The Journal of Gemmology

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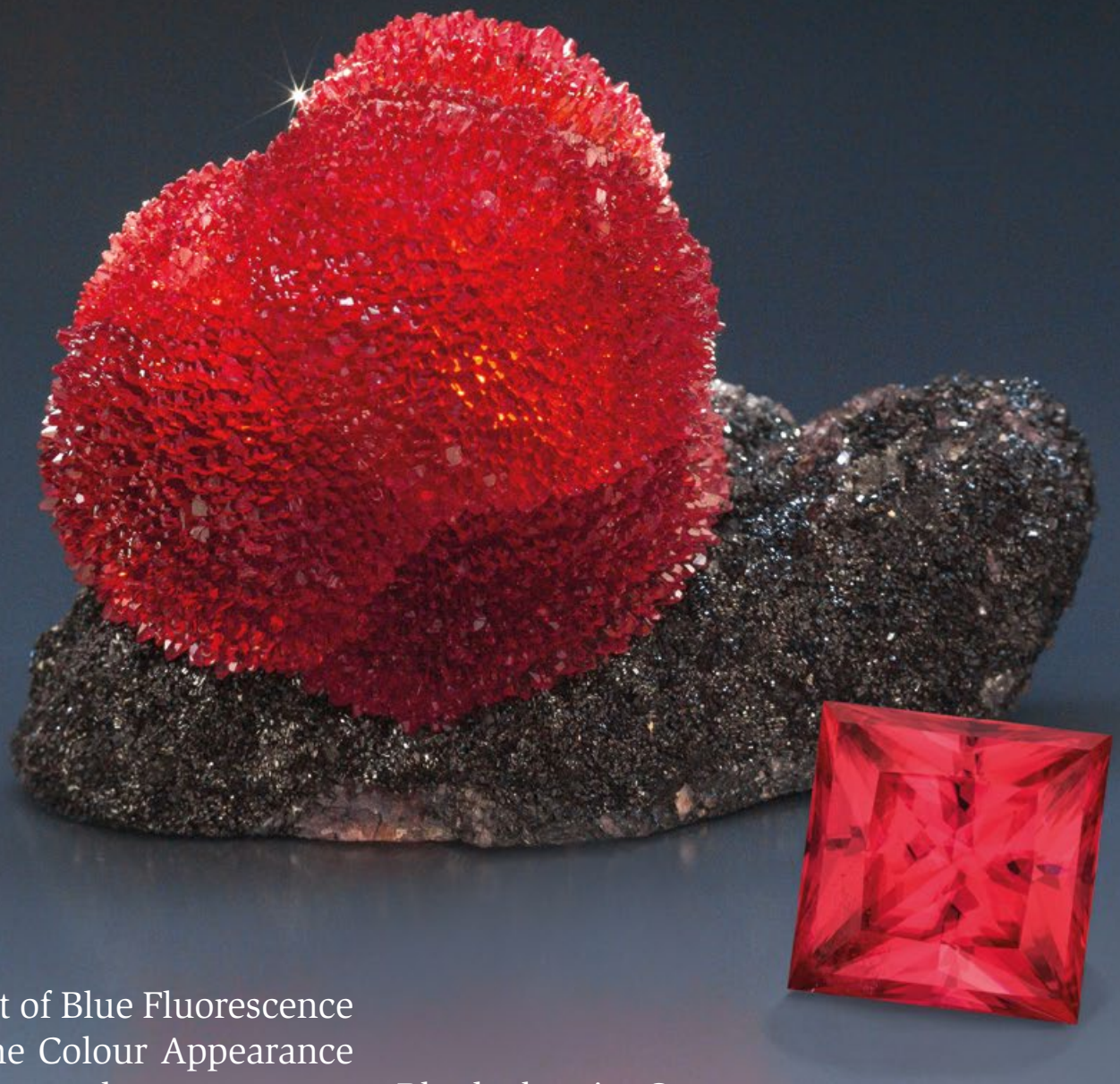

Effect of Blue Fluorescence on the Colour Appearance of Diamonds

Rhodochrosite Gems

The Hope Diamond in London

Unstable Colouration of Padparadscha-like Sapphires

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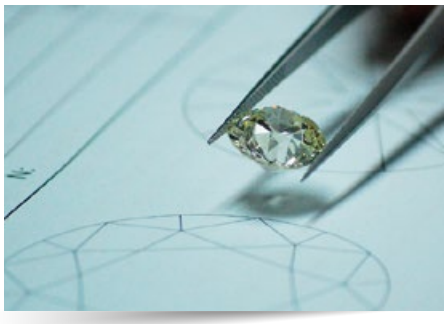

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Cover photo: *Rhodochrosite is prized as both mineral specimens and faceted stones, which are represented here by 'The Snail' (5.5 × 8.6 cm, from N'Chwaning, South Africa) and a 40.14 ct square-cut gemstone from the Sweet Home mine, Colorado, USA. For more on rhodochrosite, see the article on pp. 332–345 of this issue. Specimens courtesy of Bill Larson (Pala International/The Collector, Fallbrook, California, USA); photo by Ben DeCamp.*

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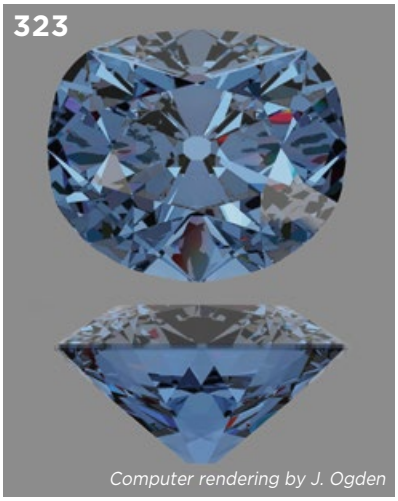

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The Journal of Gemmology

CONTENT SUBMISSION

The Editor-in-Chief is glad to consider original articles, news items, conference/excursion reports, announcements and calendar entries on subjects of gemmological interest for publication in *The Journal of Gemmology*. A guide to the various sections and the preparation of manuscripts is given at www.gem-a.com/index.php/news-publications/publications/journal-of-gemmology/submissions, or contact the Editor-in-Chief.

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What's New

INSTRUMENTATION

J-Smart

The newest, 6th generation J-Smart scanner from DRC Techno (Dharmanandan Research Center, Surat, India) was released in mid-2018, and identifies both CVD and HPHT laboratory-grown diamonds. It supersedes DRC Techno's J-Secure technology (see What's New section, Vol. 35, No. 4, 2016, pp. 271–272), and this version of J-Smart has a smaller footprint and provides faster results (90 seconds) than the previous model. The instrument can be used to screen loose or mounted diamonds 0.003 ct and larger of any shape in D through J colours. The 9 × 5½ inch (23 × 14 cm) scanning tray allows for large-scale examination of store inventories or manufacturing production. Visit www.drctechno.com/Products.aspx.

SciAps Handheld LIBS Unit

In February 2018, USA-based SciAps Inc. released its latest version of the handheld laser-induced breakdown spectroscopy instrument called the Z-300. The unit has three spectrometers for a range of 190–950 nm, making it capable of measuring every element in the periodic table from H to U. It comes with Android OS software that allows the user to customise calibrations for a variety of materials. As for all LIBS devices, a certain amount of material is vaporised, in this case with a 100 µm spot size. The unit has a replaceable cartridge to provide an argon purge to boost the signal, which is especially valuable for measuring light elements. The instrument weighs 1.8 kg with the battery and measures ~21 × 29 × 12 cm. Visit www.sciaps.com/libs-handheld-laser-analyzers/z-300.

SYNTHdetect XL

The International Institute of Diamond Grading & Research, part of the De Beers group of Companies, announced the latest generation of its synthetic diamond screening device in September 2018. Like its predecessor (see What's New section, Vol. 35, No. 8, 2017, p. 688), the 'XL' model uses time-resolved photoluminescence to screen colourless to near-colourless loose and mounted diamonds. The new model, however, can process multiple items at a faster rate and accommodates larger jewellery pieces. Visit www.debeersgroup.com/media/company-news/2018/iidgr-introduces-synthdetect-xl.

NEWS AND PUBLICATIONS

Bursztynisko, The Amber Magazine

The September 2018 issue (No. 42) of *Bursztynisko* is now available at https://issuu.com/international amberassociation/docs/bursztynisko_42_internet. Articles include a history of the Bursztyny cooperative, where amber artefacts were produced for over a century; the oldest surviving description of animal inclusions in Baltic amber; assorted short notes on amber specimens, jewellery and events; reports on notable recent exhibitions and promotions worldwide; and mid-infrared spectroscopy testing of resins.

De Beers *Diamond Insight Report 2018*

This annual report from De Beers covers major trends in the diamond value chain based on 2017 data. Demand for diamond jewellery continued to rise in 2017, primarily driven by the USA and China. Midstream trading stabilised following monetary changes that affected the Indian cutting/polishing industry, while diamond production worldwide in 2017 increased 14% over 2016. Analysis of the market indicates a need for the industry to align with the desires and values of Millennials and Generation Z. Download the report at www.debeersgroup.com/reports/insights/the-diamond-insight-report-2018.

cibjo The World Jewellery Confederation

CIBJO 2018 Special Reports

In August–October 2018, CIBJO released eight Special Reports in advance of the 2018 CIBJO Congress. The Coloured Stone Commission report covers responsible practices. The Coral Commission report surveys various topics related to sustainability and education. The Diamond Commission report looks at terminology used to distinguish natural from synthetic diamonds. The Ethics Commission report focuses on the impact on the jewellery industry of the revised Guides released by the U.S. Federal Trade Commission. The Gemmological Commission report gives results of a survey of worldwide gem labs about how they report on synthetic and treated diamonds. The Marketing & Education Commission report focuses on the impact on the jewellery market of Generation Z. The Pearl Commission report looks at the industry's commitment to marine sustainability. The Precious Metals Commission report examines the influence of political, regulatory and ISO decisions on the jewellery industry. Download them all at www.cibjo.org/news.

SAIMM THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY

Diamonds — Source to Use 2018 Proceedings

Slide presentations and full papers are available online as individual PDF files from this 11–14 June 2018 conference organised by The Southern African Institute of Mining and Metallurgy, held in Johannesburg, South Africa. They cover extensive information about the geology and mining of African diamonds, including exploration, recovery and development of specific mines, as well as keynote addresses by Ernie Blom (World Federation of Diamond Bourses) on the state of the diamond market and James A. H. Campbell (Botswana Diamonds) on financing diamond projects. Of particular interest to gemmologists is an article on De Beers' diamond verification instruments and associated research. Download the files at www.saimm.co.za/Conferences/Diamonds2018.


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LAB INFORMATION CIRCULAR

VOLUME 76 | JULY 2018

SYNTHETIC MOISSANITE AS 'FAKE' DIAMOND ROUGH

Since the later part of 2017, synthetic moissanite presented as rough diamond crystals, fashioned in the form of octahedrons (mostly distorted), has been a regular feature at the Gem Testing Laboratory, and that too, in impressive sizes of up to 16.51 carats. Recently, we received a light yellow sample (figure 1) of synthetic moissanite weighing 4.88 ct, fashioned as octahedron with flattened and rounded corners, displaying a frosty surface, typically associated with diamond rough.

Closer examination of the sample indicated that the angles and patterns of the crystal were not consistent with that of a diamond. The surface features (responsible for the frosty appearance) ranged from hexagonal to pyramidal to rectangular on different faces (figure 2), whereas, a similar pattern of growth features is expected in a diamond crystal, because of its cubic nature. It was interesting to note that two opposite faces displayed hexagonal patterns (etch pits as well as growth hillocks), while the faces oriented perpendicular to these, displayed rectangular patterns; the intermediate areas displayed pyramidal patterns. This sample further displayed conical tube-like inclusions oriented in one direction, along the length of the rectangular growth patterns or perpendicular to the hexagonal patterns. Such growth features are often seen in crystals belonging to hexagonal or trigonal crystal systems.

The crystal pattern and growth features were sufficient enough to rule out the possibility of diamond rough, while identity of this specimen was established on the basis of its doubly refractive nature under crossed-polars, hydrostatic specific gravity of 3.20, infra-red and Raman spectroscopy.

1. This 4.88 ct light yellow synthetic moissanite, fashioned as octahedron with frosted surface was presented as diamond rough.

2. The moissanite crystal displayed hexagonal etch pits and growth hillocks on faces perpendicular to 'c' axis (top, right), rectangular hillocks on faces parallel to 'c' axis (bottom, right), and pyramidal patterns at intermediate faces (top). Also note the conical tubes oriented along the 'c' axis (top).

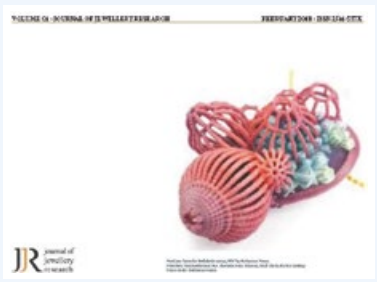
Gem Testing Laboratory (Jaipur, India) Newsletter

The July 2018 (Vol. 76) issue of GTL Jaipur's Lab Information Circular is available at http://gtljaipur.info/ProjectUpload/labDownLoad/LIC76_July%202018.pdf. It describes recent notable items submitted to the laboratory, including a fake diamond octahedron made of synthetic moissanite, a garnet-and-glass doublet, a jade-like carving of saussurite, an orange cabochon of triphylite-natrophilite, banded sphalerite marketed as 'schalenblende' and polymer-filled rubies.

IMA List of Gem Materials Updated

The Commission on Gem Materials of the International Mineralogical Association updated its list of gem materials in July 2018. A work in progress, the list includes names of gem materials (with their IMA status, if any), formulae for those with IMA status, comments (such as mineral or mineral group, colour information, etc.), and selected references. In the gem material name column, entries are shown in normal font for minerals, boldface for non-minerals (varieties and trade names), all caps for rocks, and italics for organics and glasses. To download the list, go to www.ima-mineralogy.org/docs/IMA_CGM_List_(2018-07).pdf.

Journal of Jewellery Research



A new annual peer-reviewed, open-access journal on jewellery was initiated in February 2018. Edited by Roberta Bernabei, the focus is on the 'design, theory, and praxis of jewellery studies'. Articles encompass the discussion and analysis of jewellery, both contemporary and historical, with an emphasis on visual presentation. Volume 1 includes articles on body imagery, design of digital devices, jewellery materials, jewellery from ancient burials, and the personal meanings of jewellery. Volume 2 is scheduled to go online in February 2019. Visit www.journalofjewelleryresearch.org.

OTHER RESOURCES

'The Curse of the Hope Diamond' Podcast

In August 2018, the Smithsonian Institution in Washington DC, USA, released a podcast on the Hope diamond. The 28-minute audio feature covers some of the less-than-fortunate episodes in the history of this famous blue diamond (on permanent display at the Smithsonian's National Museum of Natural History). Do these stories really mean that the Hope Diamond is cursed? To hear the tales, including interviews with

Smithsonian experts, and decide for yourself, visit www.si.edu/sidedoor/ep-1-curse-hope-diamond.

MISCELLANEOUS

New Diamond Museum in Antwerp

The city of Antwerp in Belgium has been a centre of the diamond industry for more than five centuries. May 2018 marked the opening of a new museum called 'DIVA, Antwerp Home of Diamonds' (www.divaantwerp.be), which features diamonds, jewellery (see photo above) and silversmithing. It is located in the historical heart of Antwerp (address: Suikerrui 17–19), and has a permanent hall exhibiting Antwerp's diamond story, as well as space for temporary exhibitions presented by guest curators.

Photo © DIVA, Antwerp Home of Diamonds

The first special exhibition, named 'Room of Wonder I: Axel Vervoordt', opened in October 2018 and will be on display until 28 April 2019. Axel Vervoordt is an antiquarian and interior designer who drew upon DIVA's collection and also added various loans. Among them, Pascal Entremont was invited to exhibit approximately 30 pieces of his rare gems collection. Entremont authored the 1998 book *Chasseur de Pierres* (*Gem Hunter*) and has amassed a private collection of hundreds of gems (currently available for sale) over the past 30+ years. Some of these stones were recently described in *The Journal* or are in preparation for future issues: 'Ceylon Stars', the largest known 12-rayed star sapphire from Sri Lanka, weighing 112.64 ct (Vol. 35, No. 5, 2017, pp. 430–435); 'Time Quartz', a 50.55 ct faceted rock crystal exhibiting an outstanding 'pinwheel' inclusion of black tourmaline (Vol. 35, No. 7, 2017, pp. 586–587); 'Two Pound Star', one of the world's largest star garnets at 5,737 ct; and 'Radjāh', a 149.90 ct intense pink spinel from Badakhshan (see photo below). For more information on 'Room of Wonder I: Axel Vervoordt', visit www.divaantwerp.be/en/visit/events-exhibitions/room-of-wonder-i-axel-vervoordt.

Thanh Nhan Bui
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Brussels, Belgium

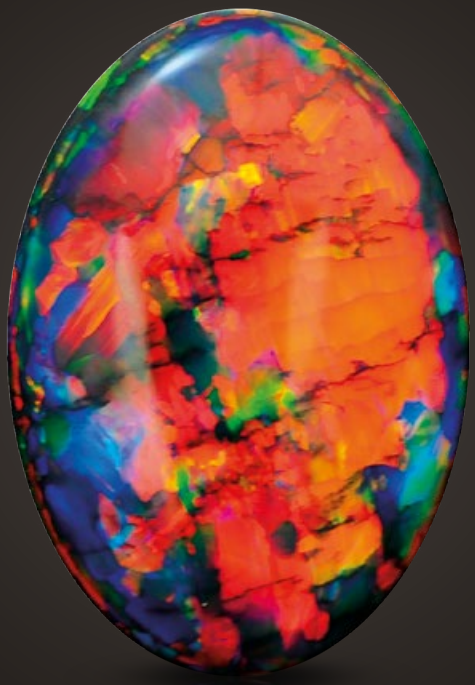
Photo by T. N. Bui

What's New provides announcements of new instruments/technology, publications, online resources and more. Inclusion in What's New does not imply recommendation or endorsement by Gem-A. Entries were prepared by Carol M. Stockton unless otherwise noted.

The Fire Within

"For in them you shall see the living fire of the ruby, the glorious purple of the amethyst, the sea-green of the emerald, all glittering together in an incredible mixture of light."

– Roman Elder Pliny, 1st Century AD



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Gem Notes

COLOURED STONES

Figure 1: This selection of brooches from the W. G. Rutherfurd collection demonstrates the beauty of picture agates and jaspers that were probably collected in New Zealand around 1912. Clockwise from the upper left: specimen BM.1985,MI15557 is mounted in a brooch with the likeness of a goat's head, while the other specimens portray landscapes (BM.1985,MI15555 'Sepia Seascape'; BM.1985,MI15550; BM.1985,MI15558 'Derwent Water'; BM.1985,MI15552 set with opals; and BM.1985,MI15549). The brooches range from 30 to 53 mm in maximum dimension. Courtesy of the NHM London, © The Trustees of the Natural History Museum, London.

W. G. Rutherfurd Collection of Agates

The gemstone and worked-object collections held in the Natural History Museum (NHM), London, have grown to ~4,500 specimens, incorporating smaller collections and individual specimens over several hundred years. The largest expansion occurred with the 1985 merger of the collections of the Geological Museum (GM; formerly the Museum of Practical Geology), which significantly increased the gemstone holdings and added many worked objects. One of the many incorporated collections consists of agates of Mr W. G. Rutherfurd Esq.

The Rutherfurd collection contained over 2,000 agates as nodules, slices and a small selection of jewellery, a large portion of which was presented to the GM. It is accompanied by a handwritten register from Rutherfurd, dated 5 May 1912, in the back of which are several pages describing its formation and his collecting trips. The agates range mostly through whites, greens, reds and browns of various sizes and appearances (e.g. Figure 1). Rutherfurd had an excellent eye for colours and patterns, and he carefully selected the best picture agates to create pieces of jewellery, wanting to make 'something better than the ordinary agate brooch'. The resulting pieces are indeed works of art. The muted tones of some of the polished slices depict misty seascapes and landscapes, framed in jewellery settings created by J. W. Ritchie of Edinburgh. Other agates in the collection were marked up for cutting to identify the best area for depicting landscapes or other patterns to be displayed in jewellery.

From a curatorial perspective, what gives this collection such value is the accompanying information, providing history and context. The register data and the correspondence between Rutherfurd and the GM staff make for a fascinating read, especially as most are dated during the First World War.

Rutherfurd began collecting agates as a schoolboy in Scotland in 1858, and his passion culminated in a collecting expedition with his wife that took them from England to New Zealand in 1910–1912. From Bristol they travelled by boat to visit Jamaica and Cuba; then to Florida and up to Quebec, Canada; and then to Vancouver, British Columbia, Canada; and finally to Brisbane in Australia and onward to New Zealand. It was in New Zealand that Rutherfurd collected a large portion of his agates—in the Clent Hills in Canterbury. He took three-day round trips when the weather permitted, by train and then horseback. He described tonnes of agates weathering out from the lava rocks, dramatically changing every 50 m with a variety of colours, including some of the best picture agates he had found. Others had stalactitic forms within clear chalcedony, plus moss agates, jaspers and common opal. Some agates, although not beautiful, were over 1 m in size. The best specimens were found on the hilltop spurs, and he commented about them being found *in situ* and not waterworn.

Correspondence with the curator at the time (John A. Howe) indicates the arrival at the GM of several crates of agates in early 1917, both for the museum to select specimens and for safekeeping during the war. In mid-1917 Rutherfurd visited the museum to unpack crates and bring the collection of brooches to be presented if 'deemed good enough', and in November he asked if 'during the raiding season what would you think of putting the brooches down below out of danger as I shall never replace them if they get a bomb'. Later correspondence discussed the best way to set agates as brooches, including backing them with 'looking glass' for maximum effect. It is assumed the agates in these brooches all originated from New Zealand. The jewellery was registered by the GM in 1923 under one number and re-registered in 1924 to give individual numbers. In the 1924 catalogue, 'New Zealand' was pencilled next to the jewellery entries, perhaps given by word of mouth, but further research would be required to confirm their provenance.

According to Smith and Cole (1996) and Oliver (1977), the Clent Hills area consists of Triassic–Jurassic sedimentary rocks (Torlesse Supergroup) overlain by a Late Cretaceous calc-alkaline volcanic suite (Mount Somers Volcanics). The volcanic rocks show multiple stages of eruptions, and one unit, the Barrosa Andesite, covers much of the Clent Hills. This unit is known for silica-rich amygdules (rounded cavities from gas bubbles in the lava filled by later mineralisation) that include agates, moss agates, chalcedony and opals matching the descriptions given by Rutherfurd of his collecting. The lava flows were deposited at a low inclination, resulting in the flat-top hills. The agates are thought to have formed not long after the Barrosa Andesite from hot silica-rich fluids associated with this higher-temperature volcanism. The agates are typically horizontally banded, assumed to indicate their orientation during formation, and the *in situ* agates have been used to indicate tilting of the andesite by later geological processes.

The beauty in these agates, combined with an understanding of their journey and the passion of the man who made it happen, makes them a fascinating part of the NHM collection.

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Natural History Museum, London

References

Oliver P.J., 1977. The Mesozoic Geology of the Mt Somers area, Canterbury: Including Geochemical and Paleomagnetic Studies of the Cretaceous Calc-Alkaline Mt Somers Volcanics. PhD thesis, University of Canterbury, 398 pp.

Smith T.R. and Cole J.W., 1996. Stratigraphic and petrological variation of the Mount Somers volcanics group, mid Canterbury, New Zealand. *New Zealand Journal of Geology and Geophysics*, **39**(3), 445–460, http://doi.org/10.1080/00288306.1996.9514725.

Axinite-(Mg) from Parachinar, Pakistan

Axinite is known from various locations in Pakistan, including the Shigar Valley area of Gilgit-Baltistan (Agheem et al., 2013) and the Taftan Mountains in Baluchistan (Fritz et al., 2007). While on a buying trip to Peshawar, Pakistan in October 2015, gem dealer Dudley Blauwet (Dudley Blauwet Gems, Louisville, Colorado, USA) was offered a 240 g parcel of rough transparent axinite from another locality: the Parachinar area, in the Federally Administered Tribal Areas within Khyber-Pakhtunkhwa Province of northwestern Pakistan. Blauwet selected 27 of the cleaner pieces weighing 100.2 g and had them faceted in July 2016. The cutting yield was rather small, due to the irregular shape and platy habit of the rough. He obtained 100 clean faceted stones that totalled 23.90 carats, with the largest gem weighing 1.36 ct. Compared

Figure 2: These purplish (to more orangey) brown axinites from Parachinar, Pakistan, weigh 0.81–1.36 ct and are strongly pleochroic, even to the unaided eye. Photo by J. C. Zwaan.

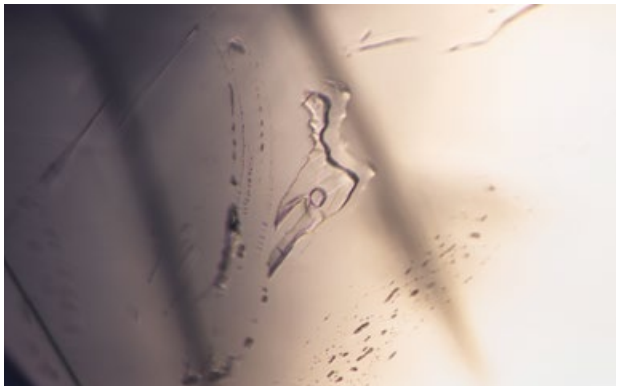

Figure 3: Partially healed fissures containing minute cavities and occasional two-phase inclusions are typical in the axinites from Parachinar. Photomicrograph by J. C. Zwaan; transmitted lighting, image width 1.4 mm.

to the brown colour of typical axinite, most of these stones showed an overall purplish brown appearance.

Blauwet loaned four faceted axinites for examination: one cushion, two ovals and one trilliant that weighed 0.81–1.36 ct (Figure 2). The stones were purplish brown or orangey brown and displayed strong pleochroism that was visible to the unaided eye. When viewed face-up and slightly tilted, the cushion and the 0.81 ct oval cut showed purplish, orangey and yellowish modifying colours, whereas the trilliant showed purplish and orangey hues and the 1.36 ct oval cut showed orangey and pale yellowish modifying colours. Using a calcite dichroscope, distinct trichroism in orangey brown, purple and light (slightly greenish) yellow was observed in each stone.

RIs ranged from 1.667 to 1.679, yielding birefringence values of 0.011–0.012. Applying the RI measurements as explained by Sturman (2007)—n_α = 1.667–1.668, n_β = 1.672–1.673 and n_γ = 1.678–1.679, with n_β being closer to n_α than to n_γ—the optic character proved to be biaxial positive. Average hydrostatic SG values were 3.23–3.25. The prism spectroscope revealed only a vague band at approximately 490 nm. The gems were inert to both long- and short-wave UV radiation.

These properties are consistent with axinite, with RIs and SGs between those of the end members axinite-(Mg)—which has RIs of 1.656–1.668, a birefringence of 0.009–0.012 and an SG in the range of 3.17–3.18—and axinite-(Fe)—which has RIs of 1.672–1.685, a birefringence of 0.010 and an SG in the range of 3.28–3.32 (cf. Deer et al., 1986; Dedeyne and Quintens, 2007). Although textbooks generally indicate the optic character of axinite is biaxial negative, the value of the optic axial angle (2V) increases with greater Mg content (cf. Deer et al., 1986), and Jobbins et al. (1975) reported an axinite-(Mg) from Tanzania to be biaxial positive, like these specimens from Pakistan.

The samples were eye clean to slightly included and contained partially healed fissures (sometimes with two-phase inclusions; Figure 3) and faint purple straight growth zoning. In addition, hexagonal and slightly rounded doubly refractive inclusions were seen in the trilliant (Figure 4). From their morphology and very low relief, these inclusions were probably apatite; Raman analysis with a Thermo DXR Raman microspectrometer was inconclusive. The principal Raman peak of apatite lies at ~967 cm^{-1}, but axinite also has a Raman feature at the same position (see below). Although the Raman spectrum of the analysed inclusion showed relatively more fluorescence (like many apatites), it was not possible to obtain a spectrum that was distinctive from the axinite host to confirm its identity.

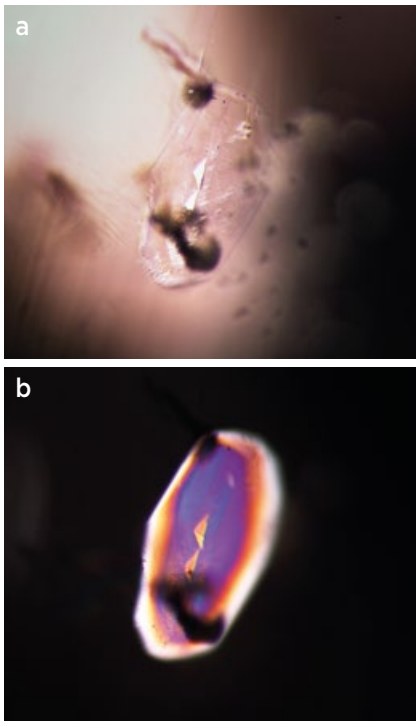

Figure 4: Doubly refractive, slightly rounded inclusions occurring in the trilliant-cut axinite are probably apatite crystals. Photomicrographs by J. C. Zwaan in (**a**) plane-polarised light and (**b**) between crossed polarisers; image widths 2.8 mm.

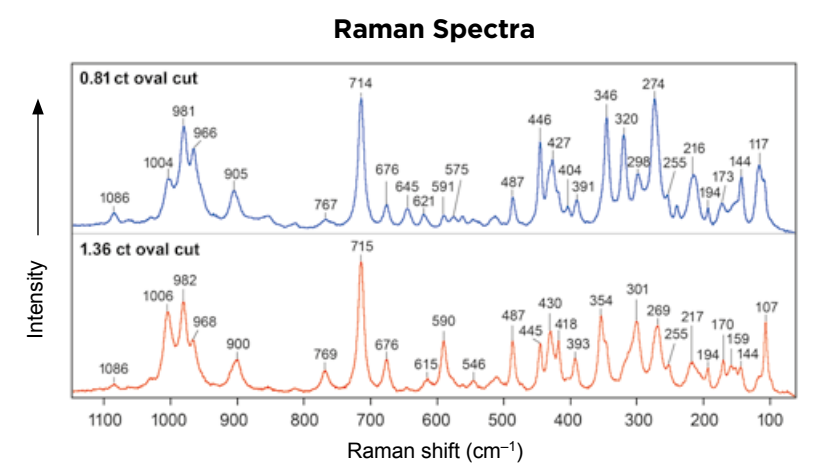

Figure 5: Two representative Raman spectra of the axinites from Parachinar show their variation and complexity; see text for explanation.

Raman spectra of three of the samples showed similar features, while the 0.81 ct oval cut produced a slightly different spectrum (Figure 5). The spectra of all four samples matched those of axinite-(Fe) in the RRUFF database; the three stones with similar spectra also matched axinite-(Mg). Raman spectra of axinites (triclinic borosilicates) are complex; the strong feature at 714 cm^{-1} is attributed to OBO-bending vibrations, while features in the ranges 1020–950 cm^{-1} and 690–380 cm^{-1} are attributed to $(SiO_4)^{2-}$ stretching and bending modes, respectively. Other features are more difficult to interpret; the band at ~902 cm^{-1} is possibly due to FeOH and MgOH deformation vibrations, while the band at ~768 cm^{-1} is ascribed to MgOH and other $M^{2+}OH$ deformations. Various bands are sometimes present at lower wavenumbers; the features at 320 and ~300 cm^{-1} are related to FeO stretching vibrations (cf. Frost et al., 2007).

Chemical analyses were obtained by energy-dispersive X-ray fluorescence (EDXRF) spectroscopy with an EDAX Orbis Micro-XRF Analyzer on the tables of the four stones, using a spot size of 300 µm. Apart from the main elements Si, Al and Ca, the analyses showed 6.1–6.8 wt.% MgO, 3.6–4.0 wt.% FeO and 0.5–0.6 wt.% MnO. This compares well with a summary of electron microprobe data for these stones provided by authors AUF and WBS, with 6.35–6.42 wt.% MgO and 3.68–3.73 wt.% FeO, giving predominantly axinite-(Mg) with a lesser proportion of axinite-(Fe). By contrast, specimens from the other localities in Pakistan mentioned in the first paragraph of this report were identified as axinite-(Fe).

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Trapiche-type Chrysoberyl

Numerous gem varieties showing a fixed star pattern within a transparent matrix have been designated 'trapiche'. In general, the non-transparent arms of the star pattern radiate from a central point or a central area toward the rim of the crystal, and they separate transparent (or at least translucent) areas of the specimen. If the transparent areas correlate with growth sectors and the arms of the star pattern represent the less transparent boundaries between such growth sectors, it is referred to as a trapiche pattern, as seen in some emeralds, rubies and tourmalines (e.g. Schmetzer et al., 1996, 2011). If the arms of the star pattern are formed by inclusions trapped within the centre of symmetry-equivalent growth sectors, it is referred to as a trapiche-type pattern, as seen in some beryls and sapphires (Schmetzer et al., 2011). Samples belonging to this second group of materials have also been designated 'trapiche-like minerals' (Pignatelli et al., 2015). In trapiche-type samples, the arms of the star pattern can become relatively wide and the transparent boundaries between growth sectors can be small.

The rough chrysoberyl described here was loaned by Farooq Hashmi (Intimate Gems, Glen Cove, New York, USA). The stone was purchased in the USA gem market and was said to have originated from Brazil. It measured 25 × 17 mm and weighed 10.18 g. Its identity as chrysoberyl was confirmed by Bear Williams (Stone Group Labs, Jefferson City, Missouri, USA) using Raman spectroscopy (GemmoRaman-532SG instrument). The sample showed one large planar face exhibiting a trapiche pattern consisting of relatively broad, milky arms separated by somewhat smaller transparent areas (Figure 6). Within the uneven part of the sample's surface, the trapiche pattern was not visible. Perpendicular to the large planar face were several crystal faces and one area with a larger re-entrant angle. In immersion and transmitted light (not shown) it could be seen that the entire sample, including the large planar face and the uneven parts of the surface, consisted of a cyclic twin (trilling). The crystal showed the common morphology of a chrysoberyl trilling with a large **a** {100} pinacoid and several smaller **i** {011} prism faces (see, e.g., Schmetzer, 2011).

By superimposing the photos taken in transparent light in immersion with those taken in reflected light in air (not shown), it was established that the twin boundaries ran through the transparent areas of the trapiche pattern, with the less transparent milky arms of the star located between the twin boundaries (Figure 7). Compared to the milky areas, the transparent zones were narrow, and different-sized areas sometimes appeared on the two sides of the twin planes. It was also apparent that the boundaries between transparent and milky zones were uneven and did not consist of planar faces or straight separation lines.

Examination of the area shown in Figure 7 at higher magnification in transmitted light (without immersion) was prevented by the combined effect of the low transparency of the chrysoberyl trilling and the approximately 9.7 mm thickness of the sample. In reflected light, the large planar **a** pinacoid of the trilling showed a dense pattern of growth striations oriented parallel to the

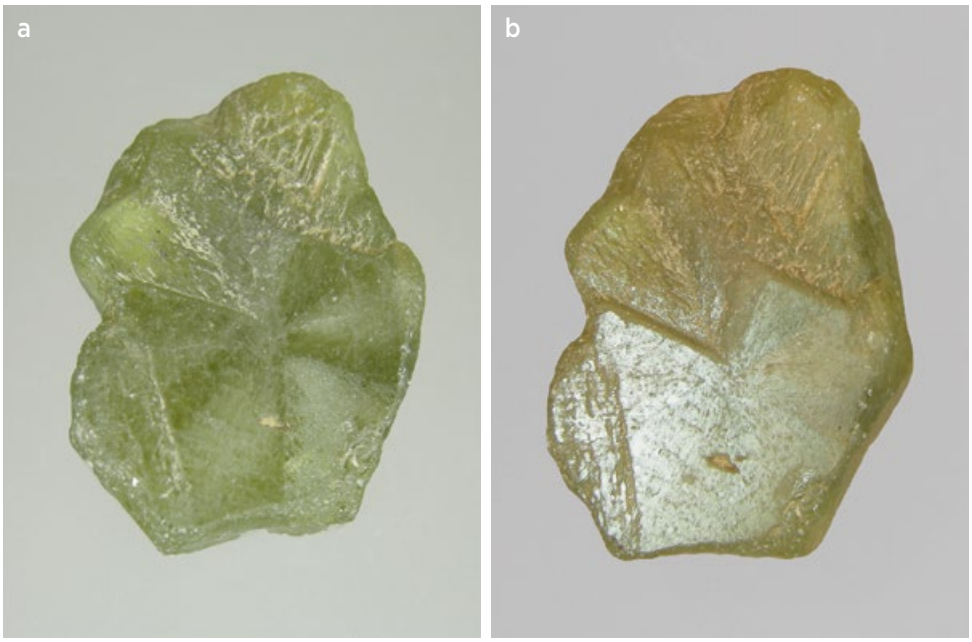

Figure 6: (**a**) This chrysoberyl trilling with a large planar face shows a trapiche-like pattern forming a fixed star consisting of larger triangular, somewhat milky areas separated by smaller transparent zones. (**b**) When the sample is tilted slightly, the larger planar face shows a homogeneous reflection. In the uneven part of the trilling (upper part of the sample), the trapiche-like pattern is not visible. The sample measures 25 × 17 mm; photos by K. Schmetzer.

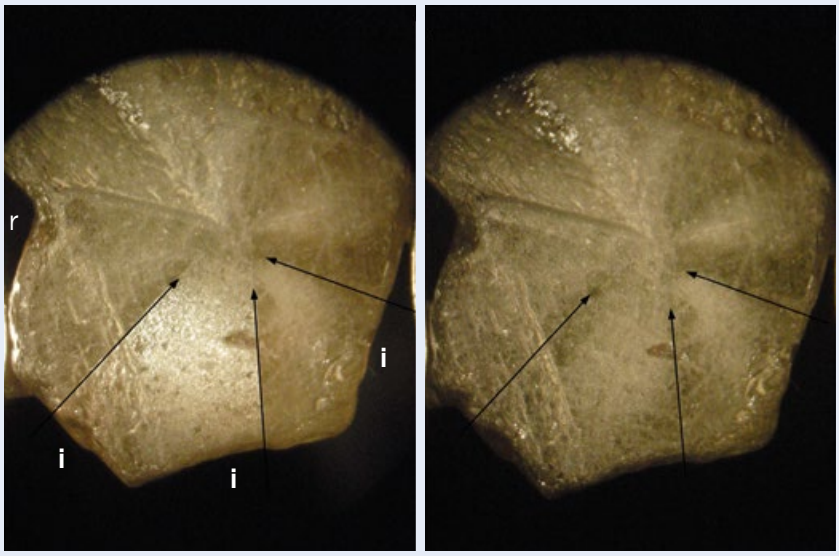

Figure 7: Viewed with reflected light at slightly different angles, the planar **a** pinacoid of the chrysoberyl trilling is seen here, as well as some **i** prism faces (perpendicular to the **a** pinacoid) and one re-entrant angle (r). Twin boundaries (black arrows) are perpendicular to the **i** prism faces and the **a** pinacoid, running through the more transparent areas that separate the milky zones forming the arms of the fixed star. Photomicrographs by K. Schmetzer; image width 16 mm.

c-axes < 001 > of the different parts of the chrysoberyl trilling (Figure 8). Due to the presence of these dense patterns of growth lines, which were observed in all the more-or-less transparent parts of the trapiche pattern, it was impossible to observe different concentrations of inclusions within the sample at high magnification (without polishing the surface of the specimen) in order to identify such inclusions.

Using the established definitions (see above), this chrysoberyl trilling should be described as trapiche-type chrysoberyl. In this special case, the different zones of the star pattern are separated by twin boundaries and not—as is commonly observed in trapiche specimens—by the boundaries between different growth sectors.

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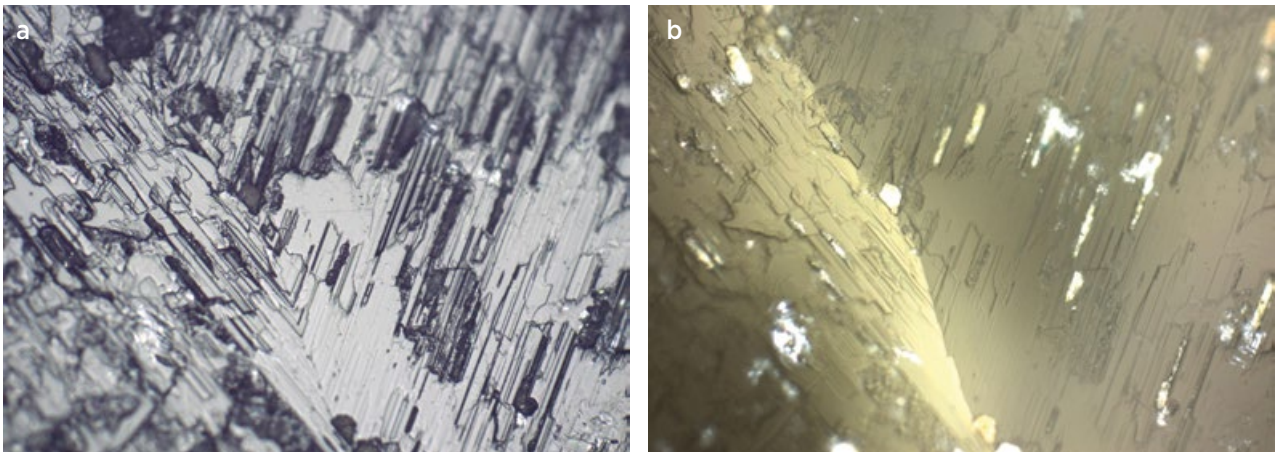

Figure 8: (**a**) At higher magnification, the chrysoberyl trilling shows a dense pattern of surface features and growth striations in reflected light; the growth features run parallel to the c-axes of the different parts of the trilling. (**b**) Viewed with crossed polarisers, the different parts of the trilling are clearly separated. Photomicrographs by H.-J. Bernhardt; fields of view 560 × 420 µm.

Montebrasite from Afghanistan

Faceted gemstones of the amblygonite-montebrasite isomorphous series $LiAlPO_4(F,OH)$ are rarely encountered in the gem trade, and mostly consist of pale 'straw' yellow material from Brazil. The mineral series has a Mohs hardness of 5½–6 and perfect cleavage on {100}, as well as some additional cleavage directions that are not as well developed. The faceted stones are commonly sold as 'amblygonite', which is ambiguous because the term can refer to any mineral of the amblygonite series or more specifically to the amblygonite mineral species, $LiAlPO_4F$. Rondeau et al. (2006) analysed several faceted specimens from Brazil, and determined that all of them were rather pure montebrasite, which they mentioned is consistent with an origin in granitic pegmatites within late-stage cavities (where fluorine was depleted relative to hydroxyl content, favouring the relatively late crystallisation of montebrasite).

In early 2017, rough stone dealer Farooq Hashmi encountered gem-quality montebrasite from Afghanistan. During a buying trip to Peshawar, Pakistan, he was shown a parcel weighing ~2 kg consisting of broken pieces that were colourless to very pale purple. He obtained one piece for research purposes, and it was faceted by Todd Wacks (Tucson Todd's Gems, Tucson, Arizona, USA) into an oval cut weighing 3.79 ct (Figure 9).

Examination of the stone by author BML showed that it was moderately included and displayed polishing marks on the table. During the faceting of the stone, Wacks reported that he was unable to obtain a good polish on the table, despite recutting it three times and changing the angle and direction of polish. Similarly, Schunk and

Figure 9: Afghanistan is the source of these montebrasite samples, consisting of a 3.79 ct gemstone and the 6.72 g piece of rough that remained after the stone was cut. Photo by B. M. Laurs.

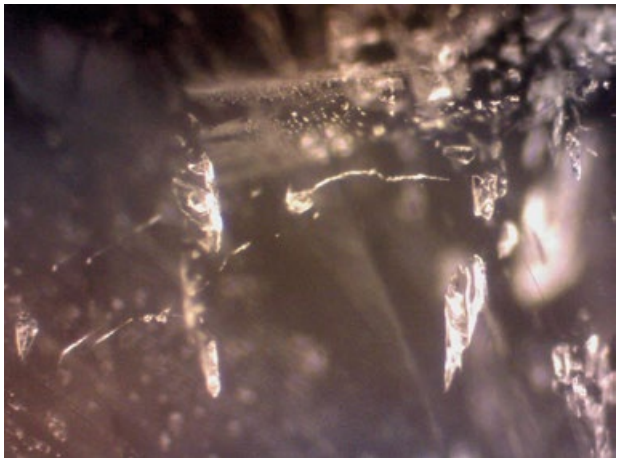

Figure 10: The Afghan montebrasite displays jagged two-phase fluid inclusions, 'fingerprints' and irregular stringers. Photomicrograph by B. M. Laurs; magnified 27×.

Deane (1955) reported that when cutting 'amblygonite', it showed a 'tendency to leave polish marks or very slight scratches rather than to leave an absolutely flawless mirror polish'. The 3.79 ct stone studied for this report yielded indistinct RI readings (apparently due to the poor polish) of approximately 1.60–1.62, for a birefringence of ~0.02. Microscopic examination revealed abundant fluid inclusions as both 'fingerprints' and jagged cavities that contained liquid and a gas bubble (Figure 10). Also present were irregular stringers and reflective liquid films, which were sometimes arranged in parallel orientation along incipient cleavages.

The chemical composition was obtained by authors AUF and WBS, who performed standard-based scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) analysis using a JEOL JSM-6400 instrument with the Iridium Ultra software package by IXRF Systems Inc. The data showed 4.4–4.8 wt.% F along with traces of Na, Mn, Fe and Ca. The amount of fluorine measured by SEM-EDS correlates well with the upper RI value (cf. Černá et al., 1973) and confirms a montebrasite composition (~60% montebrasite and ~40% amblygonite).

Although the amblygonite-montebrasite series is known to occur in various pegmatite areas of Afghanistan (Orris and Bliss, 2002), this is the first time that gem-quality material has been documented from there. The pale purple colour is unusual for montebrasite, although one of the Brazilian stones documented by Rondeau et al. (2006) was 'purple grey', and purple-and-white masses have been found by one of the present authors (AUF) at the Emmons pegmatite in Greenwood, Maine, USA.

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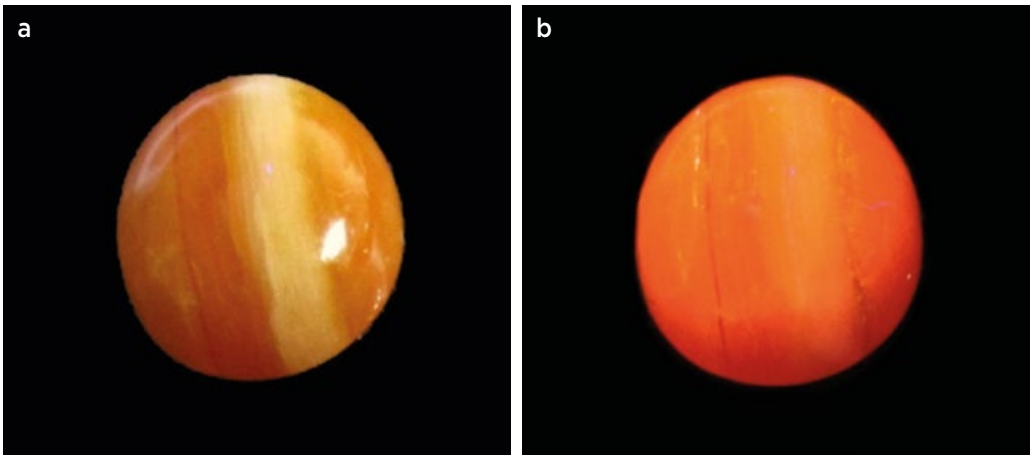

Figure 11: (**a**) This 2.20 ct opal, reportedly from Hokkaido, Japan, displays prominent banding. (**b**) Viewed with long-wave UV radiation, the sample demonstrates a vibrant orange reaction in the orange bands, but the thin transparent colourless areas are inert. Photos by B. Williams.

Orange-Fluorescing Common Opal from Japan

During the June 2018 JCK Las Vegas show in Nevada, USA, gem dealer Dudley Blauwet had some interesting banded orange common opal that was notable for exhibiting strong orange fluorescence to long-wave UV excitation. The opal came from the Shikaribetsu Lake area in Kato District, Tokachi Province, Hokkaido, Japan (Okazaki et al., 2014). This region is covered by Daisetsuzan National Park, and contains numerous volcanos and hot springs. The geochemistry of the opal was characterised by Okazaki et al. (2015) and by Kanai et al. (2016). Both studies were unable to find an unambiguous relationship between chemical composition and fluorescence colour, leading the authors to propose that organic compounds may be involved.

Blauwet had four opal cabochons weighing up to 2.20 ct, and he loaned the largest sample for examination (Figure 11a). The stone was cut as a double cabochon and showed prominent, parallel, colour banding ranging from a translucent strong orange to very pale orange with some thin transparent colourless layers (Figure 12). The latter areas were inert to the UV lamp, but the orange areas fluoresced a vibrant orange (Figure 11b), which was stronger to long-wave than to short-wave UV radiation.

The RI of the stone, approximated by the spot method, was ~1.42. Specific gravity was measured hydrostatically as 2.12. Viewed between crossed polarisers, most of the stone remained light upon rotation (consistent with an amorphous structure), and no strain was visible, but the colourless areas blinked dark with every 90° of rotation. (However, we were unable to find any evidence of the

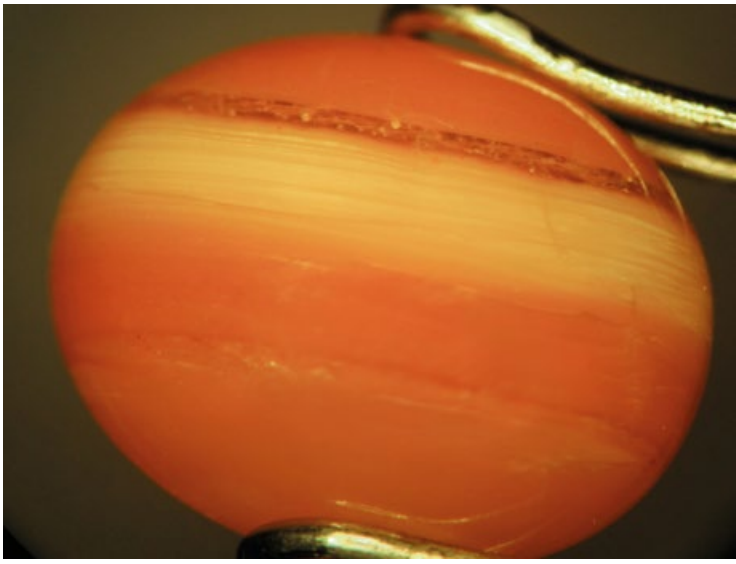

Figure 12: A closer view of the 2.20 ct opal shows the pronounced layered texture. Photo by Dean Brennan, Stone Group Laboratories.

presence of quartz to provide a reason for the blink.) There was no detectable magnetic susceptibility. No discernible results were obtained by Raman spectroscopy on either the coloured or colourless areas, but the 'fingerprint' region of the Fourier-transform infrared (FTIR) spectrum matched that of opal.

Energy-dispersive X-ray fluorescence spectroscopy with an Amptek X123-SDD spectrometer revealed the presence of minor Ca and traces of Fe, the latter being common in many orange opals. Moderate amounts of Mn were present, as were traces of Th. Using a Geiger counter, we detected low radiation emissions, at only about 1.5× background levels.

Strong orange fluorescence in common (pink) opal has been attributed to organic compounds called quinones (Fritsch et al., 2004), and may indicate the presence of organic material during the opal's formation.

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Two Large Rubies from the Pamir Mountains, Tajikistan

In 2016, a sizeable amount (about 600 g) of facet-grade ruby rough was offered on the New York market that had been collected over multiple mining seasons from the Pamir Mountains of Tajikistan. The material was examined by the author, and subsequent to manufacturing, several stones were submitted to the American Gemological Laboratories (AGL) for gemmological reports.

Rubies and pink sapphires from Tajikistan were first reported in the late 1990s (Smith, 1998). Since that time, little additional information has come forward, with the exception of an excursion to the region in 2006 (see, e.g., www.ruby-sapphire.com/tajikistan_ruby_and_spinel.htm). Since rubies of Tajik origin are not particularly well known or recognised in the gem and jewellery industry, this report provides a refresher of their key identifying features—as seen in the two largest, unheated rubies examined here, which weighed 12.08 and 17.14 ct (Figure 13).

The stones showed a highly saturated red colour. Consistent with rubies originating from marble-type deposits, they exhibited a strong red and moderate red reaction when exposed to long- and short-wave UV radiation, respectively. Microscopically, they contained

Figure 13: Weighing an impressive 12.08 ct (ring) and 17.14 ct (loose), these two unheated rubies were the best gems cut from a recent production of about 600 g of rough material from the Pamir Mountains of Tajikistan. Photo by Bilal Mahmood, AGL.

faint, very fine-grained planar clouds that had a whitish or slightly bluish appearance when illuminated with fibre-optic lighting (Figure 14). Concentrations of fine stringers were present, as well as colourless carbonate inclusions (calcite; identified by Raman spectroscopy) that commonly exhibited tiny black inclusions of their own (probably graphite). Partially healed fissures

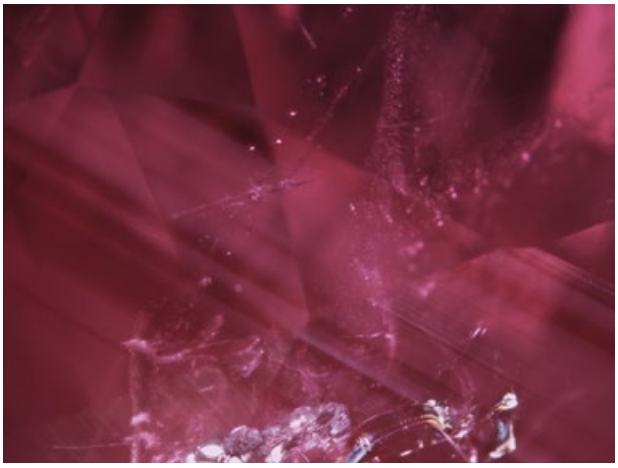

Figure 14: Common inclusion features in the rubies from Tajikistan consist of very fine-grained planar clouds that can have a whitish or faint bluish appearance when viewed with fibre-optic lighting. Photomicrograph by C. P. Smith; magnified 30×.

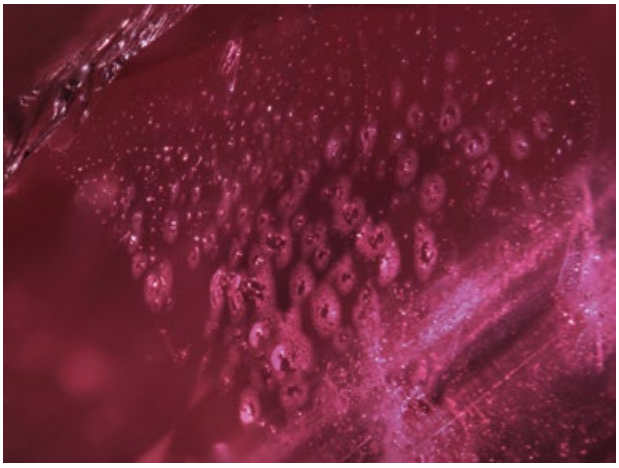

Figure 15: The most recognisable and diagnostic inclusion feature for rubies of Tajik origin consists of small negative crystals, each individually associated with basal-oriented thin films. These occur in groups along planar concentrations, as shown here, or as isolated features. Also present are fine, reflective stringers. Photomicrograph by C. P. Smith; magnified 38×.

showing various patterns were evident, as well as open fissures encrusted by epigenetic coatings of AlOOH, phyllosilicates and other minerals. However, the most distinctive inclusion feature in rubies from this source consists of negative crystals associated with tiny, basal-oriented thin films. These characteristic inclusions occurred in high numbers associated in planar concentrations (Figure 15) or as isolated features.

EDXRF spectroscopy of the two rubies revealed (in wt.%): 0.05 Ti, 0.01 V, 0.28 Cr, 0.04 Fe and 0.01 Ga for the 12.08 ct stone; and 0.03 Ti, 0.01 V, 0.14 Cr, 0.04 Fe and 0.01 Ga for the 17.14 ct ruby.

All of the features documented in this note are consistent with those reported previously for rubies and pink sapphires of Tajik origin. Beautiful, unheated stones such as these demonstrate the potential for Tajikistan to produce superior-quality rubies that can rival—and even be mistaken for—those of other, more well-known marble-type deposits of the region, including the historic Mogok Valley and, more recently, the Mong Hsu region of Myanmar (Burma), as well as the Jegdalek area of Afghanistan and Luc Yen region of northern Vietnam.

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Smith C.P., 1998. Rubies and pink sapphires from the Pamir mountain range in Tajikistan, former USSR. *Journal of Gemmology,* **26**(2), 103–109, http://doi.org/10.15506/JoG.1998.26.2.103.

Peculiar Trapiche-like Pattern in a Gold Sheen Sapphire

Gold Sheen sapphires were first described by Bui et al. (2015), in which the appearance of the golden sheen was ascribed to the presence of oriented platelets or needles that were identified as hematite and ilmenite in the form of exsolution intergrowths. A more brownish sheen of this type is also encountered in sapphires from several localities. Most Gold Sheen sapphires cut *en cabochon* exhibit a golden six-rayed star, but not 12-rayed stars as seen in black sapphires from Sri Lanka or Thailand (Bui et al., 2017). Moreover, neither a trapiche nor trapiche-like pattern, as defined by Schmetzer et al. (2011), has been reported so far in this corundum variety.

This author recently examined a Gold Sheen sapphire displaying a trapiche-like pattern (Figure 16). The sample, a marquise-shaped tablet, weighed 1.40 ct (12.03 × 6.94 × 1.32 mm) and reportedly originated from the same mine in Kenya that has produced Gold Sheen sapphire in the past. The slice was cut perpendicular to the c-axis to emphasise the golden sheen effect. The trapiche-like pattern consisted of a darker central core with six semi-transparent arms extending from the core toward the edges of the sample. In reflected light, the remainder of the stone displayed a golden sheen where the growth bands were visible.

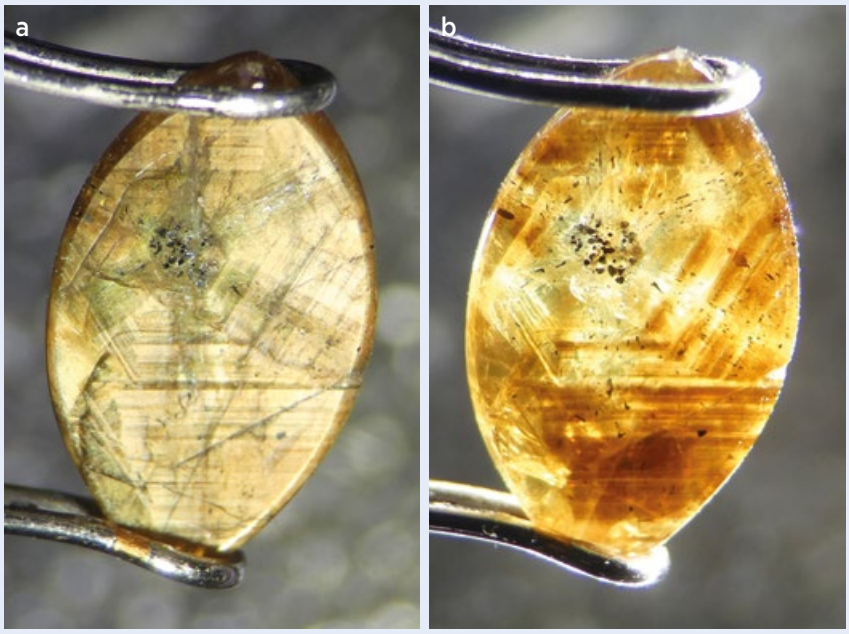

Figure 16: This 1.40 ct Gold Sheen sapphire tablet (12.03 × 6.94 × 1.32 mm) from Kenya displays a trapiche-like pattern. Photomicrographs by T. N. Bui using (**a**) brightfield and (**b**) darkfield illumination; magnified 10×.

Close examination with an optical microscope revealed that the hexagonal shape of the central core was parallel to the colour banding. The six arms were approximately perpendicular to these bands, as illustrated in Figure 17. These observations are consistent with sapphire displaying a trapiche-like pattern (see p. 245 in Gübelin and Koivula, 2008, and figure 20 in Bergman, 2016), irrespective of the nature of the inclusions forming the fixed star. The darker appearance of the central core was due to the presence of platy black inclusions that were present along the c-axis. These were identified as magnetite by a comparison to previously confirmed magnetite inclusions in Gold Sheen sapphire (see figure 13 in Bui et al., 2015), as well as the slight attraction of the sample's core to a neodymium magnet. The magnetite inclusions were also present in the six arms of the trapiche-like structure, but in lower density and mostly showing an elongated shape in the direction of the arms (Figure 17a); they were even more apparent with transmitted illumination (Figure 17b). In contrast to trapiche-like patterns reported previously in the literature for sapphire, the six branches in the present case were almost devoid of hematite/ilmenite inclusions, and they also lacked the growth bands of the interstitial areas (Figure 17b).

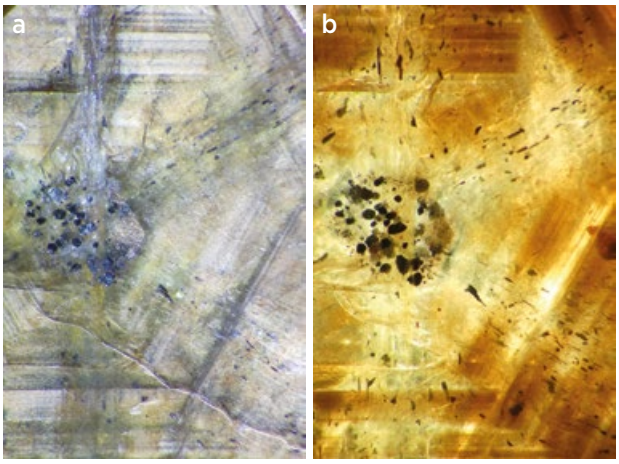

Figure 17: The core and six arms of the trapiche-like sapphire contain magnetite inclusions. In both of these areas, the hematite/ilmenite platelets and needles that form the sheen are nearly absent (**a**, brightfield illumination). Transmitted, darkfield illumination (**b**) confirms these observations. Photomicrographs by T. N. Bui; fields of view 5.67 × 3.78 mm.

Similar to the star in asteriated corundum, the colour of the arms forming the trapiche-like pattern depends on the nature of their constituting inclusions. Hematite/ilmenite inclusions lead to a brownish colour of the arms (Khotchanin et al., 2010), while rutile needles produce a white colour (Kiefert, 2012). In common trapiche-like corundums, the contrast is created by the colour of their arms versus the body colour of the stone. Here, the pattern is inverted: the arms display the body colour of sapphire while the rest of the stone displays a golden sheen.

In addition to the classical trapiche pattern (particularly in emerald), a trapiche-like pattern has been reported for several minerals but has not been as thoroughly investigated. To the best of our knowledge, the origin of the trapiche-like pattern is still not well understood. A reverse trapiche-like pattern—as seen in the present sapphire—should exist in sapphires from other localities, but no such examples are known to this author. Rough samples presenting a common or reverse

trapiche-like pattern should be investigated further to determine the origin of this phenomenon.

Acknowledgements: The author is grateful to Tanzim Khan Malik (Genuine Gems & Jewellery Co. Ltd, Bangkok, Thailand) for supplying the sample.

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Sri Lankan Sapphire with Spinel Inclusions

Recently, a 5.06 ct yellow sapphire was submitted to the American Gemological Laboratories (AGL) for testing (Figure 18). Standard gemmological analyses distinguished that this was an unheated yellow sapphire originating from Sri Lanka.

What caught the eye of this gemmologist were two well-formed octahedral crystals situated under the table of the gem (Figure 19). Raman analyses identified them as spinel. Corundum and spinel often form in similar geological environments and geographical locations. Given this, it is not surprising that spinel (as well as gahnospinel) has been identified previously in gem-quality corundum from a variety of sources, such as Sri Lanka and Myanmar/Burma (see, e.g., Gübelin and Koivula, 2008). However, it is not as common to see such euhedral colourless crystals of spinel as are present in this yellow sapphire.

Christopher P. Smith FGA

Reference

Gübelin E.J. and Koivula J.I., 2008. *Photoatlas of Inclusions in Gemstones*, Vol. 3. Opinio Publishers, Basel, Switzerland, 672 pp.

Figure 18: This 5.06 ct sapphire from Sri Lanka contains interesting inclusions under the table facet. Photo by Alex Mercado, AGL.

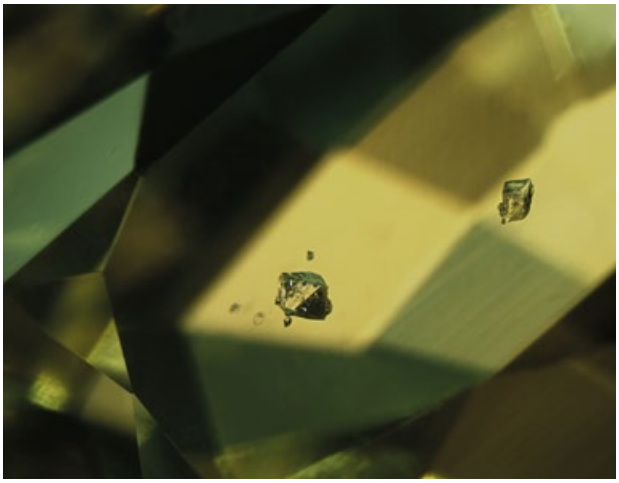

Figure 19: The inclusion scene in this sapphire is dominated by two octahedral colourless crystals that were identified by Raman spectroscopy as spinel. Photomicrograph by C. P. Smith; magnified 32x.

Colour-change Tephroite from South Africa

The olivine group is formed by three minerals: forsterite (Mg_2SiO_4), fayalite (Fe_2SiO_4) and tephroite (Mn_2SiO_4). The most important gem variety of the group is peridot, with a rather limited composition for gem-quality material of about 85–88% forsterite and 12–15% fayalite (cf. Webster, 1994). Much rarer is gemmy, colourless, near-end-member forsterite, known from Tajikistan, Sri Lanka, Myanmar and Vietnam (Hanus and Štubňa, 2017). Tephroite is the rarest mineral of the group, and to this author's knowledge only a few light violet cabochons have been cut from material originating in Sweden, Italy and the USA (New Jersey). Recently, new finds from the Wessels and N'Chwaning mines in the Kalahari manganese field in the Northern Cape Province of South Africa yielded some gem-quality tephroite.

Tephroite from South Africa forms columnar crystals up to almost 2 cm long. They are usually opaque (Figure 20), but some translucent crystals have been faceted into a few cut stones weighing up to 6 ct (Figure 21). The gems examined by this author were greenish grey in daylight and red-brown in incandescent light. Their RIs were 1.778 and over-the-limits of a standard refractometer, comparable to published data of n_α = 1.770–1.788, n_β = 1.807–1.810 and n_γ = 1.817–1.825 (Bernard and Hyršl, 2015). SG was determined hydrostatically as 4.05. The stones were strongly pleochroic (very dark brown and light brown) and were inert to UV radiation. The visible-near infrared (Vis-NIR) spectrum obtained with a GL Gem Spectrometer showed absorptions at 420, 456, 499 and 587 nm (Figure 22); the reason for the colour change was not clear.

Faceted tephroite from South Africa is interesting especially for its colour change, but it will remain a collector's rarity.

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Prague, Czech Republic

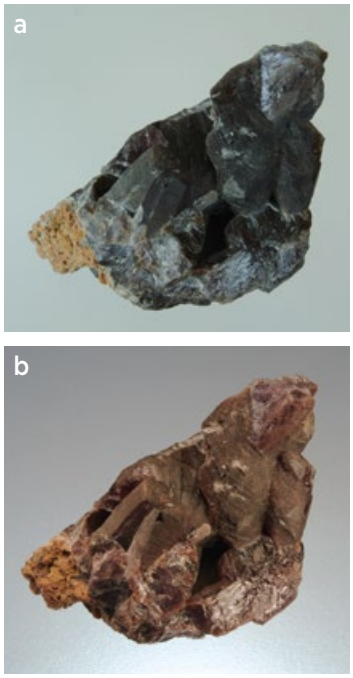

Figure 20: This tephroite crystal specimen (3.9 cm wide) from the Wessels mine in South Africa reveals a colour change from daylight (**a**) to incandescent light (**b**). Photos by J. Hyršl.

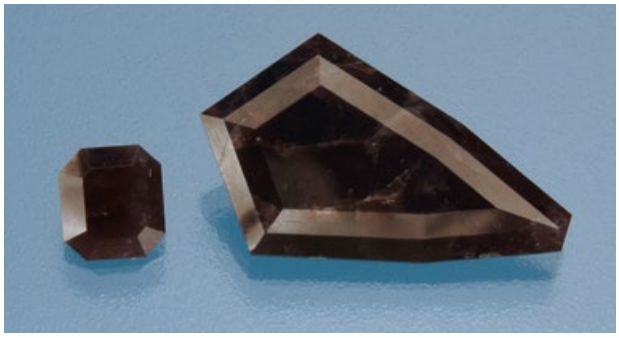

Figure 21: These faceted tephroites from South Africa weigh 0.56 and 6.25 ct. Photo by J. Hyršl.

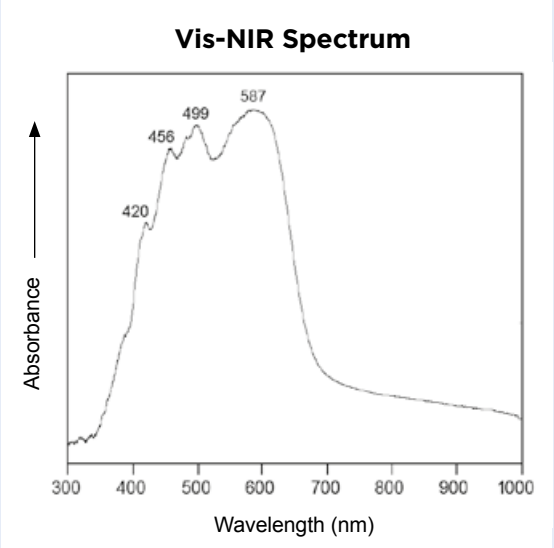

Figure 22: The Vis-NIR spectrum of tephroite from South Africa displays absorptions at 420, 456, 499 and 587 nm.

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SYNTHETICS AND SIMULANTS

Glass Imitation of Ametrine

Ametrine is a popular bicoloured quartz that comes mainly from the Anahí mine in eastern Bolivia (Vasconcelos et al., 1994). Synthetic ametrine from Russia has been known for a long time (Balitsky et al., 1999), and is usually darker than the natural material. Imitations made from pieces of citrine and amethyst that are glued together are also known.

The author bought a faceted bicoloured sample (Figure 23, top) from an Indian dealer at the Prague gem show in September 2018. It was presented as synthetic ametrine, and the price in comparison with its quality was very reasonable. The sample weighed 28.98 ct and measured 23.3 × 16.9 × 10.9 mm. The dark yellow half had a homogenous colour, while the dark violet half showed distinct colour zones at a low angle to the colour boundary (Figure 24), typical for natural amethyst exhibiting Brazil-law twinning. However, this was strange because Brazil-law twinning is very rare in both synthetic amethyst and synthetic ametrine. Also surprising was the presence of several rounded bubbles along the colour boundary (again, see Figure 24). They suggested a glued imitation, but examination of the surface with reflected light did not show any disconformity.

Figure 23: The glass imitation of ametrine (top, 28.98 ct) studied here displays darker colour and a sharper colour transition than two typical synthetic ametrines (9.62 and 2.62 ct). Photo by J. Hyršl.

Figure 24: Viewed table-down, the 28.98 ct glass imitation of ametrine in Figure 23 shows colour zoning in the dark violet half and gas bubbles along the colour boundary. Photo by J. Hyršl.

Gemmological testing easily identified the sample as a glass imitation. The RI of both halves was 1.510, the sample was isotropic and its SG was 2.45. When exposed to short-wave UV radiation, the yellow half fluoresced chalky yellow and the violet part was inert, while in long-wave UV the yellow half was inert and the violet half glowed light yellow. The presence of bubbles along the colour boundary is consistent with the identification as glass.

This shows that even glass—one of the oldest and simplest imitations—can be challenging to identify without proper testing.

Dr Jaroslav Hyršl

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A Treated Mixed-Type Synthetic Yellow Diamond

The Gem and Jewelry Institute of Thailand's Gem Testing Laboratory in Bangkok recently examined a 0.70 ct round brilliant (Figure 25) that was submitted to determine whether it was a natural or synthetic diamond

Figure 25: This 0.70 ct Fancy Vivid yellow round brilliant proved to be an HPHT-grown synthetic diamond that was apparently treated by low-pressure, high-temperature annealing. Photo by T. Sripoonjan.

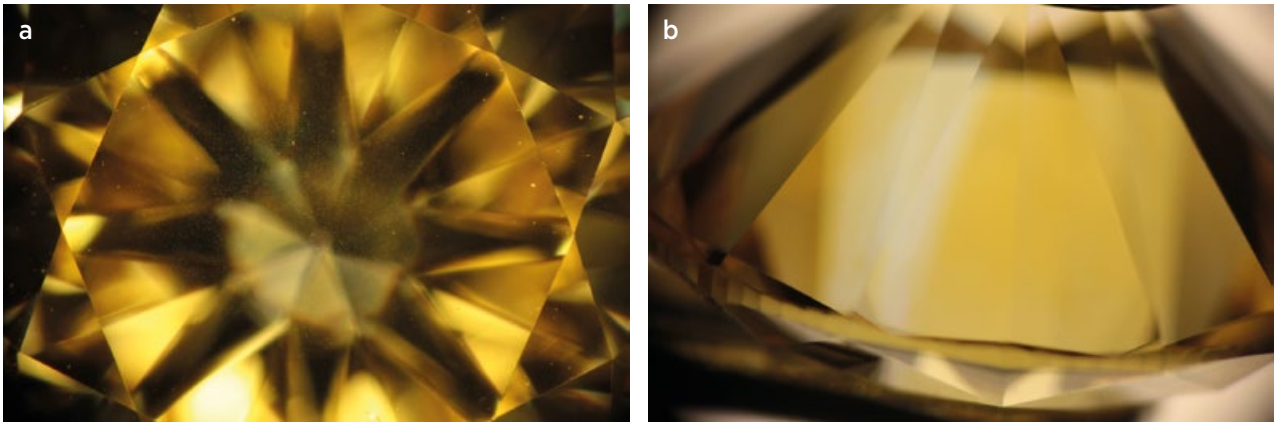

Figure 26: The 0.70 ct sample displays (**a**) clouds of pinpoint inclusions under the table facet and (**b**) yellow colour zoning through the pavilion with diffused illumination. Photomicrographs by M. Maneekrajangsaeng; magnified 50×.

and to establish the origin of its yellow colour. The sample was graded Fancy Vivid yellow with a clarity of VS_2. It fluoresced weak green to long-wave UV radiation and moderate green to short-wave UV. With magnification, clouds of pinpoint inclusions were seen under the table facet (Figure 26a) and a small fracture was present near a star facet. No strain was observed with cross-polarised filters. Examination with diffused illumination showed yellow colour zoning (Figure 26b). The DiamondView revealed the distinctive luminescence pattern of cubo-octahedral growth structures associated with high-pressure, high-temperature (HPHT) synthesis (Figure 27). The diamond was therefore identified as synthetic.

The visible-range spectrum (Figure 28a) revealed features typically attributed to type Ib diamond, with strong absorption at wavelengths below 500 nm; such a pattern, which is due to isolated single nitrogen, has also been observed in as-grown synthetic diamond (Kazuchits et al., 2016). The photoluminescence spectrum (PL) acquired with 532 nm laser excitation at liquid-nitrogen temperature showed a dominant doublet at 692/694 nm, which has been reported in high-nitrogen synthetic diamonds grown in a Ni-containing environment and after annealing at temperatures above 1,700°C (Zaitsev, 2001, p. 189), thus confirming that this was an HPHT-grown synthetic yellow diamond.

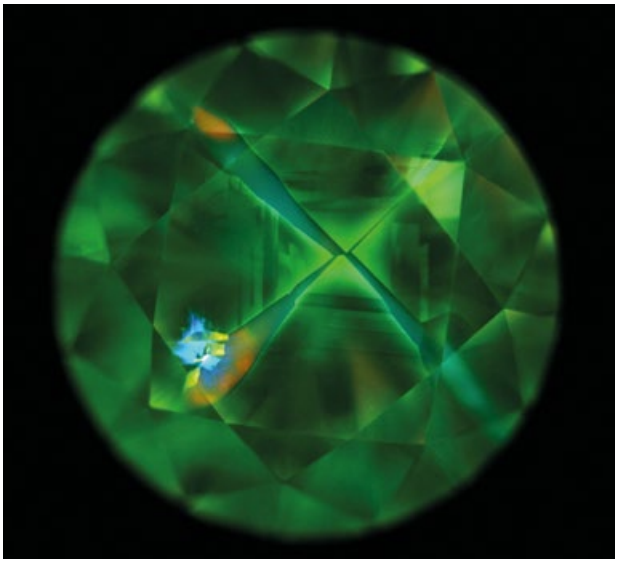

Figure 27: Seen with the DiamondView, a cubo-octahedral growth pattern is evident in the 0.70 ct synthetic diamond. Photo by M. Maneekrajangsaeng.

By contrast, the mid-IR spectrum of this synthetic diamond showed an unusual mixed type of dominant IaA (indicated by the band at 1282 cm^{-1}, due to two adjacent substitutional nitrogen atoms, N-N) and minor Ib (indicated by the bands at 1344 and 1130 cm^{-1}, due to single nitrogen), as seen in Figure 28b. Although such a mixed type is quite common among natural yellow diamonds, HPHT-grown yellow synthetic diamonds typically belong only to type Ib (Shigley et al., 1993).

Recent studies (e.g. Kazuchits et al., 2016; Kitawaki et al., 2017) suggested that the type IaA aggregation of nitrogen could occur during post-growth treatment of HPHT-grown synthetic diamond under a low-pressure, high-temperature (LPHT) annealing process. We infer that the present sample was initially synthesised as a type Ib yellow diamond by the HPHT process, and afterwards some isolated nitrogen was converted to N-N centres during LPHT treatment, as shown by the presence of the 1282 cm^{-1} band in the FTIR spectrum. This conclusion is also supported by the presence of the 692/694 nm doublet in the PL spectrum, which is known to be produced during annealing at temperatures above 1,700°C (Zaitsev, 2001).

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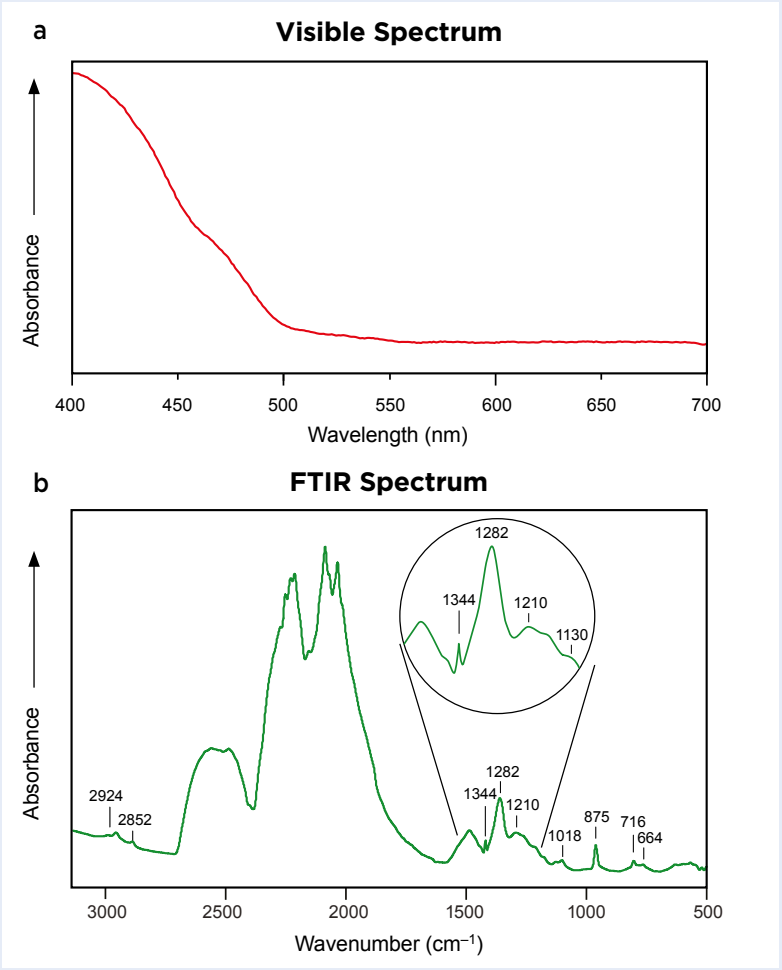

Figure 28: (**a**) The optical spectrum of the synthetic diamond reveals strong absorption at wavelengths below 500 nm. (**b**) The sample's FTIR spectrum shows features associated with mixed diamond types of IaA (1282 cm^{-1}) and Ib (1344 and 1130 cm^{-1}), which is quite unusual for synthetic diamond.

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ERRATUM

Petroleum Inclusion in Pink Spinel

In the Gem Notes section of Vol. 35, No. 1, 2016 (pp. 20–21), we described the presence of petroleum in a negative crystal inclusion in a pink spinel. At that time, we were told that this spinel was reportedly of Sri Lankan origin. Upon further inquiry with the original supplier, it has been established that this spinel was of Burmese origin. We thank Richard Hughes for bringing this to our attention.

Christopher P. Smith and Monruedee Chaipaksa

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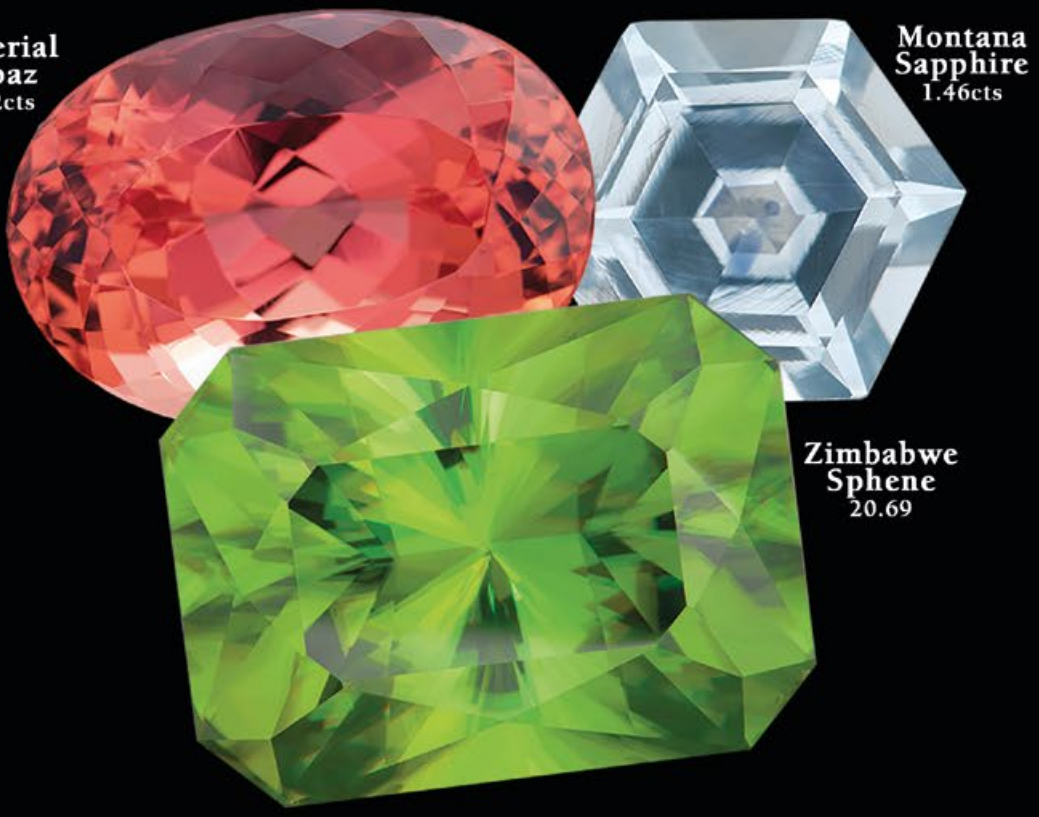

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The Effect of Blue Fluorescence on the Colour Appearance of Round-Brilliant-Cut Diamonds

Marleen Bouman, Ans Anthonis, John Chapman, Stefan Smans and Katrien De Corte

ABSTRACT: To better understand the influence of blue fluorescence on the colour appearance of (near)-colourless (D–J) diamonds, carefully selected sets of round-brilliant-cut samples of varying fluorescence intensity were observed at HRD Antwerp under lighting conditions that simulated four different environments in which diamonds are commonly viewed: Outdoor, Indoor, Grading and Office lighting. Each of these environments contained a different level of long-wave UV radiation (emitted from LEDs) combined with daylight-equivalent fluorescent lighting (filtered to remove its UV component). Diamonds were presented to observers in both table-up and table-down orientations, and the effect of blue fluorescence on their colour appearance was determined by observing them with and without the UV component of the lighting and also by visual comparison with non-fluorescent master stones in each of the four lighting environments. The observers consisted of experienced graders, industry participants and consumers. For colours of J and higher, the simulated Outdoor lighting (which contained the greatest UV component) elevated the grade of diamonds with strong and very strong fluorescence to D–E colour when viewed table-down. The table-up effect was less pronounced. The UV content of the Office lighting was insufficient to produce any observable effect, even for diamonds with very strong fluorescence. HRD Antwerp's laboratory performs colour grading in an environment that lacks significant UV radiation.

The Journal of Gemmology, **36**(4), 2018, pp. 298–315, http://doi.org/10.15506/JoG.2018.36.4.298

When illuminated by UV radiation, some diamonds emit visible light, or fluorescence. Diamonds can fluoresce in a range of colours, but the most common colour is blue (e.g. Figure 1). The effect of this blue fluorescence on the appearance of (near-)colourless diamonds has been a subject of debate for many years. In the early 20th century, fluorescence was looked at as a positive attribute because it was believed to make diamonds appear 'brighter' or whiter when viewed in daylight (Moses et al., 1997). The blue fluorescence emitted by such diamonds can counteract the appearance of a yellow tinge in their body colour, making them appear whiter. Since the late 1970s and early 80s, however, fluorescence has been perceived as an undesirable characteristic (Cowing, 2010). This has resulted in price discounts as high as 30% for strongly fluorescent diamonds. The price differentiation is linked to a number of reasons, including concerns about over-grading of colour, as well as reduced transparency (perceived as an oily appearance). The term *over-grading* refers to an improvement in colour grade that is assigned to a blue-fluorescent diamond when it is graded in a light source that contains a UV component. This effect can be seen only when the light source contains enough UV radiation to excite fluorescence and the diamond

Figure 1: These earrings and pendant are shown under normal lighting conditions (left) and under a long-wave UV lamp (right). The sapphire centre stones are surrounded by near-colourless diamonds exhibiting various fluorescence intensities and colours (i.e. mostly blue for those stones that are not inert). The earrings measure approximately 20 × 19 mm and the pendant is 30 × 28 mm. Photos courtesy of HRD Antwerp on behalf of Veilinghuis de Ruiter.

possesses sufficiently intense blue UV luminescence. Contradictory information about such diamonds has led to a great deal of confusion regarding the relation between fluorescence and the way such stones are perceived.

A few studies have investigated the effect of blue fluorescence on the appearance of polished diamonds (see Moses et al., 1997; AGA, 2009; Cowing, 2010). The research conducted for the present article uses a larger suite of diamonds across a wide spectrum of D–J colours and fluorescence intensities, observed under four different lighting conditions. The goal of this work is to investigate the influence of lighting conditions and diamond fluorescence intensity on the perception of body colour in blue-fluorescing diamonds and the magnitude of any colour difference. Initial results of this research were presented at the 4th Mediterranean Gemmological and Jewellery Conference in May 2018, the Hong Kong Jewellery & Gem Fair in September 2018 and the GIA (Gemological Institute of America) International Gemological Symposium in October 2018 (e.g. Anthonis et al., 2018a,b; De Corte, 2018; Robinson, 2018).

MATERIALS AND METHODS

We carefully selected several dozen round-brilliant-cut diamonds showing various amounts of fluorescence. Four different experiments included experienced graders, as well as industry participants and consumers in two of the experiments, who viewed the samples under four different lighting environments that were modelled to contain different levels of UV radiation. Visual comparison with non-fluorescent master stones enabled the observers to determine any difference in the colour appearance of the sample diamonds.

The standard way to colour-grade diamonds in a laboratory is to observe them through their pavilion (i.e. table-down), so that the body colour of a diamond can be assessed without being obscured by the light flashes that are typically observed through the table (Shipley and Liddicoat, 1941). However, most consumers typically see diamonds table-up when they are set in jewellery. Therefore, we used both orientations in this study: table-down in the first two experiments and table-up in the latter two experiments. Each pair of experiments was designed (1) to assess whether there was any colour difference in the various lighting environments and (2) to determine the magnitude of that difference.

Details of the fluorescence grading of diamonds at HRD Antwerp, sample selection for this study, simulation of the various lighting environments and conditions of the viewing experiments (participants and setup) are described below.

Fluorescence Grading

To select the samples used for this study, we first graded the fluorescence intensity of a large number of diamonds. Normally the HRD Antwerp lab uses a four-tiered system to grade fluorescence—*nil*, *slight*, *medium* and *strong*—as prescribed by the International Diamond Council (IDC, 2013). Three fluorescence master diamonds represent the lower boundaries for each grade (i.e. slight, medium and strong). A nil grade coincides with a diamond having a

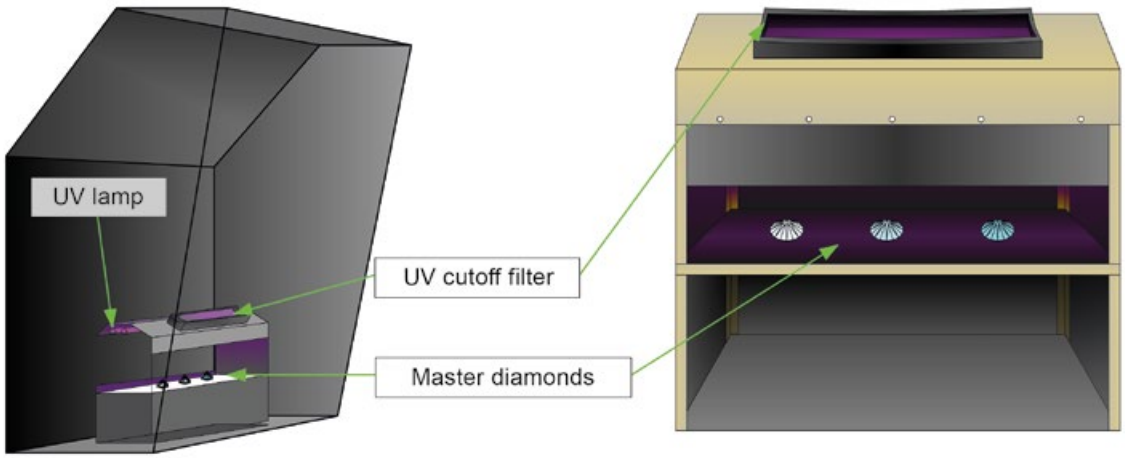

Figure 2: This diagram shows how diamond fluorescence is graded in the HRD Antwerp lab. Left: Examinations are conducted within a cabinet in a darkened room. Right: The grading box is designed so that diamonds can be placed next to fluorescence master stones. Graders look through the UV cutoff filter at the top, perpendicular to the pavilion facets. The UV lamp is located under the ceiling of the grading box, adjacent to the cutoff filter.

lower fluorescence intensity than the master diamond representing the nil/slight boundary. Internationally, the term *very strong* is also used for diamonds with intense fluorescence. Therefore, this category was also included in our research. The border between strong and very strong was determined by experienced graders using a strong-fluorescent master stone.

Fluorescence grading at HRD Antwerp is conducted in a dark room, using a small box containing a long-wave UV lamp (Figure 2). (The bulb consists of a Philips TL/4W/08 F4T5/BLB Blacklight Blue, and its emission spectrum is available in a leaflet at http://tinyurl.com/ycj4e4t9.) A UV cutoff filter at 400 nm is used to protect the viewer's eyes from harmful UV radiation. The diamond and master stones are placed table-down, and the grader looks perpendicular to the pavilion facets to compare the fluorescence of the sample with that of the master diamonds. The distance between the UV lamp and diamonds is fixed at 7 cm.

Because the diamonds in this study were observed table-up as well as table-down, we developed a method to assign the level of their fluorescence when viewed table-up. Photographs were taken of all diamonds using a fixed camera setting in a controlled environment under the UV lamp mentioned above in a darkened chamber. The fluorescence intensity of each diamond was determined from the average greyscale value of the fluorescence image. This greyscale value was used to represent the fluorescence intensity of the diamond, as schematically depicted in Figure 3.

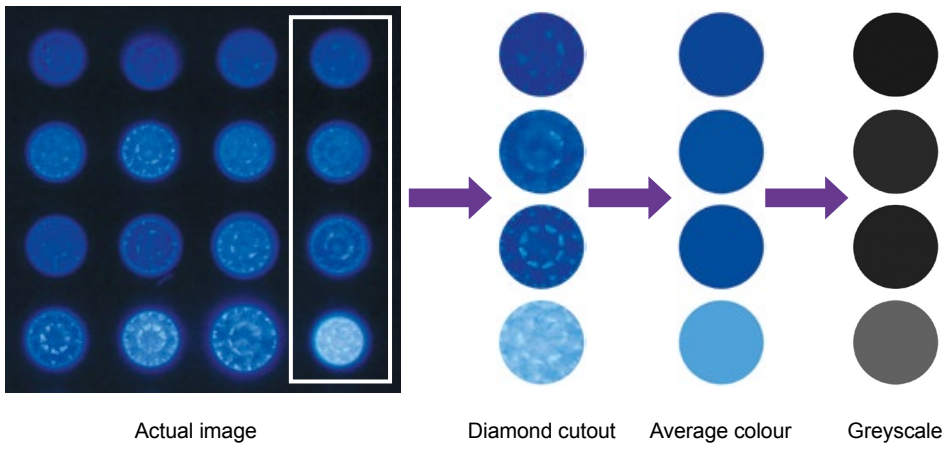

Figure 3: Diamond images are extracted from an actual photograph in order to convert the table-up fluorescence to a greyscale representation of luminescence intensity. Diamond photo courtesy of HRD Antwerp.

Sample Selection

The diamonds selected for this study met several criteria, notably (according to HRD Antwerp standards):

- Shape: round brilliant
- Weight: 0.30–1.10 ct
- Colour: D–J
- Clarity: Loupe Clean to SI_1
- Cut: excellent to very good

Fluorescence levels of the samples ranged from nil through slight, medium and strong to very strong. We further divided the slight, medium and strong fluorescence levels into sub-grades, indicated by the symbols '++', '+' and '=', which represent increasing grades, respectively. The subgrade '++slight' was not used, because the fluorescence level of those samples was so weak that the effect was not noticeably different from the nil grade.

For the table-down experiments, the samples consisted of seven colour sets (ranging from D to J) of diamonds, as shown in Table I. We initially intended to use these same diamond sets for the table-up experiments, but this was not possible because some of the diamonds were found to appear more or less fluorescent when viewed table-up. (This is probably due to inhomogeneous distribution of fluorescence being modified by internal reflections when viewed table-up.) All of the diamonds that showed a distinctly different fluorescence intensity viewed table-up compared to table-down were excluded from the table-up sample set. Seven colour sets were then assembled that included as many stones as possible (16) from the table-down set (see Table II). While the table-down set consisted of 69 diamonds, the table-up set contained 56 stones.

Table I: The 69 diamonds selected for table-down experiments (Experiments 1 and 2).*

	D COLOUR			E COLOUR			F COLOUR			G COLOUR			H COLOUR			I COLOUR			J COLOUR		
Fluo	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar
Nil	9	0.57	LC	–	–	–	60	0.55	VVS_1	32	0.71	VVS_1	15	0.56	VVS_1	39	0.70	VVS_2	–	–	–
++SL	–	–	–	–	–	–	–	–	–	62	0.50	VVS_1	46	0.46	VVS_2	–	–	–	**117**	0.60	VVS_1
+SL	42	0.55	LC	61	0.50	VVS_1	**54**	0.52	VVS_1	–	–	–	–	–	–	102	0.40	VVS_2	361	0.43	LC
=SL	**103**	0.50	VVS_1	49	0.57	VVS_1	214	0.55	VVS_2	235	0.59	LC	312	0.56	VVS_1	114	0.50	VS_1	369	0.52	VVS_2
++M	89	0.42	VVS_1	**115**	0.55	VS_2	109	0.56	VVS_2	**113**	0.55	VVS_2	99	0.40	LC	348	0.72	VVS_1	350	0.31	LC
+M	116	0.59	VVS_1	**194**	0.30	VVS_1	98	0.43	VVS_1	279	0.58	VVS_2	266	0.51	VVS_1	119	0.62	VVS_1	**381**	0.51	VVS_1
=M	108	0.51	VVS_1	193	0.36	VVS_2	**132**	0.45	VVS_1	**238**	0.53	LC	**274**	0.54	VVS_1	**253**	0.32	VVS_1	371	0.53	LC
++ST	154	0.71	VVS_1	131	0.41	VVS_1	–	–	–	158	0.76	VS_2	275	0.54	LC	**139**	0.50	LC	157	0.74	VVS_1
+ST	152	0.60	VVS_1	–	–	–	149	0.50	VVS_1	–	–	–	146	0.52	VVS_1	–	–	–	**147**	0.52	VVS_1
=ST	–	–	–	**159**	0.70	VVS_1	**110**	0.50	VVS_1	173	0.70	VVS_2	140	0.50	LC	321	0.41	VVS_1	–	–	–
++VST	176	0.71	VS_1	167	0.50	LC	169	0.53	VVS_1	179	1.01	LC	–	–	–	185	1.01	SI_1	390	0.52	VVS_2
+VST	164	0.52	LC	210	0.35	VVS_1	175	0.74	VVS_1	**171**	0.64	VVS_2	165	0.51	VVS_1	352	0.38	VVS_2	366	0.51	LC

* Abbreviations: # = sample number, ct = carat weight, Clar = clarity grade, Fluo = fluorescence intensity, SL = slight, M = medium, ST = strong and VST = very strong. Sample numbers in bold indicate those diamonds that were also used in table-up experiments. A set of 10 samples was used for every colour except E, which included nine diamonds.

Table II: The 56 diamonds selected for table-up experiments (Experiments 3 and 4).*

	D COLOUR			E COLOUR			F COLOUR			G COLOUR			H COLOUR			I COLOUR			J COLOUR		
Fluo	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar	#	ct	Clar
+SL	93	0.43	VVS_1	–	–	–	–	–	–	–	–	–	–	–	–	80	0.76	VS_2	–	–	–
=SL	**103**	0.50	VVS_1	59	0.52	VVS_1	**54**	0.52	VVS_1	245	0.58	VVS_2	101	0.41	LC	315	0.33	LC	**117**	0.60	VVS_1
++M	107	0.51	VVS_2	**115**	0.55	VS_2	95	0.43	LC	267	0.53	LC	309	0.52	VVS_1	305	0.50	VVS_1	85	0.30	LC
+M	199	0.40	VVS_1	**194**	0.30	VVS_1	97	0.42	VVS_1	**113**	0.55	VVS_2	280	0.55	VVS_1	**253**	0.32	VVS_1	340	0.50	VVS_1
=M	188	0.33	LC	218	0.55	VVS_2	**132**	0.45	VVS_1	**238**	0.53	LC	**274**	0.54	VVS_1	–	–	–	**381**	0.51	VVS_1
++ST	124	0.30	VVS_1	130	0.41	LC	142	0.50	VVS_1	265	0.50	VVS_1	295	0.42	VVS_1	**139**	0.50	LC	370	0.53	VVS_1
+ST	128	0.40	VVS_2	187	0.31	VVS_1	150	0.50	LC	135	0.41	VVS_1	251	0.30	VVS_1	338	0.51	VVS_2	156	0.73	VVS_1
=ST	122	0.31	LC	**159**	0.70	VVS_1	**110**	0.50	VVS_1	144	0.51	VVS_1	284	0.33	VVS_1	328	0.41	LC	**147**	0.52	VVS_1
++VST	–	–	–	–	–	–	–	–	–	–	–	–	148	0.58	LC	300	0.53	LC	374	0.56	VVS_1
+VST	–	–	–	229	0.33	LC	232	0.36	LC	**171**	0.64	VVS_2	–	–	–	–	–	–	–	–	–

* Abbreviations: # = sample number, ct = carat weight, Clar = clarity grade, Fluo = fluorescence intensity, SL = slight, M = medium, ST = strong and VST = very strong. Sample numbers in bold indicate those diamonds that were also used in table-down experiments. A set of eight samples was used for every colour.

Simulation of Lighting Environments

To simulate different lighting environments, a system was constructed comprising an array of 20 UV light-emitting diodes (LEDs) spanning a length of 30 cm. These LEDs emitted long-wave UV radiation centred at 365–370 nm (with a full width at half maximum of about 20 nm). The LEDs were ground down to remove the epoxy lens so as to produce a more diffuse and even illumination. A Wood's glass filter was used to remove the small component of visible light that the LEDs emitted. The LEDs were connected to a circuit that provided variable current through a potentiometer, with a switch to turn them on and off manually. The emission spectrum of the LEDs did not vary with current, other than in its intensity.

For table-down observations, the above-mentioned UV array was placed alongside an HRD colour-grading lamp for which the UV component was removed with a 3-mm-thick sheet of clear polycarbonate, which acted as an effective filter for wavelengths below 400 nm. Although diamond fluorescence can be activated by wavelengths up to 415 nm, there are no readily available filters that can remove such wavelengths while allowing even (non-colouring) transmission of the visible wavelengths. Our measurements showed that for a UV-filtered grading lamp the integrated intensity of the 400–415 nm band was about one-quarter that of the 300–400 nm band of the unfiltered lamp, suggesting that the polycarbonate sheet removes most of the fluorescence-activating radiation.

For table-up observations, the UV array was installed in a Gretag Macbeth Judge II cabinet of the type that is commonly used by major laboratories. It comprises an open-sided grey-coated 'box' with fluorescent tube lighting in the ceiling of the cabinet. The UV array was positioned alongside the daylight-equivalent fluorescent tubes, as seen in Figure 4 (left). Polycarbonate sheeting was placed in front of the fluorescent tubes. To prevent the diamonds from being exposed to ambient lighting during the observation experiments, a grey panel was installed across the opening of the cabinet. It had a small 'letter box' opening for viewing the samples, and two cut-outs in the bottom corners allowed the observer's arms to enter the cabinet (see Figure 4, right).

For both table-down and table-up configurations, the combination of the UV-filtered daylight fluorescent tubes and the adjacent strip of UV LEDs provided white-light illumination with a controllable UV component. However, because the combined spectrum of the white light and the UV LEDs does not correspond to that of the sun or common white-light sources, a significant challenge was how to mix the UV and white light to correspond to the four lighting environments that were modelled for this study (Table III).

To measure the UV component of a light source or environment, a customised sensor was developed (Figure 5) based on the fluorescence intensity of diamond. A 1 × 1 cm mosaic of strong-intensity blue-fluorescent rough diamonds was attached to a white (non-fluorescent) plate using double-sided (non-fluorescent) tape. A small housing with a stand held the plate centrally at a 45° inclination to the illumination source and a

Figure 4: Left: A Gretag Macbeth Judge II cabinet is fitted with a UV LED array covered with a Wood's filter (black area next to the fluorescent tubes), and the diamonds are viewed in the tray that is raised above the base of the cabinet. A polycarbonate filter for the fluorescent tubes is not shown in this image. Right: The cabinet was modified for the observation experiments by fitting it with a front cover to exclude ambient light. Photos courtesy of HRD Antwerp.

viewing port. To measure the white-light component of a light source or environment, the diamond mosaic was replaced with a matt-white plate. An opening above the plate through which the source light entered could be covered by either a Wood's filter (for UV radiation) or a transparent acrylic window (for white light). As the white plate was non-fluorescent, the UV properties of the window were not important for the white light measurements, and acrylic has fabrication advantages over polycarbonate. A lens, having a focal length similar to the distance to the centre of the inclined plate, was positioned in the viewing port facing the diamond mosaic or white plate. External to the lens could be placed either a camera or spectrometer, as shown in the schematic diagram in Figure 5.

An Ocean Optics Red Tide spectrometer with an aperture of 200 µm was used to measure the fluorescence strength of the diamond mosaic based on the intensity of the main emission peak at 456 nm (again, see Figure 5). Then, with the Wood's filter replaced by the acrylic window, a digital camera (Canon PowerShot SX540 HS) held against the lens was used to photograph the white plate. The brightness of the white light component was expressed by the exposure time (at ISO 100 and f/8)

Table III: The four simulated lighting environments.*

Modelled environment	Calibration conditions	Fluorescence intensity readings
Outdoor	Out of direct sunlight but with a large expanse of blue sky	117
Indoor	Next to an office window facing north-east; protected from direct sunlight by high-rise buildings	83
Grading	Under a daylight-equivalent (6,500 K) fluorescent tube, in a room with weak indirect sunlight	10
Office	In a room illuminated with Osram Dulux L (5,400 K) 55 W bulbs; a north-facing window was present but did not supply any direct light	7

* The calibrations for the Outdoor and Indoor environments were based on the weather in Antwerp in November 2017 and were performed between 10:00 and 14:00 on a nearly cloudless day.

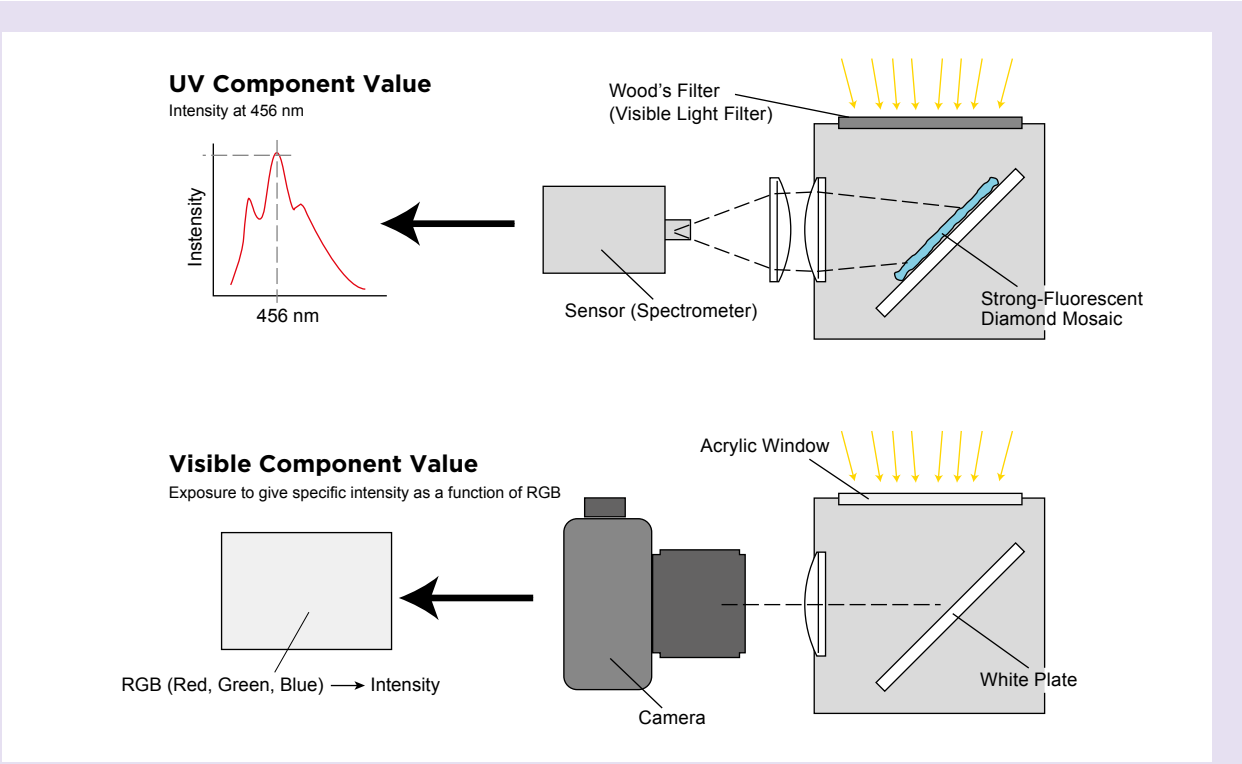

Figure 5: These schematic diagrams illustrate the calibration conditions used to model the various illumination environments. Top: A spectrometer measures the fluorescence intensity of the main peak at 456 nm for a strong-fluorescent diamond mosaic. Bottom: A digital camera photographs a white plate with a range of exposure times in order to obtain a greyscale value of 175.

required to achieve a greyscale value of 175 in the resultant image of the white plate. As it was not possible to obtain live readings of the greyscale value, initially a range of exposures was applied to generate a mathematical relationship between exposure and greyscale value. From this relationship it was then possible to determine the camera exposure that would be necessary to obtain a specified greyscale value.

For a particular viewing environment, the lighting could be characterised by the relative values of the diamond mosaic fluorescence intensity reading at 456 nm (for 2 sec) and the camera exposure necessary to obtain a greyscale value of 175 for the matt-white surface. These two figures—say 710 and 1/30 sec—provide a measure of the relative UV component in a light source. Following the example mentioned above, 1420 and 1/60 sec would therefore correspond to a light source with the same relative UV component.

The sensor array described above was then brought to the four different lighting environments to be modelled. A photograph of the white inclined plate defined the white-light intensity, after which the target diamond fluorescence level was calculated for each of the lighting conditions. After coupling the spectrometer with the housing, we adjusted the current to the LEDs until the desired fluorescence intensity (at 456 nm) was reached. The amount of current necessary to provide the level of UV radiation needed to simulate each intended lighting condition was noted. The fluorescence intensity readings of the four simulated lighting environments are given in Table III. Since there was a near-linear relationship between LED output (UV intensity) and the current applied, the readings can be considered relative to each other.

For the table-up lighting cabinet, determining the UV setting for the LEDs was more difficult because the light seen by the viewer in a diamond comes not only from the direct illumination of the lamp, but also from light scattered off the cabinet wall facing the stone (whereas the fluorescence is mostly from direct UV illumination). The calibration was thus based on photographing the surface of the cabinet wall facing the diamond.

The final lighting spectra that were used to simulate Outdoor, Indoor, Grading and Office environments are shown in Figure 6. As expected, the spectra show distinct intensity variations in the region corresponding to long-wave UV radiation from the LEDs at 365–370 nm, but are otherwise identical.

The methodology described above was checked by colour grading a strongly fluorescent diamond alongside a non-fluorescent master stone in an indoor situation (i.e. in proximity to a north-east-facing window) and finding the result consistent with that observed under the simulated Indoor environment. This was done in both table-down and table-up orientations.

Participants and Experimental Setup

Our study involved four experiments (see Table IV). In Experiments 1 and 2, a conventional laboratory viewing configuration was used to examine the diamonds through their pavilion (table-down). Only certified graders from the HRD Antwerp lab participated in this part of the study. In Experiments 3 and 4, the samples were viewed through the table (table-up). In addition to the certified graders, observers included 'industry participants' and 'consumers'. The industry participants consisted of employees from the HRD Antwerp lab who work in administration and reception (i.e. who see diamonds every day but do not have any experience with colour grading). The consumers

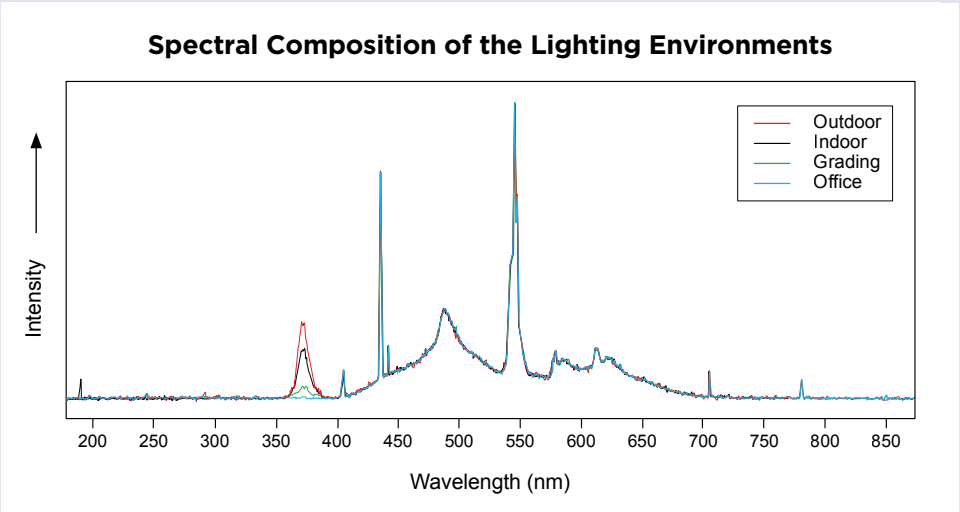

Figure 6: Emission spectra are shown for the four different simulated lighting environments. The spectra demonstrate that the UV component (<400 nm) of the Outdoor lighting is highest of the four environments, while in the Office lighting it is nearly absent.

Table IV: Overview of the four experiments that were carried out in this study.

Experiment no.	View	Objective	Samples	Views per sample	Observers[a]			Lighting environments
					Graders	Industry	Consumers	
1	Table-down	Colour difference? (yes/no)	56[b]	10	14	–	–	Outdoor Indoor Grading Office
2	Table-down	Colour grading	69	10	17	–	–	Outdoor Indoor Grading Office
3	Table-up	Colour difference? (yes/no)	56[c]	12	12	5	6	Outdoor Indoor Grading Office
4[d]	Table-up	Colour grading	49	12	13	8	14	Outdoor Indoor Grading

[a] Due to the availability of graders, industry participants and consumer observers, a larger group of people (more than 10) was used for each experiment, but each sample was viewed 10 or 12 times. (Thus, not every observer looked at every diamond.) The average of these observations was then calculated.

[b] Experiment 1 excluded diamonds with nil, ++slight and +slight fluorescence intensities. Thus, for every colour a set of eight samples was used.

[c] Experiment 3 excluded diamonds with nil fluorescence. Thus, for every colour a set of eight samples was used.

[d] Experiment 4 excluded samples with nil through =slight fluorescence intensities (except a +SL diamond was included for D and I colours since they lacked a ++VST and a +M sample, respectively). Thus, for every colour a set of seven samples was used. Office lighting was not included in Experiment 4 because no colour changes were observed in that environment in Experiment 3.

were HRD Antwerp employees who work outside the laboratory. Both sets of non-graders were included in this part of the study to investigate whether untrained people could also notice fluorescence-related colour differences that were obvious to graders. The number of observers used in each experiment is shown in Table IV.

Experiment 1 (Table-Down, Colour Difference). The objective of Experiment 1 was to determine whether a difference in colour could be noticed in the diamonds positioned table-down when switching between UV-containing and UV-free light sources. The diamonds were generally placed 25 cm below the lighting array in a dark room. For the Outdoor environment, a distance of 35 cm was used. (Because the desired UV level exceeded the output of the UV unit, the visible light was 'dimmed' by raising the daylight tube 10 cm.) The samples were arranged in rows according to their colour (Figure 7). Within each row, the diamonds were ordered by increasing fluorescence intensity from left to right. The graders were informed about the setup of the diamonds (increasing colour and fluorescence level; nil to +slight intensities were not included). For each diamond, the grader recorded if he/she observed any colour difference when switching on and off the UV source (i.e. the LEDs). This was done by 10 different graders, and we then

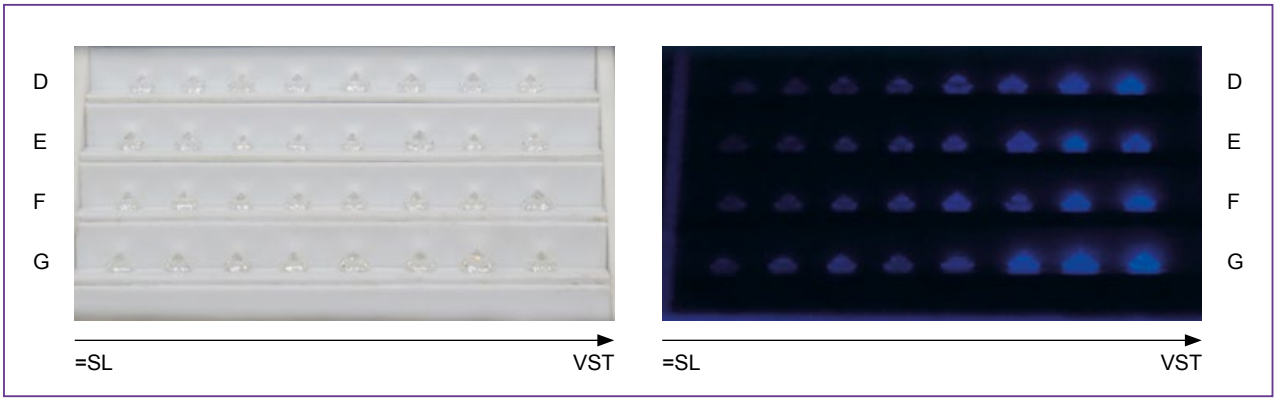

Figure 7: For the setup of Experiment 1, each row contains brilliant-cut diamonds having a certain colour grade. Here only D to G colours are shown. The diamonds have fluorescence intensities ranging from =slight to very strong, and are shown here in normal lighting (left) and under the UV lamp (right). Photos courtesy of HRD Antwerp.

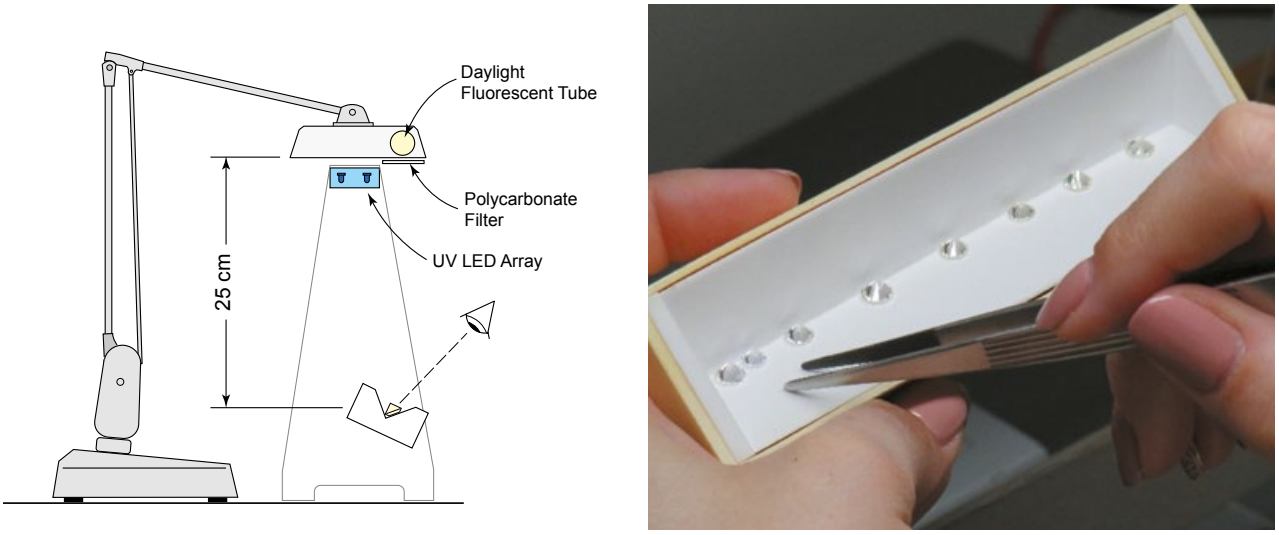

Figure 8: Left: This diagram illustrates how colour grading was conducted in Experiment 2. Right: A participant compares the colour of a sample diamond (left corner) to a set of master stones. Photo courtesy of HRD Antwerp.

calculated a single result for each sample by averaging the 10 observations. This experiment was repeated for each of the lighting environments—Outdoor, Indoor, Grading and Office.

Experiment 2 (Table-Down, Magnitude of Colour Difference). The objective of Experiment 2 was to determine the magnitude of any difference in each diamond's perceived colour in different UV-containing lighting environments. The same samples were used as in Experiment 1, except that diamonds with nil to +slight fluorescence intensities were also included.

One at a time, the samples were placed in a tray alongside a colour-grading master set of nil-fluorescing diamonds for comparison. The master diamonds met the requirements of IDC to grade colour (IDC, 2013). The tray was made of Spectralon, which is known to reflect more than 95% of all light, including UV (Georgiev and Butler, 2007). The tray was positioned approximately 25 cm under the light source (Figure 8). The graders were asked to tilt the tray to look just behind the perpendicular view of the pavilion facets. For each sample, the participants recorded the colour grade on a survey sheet (e.g. Figure 9), and this process was repeated for each

Fluorescence experiment

Name: [illegible] Date: 23 / 03 / 18

Viewing method: ☐ Table up ☒ Table down

Lighting set up: ☐ Outdoors ☐ Indoors ☒ Grading ☐ Office

Grade the color of the diamonds below in the light environment.

Grade de kleur van de onderstaande diamanten in de aangekruiste lichtomgeving.

108	= 1	158	+4	193	+2
110	++3	159	+3	210	+3
131	+2	164	+3	238	++4
132	= 2	165	+6	253	+5
139	+6	167	+3	274	+6
140	+5	169	+4	275	++6
146	= 5	171	+6	321	++6
147	+7	173	+5	352	= 7
149	+3	175	= 4	366	+7
152	+2	176	++2	371	+++7
154	+2	179	+6	390	= 7
157	= 7	185	+7		

Figure 9: An example of a completed survey sheet shows how colour grades were reported for Experiment 2.

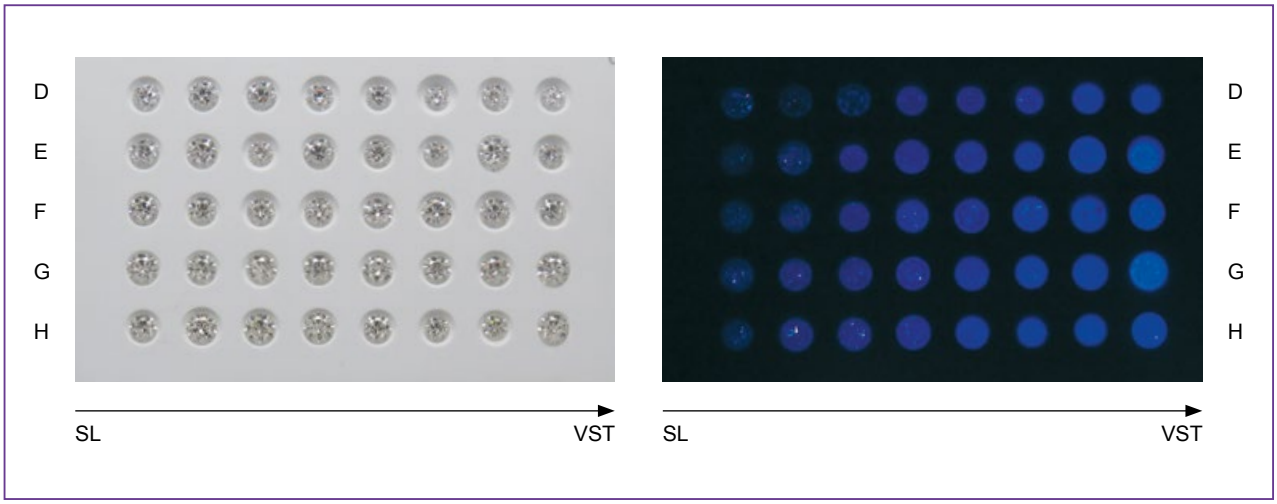

Figure 10: For Experiment 3, several rows of diamonds (here, colours D–H) are positioned table-up. The diamonds have fluorescence intensities ranging from =slight to very strong, and are shown here in normal lighting (left) and under the UV lamp (right). Photos courtesy of HRD Antwerp.

lighting environment. Observations by 10 different graders were averaged into a single result for each diamond.

An example of a completed survey sheet is shown in Figure 9. The colour grades are represented by numerical values, where D-colours are represented by a 1, E-colours by a 2 and so on. This was done so that the results could be averaged mathematically. The numerical values were subdivided using the symbols '++', '+' and '='. For instance, '++2' corresponded to a value of 2.167, '+2' corresponded to 2.5 and '=2' corresponded to 2.833.

Experiment 3 (Table-Up, Colour Difference). Experiment 3 tested whether the participants noticed any colour difference in the diamonds with and without the UV component in each of the four different lighting conditions, but with the samples oriented table-up (Figure 10). Every sample was viewed 12 times, consisting of observations from six graders (50%), three industry participants (25%) and three consumers (25%). The observation procedure was the same as in Experiment 1. Experiment 3 started in the environment with the greatest UV intensity (Outdoor) using the samples with the most fluorescence (+VST, ++VST and =ST). The tests continued with lower fluorescence strengths until participants did not observe any colour difference when switching on and off the UV source, so nil, ++slight and most +slight samples were not included in Experiments 3 and 4.

Experiment 4 (Table-Up, Magnitude of Colour Difference). In Experiment 4, samples were graded table-up in order to quantify any perceived colour difference due to fluorescence. The 12 observations per sample were again divided as above. This experiment included only those diamonds that appeared, on average, to change colour while the UV lamp was switched on and off in Experiment 3. Accordingly, samples with nil to =slight fluorescence intensities were excluded. Also, Office lighting was not included, because in Experiment 3 no colour changes were observed in that environment.

The diamonds were placed on a small strip that could be moved next to a row of non-fluorescing master diamonds spanning colour grades from D to K (Figure 11). In this way, participants were able to compare the diamond samples with the master set to determine their colour. The colour was not determined in the same level of detail as in Experiment 2 because the non-graders participating in this experiment were not trained in colour grading. Thus, the prefixes '++', '+' and '=' were not used.

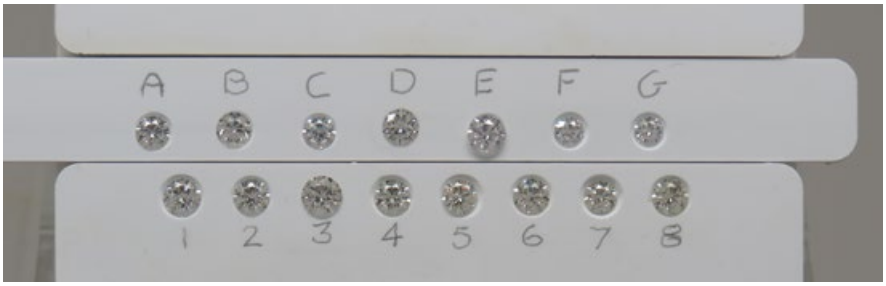

Figure 11: In Experiment 4, diamonds were observed table-up in order to evaluate the magnitude of any perceived colour difference in different lighting environments. The master set is numbered from 1 to 8, where 1 represents D colour and 8 is K colour. The series to grade is labelled A to G on a sliding strip. Photo courtesy of HRD Antwerp.

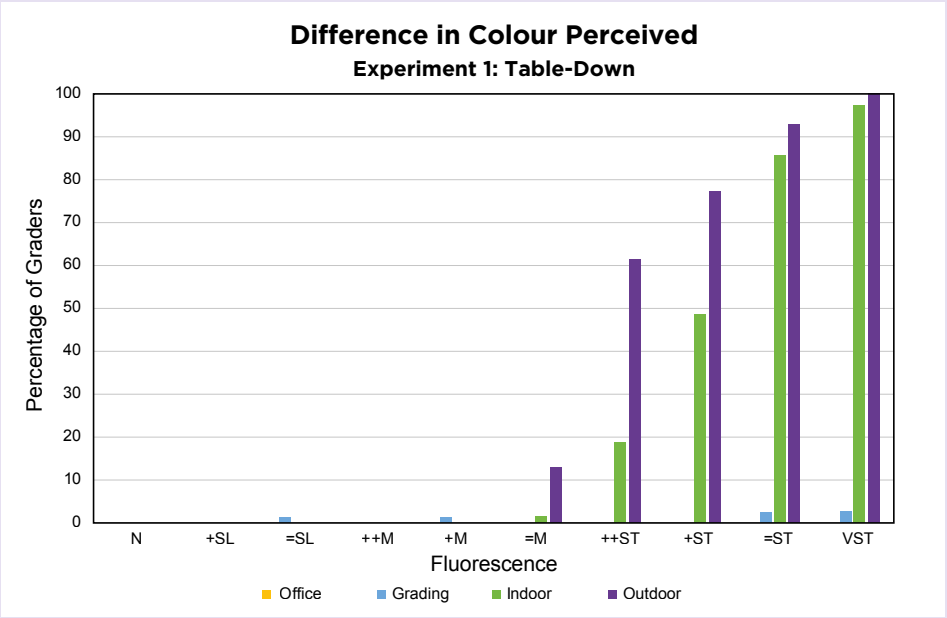

Figure 12: Results plotted for Experiment 1 show the percentage of graders who noticed a difference in colour with and without UV radiation in the diamonds viewed table-down. Participants mainly noticed a colour difference for samples with strong and very strong fluorescence levels. In addition, the effect was primarily observed in environments with higher UV content (Outdoor and Indoor).

RESULTS

Experiment 1: Table-Down, Colour Difference

Regardless of diamond colour, for simulated lighting environments containing higher UV contents (Outdoor and Indoor), graders observed a colour difference in those diamonds with medium, strong and very strong fluorescence. In the lighting environments with a low UV factor (Grading and Office), as expected, almost no colour difference was noted in any of the diamonds. The plot in Figure 12 shows the percentage of graders who noticed an effect from fluorescence in the various lighting environments. For the Grading environment, a small percentage (within the margin of error; less than 5%) could observe a difference in colour between lighting with and without UV.

Experiment 2: Table-Down, Magnitude of Colour Difference

Figures 13–16 show the results of Experiment 2. Differences seen between the HRD Antwerp lab-graded colour and each of three simulated lighting environments (Outdoor, Indoor and Office) are plotted according to diamond fluorescence intensity. (Note that results from the Grading environment are not shown in Figures 13–16 because they were equivalent to the HRD Antwerp lab-graded colour, within the errors mentioned below, as expected.) Each data point represents an average of the 10 observations of each sample. Variations in colour grading between individual participants were expressed as a numerical value of 0.67 (⅔ grade) and were determined by analysing results obtained at HRD Antwerp over the years. The error bars shown in the plots account for these differences between individual graders. The diagonal shading across the centre of each plot represents the area where no colour difference was noted.

When comparing results of the different lighting environments for diamonds with very strong fluorescence, it is clear that the UV component influenced colour appearance in the simulated Outdoor and Indoor lighting (Figure 13). For instance in the Outdoor environment, all diamonds with very strong fluorescence appear to have been 'enhanced' towards D and E colour, regardless of the colour they were graded in the lab. This means that even I- to J-colour samples with very strong fluorescence appeared as D–E colour in the Outdoor environment. As the UV component in the modelled illumination diminishes, the effect decreases as well. This is clearly visible in the results for the Indoor and Office lighting environments in Figure 13.

For samples with strong fluorescence (Figure 14), the same trends are noticeable. In the Outdoor environment, the influence of fluorescence elevates the colour grade to D or E regardless of a sample's lab grade. In the Indoor environment, it is improved by about one grade in the lower-colour stones. There is essentially no difference between the Office environment and lab-graded colour, as shown by the position and 45° slope of the regression line through the Office data.

Overall, the threshold fluorescence grade for a UV effect on colour grade in the Outdoor environment appears to be around medium (Figure 15). For slight- and nil-fluorescent

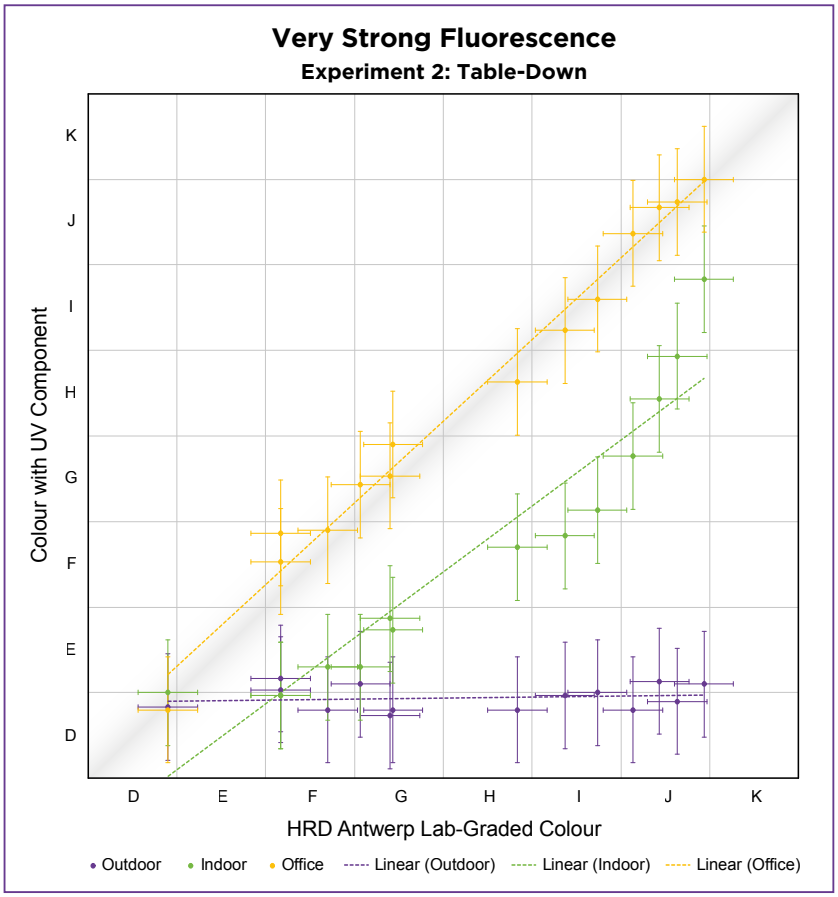

Figure 13: This graph shows the results of Experiment 2 for diamonds with very strong fluorescence graded table-down by comparing the colour observed with a UV component (y-axis) against the HRD Antwerp lab-graded colour (x-axis). The shading in the centre of the plot represents the area where no colour difference was noted. For the Outdoor environment, all samples show an apparent improvement towards D–E colour. This effect is less pronounced with Indoor and Office lighting (environments with lower UV content). Linear regression lines through the data points are added for enhanced visibility.

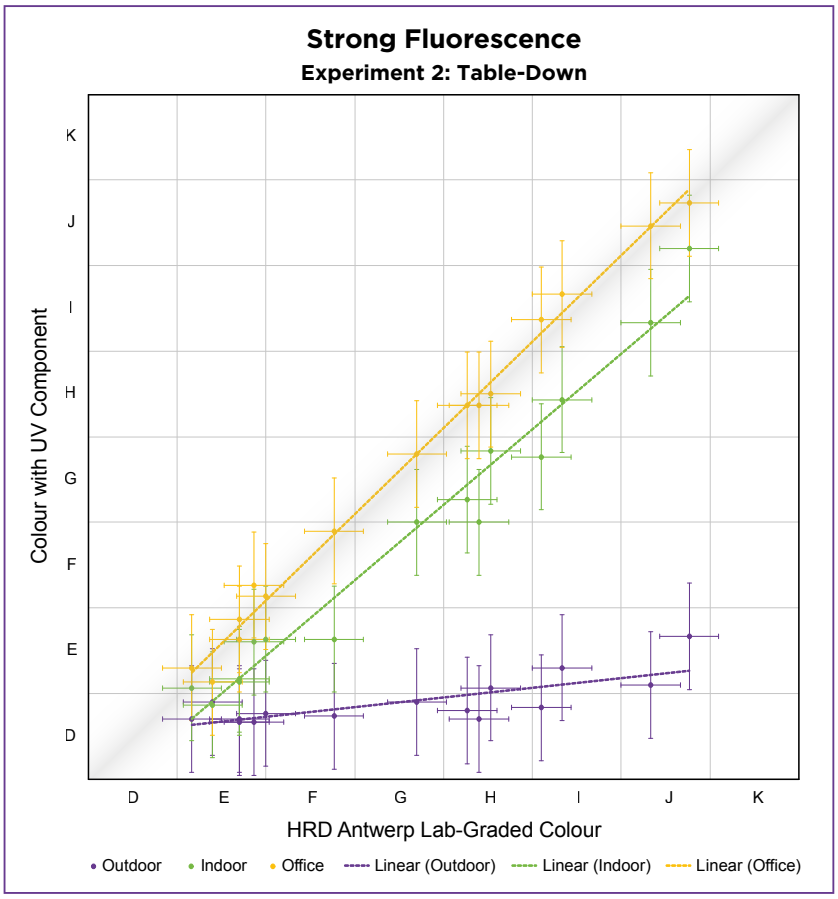

Figure 14: The results of Experiment 2 for diamonds with strong fluorescence graded table-down are displayed here. For the Outdoor environment, the samples appear to have a much better colour compared with their HRD Antwerp lab-graded colour. The influence of fluorescence on colour grade decreases for environments with a lower UV component (Indoor and Office).

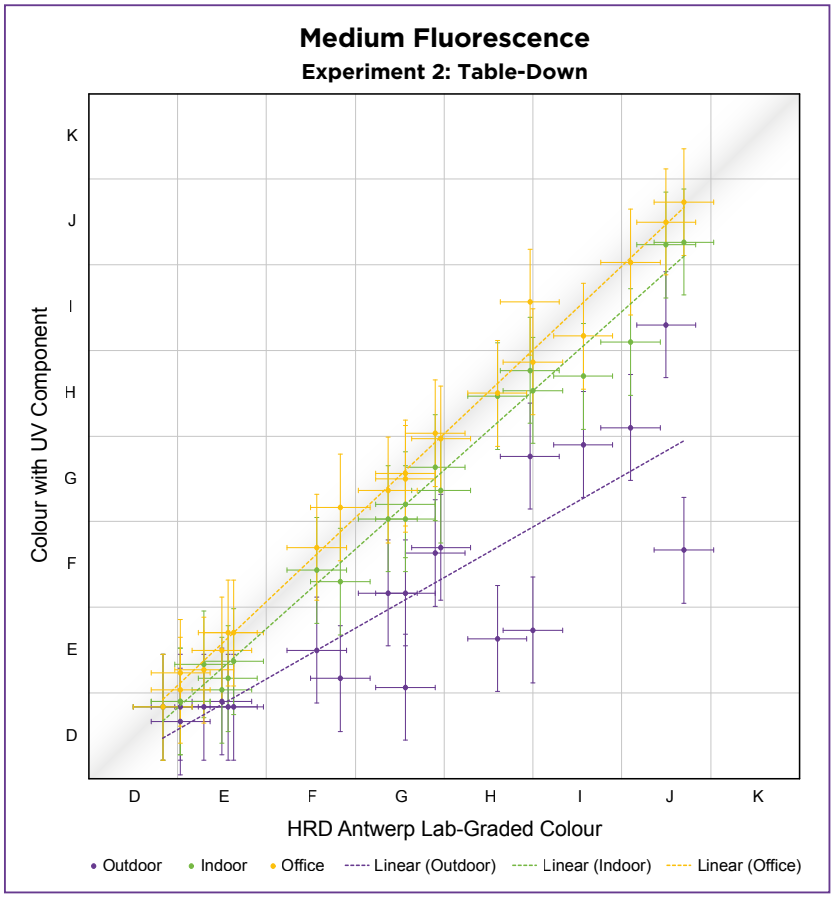

Figure 15: The results of Experiment 2 for diamonds with medium fluorescence graded table-down reveal less effect of the UV component on observed colour in comparison to the previous graphs. In addition, the data points are more scattered, in particular for the Outdoor environment.

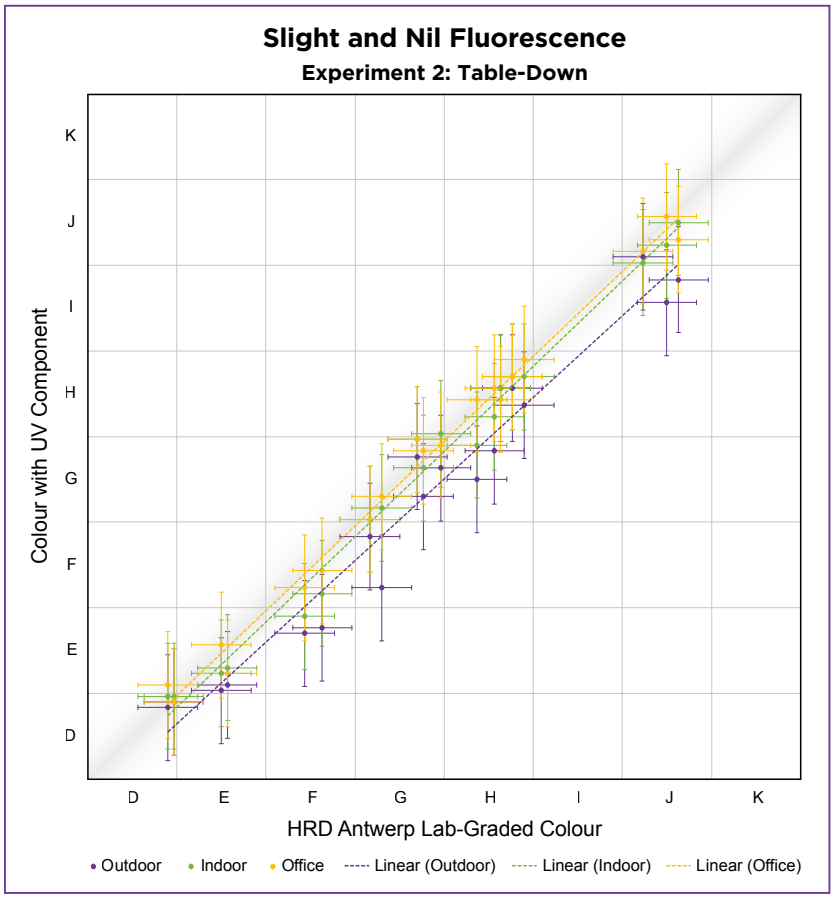

Figure 16: The results of Experiment 2 for diamonds with nil to slight fluorescence graded table-down resulted in data points that show good correlation between HRD Antwerp laboratory grading (UV-free) and UV-containing lighting conditions.

diamonds, the colour was unaffected by fluorescence, with even the Outdoor environment producing no significant colour improvement, as shown in Figure 16.

Experiment 3: Table-Up, Colour Difference

When switching on and off the UV source, participants saw a colour difference table-up in the Outdoor lighting environment for all diamonds with very strong fluorescence and for some of the strong-fluorescent diamonds as well. The colour difference seen in the Indoor environment was significantly less, with the effect mainly limited to the very strong fluorescence category. The participants reported no colour differences for diamonds in the Grading and Office lighting. The overall results are presented in Figure 17.

Examining the results for the Outdoor environment (Figure 18), it is clear that the HRD Antwerp graders, although not trained in the table-up colour grading

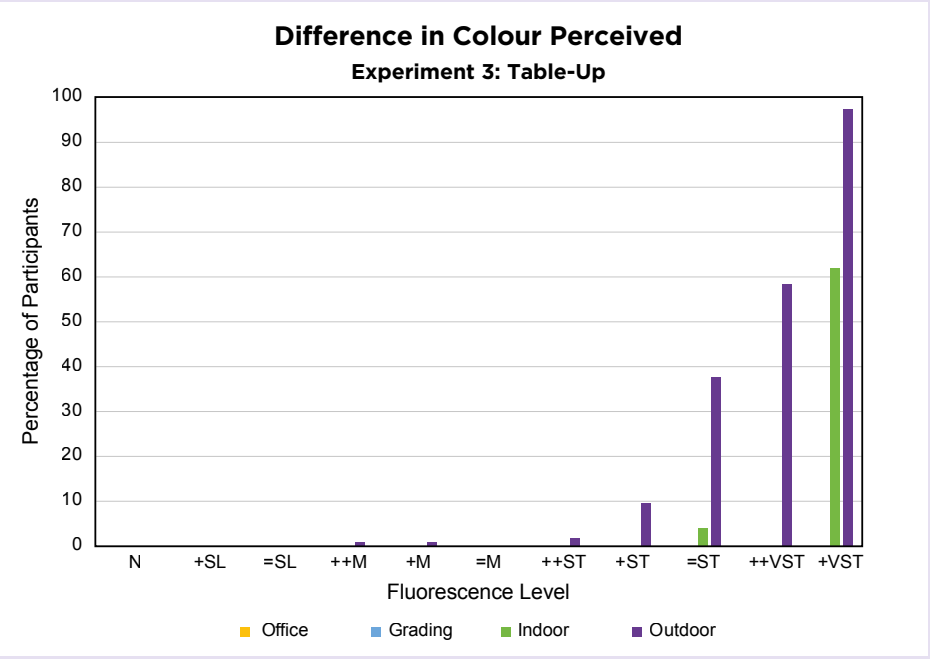

Figure 17: This plot shows the results of Experiment 3, expressed as the percentage of participants who noticed a colour difference in lighting with and without UV radiation for diamonds viewed table-up. Mainly those samples with strong and very strong fluorescence showed an effect, which was most prominent in the Outdoor environment.

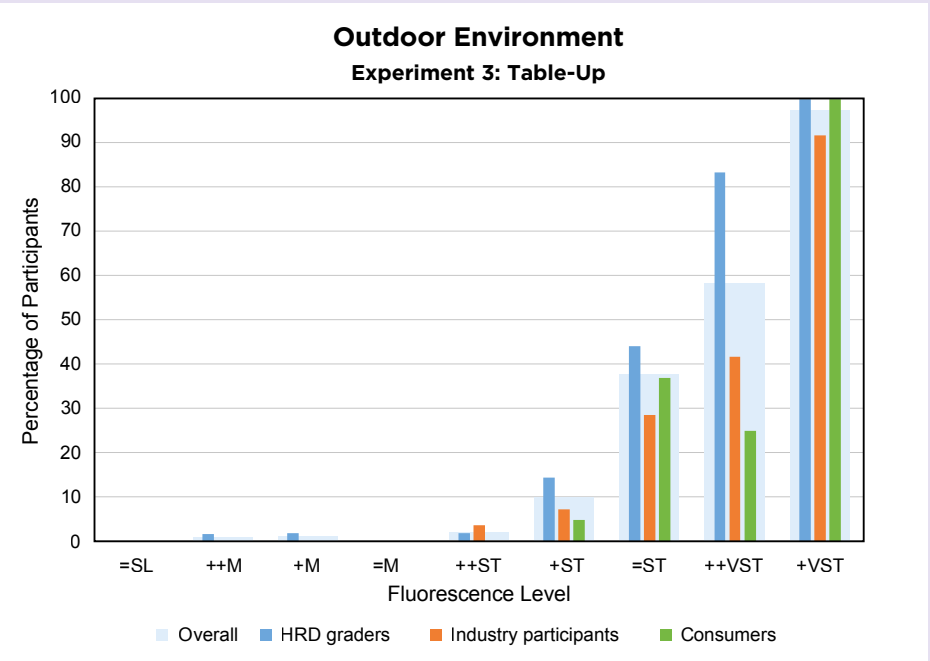

Figure 18: The perception of colour differences in diamonds viewed table-up by graders and non-graders in the Outdoor environment was found to be similar for samples with the strongest blue fluorescence. The effects of medium or less fluorescence were perceived only by HRD graders.

procedure, were more sensitive to subtle differences in colour than non-graders. For the stones with the most extreme very strong fluorescence, also known as 'over-blue' diamonds, almost every participant saw a colour difference when switching on and off the UV light source. This means that even for top colours (D–G) a change was noticed.

For the diamonds with very strong fluorescence close to the strong border (++VST), more than 80% of the HRD Antwerp graders—but only 25% of the consumers—perceived a difference in colour between the Outdoor environment and UV-free lighting. Some of the consumers also noticed a difference in colour for the strong fluorescence category, but neither consumers nor industry participants noticed any effect for lower levels of fluorescence in the Outdoor environment.

For the Indoor environment (Figure 19), the results changed drastically. Only for the diamonds with the strongest fluorescence was a colour difference noticed significantly. For the strong and lower fluorescent grades, the effect was negligible. Again, the consumers were less observant to differences in colour than more experienced participants. For the two remaining environments (Grading and Office), no colour difference was noticed by any of the participants.

Experiment 4: Table-Up, Magnitude of Colour Difference

In Figures 20–22, each data point represents an average of the 12 observations of each sample. For very strong fluorescence, some diamonds viewed table-up received a better colour grade in Outdoor conditions (Figure 20). Unfortunately, the number of data points is too limited to draw any meaningful conclusions since only six diamonds with very strong fluorescence were included. For the strong (Figure 21) and medium fluorescent diamonds (Figure 22), little or no significant differences were observed.

DISCUSSION

The debate about the effect of blue fluorescence on the appearance of a faceted diamond and the price discount for strong fluorescence is not new. However, the topic has recently experienced a renewed interest in the trade (e.g. Sivovolenko and Serov, 2018).

In 1997, GIA published an article (Moses et al., 1997) investigating the effect of blue fluorescence on the appearance of faceted diamonds. In that study, a limited sample set of 24 diamonds encompassing four colour grades (E, G, I and K) was used.

In the present study, we focused on a more extended sample set, including all colour grades ranging from D to J. We also simulated four common lighting environments (i.e. Outdoor, Indoor, Grading and Office). Our results show that there is a significant difference between table-up and table-down changes in perceived colour due to fluorescence. Apparent improvements in colour were greater in the table-down position. This is possibly related to the fact that a diamond's body colour is easier to distinguish through the pavilion. An

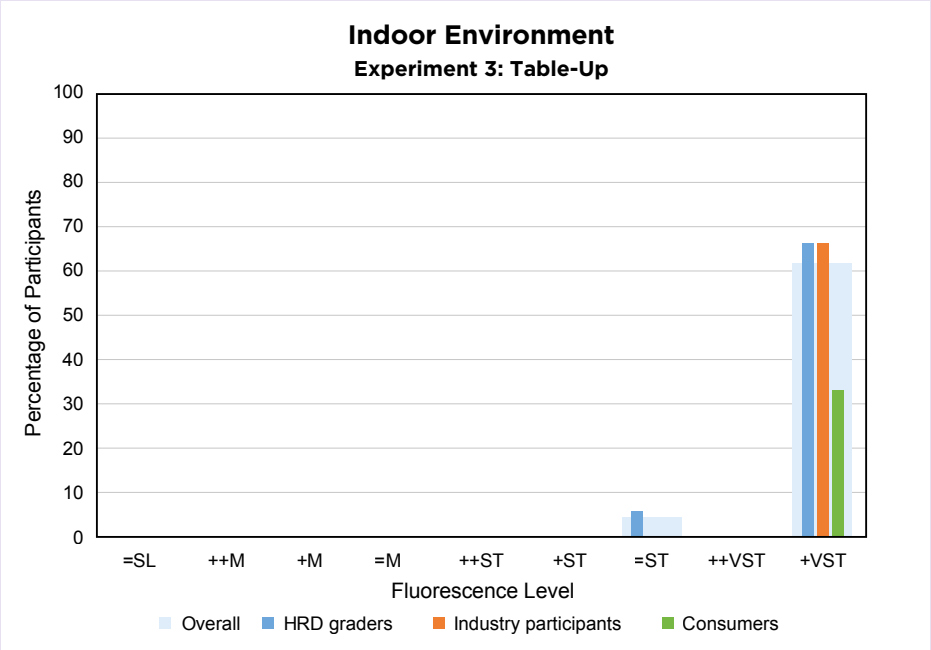

Figure 19: Graders and industry participants and, to a lesser extent, consumers perceived a difference in colour in diamonds with the strongest blue fluorescence when switching between Indoor and UV-free lighting environments.

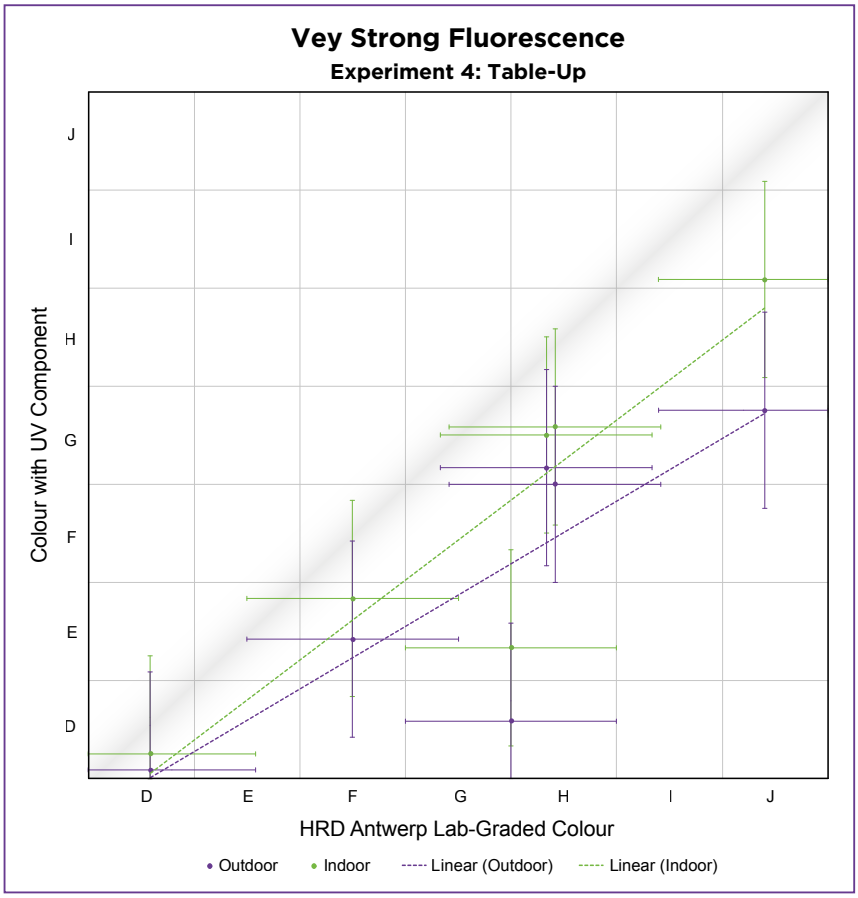

Figure 20: The results of Experiment 4 for diamonds with very strong fluorescence showed that the colour-grade improvement for the samples graded table-up is much smaller compared to table-down results.

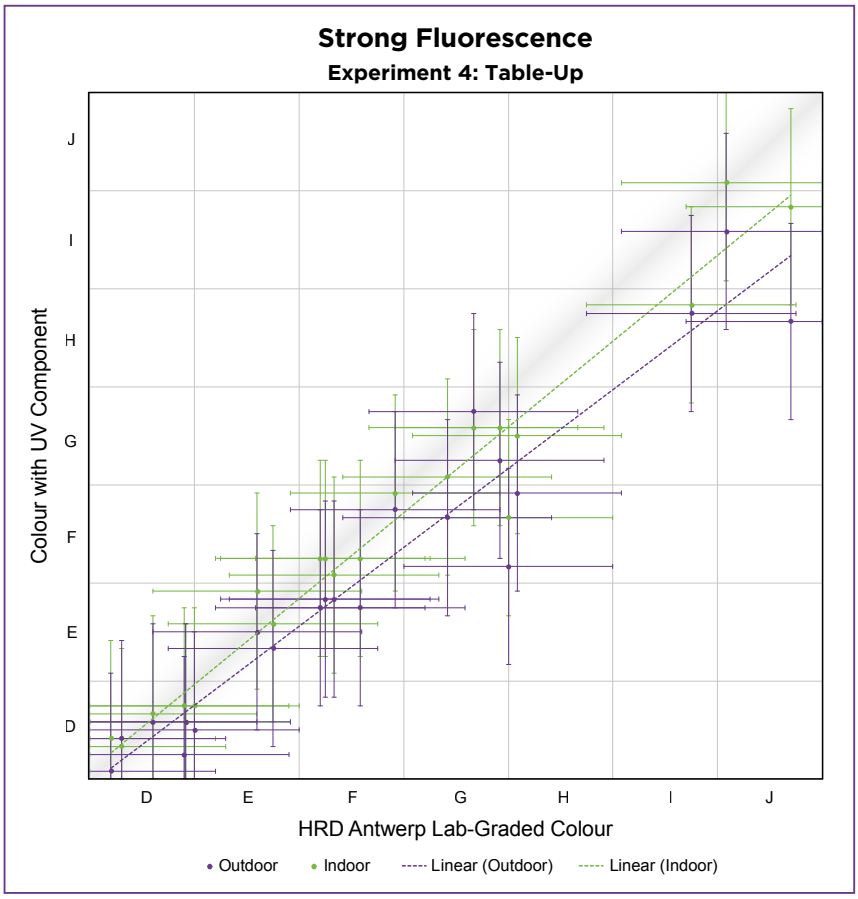

Figure 21: The results of Experiment 4 for diamonds with strong fluorescence graded table-up revealed that little or no significant difference in colour was observed.

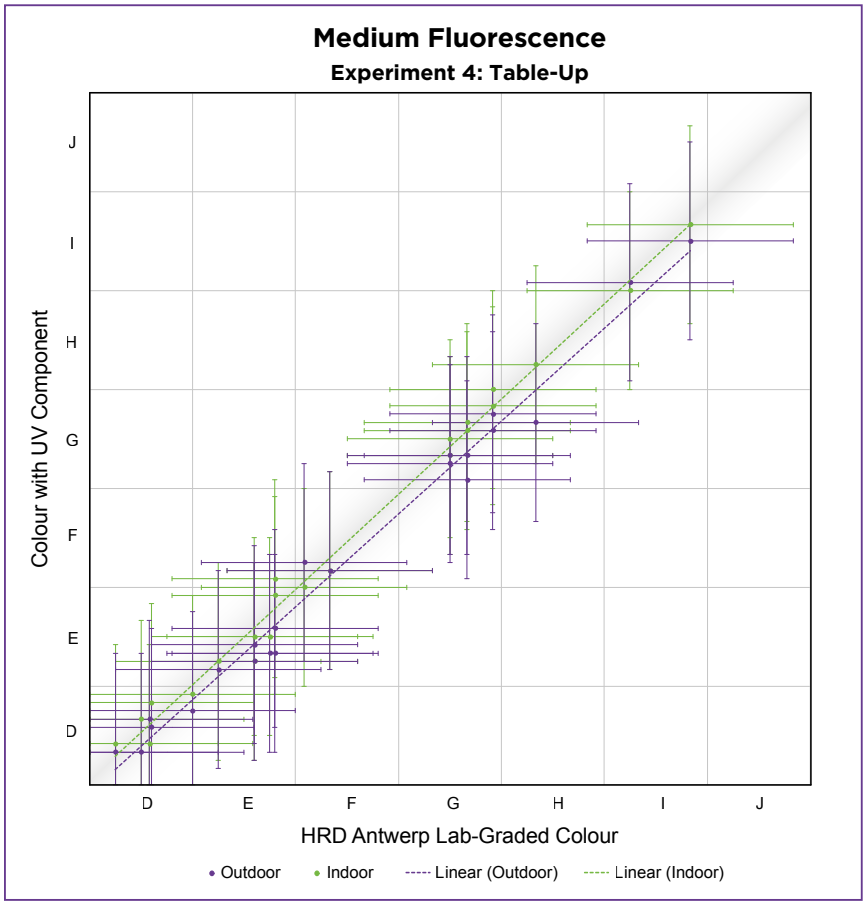

Figure 22: The results of Experiment 4 for diamonds with medium fluorescence graded table-up yielded essentially no colour difference perceived in any of the lighting environments.

interesting observation was the difference in fluorescence intensity seen between table-down and table-up directions for some samples, which is likely due to the interplay between fluorescence zoning and internal reflections in the brilliant-cut diamonds. This led to the decision to use a (partly) different sample set for the table-up experiments.

In some cases, perceived improvements in colour under lighting with a significant UV component were related to the experience of the observer. For diamonds with very strong fluorescence close to the strong border, only 25% of the consumers could detect a difference in table-up colour between the Outdoor environment and UV-free lighting (Figure 18). This means that under everyday outdoor conditions (without direct sunlight), probably only a small percentage of people would notice a fluorescence-related difference in the colour of diamonds mounted in jewellery. The effect would be most obvious in a piece of jewellery containing several diamonds of the same colour but with different fluorescence intensities.

We also found a difference between Indoor and Grading conditions, which contrasts with the results of Moses et al. (1997). In the latter, the results were more-or-less the same between these conditions, but we documented a colour improvement in Indoor conditions for very strongly fluorescent diamonds due to UV content. In addition, our study found no significant difference in perceived colour between our Grading and Office environments. As demonstrated by our lighting simulations, the UV level in the grading lamps used by HRD Antwerp does not affect the colour grade.

CONCLUSIONS

The experiments conducted for this study revealed several significant points:

1) Conventional grading through the pavilion in Outdoor conditions had the effect of improving the colour grade for diamonds with a (blue) fluorescence grade of medium and stronger, elevating the apparent colour of diamonds with E–J grades to D or E for those with strong and very strong fluorescence.

2) In table-up orientation, the intensity of blue fluorescence did not directly correlate with the fluorescence grade in the conventional table-down position, such that

a diamond with a grade of medium could show table-up fluorescence equivalent to that of a diamond having either a slight or strong grade.

3) The effect of blue fluorescence on the perceived colour appearance of a diamond viewed table-up is much less than in the table-down position.

4) For medium blue fluorescence we found no significant improvement in table-up colour appearance in Outdoor lighting.

5) Graders were more able than industry participants or consumers to discern colour differences resulting from blue fluorescence.

To conclude, we did not observe any negative impact of blue fluorescence on diamond colour. In our grading environment, the percentage of lab graders who could observe a colour difference with and without UV was insignificant. Our study shows that blue fluorescence can greatly enhance the table-down colour appearance of a strongly fluorescent diamond when viewed in outdoor conditions. For diamonds with medium or less blue fluorescence, to a casual observer there would be no apparent effect seen table-up, even when viewed outdoors. Given these observations, it can be argued that there are no grounds to justify the price penalties currently applied to blue-fluorescent diamonds—and arguably a premium could be warranted, except in the case of extreme blue fluorescence.

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Figure 1: A modern photograph illustrates the 45.52 ct Hope diamond as it is now in the Smithsonian Institution's National Museum of Natural History in Washington DC, USA. Photo by Chip Clark, Smithsonian Institution; catalogue no. NMNH G3551, photo no. 2003-37145.

Out of the Blue: The Hope Diamond in London

Jack M. Ogden

ABSTRACT: Our knowledge of the history of the French Blue/Hope diamond between the time of its theft from the French Crown Jewels in 1792 and its publication as part of the collection of Henry Philip Hope in 1839 has many tantalising gaps. Based on new research, this article covers what we now know of this diamond after its reappearance in London in 1812. A painting of the diamond by the mineralogist James Sowerby has been located, along with Sowerby's notes. These formed the basis for an advertising pamphlet for the gem produced by London jeweller Daniel Eliason, published in English and French versions, which can now be dated to 1813. We also learn that Eliason and Sowerby exhibited, or at least planned to exhibit, a blue glass model of the diamond at the Linnean Society in London. Several sources point to 1821 as being the year Henry Philip Hope purchased the diamond in London. The testimonies in the 1840s court cases surrounding the ownership of Hope's gem collection following his death in 1839 provide useful background information and, remarkably, suggest that in 1838 there was an attempt to sell the diamond back to the French Crown.

The Journal of Gemmology, **36**(4), 2018, pp. 316–331, http://doi.org/10.15506/JoG.2018.36.4.316

The history of the famous Hope blue diamond (Figure 1)—its journey from the East to the French King Louis XIV in the 17th century, its theft during the French Revolution, its pride of place in the Hope collection in London, and then its eventual arrival in the gem and mineral collection at the National Museum of Natural History in USA—is one of the best-known stories in the history of diamonds (Figure 2). The research presented here aims to fill some gaps in our knowledge of this extraordinary gem and of those who were involved when it reappeared, seemingly out of the blue, in London in 1812. Previously unpublished archival material provides a new witness to its appearance in London—the mineralogist James Sowerby, who painted it, as well as the court testimony of diamond dealer Abraham Hertz, author of the catalogue of the Hope Collection of Gems—which throws further light on various aspects of the Hope, including an attempt to sell it back to the French Crown.

OUT OF THE EAST TO FRANCE

In 1663, the French Huguenot gem dealer, Jean Baptiste Tavernier, set off on what was to be his sixth and final trip to Persia and India (Tavernier, 1676). He took with him jewellery and precious objects worth 400,000 livres (~US$10 million in modern terms), which belonged to several notable French jewellers, to offer for sale (Ogden, 2017). His aim was to sell these pieces to the Persian Shah in Isfahan (in what is now Iran), and to the Mughal Emperor in India, and then invest the proceeds in diamonds from India. One diamond generally assumed to be brought back to France from that successful trip was a large blue one weighing 112 3/16 old carats (or 115.28 metric carats; see Ogden, 2017). Tavernier gave no information as to where he purchased it, and there is one hint that he may have bought it in Iran during his somewhat trying overland journey home (Ogden, 2017). Once back in Paris in 1669, Tavernier sold this large blue stone, along with other diamonds, to the French King Louis XIV. In 1673, it was cut by Jean Pitan into a kite-shaped brilliant of 67 1/8 old carats (Bapst, 1889; equivalent to 68.9 metric carats). Decades later it was set in the Order of the Golden Fleece in the French Crown Jewels for Louis XV (Figure 3). The gem, described then as 'the blue diamond of the crown' (Bapst, 1889, p. 267), is now usually referred to as the 'French Blue'. Little more than a century after the royal purchase of the gem, it was confiscated during the French Revolution, only to be stolen from the poorly guarded Royal Repository in Paris in mid-September 1792 (Bapst, 1889, pp. 447–452. Uncertainty surrounds what happened next.

TIMELINE FOR THE FRENCH BLUE/HOPE DIAMOND

1669
Sold by Jean Baptiste Tavernier in Paris to French King Louis XIV

1673
Cut by Jean Pitan into a kite-shaped brilliant

1749
Mounted into the Golden Fleece ornament of French King Louis XV

1792
Stolen from the French Crown Jewels during the French Revolution

↕

Whereabouts unknown for 20 years

↕

1812
Recorded in London in possession of jeweller Daniel Eliason

1821
Possibly sold to Henry Philip Hope in London

1832
Certainly in the Hope collection by this time

1839
Published in Abraham Hertz's catalogue of the Hope collection

Death of Henry Philip Hope

1848
In the division of Hope's collection after his death, his nephew Henry Thomas Hope receives the Hope diamond

1862
Henry's wife Adele inherits it on Henry's death

1884
On Adele's death it is inherited by Henry Thomas Hope's grandson Lord Francis Hope

1901
Sold to London dealer Adolph Weil, who sells it to New York dealer Simon Frankel

1908
Sold to Salomon Habib, possibly for Sultan Abdul Hamid

1909
Bought at Habib auction in Paris by Paris dealer Simon Rosenau

1910
Sold to Pierre Cartier

1911
Purchased for Evalyn Walsh McLean by her husband

1949
Sold to Harry Winston following Evalyn's death

1958
Donated by Harry Winston to the Smithsonian Institution's National Museum of Natural History

Figure 2: This timeline shows the whereabouts of the French Blue/Hope diamond from 1669 until 1958, when the stone was donated to the National Museum of Natural History, where it presently resides. The blue font indicates the portion chronicled by the present article.

REAPPEARANCE IN LONDON

According to the French historian Germain Bapst, son of the last Crown Jeweller of France, in his exhaustive study of the French Crown Jewels written at the end of the 19th century, following its theft the large blue diamond was taken to London by a man he named as Cadet Guillot, where it was cleaved into two pieces to disguise it (Bapst, 1889, pp. 270–271). This seems to be the earliest mention of Guillot and his involvement, but the basis for Bapst's assertion is unclear. An alternative story is that the theft of the French Crown Jewels was an inside job by revolutionaries, and the blue diamond was used to bribe the Duke of Brunswick, who was threatening to attack France to restore the monarchy (Bapst, 1889, p. 448). This ties in with a rumour reported in the British press shortly after the theft that the revolutionaries had taken the Crown Jewels themselves and that 'their endeavours to discover the robbers are only a mere deception to deceive the public' (e.g. *Kentish Gazette*, 5 October 1792, p. 3). A further version of the tale links the French Blue with the large blue gem worn by Queen María Luisa, wife of Charles IV of Spain, in a 1799 painting by Francisco Goya (now in the Taft Museum of Art, Cincinnati, Ohio, USA), although the gem in the painting is a very different shape (Tillander, 1975). Yet another story—with a series of manifestations of its supposed curse—has the blue gem reaching Wilhelm Fals, a diamond cutter in Amsterdam. The diamond was then supposedly stolen from him by his sons and given to Francis Beaulieu of Marseille, France, who brought it to London and eventually sold it to the London diamond dealer Daniel Eliason (see the section on Eliason below).[1]

As we will see, the French Blue was in London by September 1812, with Eliason, by then cut as an oval brilliant weighing 177 grains or 44¼ pre-metric carats. The 19th-century British carat is usually stated to be around 0.2053–0.2054 grams. That would put the weight of the blue diamond as it was in London in 1812 at between approximately 45.42 and 45.44 metric carats. However, the present weight of the Hope diamond is 45.52 metric carats, and it must have lost at least a little of its weight when slight repolishing, including of the girdle, was done while it was owned by

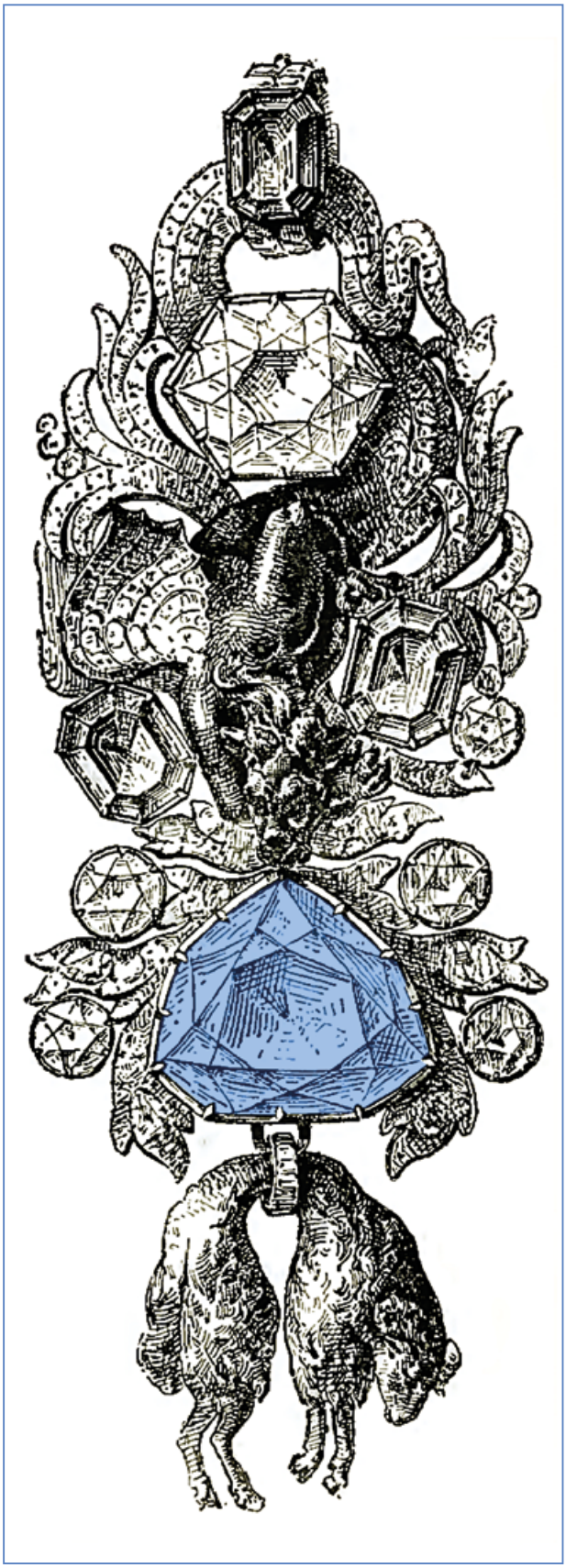


Figure 3: The ~69 ct French Blue diamond was set in the Golden Fleece ornament of Louis XV, which was designed by court jeweller Andre Jacquemin in 1749. From Bapst, 1889, p. 268.

[1] So far the present author has found no mention of a Francis (or François) Beaulieu in connection with the French Blue before this version of the theft was widely reported in the world press in 1909 (e.g. *The Times*, 25 June 1909, p. 5). The origin of this story seems unknown.

Figure 4: The business card of Cripps & Francillon names them as jewellers to his Royal Highness the Prince of Wales (the future King George IV), and also to the Duke and Duchess of Württemberg. © Bodleian Library, Oxford, John Johnson Collection.

Harry Winston in the 1950s. This means that the carat weight used by Eliason (and later by Hertz) must have been nearer to 0.206 grams or more. This seemingly would fit with an 1811 explanation (Kelly, 1811, p. 258) that there were 150 carats to 1 troy ounce, giving a carat then of just over 0.207 g.

The blue diamond later found its way to the collection of gems belonging to Henry Philip Hope and then, through various owners, to Washington DC in the USA as the Hope diamond. Research based on a surviving lead model of the gem as cut by Pitan along with computer modelling has established that the Smithsonian's Hope diamond is indeed the recut French Blue (Farges et al., 2009).

EARLY SIGHTINGS IN LONDON

London jeweller John Francillon (1743–1816), a doctor by training, was of Huguenot descent and had joined London goldsmith and watchmaker John Cripps to form the firm of Cripps & Francillon (Figure 4) no later than 1769. In September 1812, he recorded in his so-called Francillon Memo (Figure 5) a blue diamond in London weighing 177 grains (44¼ pre-metric carats) and provided a coloured drawing, having traced round it 'by leave of Mr Daniel Eliason'. He stated that 'it is beautyfull and all perfection, without specks or flaws, and the Color even and perfect all over the Diamond'. The Francillon Memo,

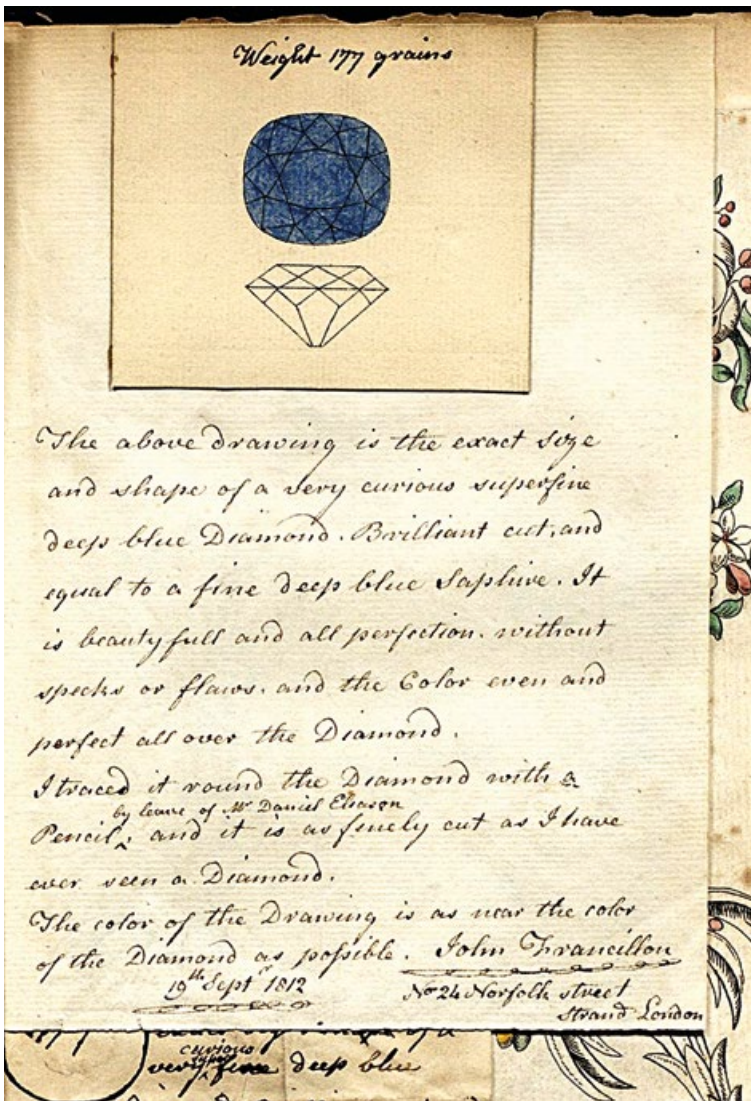


Figure 5: The so-called Francillon Memo describing the blue diamond, written in London in 1812, was found tucked within a copy of Pouget's 1762 *Traité des Pierres Précieuses*, which was once owned by George F. Kunz and perhaps by Francillon himself. Francillon's drawing of the blue diamond was attached to the Memo. Courtesy of the United States Geological Survey Library.

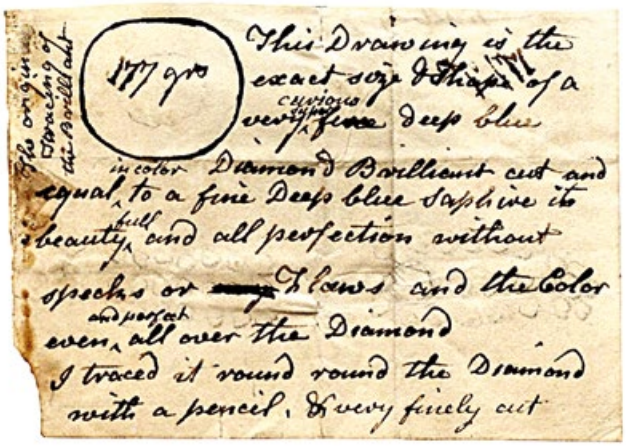


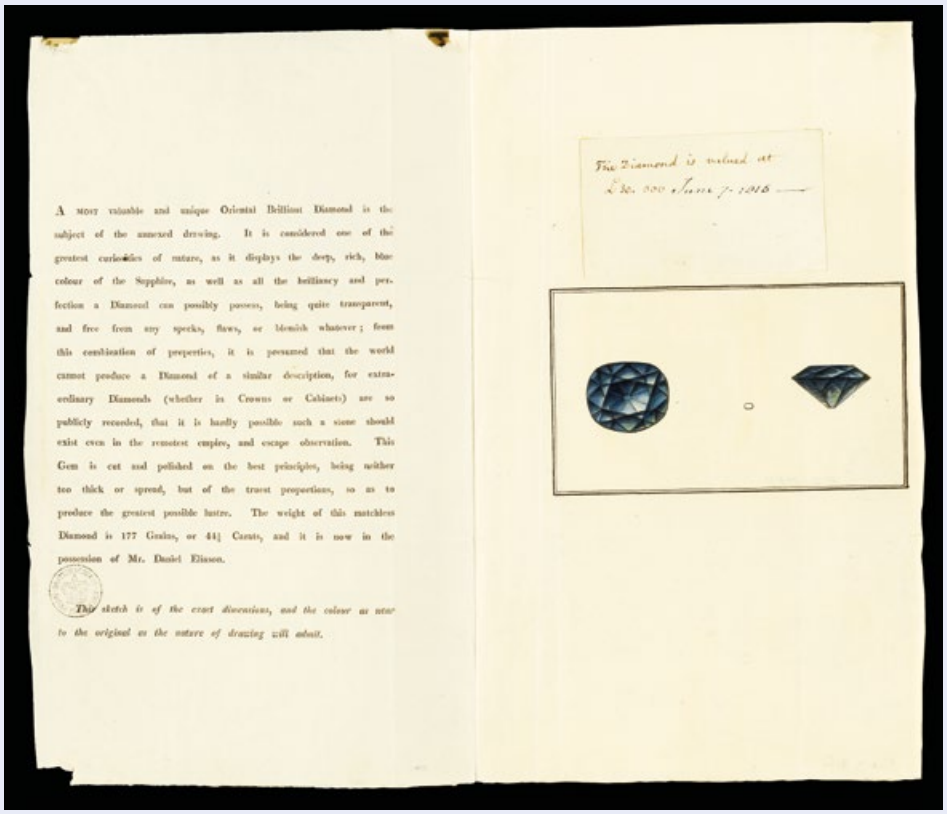
Figure 6: This rough draft of the Francillon Memo in Figure 5 was found in the same volume of Pouget's *Traité*. Courtesy of the United States Geological Survey Library.

and an earlier draft of it (Figure 6), were found tucked into a copy of the 1762 *Traité des Pierres Précieuses* by Jean Henri Prosper Pouget that was later purchased by the gem and jewellery expert George F. Kunz.[2]

Francillon's 1812 drawing and handwritten note were not published, and the diamond was not announced to the wider world until the following year, of which we have evidence of two mentions. The first is a footnote in John Mawe's 1813 *Treatise on Diamonds and Precious Stones* in which he notes the presence of 'a superlatively fine blue diamond' in London, weighing over 44 carats, but without indicating its ownership (Mawe, 1813, pp. 16–17†). Relegating the mention of this extraordinary diamond to a footnote rather than incorporating it into the text (something remedied in his second edition: Mawe, 1823) might suggest that he only saw or heard of the gem after the book was essentially complete, around spring 1813.[3] It is possible that Mawe had not seen the stone himself in 1813, but learned of it from a two-page printed pamphlet that described the diamond, with a hand-coloured illustration of it, which we can now also date to that year. The present author knows of three surviving versions of this pamphlet. Two are in French: one was bound into the same copy of Pouget's *Traité* as the Francillon Memo, and the other is in the manuscript collection of the Natural History Museum, London (Sowerby Coll. MSS B127/1). The third version, now in the British Museum (inv. no. D,2.1787), has the same text in English (Figure 7):

[2] This and other inserts in Kunz's copy of Pouget's 1762 *Traité* seem to be in the same handwriting as text annotations, which suggest that Francillon may have been the original owner of this book, as noted by Kunz (1897).

[3] Mawe's *Treatise* was described as 'nearly ready for publication' in the *Morning Post* of 23 April 1813 (p. 3) and was published the following August (*Morning Post*, 2 August 1813, p. 2).


A most valuable and unique Oriental Brilliant Diamond is the subject of the annexed drawing. It is considered one of the greatest curiosities of nature, as it displays the deep, rich, blue colour of the Sapphire, as well as all the brilliancy and perfection a Diamond can possibly possess, being quite transparent, and free from any specks, flaws, or blemish whatever; from this combination of properties, it is presumed that the world cannot produce a Diamond of a similar description, for extraordinary Diamonds (whether in Crowns or Cabinets) are so publicly recorded, that it is hardly possible such a stone should exist even in the remotest empire, and escape observation. This Gem is cut and polished on the best principles, being neither too thick or spread, but of the truest proportions, so as to produce the greatest possible lustre. The weight of this matchless Diamond is 177 Grains, or 44¼ Carats, and it is now in the possession of Mr. Daniel Eliason.

This sketch is of the exact dimensions, and the colour as near to the original as the nature of drawing will admit.

Figure 7: An English edition of a pamphlet, believed to have been written by James Sowerby, describes the blue diamond that was in the possession of Daniel Eliason, along with a hand-coloured etching showing two views of the stone and an attached note on its value. © Trustees of the British Museum, inv. no. D,2.1787.

> A most valuable and unique Oriental Brilliant Diamond is the subject of the annexed drawing. It is considered one of the greatest curiosities of nature, as it displays the deep, rich, blue colour of the Sapphire, as well as all the brilliancy and perfection a Diamond can possibly possess, being quite transparent, and free from any specks, flaws, or blemish whatever; from this combination of properties, it is presumed that the world cannot produce a Diamond of a similar description, for extraordinary Diamonds (whether in Crowns or Cabinets) are so publicly recorded, that it is hardly possible such a stone should exist even in the remotest empire, and escape observation. This Gem is cut and polished on the best principles, being neither too thick or spread, but of the truest proportions, so as to produce the greatest possible lustre. The weight of this matchless Diamond is 177 Grains, or 44¼ Carats, and it is now in the possession of Mr. Daniel Eliason.

The British Museum pamphlet in Figure 7 has glued to it a piece of paper with the handwritten note 'The Diamond is valued at £30,000 June 7, 1816'. This suggests that the stone was still in Eliason's hands and for sale in 1816. Neither the French nor the English version of this pamphlet bears the artist's name or the date when it was printed, but these can be learnt from the 1840 catalogue of London bookseller John Bohn (p. 647), in which one item is:

> 7048 Sowerby's Drawing of a most valuable and unique Oriental Brilliant Diamond, weighing 177 grains, or 44¼ Carats, and of the colour of the Sapphire, in the possession of Mr. Daniel Eliason; with description; 2 leaves, 4to. PRIVATELY PRINTED, *5s*. 1813.

This catalogue entry helps us to attribute the pamphlet text and drawing to the well-known English naturalist and illustrator James Sowerby (1757–1822), aptly the son of a lapidary.[4] The second French version of the pamphlet is in the Sowerby Archives in the library of the Natural History Museum, London, along with a hand-coloured proof printing of the illustration (as shown in the pamphlet) and Sowerby's original watercolour illustration of the gem (as reproduced in the pamphlet; Figure 8), plus his hand-written note (Figure 9; Sowerby Coll. MSS B127/2):

> The drawing which accompanies this is an humble representation of the most extraordinary Diamond in the world, and as it may not, possibly, remain in England I was desirous that the Linnean Society should have information. The Gentleman who possesses it is so kind as to further my desires by bringing a model of it to show its size, but as it could not be equalled in colour, the model as well as the drawing is much too dull, but may assist the mind with the help of description as the Gem itself is too valuable to be carried about.
>
> Its weight is 177 Grains or 44¼ Carats. It is perfectly clear and transparent and of a fine steel blue colour and lustre. It is ~~cut into~~ a perfect brilliant and has been most scientifically managed in the cutting and polishing and is now the property of D Ellison [*sic*] Esq. Merchant, London.
>
> James Sowerby

This note does not bear a date, but it and the drawing must predate the printed pamphlet of 1813. The Linnean Society, focusing on natural history, was founded in 1788, and both Sowerby and Francillon were members.

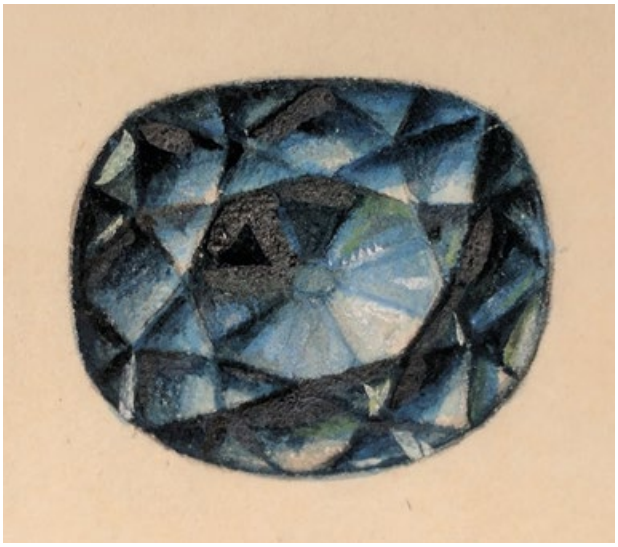
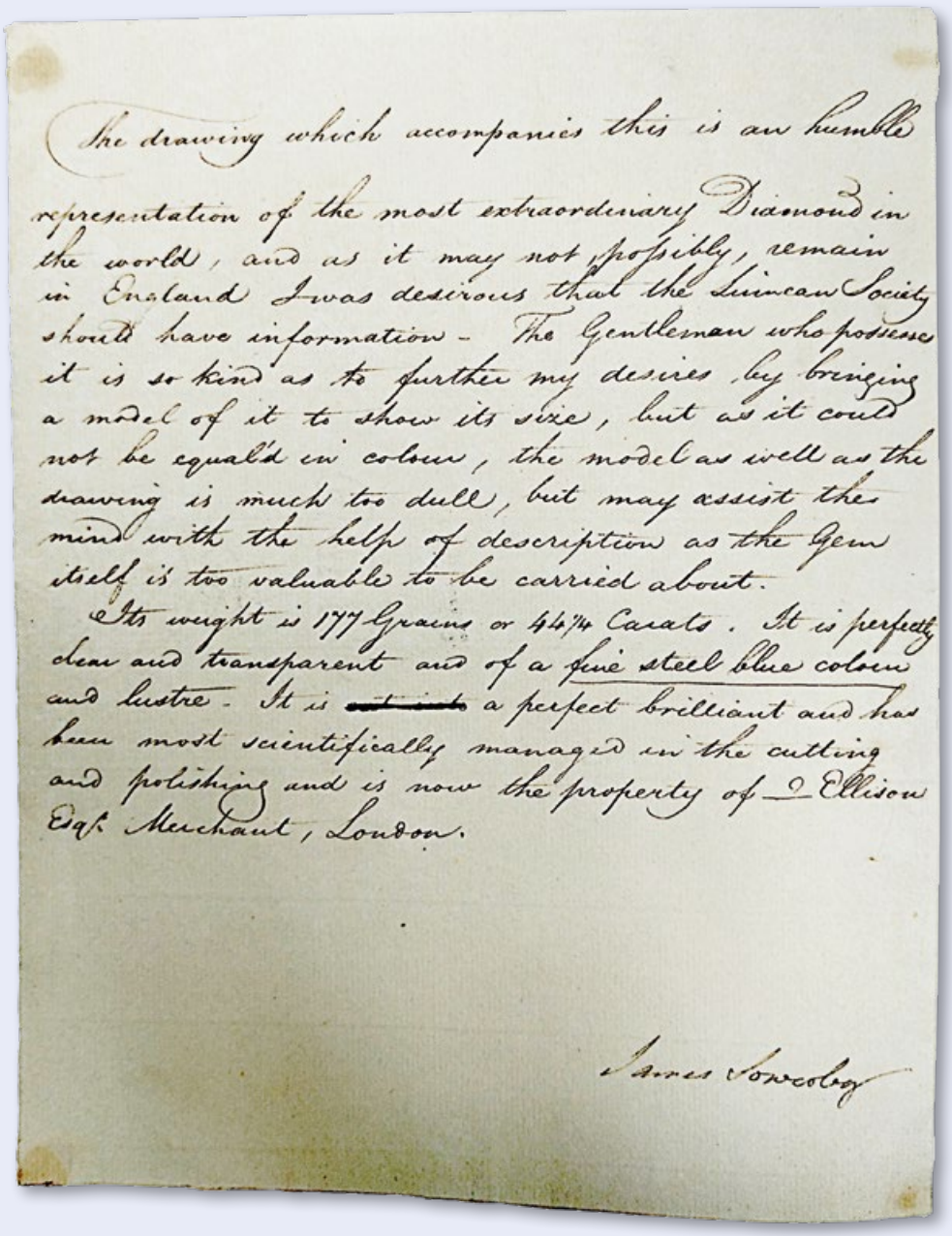


Figure 8: James Sowerby's original painting of the blue diamond dates to no later than 1813. © The Trustees of the Natural History Museum, London.

[4] It has been suggested by Paul Henderson (pers. comm., 26 June 2017)—Sowerby specialist and the author of Henderson (2015)—that there is a possibility that some of the Sowerby drawings, including those for Mawe's book, and thus perhaps the blue diamond, were actually by Sowerby's son, James de Carle Sowerby (1787–1871), who continued his father's work. However, the Sowerby who described the blue diamond in 1813 was a member of the Linnaean Society (see text) for which James junior, then about 25 years old, was probably too young. Besides, Eliason was more likely to have known James senior, who was close to his own age.



The drawing which accompanies this is an humble representation of the most extraordeniary Diamond in the world, and as it may not possibly, remain in England I was desirous that the Linnean Society should have information - The Gentleman who possesses it is so kind as to further my desires by bringing a model of it to show its size, but as it could not be equal'd in colour, the model as well as the drawing is much too dull, but may assist the mind with the help of description as the Gem itself is too valuable to be carried about.

Its weight is 177 Grains or 44¼ Carats. It is perfectly clear and transparent and of a fine steel blue colour and lustre. It is ~~a tinge~~ a perfect brilliant and has been most scientifically managed in the cutting and polishing and is now the property of D. Ellison Esq.r Merchant, London.

James Sowerby

Figure 9: This description of the blue diamond by Sowerby was written no later than 1813. Natural History Museum Library, Sowerby Coll. MSS B127/2. © The Trustees of the Natural History Museum, London.

The model would most likely have been of glass.[5] When Sowerby referred later to this diamond in his 1817 *Exotic Mineralogy*, he noted that 'Daniel Eliason, Esq. has in London a nearly perfect blue Brilliant, of 44½ carats, that is superior to any other coloured diamond known', and he added a footnote that this diamond was 'Remarkable for so little of the purple, that paste [i.e. glass] which is liable to that tinge, cannot be found to imitate it' (Sowerby, 1817, p. 40, text accompanying plates 118 and 119).

In 1812, John Francillon noted that his drawing was made by tracing round the stone. Indeed, the diamond's outline on the draft (Figure 6), like Sowerby's beautifully rendered representation (Figure 8), depicts the familiar slightly lop-sided oval shape, but Francillon's coloured 'fine copy' in Figure 5 shows a more regular oval cushion shape. The facet pattern of Sowerby's painting is essentially identical to that in the 1839 catalogue of the Henry Philip Hope collection (Hertz, 1839, pl. 5, no. 1). Figure 10 shows a computer-generated image of the blue diamond as it was around 1812–1813.

[5] Unfortunately, despite the kind efforts of Dr Isabelle Charmantier and her colleagues at the Linnean Society, London, nothing has been located in their archives to shed any further light on if and when the drawing and model were displayed at a meeting there.

DANIEL ELIASON

The possessor of the blue diamond around 1812–1813 was diamond merchant Daniel Eliason, otherwise known as Tanhum ben Elijah Neumegen, who was born in Amsterdam and moved to London. He was in business as a jeweller by at least 1782. We have various insights into Eliason's diamond business and know of at least two other major stones he handled. Another insert in Pouget's *Traité*, also possibly in Francillon's hand, reveals that in 1802 Eliason purchased a 'most superb Brilliant of fine Water, correct proportions, & noble shape' weighing 37.5 Dutch carats (about 38.6 metric carats) for £4,500 at auction from W. Sharp, Son and Kirkup, diamond and pearl brokers and auctioneers. The advertisement for the auction called this gem 'one of the finest diamonds now on sale in Europe' (*Morning Chronicle*, 15 February 1802, p. 4). Eliason also supposedly sold a 34 ct diamond to Napoleon for £8,000 that he wore at his wedding to Josephine in 1796, but 'It was not a fine and faultless gem' (*The Wesleyan Methodist Magazine*, Vol. 70, No. 1, 1847, p. 571).

Eliason was also implicated in a notorious diamond scandal and trial that, according to some observers at the time, was one of the sparks that ignited the French Revolution. Jeanne de Valois-Saint-Rémy, also known as Countess de La Motte, was guilty of (or framed for) stealing an extravagantly magnificent diamond necklace believed to have been purchased by Marie Antoinette. The various official records and depositions relating to the Countess' trial reveal the different sides to the story (see La Motte, 1789; Funck-Brentano, 1911). The Countess, an intimate of the Queen, claimed that the Queen had given her part of the necklace as a gift, and that her husband had taken these diamonds to London to sell. He took them first to Nathaniel Jefferys in Piccadilly, who made an offer but could only pay in instalments, not cash. The Count then took them to Bond Street jeweller William Gray in Piccadilly, who brought in diamond dealer Eliason. Eliason had already been shown the gems by Jefferys—diamond dealing was a small world then, as now—but a deal was struck, and Gray and Eliason bought the diamonds. Back in Paris the Countess was found guilty, and a few years later the British press reported a duel between Count de La Motte and jeweller William Gray in Brussels in August 1791 (*Oxford Journal*, 27 August 1791, p. 1). Count de La Motte won, although reports that Gray had died were later said to be erroneous. This duel took place just a day or two after the Countess died and according to some press reports was 'supposed to have related to the sale of some jewels, a few years since, taken from the Queen of France, and tendered by the Count as his own' (*Cumberland Pacquet, and Ware's Whitehaven Advertiser*, 30 August 1791, p. 2).

Anyone in possession of the stolen French Blue diamond in the years following its theft and reading Countess de La Motte's detailed and highly popular 1789 account—published in both French and English—would have Eliason's name high on the list of potential 'no-questions-asked' purchasers of major diamonds.

WHY LONDON IN 1812?

The earliest record of the blue diamond in London is of it being in Eliason's hands in 1812. An ingenious explanation for its appearance that year was provided by Winters and White (1991, 1992): This was exactly 20 years after its theft during the French Revolution and thus the time when the 20-year statute of limitations for theft at a time of war in France would have expired. However, this might not be correct: the Napoleonic law code of 1804 superseded earlier French law and clearly defined the statute of limitations for theft in civil law as just three years (§ 227). If this applied to the French Blue, it would have been available for sale after 1804; however, it is

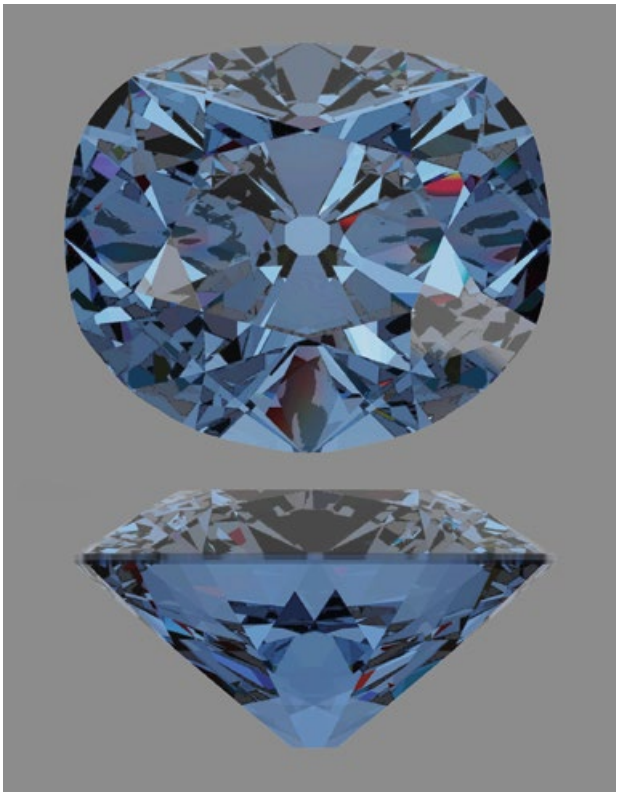


Figure 10: This computer-generated rendering of the ~44 ct blue diamond as it was in 1812–1813 is based on Sowerby's painting in Figure 8 and a later drawing in the Hope collection catalogue (Hertz, 1839, pl. 5, no. 1). Computer rendering by J. Ogden.

possible that neither civil nor martial law is applicable here. Furthermore, the French Blue diamond—as the property of the French Crown—automatically became State property when confiscated during the Revolution. For the theft of French State property, no statutes of limitation apply. Of course, the possessor of the diamond in the years leading up to 1812 may well have believed there to be such a statute. Certainly, the seeming reappearance of the diamond in London exactly 20 years after its theft in Paris seems more than a coincidence.

Another possible argument against the explanation provided by Winters and White is that it seems overly cautious to decrease the value of the French Blue by recutting it to a fraction of its former size—so that it could not be recognised—but still wait until it was deemed safe to sell because of a statute of limitations. Winters and White suggested that Mawe may have known that the stolen French Blue and Eliason's diamond were one and the same and, in Lord Balfour's words, he was 'endeavouring to lay a smokescreen so as to facilitate the eventual sale of the 44-carat gem' (Balfour, 2009, p. 133). If so, Mawe kept to his pretence with remarkable determination. The 1823 second edition of his Treatise includes a drawing of the blue diamond that Eliason had owned, and describes both this stone, which he says was sold by Eliason, and the French Blue, which he still stated to be part of the French Crown Jewels (Mawe, 1823, pp. 44 and 46). It leads to the question: was Sowerby, someone particularly well acquainted with Eliason's gem, also in on the deceit? In his 1817 *Exotic Mineralogy*, Sowerby notes Eliason's blue gem and adds that 'the most curious [diamond] is a sky-blue one, among the crown jewels of France, weighing 67 carats and two-sixteenths' (Sowerby, 1817, p. 40). On balance, it seems highly unlikely that Mawe and Sowerby suspected that the two diamonds were the same.

If Winters and White's statute-of-limitation explanation is not relevant, the diamond's 'appearance' could relate in some way to 1812 being a traumatic year for Eliason and his business partners, with perhaps an urgent need to raise money. In 1810, Abraham Goldsmid, Eliason's son-in-law and a business partner, killed himself after having got into huge debt through the sale of Exchequer Bills for the government. In June 1812 an Act of Parliament was passed 'to provide for the more complete and effectual Liquidation of this debt from the late Abraham Goldsmid, Merchant and his surviving Partners' (*Crown Debt of Abraham Goldsmid*, 52 George III. c.75). There were also other changes. Eliason had quit his partnership with George Goldsmid and George's son in effect from 1 January 1812 (Hackney Archives Department M1481).

GEORGE IV DIAMOND

It is almost certain that Eliason had sold the blue diamond before his death at the age of 91 on 17 November 1824, as there is no mention of the diamond in his will (PROB 11/1693/189) or in the catalogue of March 1825 when Christies auctioned 'A small but highly valuable and particularly select assemblage of set and loose brilliants, including several of considerable magnitude and unparalleled beauty, being the remaining stock of the late Partnership of Messrs. Daniel Eliason and Nephews' (*Morning Chronicle*, 17 February 1825, p. 4). The largest diamonds on offer weighed 18 and 15.3 ct.

In 1822, mineralogist Delvalle Lowry (later Delvalle Varley) mentioned the blue diamond in her book on mineralogy, presented as a series of conversations between her and two other women, 'Frances' and 'Mary' (Varley, 1822, p. 288). When asked if she owned a blue diamond, she replied that she had one with a faint tinge, and then mentioned 'the large one in the possession of Mr Eliason, which you have probably heard of'. Mary replied that she had heard it was worth £30,000. By early 1822 it was being widely reported in the British press that 'a violet-coloured diamond has lately been purchased by his Majesty for 20,000L [£20,000], and that Mr. ELIASON, of Hatton-garden, is setting it'. This referred to King George IV, who was crowned in July 1821, and the assumption has been that this was the diamond we now know as the Hope. An early statement of Royal ownership is in the *Leicester Chronicle* on 16 February 1822 (p. 3), seemingly quoting a report in the *Morning Chronicle* from a few days earlier, but not located by the present author. The following year, Mawe noted that Eliason's large blue diamond was said to be owned by the King (Mawe, 1823, p. 44). In 1831, in his *A Memoir on the Diamond*, John Murray mentioned 'the so-called George IV diamond', said to weigh 29½ ct, and 'of a rich and splendid blue colour' sold to the King by Eliason for £22,000 and worn in his coronation crown. It quotes Mawe on the 44 ct blue diamond that belonged to Eliason and was reported as having been sold by Eliason to the King of Holland (Murray, 1831, p. 41). He illustrates the George IV diamond along with other important diamonds in plate 1 of his book, based on 'correct and beautiful models' in his possession. It is not the lop-sided oval of the Hope but bears similarities to Francillon's representation of Eliason's stone. The weight discrepancy between the King's supposed 29½ ct blue diamond, as quoted by Murray, and the 44¼ ct Hope was presumably an error—unless there were two large blue diamonds. An error seems more likely. In his 1839

second edition, Murray gives the weight of George IV's blue diamond as 44¼ ct, with the same drawing forming his plate (Murray, 1839, pp. 49–50).

By the mid-1840s, it appears that the George IV diamond was assumed to be the same as the large blue diamond published in the 1839 catalogue of the Hope Collection, even though the author of the latter, Bram Hertz, does not mention any royal connection. For example, *The Wesleyan Methodist Magazine* in 1847 (Vol. 70, No. 1, p. 568) noted that the George IV diamond had been sold by Eliason to Hope for £13,000. This assumption has continued to the present time.

It is not impossible, of course, that George IV had owned the diamond, possibly while he was still Prince of Wales. He may have sold it to Eliason sometime prior to 1812, but then wanted to borrow it back for his coronation in 1821. There is no real evidence for this, and it seems doubtful. It was noted above that one theory regarding the French Blue's theft at the time of the Revolution in 1792 was that revolutionaries used it to bribe Charles William Ferdinand, Duke of Brunswick, to give up on his attempt to restore the French monarchy by force.[6] Three years later, the Duke of Brunswick's daughter Caroline married George, Prince of Wales. Although this is an intriguing coincidence, there is no evidence for the 'bribery' theory or that the Duke had possessed the diamond. The Duke's grandson, Charles II, Duke of Brunswick, was a famous diamond collector and owned a small blue diamond that several have suggested was fashioned from the smaller section cut off the French Blue, but the recent computer modelling of the French Blue strongly suggests that it cannot have been. This intriguing but almost certainly erroneous Brunswick link across the three generations was seemingly first suggested in Charles Dickens' magazine *All Year Round* in 1894 (Vol. 12, No. 293, Third Series, 11 August, pp. 126–132).

It has been speculated that George IV had owned the Hope based on a portrait in the Owensboro Museum of Fine Art in Kentucky, USA: 'it was obvious from across the room that the blue ovoid stone in it, near the bottom of the Golden Fleece worn by King George IV of England, was the same stone we know as the Hope Diamond' (Winters and White, 1992, p. 49).[7] The difficulty with this theory, apart from the chronology, is that the Golden Fleece ornament shown on the Owensboro portrait is remarkably close to one still in the Royal Collection (Figure 11), which is set with a fine cushion-shaped blue sapphire (Royal Collection RCIN 441169). The King appears to have owned at least three ornaments of this type, and one may have once been set with the large blue diamond. Equally the sapphire could be a later

Figure 11: The 'Order of the Golden Fleece; Badge of Prince Albert' is set with a large sapphire. It may have belonged to George IV ca 1820. Royal Collection RCIN 441169, 9 × 6 cm. Royal Collection Trust/© Her Majesty Queen Elizabeth II, 2018.

[6] The Duke's 'Brunswick Proclamation' of 25 July 1792 had threatened war with France unless the French King Louis was restored to the throne.

[7] This painting by Sir Thomas Lawrence (1769–1830) is one of numerous portraits of the King by this painter or his studio. The earliest seemingly is from 1818 and is now in the Hugh Lane Gallery, Dublin (Garlick, 1964, pp. 86–88).

replacement for a blue diamond, but without further documentary evidence the portraits cannot support that the Hope diamond was once owned by King George.[8] The origin for the various mentions of the King purchasing the diamond from early 1822 onwards, including Mawe's clear statement, is puzzling but may just be erroneous. Nevertheless, as we will see, the sale of the diamond may well have taken place in 1821, but to Henry Philip Hope.

HENRY PHILIP HOPE

By 1832, the blue diamond had entered the collection of Henry Philip Hope in London (Figure 12; 1774–1839), the youngest son of Jan (or John) Hope, a Dutch banker. At his death in 1839, there was no mention of his gem collection in his will, and his executors thus assumed the stones should be distributed between the three

Figure 12: This portrait of Henry Philip Hope (1774–1839) was painted in enamel by Henry Bone in 1802. Courtesy of Cognacq-Jay Museum, Paris, France; inv. no. J786.

Figure 13: This business card of Abraham Hertz dates to ca 1840, after he had moved to Great Marlborough Street. © Bodleian Library, Oxford, John Johnson Collection.

nephews—Henry Thomas Hope, Adrian John Hope and Alexander Beresford Hope—as part of the residual estate. It was not to be so simple. Alexander claimed that the gem collection had been gifted to him in deeds dated 1832 and 1838, while Henry Thomas Hope claimed that the gems belonged to him under the terms of another deed from 1821. This was all played out in court in a series of cases debating the veracity of the deeds through the 1840s. Ultimately, in 1848, Henry Thomas Hope received a selection of the gems, including the large blue diamond. The court cases are of particular interest because of the specific light they throw on the diamond.[9]

One witness in the 1840s court proceedings, Abraham Hertz, a gem dealer and diamond expert, had learned his trade working for the London diamond dealer Levi Barent Cohen. Cohen was the cousin of the wife of George Goldsmid, one of Eliason's business partners, and became a successful diamond dealer in his own right (Kaplan, 2006, pp. 7–8; Ogden, forthcoming). His business card is shown in Figure 13. Hertz said he was shown Hope's gems in 1832, when he argued that the gems could not properly be called a collection until they had been scientifically classified. In late 1832 or early 1833, Hertz began working with Hope part time to organise the collection, modestly enlarge it to fill gaps, and advise on the recutting and setting of some of the stones. His masterful catalogue of the collection was published in August 1839 (Hertz, 1839) and included a simple drawing of the large blue diamond (Figure 14).

In Hertz's court testimony, he said that when he first saw the Hope collection in 1832, 'a blue diamond of great value' was already part of it and that 'Mr. Hope paid for the blue diamond £13,000' (*The Standard*, 3 December 1844, p. 4). This price is far lower than the earlier asking price of £30,000 in 1816, as noted on the slip of paper glued onto the pamphlet in Figure 7. According to press reports at the time of the 1851 Great Exhibition, Hope had managed to purchase the blue diamond for this low price because 'the diamond-merchant in whose possession it was being in want of money, and finding some difficulty in meeting with a customer for so valuable a gem' (*The Standard*, 17 June 1851, p. 3). The Scottish scientist David Brewster also noted that although it sold for £13,000, the diamond had earlier been pledged for sums of £15,000 and £16,000 (Brewster, 1852, p. 221). Brewster based his information about the price paid on a currently untraceable account from mineralogist James Tennant. Tennant had been an assistant to Mawe, who became acquainted with the blue diamond when it was still in Eliason's hands.

The date of Henry Philip Hope's purchase of the large blue diamond is unclear, but it was certainly prior to 1832 when Hertz saw the stone in Hope's collection, and there is evidence that it may have been considerably earlier. Henry Thomas Hope took possession of the large blue diamond in the agreement reached by the three nephews following the 1840s court cases. This suggests that it had been purchased by his uncle no later than 1821, when the deed in his favour had been drawn up. Perhaps the

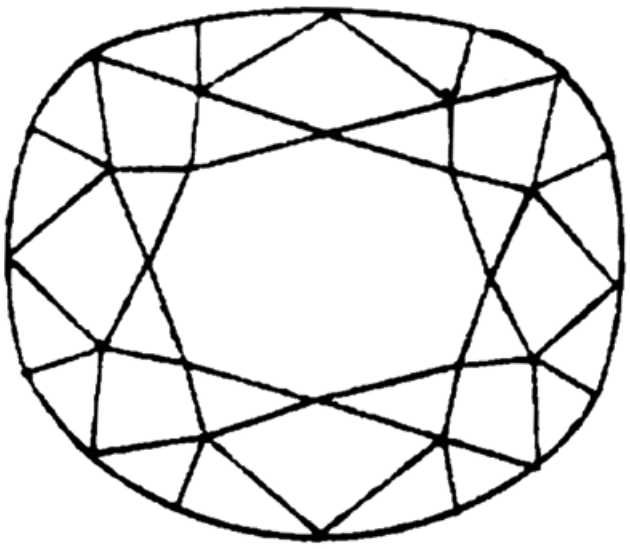


Figure 14: This drawing from the Hope collection catalogue shows the Hope diamond as it was in 1839. From Hertz (1839, pl. 5).

[8] Interestingly, there is one large blue diamond that was in a Golden Fleece ornament at around this time—the Wittelsbach, which had been mounted in the Bavarian Elector's Golden Fleece in 1745, then remounted in a crown in 1806.

[9] The details here and following are from the abundant press reports of the 1840s court cases.

addition of the rare and valuable blue diamond to the collection prompted Henry Philip Hope to consider the collection's long-term future, hence the deed.

We find corroboration for an 1821 purchase date, albeit of uncertain veracity, in the 1845 *Memoirs* of the manufacturer and inventor Sir Edward Thomason. He recalled that in 1816 he gave a lecture on diamonds to the Birmingham Philosophical Society, his fifth presentation to them on the topic of minerals. He described this lecture and expanded on it in his *Memoirs*, which include a description of the 25 most important diamonds in the world. One was what he calls 'The Blue Hope'. He recounted the following (Thomason, 1845, pp. 134–136):

> Mr. Elliason [*sic*], the great diamond merchant, residing in London, in 1821 (the year of the coronation of George IV.), was possessed of a very fine oval diamond of a sky blue, and of intense brilliancy. It was cut and polished as a brilliant, and its play of colour was matchless. In spread it was two-thirds the size of the Piggot diamond, being a little thinner, which the colour made up for; and it was of the same oval form. Report said that Mr. Elliason had visited the different courts in Europe, first asking £30,000, although it weighed only 27½ [*sic*] carats, and of course, if it had been white, the usual colour of the diamond would only be valued at £6,050. Before he left the continent he came down to £20,000, but could not find a purchaser. George the IVth was desirous to have this diamond to ornament the belt of his plume of feathers at his coronation, on the 19th of July, 1821; a treaty was commenced to have the loan of this stone for three days. Mr. Elliason was very adverse to lend any of his diamonds; the King's private exchequer or privy purse was too low to make the purchase, and an offer was made to Mr. Elliason of 1,000 guineas for the use of it for the day. Mr. Elliason required to have some days to consider it, when, in the meantime, Mr. Hope called upon Mr. Elliason about it, as he had frequently done in admiration of this beautiful gem; but Mr. Elliason always demanded too much. Hearing, however, that it was likely to be hired out for the occasion of the coronation, which circumstance of making it thus public would, in his feelings, much reduce its value, he observed to Mr. Elliason that he called upon him once more respecting the sky blue diamond; and after having stated that he found the King would not purchase it even for the approaching coronation, another opportunity might not occur for years, and he would make him a last offer, conducted, as report says, as follows:—Mr. Hope called for pen and ink, and filled up a cheque for 13,000 guineas, placed his watch upon the table, and said he would give Mr. Elliason, five minutes only, to determine to make up his mind, whether to take up the cheque or the diamond. When the time arrived within a few seconds of the five minutes, Mr. Elliason pocketed the cheque, with much grumbling, declaring it more than "dog cheap." Mr. Hope placed the diamond in his splendid collection of minerals among the order of combustibles.

If essentially accurate, Thomason's account would place Hope's purchase of the blue diamond to sometime just prior to mid-July 1821 and supports the other accounts of the price paid. The guinea was £1.1s (£1.05) making the price mentioned by Thomason £13,650. The detail he gives does have the ring of truth about it, such as the attempts to sell it in Europe (recalling the French version of Sowerby's pamphlet and Eliason's wish to bring the stone to the attention of the Linnean Society because it might leave England) and the Prince of Wales' wish to rent it for three days for his coronation. The noted original asking price of £30,000 also matches that given elsewhere. Furthermore, according to this account, Hope was already acquainted with the blue diamond, having seen it several times with Eliason. It is unfortunate that the nature of the 'report' on which Thomason's account was based is unknown.

A more melodramatic story of the purchase appeared a few years after Thomason's memoirs, at the time of the Great Exhibition in 1851, in the *Illustrated London News* (Vol. 18, 7 June 1851, p. 516). Here Eliason has three rather than five minutes to make up his mind and looks aghast at Hope's 'cool, and calm, and determined' face as the watch ticks, culminating in the less respectful final statement: 'You've got it cheap—dog—dirt cheap'. Whether the *Illustrated London News* drew its account from Thomason or they both derived from the same untraced 'report' is so far unknown.

In his catalogue of the collection, Hertz noted that the large blue diamond 'on account of its mounting, could not be placed in the drawer with the diamonds, but is kept in Drawer 16, together with the other extraordinary specimens of this collection' (Hertz, 1839, p. 25). He describes the mount as having 'a border *en arabesque* of small rose diamonds, surrounded by 20 brilliants of equal size, shape, and cutting, and of the finest water, and averaging four grains [1 ct] each'. This was almost certainly the setting in which Henry Thomas Hope displayed the diamond at the 1851 Great Exhibition in London (Figure 15, based on Ellis, 1851, p. 682). James

Tennant's description of the diamond on show in 1851 (Tennant, 1853, p. 86) is almost identical to Hertz's 1839 catalogue entry. Hertz oversaw some simple setting and resetting of some of Hope's gems, so as to best show off the stones, but it seems unlikely that he would be a proponent of mounting the rare blue diamond in such an elaborate form (*Evening Mail*, 4 December 1844, p. 3). The suspicion must be that the mount dates back at least as far as Henry Philip Hope's purchase of the diamond. The style of the mount would certainly allow for a date around 1820.[10]

From the Hope family the large blue diamond made its way through various hands until it reached the National Museum of Natural History, part of the Smithsonian Institution, in Washington DC in 1958 (Figure 1), nearly three centuries after Jean-Baptiste Tavernier had purchased the gem.

THE EQUATION OF THE HOPE AND THE FRENCH BLUE

There is another interesting revelation in Hertz's court testimony. He said that in 1838 he was negotiating the sale of Hope's large blue diamond, 'the only one of value in the world', to the 'King of France'. The gem was worth £30,000 and Hope 'did not wish to have such a valuable one in his collection'. This raises the question as to whether Hope and Hertz were unaware of the origin of the diamond, or were they knowingly negotiating to repatriate it?

In his 1839 catalogue of the Hope gems, Hertz says of the blue diamond (Hertz, 1839, p. 25):

> …we may presume that there exists no cabinet, nor any collection of crown jewels in the world, which can boast of the possession of so curious and fine a gem as the one we are now describing; and we expect to be borne out in our opinion by our readers, since there are extant historical records and treatises on the precious gems, which give us descriptions of all the extraordinary diamonds in the possession of all the crowned heads of Europe, as well as of the princes of Eastern countries. But in vain do we search for any record of a gem which can, in point of curiosity, beauty, and perfection, be compared with this blue brilliant.

We might assume that a diamond expert such as Hertz, acquainted with 'extant historical records and treatises on the precious gems', would have read of Tavernier's large blue gem and known of the famous French Blue, if only from Mawe's mention of it. This is not the first time that Hertz's apparent ignorance of the French Blue has been pointed out. In 1890, Adela Orpen commented that 'Mr. Hertz was no doubt a good jeweller and a clever expert, but he was not very learned in the history of precious stones or he could never have made this astonishing claim' (Orpen, 1890, p. 128). With the benefit of hindsight, it is tempting to see in Hertz's statements that he knew or suspected something of the Hope diamond's history. If Hertz knew Hope's blue diamond to be the stolen French Blue, one would indeed have searched in vain among the crown jewels of Europe for another such stone.

Suspicions that Hope's diamond was the French

Figure 15: The drawing on the left illustrates the Hope diamond as it was displayed at the Great Exhibition in 1851, and as described in Hertz (1839), and thus probably as it was when first purchased by Hope. On the right is a computer-generated rendering based on the drawing and description, allowing for the asymmetrical shape of the diamond. Computer rendering by J. Ogden.

[10] Edwin Streeter in the 4th edition of his *Precious Stones and Gems* (1884, facing p. 21) shows the Hope diamond in a pendant mount, superficially similar to that in Figure 15, but certainly not the same.

Blue only appear publicly nearly two decades after the publication of Hertz's Hope catalogue. Charles Barbot, a jeweller, voiced in 1856 'We suspect it, because of its rare perfection, to be the reduction of the blue diamond of France' (Barbot, 1858, p. 269). Barbot may have seen the Hope the previous year when it had been in Paris at the 1855 Exhibition, by then set in a girdle ornament made by the jewellers Hancock of Bruton Street, London (Figure 16). The centre section had the 'celebrated blue Hope diamond, and on each side two very rich rubies'.

Nevertheless, the equation of the Hope with the French Blue had been made prior to 1855 by someone. A lead model of the gem prior to recutting had been donated to the Museum of Natural History in Paris by Mr Achard, a Parisian lapidary who died in 1832 (Farges et al., 2009, p. 11; and F. Farges, pers. comm., 27 October 2018). The museum catalogue entry for 1850 described the blue diamond as remarkable for its clarity and belonging to Mr 'Hoppe' of London (Farges et al., 2009, p. 8). This model played a leading role in the recent recreation of the size and exact cut of the French Blue, and its equation with the Hope, but it has raised as many questions as it has answered. The lead model is a cast made before re-cutting the diamond as the oval brilliant. In theory, it could have been made any time from the late 1600s onwards, but such casts were most typically made when recutting was being planned. One explanation is that Achard recut the French Blue, or it had passed through his hands when its re-cutting was being considered.[11] The mention of 'Hoppe'—presumably Hope—is particularly intriguing, because it shows that Achard knew that the French Blue was now the Hope, but possibly Achard only became aware of its ownership when he recognised it in Hope's collection.

CONCLUSIONS

The present article fills in some of the missing history of the Hope diamond and offers some new discoveries. Sowerby's painting and comments on it when it was first in London have now been identified, and press accounts and court proceedings have shed further light on Henry Philip Hope's purchase of the gem and mention an 1830s attempt to sell it back to French royalty. Future researchers will no doubt gradually complete more of the history and, hopefully, find out where it was between its theft in 1792 and its reappearance in London in 1812. Until then, as the saying almost goes, it can be as satisfying to travel with the Hope as to arrive.

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Figure 16: This drawing of the girdle ornament exhibited by Hancock's of London at the 1855 Paris Exhibition shows the Hope diamond (centre) flanked by two large rubies. From the *Illustrated London News* (Vol. 27, No. 752, 14 July 1855, pp. 51–52).

[11] The use of lead casts of diamonds to plan cutting or recutting is well attested as far back as the Renaissance (Ogden, 2018, pp. 211–212).

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Rhodochrosite Gems: Properties and Provenance

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ABSTRACT: Gem-quality rhodochrosite is rarely encountered, and is here described and characterised from the few known localities in the USA (Colorado), China, South Africa, Peru, Argentina and Brazil. The gemstones examined for this study were all relatively clean, with the main internal features consisting of partially healed fissures and two- and three-phase inclusions. Generally, rhodochrosite from China showed the most visible internal features, whereas the samples from South Africa showed peculiar growth-zoning patterns, which can be related to the distinctive crystal habits of material from this locality. A reconnaissance study of the chemical composition of a few samples from each locality showed that the South African stones were the purest rhodochrosite, with low Mg and very low Ca and Fe. The Brazilian material showed the highest Fe content, along with very low Mg, while rhodochrosite from China showed greater Mg but low Ca. Elevated traces of Pb, Y and heavy REEs were found in rhodochrosite from Colorado.

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Rhodochrosite is a trigonal manganese carbonate ($MnCO_3$) that is not commonly encountered in the gem trade. Although its intense pink-to-red colour is prized by gem connoisseurs, its low hardness (3½–4 on the Mohs scale) and perfect cleavage on {10$\bar{1}$1} make it a collector's stone. Lustrous, well-formed crystal specimens of rhodochrosite are highly valued by mineral collectors. It usually occurs as translucent-to-opaque, fine-grained aggregates—often showing a banded pattern of white and pink due to the presence of impurities—but transparent gem-quality single-crystal rhodochrosite is known from a few localities. In particular, the Sweet Home mine in Colorado, USA, yielded considerable amounts of facetable rough from the 1990s until 2004 when it was closed, and significant quantities of gem-quality material have also come from the Kalahari Desert region in South Africa and from Guangxi, China (e.g. Webster, 1994; Knox and Lees, 1997; Weldon, 2007; Lees, 2009; Cairncross et al., 2017).

Because gem rhodochrosite is so rare, relatively little work has been done to study gem-quality stones of various provenance. Recently the authors had the opportunity to characterise an important suite of high-quality faceted rhodochrosite (Figure 1), together with offcuts and rough material from some of these samples, as well as pieces obtained from additional localities. This article provides a summary examination of these samples, with gemmological properties as well as spectroscopic and chemical characteristics of material from the USA (Colorado), China, South Africa, Peru, Argentina and Brazil.

Figure 1: This collection of 10 faceted rhodochrosites was examined for this report. Two stones are from the USA (Sweet Home mine, Colorado), weighing 5.04 (**no. 8**) and 11.04 ct (**no. 1**); three are from China, weighing 6.53 (**no. 4**), 7.65 (**no. 7**) and 7.96 ct (**no. 3**); three are from South Africa, weighing 4.84 (**no. 9**), 5.03 (**no. 10**) and 9.43 ct (**no. 5**); and two are from Peru, weighing 6.22 (**no. 2**) and 6.51 ct (**no. 6**). Courtesy of Bill Larson; photo by Robert Weldon.

GEOLOGICAL SETTING OF VARIOUS RHODOCHROSITE DEPOSITS

The most famous source of gem-quality rhodochrosite is the Sweet Home mine in the Alma District of Colorado, where fine crystal specimens were recovered from cavities at the intersections of faults and quartz-pyrite-sphalerite-fluorite veins that are hosted by monzonite porphyry and granodiorite; the veins are interpreted to represent a porphyry-molybdenum type hydrothermal deposit (Misantoni et al., 1998; Bartos et al., 2006). High-quality specimen- and gem-grade rhodochrosite also has been extracted from the Wutong mine in China's Guangxi Zhuang Autonomous Region (Lees, 2009), where hübnerite-rhodochrosite veins are hosted by an Ag-Pb-Zn deposit that is interpreted to represent a relatively shallow magmatic-hydrothermal system (Lecumberri-Sanchez et al., 2013). In the Kalahari manganese field in the Northern Cape Province of South Africa, fine gem-quality rhodochrosite was recovered in 1977–1978 at the N'Chwaning I mine (Cairncross et al., 2017; see, e.g., Figure 2). The geological history of this region is complex, having undergone several periods of deformation and alteration over its 2.2 billion years. Most of the gem- and specimen-quality minerals in the Kalahari manganese field are related to the so-called Wessels hydrothermal event (1.0–1.25 billion years ago; Gutzmer and Beukes, 1996), but the rhodochrosite formation is believed to have happened much later (i.e. 45–90 million years ago), during the Smartt alteration event (Cairncross and Beukes, 2013).

There are many localities for rhodochrosite in Peru, but only three places have yielded banded material used for cabochons: the Manuelita mine in Morococha District (very similar to stones from Argentina), Yauricocha near Huancavelica, and the Huinac mine near Huaraz (Hyršl, 2017). In addition, well-formed translucent-to-transparent crystals are known particularly from Pasto Bueno and the Uchucchacua mine; the majority of faceted Peruvian rhodochrosite (e.g. Figure 3) comes from there, where Ag-Mn-Pb-Zn mineralisation occurs as veins and skarns in fractured limestone adjacent to dacite intrusions (Crowley et al., 1997; Hyršl et al., 2011). Large quantities of rhodochrosite have been mined from the Catamarca region of Argentina for nearly six decades. Although most of the material is opaque to semi-transparent, it has been used extensively as a gem (mainly cabochons; e.g. Figure 4) and ornamental material due to its rhythmic banding. Much of this material has been cut from rhodochrosite stalactites mined at the Capillitas mine, where rhodochrosite occurs as a gangue mineral (with quartz and barite) associated with polymetallic sulphide veins containing complex Cu-Pb-Zn-Fe-Mn-As-Sb epithermal mineralisation (Putz et al., 2009). In Brazil, small amounts of gem-quality rhodochrosite (e.g. Figure 5) have occasionally come from granitic pegmatites in the Virgem da Lapa area of Minas Gerais State (Zwaan, 2015).

Figure 2: These rhodochrosites (2.85 and 3.65 ct) show distinct differences in colour and are both from the N'Chwaning I mine in South Africa. Specimens and photo courtesy of Bruce Cairncross.

Figure 3: Peru's Uchucchacua mine is the source of this 13.90 ct rhodochrosite. Specimen and photo courtesy of Jaroslav Hyršl.

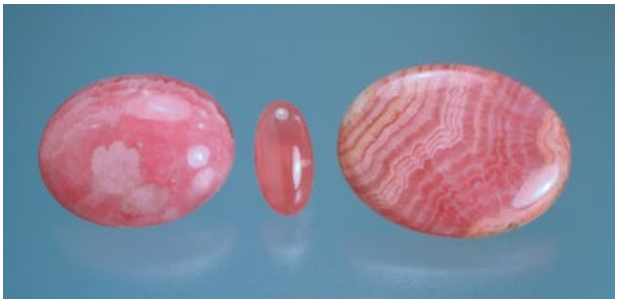

Figure 4: Rhodochrosite from Argentina is cut into cabochons that commonly display banded patterns. The largest stone is 38.7 mm wide and weighs 98.51 ct, while the smallest is 19.5 mm tall and weighs 9.76 ct. Specimens and photo courtesy of Jaroslav Hyršl.

Figure 5: Weighing 7.78 ct, this faceted rhodochrosite is from Brazil. Photo by Dirk van der Marel.

MATERIALS AND METHODS

Samples

A total of 31 transparent to translucent rhodochrosites were studied for this report (Table I). Ten of these consisted of fine-quality faceted gemstones ranging from 4.84 to 11.04 ct (Figure 1) that were loaned by Bill Larson (Pala International, Fallbrook, California, USA) and came from various localities: China, Peru, South Africa and the USA (Colorado). The other 21 samples were kindly donated for this project by Brett and Allyce Kosnar (Kosnar Gem Co., Golden, Colorado, USA). A portion of this material included crystals, cleavage fragments and offcuts obtained when Brett Kosnar faceted some of the stones for Bill Larson. In addition, this donation included three oval faceted stones from the Wutong mine in China and a crystal cluster from the Uchucchacua mine in Peru.

The Larson samples were examined at the Gemological Institute of America (GIA) in Carlsbad, California, and the Kosnar donations were characterised at the Netherlands Gemmological Laboratory (NGL) in Leiden.

Microscopic Analysis and Spectroscopy

Physical properties were measured and observed on the Kosnar samples using standard gemmological instruments. A System Eickhorst GemLED refractometer was used to obtain RIs on three faceted rhodochrosites from China, and SG was measured using the hydrostatic method on the three faceted stones from China and on most of the rough samples. (Not measured were two of the rough samples because of their small size and one matrix specimen from Peru.) Pleochroism was observed with a calcite dichroscope, and absorption spectra were viewed with a prism-type spectroscope. Long-wave (366 nm) and short-wave (254 nm) UV lamps were used to check for fluorescence. Internal features were observed with a standard gemmological microscope and a Nikon Eclipse E600POL polarising microscope, together with a Nikon DS-Ri2 camera for recording images. At GIA, a Nikon Eclipse LV100 compound microscope, also outfitted with a Nikon DS-Ri2 camera, was used to image internal features in the Larson samples.

At GIA, ultraviolet-visible-near-infrared (UV-Vis-NIR) and infrared absorption spectra of the Larson samples were collected using a PerkinElmer Lambda 950 spectrometer and a Thermo Nicolet 6700 Fourier-transform infrared spectrometer, respectively. Unoriented Raman spectra of the rhodochrosites were taken using a Renishaw inVia Raman system with a 514 nm laser. Inclusions in four Kosnar samples were analysed at NGL with a Thermo DXR micro-Raman spectrometer using 532 nm laser excitation.

LA-ICP-MS Chemical Analysis

Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was used to determine the trace-element composition of 18 of the Kosnar rhodochrosite samples (15 rough and the three Chinese faceted stones). Analyses were performed at the Institut für Geowissenschaften, Johannes Gutenberg-Universität Mainz, Germany, using an ESI NWR193 excimer laser equipped with a TwoVol2 ablation cell coupled to an Agilent 7500ce quadrupole ICP-MS.

On each sample, 3–11 spot analyses were performed. Most were randomly distributed across the sample surface, but a line of 11 spot analyses was made on one larger sample from Argentina. We used a spot size of 80 µm and a pulse repetition rate of 10 Hz. The energy density was about 3.5 J/cm^2. Ablation was carried out in a He atmosphere, and the sample gas was mixed with Ar before entering the plasma. For each analysis, background signals were acquired for 15 s, followed by 30 s of ablation and a 20 s wash out. We used the multi-element synthetic glass NIST SRM 610 for calibration of the element concentrations, applying the preferred values of the reference material reported in the GeoReM database (http://georem.mpch-mainz.gwdg.de; version 21, January 2017; Jochum et al., 2005, 2011) as the 'true' concentrations to calculate the element concentrations of the samples. In addition, we analysed the reference materials FeMnOx-1 (Jochum et al., 2016), USGS BCR-2G and USGS MACS-3 during each sequence as quality control materials (QCMs) to monitor precision and accuracy of

Table I: Optical and physical properties of gem-quality rhodochrosite from various occurrences.*

Country	USA		China	South Africa	Peru	Brazil	Argentina
Locality	Sweet Home mine, Mount Bross, Alma District, Park County, Colorado	Sunnyside mine group, Bonita Peak, Gladstone, Eureka District, San Juan County, Colorado	Wutong mine, Liubao, Cangwu County, Wuzhou prefecture, Guangxi Zhuang Autonomous Region	N'Chwaning mines, Kuruman, Northern Cape Province	Uchucchacua mine, Oyon Province, Lima Department	Minas Gerais	Capillitas mine, Andalgalá Department, Catamarca
Samples	Two faceted (5.04 and 11.04 ct); two rough (0.66 and 2.12 g)	Two rough (1.43 and 2.55 g)	Six faceted (0.29, 0.29, 0.76, 6.53, 7.65 and 7.96 ct)	Three faceted (4.84, 5.03 and 9.43 ct); three rough (0.03, 0.10 and 1.38 g)	Two faceted (6.22 and 6.51 ct); one rough (1.07 g); one crystal cluster (18.5 g)	Seven rough (0.04, 0.05, 0.13, 0.14, 0.15, 0.21 and 1.10 g)	Two cabochons (8.06 and 30.56 ct)
Diaphaneity	Transparent	Transparent	Transparent	Transparent	Transparent	Transparent	Transparent to translucent
Colour	Pink, orangey pink	Pink	(Strong) pink	Light pink-orange; orangey red	Pink-orange, orangey pink-red and pink-red	Light pink, pink and light, slightly orangey pink	Pink and white banding
Pleochroism	Moderate pink and light orange	Moderate pink and light orange	Weak light pink and light orange to distinct pink and very light orange	Weak orangey pink and light orange	Distinct pink-red and (light) orange	Weak light pink and light orange, or moderate pink and light orange	Weak orangey pink and light pinkish orange, or moderate pink and light orange
RI (lower reading)	—	—	1.600	—	—	—	—
SG	3.57–3.63	3.54–3.59	3.71–3.73	3.65–3.66	3.65	3.63–3.72	3.59–3.63
Internal features	Relatively clean; veil-like partially healed fissures and fluid inclusions (two-phase, some rhombohedral)	Relatively clean; two-phase inclusions; faint straight colour zoning	(Large) partially healed fissures and rhombohedral two-phase fluid inclusions; fine parallel needle-like inclusions	Minute rounded to subhedral (rhombohedral) grey inclusions; light orange and pink alternating straight and spiky, chevron-like zoning	Partially healed fissures with geometric patterns; growth lines; straight and narrow alternating zones of orange and pink	Relatively clean; partially healed fissures; fluid inclusions (two- and three-phase); randomly oriented needle-like inclusions; colourless mica	Many partially healed fissures; minute inclusions

* All samples were inert to long- and short-wave UV radiation, and the spectroscope showed a dark band at ~410 nm and weaker bands at ~450 and 550 nm.

the measurements. The program GLITTER 4.4.1 (www.glitter-gemoc.com; Griffin et al., 2008) was used for data reduction. Measured isotope intensities were normalised to ^{55}Mn, applying the stoichiometric MnO content of $MnCO_3$ of 61.71 wt.% for the rhodochrosite samples and the values reported in the GeoReM database for the QCMs. The measured concentrations of most elements in the QCMs agreed within 15% of the preferred values reported in the GeoReM database for FeMnOx-1 and USGS BCR-2G, and for the preliminary reference values for USGS MACS-3 in Jochum et al. (2012). For the QCMs, relative standard deviations (1RSD) for the averaged element concentrations determined during the experiment were typically < 10%.

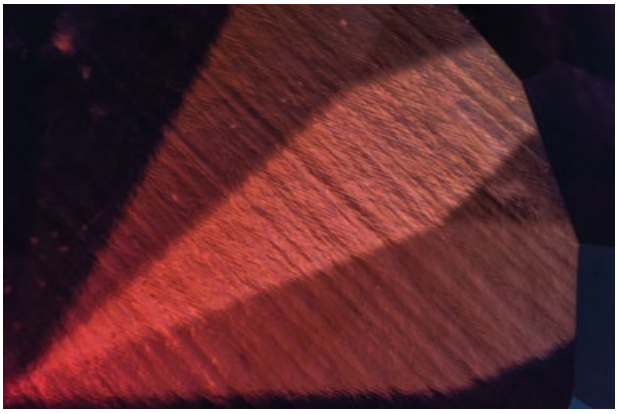

Figure 6: Prominent growth zoning is commonly displayed in South African rhodochrosite, which is here observed as linear zones of roiled graining in a 4.84 ct stone (no. 9 in Figure 1). Photomicrograph by N. D. Renfro; image width 4.6 mm.

RESULTS

Gemmological Properties

The gemmological properties of the studied rhodochrosites are listed in Table I. All were transparent, except for the samples from Argentina, which contained white translucent bands. Colours varied from light pink to (strong) pink and pink-red, with or without orange as a modifier; the more orangey stones were from South Africa and Peru, and samples with the darkest tones were from South Africa.

The RI readings of the faceted rhodochrosites from China showed one shadow line at a minimum value of 1.600 and a higher value that was above the limit of the refractometer (>1.790). The birefringence of rhodochrosite is 0.220 (e.g. Webster, 1994), which means that the higher RI was probably around 1.820. Hydrostatic SG values varied between 3.54 and 3.73, with rhodochrosite from China and Brazil showing the highest average values (3.72 and 3.68, respectively). These SGs are the highest known for this mineral; by comparison, Webster (1994) reported an SG range of 3.45–3.70.

Depending on their overall colour appearance, the samples displayed varying dichroism: weak in orangey pink and light (pinkish) orange or in light pink and light orange; and moderate-to-distinct in pink and (very) light orange or pink-red and (light) orange. The samples were inert to both long- and short-wave UV radiation. The spectroscope showed a dark band at ~410 nm and weaker bands at ~450 and 550 nm.

Microscopic Characteristics

The rhodochrosites from most of the localities were relatively clean. The main exception was the Argentina samples, which were microcrystalline (causing somewhat diminished transparency) and also locally contained white impurities. Of the single-crystal samples, the Chinese rhodochrosite generally showed the most visible internal features.

The South African rhodochrosites displayed prominent growth zoning (e.g. Figure 6). This was seen as undulating to straight, alternating light orange and pink colour zoning and a columnar type of zoning, but also swirly growth lines and spiky, chevron-like growth zoning. One stone also showed minute rounded, subhedral (rhombohedral) grey inclusions, most of which appeared flat. They could not be identified by Raman micro-spectroscopy.

The rhodochrosites from Colorado, China and Brazil all showed similar inclusions: partially healed fissures (e.g. Figure 7a) and fluid inclusions containing a gas bubble (e.g. Figure 7b). The samples from Colorado showed fine, veil-like, partially healed fissures and quite a few two-phase inclusions with rhombohedral

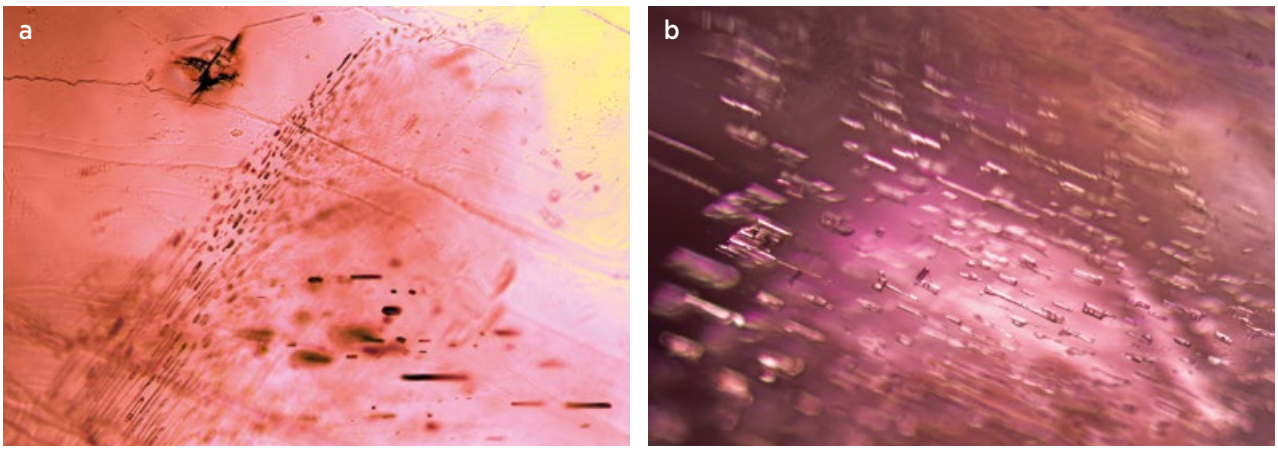

Figure 7: Partially healed fissures were typically encountered in rhodochrosite from Colorado, China and Brazil. They commonly contain two-phase fluid inclusions, as shown here in samples from Colorado (**a**, transmitted light) and China (**b**, darkfield illumination). Photomicrographs by J. C. Zwaan; image widths 1.2 mm.

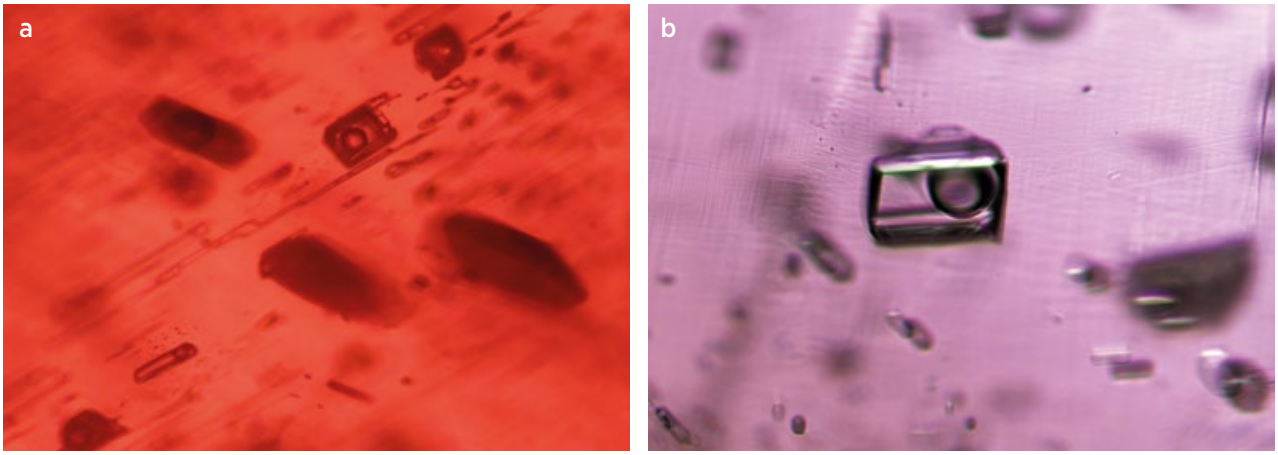

Figure 8: Rhombohedral negative inclusions, containing liquid and a gas bubble, were seen in rhodochrosite from both China and Colorado. (**a**) A tiny negative crystal occurs in the middle of a partially healed fissure in a rhodochrosite from the Sweet Home mine, Colorado. (**b**) A slightly larger negative crystal is present in a rhodochrosite from China. Photomicrographs by J. C. Zwaan; transmitted light, image widths 0.40 mm (a) and 0.33 mm (b).

Figure 9: This two-phase (liquid and gas) fluid inclusion is present in a rhodochrosite from China (no. 4 in Figure 1). Photomicrograph by N. D. Renfro, image width 1.2 mm.

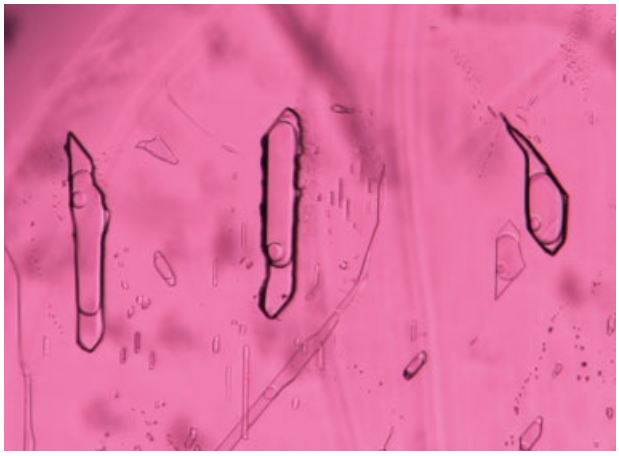

Figure 10: Three-phase inclusions, containing two immiscible liquids and a gas bubble, occur in this rhodochrosite from Brazil. Photomicrograph by J. C. Zwaan; image width 0.4 mm.

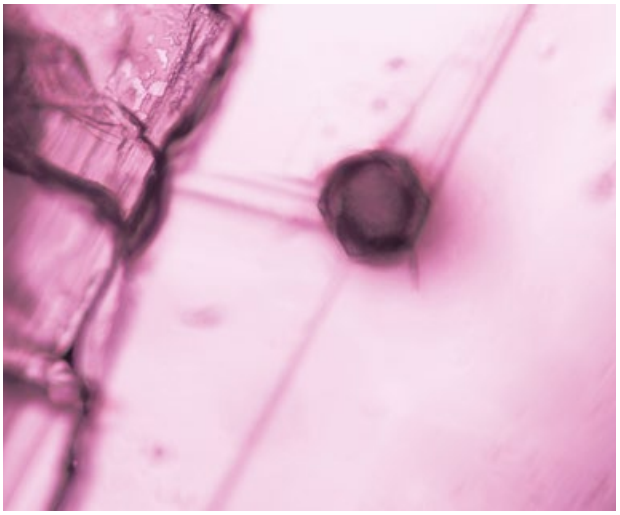

Figure 11: A six-sided tabular crystal of mica (either muscovite or trilithionite) is present in a rhodochrosite from Brazil. Photomicrograph by J. C. Zwaan; image width 0.6 mm.

negative crystals (Figure 8a). The Chinese samples also showed rhombohedral negative crystals (Figure 8b) and fairly large, partially healed fissures containing larger two-phase inclusions (Figure 9); one stone contained fine, parallel-oriented, needle-like inclusions. The Brazilian stones showed not only two-phase but also three-phase (liquid-liquid-gas) inclusions (Figure 10). One Brazilian rhodochrosite contained randomly oriented needle-like inclusions. Two Brazilian stones hosted small, colourless crystals (e.g. Figure 11) that were identified as mica: Raman analysis revealed either muscovite or trilithionite (a lithium-rich mica). In the samples from Peru, we encountered partially healed fissures with geometric patterns, straight and slightly undulating growth lines, and also straight and narrow alternating zones of orange and pink. Finally, the Argentinian stones contained small partially healed fissures and abundant minute inclusions.

Spectroscopy

All 10 samples in Figure 1 showed a typical UV-Vis-NIR spectrum for rhodochrosite (Figure 12), with pronounced peaks at ~342–343, ~362–363 and 407 nm, and slightly broader bands at 312, ~443–446 and ~542–551 nm, which are all attributed to Mn^{2+} (cf. Jørgensen et al., 1954). Although only two to four rhodochrosites from each country were analysed, the spectra showed slight but systematic differences. The samples from South Africa displayed a gradual increase in absorption towards shorter wavelengths, while the Chinese material showed a slight gradual increase in absorption from 800 towards 1000 nm. Rhodochrosite from Peru had a very intense absorption at 407 nm relative to the other bands. Earlier analysis of rhodochrosite from Brazil showed a similar absorption trend towards longer wavelengths as seen in the Chinese material (cf. Zwaan, 2015).

Mid-infrared spectra (Figure 13) typically recorded broad and strong absorption bands in the 3050–2750, 2650–2400 and 2250–2100 cm^{-1} regions, pronounced features at approximately 4229–4227, 3913–3905, 3564, 3203, 3132, 2276–2274 and 1948 cm^{-1} (with the first three having shoulders at higher wavenumbers), and weak broad bands at 5282, 4970 and 4601 cm^{-1}. The spectra of the South African rhodochrosites showed a broader strong absorption region, between roughly 3600 and 2750 cm^{-1} (Figure 13b), and in one stone even between 3600 and 2400 cm^{-1}.

Raman analysis of each stone yielded a carbonate spectrum, with the main peak typically at 1087 cm^{-1}, and additional features at 1726, 1415, 719, 289 and 184 cm^{-1} (Figure 14), in agreement with Komura et al. (1983). Vibrations related to the symmetric stretching of the CO_3^{2-} anion at about 1087 cm^{-1} are quite similar for rhodochrosite and calcite. Only at the lower wavenumbers can the two carbonates be differentiated, with rhodochrosite showing bands at 719, 289 and 184 cm^{-1} (the latter two bands being due to translatory oscillations between the cation and anion groups, Mn^{2+} and CO_3^{2-}), as opposed to calcite, which has bands at 712–711, 281 and 155 cm^{-1} (e.g. Wehrmeister et al., 2009).

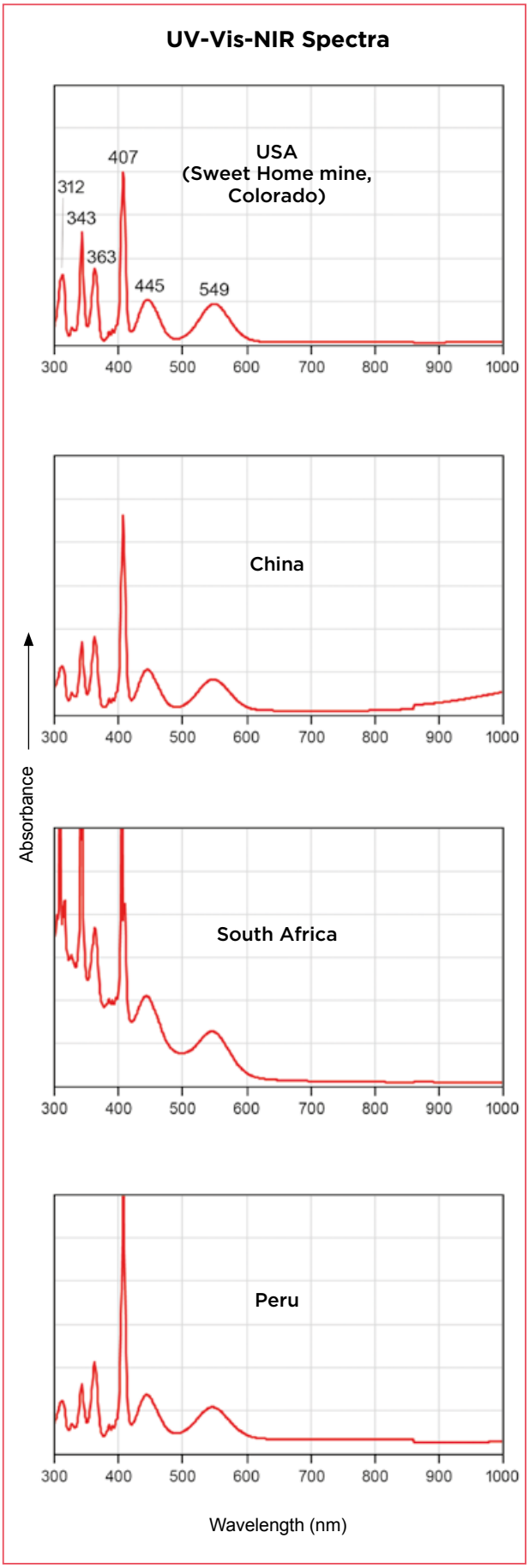

Figure 12: Representative UV-Vis-NIR spectra are shown for rhodochrosite from the USA (Sweet Home mine, Colorado), China, South Africa and Peru. The spectra were taken from a 5.04 ct rectangle, a 6.53 ct cushion, a 5.03 ct fancy cut and a 6.51 ct cushion (nos. 8, 4, 10 and 6, respectively, in Figure 1).

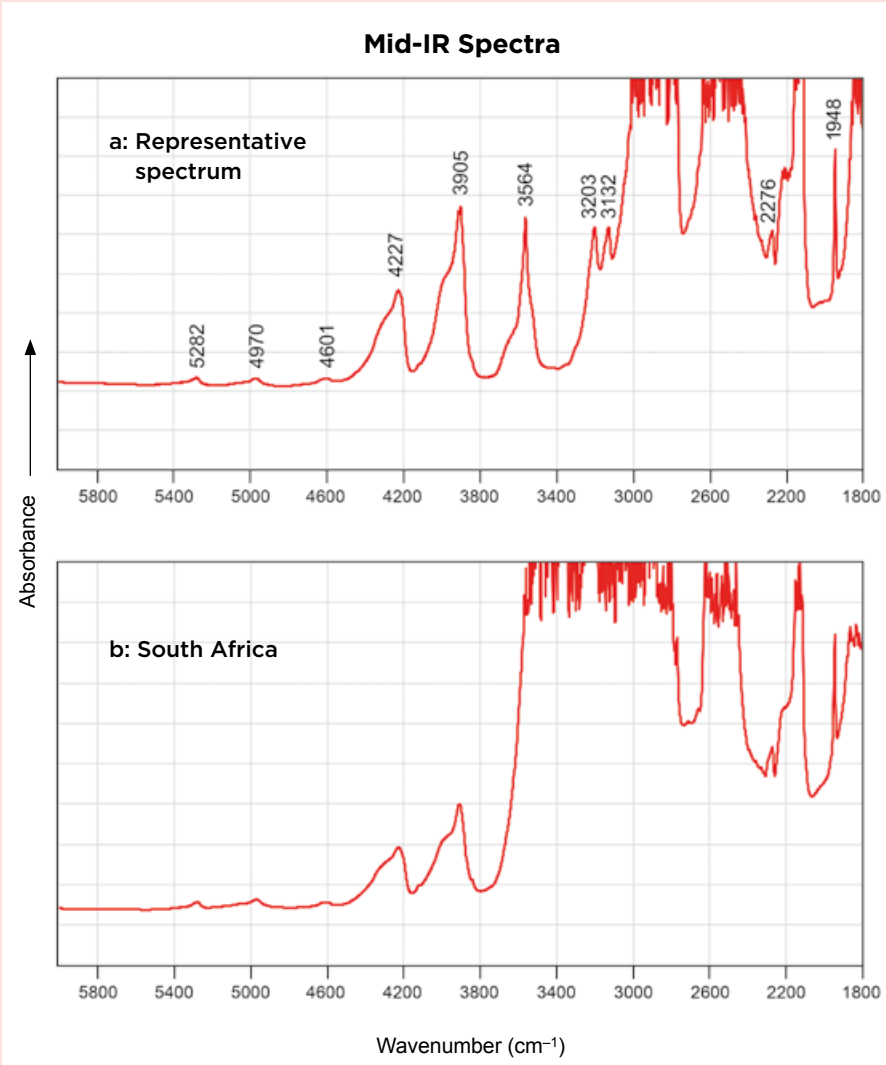

Figure 13: A representative mid-IR spectrum of rhodochrosite specimens from various localities studied for this report (**a**) is compared to a spectrum from a South African rhodochrosite (**b**) that shows strong and broad absorption between 3600 and 2750 cm^{-1}. The spectra were collected from a 6.22 ct oval and a 9.43 ct octagon (nos. 2 and 5, respectively, in Figure 1).

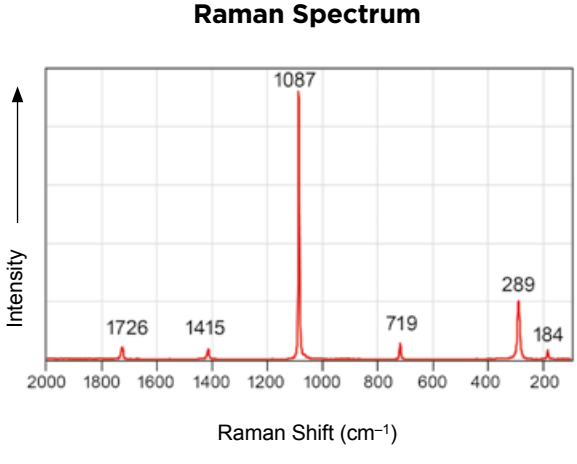

Figure 14: This Raman spectrum of an 11.04 ct rhodochrosite from Colorado (no. 1) is representative of the spectra collected from all 10 stones depicted in Figure 1.

Chemical Composition

The chemical composition of the analysed samples is summarised in Table II. The main trace elements were Fe (average 21–41,110 ppmw), Ca (average 51–12,740 ppmw) and Mg (average 62–3,570 ppmw). Also present in most samples at varying concentrations were Na (average < 215 ppmw) and Al (average < 61 ppmw). Zn was detected in all samples (average 3.1–220 ppmw) except in those from Peru. Minute traces of Mo were found in every sample (average 1.5–1.9 ppmw). For the rare-earth elements (REEs), the heavier REEs such as Dy, Er and Yb were commonly detected.

The white-banded, microcrystalline rhodochrosite from Argentina showed much higher values of Ca, Mg and Na (on average) than the singe-crystal transparent material from the other localities. The Argentina samples also showed considerable W, which was barely detected in only some of the transparent rhodochrosites.

Table II: Range of trace-element concentrations by LA-ICP-MS in rhodochrosite from various occurrences.[a]

Locality	USA (Sweet Home mine, Colorado)		USA (Sunnyside mine group, Colorado)		China		South Africa		Peru		Brazil		Argentina	
No. samples	2		2		3		3		2		4		2	
No. analyses	8		8		11		11		6		14		14	
Minor and trace elements (ppmw)	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Li	bdl	–	bdl[b]-0.65	–	bdl	–	bdl-0.20	–	bdl-0.32	–	bdl-0.22	–	bdl-13	3.8
Na	bdl	–	bdl-194	46	bdl	–	bdl	–	bdl-13.6	6.4	bdl	–	bdl-2534	215
Mg	174-409	264	155-1650	672	555-1490	809	57-206	108	52-131	91	28-87	62	767-10050	3570
Al	bdl	–	bdl-352	68	bdl-0.53	–	9-31	21	bdl	–	bdl-2.9	–	bdl-154	61
Ca	292-2710	1280	1390-11460	4920	182-549	296	bdl-101	51	bdl-5650	2730	2380-3230	2920	361-47190	12740
Fe	1190-13170	7020	8440-26760	13390	4480-9390	6170	11-34	21	2220-4480	3310	26990-50740	41110	7120-54130	18520
Cu	bdl	–	bdl-2.7	–	bdl	–	bdl-5.8	–	bdl	–	bdl	–	bdl-2.2	–
Zn	14-62	34	19-1660	407	9.7-31	16	1.9-5.6	3.1	bdl	–	43-54	48	bdl-383	46
As	bdl	–	bdl	–	bdl	–	bdl	–	bdl-5.3	–	bdl	–	bdl	–
Rb	bdl	–	bdl-2.0	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl	–
Sr	bdl-0.43	–	bdl-1.0	–	0.05-0.21	0.09	bdl-0.12	–	bdl-2.48	1.2	bdl	–	bdl-22	4.0
Y	bdl-16	7	bdl-4.4	3.1	bdl-1.9	–	bdl-0.20	–	bdl	–	bdl-1.3	0.38	bdl-2.8	–
Mo	1.2-1.9	1.6	1.6-4.8	2.2	1.2-1.7	1.5	1.3-2.1	1.8	1.6-2.0	1.7	1.4-2.0	1.6	1.2-1.8	1.6
Ag	bdl	–	bdl-0.50	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl-4.9	0.45
Sn	bdl	–	bdl-1.5	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl-3.1	0.73
Cs	bdl	–	bdl-0.14	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl	–
Ba	bdl	–	bdl-1.5	–	bdl	–	bdl	–	bdl-0.38	–	bdl	–	bdl-3.3	0.54
La	bdl-0.45	–	bdl-0.11	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl-0.06	–
Ce	bdl-0.95	0.29	bdl-0.86	0.22	bdl	–	bdl	–	bdl	–	bdl	–	bdl-0.48	–
Pr	bdl-0.10	–	bdl-0.49	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl	–
Nd	bdl-0.62	–	bdl-0.25	–	bdl	–	bdl	–	bdl	–	bdl	–	bdl	–
Sm	bdl-0.51	–	bdl-0.18	–	bdl-0.21	–	bdl	–	bdl	–	bdl	–	bdl	–
Eu	bdl-0.09	–	bdl-0.03	–	bdl-0.05	–	bdl	–	bdl	–	bdl	–	bdl-0.11	–
Gd	bdl-1.1	–	bdl-0.31	–	bdl-0.63	–	bdl	–	bdl	–	bdl	–	bdl	–
Tb	bdl-0.29	–	bdl-0.07	–	bdl-0.21	–	bdl	–	bdl	–	bdl	–	bdl	–
Dy	bdl-2.7	1.3	bdl-0.62	–	bdl-1.9	–	bdl-0.03	–	bdl	–	bdl-0.08	–	bdl-0.63	–
Ho	bdl-0.60	0.30	0.05-0.19	–	bdl-0.48	0.09	bdl	–	bdl	–	bdl	–	bdl-0.12	–
Er	bdl-2.4	1.2	0.22-0.81	–	bdl-1.9	0.38	bdl-0.02	–	bdl	–	bdl-0.13	–	bdl-0.48	–
Tm	bdl-0.45	0.24	bdl-0.19	–	bdl-0.33	–	bdl	–	bdl	–	bdl-0.04	–	bdl-0.08	–
Yb	bdl-4.0	2.1	0.48-1.8	1.1	bdl-2.8	0.53	bdl	–	bdl	–	bdl-0.81	–	bdl-0.83	–
Lu	bdl-0.60	0.33	bdl-0.29	0.20	bdl-0.38	0.07	bdl	–	bdl	–	bdl-0.17	–	bdl-0.17	–
W	bdl	–	bdl-2.5	0.6	bdl	–	bdl	–	0.02-3.0	1.5	bdl	–	6.2-239	77
Pb	bdl	–	bdl-73	17	bdl	–	bdl	–	bdl-0.92	–	bdl	–	bdl-0.82	–
U	bdl-0.06	–	bdl-3.5	0.73	bdl	–	bdl-0.06	–	bdl	–	bdl	–	bdl-0.07	–

[a] Data are reported in parts per million by weight (ppmw). Data for B, Si and P were not included because of interference effects. Interference with both boron isotopes (^{10}B and ^{11}B) is assumed to come from an overlap with the large carbon peak (also called the ^{12}C spread) that is caused by the abundance of carbon present in a $MnCO_3$ sample (cf. May and Wiedmeyer, 1998). Interferences could not be corrected by the reference material because no carbon was present in the NIST glasses. The same applies to the Si isotopes: interferences occur such as $^{12}C^{16}O^1H^+$, $^{12}C^{16}O^1H^{2+}$, $^{12}C^{17}O^+$, $^{13}C^{16}O^+$, $^{13}C^{16}O^1H^+$ and $^{13}C^{17}O^+$; P also has interferences involving carbon: $^{13}C^{18}O^+$ and $^{12}C^{18}O^1H^+$ (May and Wiedmeyer, 1998; Jochum et al., 2012).

[b] bdl = below detection limit; Sb and Au were below detection limits in all analyses. Averages are not provided where most values were below detection limit and/or averages were under the limit of quantification.

DISCUSSION AND CONCLUSIONS

Overall, the gem-quality rhodochrosites studied for this report showed many similar characteristics, as well as some differences. The darkest and most orangey samples came from South Africa, but as seen in Figure 2 even a single mine can yield material ranging from orange to pink. The most common internal features were partially healed fissures and two-phase fluid-and-gas inclusions; mineral inclusions were rarely encountered. The peculiar growth zoning observed in the faceted rhodochrosites from South Africa may be related to the distinctive crystal forms and habits of the rough. Transparent, intergrown spherical aggregates and distinct 'wheat-sheaf' aggregates of subparallel crystals are known for rhodochrosite from the N'Chwaning mine, and trigonal wheat-sheaf habits are typical of rhodochrosite from the Hotazel mine (Wilson and Dunn, 1978; Cairncross et al., 2017). The undulating, swirly and spiky growth zoning could be understood to reflect those typical habits, and in particular the chevron-like zoning can be related to the trigonal wheat-sheaf habit (cf. Wilson and Dunn, 1978, especially figure 5g).

UV-Vis-NIR spectra showed some systematic differences in absorption towards shorter or longer wavelengths (in samples from South Africa and China, respectively), although the spectra are not baseline corrected so some caution must be taken in their interpretation. The intense pink-to-orange-to-red colour of rhodochrosite is due to a series of Mn^{2+}-related absorptions that result in the transmission of mainly orange-red and some blue wavelengths. (The addition of blue and red create magenta, consistent with the pink colour of some rhodochrosite.) Wenrich (1998) noted that the most highly saturated colour of Sweet Home rhodochrosite corresponds to purer $MnCO_3$ content (i.e. lower impurities of Ca, Mg and particularly Fe). The more orangey colour of the South African samples studied for this report may correspond to their greater absorption in the blue/violet end of the spectrum, the cause of which is unknown to the authors. The South African rhodochrosites also yielded distinctive mid-infrared spectra, which showed broader absorptions (compared to the other samples) between roughly 3600 and 2400 cm^{-1}.

Although only a limited number of stones from each locality were analysed by LA-ICP-MS for their chemical composition, some trends became apparent that may be indicative of a particular provenance. Setting aside the rhodochrosite from Argentina, which contained high levels of impurities, plotting of Ca vs. Mg (Figure 15) and Fe vs. Mg (Figure 16) shows relatively low Mg, Ca and Fe in rhodochrosite from South Africa (which had the most pure rhodochrosite composition); relatively low Ca and some high to very high Mg values in rhodochrosite from China; and low-to-moderate Mg, Ca and Fe in rhodochrosite from Colorado (except for one stone from the Sunnyside mine group, which showed high Ca and Mg contents). Brazilian rhodochrosite displays intermediate

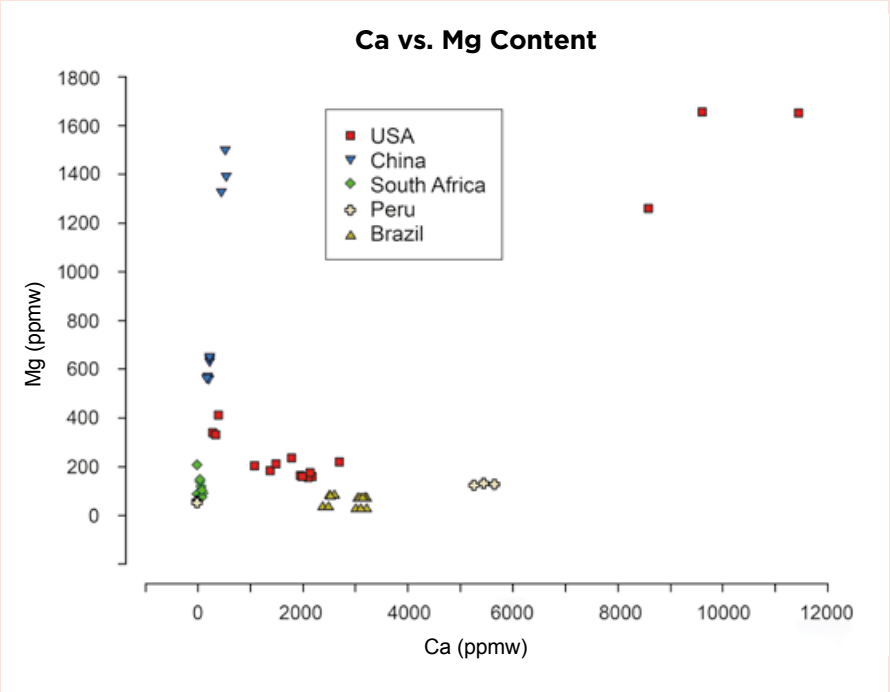

Figure 15: A plot of Ca vs. Mg in the analysed rhodochrosites shows different trends for each provenance, with some overlap in the stones from South Africa and Peru.

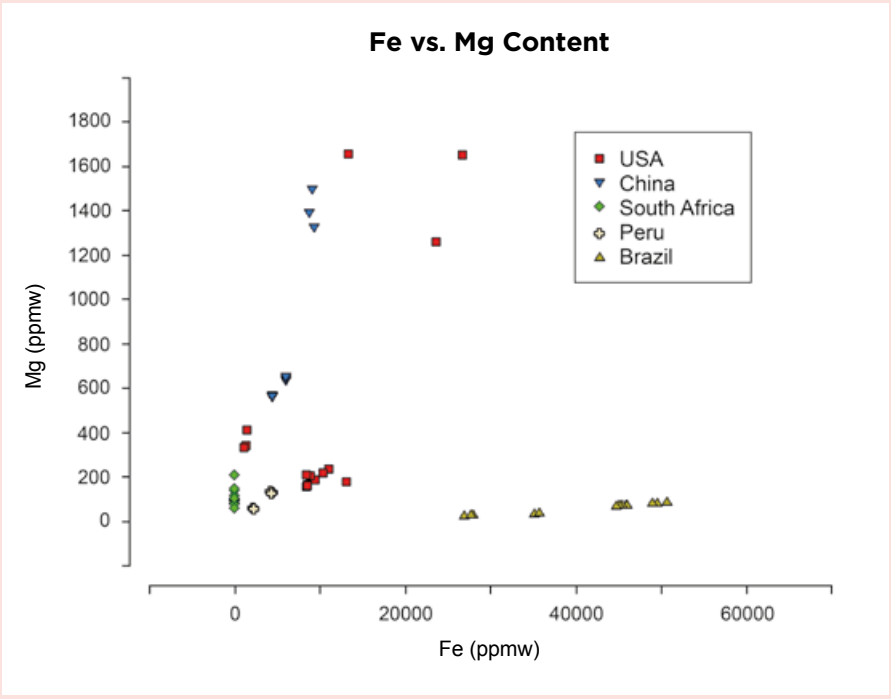

Figure 16: A plot of Fe vs. Mg in the analysed rhodochrosites shows a clear separation between the South African, Brazilian and Chinese stones.

Ca and very low Mg, but very high Fe. The enriched Fe content of Brazilian rhodochrosite is consistent with an earlier study on a crystal and faceted stone (Zwaan, 2015). Finally, rhodochrosite from Peru shows a trend of low to fairly high Ca, with Fe and Mg staying low.

Other elements were present only in trace amounts. On average, Colorado rhodochrosites showed substantially higher Y concentrations compared with samples from the other localities. In addition, the higher average Zn and Pb contents in the rhodochrosites from Colorado are influenced largely by the previously mentioned sample from the Sunnyside mine group which gave 1,420 and 1,660 ppmw Zn and 58 and 73 ppmw Pb. The other Zn measurements in Colorado rhodochrosite were all between 14 and 62 ppmw, hence at similar levels to those in the samples from China and Brazil. The other Pb measurements in Colorado rhodochrosite all ranged from below detection levels up to 1 ppmw, as in the samples from all other localities.

REEs were largely absent from the analysed samples, but trace amounts of heavy REEs—in particular Dy, Er and Yb—were detected in rhodochrosite from Colorado (especially from the Sweet Home mine), showing linear trends when plotting Er vs. Dy and Er vs. Yb. One of the Chinese stones showed similar trends (Figure 17). Mineralised magmatic, metasomatic or hydrothermal fluids are sometimes enriched in Y and heavy REEs, and can be present during late-stage granite and pegmatite development (e.g. Fryer and Edgar, 1977). The elevated

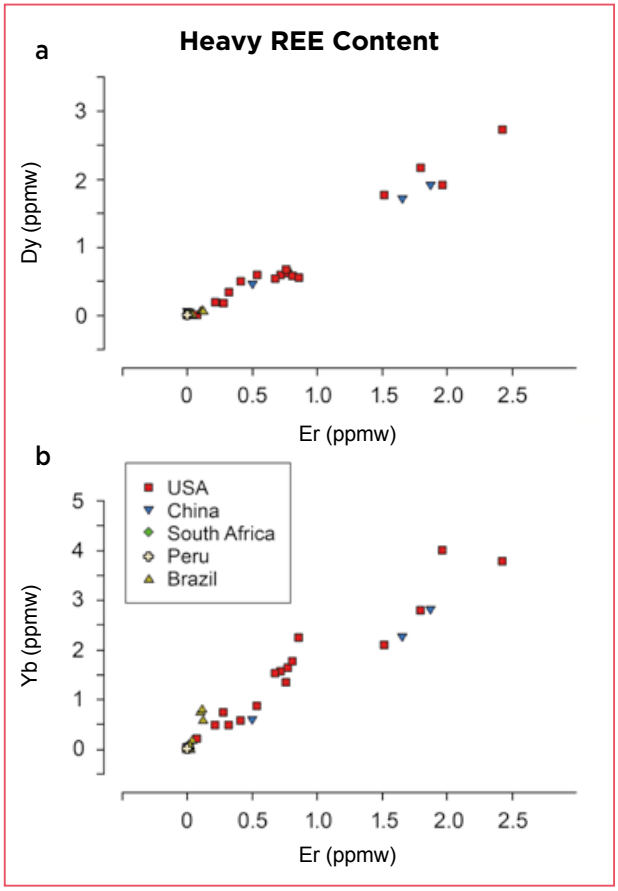

Figure 17: Traces of heavy REEs were measured in some of the analysed rhodochrosites, particularly in the stones from Colorado and China. These plots of (**a**) Er vs. Dy and (**b**) Er vs. Yb display a linear trend, showing that contents of these elements increase or decrease simultaneously.

Y and heavy REE concentrations in the Colorado rhodochrosite are therefore consistent with the hydrothermal mineralisation inferred for the Sweet Home mine, having both magmatic and externally derived (meteoric) fluid sources, occurring coeval with a final stage of magmatic activity, at depths of about 3,000 m, as proposed by Lüders et al. (2008).

Overall, the systematic variations in the chemical data obtained in this study suggest that more samples should be analysed to obtain a better idea of the compositional range of gem rhodochrosite from various localities.

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Figure 1: This 9.1 ct sapphire from the Ambatondrazaka area of Madagascar shows vivid pink colouration (far left). After exposure to a long-wave UV lamp for a few minutes, the stone changed to a vivid pinkish orange typical of that shown by padparadscha sapphires (centre). With fade testing, the colour shifted back to the chromium-related pink colour (below). Composite photo by Vito Lanzafame, SSEF.

Unstable Colouration of Padparadscha-like Sapphires

Michael S. Krzemnicki, Alexander Klumb and Judith Braun

ABSTRACT: After the October 2016 discovery of a new gem deposit at Bemainty near Ambatondrazaka, Madagascar, a number of sapphires with padparadscha-like colour entered the trade. However, most of these stones were found to have unstable colour, which changes from pinkish orange to more-or-less pure pink after a few weeks in daylight. In this study, the authors investigate the colour stability of padparadscha-type sapphires of metamorphic origin—mainly those originating from Madagascar (Ambatondrazaka and Ilakaka) and Sri Lanka. The 48 samples could be separated into three groups after colour-stability testing: sapphires that did not show a noticeably different appearance (case A); sapphires with a slight-to-moderate colour difference within the padparadscha range (case B); and fancy-colour sapphires showing a distinct change in appearance that fell outside of the padparadscha range (case C). The last situation was especially common for the stones from Ambatondrazaka, thus revealing that careful colour-stability testing is mandatory for proper gemmological identification of any sapphire showing a yellow to orange colour component.

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In late 2016, a 9.1 ct stone was submitted to the Swiss Gemmological Institute SSEF by a client as a padparadscha sapphire, a sought-after variety of corundum showing pinkish orange to orangey pink colour (cf. Crowningshield, 1983). After the routine analytical work was completed, it became evident that the stone was vivid pink instead of showing a padparadscha appearance. This colour difference led us to perform further research on the causes and stability of padparadscha colouration.

Our examination revealed that the colour of the stone changed considerably to a vivid pinkish orange by simply exposing it to a long-wave UV lamp for a few minutes (Figure 1). The orange colour component, however, was not stable and slowly faded in the course of several days to weeks (or hours with colour-stability testing), as was later confirmed by the client who had submitted the stone as a padparadscha sapphire.

Having encountered a number of similar cases in the past few months (Krzemnicki, 2018), this article presents our findings on padparadscha-like sapphires with unstable colour, with special emphasis on such stones from a recently discovered deposit at Bemainty, near Ambatondrazaka, Madagascar.

PADPARADSCHA: DEFINITION, COLOUR CAUSES AND STABILITY

Padparadscha sapphires are generally described as exhibiting a pinkish orange to orangey pink colour of moderate to low saturation (Crowningshield, 1983; Notari, 1996; LMHC, 2018). Originally known from alluvial deposits in Sri Lanka, today this attractive variety of corundum is also mined in Tanzania (e.g. Tunduru; Johnson and Koivula, 1997) and Madagascar (e.g. Ilakaka; Milisenda et al., 2001), with additional production coming from a recently discovered deposit near Ambatondrazaka, which is also a source of exceptional blue sapphires of large sizes (Perkins and Pardieu, 2016; Krzemnicki, 2017; Pardieu et al., 2017).

From a gemmological viewpoint, padparadscha colour can be described as a subtle and variable mixture of pink and orange, commonly resulting from the absorption of visible light by Cr^{3+} (main bands at 410 and 560 nm, responsible for the pink component) and one or more yellow to orange colour centres (Schmetzer et al., 1983, Nassau and Valente, 1987; Schmetzer and Schwarz, 2005; Hughes et al., 2017 and references therein) that are partly superposed by absorptions from Fe^{3+} at 385, 390 and 450 nm. As such, padparadscha sapphires can show variable absorption spectra. In terms of colour stability, it can further be assumed that the pink colour is stable, as it is only related to the concentration of Cr^{3+}. However, the stability of the yellow-to-orange colour component is more complex. It has been known for many years that yellow to orangey yellow hues induced by colour centres (formed naturally or by artificial irradiation) in corundum are not always stable (i.e. type 2 of Nassau and Valente, 1987), thus resulting in a yellow colour that fades slowly upon exposure to daylight (Schiffmann, 1981; Nassau and Valente, 1987; Hughes et al., 2017). Additional cases of colour centres that are unstable in daylight are not uncommon in mineralogy, as seen, for example, in some amethyst (Hatipoğlu et al., 2011), and also quite dramatically in Maxixe-type beryl (Nassau et al., 1976) and in hackmanite—a rare sulphur-bearing variety of sodalite that becomes stunningly purple after brief exposure to UV radiation before fading (rather quickly) to greyish white in daylight (Medved, 1954; Kondo and Beaton, 2009).

The effect of fading in daylight and reactivation by UV radiation is known in the scientific literature as *reversible photochromism* or *tenebrescence* (Medved, 1954; Kirk, 1955). Interestingly, this effect has been reported previously for synthetic corundum (Hughes et al., 2017) and for a light blue heat-treated sapphire (Gaievskyi et al., 2014), and has also been observed in SSEF's in-house colour-stability studies on a small number of unheated yellow sapphires from Sri Lanka (cf. Hughes, 1997). In all of these cases, the stones consistently gained slight brownish yellow to marked yellow hues after UV exposure, which under normal lighting conditions faded out over a period of several days (or hours with fade testing; see below for parameters). So far, none of the tenebrescent unheated yellow sapphires we have seen changed completely to colourless after fade testing, but instead they showed a noticeable reduction in their yellow colour saturation, which suggests they were coloured by a combination of stable (in terms of exposure to daylight) and unstable yellow colour centres.

MATERIALS AND METHODS

Over a period of several months, the authors analysed 48 sapphires of metamorphic origin that showed padparadscha-like colour (see Table I). All of them were unheated except for one sample from Ambatondrazaka. Apart from microscopic observation and routine gemmological testing—as well as chemical analysis, Fourier-transform infrared (FTIR) spectroscopy and Raman spectroscopy—all studied samples were investigated using SSEF's standardised colour-stability testing protocol. Their

Table I: Sapphires of padparadscha-like colour investigated for this study.

Origin*	No. samples	Weight range (ct)	No. samples with a distinct change of colour
Sri Lanka	12	1.14–20.2	1 (8.3%)
Madagascar (Ilakaka)	17	0.88–3.07	3 (17.6%)
Madagascar (Ambaton-drazaka)	11	4.18–30.4	9 (81.8%)
Unknown origin	8	1.17–12.4	1 (12.5%)

* The indicated origin is based on a combination of analytical data and microscopic observation.

colour was observed in three stages: initially just after submission to the laboratory (stage 1), after fade testing (stage 2) and finally after exposure to a long-wave UV lamp (stage 3). When a pink stone was submitted, stages 2 and 3 were swapped, thus performing the long-wave UV exposure and then (if it changed to a padparadscha-like colour) subsequently pursuing the fade testing.

For fade testing, we followed a protocol used at SSEF for many years to examine the colour stability of gems (K. Schmetzer, pers. comm., 2009), mostly for yellow sapphires. The stone is placed in a reflecting bowl made of aluminium foil and exposed for three hours to a daylight-equivalent light source (100 W halogen Fiberoptic Heim LQ 1100). (During this process, the stone is slightly heated by the light exposure, but never above approximately 70°C.) For UV activation testing, the stone is placed in a black box for 10 minutes directly on the glass plate of a long-wave UV lamp (6 W Vilber Lourmat VL-6.LC).

After each stage, visual colour grading was performed by at least two gemmologists using the padparadscha sapphire chart developed by Notari (1996) and Munsell colour charts under daylight-equivalent illumination. The stones were also photo-documented in a white light box (cube of approximately 1 m^2 with a colour temperature of 5,500 K) using a Nikon F7 camera under standardised settings and lighting conditions. In addition, polarised absorption spectra in the 300–800 nm range were collected (ordinary ray) after each stage using either a Cary 500 ultraviolet-visible–near infrared (UV-Vis-NIR) spectrophotometer or SSEF's portable UV-Vis spectrometer manufactured by SattGems SA, a subsidiary of SSEF.

RESULTS AND DISCUSSION

Properties of the Ambatondrazaka Samples

Interestingly, most of the sapphires with unstable padparadscha-like colour originated from the Ambatondrazaka area of Madagascar (see below). Based on our observations, these sapphires commonly contain very few inclusions, and they are often characterised by distinct purple colour zoning (Figure 2). Also typical are fine 'milky' lamellae with a spacing of approximately 100 µm (Figure 3). Similar zoning features have been seen occasionally in blue sapphires from this deposit (e.g. Krzemnicki, 2017). In addition, we observed small zones of dispersed (presumably exsolved) particles (Figure 4) resembling those seen in yellow and padparadscha sapphires from Sri Lanka (cf. Hughes et al., 2017, p. 603). These particle zones were, however, less pronounced and less common than in stones from Sri Lanka.

A few of the studied samples from Ambatondrazaka contained very tiny inclusions of slightly rounded prismatic shape that were identified by Raman spectroscopy as zircon. They showed broad Raman peaks resulting

Figure 2: This exceptional 30 ct fancy-colour sapphire from Ambatondrazaka displays a distinct purplish colour zone, and therefore would not be termed 'padparadscha'. Composite photo by Luc Phan, SSEF.

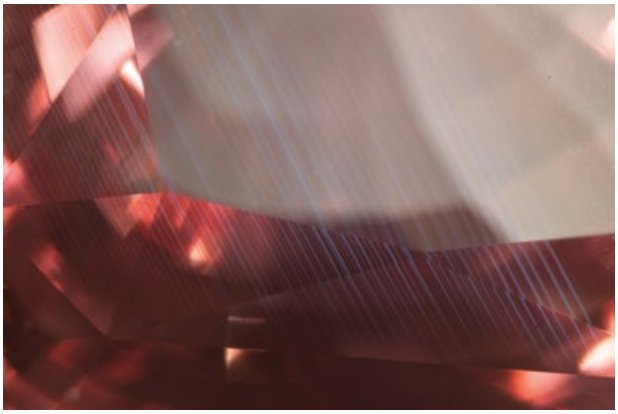

Figure 3: Fine 'milky' lamellae are seen in this fancy-colour sapphire from Ambatondrazaka. Photomicrograph by M. S. Krzemnicki; magnified 30×.

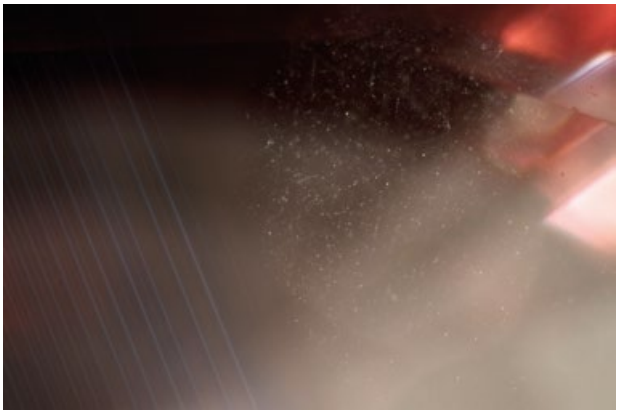

Figure 4: A group of tiny particles are present in a fancy-colour sapphire from Ambatondrazaka. See also the 'milky' lamellar zoning on the left side of the image. Photomicrograph by M. S. Krzemnicki; magnified 50×.

from metamictisation (Figure 5), a feature also characteristic for Kashmir-like blue sapphires from the same deposit (Krzemnicki, 2017).

Colour-Stability Testing

The samples could be separated into three groups after fade testing: sapphires with no notable difference in appearance (case A); sapphires that showed a slight-to-moderate shift of colour within the padparadscha colour range (case B); and fancy-colour sapphires with unstable colour that distinctly changed from padparadscha-like pinkish orange to pink (case C). These groups mostly apply to unheated sapphires of padparadscha-like colours, although they may also be encountered in some heated stones of similar colours. Interestingly, most of the 'case C' stones were found to originate from the Bemainty deposit near Ambatondrazaka in Madagascar, while fewer of this type were noted from the more 'classic' sources of Ilakaka and Sri Lanka.

Case A. Colour-Stable Samples: Nine of the 48 study samples showed no noticeable change in appearance after fade testing (four from Sri Lanka, two from Ilakaka and three of unknown origin). Their colour ranged from 'classic' padparadscha (see Figure 6, inset photos) to orangey pink (including vivid orangey to reddish pink

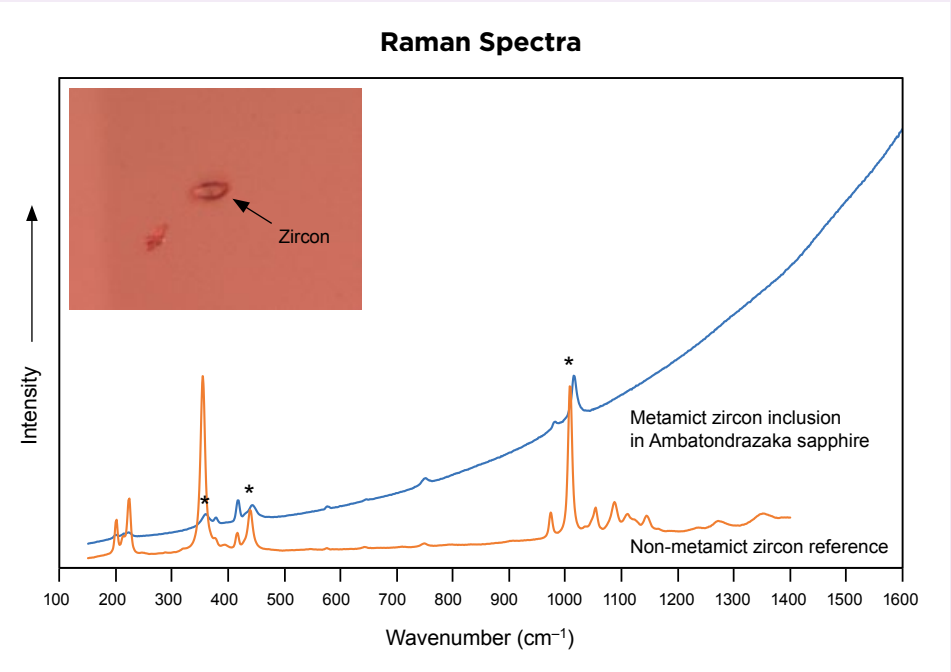

Figure 5: The Raman spectrum of a zircon inclusion in a padparadscha-like sapphire from Ambatondrazaka reveals its metamict nature, compared to a reference spectrum of a non-metamict zircon inclusion (together with some additional tiny Raman peaks). Asterisks mark the main Raman peaks of zircon shown by the inclusion. Inset photomicrograph by M. S. Krzemnicki; magnified 50×.

that was strongly zoned, and thus out of the padparadscha colour range as defined by SSEF and LMHC; e.g. Figure 7). Case A stones also showed only very minor differences in their absorption spectra before and after fade testing (again, see Figures 6 and 7). Their spectra revealed a general and more-or-less steady increase in absorption towards the ultraviolet region due to stable yellow colour centres, overprinted by broad Cr^{3+} bands and more-or-less prominent Fe^{3+} absorption peaks.

Case B. Samples with Somewhat Unstable Colour: A slight to moderate shift of colour was shown by 25 of the studied samples after fade testing (and/or long-wave UV exposure). Their shift in appearance mostly affected the intensity of the orange hue (Figure 8), but not enough to disqualify them from the padparadscha colour range (Notari, 1996; LMHC, 2018). Sapphires of this group mostly originated from Sri Lanka (seven samples) and Ilakaka (12 samples); six were of unknown origin.

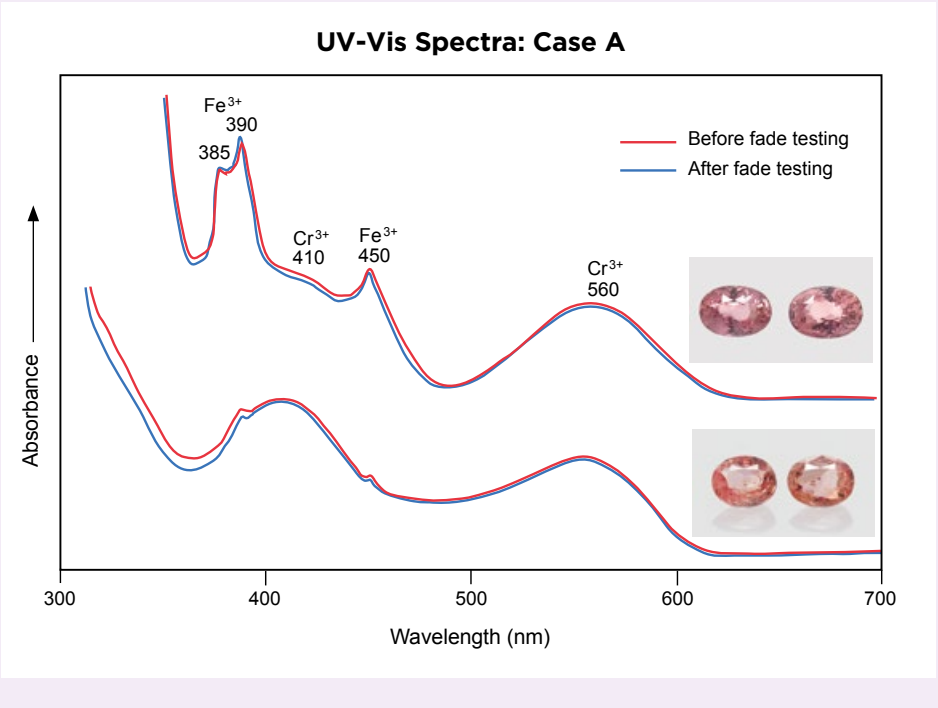

Figure 6: UV-Vis absorption spectra (ordinary ray) are shown for two padparadscha sapphires that do not display any noticeable difference in colour before and after fade testing (case A). The stones differ mainly in the intensity of their Fe^{3+}-related absorptions. The sapphires weigh 5.42 ct (top) and 5.05 ct (bottom), and the images show the stones before (left) and after (right) fade testing. Inset photos by M. S. Krzemnicki.

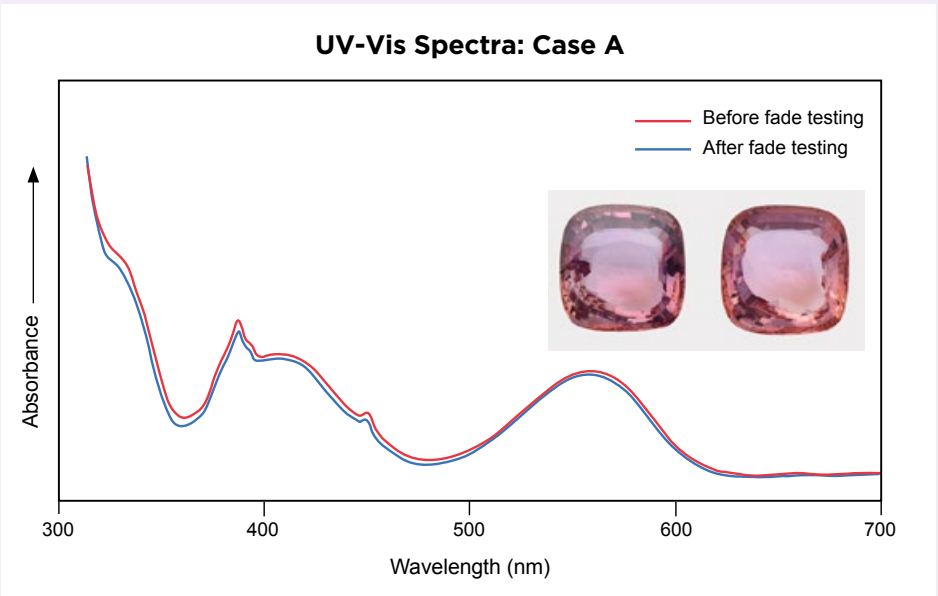

Figure 7: The nearly identical absorption spectra of a 12.02 ct sapphire with a distinct purplish pink colour zone (thus disqualifying it as padparadscha; see LMHC, 2018) are consistent with the lack of a noticeable colour difference before and after fade testing (i.e. case A). Inset photos by M. S. Krzemnicki.

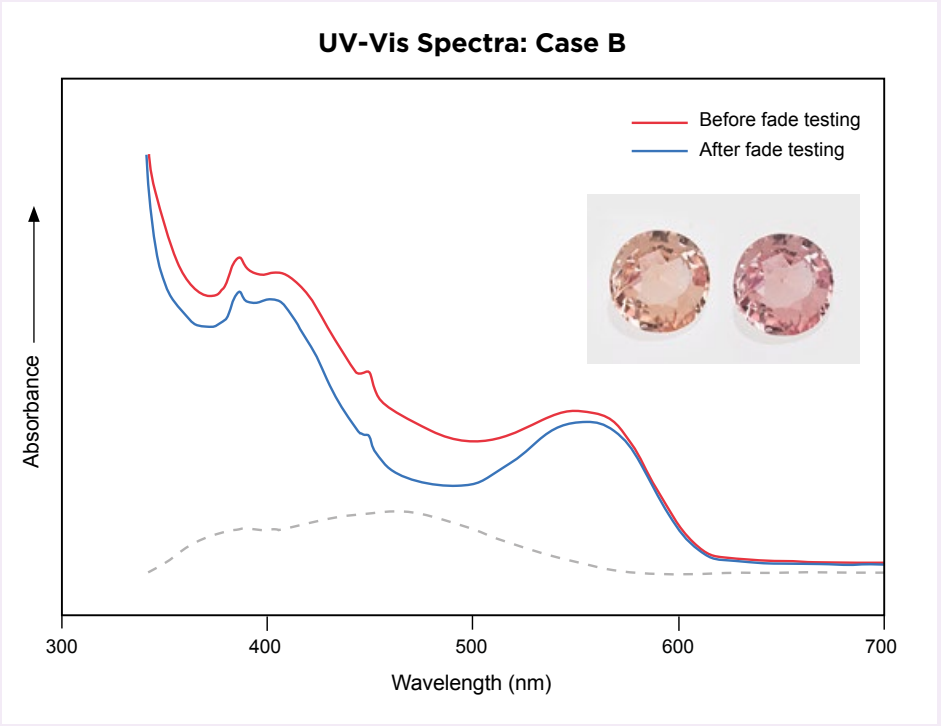

Figure 8: A 1.05 ct sapphire with a moderate change of colour before (left) and after (right) fade testing—but within the range of padparadscha; i.e. case B—yielded these absorption spectra. The dashed grey line shows the result of subtracting one trace from the other, representing the spectral contribution from the unstable orange or yellow colour centre. Inset photos by M. S. Krzemnicki.

Their absorption spectra before and after fade testing were characterised by a notable change due to variations in the strength of an unstable orange or yellow colour centre superposed on an existing stable yellow colour centre (possibly a trapped hole involving Mg^{2+} associated with an Fe^{3+} chromophore; see Emmett et al., 2017). The presence of this unstable orange or yellow colour centre is visualised by the grey dashed line in Figure 8, which represents a subtraction of the absorption spectra before and after fade testing.

Case C. Samples with Distinctly Unstable Colour: Most interestingly, 14 of the stones showed a distinct change in appearance, with a padparadscha-like orange-pink colour seen only after being activated by long-wave UV radiation (unstable colour) and a more-or-less pure pink hue after fade testing. As shown in Table I, most of the case C sapphires were from Ambatondrazaka (nine samples), compared to those from Ilakaka (three), from Sri Lanka (one) and of unknown origin (one).

Similar to the stones in case B, the absorption spectra of the case C samples were characterised by the presence of an unstable colour centre (represented by the grey dashed line in Figures 9 and 10) that pushed their colour towards pinkish orange when activated by UV radiation. However, in contrast to the abovementioned case B, these fancy-colour sapphires completely lacked or had only a very weak stable yellow colour centre, as can be seen by their lack of absorption, and thus a distinct transmission window, at ~480 nm after fade testing (Figure 11). The contrasting colour behaviour of case B can be explained by the presence of a stable yellow colour centre that is discernible by the greater absorption in the transmission window region at ~480 nm and therefore is less affected by fade testing (again, see Figure 11). This absence of a stable yellow colour centre in case C samples results in a more-or-less pure pink colour after fade testing. This 'stable' colour is thus distinctly out of the padparadscha colour range (Figure 12).

CONCLUSIONS

This study shows that metamorphic sapphires of padparadscha-like colour do not always have stable colouration, very similar to that of some yellow sapphires. Instead, they may show a tenebrescent behaviour in which the yellow/orange colour component is developed by long-wave UV exposure and is faded by exposure to daylight over time. While most of the studied samples from 'classic' sources in Sri Lanka and Ilakaka in Madagascar showed no change in appearance or a slight-to-moderate colour difference after colour-stability testing, sapphires from the recently discovered deposit near Ambatondrazaka in Madagascar often showed a distinct colour instability, shifting from pinkish orange (when 'activated' by a long-wave UV lamp) to pure pink

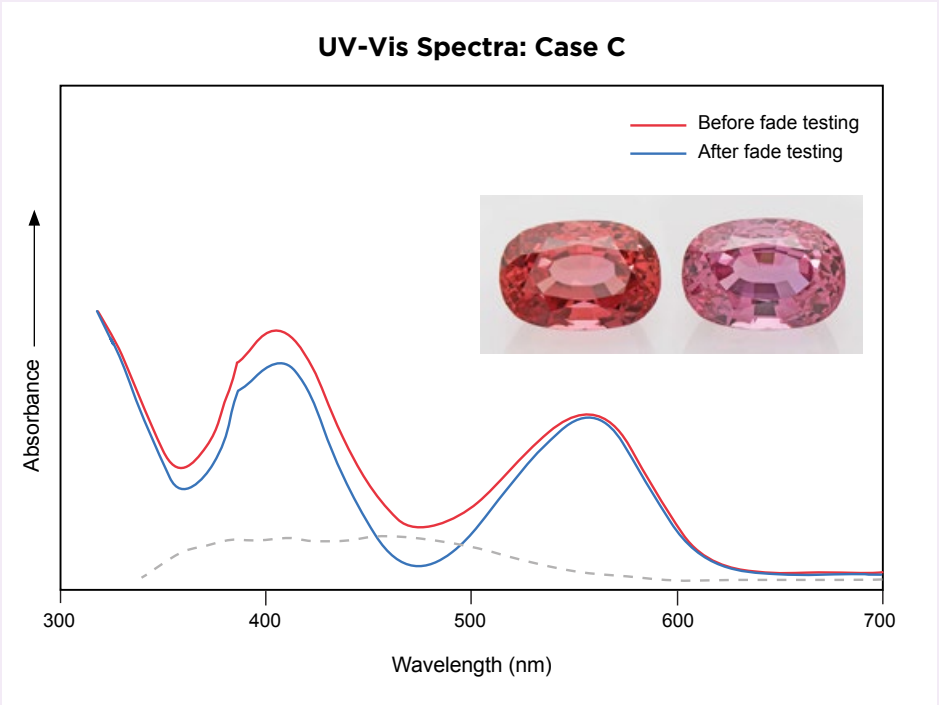

Figure 9: The 9.1 ct fancy-colour sapphire in Figure 1 displays a distinct difference in appearance before (left) and after (right) fade testing (i.e. case C), and yielded these absorption spectra. The dashed grey line representing subtraction of the two spectra shows the spectral contribution from the unstable orange or yellow colour centre. Conversely, there is no evidence of a stable yellow colour centre, which explains why the difference in appearance is so distinct. Inset photos by M. S. Krzemnicki.

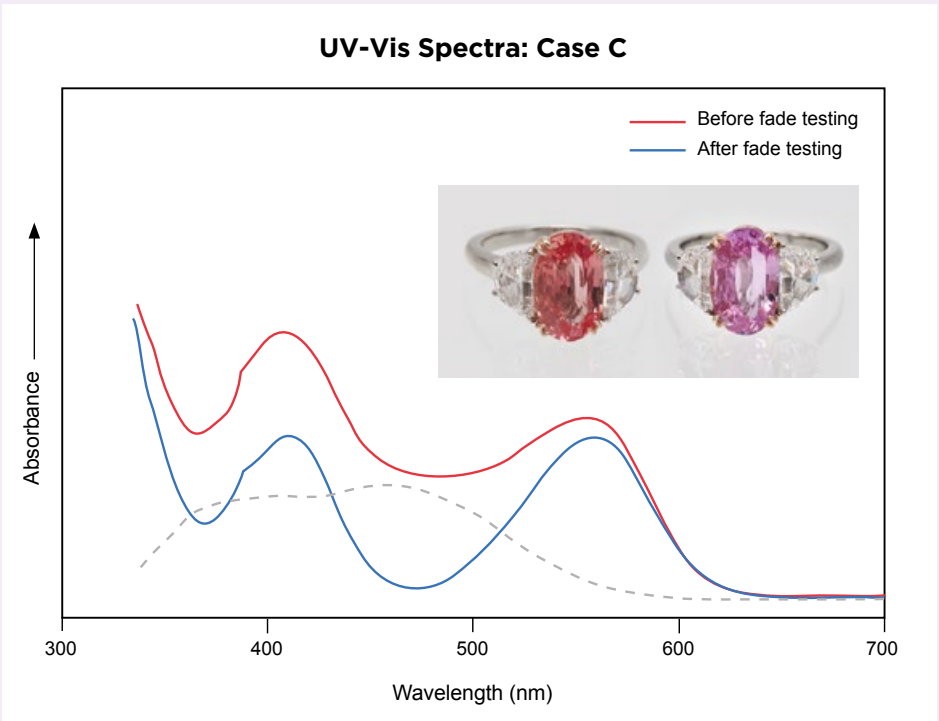

Figure 10: The absorption spectra of a ring-mounted fancy-colour sapphire (declared weight of 4.00 ct) show a distinct difference in appearance after fade testing (i.e. case C). The spectra demonstrate the contribution of an unstable orange or yellow colour centre (represented by the dashed grey line) that is even stronger than that in Figure 9. Inset photos by M. S. Krzemnicki.

after several weeks (or hours under fade-testing conditions) in daylight. Such stones that shift to a colour that is out of the padparadscha range should not be assigned the coveted varietal name 'padparadscha', which historically refers to pinkish orange to orangey pink stones that are colour-stable within this range (see LMHC, 2018).

The results of this study highlight the need to carefully test the colour stability of any corundum showing a yellow to orange colour component before an identification report is finalised.

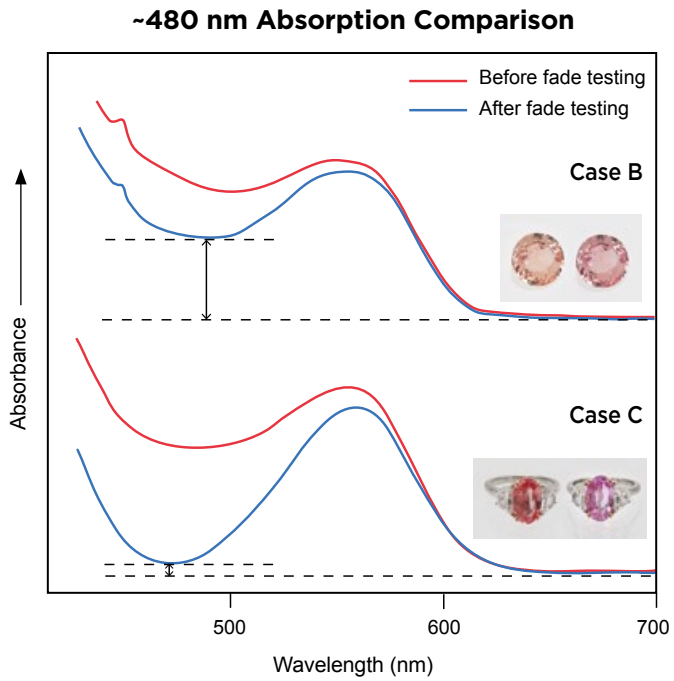

Figure 11: The main criteria that separate padparadscha sapphires with a slight to moderate shift in colour (case B) from fancy-colour sapphires with a distinct change in appearance (case C) after fade testing is not only the presence and strength of an unstable orange or yellow colour centre (see dashed grey lines in Figures 8–10), but mostly the prevalence of a stable yellow colour centre, which is visualised here by the large (top) or small (bottom) absorption step at ~480 nm before and after fade testing. The examples shown here are excerpted from Figures 8 and 10.

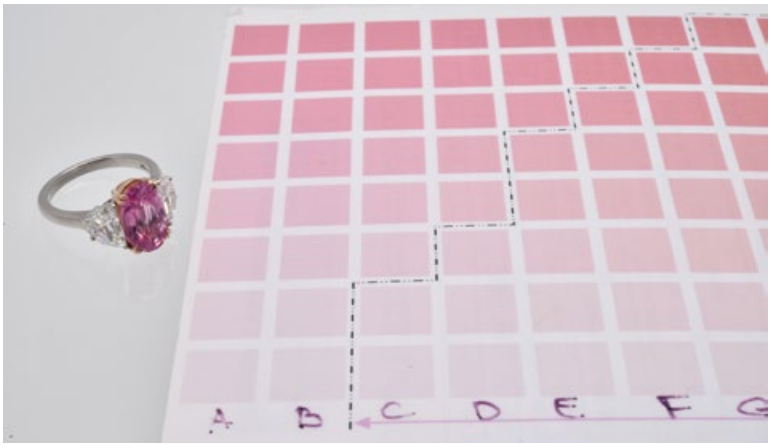

Figure 12: A fancy-colour sapphire ring (also seen in Figures 10 and 11) is shown next to a small portion of a chart proposed by Notari (1996) to represent padparadscha colour space (starting to the right of the dashed line). The pink colour of the sapphire shown here after fade testing falls outside of the padparadscha range. Photo by Luc Phan, SSEF.

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Conferences

4TH MEDITERRANEAN GEMMOLOGICAL AND JEWELLERY CONFERENCE

Following the previous Mediterranean Gemmological and Jewellery Conferences in Greece (2015), Spain (2016) and Italy (2017), the 4th MGJC took place in Budva, Montenegro, 18–20 May 2018. It was organised by the CGL-GRS Swiss Canadian Gemlab (Canada) and the Independent Gemological Laboratory (Greece), and supported by OctoNus (Finland), Magilabs (Italy/Finland), MSU Gemmological Centre (Russia), International Institute of Diamond Grading & Research (IIDGR; UK), Gemewizard (Israel), Gemetrix (Australia), HRD Antwerp (Belgium), the National Council of Jewellery Valuers (Australia) and the National Association of Jewelry Appraisers (USA). The conference attracted 75 participants from more than 25 countries (e.g. Figure 1).

The major theme of the conference was 'Synthetic Diamonds and Gems in 21st Century' and 10 speakers covered this topic. Invited lecturer **Dr Thomas Hainschwang** (GGTL, Balzers, Lichtenstein) presented 'Colour origin of untreated and treated natural and synthetic diamonds'. His presentation gave an overview of the colours that can be found in natural and synthetic diamonds, the colours that can be created by treatments and the challenge of identifying their origin. **Roman Serov** (OctoNus, Tampere, Finland, and Moscow State University Gemmological Center, Moscow, Russia) explained the 'Impact of fluorescence on diamond appearance'. He and his colleagues have developed a device for creating a lighting environment with different levels of UV content corresponding to D65 lighting, laboratory lighting and UV-free lighting, and objectively measuring the impact of fluorescence on diamond appearance. **Dr Philip Martineau** (De Beers Technologies Research Centre, Maidenhead, Berkshire) updated participants on 'CVD synthetic diamonds and their detection'. His talk described the development of different generations of screening and detection equipment now sold by IIDGR, including the new instruments launched in 2018: AMS2 and SYNTH-detect. **Branko Deljanin** (CGL-GRS Swiss Canadian Gemlab, Vancouver, British Columbia, Canada) and **George Spyromilios** (Independent Gemological Laboratory, Athens, Greece) covered 'Identification of melee to large synthetic HPHT-grown diamonds with standard instruments'. They described the use of fluorescence, phosphorescence and cross-polarising filters to help identify high-pressure, high-temperature (HPHT)-grown and most chemical vapour deposition (CVD)-grown synthetics using standard instruments (e.g. those included in MGJC's portable Synthetic Diamond Identification Kit).

Figure 1: MGJC 2018 participants gather at Budva beach before the conference's gala dinner. Photo courtesy of Branko Deljanin.

Ans Anthonis (HRD, Antwerp, Belgium) delivered a presentation titled 'Red carpet for blue fluorescent diamonds?' detailing results of research investigating the relationship between fluorescence and colour grade, in which it was found that the levels of UV in standard office and grading lighting were insignificant to produce any observable effect, even for diamonds having very strong fluorescence. **Ya'akov Almor** (MDBC Ltd, Tel Aviv, Israel) talked on 'Present and future of synthetic diamond jewellery – the ethical challenges'. Synthetic diamonds have proven to be a blessing in disguise, as the industry at large has been forced to invest in the generic promotion of natural diamonds and, consequently, to rethink how diamonds need to be marketed to the consumer. **Menahem Sevdermish** and **Guy Borenstein** (Gemewizard, Ramat Gan, Israel) introduced 'Big data analysis and insights in the online gem and jewellery trade'. Big data analytics is the process of collecting, organising and analysing large data volumes to reveal hidden patterns and unfamiliar correlations, identify market trends, and extract other useful information which otherwise might go unnoticed. **Bear Williams** (Stone Group Labs, Jefferson City, Missouri, USA) gave a talk on 'Insights into gemmological observations and techniques'. He noted that microscopy and fluorescent reactions can reveal the hidden practise of adding chemical chromophores into flux mixtures that can be diffused into corundum to create a natural-appearing colour. In his talk on 'Gem lab notes from Canada', **Branko Deljanin** covered some unusual new imitations, such as star CZ and star hematite-ilmenite sold as natural star rutile from Sri Lanka. **Martin Steinbach** (Steinbach – Gems with a Star, Idar-Oberstein, Germany) gave a presentation on asterism in gems, and he covered the history of asterism, the treatments and imitations of star stones, synthetic stars, double stars, networks of stars and various star gems (e.g. ruby, sapphire, quartz and spinel) showing 12–24 rays. In a talk on 'Tracking gemstones at auction', **Gail Brett Levine** (National Association of Jewelry Appraisers, Rego Park, New York, USA) observed that the prices achieved at auction for certificated rubies, emeralds and sapphires are not sufficient for valuations of other such gems without understanding the descriptive value factors, limitations of lab reports and country of origin.

A 'round table' discussion on 'Marketing of synthetic diamonds and synthetic gems in 21st century' included seven international experts and was guided by moderator **Ya'akov Almor**. Panellists were **Dr Thomas Hainschwang**, **Branko Deljanin**, **Yuri Shelementiev** (Moscow State University Gemmological Center), **Cara Williams** (Stone Group Labs), **Alberto Scarani** (Magilabs, Rome, Italy), **Dr Joe C. C. Yuan** (Taidiam Technology, Taipei, Taiwan) and **Sergey Sivovolenko** (OctoNus). With the increasing presence of synthetic diamonds on the market, the direction of the industry is changing. The panel and audience explored the impact of synthetic gems and diamonds and how they are establishing themselves in the gem and jewellery market.

Figure 2: Mikko Åström of Magilabs demonstrates the EXA spectrometer during a workshop at the MGJC. Photo courtesy of Branko Deljanin.

Participants were offered hands-on experience at various pre- and post-conference workshops (Figure 2). Basic workshops were 'Unusual uses of portable, affordable tools in identifying most gems in the marketplace' by **Antoinette Matlins** (South Woodstock, Vermont, USA) and 'Ruby, sapphire, emerald and coloured diamond grading' by **Menahem Sevdermish** and **Guy Borenstein**. Intermediate-level workshops were offered on 'ID of rubies and sapphires treatments with standard and advanced instruments' by **Branko Deljanin** and 'ID of natural and synthetic emeralds with standard and advanced instruments' by **Yuri Shelementiev**. Two intermediate-to-advanced workshops on diamonds were given on 'ID of loose and mounted synthetic diamonds with portable instruments' by **Branko Deljanin** and **George Spyromilios** and 'ID of treated synthetic and natural diamonds with standard and advanced instruments' by **Mikko** Åström (Magilabs, Järvenpää, Finland; Figure 2) and **Alberto Scarani**.

Posters and equipment displays gave participants further opportunities to increase their knowledge. A proceedings volume (for 2018, as well as past years) is available for purchase at www.brankogems.com/shop/proceedings/proceedings-2018-mediterranean-gem-and-jewellery-conference-budva-montenegro.

The 5th MGJC will take place 17–19 May 2019 in Limassol, Cyprus. The main topic will be 'Manufacturing of Gems and Diamonds'. For more details on the programme, venue, tours and workshops visit www.gemconference.com.

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GIA SYMPOSIUM

Hosted by the Gemological Institute of America (GIA), the 2018 GIA Symposium took place 7–9 October at the Westin Carlsbad Resort and Spa in Carlsbad, California, USA. Approximately 770 full registrants and students attended the conference (both research and business tracks) from 36 countries. About 190 of them primarily attended the research track, and the research session was commonly near the full capacity of 320 people since the attendees could move as they chose between the research and business sessions. This report highlights those oral presentations of greatest interest to gemmologists. A conference proceedings volume containing abstracts of all the oral and poster presentations in the research track was published in the Fall 2018 issue of *Gems & Gemology*.

Diamonds were covered in several talks. **Dr Christopher Breeding** (GIA, Carlsbad) reviewed the effect of lattice defects on the colour of diamond. He also stressed the rarity of coloured diamonds, which make up only 0.4% of the diamonds submitted to GIA for reports. Of those, 70% are yellow, 17% are 'red' (including red, pink, purple and brown), 10% are green and 3% are 'blue' (including blue to violet). **Dr Wuyi Wang** (GIA, New York, New York) examined the properties of 'true' canary yellow diamonds, which consist of very rare type Ib stones with a highly saturated yellow colour. The main sources of such diamonds are the Zimmi deposit in Sierra Leone and mines in Siberia, Russia. They typically display a patchy colour distribution, very weak or no strain, and green fluorescence in the DiamondView. **Dr Ulrika F. S. D'Haenens-Johansson** (GIA, New York) studied some large rough diamonds that were recovered in late 2015 from the Karowe mine in Botswana by Lucara Diamond Corp. These stones were found at approximately the same time as the 1,109 ct Lesedi la Rona; two offcuts from this rough diamond were also studied. The Fourier-transform infrared (FTIR) and photoluminescence (PL) spectral characteristics, as well as zoning patterns of blue fluorescence seen in the DiamondView, suggest that all of these samples originally formed a single piece of rough that weighed more than 2,774 ct. **Ans Anthonis** (HRD Antwerp, Belgium) examined the impact of blue fluorescence on the colour appearance of round brilliant-cut diamonds. Various groups of observers examined numerous stones, which were grouped according to fluorescence strength, both table-up and table-down, under four different simulated lighting conditions: outdoor, indoor (near a window), office and grading; the latter two environments contained virtually no UV component. Viewed table-down, significant differences in colour (i.e. a whiter appearance) were seen only in the outdoor and indoor (near a window) environments for diamonds that had very strong or strong fluorescence. The effect was less pronounced when viewed table-up, with a significant colour difference seen only in the outdoor lighting environment for diamonds with very strong fluorescence. **Janak Mistry** (Lexus Group, Gujarat, India) used computer-generated imagery to render the appearance of brilliance and fire in faceted diamonds. The appearance of an actual diamond is influenced by a combination of objective optical effects and subjective perceptions. The amount of brilliance is strongly affected by pattern contrasts as well as movement, while fire is particularly dependent on the size of the colour flashes (i.e. affected by cutting style). **Sergey Sivovolenko** (OctoNus, Tampere, Finland) delivered a presentation for **Roman Serov** on performing quantitative absorption spectrum reconstructions to model the effect of different cutting styles on the colour appearance of fancy-colour diamonds. Using OctoNus software, he showed how a 1.20 ct Fancy yellow radiant could be recut into a 1.00 ct Fancy Intense yellow diamond.

Synthetic diamonds were also described in a series of presentations. **Dr David Fisher** (De Beers Technologies, Maidenhead, Berkshire) reviewed the challenges of detecting and screening for synthetic diamonds (Figure 3). He discussed the capabilities and limitations of the DiamondView, AMS2 and SYNTHdetect instruments, and then presented a brief synopsis of the CVD synthetics that are being sold in De Beers' new Lightbox jewellery line. They are easily identified by their orange-to-pink luminescence in the DiamondView, as well as their yellow fluorescence in the SYNTHdetect instrument. They also show a 596/597 nm doublet in their photoluminescence spectra, which is indicative of a CVD origin. **Dr Sally Eaton-Magaña** (GIA, Carlsbad) provided a summary of the CVD synthetic diamonds seen in GIA's

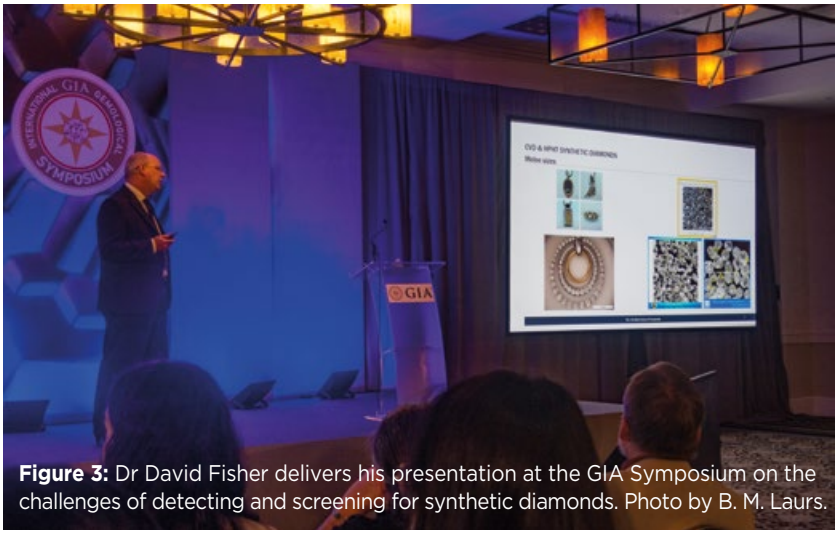

Figure 3: Dr David Fisher delivers his presentation at the GIA Symposium on the challenges of detecting and screening for synthetic diamonds. Photo by B. M. Laurs.

laboratories. The (near-)colourless products typically are G-to-N colour and of high clarity, with any inclusions formed by non-diamond carbon, pinpoints and clouds. While those submitted in 2003–2013 showed some UV fluorescence (typically green, yellow or orange), in 2014–2018 almost all of them were inert. Approximately 74% had undergone post-growth HPHT treatment to remove brown colouration, while ~26% were untreated. **Dr Taijin Lu** (National Gemstone Testing Center, Beijing, China) chronicled recent developments in synthetic diamonds in China. HPHT synthetics are being produced by at least 10 companies, mostly using cubic presses that employ the temperature gradient technique. Type Ib crystals may attain weights of 10+ ct with those ranging up to 3–4 ct being mass produced, while type IIa crystals may reach 8 ct with those under 1 ct being mass produced in the D-to-H colour range. CVD synthetics are produced mostly by DC arc plasma torch technology, yielding type IIa and IIb crystals that are mass produced in sizes ranging up to 12 × 12 × 3 mm. **Dr Hiroshi Kitawaki** (Central Gem Laboratory, Tokyo, Japan) described a 0.192 ct low-pressure, high-temperature (LPHT) treated pink CVD synthetic diamond. While pink CVD synthetics are typically produced using HPHT treatment followed by irradiation with electrons and then low-temperature annealing, the spectral characteristics of this sample indicated that it had undergone LPHT treatment in the range of 1,500–1,700°C.

Diamond geology was covered in detail. **Dr D. Graham Pearson** (University of Alberta, Edmonton, Alberta, Canada) discussed modern advances in the understanding of diamond formation. He emphasised that diamond-bearing terranes need not be exclusively Archean age (>2.5 billion years old), but may also be Proterozoic, as shown by the presence of diamond-bearing pipes in Canada's Sask craton and in Siberia, both of which have lithosphere ages of ~2 billion years old. **Dr Steven Shirey** (Carnegie Institution for Science, Washington DC, USA) reviewed how to obtain and interpret diamond ages. Syngenetic mineral inclusions may provide useful age data, with silicates occurring in lithospheric and superdeep diamonds (datable by Rb-Sr, Sm-Nd and K-Ar methods), and sulphides occurring in lithospheric diamonds (datable by the Re-Os method). The ages provide insights into the relationship between continental geology and origin of diamond-bearing fluids. **Dr Thomas Stachel** (University of Alberta) covered diamond-forming reactions in the earth's mantle. He indicated that the most important reaction involves diamond precipitation from the cooling of high-density C-, H- and O-bearing fluids according to the reaction $CO_2 + CH_4 = C$ (diamond) $+ H_2O$. In this fluid-driven reaction, the mantle wallrocks do not actively participate in diamond formation. **Dr Evan Smith** (GIA, New York) explained the formation of type IIa and IIb diamonds. Type IIa stones are typically large and contain relatively few inclusions, but recent investigations of syngenetic inclusion clusters have revealed the presence of majoritic garnet and $CaSiO_3$-perovskite, which indicate formation at extreme depths of 360–750 km. Rare inclusions in type IIb diamonds also indicate superdeep formation, and the traces of boron that colour these diamonds are derived from subducted seafloor at depths greater than 660 km.

Presentations on coloured stones covered a wide range of gem materials. **Dr Emmanuel Fritsch** (Institut des Matériaux Jean Rouxel and University of Nantes, France) provided compelling evidence that 'boehmite needles' in corundum are actually crystallographically oriented tube-like inclusions known as rose channels. The empty channels form at the intersections of polysynthetic twin planes, and may be explained by deformation twinning that creates vacancies that could migrate to form hollow tubes. **Dr Aaron Palke** (GIA, Carlsbad) examined the colouration of Co-bearing spinel. GIA's laboratory defines this gem variety as having a bright, saturated blue colour that is mainly due to Co. Although Fe may also be present, the visible absorption spectrum must be dominated by Co^{2+} absorptions at ~550, 580 and 630 nm. In general, at least 50 ppm Co is necessary to produce the colouration

associated with 'cobalt spinel', although smaller quantities may produce suitable colour in larger stones (e.g. ~20 ppm for an 8 ct gem). **Dr Barbara Dutrow** (Louisiana State University, Baton Rouge, Louisiana, USA) looked at the importance of tourmaline as a guide to geological evolution. By selectively encoding chemical information about its formational environment that is retained through long periods of geological time, tourmaline can reveal insights about processes in the earth's crust. Information can be gleaned on the tourmaline's original host rock environment/composition/provenance, the thermal history of metamorphic reactions that are related to tectonic events, and the fluid composition, pressure conditions and time of formation of tourmaline-bearing rocks. **Dr Zemin Luo** (China University of Geosciences, Wuhan) performed trace-element analysis on green nephrite from five major origins in Canada (British Columbia), Russia (Siberia), Taiwan and China (Hetian and Manasi in Xinjiang). Linear discriminant analysis of the data showed a clear separation between nephrite from Siberia and Manasi, but overlaps between nephrite from British Columbia, Taiwan and Hetian. The most important trace-element trends were relatively low Ba, Sr and Ti in nephrite from Manasi and high contents of these elements in British Columbian samples. **Martin Steinbach** (Steinbach – Gems with a Star, Idar-Oberstein, Germany) provided an overview of asteriated gems. He indicated that approximately 60 gem varieties are known to show asterism, and there are also about 15 trapiche gem types that show fixed stars. The most important sources of star stones are Sri Lanka, Brazil, India, Madagascar, Tanzania and Vietnam.

Presentations on new technologies included laboratory as well as digital (Internet) topics. **Dr Raquel Alonso-Perez** (Harvard University, Cambridge, Massachusetts, USA) analysed emeralds from ~20 localities worldwide, with a combined approach of inductively coupled plasma mass spectrometry (ICP-MS) and Raman spectroscopy, for the purpose of origin determination and to establish petrogenetic indicators for the various deposits. Approximately 5–10 mg of the samples were digested for ICP-MS analysis to obtain trace-element signatures, while Raman spectroscopy employed a hyperspectral darkfield technique to obtain information on the channel constituents of the emeralds. Colombian samples were identifiable by both techniques, while emeralds from Zambia, Madagascar and Brazil showed enrichments in heavy rare-earth elements. **Dr Claudio Milisenda** (DSEF German Gem Lab, Idar-Oberstein, Germany) examined the value of photoluminescence spectroscopy for coloured stone identification. This technique can be used to separate natural vs. synthetic vs. heated spinel; to identify dyed corundum, coral and pearls; to detect fracture filling; and in some cases to provide an indication of a gem's geographic origin (e.g. for corundum and Cu-bearing tourmaline). In addition, PL spectroscopy can be used to identify mineral species (if reference spectra are available) and as a screening device when examining coloured stone parcels. **Menahem Sevdermish** (Gemewizard, Ramat Gan, Israel) used 'big data analysis' to provide insights into the online gem and jewellery trade (see MGJC report on p. 357). By tabulating the prices, reported attributes (including whether natural, treated or synthetic) and colour (determined digitally using the Gemewizard system) of gems that are offered through a popular online selling platform, the software is able to flag items that have anomalous properties and therefore may be fraudulently represented by the seller. **Klemens Link** (Gübelin Gem Lab, Lucerne, Switzerland) discussed the Provenance Proof blockchain, which will launch in February 2019 to coincide with the gem shows in Tucson, Arizona, USA. This system for following stones through the entire supply chain is independent from the Gübelin Gem Lab and will be free for anyone to use. To connect the digital information in the blockchain with an actual gem, users may consider using the Paternity Test (to implant DNA-encoded nanoparticles into the stone), which is currently available only for emeralds. **Dr Gregory Hodgins** (University of Arizona, Tucson) explained the radiocarbon (^{14}C) age dating of pearls. He explained the data corrections that are necessary due to the inhomogeneous distribution of ^{14}C in the world's oceans, and how above-ground nuclear testing that caused a spike in ^{14}C from 1955 onward must be taken into account. **Chunhui Zhou** (GIA, New York) discussed the limitations and future potential of 'unconventional' techniques in pearl testing, including radiocarbon age dating, DNA barcoding, chemical/isotopic analysis and three-dimensional reconstruction of internal structures.

Gem localities were the subject of four presentations. **Wim Vertriest** (GIA, Bangkok, Thailand) described GIA's field gemmology programme as a modern approach to origin determination. The main focus is on obtaining reliable samples, which is accomplished by going to the mining locations and keeping detailed records of how the samples are acquired. So far, 20,626 samples have been obtained (mostly ruby, emerald and sapphire) during 90 field expeditions over the past decade. **Peter Lyckberg** (Museum of Natural History, Luxembourg) documented gem pegmatites in Ukraine, Russia, Afghanistan and

Pakistan (see also p. 256 of the IMA conference report in *The Journal*, Vol. 36, No. 3, 2018). He focused mainly on the Ukraine deposits, for which ~1,900 pegmatites are known and ~1,500 of them have been mined. They are important sources of gem-quality heliodor and topaz (light brown/blue, sometimes bicoloured). **Dr Lee Groat** (University of British Columbia, Vancouver, Canada) recounted his scientific studies of various coloured stone deposits in Canada. Although challenges to fieldwork include the remoteness of the localities, harsh climate in Arctic regions and the often small size of the gem showings, such studies may provide clues to explore for similar deposits elsewhere. Groat also reviewed origin determination of emeralds and rubies using chemical and isotopic analysis. **William Larson** (Pala International, Fallbrook, California) profiled gems and their localities from pegmatites in San Diego County, California. Most of the gem and mineral production occurred in 1900–1912 and was driven by Chinese Empress Dowager Cixi's desire for pink-to-red tourmaline (e.g. Figure 4). Larson recounted his personal experience with many exciting discoveries at the Tourmaline Queen and Himalaya mines, and also described recent developments at the Oceanview mine (for kunzite and bicoloured pink-green tourmaline) and the Mountain Lily mine (which is currently being explored for tourmaline and topaz).

Figure 4: This antique Chinese snuff bottle (5 × 4 × 2.5 cm) is carved of tourmaline from the Himalaya mine in San Diego County, California. Courtesy of Pala International; photo by Mia Dixon.

In other presentations, **Edward Boehm** (RareSource, Chattanooga, Tennessee, USA) explained the challenges of working as a gem trader in the 21st century. Successful dealers must differentiate themselves from others who are buying gems in cutting centres, and also must be more knowledgeable about all aspects of the trade, from evaluating rough material and identifying treatments and synthetics to becoming vertically integrated in the business. Due to gem traceability requirements from large publically traded retailers, Boehm predicted that origin determination and stone tracing will become even more important in the future. **Dr Saleem Ali** (University of Delaware, Newark, USA) examined sustainability in the gem industry. Although there are many challenges to sustainability, particularly in the highly fragmented coloured stone arena, some possible solutions include (1) life-cycle analysis to measure the impacts of mining in both ecological and social terms, (2) consumer education about gem origin and the impact of mine development coupled with origin assurance, and (3) conservation initiatives such as levying mineral-origin 'royalties' each time a gem is sold to promote wildlife conservation in the mining area. **Cristina Villegas** (Pact, Washington DC, USA) described a collaboration between GIA and her company to help close the knowledge gap across the supply chain in Tanzania. The team provided two days of theoretical and practical training to local miners, accompanied by simple educational reference books and sorting trays. This provided the miners with greater knowledge about quality/value factors, more confidence in dealing with gem rough, increased financial independence, and better preparation of the gem rough for selling and cutting.

Brendan M. Laurs FGA

CANADIAN GEMMOLOGICAL ASSOCIATION CONFERENCE

Celebrating the 60th anniversary of the Canadian Gemmological Association (CGA), Gem Conference 2018 took place 19–21 October in Vancouver, British Columbia, Canada. Approximately 70 people attended, representing six countries (Australia, Canada, Costa Rica, Hong Kong, UK and USA).

CGA president **Donna Hawrelko** opened the conference, and she then asked various CGA staff and students to take turns introducing the speakers. **Duncan Parker** (Dupuis Fine Jewellery Auctioneers, Toronto, Ontario, Canada) surveyed gems in ancient texts. The oldest mentions were by Aristotle, Theoprastus and Pliny the

Elder, and these were followed by an approximately 1,600 year gap until publications on gemmological topics were resumed by Robert Boyle and subsequently by authors such as David Jefferies, William Hyde Wollaston, Lewis Feuchtwanger, Edward Streeter, Julius Wodiska, Herbert Smith and A. H. Church.

Joseph DuMouchelle (Joseph DuMouchelle Jewelry Buyers, Birmingham, Michigan, USA) chronicled trends in jewellery and collectibles at auction. In general, auction prices are reflective of shifting world markets, changes in consumer buying habits and style, and the status of the economy. For 2018 and beyond, he indicated that buyers are returning (with a focus on quality), and also that signed pieces and understated styles should remain popular. The Internet has revolutionised auctions by providing access to a worldwide market, with buyers for nearly everything.

Mike Botha (Embee Diamonds, Prince Albert, Saskatchewan, Canada) described his development of the Sirius Star diamond cut to provide more light return than a standard round brilliant. The cut employs 32 crown facets and 48 pavilion facets (in four tiers), resulting in a diamond that reportedly looks larger and brighter due to more even light distribution from the crown mains, star facets and table. He has subsequently developed variations of the Sirius Star in octagon, square and cushion shapes, in patterns that incorporate 80, 84, 88 or 100 facets.

Kelly Ross (Ross Inc., Edmonton, Alberta, Canada, and formerly diamond programme coordinator for the Royal Canadian Mounted Police) explained how stolen jewellery is used by criminals to pay debts (i.e. to drug dealers) or to obtain illicit drugs. Cases involving jewellery theft are often difficult to bring to trial because of the difficulty of proving that seized items are the proceeds of a crime, as well as the time-consuming process of doing so.

Jon Phillips (Corona Jewellery Co., Toronto, Ontario, Canada) reviewed recent developments pertaining to Canadian diamonds. Canada is now the second largest diamond producer by volume and fourth largest by value. Currently active mines include Ekati, Diavik, Gahcho Kué, Renard and Victor, and future diamond production is expected from Chidliak and the Star-Orion South project. The sorting, evaluation and sales of Canadian diamond rough mainly take place in India and Botswana (with a small amount being done in Antwerp, Belgium). Nearly all of the diamonds undergo manufacturing in India.

Simon O'Brien (De Beers Group of Companies, Calgary, Alberta, Canada) explained De Beers' new 'Building Forever' initiative, which focuses on building trust through natural, conflict-free diamonds, community benefit and environmental quality at the mines. He emphasised that such positive aspects provide important talking points for educating the gem-buying public. He also described De Beers' newly developed Lightbox synthetic diamond jewellery, which is being positioned in the market to commemorate 'incremental' occasions and self-purchase.

Dr Çiğdem Lüle (Kybele LLC, Buffalo Grove, Illinois, USA) reviewed the occurrences and varieties of garnets, as well as their history and lore. Garnets are common today, but they were rare in the Western world until Alexander the Great opened up trade routes with the East (e.g. the Silk Road), and subsequently they were obtained by Roman seafarers.

Andrew Cody (Cody Opal, Melbourne, Victoria, Australia) covered opal classification according to type and variety. He indicated that uniform opal nomenclature is needed to avoid inconsistencies in terminology used by gemmological laboratories and educational institutions. He displayed a complete opal master reference set (see *The Journal*, Vol. 36, No. 2, 2018, pp. 110–111) that was obtained by CGA, and mentioned the development of an exciting new resource that will published in the near future called *The Opal Handbook for Professionals*.

Lily Vongwattanakit (Van Cleef & Arpels, New York, New York, USA) described in detail the process of creating exquisite jewellery art at Van Cleef & Arpels. Such jewels represent beauty, femininity, refinement, artistic essence, innovation, uniqueness and exceptional craftsmanship. Most of the pieces take two years to complete, and a number of steps are required including inspiration, obtaining the stones, designing and rendering. The last process is particularly time consuming because before being manufactured each piece is made into a three-dimensional model (using pewter for the metal and glass for the gems).

Gary Roskin (International Colored Gemstone Association, New York, New York, USA) examined various aspects of the value vs. price vs. cost of gem materials (i.e. someone's belief of worth vs. what someone is willing to pay vs. what is actually paid). He indicated that uncertainty in the global economy is driving the ultra-wealthy to diversify their holdings to include high-value gemstones such as coloured diamonds. He then reviewed some market trends derived from the September 2017 Hong Kong Jewellery & Gem Fair.

Sarah Steele (Ebor Jetworks Ltd, Whitby) surveyed the history, properties and characterisation of jet. Used for ornamentation and decorations for 19,000 years, jet became the biggest gem trend in 1830–1910 when

the British government issued a decree for its use in mourning jewellery. However, its popularity collapsed when large quantities of inferior-quality jet were imported from Spain, causing a loss in consumer confidence. It is desirable to know the source of jet due to general differences in the stability of the material from various localities, and efforts are currently underway to find a non-destructive spectral technique for doing so.

Alex Grizenko (Lucent Diamonds Inc., Los Angeles, California, USA) reviewed the growth techniques and identification of synthetic diamonds produced by both HPHT and CVD methods. He also summarised methods of separating natural from synthetic diamonds (HPHT and CVD) using classical gemmological techniques and various screening devices.

Dr Lee Groat (University of British Columbia, Vancouver, Canada) explored coloured stone localities in Canada (see GIA Symposium report on p. 361). He also briefly looked at processes affecting the clarity of gem materials, such as fracturing due to stress and the subsequent healing of fissures that is accompanied by the formation of secondary fluid inclusions, which are the main cause of diminished transparency in gem crystals.

Art Samuels (Vivid Diamonds & Jewelry and EstateBuyers.com, Florida, USA) provided diverse insights from his extensive experience dealing with gems and jewellery. He covered the risks and rewards of recutting diamonds for improved clarity grades, decolourising brown type IIa diamonds via HPHT processing, and challenging GIA laboratory reports for diamonds with borderline SI_2/I_1 clarity grades and Fancy Deep/Fancy Vivid colour grades.

Stuart Robertson (Gemworld International Inc., Glenview, Illinois, USA) examined various trends in the gem industry. Millennials represent the greatest potential market for future jewellery consumption, but they demand non-traditional styles and materials that tie into their need for individualism. They are best approached through e-commerce, social media and influencer marketing (i.e. in which a person with lots of followers 'likes' a product on social media). For the coloured stone market, Robertson predicted that garnet is poised for increasing popularity, and that there will be a growth in demand for non-classic gems.

Dr Dominic Mok (Asian Gemmological Institute and Laboratory Ltd, Hong Kong) reviewed jade quality factors and grading. He emphasised the '3Cs' of **c**lass (overall variety), **c**olour (hue description) and **c**raftsmanship (execution of shape and polish); other important considerations include size, transparency, internal shine and purity. He also explained testing protocols for jade using microscopy and spectroscopy (FTIR, ultraviolet-visible and Raman).

Figure 5: CGA president Donna Hawrelko presents the inaugural CGA Diamond Award to Alan Hodgkinson in recognition of his outstanding contributions to Canadian gemmology. Photo by Kenneth Waters.

Alan Hodgkinson (Whinhurst, West Kilbride, Scotland) described simple gemmological techniques for differentiating various gem materials with overlapping RI values or for cases where RI values cannot be obtained (such as some mounted stones), which included natural vs. synthetic Co-bearing spinel, red spinel vs. garnet, red beryl vs. ruby and blue kyanite vs. sapphire. He also reminded the audience about the use of top-lighting with the refractometer to obtain RI values of gems for which clear readings are difficult to obtain.

Several awards were given during the CGA Banquet on 21 October. The **CGA Lifetime Achievement Award** was presented to **Donna Hawrelko**, the inaugural **CGA Diamond Award** for outstanding contributions to Canadian gemmology was awarded to **Alan Hodgkinson** (Figure 5) and winners were announced for CGA's first jewellery design contest: 1st place went to **Yiwei Zhang** (George Brown College, Toronto, Ontario) for her Sprout Spring neckpiece, 2nd place went to **Jackie Zheng** (Vancouver Community College, Vancouver, British Columbia) for his Autumn Melody bracelet, 3rd place went to **Alexandro Gage** (Vancouver Community College) for his After Picasso pendant and an honourable mention went to **Charlize Nhung** (OCAD University, Toronto) for her Element of Canada necklace.

Four workshops took place before and after the conference: visual optics by **Alan Hodgkinson**, jade by **Dr Dominic Mok**, opals by **Andrew Cody** and common gem treatments by **Dr Çiğdem Lüle**.

Brendan M. Laurs FGA

GEM-A CONFERENCE

On 3–4 November 2018, gemmologists from around the world gathered for the annual Gem-A Conference at etc.venues County Hall in London. With close to 300 attendees over the two days, the delegates were treated to a variety of talks ranging from gemmology to geology, sustainable mining, and artistic cutting and jewellery.

Gem-A CEO **Alan Hart** opened the conference by noting that 2018 marks 110 years of organised gemmology in the UK, since Samuel Barnett originally proposed gemmological education to the National Association of Goldsmiths in 1908. Celebrating Gem-A's proud history, and the legacy of Basil Anderson starting the world's first gem-testing laboratory, this year's conference presentations demonstrated the multi-disciplinary and international nature of Gem-A, as well as an increasing focus on social and gender equality in our industry.

Internationally renowned Hong Kong jewellery artist and innovator **Wallace Chan** explored his philosophy and journey as a gem cutter and carver, and how his past mistakes formed an essential part of his progress. Chan shared the insights behind some of his spectacular creations, including the illusionary carving technique called the Wallace Cut, the butterfly-themed jewels that showcase his mastery of titanium metalwork, and his Secret Abyss project that took over a decade and many broken pieces of rock crystal to complete. Asserting 'failure is part of the process', Chan demonstrated how unexpected turns often form part of the creative journey.

Dr Eloïse Gaillou (Mines ParisTech, Paris, France) discussed the various defects that cause colour in diamonds. Given the increasing popularity of coloured diamonds, which have been attaining record prices at auction houses across the globe, Gaillou asserted the importance of understanding the causes of their colour to help differentiate between natural, treated and synthetic diamonds. She explored the various types of defects that cause blue, pink-to-red, green, yellow and brown colouration, as well as the types of inclusions that create a black or white appearance in diamond.

Geologist and mineral expert **Peter Lyckberg** (Museum of Natural History, Luxembourg) discussed gem-bearing pegmatites of Afghanistan and Pakistan. Emphasising the importance of studying gems *in situ* at their deposits to ensure the correct information is obtained for museum collections, Lyckberg displayed stunning images of his visits to several important gem and mineral localities. Some of the specimen highlights were a spiral-included aquamarine and a top-quality matrix specimen of aquamarine from Pakistan's Shigar Valley.

Master faceter **Victor Tuzlukov** (Bangkok, Thailand) discussed precision-cut gemstones according to their high level of perfection and lack of faceting defects (Figure 6). He also shared the philosophy behind his Heritage cuts, and his experience with teaching precision gem-cutting, which demands attentiveness, accuracy and harmony, and taps into creative consciousness as well as knowledge of the natural sciences.

Closing Saturday's presentations, **Justin Hunter** (J. Hunter Pearls, Savusavu, Fiji) outlined his initiatives to preserve, protect and sustain the oceans through pearl farming. In 2016 his farm was severely damaged by cyclone Winston, nearly causing him to close operations, but he saw first-hand how the local inhabitants (many of whom were his employees) needed the pearl farm to remain open. Since pearl farms require healthy oceans to function, this experience proved the value of tropical marine biodiversity. In 2017 he created the Fiji Pearl Development Plan, which envisions a 'blue industry' that focuses on sustainable living conditions for island communities who have given up their fishing grounds for the creation of marine protected areas.

Writer, jewellery expert and entrepreneur **Monica Stephenson** (Anza Gems and iDazzle.com, Seattle, Washington, USA) began Sunday's presentations by taking the audience on a virtual trip to an East African tsavorite mine that is worked by local artisanal diggers. Stephenson wants to refocus the narrative of African mining away from 'blood diamonds' towards the positive impact that gems can have on mining communities. To this end, she shared how she uses her past jewellery experience and her new contacts in East Africa to ensure the industry reinvests back into the community—particularly by supporting women miners and artisans.

Gem and mineral collector/dealer **Federico Bärlocher** (Yangon, Myanmar, and Como, Italy) investigated the ruby deposits of Mogok, Myanmar. With 1,200 mines,

Figure 6: Weighing 122.83 ct, this kunzite faceted by Victor Tuzlukov provides a fine example of precision and artistic gem cutting. Called 'Faces of Perfection', the stone is part of Tuzlukov's Heritage series. Photo by Arjuna Irsutti, Bangkok, Thailand.

this unique locality hosts important occurrences of ruby, sapphire, spinel, peridot and many other gems. Bärlocher explained how local people recently began using UV torches to search for rubies at night in mine tailings, and then he showed a documentary film exploring the underground workings and processing plants at the Dattaw and Kadoke-Tat ruby mines.

Figure 7: Dr Jeff Post delivers his presentation to a packed room at the Gem-A Conference. Photo by Henry Mesa.

Dr Jeffrey Post (National Gem and Mineral Collection, Smithsonian Institution, Washington DC, USA; Figure 7) discussed the impact of the Hope diamond on the museum's collection. With its fascinating history of intrigue, famous owners and reported curses, it generates widespread curiosity that few other objects can attain. And, being a 45.52 ct blue diamond, it is truly a unique treasure of the earth. Post noted that attendance to the Smithsonian almost doubled after the Hope arrived, and he shared research proving it was recut from the French Blue diamond (which had a facet pattern suggesting a bespoke design for 'Sun King' Louis XIV of France). Post concluded that gems and minerals provide a wonderful way to get people into science exhibits, as they capture the imagination and inspire scientists of the future.

Rui Galopim de Carvalho (PortugalGemas Academy, Lisbon, Portugal) explored various aspects of precious coral. He emphasised the important distinction between reef-forming coral and precious coral. Of the 7,000 species of coral that are known, only eight of these constitute precious coral. Education of the trade and consumers is key to ensuring sustainability and responsible sourcing in the coral industry. Sharing insights from his work on CIBJO's Coral Commission, Galopim de Carvalho discussed CITES regulations for protecting certain precious corals and the exciting initiatives currently under investigation to help reintroduce precious corals into depleted seabeds.

London-based fine-jewellery specialist **Joanna Hardy** closed Sunday's talks by exploring the history of emeralds —from the desert landscape of Cleopatra's emerald mine in ancient Egypt to the Byzantine empress Theodora bedecked with emeralds. Hardy then shared her recent experience with visiting the Coscuez mine in Colombia and also mentioned the 2017 discovery of a 144.65 ct alluvial emerald called the Apple of Muzo. She completed her presentation by showing some exquisite emerald items from London's Cheapside Hoard, as well as more modern creations that included jewellery manufactured by Van Cleef & Arpels and a radiant Princess Eugenie wearing the Greville Tiara made by Boucheron in 1919.

The conference was closed by Gem-A president **Maggie Campbell Pedersen**, who commented on the international nature of our industry. The speakers explored a wide variety of places, taking the audience up mountains, to the depths of the earth and sea, and to exquisite collections in world-renowned museums. A continual theme was the importance of sustainability in procuring gem materials, and the need to benefit local communities and protect our planet. Presentations covered the deeper meaning of gem cuts and their poetic philosophies, and investigated the stories behind gems from the deepest mines to the workshops of the most revered designers.

On 5 November, three workshops were held at Gem-A's headquarters: coloured stone grading and pricing (hosted by **Richard Drucker**, Gemworld International Inc., Glenview, Illinois, USA), fluorescence spectroscopy (hosted by **Alberto Scarani** and **Mikko Åström** of Magilabs, Rome, Italy, and Järvenpää, Finland) and social media etiquette (hosted by **Monica Stephenson** and freelance jewellery and watch editor **Barbara Palumbo**). That evening marked Gem-A's graduation ceremony and presentation of awards at the Royal Institution of Great Britain in London.

On 6 November, field trips took attendees to private viewings of the British Crown Jewels at the Tower of London, the gem and mineral collection at the Natural History Museum, and the Jewellery Gallery at the Victoria and Albert Museum.

Sarah Bremner
Gem-A, London

Brendan M. Laurs FGA

Gem-A Notices

GEM-A CONFERENCE 2018

The 2018 Gem-A Conference was held at etc.venues County Hall, London, on 3 and 4 November. Highlights of the speaker presentations are reported in the Conferences section of this issue of *The Journal*, pages 364–365, and round up in the Winter 2018 issue of *Gems&Jewellery*. Workshops took place on 5 November at Gem-A HQ, and on 6 November some delegates visited the Mineral Gallery at the Natural History Museum for a guided tour by Gem-A CEO Alan Hart, while others went on a private tour of the British Crown Jewels at the Tower of London or attended a jewellery handling session at the V&A Museum.

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We would also like to thank DG3 Diversified Global Graphics Group (www.dg3.com) for producing the Gem-A Conference materials.

GRADUATION CEREMONY

The 2018 Graduation Ceremony was held at the Royal Institution of Great Britain, Albemarle Street, London, on 5 November. This year, 600 students passed the Gemmology and Diamond Diploma examinations, and 46 of these students passed with Distinction. November's Graduation was a truly international gathering with successful candidates joining us from Canada, China, France, Hong Kong, India, Italy, Japan, Lithuania, Madagascar, Malaysia, Myanmar, The Netherlands, Norway, Russia, Spain, Sweden, Switzerland, Taiwan, USA and Venezuela, as well as the UK. Alan Hart, CEO of Gem-A, opened the ceremony by welcoming graduates, families and guests to the Royal Institution (RI), and celebrated the shared history between Gem-A and the RI: Nobel Prize winners Sir William Henry Bragg and his son Sir Lawrence Bragg were both resident professors at the RI and Gem-A presidents.

Guest speaker John Benjamin FGA DGA gave an inspiring speech on the value of the post-nominals across the world, before presenting the Diplomas, and Maggie Campbell Pedersen FGA ABIPP, Gem-A President, awarded the Gem-A Medals and Prizes.

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Leïla Ben Haj Larbi, France
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Jean Dominique Bouriaud, France
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Taffy Schneider, United Kingdom
Deping Shi, P.R. China
Derui Shi, P.R. China
Hao Sun, P.R. China
Zhulin Sun, P.R. China
Maki Takashima, Japan
Stacie Tayler, United Kingdom
Yidan Wang, P.R. China
Ziting Wang, P.R. China
Xiaojing Wang, P.R. China
Qiuyue Wang, P.R. China
Fanbo Wei, P.R. China
Hiu Mei Wong, Hong Kong

Shaokun Wu, P.R. China
Chenjie Xiao, P.R. China
Xiaotong Xie, P.R. China
Bingqing Xie, P.R. China
Biqian Xing, P.R. China
Lin Yang, P.R. China
Yao Yao, P.R. China
Yuzuru Yoshida, Japan
Tiantian Yu, P.R. China
Xiangyi Zeng, P.R. China
Zhaohui Zhang, P.R. China
Sufei Zhang, P.R. China
Tingya Zhang, P.R. China
Wenchu Zhang, P.R. China
Yu Zhang, P.R. China
Yufei Zhang, P.R. China
Chenjia Zhang, P.R. China
Lian Zhang, P.R. China
Hanbin Zhang, P.R. China
Yue Zhang, P.R. China
Xiaojing Zhao, P.R. China
Fen Zheng, P.R. China
Li Zhou, P.R. China
Yuying Zhou, P.R. China
Rui Zhou, P.R. China

GEMMOLOGY DIPLOMA PASSES WITH DISTINCTION

Noémie Carlier-Mensan, France
Hung-Ju Chen, Taiwan (R.O.C.)
Xiaohua Chen, P.R. China
Jiayi Gao, P.R. China
Xinyu Gong, P.R. China
Wing Yan Leung, Hong Kong
Zoe Lewis, United Kingdom
Enqi Li, P.R. China
Yunting Li, P.R. China
Shan Li, P.R. China
Xiaomin Liu, P.R. China
Xinwei Liu, P.R. China
Jing Luo, P.R. China
Sarah Osprey, United Kingdom
Zheng Qin, P.R. China
Nathalie Reitzer-Minet, France
Jiaqi Shen, P.R. China
Ziqing Shen, P.R. China
Haoxiang Sun, P.R. China
Jiaxin Wan, P.R. China
Natsumi Yamamoto, Japan
Hongyan Yuan, P.R. China
Ziyun Zhang, P.R. China
Peng Zhang, P.R. China
Cuiling Zhen, P.R. China

DIAMOND DIPLOMA PASSES

Karoline Aas-Engelstad, Norway
Phillam Aliga, United Kingdom
Haseena Aswat, United Kingdom
Adeline Auvinet, France
Elizabeth Bailey, United Kingdom
Laura Baldock, United Kingdom
Saul Castro Gomez, Sweden
Nicole Wing Sum Chan, Hong Kong
Wing Lan Chan, Hong Kong
Chin Fung Nelson Cheng, Hong Kong
Man Yuk Cheung, Hong Kong
Sum Yee Cho, Hong Kong
Chung Tak Redi Choi, Hong Kong
Cheung Choi, Hong Kong
Nim Yan Chu, Hong Kong
Hoi Kin Chu, P.R. China
Yin Fong Chu, Hong Kong
Nga Nga Chuang, P.R. China

Ella Clarke, United Kingdom
João Da Silva Baptista, Portugal
Andrew Dobrzanski, Scotland, United Kingdom
Liz Fortune, Scotland, United Kingdom
Izumi Fuchino, Japan
Nathan Gray, United Kingdom
Sheng-Wen Huang, Taiwan (R.O.C.)
Joseph Hukins, United Kingdom
Saarah Hyder, United Kingdom
Tom Jarvis, United Kingdom
Qi Jin, P.R. China
Krystina Johnson, United Kingdom
Wing Shan Kam, Hong Kong
Aly Khalil, Egypt
Nicholas King, United Kingdom
Balraj Kler, United Kingdom
Laura Knowles-Cutler, United Kingdom
Valeriia Kuznetsova, Russia
Pak Sing Jacky Kwok, Hong Kong
Chin-Ting Kwong, Hong Kong
Fung Chi Charlie Lai, Hong Kong
Po Ha Lam, Hong Kong
Chi Wa Lau, Hong Kong
Yuk Fung Lau, Hong Kong
Chin Pang Lee, Hong Kong
Yi-Chen Lee, Taiwan (R.O.C.)
Ming Ki Lee, Hong Kong
Aliana Leong, P.R. China
Kin Shing Leung, P.R. China
Da Li, P.R. China
Qi Li, P.R. China
Peishan Li, Hong Kong
Yazhu Liu, P.R. China
Li Juan Luo, Hong Kong
Kayleigh McDermott, United Kingdom
Ian McLeod, United Kingdom
Hoi Ting Mok, Hong Kong
Joanne Moore, United Kingdom
Ayako Nakase, Japan
Gary Nelson, United Kingdom
Nathan Oke, United Kingdom
Emi Okubo, Japan
Lara Oyedele, United Kingdom
Jennifer Pardoe, United Kingdom
Stephane Phan, Hong Kong
Denitsa Popova, Scotland, United Kingdom
Brianna Quinn, United Kingdom
Elva Robins, Republic of Ireland
Miyuki Sato, Japan
Vanessa Elisabeth Maria Schuch-Des Forges, UK
Yan Pok Sher, Hong Kong
Chung Yin Sin, Hong Kong
Lisa Spence, United Kingdom
Ka Yan Tang, Hong Kong
Laura Thatcher, United Kingdom
Sarah Thorneloe, United Kingdom
Sarah-Jane Tidy, United Kingdom
Wai Hong Wong, Macau
Nga Wai Wong, Hong Kong
Freya Worrall, United Kingdom
Lucy Yao, P.R. China
Hiu Ying Rosa Yeung, Hong Kong
Man Hoi Yip, Hong Kong
Po Yan Yiu, Hong Kong
Wing Ho Yuen, Hong Kong
Mei Yuk Yung, P.R. China

DIAMOND DIPLOMA PASSES WITH MERIT

Siu Foon Elisa Chung, P.R. China
Leigh Davis, United Kingdom
Brian Denney, United States of America
Leona Eyre, United Kingdom
Lily Faber, United Kingdom
Ziyou Fan, United Kingdom
Andrea Giner-Serra, United Kingdom
Matthew Handley, United Kingdom
Prudence Hopkins, United Kingdom
Monika Jockute, United Kingdom

Mika Konishi, Japan
Yannick Le Guennec, Canada
Sarah Little, United Kingdom
Anu Malhi, United Kingdom
Abigail Marsh, United Kingdom
Ross Pietkiewicz, United Kingdom
Charlotte Pittel, United Kingdom
Hannah Ratcliffe, United Kingdom
Craig Smith, United Kingdom
Felicitas Sohm Reubi, Japan
Sullivan Taylor, United Kingdom
Hei Ching Elly To, Hong Kong
Nicole Unsworth, United Kingdom
Kai-Lee Wang, Taiwan (R.O.C.)
Jia Hui Yang, P.R. China
Meng-Pei Yang, Taiwan (R.O.C.)
Yi-Chen Yeh, Taiwan (R.O.C.)
Isabelle Chen Zhou, United Kingdom

DIAMOND DIPLOMA PASSES WITH DISTINCTION

Pixie Allen, United Kingdom
Toby Cairn, United Kingdom
Ruth Davis, Scotland, United Kingdom
Catherine Fox, United Kingdom
Penelope Gilliver, United Kingdom
Yu Hanaki, Japan
Paul Haywood, United Kingdom
Gill Hughes, United Kingdom
Emily Jones, United Kingdom
Wei Hao Li, Taiwan (R.O.C.)
Eleanor Marshall, United Kingdom
Lola Rafieva, United Kingdom
Anna Robertson, United Kingdom
Mina Sasaki, Japan
George Shihadeh, United States of America
Asako Takagi, Japan
Isobel Turner, United Kingdom
Naomi Vane-Wright, United Kingdom
Beth West, United Kingdom
Wei Karen Xu, United Kingdom
Yuxin Zhang, P.R. China

PRIZE AND MEDAL WINNERS

Awards and prizes presented to the best candidates of the year, selected from our students worldwide.

GEMMOLOGY FOUNDATION CERTIFICATE

Anderson Medal

Awarded for the best set of papers for the year in the Foundation examination.

This medal was established in 1981 in honour of Basil W. Anderson FGA, former Director of the Gem Testing Laboratory, London.

2018 Winner: Charlotte Glyde, Online Student, UK

GEMMOLOGY DIPLOMA

Christie's Prize for Gemmology

Awarded to the candidate submitting the best papers of the year for the Gemmology Diploma examination.

This prize was established in 1954 as the Rayner Prize, renamed the Diploma Trade Prize in 1991, replaced and sponsored from 2001 by Christie's London.

2018 Winner: Zoe Lewis, Online Student, UK

Anderson Bank Prize

Awarded for the best set of Theory papers for the year in the Gemmology Diploma examination.

Established in 1981 and named after Basil W. Anderson FGA and Dr H. Bank FGA, former director of the German Gemmological Association in Idar-Oberstein, Germany.

2018 Winner: Dr Juliette Hibou, Daytime Student, Gem-A London

Tully Medal

Recognises an individual who submits the best set of answers in the Gemmology Diploma examination in any one year and who is also, in the opinion of the Examiners, of sufficiently high standard to merit the award.

This silver medal was established in 1930 in memory of B J Tully, the inventor of the table model refractometer for jewellers.

2018 Winner: Zoe Lewis, Online Student, UK

The Read Practical Prize

Awarded to the candidate who submitted the best practical papers of the year for the Gemmology Diploma examination.

First awarded in 2009 and named in memory of Peter Read FGA, author and former tutor for Gem-A. In 2018 the prize is sponsored by Richard Drucker FGA (Hons) of Gemworld International.

2018 Winner: Sarah Osprey, Evening Student, Gem-A London

Gem-A would like to congratulate all of our students who achieved such fantastic results!

DIAMOND DIPLOMA

The Deeks Diamond Prize

Awarded to the best theory candidate of the year in the Diamond Diploma examination.

First awarded in 2001, the prize is sponsored by Noel W. Deeks FGA DGA, a Vice-President of the Association.

2018 Winner: Da Li, a Student from BGGI Beijing

The Mok Diamond Practical Prize

Awarded to the best practical candidate in the Diamond Practical examination.

First awarded in 2009 and sponsored by Dr Dominic Mok FGA DGA, AGIL, Hong Kong.

2018 Winner: Anna Williamson, Daytime Student, Gem-A London

The Bruton Medal

Awarded to the overall best candidate of the year in the Diamond Diploma examination.

This silver medal was established in 1996 in honour of Eric Bruton FGA to recognise his work in the field of diamonds.

2018 Winner: Beth West, Daytime Student, Gem-A London

GIFTS TO THE ASSOCIATION

Gem-A is most grateful to the following for their generous donations that will support continued research and teaching:

G. F. Williams, London, for one turquoise simulant, 13 small faceted rubies and five oval amethysts.

Freya Worrall, London, for a yellow synthetic sapphire.

GEM-A ANNUAL GENERAL MEETING 2018

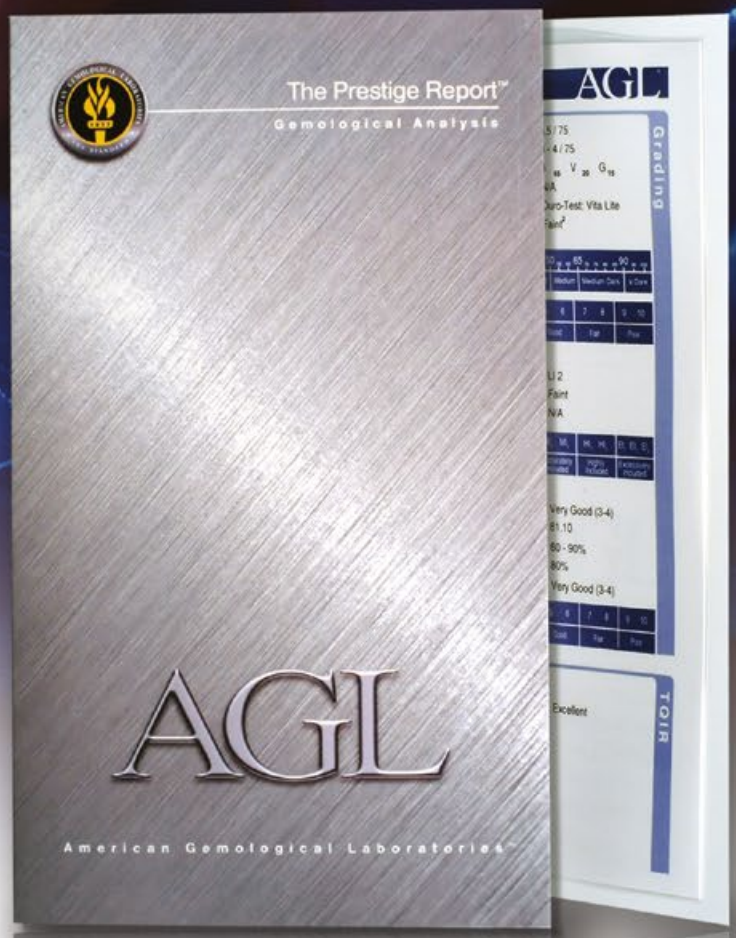
The 2018 AGM was held at The Goldsmiths' Centre, London, on Tuesday 2 October and was opened at 18:35 by Justine Carmody FGA, Chair of the Association's board. In accordance with the articles of the Association, trustees Justine Carmody, Christopher Smith FGA and Jack Ogden FGA FSA retired by rotation. Being eligible, all offered themselves for re-election. Nigel Israel FSA FGA DGA chaired this motion, and all three were reinstated. Nigel Israel and Kerry Gregory FGA DGA retired as trustees at the conclusion of the AGM.

In additional orders of business, suggestions of holding the AGM during the conference/graduation period were raised and discussed. Justine Carmody stated that all suggestions will be taken into consideration and reviewed by the board to increase members' attendance at the AGM and to make the meeting more accessible. The date of the next meeting will be advised and the AGM was formally brought to a close at 19:11.

The Goldsmiths' Centre, London.

An innovator in gemstone reporting

• Identification of colored gemstones • Country of origin determination • Full quality and color grading analysis



AMERICAN GEMOLOGICAL LABORATORIES AGL

580 5th Ave • Suite 706 • New York, NY 10036, USA
www.aglgemlab.com • +1 (212) 704 - 0727

Learning Opportunities

CONFERENCES AND SEMINARS

21st FEEG Symposium
19 January 2019
Vicenza, Italy
http://feeg-education.com/symposium
Note: Takes place during the Vicenzaoro January International Gold and Jewellery Show, which occurs 18–23 January 2019

3rd Jewelry Industry Summit
2–3 February 2019
Tucson, Arizona, USA
www.jewelryindustrysummit.com

51st NAJA ACE© IT Annual Winter Educational Conference
3–4 February 2019
Tucson, Arizona, USA
www.najaappraisers.com/html/conferences.html

AGTA Gemfair Tucson
5–10 February 2019
Tucson, Arizona, USA
https://agta.org/seminars
Note: Includes a seminar programme

AGA Tucson Gemological Conference
6 February 2019
Tucson, Arizona, USA
https://accreditedgemologists.org/currevent.php

Tucson Gem and Mineral Show
14–17 February 2019
Tucson, Arizona, USA
www.tgms.org/show
Note: Includes a seminar programme

Inhorgenta Munich
22–25 February 2019
Munich, Germany
www.inhorgenta.com/events-news/inhorgenta-forum/index-2.html
Note: Includes a seminar programme

Gem-A Midlands Branch Conference
23 February 2019
Birmingham
Email louiseludlam@hotmail.com

Prospectors & Developers Association of Canada
3–6 March 2019
Toronto, Ontario, Canada
www.pdac.ca/convention
Session of interest: Diamond Exploration and Mining: Optimizing Outcomes through Increased Understanding of Technology

Hasselt Diamond Workshop 2019: SBDD XXIV
13–15 March 2019
Hasselt, Belgium
www.uhasselt.be/SBDD

Copenhagen Gemmological Symposium
23–24 March 2019
Copenhagen, Denmark
www.gemmologi.dk

American Gem Society Conclave
8–10 April 2019
Seattle, Washington, USA
www.americangemsociety.org/page/conclave2019

45th Rochester Mineralogical Symposium
11–14 April 2019
Rochester, New York, USA
www.rasny.org/minsymp

Scottish Gemmological Association Conference
3–6 May 2019
Cumbernauld, Scotland
www.scottishgemmology.org/conference

GAC-MAC-IAH (Geological Association of Canada–Mineralogical Association of Canada–International Association of Hydrogeologists)
12–15 May 2019
Québec City, Québec, Canada
www.gacmac-quebec2019.ca/en
Session of interest: Recent Advances in the Study of Gems and Gem Deposits

NDNC 2019: 13th New Diamond and Nano Carbons Conference
12–17 May 2019
Hualien, Taiwan
www.ndnc2019.org

5th Mediterranean Gemmological & Jewellery Conference
17–19 May 2019
Limassol, Cyprus
https://gemconference.com

The 33rd Annual Santa Fe Symposium
19–22 May 2019
Albuquerque, New Mexico, USA
www.santafesymposium.org

48th Annual Society of North American Goldsmiths (SNAG) Conference
22–25 May 2019
Chicago, Illinois, USA
www.snagmetalsmith.org/conferences/the-loop

European Gemmological Symposium 2019
24–26 May 2019
Idar-Oberstein, Germany
www.dgemg.com/en/organisation/16-newsletter/termine/385-european-gemmological-symposium-2019.html

JCK Las Vegas
31 May–3 June 2019
Las Vegas, Nevada, USA
http://lasvegas.jckonline.com
Note: Includes a seminar programme

International Exposition of Agate
6–9 June 2019
Austin, Texas, USA
https://ntrocks.com/international-exposition-of-agate
Note: Includes a seminar programme

PEG 2019: 9th International Symposium on Granitic Pegmatites
11–18 June 2019
Pala, California, USA
http://peg2019.com/index.html
Note: Includes field trips to gem-bearing pegmatites

Northwest Jewelry Conference
9–11 August 2019
Seattle, Washington, USA
http://northwestjewelryconference.com

Dallas Mineral Collecting Symposium
23–25 August 2019
Dallas, Texas, USA
www.dallassymposium.org

15th Biennial Meeting of the Society for Geology Applied to Mineral Deposits
27–30 August 2019
Glasgow, Scotland
www.sga2019glasgow.com
Session of interest: Supergenes, Gems and Non-Metallic Ores

36th International Gemmological Conference
27–30 August 2019
Nantes, France
www.igc-gemmology.org

42nd Joint Mineralogical Societies of Australasia Seminar
31 August–1 September 2019
Perth, Western Australia
www.mineral.org.au/seminar/seminar19.html

9th European Conference on Mineralogy and Spectroscopy (ECMS 2019)
11–14 September 2019
Prague, Czech Republic
http://ecms2019.eu
Workshop of interest: Gemstone deposits

14th International Congress for Applied Mineralogy (ICAM 2019)
23–27 September 2019
Belgorod, Russia
www.geo.komisc.ru/icam2019/en
Themes of interest: Precious Stones; Cultural Heritage

ICA Congress
12–15 October 2019
Bangkok, Thailand
www.gemstone.org/events/2019-congress

EXHIBITS

Europe

Horta & Wolfers: Reopening of the Wolfers Frères Jewellery Store, 1912
Until 30 December 2018
Art & History Museum, Brussels, Belgium
www.kmkg-mrah.be/expositions/horta-wolfers

The Portland Miniatures: Joel Arthur Rosenthal
Until 31 December 2018
The Harley Gallery, Welbeck, Worksop, Nottinghamshire
www.harleygallery.co.uk/exhibition/the-portland-miniatures-joel-arthur-rosenthal

From Zeus to Earth and from Chile to Neapolis
Until 31 December 2018
Ilias Lalounis Jewelry Museum, Athens, Greece
http://lalaounis-jewelrymuseum.gr/en/exTdetails.asp?exid=39

East Meets West – Jewelled Splendours of the Art Deco Era
Until 6 January 2019
Schmuckmuseum Pforzheim, Germany
www.schmuckmuseum.de/en/current.html

Hidden Gems: Scotland's Agates
Until 6 January 2019
National Museum of Scotland, Edinburgh
www.nms.ac.uk/national-museum-of-scotland/whats-on/hidden-gems-scotland-s-agates

Victoria Revealed
Until 6 January 2019
Kensington Palace, London
www.hrp.org.uk/kensington-palace/explore/victoria-revealed/#gs.Z=4WqrY

BVLGARI. Tribute to Femininity. Magnificent Roman Jewels
Until 13 January 2019
The Moscow Kremlin Museums, Russia
www.kreml.ru/en-Us/exhibitions/moscow-kremlin-exhibitions/bvlgari-tribute-to-femininity

Bijoux-Bijoux! Costume Jewellery from Chanel to Dior
Until 27 January 2019
Kunstgewerbemuseum, Berlin, Germany
www.smb.museum/en/exhibitions/detail/bijoux-bijoux-modeschmuck-von-chanel-bis-dior.html

Die Bilderwelt der Kelten (The Imagery of the Celts)
Until 27 January 2019
Kelten Römer Museum Manching, Germany
www.museum-manching.de/index.php?id=743,47

Russia: Royalty & the Romanovs
Until 28 April 2019
The Queen's Gallery, Buckingham Palace, London
http://tinyurl.com/ybecrdbj

Bejewelled: Badges, Brotherhood and Identity
Until 24 August 2019
The Library and Museum of Freemasonry, Freemasons' Hall, London
http://freemasonry.london.museum/event/bejewelled-badges-brotherhood-identity

The Crown of Kerch: Treasures from the Dawn of European History
Until 29 September 2019
Neues Museum, Berlin, Germany
www.smb.museum/en/exhibitions/detail/die-krone-von-kertsch.html

North America

Fabergé Rediscovered
Until 13 January 2019
Hillwood Estate Museum & Gardens, Washington DC, USA
http://hillwoodmuseum.org/faberge-rediscovered

Emperors & Jewels: Treasures of the Indian Courts from the al-Sabah Collection, Kuwait
Until 27 January 2019
Aga Khan Museum, Toronto, Ontario, Canada
www.agakhanmuseum.org/exhibitions/emperors-and-jewels

Outrageous Ornament: Extreme Jewelry in the 21st Century
Until 27 January 2019
Katonah Museum of Art, Katonah, New York, USA
www.katonahmuseum.org/exhibitions

Maker & Muse: Women and Early Twentieth Century Art Jewelry
29 January–26 May 2019
Flagler Museum, Palm Beach, Florida, USA
http://tinyurl.com/y896wt9u

Beadwork Adorns the World
Until 3 February 2019
Museum of International Folk Art, Santa Fe, New Mexico, USA
http://internationalfolkart.org/exhibition/3348/beadwork-adorns-the-world

Empresses of China's Forbidden City
Until 10 February 2019
Peabody Essex Museum, Salem, Massachusetts, USA
https://pem.org/exhibitions/empresses-of-chinas-forbidden-city

East Meets West: Jewels of the Maharajas from the Al Thani Collection
Until 24 February 2019
Legion of Honor Museum, San Francisco, California, USA
http://legionofhonor.famsf.org/exhibitions/east-meets-west

Jewelry: The Body Transformed
Until 24 February 2019
The Met Fifth Avenue, New York, New York, USA
www.metmuseum.org/exhibitions/listings/2018/jewelry

Treasures of a Desert Kingdom: The Royal Arts of Jodhpur, India
9 March–2 September 2019
Royal Ontario Museum, Toronto, Canada
www.rom.on.ca/en/exhibitions-galleries/exhibitions/rajasthan

Boston Made Arts and Crafts Jewelry and Metalwork
Until 29 March 2020
Museum of Fine Arts, Boston, Massachusetts, USA
www.mfa.org/exhibitions/boston-made

Uneasy Beauty: Discomfort in Contemporary Adornment
Until 21 April 2019
Fuller Craft Museum, Brockton, Massachusetts, USA
https://fullercraft.org/event/uneasy-beauty-discomfort-contemporary-adornment

Ornamental Traditions: Jewelry from Bukhara
Until 30 June 2019
Art Institute of Chicago, Illinois, USA
www.artic.edu/exhibition/ornamental-traditions-jewelry-bukhara

OTHER EDUCATIONAL OPPORTUNITIES

Gem-A Workshops and Short Courses
Gem-A, London
https://gem-a.com/education

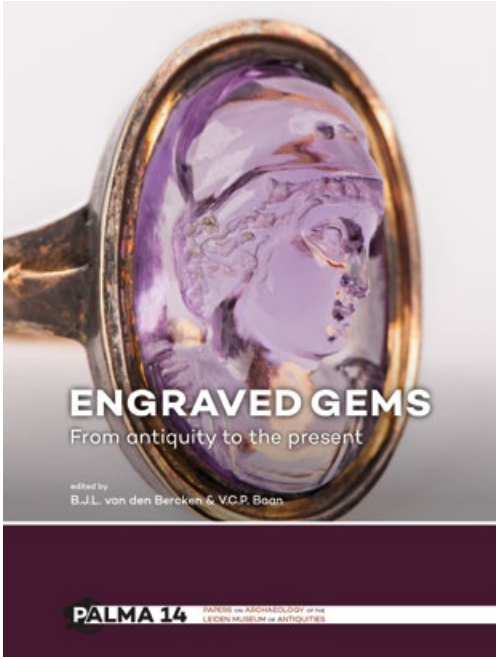
- Understanding Diamond Grading Workshop
  10 and 31 January 2019
- Understanding Gemstones Workshop
  10 and 28 January 2019
- Understanding Diamond Simulants Workshop
  11 January 2019
- Understanding Gemstone Testing Workshop
  11 and 29 January 2019
- Investigating Jade and its Imitations Workshop
  8 March 2019
- Diamond Grading and Identification Short Course
  25 February–1 March 2019; 1–5 April 2019; 8–12 July 2019
- Diploma Preparation Short Course (new for 2019, UK only)
  28 January–1 February 2019

Lectures with the Society of Jewellery Historians
Burlington House, London
www.societyofjewelleryhistorians.ac.uk/current_lectures

- Martin Henig—Personal Cameos of Roman Date in the Content Family Collection
  22 January 2019
- Jack Ogden—A Whiter Shade of Pale: Platinum in 19th Century Jewellery
  26 February 2019
- Peter Semrád—The Story Behind 'Hungarian' Opals
  26 March 2019
- Beth Wees—TBA
  25 June 2019
- Rachel Church—Brooches, Badges and Pins at the Victoria and Albert Museum
  26 November 2019

Lecture: An Archaeologist's Wife and Her Jewellery: A Window into 19th Century 'Assyriamania'
17 January 2019
The British Museum, London
http://tinyurl.com/ya7yxbhd

New Media



Engraved Gems: From Antiquity to the Present

Ed. by Ben J. L. van den Bercken and Vivian C. P. Baan, 2017. Papers on Archaeology of the Leiden Museum of Antiquities (PALMA) 14, Sidestone Press, Leiden, The Netherlands, www.sidestone.com/books/engraved-gems, 184 pages, illus., ISBN 978-9088905063 (hardcover) or 978-9088905056 (softcover). €120.00 hardcover, €39.95 softcover, €9.95 eBook or read online for free.

A collection of about 4,300 ancient engraved gems and about 20,000 gem impressions returned to Leiden in 2013 and found a new home at the National Museum of Antiquities (Rijksmuseum van Oudheden, or RMO). Originally, the collection was drawn together by a decree of William I, the first king of The Netherlands, from the Royal Collection and the National Numismatic Collection to form the Royal Collection of Coins, Medals and Engraved Gems of The Hague ('Royal Coin Cabinet' or 'Penningkabinet'). Since 1816 and during most of the time since then, when the collection was housed in Leiden, and later in Utrecht at the 'Money Museum' (GeldMuseum), public display was limited, as was the opportunity for scholarly study of the objects. When the GeldMuseum closed its doors in 2013, the gems and related objects in the Penningkabinet moved back to Leiden, but this time to a more salutary setting at the RMO. The existing collection of glyptic (engraved gems) and related materials at the RMO was then extended four-fold, and the cultural epochs now range from mid-third millennium Mesopotamia to modern Europe.

Committed to displaying more of the engraved gems, and by doing so making them available to researchers, the RMO mounted an exhibition in 2016 called 'Splendour & Precision' and also hosted a conference that was titled 'From Cylinder Seals to Lippert's Dactyliotheca'. These events coincided with the bicentennial of the founding of the Penningkabinet and commemorated the RMO's now significantly expanded antiquities collection. Eleven papers based on the conference programme, plus three additional articles, were published the following year in the RMO's PALMA series, titled *Engraved Gems: From Antiquity to the Present*, which is reviewed here. Prior to this, the only other major publication on the ancient gems in the Penningkabinet was the 1978 *catalogue raisonné* by Marianne Maaskant-Kleibrink. It was a landmark contribution to ancient gem studies, as she identified typologically distinct characteristics based on toolwork/engraving technique and grouped the gems accordingly within the conventional cultural chronology and subject/style arrangement. She had a keen eye for associating artists with their preferred materials and their choice of gems to complement the carved subject. Later, the methodology that Prof. Kleibrink developed and refined enabled her to recognise groups of gems as products of specific workshops, and even the handiwork of different artists.

While the collections now assembled under one roof in Leiden have a broad historical sweep—more than four and a half millennia—the RMO curators acknowledge that they cannot boast of prodigious volume, depth or number of masterworks on a par with the monumental collections of Europe such as those found in Berlin, Florence, St Petersburg or Vienna. However, as the work of Prof. Kleibrink demonstrates, there is much to commend what has been brought together in Leiden. Clearly, the organisers of the 2016 conference appreciated where the strengths of the collection lay, not only in its exceptional specimens, but also in the history of its assembled parts—how the collections were formed, dispersed and created anew, and how gems were interpreted, valued and put to use at different times since antiquity.

Reverend Prof. Martin Henig, specialist in ancient gems from archaeological contexts in Roman Britain, was the keynote speaker for the 2016 conference. In his essay, he examines old collections of Roman gemstones whose connection with their archaeological findspot

is lost, as is the case for most of the ancient gems in the collections of major European museums, including Leiden. Acknowledging the value of a 'stratigraphical context', he reminds the reader that because of their value, many gems were never buried but survive from antiquity passed from one owner to the next, each one in succession attaching the imprint of his or her own values and uses to the 'object biography', whether as an individual gem or a collection. For gems that survive as heirlooms, Prof. Henig thoughtfully considers their role as 'witnesses to historical events'. This essay sets the stage very well for the papers that follow, more or less in cultural chronological order.

Some authors of the articles in this book focus in detail on a single gem or genre. Attilio Mastrocinque elucidates his process for deducing alternative interpretations of inscriptions on two gemstones. Marianne Kleibrink examines the features of comparable gem types (comparanda) depicting Cassandra, the prophetess of mythology who warned of the fall of Troy at the hands of the Greeks. Prof. Kleibrink draws attention to how the compositions very much reflect the intentions of different gem carvers, each emphasising different aspects of Cassandra's tragic demise. Diederik Meijer introduces the RMO's collection of Mesopotamian cylinder seals, with the promise of a complete catalogue forthcoming. Ben van der Bercken contributes a paper on 14 previously unpublished ancient Egyptian and Archaic Greek scarabs. Rika Gyselen explains how the owners of intaglios are identified in a Sasanian gem's engraved features, and the tell-tale indications of reuse and recutting, which are distinctly different from earlier and contemporary cultures. In a continuation of a discussion on *grylloi* by Kenneth Lapatin in a 2011 British Museum seminar, Carina Weiss differentiates the physiognomic features of fantastical hybrid creatures and mask-head depictions prevalent in ancient glyptic. In addition to the features differentiating *grylloi* from non-*grylloi*, she suggests that the intended use of the engraved gem is an important criterion for differentiating *grylloi* from *baskania*, which are apotropaic amulets (produced to ward off evil).

Historical perspective on the production and use of cameo carving bridges the art form in antiquity to its enthusiastic revival in the Renaissance, which then persisted in the production of adaptive forms into the 19th century (Platz-Horster and Wagner). That brings the reader fully into the modern era. Marcia Pointon focuses on a single ancient gem whose engraved subject and quality of carving inspired a painting by no less an artist than Peter Paul Rubens in the 17th century. Jørge Hein examines a 17th century gilt porcelain lidded bowl inlaid with 79 cameos and 19 intaglios (most of which were produced during the Renaissance). The bowl belongs to a group of luxury vessels produced for northern European royal patrons in the 16th to 18th centuries. The ornate decoration, gilded flourishes and lapidary-encrusted surfaces may seem like a baroque artistic confection to a 21st century sensibility, but they serve to illuminate the object biography of an ancient art form co-opted and repurposed in an altogether novel way.

The history of ancient gems is the subject of an essay by Valentin Kockel. The gem cabinets or *dactyliotheca* popularised in the 18th and 19th centuries are yet another iteration in the history of the use and study of ancient gems. Dealers targeting antiquarian collectors hit upon an ingenious way to market antiquities to a wider audience, making impressions of gems in wax, clay or paste (sometimes called collectively 'sulphurs'), which is how they were appreciated anyway (not in the original carved gem itself). The pastes were curated as both customised and pre-packaged groupings arranged in cabinets with many narrow drawers. Often the case was made to resemble an oversized book. In this way, endless copies of an original engraved gem could be sold (while the dealer/collector could retain the original). Their aim was not only pecuniary, but depth of audience reach. The cabinets were popular as educational props for art historians and archaeologists teaching their discipline, or antiquarians demonstrating their connoisseurship.

Hanco Zwaan and Christine Swaving present a report on gemmological analyses performed on selected gems in the collection, primarily with the aim of confirming sight identifications. Of the gems they examined, 35% had been misidentified. Even today, analytical studies are often omitted from volumes whose main interest is historical or archaeological. If correct identification is its own virtue, once ascertained, other questions of more pressing interest to archaeologists might be answered. That the RMO has such capable experts with facilities nearby should encourage the curators to initiate further analytical investigations into its collection of ancient gems.

This inaugural publication on engraved gems under the auspices of the Rijksmuseum van Oudheden is an excellent step toward bringing the collection out from the shadows and into the light. This volume of papers written by specialists for other specialists should not dissuade the curious reader. It is accessible and provides a unique view into the histories and cultures of bygone eras.

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Suomen Korukivet/ Gemstones of Finland

Ed. by Kari A. Kinnunen, 2017. Geological Survey of Finland, Espoo, http://tinyurl.com/ycfzbqw9, 342 pages, illus., ISBN 978-9522172532 (hardcover) or 978-9522172549 (eBook). €40.00 hardcover or free eBook (http://tupa.gtk.fi/julkaisu/erikoisjulkaisu/ej_098.pdf; in Finnish and English).

This recent publication from the Geological Survey of Finland is a welcome contribution to national monographs on gem materials. Finland could be viewed as the no. 1 producer of gem materials in Europe during the past few decades, if one considers its spectrum of gems and the large crystals found at the granitic pegmatite exploited by the Karelia Beryl mine near Luumäki in Karelia, south-east Finland, which are of a quality and size not found anywhere else in Europe.

The book commences by introducing the eight contributing authors, all of whom are well-known geologists of the Geological Survey of Finland and the University of Helsinki. Many of the authors have a life-long personal interest in geology/mineralogy—pursuing this field not merely as a job—and have extensive field and laboratory experience.

This is followed by a 55-page chapter that provides a detailed introduction to the field of Finnish *korukivet* and *jalokivet*. Nordic countries use these two variations for the word *stone* in jewellery, meaning *gemstone* and *precious stone*, respectively. *Korukivet* could be, for instance, coloured opaque beryl, jasper or aventurine, but not a stone for faceting such as transparent green beryl or heliodor (which would be referred to as *jalokivet*). The interpretations of the meaning of *gemstone* and *precious stone* vary with cultures, traditions and time. Since the 1960s, as the authors point out, the outdated *semi-precious stone* is generally disused in Europe.

The chapter is subdivided into concise sections such as 'Finnish Speciality, Rock Types as Gemstones', with a map showing the main locations of about 100 deposits. It is refreshing to see that the Geological Survey is aware of, and clearly writes about, the importance of some old abandoned mines for mineral tourism, where many local and foreign collectors come and search for minerals during weekends and holidays. The authors also take us through a variety of other topics including: 'The Properties of Gemstones', 'The Gifts of Light', 'Inclusions in Gemstones' and 'Beauty is Born from Shape'. In 'Associations, the Founts of Gemstone Knowledge', well-selected photographs show mine tailings, mineral shows, local 'rock clubs' and how to get children interested by organising treasure hunts. 'Identification in Laboratories' provides a nice introduction to mineral identification, and a small section also introduces trade names such as Spectrolite. The choice of themes and images, and the way they are presented in short but informative sections, is excellent. This chapter is not intended for an advanced mineralogist or gemmologist, but rather for the beginner, but nevertheless should certainly be read by everyone for its beauty of selection and presentation. If you want to understand Nordic and especially Finnish culture this chapter provides a very good introduction, and an appreciation of what Finland has to offer. This is all the more relevant given the education reforms in Finland that provide more free time to explore and discover these wonders, optimising education both in and out of the classroom.

The following chapters cover various regions, starting with southern Finland. The authors note how this region was mined for garnet at Kitilä by Sweden's King Johan III in the 16th century. For 800 years, Sweden had four main regions, with the most south-eastern area being Finland. Since the beginning of the 1580s, garnets (believed to be rubies) were mined by the barrel-load on the king's order in this south-east corner of Karelia, and were sent to the court. (Subsequently, in 1809, Russia forced Sweden to give up Finland and part of Lapland, as well as Österbotten, and these areas became a semi-independent Grand Duchy of Russia.) The authors present Adolf Erik Nordenskiöld as the father of mineralogy in Finland during the 1800s, with the first gem deposits discovered in the south and along the coast, where there were more people and more mining/quarrying activities. Covering this period, the authors note how in 1930 Prof. Pentti Eskola found a large gem-quality topaz crystal at Väkkärä quarry at Eurajoki during the construction of anti-tank obstacles at the Salpa Line. This chapter also covers the

most well-known, and quantitatively significant, finds of Spectrolite and gem beryl in the anorthosite and rapakivi granitic pegmatites of the Viborg massif in Karelia. The history of both deposits is covered with concise descriptions of key elements regarding geology and mineralogy, and is accompanied by excellent images of Spectrolite twinning, beryl etching and finished jewellery. At this stage it will be clear to the reader that Finland has more to offer than most people are aware of, and this is just the start. A full-page photograph depicts a well-formed crystal of bicoloured topaz from Kotka set in jewellery, followed by a faceted one. Next follows a description of the Viitaniemi lithium pegmatite, which is also rich in topaz as well as rare phosphates. Gems from here include rose quartz and blue topaz that was found as fist-sized crystals. Graphic granite is presented as a popular ornamental gem that is heavily used in Finland.

The next chapter, on eastern and central Finland, presents various gems including diamond crystals in and out of matrix, Nuummite, cordierite and more.

In the chapter on western Finland we are taken to the famous Kaatiala pegmatite, known from at least 1855 when its first description was published. Here, green and red tourmaline, rose quartz, amethyst, goshenite, heliodor and even columbite were faceted. This is followed by the Haapaluoma pegmatite, which is well described and known for its rubellite, kunzite, deep purple lepidolite and morganite.

The chapter on northern Finland introduces the reader to a giant amethyst deposit found in 1985 at Lampivaara, which is now a tourist attraction with 15,000–20,000 visitors per year. A rich *in situ* vein is pictured, as are faceted stones as well as deeply coloured amethyst crystal groups weighing up to 650 kg. At the end of the chapter, gem-quality rubies and sapphires found in the gold washings are also presented.

Each chapter is followed by a very handy reference list, which is easier to navigate than an extensive single reference list at the end of the book. The large format, good colour reproductions and, most importantly, the detailed information provided in an easily accessible way that spans geology, history, mineralogy, gemmology and the connection to people, is a rare and excellent way to present the subject to everyone. The authors are heartily congratulated on a most welcome book for which years of work have clearly gone into its preparation. I highly recommend it to any serious library, researcher and collector.

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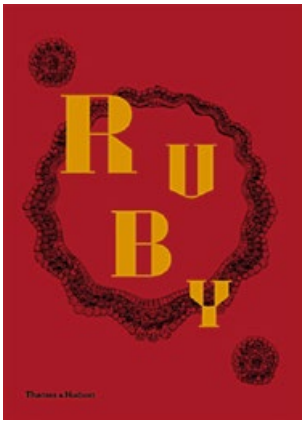

Ruby: The King of Gems

By Joanna Hardy, 2017. Thames & Hudson, London, http://tinyurl.com/ya823apy, 328 pages, illus., ISBN 978-0500519417. £75.00 hardcover.

Ruby: The King of Gems is a beautifully illustrated and expertly researched tribute to the alluring and regal sovereign of all gemstones. The artistic layout, from the modern font to full-page photos of inclusions, complements the treasure trove of historically significant jewellery and gemstone images that are generously featured throughout the book.

Following the introduction, the first chapter 'Ruby Spinel' is a surprising but very well-deserved tribute to spinel, which, as many gem traders know, has contributed greatly to the fame and reverence ruby has received. Most of the famous large red gems in royal and ecclesiastical regalia that were thought to be ruby are actually spinel. This chapter features images and the fascinating histories associated with many of these regal red spinels. These unusually large spinels were likely discovered in Badakhshan along the Silk Road that linked China with Europe. Their size made them ideal for Mughal rulers who inscribed their names on the gems to claim ownership and posterity over the prior owner. These gems were considered important symbols of power and wealth, and they were also used for adornment. Trade and conquest resulted in many of the largest of these spinels adorning prominent positions in the crown jewels of England, Russia, Iran and India. Such spinels have become so famous as 'rubies' that they still retain names such as the 'Black Prince's ruby' and the 'Timur ruby'. An approximately 400 ct spinel is the centrepiece of the Great Imperial Crown first worn by Catherine the Great, who was Russia's longest reigning female ruler, serving as empress from 1762 to 1796.

The second chapter, 'Ruby the King of Gems', provides an early history and clearly accounts for why

ruby is still regarded as one of the most valuable gems. Rubies were of course also traded along the Silk Road and were highly coveted even though gem-quality material was typically much smaller than their spinel counterparts. Burma was historically the main source for fine rubies, and it is still the most sought-after locality for connoisseurs despite many new sources discovered in the late 20th and early 21st centuries. Hardy provides a fascinating summary of early Burmese ruby mining and history, including a detailed story of the infamous Nga Mauk ruby. The images and descriptions of early Burmese, Chinese, English, Persian, Russian and Indian jewels are exceptional in quality and detail.

The third chapter, titled 'Pioneers', is one of my favourite sections. Hardy starts out by attempting to 'lift the veil of mystery' not only about famous gem-producing localities but also about the explorers and traders who paved the way for future generations. She accurately writes, 'Gems have always attracted the adventurous and the passionate, individuals in pursuit of dreams, egos, wealth and power who expect to find their fortunes through dealing with gemstones, only to become victims of their quest, discovering that instant monetary gratification may not be so easy to obtain'. Most dealers would agree that buying and selling gems is one of the most incredibly exciting, rewarding and often humbling professions one can pursue. Hardy elaborates that 'knowledge and patience are key to understanding the complexities and challenges that the gemstone market entails. It takes time, appreciation and a passion for the subject to make a success of the gem business, along with a sprinkling of good fortune'.

Hardy goes on to feature Old European sovereign and coronation jewellery, describing how their historical influence weaves in and out of the social and political fabric of the period. One of the highlights is a fascinating story of the discovery of long-lost Hennell jewellery renderings. These beautifully illustrated drawings showcase the attention to detail and design aesthetic that represented this 'age of elegance and splendor'.

The famous Mallerio dits Meller firm was one of the most prolific creators of neo-classical royal regalia for the likes of Marie Antoinette, Josephine Bonaparte, Queen Victoria and even Princess Grace of Monaco. A full-page colour photograph of Princess Grace wearing a fabulous neo-classical Cartier ruby and diamond diadem along with a diamond necklace showcases the enduring influence and cultural importance associated with the high-end jewellery of that period.

The 'Gilded Age' is featured next with incredible examples of the talents of the house of Boucheron. One of the most interesting parts of this chapter is the inclusion of hand-drawn illustrations showing rubies once owned by Boucheron accompanied by detailed descriptions of their colour, weight, shape and internal features. Boucheron and Chaumet were also famous for the Art Nouveau garland style of jewellery creation. (My favourite piece in the entire book is a ruby and diamond hummingbird aigrette, because it so beautifully captures the grace and energy of that magical creature and because it has always been my mother's favourite bird.) This chapter concludes with another fabulous photo of the Mackay ruby and diamond necklace by Boucheron.

In the late 19th to early 20th centuries, India had a powerful influence on Western jewellery design. Parisian houses such as Cartier, Chaumet, Van Cleef & Arpels, Lacloche Freres and others created Indian-inspired jewels for the wealthy Maharajahs and Maharanis, ushering in a period of opulent ruby, pearl and diamond bib necklaces, turban ornaments, and playful 'Tutti Frutti' bracelets and earrings. In the early 20th century and into the 1920s, floral and architectural influences from Paris and America were derived from topics ranging from nature and skyscrapers to opulent manicured gardens and homes of the aristocracy. With these themes, combined with the discovery of Egyptian King Tutankhamen's tomb, jewellery evolved into the more geometric linear 'Art Deco' style that was so representative of the optimism coming from the New World.

Unfortunately, the Great Depression followed by World War II put a sudden end to the frivolity of the Roaring Twenties. The military's need for precious metals brought on a more toned-down conservative style, which then evolved into the 'Retro' period of the 1940s and '50s. This was followed by a more decadent style led by Cartier, Chaumet, Van Cleef & Arpels, Boivin & Belperron, David Webb, Vedura and even Dali. The 1970s–80s featured bold cabochon and large faceted ruby pieces by the Parisian houses mentioned above, as well as Bulgari, Grima, Boghossian, Hemmerle, Millerio, Graff, Henry Dunay and others. The early 21st century has enjoyed a renaissance of contemporary style that has challenged even the lasting influence of the Art Deco period. Artists such as JAR, Michelle Ong, Wallace Chan, Lauren Adriana, Bina Goenka, Fei Lui and Leo De Vroomen are all featured with fabulous photos of their dream-like creations. Hardy concludes this incredible tribute to ruby with a chapter on 'Technique', focused on jewellery design and fabrication followed by examples of rubies from the relatively new mines in Mozambique compared with the traditional sources of Thailand, Cambodia and Myanmar (Burma).

I can honestly say that in the 40-plus years I've been reading about gems, I have never experienced greater joy than from this fabulous tribute to ruby. The fact that Hardy gives such credit to spinel in the first chapter certainly influenced my initial reaction, but as I continued to read on, I became almost hypnotised by the immense amount of fascinating information, figures and photos she provides with such artistic style and grace. I even carried the book on several of my travels over the past year, getting odd looks from fellow passengers as I pulled out this large ruby-red tome. Most quickly became engrossed while stealing glances of the incredible jewellery photos and illustrations. I highly recommend this magnificent work of art to anyone who wants to learn almost everything there is to know about ruby and the jewellery containing it, or simply wants to be mesmerised by Hardy's storytelling expertise to escape from the burdens of the 'real world' for a while. Enjoy!

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