and well within the normal margin of error expected in third place observations by different individuals. It is suggested that a small correction could be made, but in abstracter's opinion this would hardly be necessary. R.K.M.

THIMES (J.L.). *Ivory identification*. Lapidary J., **38**, 10, 1320-7, 25 figs, 1985.

A useful and comprehensive guide to ivory and its identification. M.O'D.

WEISE (C.). *Bergkristall-Lagerstätten in Goias und Minas Gerais, Brasilien*. (Rock crystal locations in Minas Gerais and Goias, Brazil.) Lapis, **10**, 3, 13-22, 19 figs (13 in colour), 1985.

The deposits discussed are at Corinto and Diamantina, Minas Gerais and at Niquelandia and San Luis do Tocantins, Goias. M.O'D.

WOENSDREGT (C.F.), WEIBEL (M.), WESSICKEN (R.). *Electron microscopical investigation of oriented magnetite and amphibole in black star diopside*. Schweiz.Mineralog. Petrograph.Mitteilungen, **63**, 2/3, 167-76, 3 figs, 11 photos, 1983.

Investigating the cause of four-fold asterism in black star diopside from Namakkal, Tamil Nadu, India, the authors conducted TEM determinations. The diopside contains oriented inclusions of magnetite parallel to [010] of the diopside host. Magnetite blades cause the asterism effect when the diopside is cut 'en cabochon', perpendicular to its *b*-axis. There are two different orientations of magnetite inclusions, both having [110] of the magnetite parallel to [010] of diopside. While the "Z' type of inclusions have $[111]_{Mt} \| [100]_{Di}$ the "X' type of inclusions are $[111]_{Mt} \wedge [100]_{Di} = 6°$. The oriented inclusions of amphiboles are of minor importance and do not contribute to asterism. W.S.

ZEITNER (J.C.). *Gems named for their colors*. Lapidary J., **38**, 11, 1392-8, 4 figs, 1985.

Some gem name derivations are given but care should be taken since some at least of the derivations are inaccurately referred to classical roots. M.O'D.

ZWAAN (P.C.). *Sapphires and other gems from Sri Lanka*. Proceedings of the International Precious Stone Congress, Tel Aviv, April 10-14, 1983, 8-10, 1983.

Blue sapphire is the most important Sri Lankan gemstone but it is worked only in alluvial deposits. Notes are given on the various localities, mining and cutting methods, and on the other Sri Lankan gemstones; the latter include moonstone (the best from Meetiyagoda), chrysoberyl, spinel, and zircons of various colours (often called tourmalines). R.A.H.

Argyle Diamond Mines Joint Venture. The Rio Tinto Zinc Corporation PLC Annual Report and Accounts (1984), 16-17, one fig. in colour, 1985.

Alluvial ore processed was 38% more than in 1983. Work aimed at production from the kimberlite pipe in early 1986 was more than 50% complete. J.R.H.C.

BOOK REVIEWS

CHHOTILAL (K.). *Diamonds from India.* Revised edn. Gem & Jewellery Export Promotion Council, Bombay, 1984. pp. x, 102. Illus. in black-and-white. Price on application.

An excellent overview not only of Indian diamonds, both industrial and gem, but of the diamond trade in general. Details of the polishing process are given as well as a corpus of useful statistics covering exports from India. M.O'D.

DEWANI (M.D.). *The magic of Indian diamonds.* Gems & Jewellery Export Promotion Council, Bombay, 1984. pp. vii, 36. Illus. in black-and-white and in colour. Price on application.

A short account of Indian diamond production with illustrations of famous stones and some statistics. M.O'D.

NG (J.Y.), ROOT (E.). *Jade for you: value guide to fine jewelry jade.* Jade N Gem Corporation, Los Angeles, 1984. pp. 107. 42 black-and-white illus. and 61 in colour. $45.00.

This book attempts to carry out exactly what its title implies. It relies upon a series of good photographs and a step by step scheme of evaluation.

Following introductory chapters on the jade materials and history, the authors set out their main theme on jade assessment. The beauty of jade is divided into the following elements: colour and tone, texture, translucency or clarity, desirable shape or balance, size and dimensions, polish and finish (which includes the matching or graduation in the case of pairs or beads). A series of explanatory colour photographs follows. Simulants and dyeing are covered next. The detailed evaluation scheme follows – with imaginary examples and a series of photographs illustrating the inspection procedure. Finally there is a comprehensive colour chart illustrating cabochons of various grades and colours with a key showing suggested 1984 prices based upon experience in Hong Kong and U.S.A.

This is a well-produced book amply illustrated with colour photographs, which possibly tend to be a little bright. At $45 it is expensive in Europe, but it should be on the bookshelves of anyone with a serious interest in jade. E.A.J.

Synthesis, crystal growth and characterization. North-Holland Publishing Company, Amsterdam, 1982. pp. xii, 568. Illus. in black-and-white. US$61.00.

This useful volume contains the proceedings of the International School on Synthesis, Crystal Growth and Characterization of Materials for Energy Conversion and Storage, held on 12th to 23rd October, 1981, at the National Physical Laboratory, New Delhi. It comprises papers of a basic nature, designed to present the topic to those whose speciality may be different. The first paper reviews developments in crystal growth and lattice imperfection studies over a period of 30 years; it is followed by papers on the growth and characteristics of crystals with valence instabilities. Succeeding papers review hydrothermal and other techniques with some useful notes on the growth of oxides with very high melting points, including zirconia and hafnia. The remainder of papers deal with characterization and these are useful without breaking very much new ground. An interesting final paper, by Professor D.S. Kothari, comments on the relationship between modern physics and Syadvada. M.O'D.

ASSOCIATION NOTICES

OBITUARY

Mr Tom Ratcliffe, F.G.A. (D.1936), Buxton, died on 13th March, 1985.

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to the following for their gifts:

Mr R. Holt, F.G.A., London, for rough stones, including pieces of zircon from China, corundum from East Africa, aquamarine from Nigeria and indicolite from South Africa.

Miss P. Lapworth, F.G.A.A., Guildford, Surrey, for sets of the *Australian Gemmologist* for 1983 and 1984.

Mr Ben H. Smith, Jr, F.G.A., Wilmington, North Carolina, U.S.A., for the following: (1) *Mineral collecting sites in North Carolina*, by W.F. Wilson and B.J. McKenzie, Geological Survey Information Circular 24, North Carolina Department of Natural Resources and Community Development (Geological Survey Section), Raleigh, N.C., 1978; (2) *Gold Resources of North Carolina*, by P. Albert Carpenter, III, Information Circular 21, North Carolina Department of Natural and Economic Resources (Office of Earth Resources, Division of Mineral Resources), Raleigh, 1972: (3) mica sheet enclosing flattened garnet, from Mitchell and Yancey Counties, North Carolina: (4) tourmaline in matrix from Crabtree Emerald Mine, Little Switzerland, North Carolina: (5) piece of corundum from Waywood County, North Carolina: (6) piece of a hiddenite crystal from North Carolina: and (7) smoky quartz from North Carolina faceted by the donor.

E.A. Thomson (Gems) Ltd, London, for a piece of silkium (bought from a company making solar panels).

NEWS OF FELLOWS

On 15th April, 1985, Mr M.J. O'Donoghue, M.A., F.G.S., F.G.A., gave a talk on 'The gemstone business' to the Sevenoaks Branch of the British Red Cross.

MEMBERS' MEETINGS

London

On 23rd April, 1985, at the Flett Theatre, Geological Museum, Exhibition Road, London S.W.7., Dr J.W. Harris gave an illustrated talk entitled 'A geologist's perception of diamond'.

On 28th May, 1985, at the Flett Theatre, following the Annual General Meeting (see p. 643) Mr M.J. O'Donoghue, M.A., F.G.S., F.G.A., gave a talk entitled 'The geology of gemstone deposits'.

Midlands Branch

On 29th March, 1985, at Dr Johnson House, Bull Street, Birmingham, Mr G. Jones gave an illustrated talk on microphotography.

On 26th April, 1985, at Dr Johnson House, the Annual General Meeting was held at which Mr C.L. Hundy, F.G.A., and Mr D.M. Larcher, F.G.A., were re-elected Chairman and Secretary respectively.

North West Branch

On 20th June, 1985, at Church House, Hanover Street, Liverpool 1, Mr C.R. Cavey, F.G.A., gave a talk entitled 'Gem crystals, their forms, collectability and associations'.

South Yorkshire & District Branch

On 25th April, 1985, at Sheffield City Polytechnic, a practical evening was held with emphasis on the recognition of diamond.

ANNUAL GENERAL MEETING, 1985

The 54th Annual General Meeting of the Association was held on Tuesday, 28th May, 1985, at the Flett Theatre, Geological Museum, Exhibition Road, London S.W.7.

The Chairman, Mr David Callaghan, F.G.A., opened the meeting by welcoming Mr Howard Rubin, an Ordinary Member, from New York and then expanded on some of the items in the Annual Report, adding the announcement that the Basil Anderson Appeal he had launched in November to raise a fund of £25000 for the purchase of the Basil Anderson Spectrophotometer had nearly reached £20000. 'We are determined to reach the £25000 total', he said, 'but as a result of the substantial amount we have raised the instrument is now installed in the British Gem Testing Laboratory and is in use.'

After thanking Mr John Chisholm for his years of editorship of the *Journal*, the Chairman announced Mr Chisholm's impending retirement at the end of the year, after which the *Journal* would be in the sole charge of Mr Alan Jobbins as Editor.*

Last year it was hoped that the newly designed Correspondence Course in Gemmology would be ready for 1985, but it had been decided to start the Preliminary Course in September 1986 and the Diploma Course in 1987. A Gem Diamond Course was being developed, which would be launched in 1986.

The Association now had three branches—Midlands Branch, North-West Branch and South Yorkshire & District Branch—which held regular meetings of their own, and the Branch Chairmen attended Council Meetings.

Continuing, Mr Callaghan forecast that some interesting new instruments would become available in the next month or so. 'We are always looking to the future', he said. 'It holds a big development for this Association in the not too distant

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*See page 549 above, lines 16 to 20.—Ed.

future. We are approaching the end of our tenure at our present premises. In the next year or so, you will be hearing more about this.'

Mr Nigel Israel, F.G.A., the Honorary Treasurer, then presented his financial report with charts on a screen and the adoption of the Report and Accounts was duly proposed, seconded and carried.

Sir Frank Claringbull, Mr David Callaghan, Mr Noel Deeks and Mr Nigel Israel were then re-elected as President, Chairman, Vice-Chairman and Honorary Treasurer respectively: Messrs C. Cavey, L. Cole, P. Daly, A. Hodgkinson, C. Jones and A. Round were re-elected and Mr Robert W. Croydon, F.G.A., and Mr G. Neary, F.G.A., were elected to the Council.

Messrs Ernst & Whinney were re-appointed Auditors, and the proceedings then terminated.

COUNCIL MEETING

At the meeting of Council held on the 28th May, 1985, at the Flett Theatre, Geological Museum, Exhibition Road, London S.W.7., the business transacted included:

(1) receipt of a report from the Chairman that the Basil Anderson Appeal fund stood at £19,111 to date;

(2) decision to increase the subscription for 1986 for all members of the Association (whether Fellows, Associate or Ordinary Members) (a) if residing in the United Kingdom to £25 and (b) if residing outside the United Kingdom to US$50; and

(3) the election to membership of the following:

FELLOWSHIP

Duckett, Karen L., Long Preston. 1984
Banks-Lyon, Rodney, Bristol. 1984
Lui, Elizabeth S-H., Kowloon, Hong Kong. 1984
Malkani, Monica, Bombay, India. 1984
Smiley, Laurianne, Dublin, Ireland. 1982
Zwyssig, Urs, Bangkok, Thailand. 1984

ORDINARY MEMBERSHIP

Calvino, Esperanza, New York, N.Y., U.S.A.
Green, Margaret D.V., Haverfordwest.
Heibrandt, L. Peter, Bro, Sweden.
Hoi, Josephine B.S., London.
Judge, Susan D., Pinecrest, Hong Kong.
Lam, Angela F-H., Shatin, N.T., Hong Kong.
Lippiatt, Irene, Perth, W. Australia.
Lisgarten, John N., Chatham.
Macan Markar, Noorul N., Colombo, Sri Lanka.
Merk, Roger L., San Diego, Ca, U.S.A.
Mohiudin, Syed M., Oman.
Monnas, Edith S., Athens, Greece.
Perera, Cabandugamage L., Colombo, Sri Lanka.
Pongratz, Richard I., Arlington, Tex., U.S.A.
Powell, Warren, Prestwich.
Samaranayake, Ravinda, Colombo, Sri Lanka.
Shah, Nilesh D., Nairobi, Kenya.
Taylor, Anne R.E., Poole.
Tsekouras, Basilio, Athens, Greece.

REPORT ON I.C.A. CONGRESS, IDAR-OBERSTEIN, 1985

The first Congress of the International Colored Gemstone Association was held in Idar-Oberstein from 20th to 22nd May. Some two hundred delegates—dealers, miners and gemmologists—from twenty-six countries attended. The Gemmological Association of Great Britain was represented by Chairman David Callaghan, Chief Examiner Alan Jobbins and Deputy Secretary Jonathan Brown. A team from G.I.A. included Chairman Richard Liddicoat and Vice-President Robert Crowningshield. Among the delegates were Dr Edward Gübelin, famous for his research into gemstone inclusions, Dr Hermann Bank and Mike Roman, of Jewelers of America.

I.C.A. was born largely as a result of the world recession and its effects on the international gem market. For some time the industry has laboured in a trough, beset by increasing problems such as how to deal with new synthetics and treatments, and how to react to the possible extension of the trade into the investment market. Exploratory sessions in 1983 led to a major meeting of dealers in Acapulco early in 1984.* There the resolution was taken to form I.C.A. with the primary aim of promoting the sale of coloured gemstones. Roland Naftule, of Nafco Gems, Phoenix, U.S.A. has worked tirelessly to bring the trade together in this new Association, which owes much to his vision and tenacity. I.C.A. is now to be constituted as an entity under Swiss law, because, says Roland Naftule, that system can best give effect to a democratic constitution, ensuring that the Association responds accurately to the consensus of its membership.

Congress sessions dealt with the major promotional aims of I.C.A., education relative to marketing, gemstone treatments, synthetics, colour nomenclature and grading, investment and appraisal, and international trade and regulations. It was a crowded programme interspersed with much informal discussion and an ambitious entertainment programme. Sessions were lively and exchanges sometimes heated, but observers were impressed by the remarkable extent of agreement that was achieved on all major issues.

Congress did not duck the controversial issues. Maurice Shire, of New York, who generally enhanced proceedings with his forthrightness and wit, called on the Congress to condemn roundly any extension of the coloured gem trade into the investment field. This it did by an overwhelming majority.

Trade ethics were to the fore at several points, but there was a less clear line on the problem of disclosure in relation to treated gemstones. Clearly the heat treatment of corundum was in the minds of all the delegates, and the general opinion appeared to be that almost all corundum gems now coming on the market have been heat treated to enhance their colour. This treatment is permanent and is not required to be disclosed under the terms of the articles of the C.I.B.J.O. Code, which I.C.A. has adopted. Some dealers remained worried by the situation, and strong feelings were expressed in various quarters that full disclosure should be made to the trade and the consumer in all cases where stones are treated. There was deep division over the status of oiled emeralds and complex questions were raised over what the position should be if oiling was developed with a coloured oil, the effect of which would be permanent.

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*See p.288 above.—Ed.

On the question of colour communication and grading, a session chaired by Alan Jobbins, it was generally agreed that dealers used to doing business with each other tended to develop a workable colour language of their own. The real problem was communicating down the chain of supply with retailers and consumers. Something should be done towards establishing a colour communication system that would overcome the difficulty, although the technical problems involved had been outlined eloquently in a presentation by Stuart Robinson, of New York. Congress was against the idea of grading certificates for coloured gemstones, but many feared that a widely adopted colour communication system would inevitably lead on to grading and certificates.

Robert Crowningshield, of the G.I.A., gave an entertaining presentation on the current state of affairs over synthetic gemstones. The distinguished panel for this session included Dr Bank and Dr Gübelin. There was much debate on detection methods for some of the new synthetic corundums, and delegates were obviously uneasy about the problems posed by some of these. Dr Henry Hänni, of Zurich, was more confident than most on the issue of detection, stating that about 90 per cent. of the new synthetic corundums could be identified as such by studying their inclusions with an ordinary gemmological microscope. Dr Gübelin was more cautious and felt that traders should make much greater use of the laboratories in their own countries. Congress thoroughly disapproved of such descriptions as 'cultured' being applied to synthetics.

The promotion of the industry is the chief aim of I.C.A., and its leaders have gone on record to the effect that they want the organization to promote coloured gemstones in a way similar to De Beers' world-wide promotion of diamonds. The intensity with which the new association has been formed suggests that this may not be an unreal ambition. Certainly a very positive start has been made, and when Roland Naftule called for donations to a promotional fund, dealers rose to their feet amid resounding applause and pledged nearly a hundred thousand dollars as a 'fighting fund'.

Debate on the subject of promotion extended into the area of education in a session on education relative to marketing, which was chaired by Jonathan Brown. Douglas Hucker, of the U.S.A., gave a stimulating presentation and many issues were explored. The need to educate both trade and consumer was recognized and many ideas were put forward as to how this might be done. It was agreed that support should be given to gemmological and trade associations in members' countries, and that consideration should be given to the use of pamphlets and brochures as an alternative way of disseminating information.

Apart from the Congress sessions, there was an extensive programme of committee meetings, and the board of directors was appointed on the nominations of Congress. The elected officers of I.C.A. are Roland Naftule (U.S.A.) President, Rashmikant Durlabhji (India) First Vice-President, Konrad Wild (West Germany) Second Vice-President, Stuart Robinson (U.S.A.) First Secretary, Israel Eliezri (Israel) Second Secretary, Claud Barguirdjian (France) Treasurer.

HARROW COLLEGE OF FURTHER EDUCATION
GEMMOLOGY COURSE

A 30 week course in gemmology for the preliminary examination will commence on Monday, 30th September (afternoon or evening) at Harrow College of Higher Education, Northwick Park, Harrow, HA1 3TP. The lectures will be given by Mr F. A. Fryer, B.Sc, C.Chem., M.R.S.C., F.G.A, from whom further details may be obtained.

LETTER TO THE EDITOR

From R. Keith Mitchell, F.G.A.

Dear Sir,

Mr E. Gamini Zoysa, of the State Gem Corporation, Sir Lanka has given us an interesting and well illustrated account of the recent find of colourless enstatite in the Embilipitiya region of his country.

A single small crystal has come into my possession for a few days, and I am very surprised indeed to find that an almost colourless enstatite (off-white would be my description of it) shows the 506nm sharp absorption line and a less clear broad band centred at 546nm. The 506 line is well known in both green and brown enstatites, but to find that it survives even in the colourless material is something unexpected. Strong spectra in colourless stones are the exception rather than the rule. This particular specimen gives RI of 1.654 and 1.663, slightly lower than the figures quoted by Zoysa and fractionally lower than the lowest figures quoted in Herbert Smith's *Gemstones*. Dana Ford gives even lower figures for an artifically produced pure enstatite. Mr Zoysa mentions that 1% of iron was found in these stones, but he did not mention the absorption pattern, which is after all a valuable testing factor.

Yours etc.,
R. KEITH MITCHELL

Orpington, Kent.
15th April, 1985.

CORRIGENDA

On p.482 above, the reference at the end of the footnote should read '(7,8)'

On p.483 above, 3rd para., line 1, for 'Kniscka' read 'Knischka'

On p.493 above, top left-hand corner of Fig. 4, for '130' read '100'

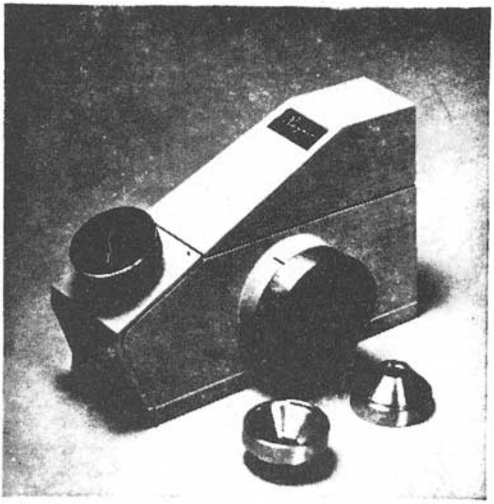
On p.529 above, in line 13, for '1948/2' read '1984/2'

On p.532 above, in 2nd line from foot, for 'iiis' read 'is'

On p.537 above, in 12th line from foot, for 'First-sized' read 'Fist-sized'

On p.546 above, in first line of 3rd Book Review, after 'New York' add ', 1983'

On p.553 above, in line 20, for 'produced' read 'produce'



Historical Note

The Gemmological Association of Great Britain was originally founded in 1908 as the Education Committee of the National Association of Goldsmiths and reconstituted in 1931 as the Gemmological Association. Its name was extended to Gemmological Association of Great Britain in 1938, and finally in 1944 it was incorporated in that name under the Companies Acts as a company limited by guarantee (registered in England, no. 433063).

Affiliated Associations are the Gemmological Association of Australia, the Canadian Gemmological Association, the Gem and Mineral Society of Zimbabwe, the Gemmological Association of Hong Kong, the Gemmological Association of South Africa and the Singapore Gemologist Society.

The *Journal of Gemmology* was first published by the Association in 1947. It is a quarterly, published in January, April, July, and October each year, and is issued free to Fellows and Members of the Association. Opinions expressed by authors are not necessarily endorsed by the Association.

Notes for Contributors

The Editors are glad to consider original articles shedding new light on subjects of gemmological interest for publication in the *Journal.* Articles are not normally accepted which have already been published elsewhere in English, and an article is accepted only on the understanding that (1) full information as to any previous publication (whether in English or another language) has been given, (2) it is not under consideration for publication elsewhere and (3) it will not be published elsewhere without the consent of the Editors.

Articles published are paid for, and a minimum of 25 prints of individual articles may be supplied to authors provided application is made on or before approval of proofs. Applications for prints should be made to the Secretary of the Association—not to the Editors—and current rates of payment for articles and terms for the supply of prints may be obtained also from the Secretary.

Although not a mandatory requirement, it is most helpful if articles are typed (together with a carbon copy) in double spacing on one side of the paper, with good margins at sides, top and foot of each page. Articles may be of any length, but it should be borne in mind that long articles are more difficult to fit in than short ones: in practice, an article of much more than 10 000 words (unless capable of division into parts or of exceptional importance) is unlikely to be acceptable, while a short note of 400 or 500 words may achieve early publication.

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Gemmological Association of Great Britain
Registered Office: Saint Dunstan's House, Carey Lane, London EC2V 8AB

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