

VOLUME XXXIX

GEMS & GEMOLOGY

NUMBER 1

Featuring:

*Photomicrography
for Gemologists*

Poudretteite

Grandidierite

THE QUARTERLY JOURNAL OF THE GEMOLOGICAL INSTITUTE OF AMERICA



pg. 16



pg. 25

EDITORIAL

- 1 **In Honor of Dr. Edward J. Gübelin**
Alice S. Keller

FEATURE ARTICLES

- 4 **Photomicrography for Gemologists**
John I. Koivula

Reviews the fundamentals of gemological photomicrography and introduces new techniques, advances, and discoveries in the field.

NOTES AND NEW TECHNIQUES

- 24 **Poudretteite: A Rare Gem Species from the Mogok Valley**
Christopher P. Smith, George Bosshart, Stefan Graeser, Henry Hänni, Detlef Günther, Kathrin Hametner, and Edward J. Gübelin

Complete description of a faceted 3 ct specimen of the rare mineral poudretteite, previously known only as tiny crystals from Canada.

- 32 **The First Transparent Faceted Grandidierite, from Sri Lanka**
Karl Schmetzer, Murray Burford, Lore Kiefert, and Heinz-Jürgen Bernhardt

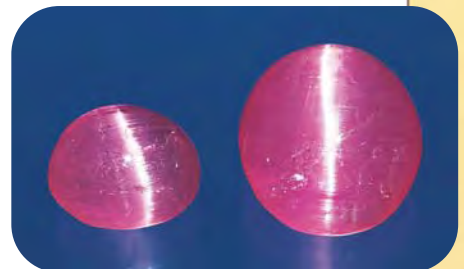
Presents the gemological, chemical, and spectroscopic properties of the first known transparent faceted grandidierite.

REGULAR FEATURES

- 38 **Gem Trade Lab Notes**
- Diamond with fracture filling to alter color • Intensely colored type IIa diamond with substantial nitrogen-related defects • Diamond with unusual overgrowth
 - Euclase specimen, with apatite and feldspar • “Cherry quartz” glass imitation
 - Cat’s-eye opal • “Blue” quartz • Heat-treated ruby with a large glass-filled cavity • Play-of-color zircon
- 48 **Gem News International**
- 2003 Tucson report • Dyed “landscape” agate • Carved Brazilian bicolored beryl and Nigerian tourmaline • New deep pink Cs-“beryl” from Madagascar • New demantoid find in Kladovka, Russia • Fire opal from Oregon
 - Cultured pearls with diamond insets • Gemewizard™ gem communication and trading software • AGTA corundum panel • European Commission approves De Beers Supplier of Choice initiative • Type IaB diamond showing “tatami” strain pattern • Poldervaartite from South Africa • Triphylite inclusions in quartz
 - LifeGem synthetic diamonds • Conference reports • Announcements
- 65 **The Dr. Edward J. Gübelin Most Valuable Article Award**
- 67 **2003 Gems & Gemology Challenge**
- 69 **Book Reviews**
- 72 **Gemological Abstracts**



pg. 33



pg. 51

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Subscriptions to addresses in the U.S. are priced as follows: **\$69.95** for one year (4 issues), **\$179.95** for three years (12 issues). Subscriptions sent elsewhere are **\$80.00** for one year, **\$210.00** for three years.

Special annual subscription rates are available for GIA Alumni Association members and students actively involved in a GIA program: **\$59.95** to addresses in the U.S.; **\$70.00** elsewhere. Your student number must be listed at the time your subscription is entered.

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To obtain a Japanese translation of *Gems & Gemology*, contact GIA Japan, Okachimachi Cy Bldg., 5-15-14 Ueno, Taitoku, Tokyo 110, Japan. Our Canadian goods and service registration number is 126142892RT.

MANUSCRIPT SUBMISSIONS

Gems & Gemology welcomes the submission of articles on all aspects of the field. Please see the Guidelines for Authors in the Summer 2002 issue of the journal, or contact the Managing Editor for a copy. Letters on articles published in *Gems & Gemology* are also welcome.

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Gems & Gemology is published quarterly by the Gemological Institute of America, a nonprofit educational organization for the jewelry industry, 5345 Armada Drive, Carlsbad, CA 92008.

Postmaster: Return undeliverable copies of *Gems & Gemology* to 5345 Armada Drive, Carlsbad, CA 92008.

Any opinions expressed in signed articles are understood to be the opinions of the authors and not of the publisher.

ABOUT THE COVER

Photomicrography is one of the cornerstones of modern gemology, enabling researchers to capture the identifying features within a gemstone. At the same time, it is an artistic expression of the beauty of gems. In the lead article of this issue, renowned photomicrographer John Koivula presents his approach to producing high-quality gemological images. Clearly detailing its fibrous structure, this photomicrograph of a fire agate from Deer Creek, Arizona, was taken by Mr. Koivula using polarized light and a first-order red compensator, together with shadowing and fiber-optic illumination. Magnified 35x.

Color separations for Gems & Gemology are by PacificPreMedia, Carlsbad, California. Printing is by Fry Communications Inc., Mechanicsburg, Pennsylvania.

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In Honor of Dr. Edward J. Gübelin

“Very few people realize that in these jewels they have the presence of natural monuments of a past that reaches back many thousands of years prior To those who are able to explore their secrets, precious stones relate a story as interesting as that of the huge pyramids erected by the Pharaohs at Memphis, and it would seem that their sublime internal spheres might best be called, ‘The Fingerprints of God.’”

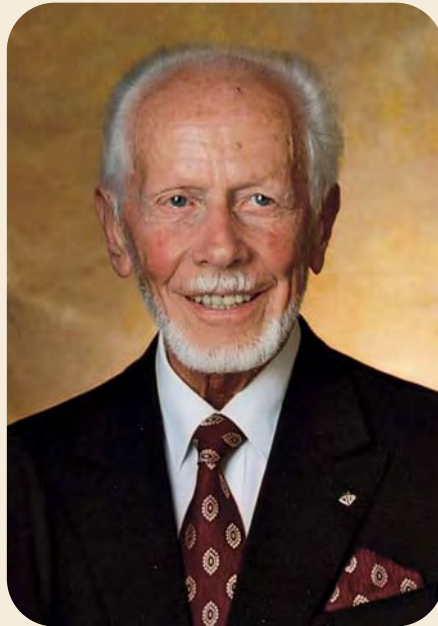
Edward J. Gübelin,
Inclusions as a Means of Gemstone Identification, 1953

When Edward J. Gübelin first peered through a microscope as a young man, inclusions in gems were generally considered disagreeable “flaws” or “imperfections.” Today, however, gemologists almost instinctively recognize the diagnostic importance and natural beauty of inclusions. This evolution in itself is a tribute to Dr. Gübelin’s remarkable career.

Having recently reached the venerable age of 90, Dr. Gübelin is one of the world’s most honored gemologists. A prolific lecturer and writer, he has numerous books and more than 150 research papers to his credit. An intrepid adventurer, he has traveled the globe to explore the world’s most important gem sources.

Dr. Gübelin’s journey began in Lucerne, Switzerland. Born into a watchmaking family, he decided to pursue a career in gemology in the 1930s, soon after his father established the first privately owned Swiss gemological laboratory (in Lucerne). He studied at the universities of Zurich and Vienna, earning a Ph.D. in mineralogy at the latter in 1938. It was during the 1936–37 winter term in Vienna, while studying under Prof. Hermann Michel, that he first learned to distinguish inclusions and appreciate their significance to the identification of gemstones.

After obtaining his doctorate, Dr. Gübelin became one of the first resident students at GIA in Los Angeles—later he would be elected the Institute’s first Research Member—and earned a Certified Gemologist diploma in 1939. That same year, Dr.



Gübelin returned to Switzerland to help run the family business.

His ongoing research into gem inclusions led to a series of articles written for *Gems & Gemology* during the 1940s. GIA founder Robert M. Shipley Sr. encouraged him to go even farther and put together a book on the subject of inclusions. Dr. Gübelin decided to postpone publication of this work until he could incorporate the latest discoveries, such as on new synthetic gem materials.

In January 1953, more than a decade after he began work on it, *Inclusions as a Means of Gemstone Identification* was published. This volume presented the first systematic classification of inclusions in diamonds, colored stones, and synthetic gem materials. With

more than 250 photographs, it demonstrated how inclusions could help reveal the identity and source of gems. *Inclusions* became a classic, changing the face of modern gemology.

Dr. Gübelin continued to contribute in a variety of areas, with the 1963 film “Mogok, the Valley of Rubies” and books such as *Internal World of Gemstones* (1974) and *The Color Treasury of Gemstones* (1975). In 1986, he collaborated with John Koivula on the *Photoatlas of Inclusions in Gemstones*, which is still considered the most important contemporary book on the subject. One of his most widely seen contributions is the informative “World Map of Gem Deposits,” published in 1988, which can be found on the walls of jewelry stores and gemological laboratories alike. Most recently, in 2000, he published the comprehensive,

beautifully illustrated *Gemstones: Symbols of Beauty and Power*, with Franz-Xaver Erni.

Today, Dr. Gübelin remains an active figure in the gemological community. He is a regular presenter at meetings of

the Swiss Gemmological Society, sharing gems from his incomparable collection and slides of his latest inclusion discoveries. Although he has scaled down his travel somewhat, he still appears at conferences and lectures on occasion. Fluent in five languages, he maintains an active correspondence with colleagues around the world from his home in Lucerne. Since 1997, he has generously sponsored *Gems & Gemology's* annual

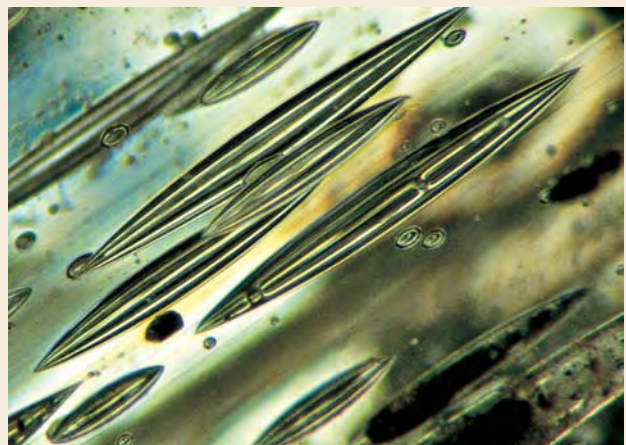
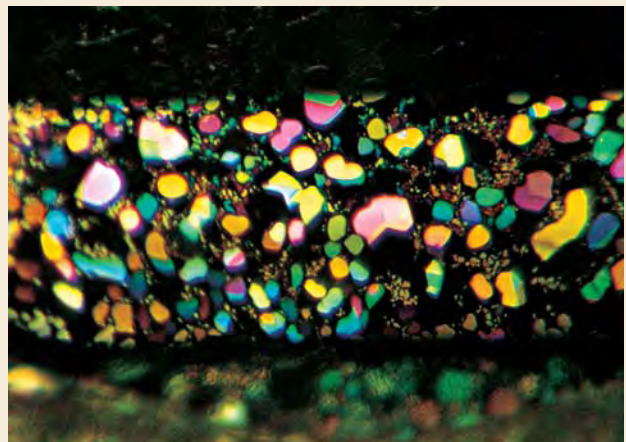
Most Valuable Article Award (see page 65–66). And he continues to work daily on Volume 2 of the world-renowned *Photoatlas*.

I will always be grateful for Dr. Gübelin's support of a young, unknown editor more than two decades ago, when he supplied the lead article in the first issue of the "new" *Gems & Gemology*. That Spring 1981 article, "Zabargad: The Ancient Peridot Island in the Red Sea," is still the classic reference on this historic locality. In the many years since then, I have been privileged to visit with Dr. Gübelin on several occasions and to glimpse part of his fascinating collection. Like others in the gemological community, I treasure every beautifully scripted letter I receive from him, and find his warmth, enthusiasm, and charm unequalled.

All of the articles in this issue reflect areas of passion for Dr. Gübelin: new gem materials—poudretteite and grandierite—and photomicrography. The article by John Koivula in particular was written especially as a gift to the gemological community in honor of his long-time friend and collaborator. With this issue, we wish Dr. Edward J. Gübelin a happy 90th birthday, and we thank him for his lifelong contribution to the beauty and knowledge of gemology.

Alice S. Keller, Editor-in-Chief
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These photomicrographs by Dr. Edward Gübelin illustrate the superb techniques he has demonstrated over more than six decades. At the top, Dr. Gübelin reveals a euhedral apatite crystal in a ruby from Mogok (magnified 50×). The central image shows an accumulation of confetti-like fluid films on basal planes in a green beryl from Madagascar (magnified 66×). On the bottom, stretched air bubbles mimic natural inclusions in this glass imitation of aquamarine (magnified 25×).



PHOTOMICROGRAPHY FOR GEMOLOGISTS

By John I. Koivula

Just because you don't see it, doesn't mean it isn't there.

Many areas in the jewelry industry—education, gemological research, lecturing, publication, and laboratory and inventory documentation, to name a few—either require or benefit from high-quality photomicrography. This article reviews the basic requirements of gemological photomicrography and introduces new techniques, advances, and discoveries in the field. Proper illumination is critical to obtaining the best possible photomicrographs of gemological subjects, as is the cleanliness of the photomicroscope and the area around it. Equally as important is an understanding of the features one sees and the role they might play in the identification process.

This article is dedicated to Dr. Edward J. Gübelin, one of the great pioneers of gemological photomicrography and the first gemologist to truly appreciate the unparalleled beauty of gems in nature's microcosm.

Without photomicrography, gemology as we know it would be virtually nonexistent. The photomicrographer explores the surfaces and interiors of gems with a microscope, and prepares images that record and convey information that is normally hidden from view. Today, nearly all professional gemological researchers take and publish their own photomicrographs. When researchers report the identifying features of new synthetics, treatments, and natural gems from new geographic localities, they include photomicrographs that are instrumental to the jeweler/gemologist in identifying these new materials. One needs only to look through issues of *Gems & Gemology*, or any of the other various international gemological journals, to see how dependent gemology has become on these illustrations of the microscopic features of gems. Via the printed page, these photomicrographs instantly update the reader.

Although the basics of photographing through a microscope are easily learned and applied (see, e.g., "Photomicrography..." 1986–87), high-quality photomicrography is an art-science that is never fully

mastered. It only continues to improve over time with much practice, great patience, and at least some imagination. A gemological photomicrographer must understand a subject in order to bring out or highlight any significant details, and to know how the subject will appear on film. That is the science (figure 1). Artistry, however, requires that those details be presented in an eye-pleasing photograph, since along with durability and rarity, beauty is one of the primary virtues of any "gem" (figure 2).

It is neither possible nor feasible to own every beautiful or scientifically interesting gem encountered. With the ability to take photomicrographs, however, one can document any notable or educational micro-features. Over time, it is possible to create a visual media library that can be used as a reference and documentation source in gem identi-

See end of article for About the Authors and Acknowledgments.

Note that all photomicrographs are by the author.

GEMS & GEMOLOGY, Vol. 39, No. 1, pp. 4–23.

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Figure 1. This decrepitation halo surrounding a fluid inclusion in a natural, untreated Thai ruby was captured on film using a combination of darkfield and fiber-optic illumination. A Polaroid analyzer was also used to eliminate image doubling, thereby providing a sharper photo. Magnified 45x.

fication situations. Such a library also can be employed as an independent image resource for lectures and other presentations, and, in the case of certain beautiful photos (figure 3), even as an inspirational form of aesthetically pleasing natural art.

In the pursuit of photomicrography, the cleanliness and stability of the microscope are critical, and the effects of light on the subject inclusion must be fully understood in order to determine what method(s) of illumination will yield the most useful photographic image. In addition, specialized techniques can save film and time while producing top-quality photomicrographs. Although some of these techniques are usually mastered only through decades of experience, it is never too late to start learning and refining what you already know. This article discusses these various factors and techniques, such as the importance of a properly prepared microscope and photographic subject, as well as the control of vibrations and the factor of time itself. It also examines several methods of illumination adaptable to a standard gemological microscope. It is intended not only to introduce readers to gemological photomicrography, but also to show them the possibilities offered by this always interesting and often beautiful realm.

PROPER TERMINOLOGY

The terms *photomicrography* and *microphotography* do not mean the same thing and are not interchangeable. The scientifically correct term for taking pictures through a microscope is *photomicrography*

(Bradbury et al., 1989), which has longstanding precedence ("Photomicrograph . . .," 1887). The images produced are properly called *photomicrographs* or simply *photographs*. *Microphotography* is the technique used to reduce a macroscopic image to one that is too small to be resolved by the unaided eye. For example, microphotography is used in the production of microfilm, where the contents of entire newspapers are reduced to very tiny photographs. These images are called *microphotographs* or, *in sequence, microfilms*.

DIGITAL VERSUS FILM

All of the images published in this article were produced from 35 mm professional film (with ASA's ranging from 64 to 160). While some gemologists may consider digital photomicrography more "up to date," in my experience the color saturation and resolution obtained on the best digital cameras is not yet as good as can be obtained using a fine-grained professional film. While photomicrographic images obtained from a digital camera may look excellent, if the same subject is photographed on professional film, and two images are placed side-by-side, the superiority of the film image then becomes obvious. The quality of scanners today is such that you still can obtain a better digital image by scanning a slide than if you use digital photomicrography directly. While there is virtually no doubt that digital photomicrography will someday surpass and probably replace film, this has not yet occurred.

SOME REQUIREMENTS

There are three primary steps to effective examination of the external and internal microscopic characteristics of any gem. The first is found in a sound scientific and gemological knowledge of the subject. The second is found in the quality of the microscope's optics, while the third is linked to illumination techniques.

As the first step, the photomicrographer must have a sound working knowledge of inclusions in gems and how they react to various forms of illumination. This knowledge can be gained by reading the technical literature, both journals such as *Gems & Gemology* and *Journal of Gemmology*, and books such as *The Photoatlas of Inclusions in Gemstones* (Gübelin and Koivula, 1986).

The second step is obtaining the best optics, and there really is no substitute for high quality. With optics, you more-or-less get exactly what you pay for. While there might be a premium for certain well-known brand names, if you choose to spend as little as possible on a photomicroscope, then your talent will quickly surpass your microscope's usefulness, you will quickly outgrow that microscope, and you will never achieve the results you are after. A used photomicroscope with excellent optics is much better than a brand new one with an inferior optical system.

The third step is understanding the various illumination techniques that are available to both best visualize the microscopic feature and best capture it in a photograph. This is discussed in detail below.

There are also a number of other concerns that are intrinsic to the process of photomicrography. How can vibrations be reduced or eliminated? How can exposure time be controlled or reduced? What is the best way to clean the equipment and the stones to be photographed? And so on. What follows is a review of some of these important considerations for photographing inclusions and other features through a microscope, to ensure the most positive experience and the best possible images.

VIBRATION CONTROL

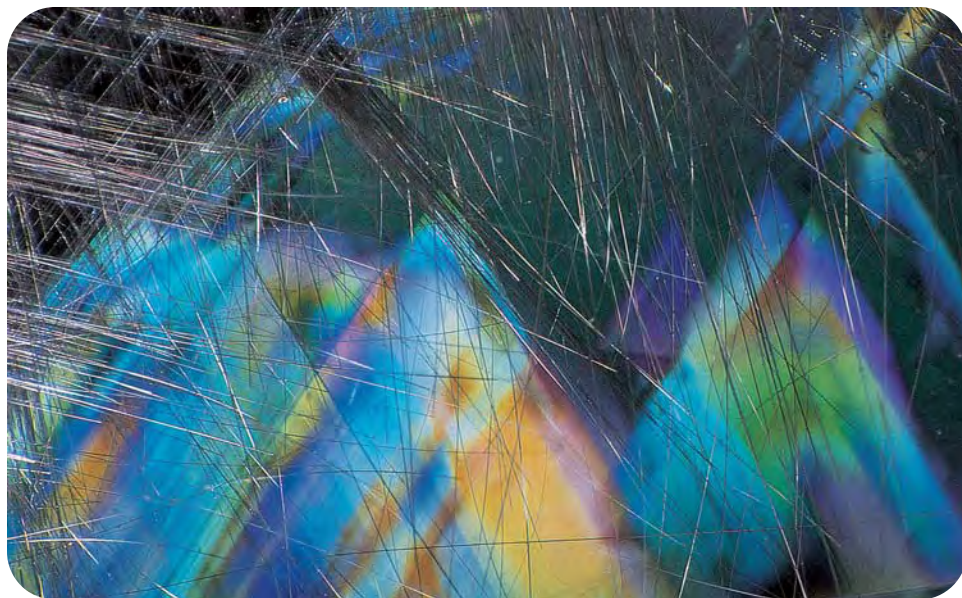
Vibration problems are one of the greatest threats to good photomicrographs. It is, therefore, critical that the photomicrographic unit be protected from unavoidable room vibrations during the entire exposure cycle. Optical isolation benches and air flotation tables have been designed for this specific purpose, but the high cost of such tables (typically several thousand dollars for one 3 × 3 feet [approximately 1 m²]) is prohibitive for most photomicrographers. Making your own vibration control stage is the logical alternative, and doing so can be relatively easy.

First, if at all possible, find a ground floor or basement location for your photomicroscope, preferably a thick concrete slab that has been poured directly over firm soil or bedrock and covered with a firm finish flooring material such as vinyl or vinyl composition tile. Avoid floating floors and areas subject to frequent harsh vibrations (such as near a manufacturing



Figure 2. Photomicrographic images can be either soft or bold. A combination of shadowing to bring out the vibrant colors and fiber-optic illumination to highlight the pseudo-vegetation was used to create this soft, imaginative "Aurora Borealis" in a dendritic iris agate carved by Falk Burger. Magnified 4×.

Figure 3. Polarized light and fiber-optic illumination combine to form this bold rainy mountain scene in a quartz faceted by Leon Agee. The patterned colors are caused by Brazil-law twinning, while light reflecting from rutile needles produces the “wind-driven rain.” Magnified 5×.



area or a workshop). Then place a soft layer of dense, short-pile carpeting or rubber matting of a neutral color in the immediate area around the photo space in case something is dropped accidentally. The photo room itself need not be large (5 × 6 feet will work), but it should be capable of near-total darkness.

Once the photo room has been chosen, start with a hard, sturdy, thick-surfaced table as a primary base for your microscope, camera, and lighting equipment. To build an anti-vibration “sandwich,” place a rubber cushion that is larger than the base of your microscope and about $\frac{1}{4}$ inch (6.4 mm) thick on the table. On top of that put a $\frac{1}{4}$ – $\frac{1}{2}$ inch (6–12 mm) thick steel plate of the same dimensions as the rubber cushion, and then position a rubber cushion similar to the first over the steel plate. Last, place a 1–3 inch (approximately 2.5–7.5 cm) thick granite (or similar hard rock) slab on the top cushion, which then holds the photomicrographic unit. This set-up eliminates vibrations for virtually all magnifications below about 100–150× (Koivula, 1981), although it is still important to avoid touching the table or any of the equipment during the actual exposure.

MODERN EQUIPMENT

Since there is no substitute for good optics, you should expect to spend several thousand dollars to properly equip a gemological photomicroscope. Obviously the most costly piece of equipment is the microscope itself, followed by the camera and the fiber-optic illuminators. As shown in figure 4, there are two bifurcated illuminators in the set-up I use, which gives a total of four controllable light pipes,

two on each side of the microscope. This set-up is highly recommended for its versatility. The fiber-optic illuminators can be purchased through manufacturers such as Dolan Jenner, Nikon, or Zeiss, or from distributors such as GIA Gem Instruments or Edmund Scientific.

The Internet is a great place to start in your search for a photomicroscope. All of the major manufacturers of high-quality optical equipment have Web sites that show the full range of their products, as well as ancillary equipment useful to the photomicrographer. There are also some excellent Web sites that list used microscopes for sale from all of the major manufacturers. Many of these have been very well maintained, with optics in excellent “as new” condition.

Currently, no one manufacturer produces an all-inclusive, ideal photomicroscope for gemology. Such set-ups evolve over time, typically user-assembled hybrids with components designed to handle specific gemological photo situations. For example, the gemological photomicroscope set-up pictured in figure 4 has evolved around a basic, but no longer manufactured, Nikon SMZ-10 zoom stereo trinocular photomicroscope with a built-in double iris diaphragm for depth-of-field control. It rests on a GIA Gem Instruments custom-made base with a built-in darkfield-transmitted light system that incorporates a 150-watt quartz halogen light source. The base itself is mounted to a large steel plate for added stability, and the post that holds the microscope to the base is 10 inches (about 25 cm) longer than a normal post, which allows much larger specimens to be examined and photographed.



Figure 4. Housed in a sturdy protective cabinet, the author's gemological photomicrographic system uses a trinocular arrangement so that the camera remains in place when the system is being used as a binocular microscope. Note that this custom-made darkfield and transmitted light system uses two fiber-optic illuminators (with a white film canister diffuser on the wand that is lit), but it is also easily set up for applications with polarized light, shadowing, and ultraviolet illumination. Photo by Maha Tannous.

As noted in the article "Photomicrography: A 'how-to' for today's jeweler-gemologist" (1986–1987), you can get good, usable photomicrographs by purchasing a camera-to-microscope adaptor that will allow you to mount a 35 mm single-lens-reflex camera on virtually any binocular microscope. Ultimately, you determine how far you go with gemological photomicrography. When putting together a gemological photomicrographic system, it is most important to remember that there is no substitute for high-quality optics, and proper illumination is critical.

TIME, EXPOSURE TIME, AND FILM

Forget film cost and developing. *Your time* is the single most valuable asset you invest when practicing photomicrography. You should use it, and use it wisely. Take the time to clean the subject, position the stone, and select the correct illumination and adjust it appropriately. As you are beginning work in this area, the more time you spend on a photo, the fewer mistakes you will make. As you become more experienced, you will need less time, but it will always be your most important commodity.

Another time consideration in photomicrography is exposure time. While time may be a friend during sample preparation and set-up, with exposure time, shorter is always better. Long exposure

times not only can increase the risk of vibration problems, but they also can affect the quality of the color captured by the film.

Exposure time is dictated by the speed of the film you use and the amount of light reaching the film. While it might be tempting to choose a faster film, it is normally better to increase the lighting on the subject, when possible. Slower films use smaller chemical grains to capture the image; exposure times are longer but images are much sharper. Faster films use larger grains that capture images more quickly, but, in general, such larger grains produce grainier photos. If a photograph is to be enlarged in any significant degree, as is usually the case with gemological photomicrographs, the sharpness of the recorded image is an important consideration. It is particularly critical with 35 mm transparencies, because of the smaller format. Likewise, for the same reasons, higher film speed equates to a lower quality of color. Between low-speed, fine-grain 64 ASA tungsten professional film and higher-speed, larger-grain 400 ASA film, you will see an obvious difference in image sharpness, color saturation, and overall richness of the photograph.

STARTING CLEAN

There is no substitute for cleanliness in photomicrography. Oily or greasy smudges on your lenses will produce fuzzy, blurred images, making it virtually impossible to obtain proper focus. Dirt particles block light

Figure 5. Items for cleaning optical equipment as well as gems, such as compressed air, a camel's-hair blower brush, cleaning fluids, a gem cloth, and lens paper, should always be kept close at hand while doing gemological photomicrography. Photo by Maha Tannous.



and can create dark artifacts or spots on photographs. Your camera, microscope, lenses, and other associated components (again, see figure 4), are precision instruments that should be treated with respect and care. They should be covered and stored safely when not in use, and you should never smoke, eat, or drink around them or any other optical equipment.

Even with proper precautions, however, lenses and other photographic equipment will still become dirty through normal use. When this occurs, cleaning requires proper procedures and equipment (figure 5). A quick “dry wipe” will damage a lens’s coating and almost guarantees a scratched surface. Cleaning should begin with a blast of compressed air to remove all loose dirt particles. Any stubborn dust can be loosened with a soft camel’s-hair brush, followed by another dose of compressed air. Fingerprints, nose prints, and any other greasy smudges can be removed with any of the standard quick-evaporating lens cleaners together with a lint-free lens tissue.

Dust and grease on your photographic subject will cause the same problems they cause on your lenses, so cleaning here is just as important. Even tiny dust particles on a gem can show up as bright hot spots or dark artifacts on the developed film, depending on how the subject was illuminated and the nature and diaphaneity of the “dust” itself. Oily smudges and fingerprints on the surface of the subject will diminish clarity and distort the view of a gem’s interior. While wiping the stone with a clean, lint-free gem cloth is often sufficient, very oily or dirty subjects should be cleaned with water or a mild detergent, followed by a lens tissue to clean the surface. Special care should be taken first, however, to ensure that hard particulate matter is not stuck to the surface; wiping such a stone could result in scratching, since the cloth or tissue will serve as a carrier for any small, hard particles. Initial examination at about 5–10 \times with fiber-optic lighting should reveal any such material.

While care should be taken during the cleaning of any gem material, the softer the gem material the more cautious one should be. For example, a ruby with a Mohs hardness of 9 is much less susceptible to scratching than is a faceted fluorite with a Mohs hardness of 4. While both can be scratched, it is considerably more difficult to damage the ruby.

Dust can still settle on or be attracted to your subject even after cleaning, especially if you are working with troublesome dust gatherers such as tourmaline. Pyroelectric gem materials can attract new dust, especially when warmed by the illuminators com-

monly used in photomicrography. It is particularly important to constantly check for newly arrived dust with such stones. As when cleaning your lenses, canned air and a camel’s-hair blower brush are useful; if carefully handled, a fine-point needle probe can also be used to remove small dust particles. The tools you use for routine cleaning of lenses and gemological subjects should be kept nearby while you work. It is also important to check your subject through the camera or microscope before each and every exposure to be sure an unwanted dust particle has not settled in the field of view, or to be sure that neither the lighting nor the subject has shifted position.

ILLUMINATION TECHNIQUES FOR PHOTOMICROGRAPHY

The very first “rule” of photomicrography is: Without proper illumination, you never know what you’re missing. A broad collection of photomicrographic lighting accessories that greatly expand the usefulness of a gemological darkfield microscope are shown in figure 6 and described in the sections below.

While sometimes a single illumination technique will be sufficient, more often than not two or more techniques are needed to produce a high-quality gemological photomicrograph. Today, these meth-

Figure 6. This collection of lighting accessories would be found in any complete gemological photomicrographic laboratory. Shown here are a single-wand fiber-optic illuminator; a pinpoint fiber-optic illuminator with two end attachments; two Polaroid plates and a first-order red compensator; a white diffusing plate; two iris diaphragms for shadowing; two modified film cans and two black paper strips for hot spot control; and a shallow glass evaporating dish for partial immersion if needed. Photo by Maha Tannous.



ods include fiber-optic, pinpoint, light “painting,” and darkfield illumination, as well as transmitted, diffused transmitted, and polarized light. Among the tools that can be used to maximize the effectiveness of the different illuminants are the first-order red compensator and shadowing. For special situations, photomicrographs may be taken using an ultraviolet unit or with the stone in immersion.

When the first *Gems & Gemology* article on “Photographing Inclusions” was published (Koivula, 1981), darkfield illumination was considered the most useful illumination technique in gemological microscopy. Over the last two decades, that designation has shifted, and fiber-optic illumination is now considered to be the single most useful form of lighting in gemology for photomicrography as well as gem identification. Certainly, dark-

Figure 7. This highly diagnostic “zebra stripe” fracture pattern in natural “iris” amethyst shows vibrant iridescent colors in fiber-optic illumination. Magnified 2×.

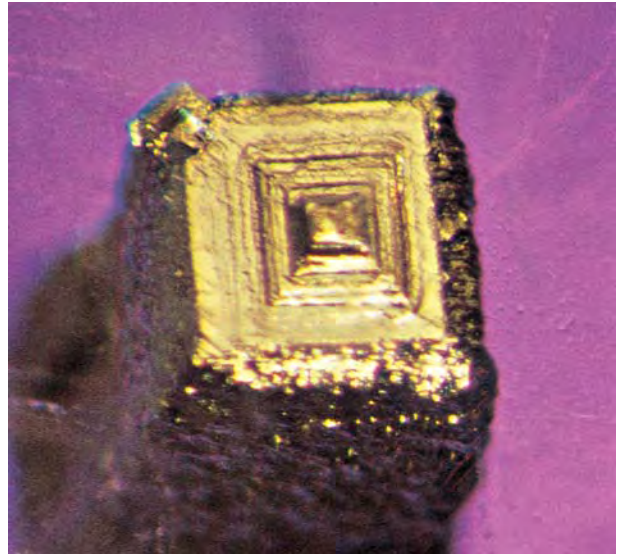
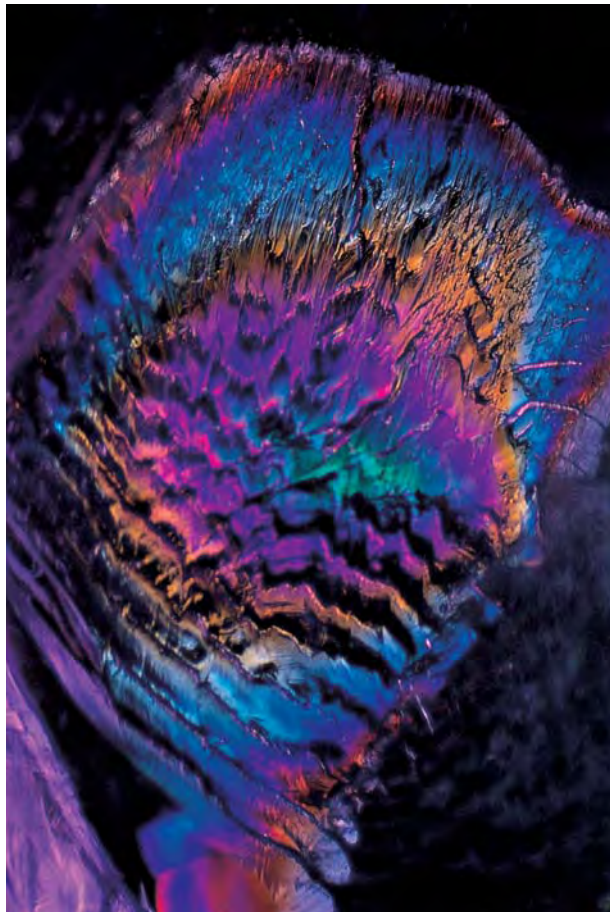


Figure 8. Fiber-optic illumination was used to highlight the surface of this pyrite crystal in fluorite, bringing out growth details that otherwise would be difficult to see. Magnified 10×.

field illumination still has its place, especially in diamond clarity grading. Where photomicrography is concerned, however, fiber-optic illumination is without peer, and so we will start there.

Fiber-optic Illumination. The use of fiber-optic illumination in gemology was first introduced in the late 1970s and in *Gems & Gemology* a few years later (Koivula, 1981). A fiber-optic light is not only effective in obtaining a specific effect or viewing a specific feature, but it is also versatile, in that the

Figure 9. Opaque gems, which look essentially black in darkfield, usually respond well to fiber-optic illumination. Pyrite, chalcocite, and quartz are all present in the webbing of this untreated spider-web turquoise. Magnified 10×.

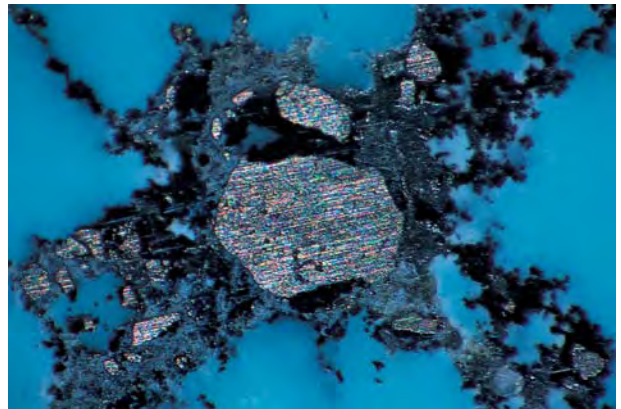
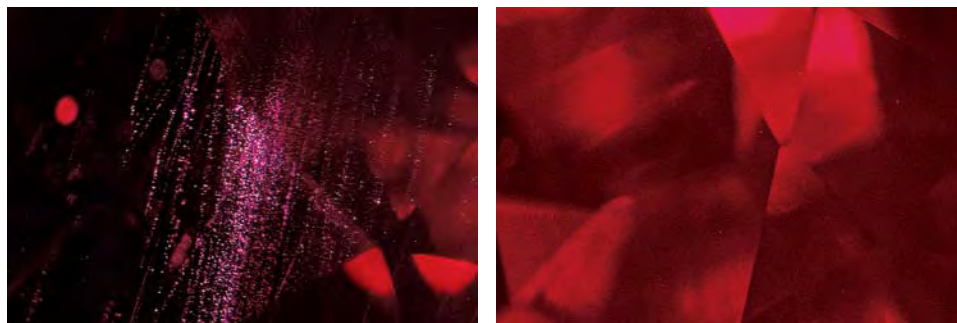


Figure 10. Fiber-optic illumination reveals the rain-like stringers of flux particles in a Kashan synthetic ruby (left). In darkfield conditions, without fiber-optic illumination, the flux “rain” in the same Kashan synthetic ruby is no longer visible (right). Magnified 15 \times .



object can be illuminated from virtually any angle (again, see figure 4).

Transparent, translucent, and opaque gems all respond well to fiber-optic lighting. The results can be both beautiful and informative. Fractures, cleavages, and ultra-thin fluid inclusions become decorated with vibrant iridescent colors (figure 7). Interfaces surrounding included crystals show details of growth that otherwise elude observation (figure 8), while reflecting back facets return light to the observer’s eye, seemingly magnifying the intensity and the richness of color. Opaque gems, which look essentially black in darkfield, often show startling patterns and/or variations of color when explored with fiber-optic illumination (figure 9; “Fiber optic illumination. . .,” 1988).

Today, it doesn’t seem possible for anyone on the technical side of the gem industry to get along without a fiber-optic illumination system for their microscope. And, indeed, some microscope systems have such a system built in. At the microscopic level, there are internal characteristics in gems that you just cannot see without this form of illumination. One example is the so-called “rain” trails of tiny flux particles that are characteristic of Kashan synthetic rubies (figure 10, left), which often go undetected in darkfield alone (figure 10, right). Another startlingly clear example of the inadequacy of darkfield illumination was recently published in *Gems & Gemology* (Koivula and Tannous, 2001, p. 58). In this example, a beautiful stellate cloud of pinpoint inclusions in diamond was only visible in its diamond host with fiber-optic illumination.

Fiber optics also can be used to examine the surfaces of both rough and faceted gems for irregularities. These might include surface growth or etch features, surface-reaching cracks, or polishing lines. Scanning the surface of the stone with a fiber-optic wand is of tremendous value in the photomicrography of important details on the surfaces of gems and related materials, particularly in the detection of

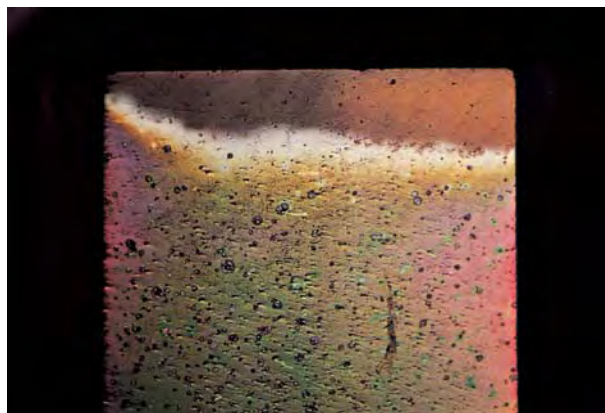
some surface treatments, such as the oiling of emeralds, fracture filling of diamonds, and coatings as on Aqua Aura quartz (figure 11).

If the light is too harsh, or produces too much glare, fiber-optic illumination can be controlled by placing a translucent white diffusing filter over the end of the light pipe. From experience, I have found that a translucent white film canister makes a great diffuser: Simply punch a hole in the lid and push the film canister over the end of the light pipe (again, see figure 4).

Over the years, other forms of fiber-optic illumination have been adopted for use in gemology. Two particularly important ones are pinpoint illumination and light painting.

Pinpoint Illumination. As its name suggests, pinpoint illumination is ideally suited for getting light into tight or difficult places. Pinpoint illumination (Koivula, 1982a) employs a long, very flexible light pipe with interchangeable straight and curved tips of various diameters down to a millimeter (again, see figure 6). An adaptor can be used to convert a standard fiber-optic light source to a pinpoint illuminator.

Figure 11. Details of the gold coating on the surface of an Aqua Aura quartz are clearly visible with shadowed fiber-optic illumination. Magnified 5 \times .



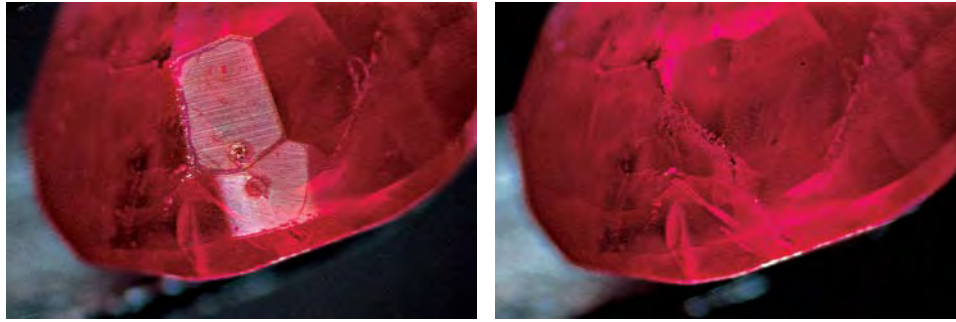


Figure 12. Pinpoint fiber-optic illumination clearly shows the rupture craters on the surface of a high-temperature heat-treated ruby (left). Without the pinpoint illuminator to highlight the surface, using only darkfield, the surface damage on the heat-treated ruby is not visible (right). Magnified 12 \times .

With pinpoint illumination, it is possible to highlight specific regions in or on a gem (figure 12, left) that might otherwise go unnoticed (figure 12, right), or quickly locate very small inclusions. It is also possible to effectively illuminate mounted stones no matter how complex the mounting; even those in closed-back settings are easily examined using this technique. Pinpoint fiber-optic illumination is perhaps the most versatile form of ancillary lighting available for gemologists concerned with gem identification or evaluation.

Light Painting. Light painting is a variant of pinpoint fiber-optic illumination. As with all techniques, it takes some practice to use effectively. It is also a technique that will often surprise you with its results, and it probably never can be fully mastered. In light painting, you use a pinpoint fiber-optic wand just as an artist uses a paint brush, in that you keep the wand moving and “stroke” the subject with

Figure 13. This image showing a comet-like sprig of rutile in quartz was created by light painting using a pinpoint fiber-optic illuminator. Magnified 10 \times .



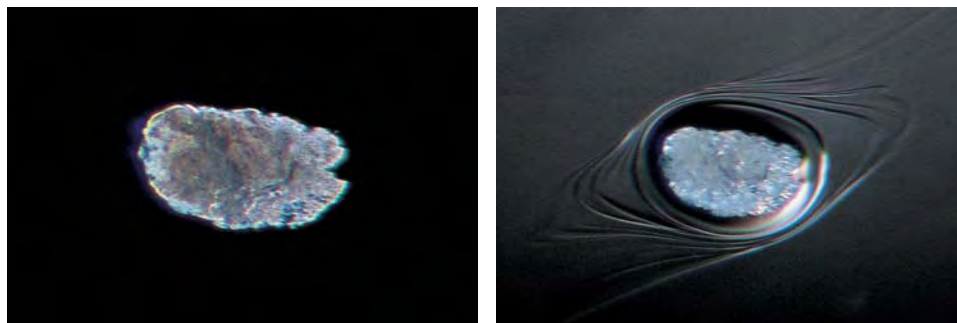
light from various angles during the exposure cycle. It usually works best on transparent subjects, with the light directed either from below or from the side (figure 13), since the use of light painting from overhead angles will often result in hot spots. It is a supplementary technique to other forms of illumination such as darkfield and transmitted lighting, and can be helpful in reducing exposure times in low-light situations such as those encountered when using polarized or ultraviolet illumination.

Darkfield Illumination. Darkfield illumination, the method used internationally in diamond grading, is the “workhorse” of lighting techniques, the one most gemologists use for colored stones as well as diamonds. Most jewelers and appraisers rely almost entirely on darkfield illumination in their gemological work with a microscope. The primary reasons for this are twofold: Darkfield illumination as married to the gemological microscope is what is taught, and darkfield illumination is what is sold as the “built-in” illumination system on today’s advanced gemological microscopes.

Even though it has been surpassed by fiber-optic illumination for gem identification and photomicrography, darkfield still remains an important illumination technique for all gemological applications, including the routine observation and photography of inclusions.

With the darkfield technique, whereby light transmitted from below is reflected around the sides of an opaque light shield by a mirror-like reflector (as illustrated in Koivula, 1981), only light that is scattered or reflected by the inclusions is seen through the microscope and captured on film. The inclusion subjects appear relatively bright against a dark background (figure 14, left). However, if darkfield is the only method employed, significant details may be missed, as shown in figure 14, right—the same image taken with shadowing (see below) in addition to darkfield. Darkfield lighting is most applicable to the study of transparent-to-

Figure 14. Darkfield illumination is designed to show inclusions brightly against a dark background. On the left, a white solid in a manufactured glass is clearly revealed. If shadowing is also used (right), the flow lines in the glass surrounding the white solid can be seen as well. Magnified 30 \times .



translucent included crystals, small fluid inclusions, and partially healed fissures (figure 15).

While darkfield is an excellent method for lighting the interior of diamonds for commercial grading, it is not the only method that should be applied to diamonds for comprehensive gemological investigation, because it frequently does not reveal all the details. However, when coupled with fiber-optic illumination, a darkfield system is an excellent choice for most gemological applications.

Transmitted Light. Sometimes referred to as transillumination, lightfield, or brightfield, direct (undiffused) transmitted light is produced by allowing light to pass directly up through the gem into the microscope system by removing the darkfield light shield (Koivula, 1981). Because so much of the detail normally seen with fiber-optic or darkfield illumination is lost in direct, undiffused transmitted light—darkly colored or opaque included crystals and fine growth features, for example, are virtually washed out—this method is of limited use. However, some details that

Figure 15. Darkfield lighting is used to study transparent-to-translucent included crystals, small fluid inclusions, and partially healed cracks, all of which are illustrated in this image of a spessartine garnet in quartz. Magnified 3 \times .



are not visible with either darkfield or fiber-optic illumination, such as voids and fluid chambers, often stand out readily in a beam of direct transmitted light. Large negative crystals (figure 16) and fluid inclusions are very easily examined. Color zoning (figure 17) is also easily observed and photographed, as are some large, flat, transparent to translucent mineral inclusions (figure 18).

Direct, undiffused transmitted light has other advantages as well. Exposure times are at their shortest, and small dust particles on the surface of the host gem rarely show up on film, since the quantity of light washing around them tends to cancel their ability to interfere with light transmission.

Diffused Transmitted Light. Transmitted light is more useful when it is diffused by adding a translucent white filter between the light source and the subject. With such a filter, strong reflections and glare are essentially eliminated and an evenly illuminated image results.

There are basically two different ways to diffuse transmitted light. The first and most commonly used method utilizes a flat plate of translucent

Figure 16. Transmitted light was used to illuminate this relatively large negative crystal in an amethyst from Mexico. Magnified 10 \times .



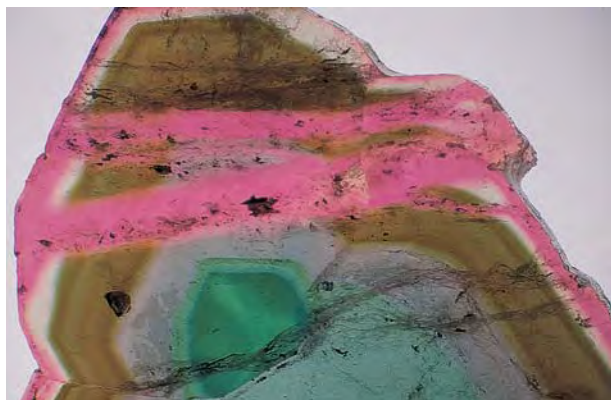


Figure 17. Elaborate color zoning in a cross-section of tourmaline is easily observed and photographed using transmitted light. Magnified 4 \times .

white glass or plastic that is placed over the light well of the microscope, just below the subject. High-quality diffuser plates specifically designed to fit in the opening over the well of the microscope are manufactured and sold for this purpose (again, see figure 6).

“Tenting,” the second method, is achieved by enveloping the subject from below and on all sides with a custom-made light diffuser so that only diffused light enters the stone. So-called custom-made diffusers ideally suited for this purpose are easier to manufacture than it might seem. A little imagination, a sharp knife or razor blade, and some empty translucent white plastic 35 mm film canisters are all that is needed, the same type previously recommended for use on the ends of fiber-optic illuminators to diffuse their light.

Diffused transmitted light is an excellent way to

Figure 18. Using transmitted light, three generations of mica—green, colorless, and brown—are readily imaged in their Brazilian quartz host. Magnified 5 \times .

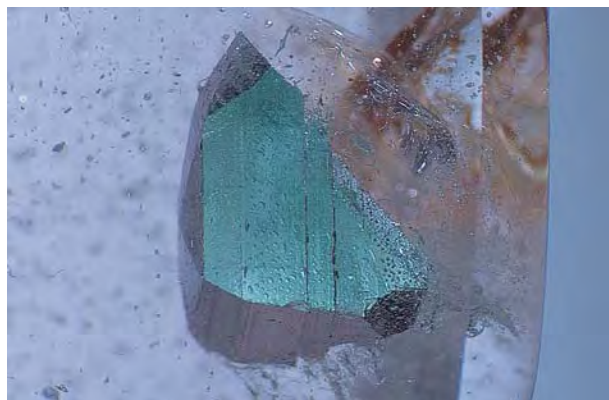
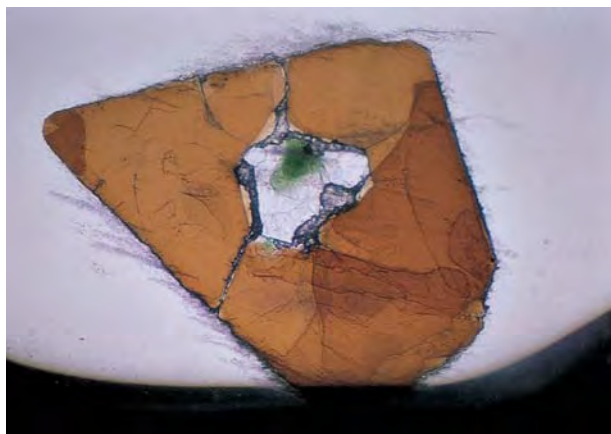


Figure 19. Diffused transmitted light is an excellent way to observe color in transparent-to-translucent mineral inclusions. The green color of this fluorite inclusion in topaz is clearly seen with this technique. Magnified 7 \times .

observe color in transparent-to-translucent mineral inclusions in both faceted (figure 19) and rough stones. With the addition of a polarizing analyzer over the objective lens, above the subject, it also becomes relatively easy to check for pleochroism in colorful crystal inclusions. Diffused transmitted light, particularly tenting, also makes even relatively subtle color zoning easy to observe and photograph (figure 20).

Polarized Light. Despite its great utility in gemology, polarized light microscopy is often neglected by gemologists, who consider it solely a mineralogist’s tool (McCrone et al., 1979). Many important gem

Figure 20. Tenting, a form of diffused transmitted light, was used to resolve the relatively subtle “umbrella effect” color zoning that proves that this diamond has been cyclotron irradiated and heat treated. Magnified 20 \times .

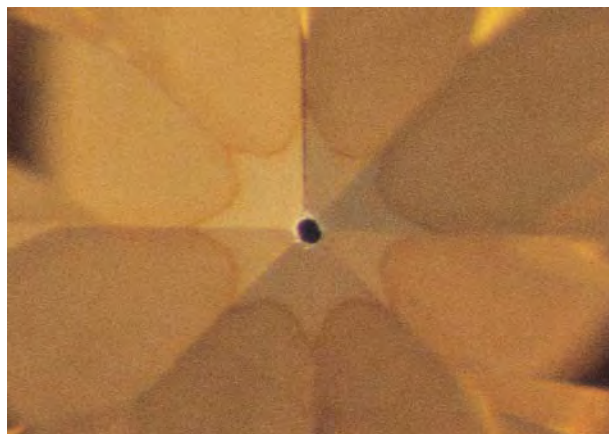
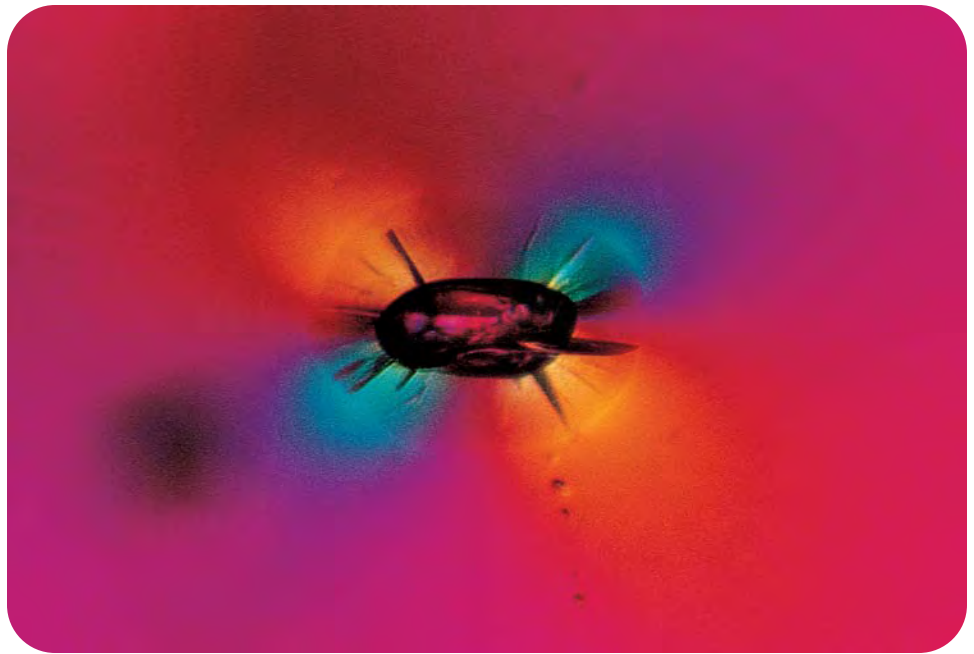


Figure 21. Internal strain around this tiny zircon crystal in a Sri Lankan spinel is made visible using polarized light. Magnified 60×.



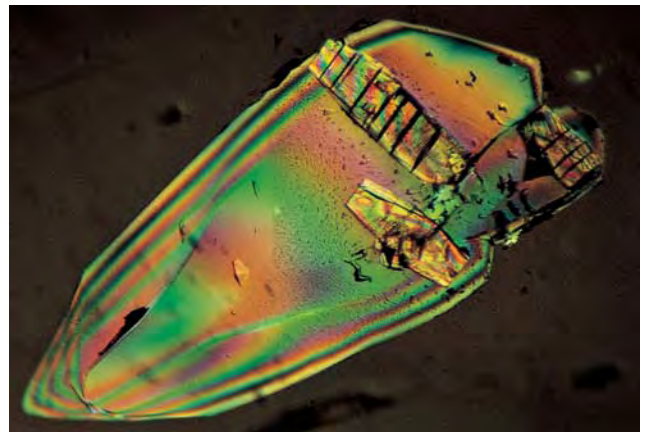
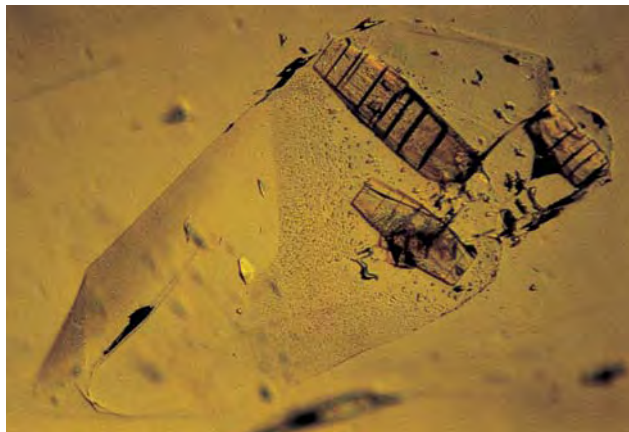
features need polarized light for clear viewing, among them internal strain around included crystals (figure 21), crystal-intergrowth induced strain, optically active twinning, and optic figures. Included crystals of a doubly refractive material that otherwise show very low relief are easily seen in polarized light (figure 22). Especially for those employing this technique for the first time, the world of polarized light microscopy can be both startling and beautiful.

Temporarily converting a gemological micro-

scope with transmitted light capabilities to a polarizing microscope is a very simple process. The only requirement is a pair of polarizing plates that can be placed above and below the gem subject (Koivula, 1981). However, while unprotected plastic sheet filters, with their fine scratches and slightly warped surfaces, may be adequate for routine examinations, photomicrography requires polarizing filters of good optical quality.

With the microscope's darkfield light shield removed for direct transmission of light, one plate,

Figure 22. If they are doubly refractive, mineral inclusions of very low relief will stand out readily when polarized light is used. The quartz crystal in this golden beryl (heliodor) shows low relief in transmitted light (left), because the refractive index of the inclusion is near that of the host. The mica inclusions in the included quartz crystal are more visible because they are darker. In polarized light (right), the quartz inclusion lights up with interference colors that make it clearly visible in the beryl host. Magnified 10×.



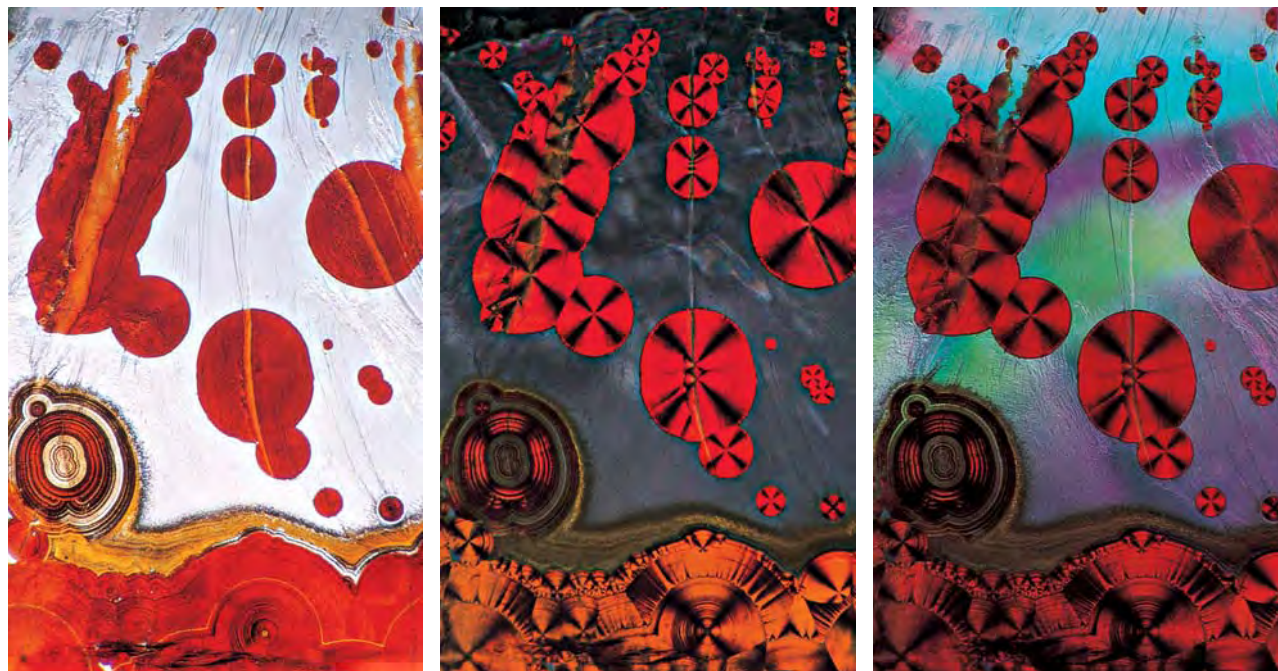


Figure 23. The first-order red compensator not only dramatically reduces the exposure times required to photograph with polarized light, but it creates some very pleasing images as well. This sequence shows epigenetic hematite radial concretions lining a fracture in quartz. The photomicrograph on the left was taken in direct transmitted light, with an exposure time of only 0.94 seconds. The center image, taken in polarized light, reveals extinction crosses in all the hematite concretions, thus showing their radial crystalline structure. The exposure time was 45.31 seconds. When the same internal scene was photographed in polarized light with a first-order red compensator (right), the extinction crosses are again present in all the hematite concretions, but the background of the quartz host has become brighter and more colorful. This was achieved with an exposure time of only 5.72 seconds. Magnified 12 \times .

called the *polarizer*, should be placed over the light port and under the gem subject. The other plate, called the *analyzer*, should be placed above the gem subject just below the microscope's objectives. Unlike a polariscope, where the analyzer is rotated and the polarizer remains fixed, in this set-up both plates can be rotated. In addition, if the polarizer is removed and the analyzer is rotated, images of inclusions in such strongly birefringent gems as peridot or zircon can be captured easily by clearing the otherwise strongly doubled image.

However, because the polarizing plates filter out much of the light passing through them, exposure times can be exceedingly long. This can be dealt with by using fiber-optic illumination as a supplemental source of light, or by the addition of a first-order red compensator in the light path.

First-Order Red Compensator. In most cases where low levels of light might require extremely long exposure times (e.g., due to the use of polarizers), a filter known as a *first-order red compensator* will

dramatically reduce the time required, thereby diminishing the effects of vibrations on photomicrographs (Koivula, 1984). In addition, this filter will intensify low-order, dull, interference, or strain colors, making them much more vibrant.

Unlike what its name might imply, the first-order red compensator is not a red-colored filter. Instead, it is a virtually colorless laminated plastic plate that is inserted in the light path between the polarizer and the subject. When used in this fashion, it imparts a bright magenta color to the blackness, hence the name.

The use of a first-order red compensator in gemological photomicrography not only reduces exposure times dramatically, but it also creates some very pleasing images, as evident in these photomicrographs of epigenetic hematite concretions lining a fracture in quartz taken in direct transmitted light, in polarized light, and with a first-order red compensator in position (figure 23). In addition, this filter is particularly useful in revealing specific features for both gem identification and subsequent photomi-

crography. For example, it can be used to enhance strain colors and patterns, which is helpful in the separation of diamond from substitutes such as synthetic cubic zirconia and yttrium aluminum garnet.

Shadowing. If you have ever seen curved striae in a flame-fusion synthetic ruby, then you have used shadowing. Your microscope was probably set in darkfield mode, but it was not darkfield that made the striae visible. The basic principle behind the shadowing technique involves direct interference with the passage of light from the microscope light well, up through the subject, and into the microscope lenses. This interference causes the light to be diffracted and scattered at the edge of an opaque light shield inserted into the light path below the subject. As a result, light is transmitted into certain portions of the subject, while other areas appear to be darkened or shadowed (Koivula, 1982b). The desired effect is to increase contrast between the host and any inclusions or growth characteristics that might be present. If properly done, the invisible may become visible, and the results can be quite dramatic.

This light interference can be accomplished in a number of ways. The easiest method of shadowing is simply to “stop down” the iris diaphragm over the microscope’s light well. Such a diaphragm is built into most gemological microscopes, so it is easily adapted to shadowing. While looking through the microscope, as the shadow edge approaches and the subject descends into darkness, you will see greater contrast in the image at the edge of the shadow (figure 24). Since shadowing is somewhat directionally dependent, more dramatic results can be obtained through experimentation with a variety of opaque light shields that can be inserted into the light path below the subject at various angles.

Shadowing is also useful to achieve greater contrast when examining surfaces with a fiber-optic illuminator. Contrasting color filters can be inserted

or partially inserted into the light path to highlight specific features. This is relatively easy to do.

First, set up the illuminator so that the surface being examined is reflecting brightly through the microscope. Then either slowly move the illuminator so that a shadow begins to appear on the surface, or insert an opaque light shield in front of the illuminator to partially block the light. At the edge of the shadow caused by either of these two methods, the contrast of any surface irregularities—such as polishing draglines extending from surface-reaching cracks, or surface etch or growth features—will be visibly increased. It is amazing how much detail can be revealed by this simple technique. It is also distressing to realize how much visual information can be missed if the technique is never used.

Ultraviolet Illumination. I am going to start this section by pointing out that ultraviolet light is **dangerous** to your vision! If you are going to attempt ultraviolet photomicrography you **must** wear eye protection at all times. While I have taken photomicrographs using short-wave UV, I generally try to avoid this, since the potential risk increases as wavelength decreases. In my opinion, while long-wave UV also is questionable, it is preferable to short-wave UV.

With that said, ultraviolet light does have a small role in photomicrography and inclusion research (Koivula, 1981). For example, certain gem materials, such as quartz or fluorite, are transparent to ultraviolet wavelengths, but inclusions of organic fluids and fluorescent solids will be seen to glow under the influence of the ultraviolet radiation (figure 25). Structural features in some materials, such as the highly diagnostic isometric patterns in synthetic diamonds (see, e.g., Shigley et al., 1995), also can be viewed and photographed using an ultraviolet lamp. Other UV effects on specific minerals are described by Robbins (1994).

Figure 24. In darkfield illumination (left), the interior of this Seiko floating-zone refined synthetic ruby shows only a hint of its internal structure. With the shadowing technique (right), there is a dramatic change in the visibility of its roiled internal structure. Magnified 15 \times .

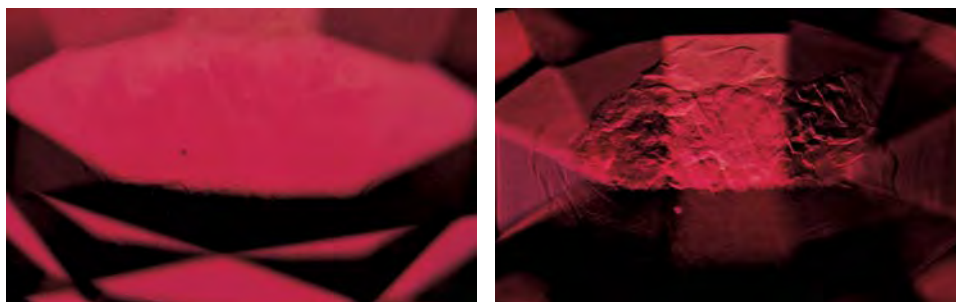
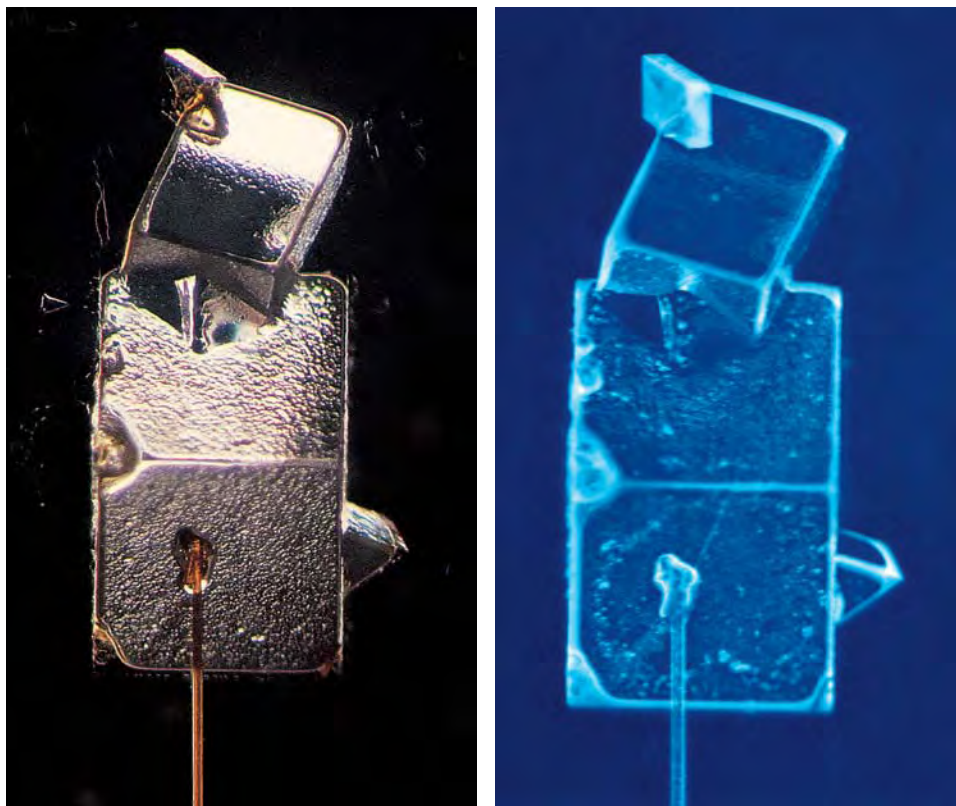


Figure 25. A combination of darkfield and fiber-optic illumination (left) reveals great detail in these calcite crystals “impaled” on a rutile needle in Brazilian quartz. With long-wave UV radiation (right), a distinctive blue luminescence is now evident, which indicates that natural petroleum is lining the surfaces of the calcite crystals and rutile needle. Magnified 20 \times .



Because of the low light generated by the UV lamp, ultraviolet photomicrography often requires excessively long exposure times. As with polarized light, supplemental fiber-optic illumination also can be used here to shorten the exposure time as long as it does not overpower the desired effects of the ultraviolet radiation in the photomicrograph.

To make double-sure that the message of danger is clear, let me state—once again—that when using ultraviolet illumination in gem testing you should **take extreme care to protect your eyes** from either direct or reflected exposure to the ultraviolet radiation. This is particularly true of short-wave UV. There are filters, glasses, and goggles made specifically for the purpose of UV eye protection. If you have a situation that requires such photomicrography, be sure to use at least one of these protective devices at all times.

Immersion. Total immersion in a liquid such as methylene iodide is useful for certain gem identification purposes (see, e.g., “Immersion...,” 1988–89). Indeed, many gemologists have published effective photomicrographs of features seen with total immersion that are important in the identification of treatments, synthetics, and locality of origin in particular (see, e.g., Kane et al., 1990; McClure et al.,

1993; Schmetzer, 1996; Smith, 1996). Nevertheless, I continue to believe, as I stated in 1981, that total immersion in a dense, heavy liquid has no place in photomicrography; the results achieved by the authors listed above using total immersion could also have been obtained using much less liquid through the technique of partial immersion. In keeping with this belief, none of the photomicrographs shown in this article were taken using total immersion.

In photomicrography, the quality of the image is lowered with every lens or other optically dense medium that is placed between the film plane and the subject (Koivula, 1981). Even today, the most commonly used immersion liquids are malodorous, toxic organic compounds that typically are colored and very dense. The most popular among these is the specific gravity liquid methylene iodide.

Not only are such liquids difficult (and potentially dangerous) to work with, but they often are light-sensitive; as a result, they may darken after brief exposure to strong lighting. In addition, filters must be used to remove microscopic dust particles that commonly contaminate the liquids, or they will appear through the microscope as “floaters” that constantly move in and out of focus. Another problem for the photomicrographer is that these

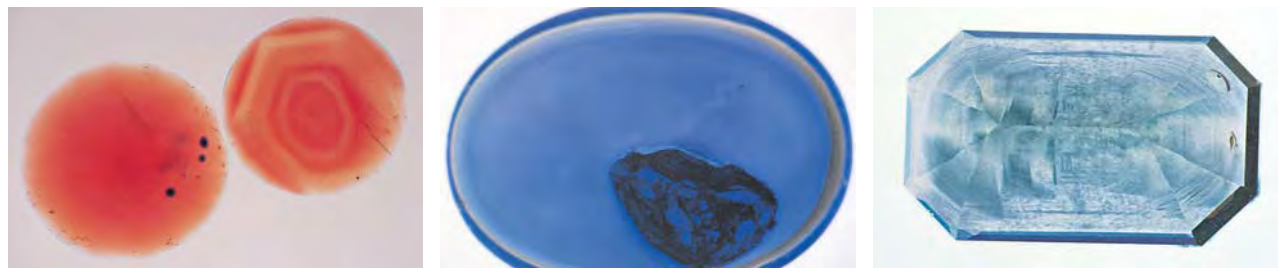


Figure 26. These three photos were all taken in an evaporating dish using partial immersion with methylene iodide and diffused transmitted light. On the left, one of the 4.2 mm bulk-diffused Madagascar sapphires shows the yellow rim indicative of beryllium treatment, whereas the other reveals alteration of the originally pink hexagonal zoning to orange and yellow. The center image details irregular spotty coloration on the surface of a 7.1-mm-long bulk-diffused blue sapphire cabochon. And the image on the right shows structurally aligned, internally diffused blue “ink spots” in an 8.6-mm-long heat-treated sapphire from Rock Creek, Montana.

dense liquids tend to have convection currents that may appear as heat wave-like swirls in the microscope and thus distort the photographed image.

Moreover, the color of the liquid usually interferes with the color of the subject matter; brown emeralds and rubies come to mind. The use of immersion to reduce facet reflections is particularly disturbing, as not only can such reflections add to the effectiveness of the photomicrograph, but the benefits to the image are usually outweighed by the reduction in quality that inevitably results from the use of an optically dense colored liquid and total immersion.

When immersion seems necessary or advantageous—and there are times when it is, such as in the detection of bulk “surface” diffusion in faceted sapphires (figure 26, left) or cabochons (figure 26, center), or in the examination of some sapphires for evidence of heat treatment (figure 26, right)—a modified immersion technique, in place of total immersion, can be very effective. This technique employs only a few drops of a refractive index liquid, such as a Cargille liquid, or a specific gravity liquid such as methylene iodide. The small amount of liquid is placed at the center of a small glass evaporating dish (again, see figure 6), which is positioned over the well of the microscope. The gem is dipped into the liquid, and, as the liquid wets the back facets of the stone, the distracting reflections from them seem to almost disappear, allowing a much clearer view of the gem’s interior. The top of the stone also can be wetted simultaneously with the same liquid, as described below in the “Quick Polish” technique.

Partial immersion has several advantages over total immersion. Only a very small amount of liquid is needed, so the effects of the liquid’s color and

density currents on image quality are minimized. In addition, clean up is very easy, and the strong odors that are so prevalent during total immersion are greatly reduced.

QUICK POLISH

Sometimes, whether one is dealing with a rough crystal, a water-worn stone, a soft gem, or just a badly worn gemstone, the surface of the subject may be too scratched or poorly polished to allow a clear image of the interior (figure 27, left). Rather than taking the drastic—and destructive—step of (re)polishing the material, a modified immersion technique known as a “quick polish” can work very effectively. Simply by spreading on the stone a small drop of refractive index fluid with an R.I. close to that of the gem material, the scratches and other interfering surface characteristics can be made effectively transparent, allowing a clear view of the gem’s interior (figure 27, right).

Unlike total (or even partial) immersion, this method uses so little R.I. fluid that any effects on image quality (such as fluid color and density currents) are negligible, and clean up and the unpleasant odors of R.I. fluid are minimized. In addition, it allows back-facet reflection where necessary to highlight inclusions. Finally, regardless of the stone’s surface condition, this method can aid in locating (and photographing) optic figures in anisotropic gemstones, without having to resort to total immersion.

CONTROLLING HOT SPOTS

“Hot spots” are areas of such intense brightness that it is impossible to balance the lighting for photography. When hot spots are present, the image

produced of the desired area will either be too dark or “burned out” (i.e., over-exposed) from the brightness. Neither is desirable. In such situations, it is important to eliminate the effect of hot spots by learning to control them.

There are basically two methods for controlling hot spots. The first is illustrated in figure 28. In the image on the left in figure 28, a hot spot is visible in the form of a bright, distracting facet reflection. In the image on the right, the hot spot is gone. To eliminate the hot spot, the stone was rotated or tilted slightly, causing the reflection to disappear. This method is not always successful, though, as the movement of the stone often causes other hot spots to appear.

The second and more effective method of controlling hot spots is based on the recognition that if you see a hot spot in your field of view, it has to be caused by one of your light sources. If the 360° dark-field light ring is causing the problem, you know that the hot spot has to be produced somewhere around that ring of light. To block the hot spot, simply take a thin strip of opaque black paper (about half an inch [1.25 cm] wide) and bend it so a section can hang over the edge of the light well to block a portion of the light from the microscope’s darkfield light ring. Then, while looking through the microscope, just move the opaque paper strip around the ring until the hot spot disappears (figure 29). Using this method, you do not have to move the stone at all. Compare figure 28 (left) to figure 29 and you will see that, with the exception of the hot spot reflection from the facet in figure 28, the position of the inclusions is identical.

The same means of hot spot control can be used on a fiber-optic illuminator, if that is the cause of the hot spot in the field of view. This can be done by sliding an opaque light shield in front of the fiber-optic light source so it blocks half of the light coming from the light pipe. Then, while looking through the microscope, slowly rotate the light shield. At some point in the 360° degree rotation of the light shield in front of the light pipe, the hot spot will disappear, or at least be greatly reduced in intensity. A simple fiber-optic light shield for blocking hot spots can be manufactured from a film canister. There are two types you can construct (figure 30). The translucent white light shield provides diffused fiber-optic illumination, while the one constructed from an opaque black film canister provides intense direct fiber-optic illumination.

Angle of Illumination. Just because you see something when a gemological subject is illuminated from one direction does not mean that you won’t see an entirely different scene if you illuminate it from another direction. This is dramatically illustrated by the fern-like pattern in an opal from Virgin Valley, Nevada, that is shown in figure 31. In one orientation of the fiber-optic light, the main body of the opal is a pale blue-green while the fern pattern is dark gray to black. By simply moving the light to the opposite side of the opal, the fern pattern now appears vivid green while the surrounding opal has darkened considerably.

A slightly less dramatic but equally important illustration of proper illumination angle in gemology and

Figure 27. Holding a soldier and a worker termite captive, this copal from Madagascar is badly scratched, which drastically affects the quality of the image (left). However, spreading a droplet of sesame oil (R.I. 1.47) over the surface creates a “quick polish” on the copal, so the termites can be photographed clearly (right). Magnified 5×.



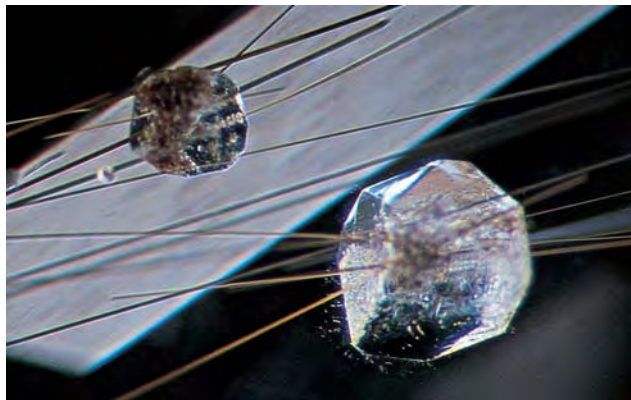


Figure 28. A facet-reflection “hot spot” distracts from the calcite and rutile inclusions in quartz visible in the photo on the left. By slightly tilting the quartz, the hot spot is eliminated (right). This does not always work, however, as the movement often causes new hot spots to appear in other areas of the stone. Notice also that the two images are no longer an exact match in the positioning of the inclusions. Magnified 15×.



Figure 29. An even more effective method of controlling hot spots is to block the light source rather than moving the subject. This is done by placing a thin strip of opaque black paper in front of the area of the light that is producing the hot spot. Compare this image to the one on the left in figure 28 (with the hot spot): The position of the inclusions in this photo is an exact match. Magnified 15×.

photomicrography is found in the sequence shown in figure 32. In this sequence, the angle of illumination is changed by moving the stone, rather than the light source. In the image on the left, a filled crack in an emerald is virtually invisible in darkfield illumination when viewed parallel to its plane. As the stone is tilted slightly, the air trapped inside the filler becomes visible (center image). Tilting the stone only a little further causes the reflection from the trapped air in the filled crack to virtually disappear again (image on the right). There is only a shallow angle of clear visibility in the detection of this filled crack, which shows that angle of illumination is very important.

Figure 30. Simple light shields for blocking hot spots produced by fiber-optic illuminators can be manufactured from plastic film canisters. The translucent white light shield provides diffused fiber-optic illumination, while the one constructed from an opaque black film canister provides intense direct fiber-optic lighting. Photo by Maha Tannous.



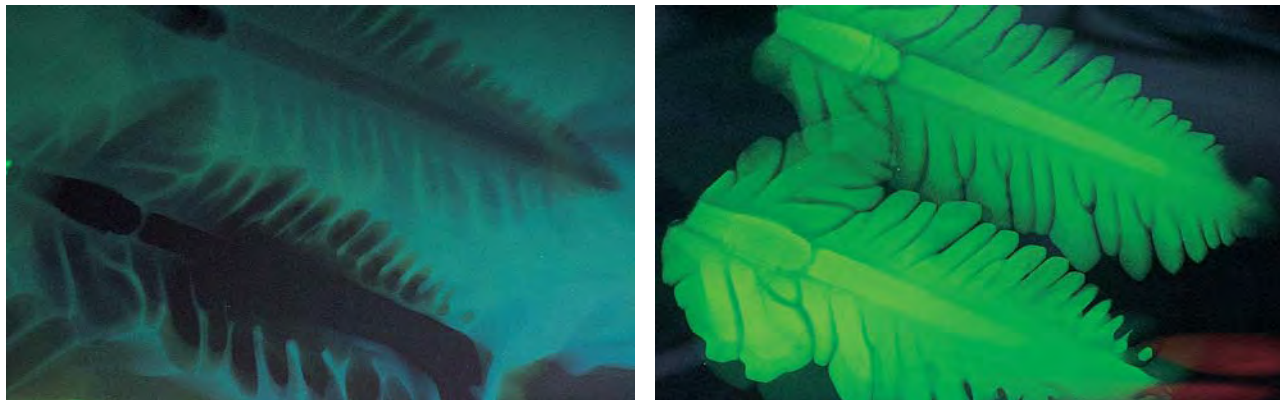


Figure 31. This pair of photomicrographs dramatically illustrates how important angle of illumination can be. In the fiber-optic image on the left, the fern-like pattern in an opal from Virgin Valley, Nevada, is dark while the main body of the opal is a pale blue-green. By simply moving the fiber-optic light to the opposite side of the opal (right), the fern pattern now appears as a vivid green while the surrounding opal is dark. Magnified 4 \times .

Focus and Problem Detection. If illumination is handled properly, then the best possible focus, coupled with the maximum depth of field, will usually give the best photomicrograph. An example of a photomicrograph with the main subjects clearly in focus is shown in figure 33 (left), a group of blue apatite inclusions in quartz.

If an image appears to be poorly focused, and is not as sharp as you expected it to be, it is important to identify whether the problem is a question of focus or vibration. If it is a focus problem, then some areas within the photograph will be in sharp focus, even if your desired subject is not (see, e.g., figure 33, center). If it is a vibration problem, then there will be no sharply focused areas in the image and all edges and details will appear blurred (figure 33, right).

CONCLUSION

Just because you don't see it, doesn't mean it isn't there.

This short sentence is an excellent summation of why proper illumination is so important to gemology in general and photomicrography in particular. For the photomicrographer interested in producing high-quality gemological images, there are no short cuts where illumination is concerned. Properly identified and catalogued (recording, for example, the magnification, lighting techniques employed, type of gem, origin locality if known, the identity of the inclusion, and how the identity was established), photomicrographs can help the gemologist in the routine identification of gems and whether they are natural, treated, synthetic, or imitation. They can even help "fingerprint" a specific

Figure 32. Another illustration of the importance of illumination angle is found in this darkfield sequence of three photomicrographs, each of which represents a slight tilting of the emerald relative to the light. In the image on the left, a filled crack is virtually invisible when viewed parallel to its plane. In the center view, as the stone is slightly tilted the air trapped inside the filler becomes visible, revealing the presence of the filling itself. Tilting the emerald only a little further causes the reflection from the trapped air in the filled crack to virtually disappear again. Magnified 15 \times .



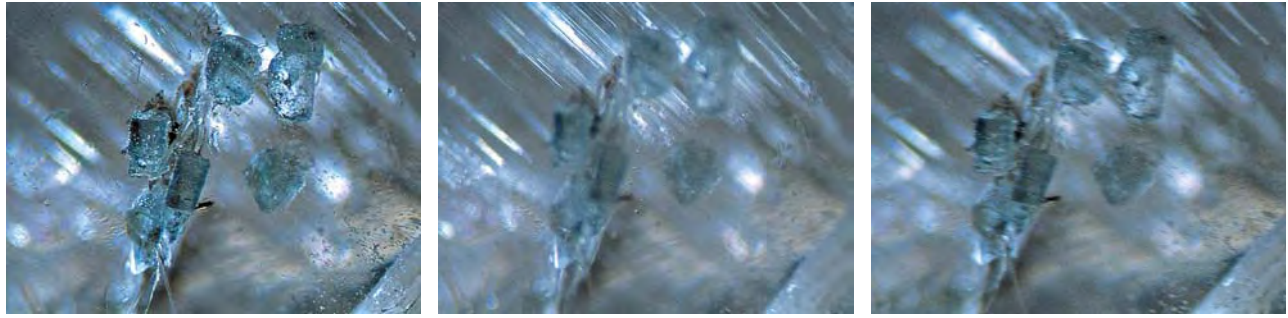


Figure 33. This well-focused photomicrograph (left) shows a cluster of light blue apatite inclusions clearly in focus in their host quartz. In the center image, the apatite inclusions are not in focus, but some of the background clearly is. This must, therefore, be a focus problem. In the view of the same scene on the far right, nothing is in focus. Therefore, this is probably a vibration problem. Magnified 25 \times .

stone, providing extremely valuable proof of provenance should legal problems arise.

That the photomicrograph may also be beautiful is an added benefit.

The three most important factors to remember

are knowledge of your subject, quality of your equipment, and proper illumination. The two most valuable commodities in your possession as a gemological photomicrographer are time and imagination. Use them wisely.

ABOUT THE AUTHOR

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ACKNOWLEDGMENTS: The author thanks the following for their continued support in providing numerous interesting gems to photograph: Leon Agee, Agee Lapidary, Deer Park, Washington; Luciana Barbosa, Gemological Center, Belo Horizonte, Brazil; Edward Boehm, Joeb Enterprises, Solana Beach, California; Falk Burger, Hard Works, Los Alamos, New Mexico; John Fuhrbach, Jonz, Amarillo, Texas; Mike and Pat Gray, Coast-to-

Coast, Missoula, Montana; Martin Guptill, Canyon Country, California; Jack Lowell, Tempe, Arizona; Dee Parsons, Santa Paula, California; William Pinch, Pittsford, New York; Dr. Frederick Pough, Reno, Nevada; Elaine Rohrbach, Gem Fare, Pittstown, New Jersey; Kevin Lane Smith, Tucson, Arizona; Mark Smith, Bangkok, Thailand; Edward Swoboda, Beverly Hills, California; and Bill Vance, Waldport, Oregon. Thanks also to colleagues at the GIA Gem Trade Laboratory—Dino DeGhionno, Karin Hurwit, Shane McClure, Thomas Moses, Philip Owens, Elizabeth Quinn, Kim Rockwell, Mary Smith, Maha Tannous, and Cheryl Wentzell—for sharing many interesting gems.

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POUDRETTEITE: A RARE GEM SPECIES FROM THE MOGOK VALLEY

By Christopher P. Smith, George Bosshart, Stefan Graeser, Henry Hänni, Detlef Günther, Kathrin Hametner, and Edward J. Gübelin

In 2000, an unfamiliar gemstone was purchased in Mogok. It subsequently proved to be the rare borosilicate poudretteite, a mineral that previously had been identified only as tiny crystals from Mont Saint-Hilaire, Quebec, Canada. This article presents a complete gemological description of this unique gemstone and furthers the characterization of this mineral by advanced spectroscopic and chemical analytical techniques.

The Mogok Valley in the Shan State of upper Myanmar (Burma) is a region rich in history, tradition, lore, and gems. Myanmar is commonly referred to as the world's premier source of ruby, sapphire, spinel, peridot, and jadeite. In addition, the Mogok Stone Tract plays host to a wide range of other notable gem species and varieties, including amethyst, andalusite, danburite, garnet, goshenite, scapolite, topaz, tourmaline, and zircon. It has also produced a number of very rare gems, such as sinhalite, colorless chrysoberyl, taaffeite, and painite (see, e.g., Kammerling et al., 1994; Themelis, 2000).

In November 2000, an Italian dealer buying gems in Mogok was shown a 3 ct faceted gemstone (figure 1) that the local gem merchant/gemologist could not identify (F. Barlocher, pers. comm., 2000). This gemstone was subsequently submitted to the Gübelin Gem Lab for examination and identification. On the basis of the results given in this article, it proved to be the first documented gem-quality specimen of poudretteite, a mineral that has been reported previously from only one source in the province of Quebec, Canada (Grice et al., 1987), and only in

small numbers and sizes (see below). These results were also given to R. Schlüssel, who subsequently included poudretteite in his book on Mogok (Schlüssel, 2002). This extremely rare sample permits the first comprehensive gemological description of this material and expansion of the body of analytical data for this mineral by a variety of techniques that had not been used previously.

BACKGROUND

The first description of the mineral poudretteite was published by Grice et al. (1987), with additional original data subsequently provided by Hawthorne and Grice (1990). Just seven crystals were discovered at Mont Saint-Hilaire, Rouville County, Quebec, Canada, during the mid-1960s. However, these specimens were not recognized and registered as a new mineral until July 1986 (J. Grice, pers. comm., 2001). The mineral was named after the Poudrette family, who owned and operated the Carrière R. Poudrette, the quarry on Mont Saint-Hilaire that produced the crystals. Until now, these were the only specimens of poudretteite known to exist.

Grice et al. (1987) reported that the poudretteite occurred in marble xenoliths within a nepheline syenite breccia, associated with pectolite, apophyllite, and minor aegirine. The crystals were found to be $\text{KNa}_2\text{B}_3\text{Si}_{12}\text{O}_{30}$ and were described as colorless to very pale pink, roughly equidimensional, deeply

See end of article for About the Authors and Acknowledgments.

Article submitted November 12, 2001.

GEMS & GEMOLOGY, Vol. 39, No. 1, pp. 24–31.

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etched, barrel-shaped hexagonal prisms measuring up to 5 mm in longest dimension.

Poudretteite was referred to as a new member of the "osumilite group" by Grice et al. (1987); osumilite itself was first described in 1956. Because milarite (described in 1870) is the prototype mineral for the large structural group that includes osumilite, for historical reasons some came to prefer the term *milarite group* (e.g., Hawthorne and Grice, 1990; Hawthorne et al., 1991). Yet Clark (1993) and Mandarino (1999) continued to use the term *osumilite group*. Inasmuch as both group names are currently used in the mineralogical literature, and until there is unanimity in mineralogical terminology, we will refer to poudretteite as belonging to the osumilite/milarite group.

There are 17 minerals in the osumilite/milarite group (Mandarino, 1999). Of these, only sugilite is familiar to most gemologists (see, e.g., Shigley et al., 1987). Sogdianite, another mineral in this group, has also been encountered, though rarely, in gem quality (Bank et al., 1978; Dillmann, 1978).

ANALYTICAL METHODS

We used standard gemological techniques to record the refractive indices (with a sodium vapor lamp), birefringence, optic character, pleochroism, specific gravity (by the hydrostatic method), absorption spectra (with a desk-model spectroscope), and reaction to long- and short- wave ultraviolet radiation (with a combination 365 nm and 254 nm lamp). The internal features were studied with binocular microscopes and fiber-optic and other illumination techniques. To analyze the internal growth structures, we used a horizontal microscope, a specially designed stone holder, and a mini-goniometer contained in one of the oculars of the microscope, employing the methods described by Kiefert and Schmetzer (1991) and Smith (1996).

Identification of the gemstone as poudretteite was done by X-ray diffraction analysis, performed with a Debye-Scherrer camera that was 90 mm in diameter and used FeK radiation. Film shrinkage was corrected using a quartz standard. The powder pattern was indexed applying the program by Benoit (1987), and lattice parameters were refined after Holland and Redfern (1997).

To record the UV, visible, and near-infrared absorption spectra (200–2500 nm), we used a Perkin Elmer Lambda 19 dual-beam spectrometer, equipped with beam condensers and polarizers (Polaroid



Figure 1. This extremely rare 3.00 ct poudretteite was recovered recently from the Mogok Valley of upper Myanmar. Previously, only small crystals of poudretteite had been found during the 1960s in the Mont Saint-Hilaire syenite complex of Quebec. Photo by Phillip Hitz.

HNPB filters for the 270–820 nm range, and a calcite polarizer with a goniometer scale for the 820–2500 nm range). The region from 200 to 270 nm was recorded in unpolarized light. For the 200–820 nm range, the spectra were run at a speed of 1 nm/sec and with a spectral slit width of 0.5 nm. For the 820–2500 nm range, the scan speed was increased to 2 nm/sec with a slit width automatically adjusted to the recorded signal intensity.

We also used two other methods for infrared spectrometry. First, a minute scraping of powder from the gemstone (<0.001 ct) was admixed to >100 parts of dry KBr salt, ground together in an alumina mortar, evacuated, and pressed to form a transparent pellet 5 mm in diameter. We collected the mid-infrared spectrum of the pellet using a dispersive Perkin Elmer 883 spectrometer in the region between 4000 and 250 cm^{-1} , thus connecting the end of the near-infrared region at 2500 nm (4000 cm^{-1} is equivalent to 2500 nm). Second, we analyzed the 3 ct gemstone itself in the 7000–400 cm^{-1} region with a Pye-Unicam 9624 Fourier-transform infrared (FTIR) spectrometer and a Specac 5 \times beam condenser, recording 200 scans at 4 cm^{-1} resolution. In the absence of polarization accessories, mid-infrared spectra were taken in beam directions oriented nearly parallel (||) and perpendicular (\perp) to the optic axis of the gemstone. The two methods were used because gemstones measuring several millimeters in thickness, when recorded in the transmission mode (e.g., with a beam condenser), show total absorption

below about 2000 cm^{-1} but very strongly enhanced absorption characteristics above 2000 cm^{-1} , whereas the KBr pellet will produce spectra in the region below 2000 cm^{-1} (the fingerprinting region) but very little detail above that. The reason for this is the extreme difference in optical path length of the IR beam through the pulverized sample in a KBr pellet (on the order of $1\text{ }\mu\text{m}$) and through the bulk of a gemstone (here 6–7 mm).

Raman analysis was conducted with a Renishaw 2000 Raman microspectrometer equipped with a helium/cadmium laser (excitation at 325 nm) and an argon-ion laser (excitation at 514.5 nm). In the absence of polarization accessories, Raman spectra were taken in beam directions oriented nearly parallel and perpendicular to the optic axis of the gemstone.

Quantitative chemical composition was determined by laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS), which is capable of measuring major, minor, and trace elements (see, e.g., Longerich et al., 1996; Günther and Heinrich, 1999). LA-ICP-MS analyses were taken a total of four times, with five ablations (i.e., few-nanogram samples) taken each time for a statistical result. The level of detection that this technique permits is on the order of less than 1 ppm, which makes it much more sensitive than some of the more traditional energy-dispersive chemical analyses techniques, such as SEM-EDS or EDXRF. In addition, a much wider range of elements may be detected than is possible by these other techniques.

TABLE 1. Gemological properties of poudretteite.

Property	Mogok	Mont Saint-Hilaire ^a
Weight	3.00 ct	Not reported (tiny crystals)
Color	Purple-pink	Colorless to very pale pink
Hardness (Mohs scale)	Not tested	Approximately 5
Refractive index	$n_o = 1.511$, $n_e = 1.532$	$n_o = 1.516$, $n_e = 1.532$
Birefringence	0.021	0.016
Optic character	Uniaxial positive	Uniaxial positive
Specific gravity	2.527	2.511 (measured) 2.53 (calculated)
Pleochroism	Strong; saturated purple-pink parallel to the c-axis (o-ray); near-colorless to pale brown perpendicular to the c-axis (e-ray)	Not described
UV fluorescence	Inert	Inert
Visible absorption spectrum	No distinct lines; a faint, broad band centered at approximately 530 nm	Not described

^aFrom Grice (1987).

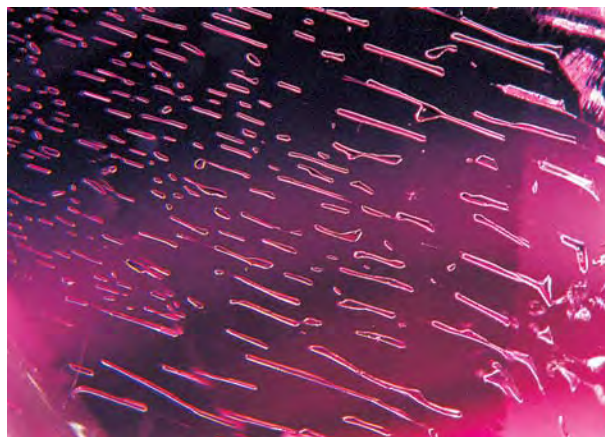


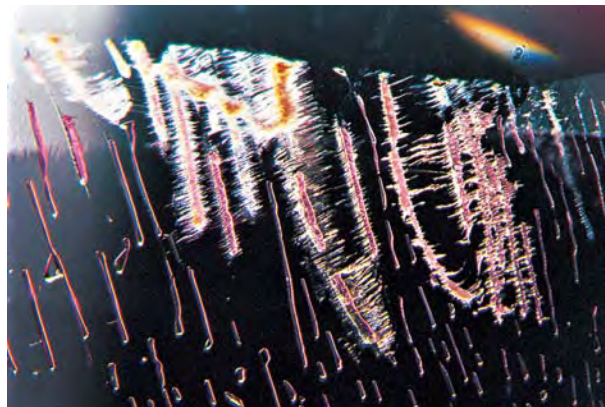
Figure 2. A healed fissure that traverses one side of this extraordinary gemstone consists of equidimensional-to-oblong liquid and liquid-gas inclusions in a parallel formation. Photomicrograph by C. P. Smith; magnified 28 \times .

RESULTS

Gemological Characteristics. *General Description.* The gemstone weighs 3.00 ct and is fashioned into a cushion shape, with a brilliant-cut crown and a step-cut pavilion. Its measurements are $7.97 \times 7.91 \times 8.62\text{ mm}$. Face-up, it displays a saturated purple-pink hue (again, see figure 1). However, when the stone is tilted in certain directions, the color appears much less intense (refer to Pleochroism in table 1, and Color Zoning below).

Physical Properties. In table 1, the physical properties are compared to the data previously reported for poudretteite from Quebec. We found no significant differences in the properties of this gem material as

Figure 3. Just below the surface of the stone, oblong and angular negative crystals in the healed fissure are associated with a series of small, parallel fissures. Photomicrograph by C. P. Smith, magnified 32 \times .



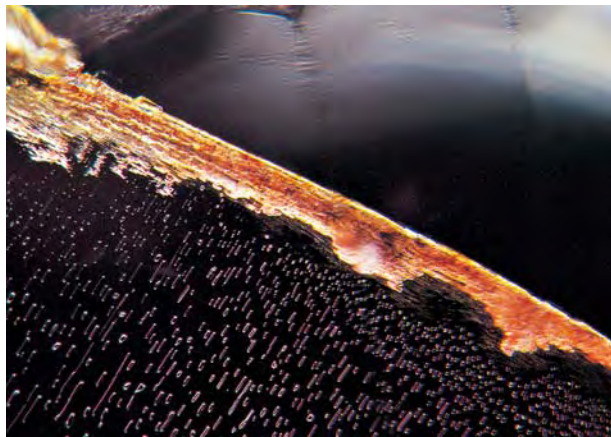


Figure 4. The innermost extension of the healed fissure is delineated by a narrow channel. Clearly evident in this image is the irregular outline and very coarse surface texture of this channel, which is filled with an orange-brown epigenetic material. Photomicrograph by C. P. Smith; magnified 30 \times .

compared to those reported for poudretteite from Mont Saint-Hilaire.

Inclusions. The specimen is transparent and gem quality, with only a few inclusions present. One side of the gem is traversed by a healed fissure within which are equidimensional-to-oblong liquid or liquid-gas inclusions (figure 2). Just below the surface, this healed fissure also contains a series of oblong and angular negative crystals that are associated with a series of small fissures all oriented parallel to one another (figure 3). The innermost extension of the healed fissure is delineated by a long, irregular, coarsely textured etch channel that has been filled

Figure 6. A few coarse aggregates of small, colorless-to-white crystals in the poudretteite were identified as feldspar. Photomicrograph by C. P. Smith; magnified 70 \times .

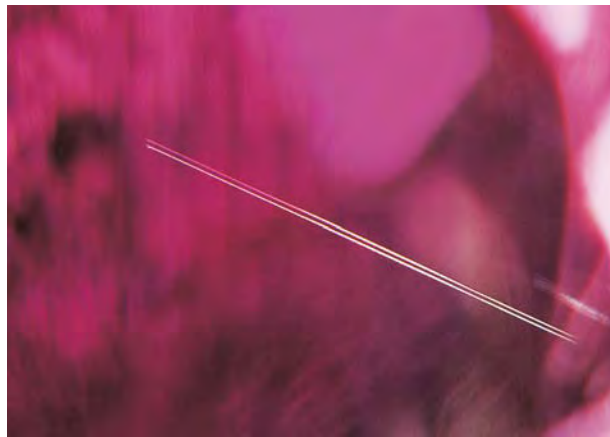
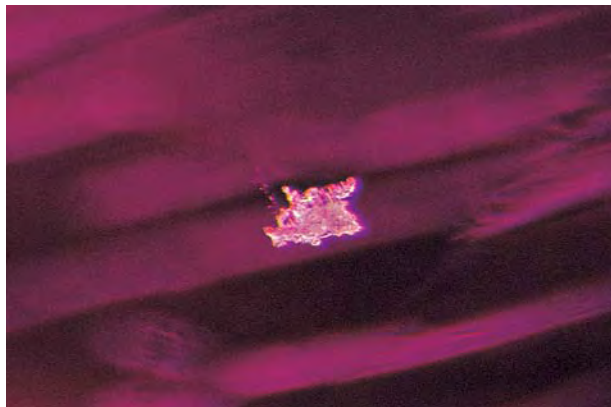
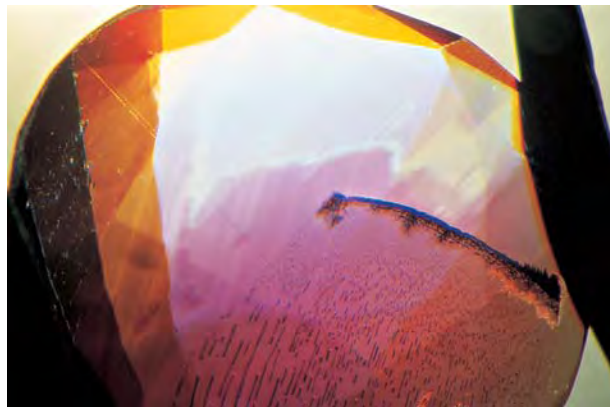


Figure 5. Very fine growth tubes were also noted in the poudretteite. Here a needle-like growth tube appears doubled as a result of birefringence. Photomicrograph by C. P. Smith; magnified 32 \times .

with an opaque orange-brown material (figure 4). Also present are a few needle-like growth tubes (figure 5) and small aggregates of pinpoint inclusions. A few coarse aggregates of larger crystals (figure 6) were identified as feldspar by Raman analysis.

Internal Growth Structures and Color Zoning. When immersed in a near-colorless oil mixture (R.I. \sim 1.51), the poudretteite showed distinct color zoning and growth features parallel to the optic axis (figure 7). An

Figure 7. Distinct color zoning and subtle growth structures were noted in the faceted poudretteite. As evident here in immersion, one stage of the crystal growth is characterized by an intense coloration, with no significant growth structures visible, whereas the outer stages beyond this intense coloration show less uniform, weaker color zoning and more developed growth structures parallel to the prism faces. The irregular outline of the intense color zone corresponds to a period in which the original crystal experienced heavy etching. Photomicrograph by C. P. Smith; magnified 7 \times .



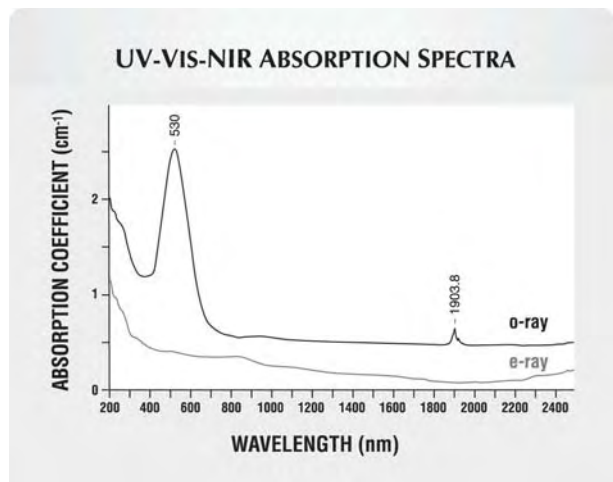


Figure 8. For the “ordinary ray,” the UV-Vis-NIR spectrum of the 3 ct poudretteite exhibits a strong and broad absorption band centered at approximately 530 nm and a sharp peak at 1903.8 nm, accompanied by weak sidebands. In the “extraordinary ray” spectrum, these features are completely absent. The dominant absorption band centered at 530 nm in the green region of the visible spectrum is responsible for the intense purple-pink color of the poudretteite. In contrast, the weak absorption slope in the visible region (from 380 to 760 nm) of the e-ray spectrum causes a nearly colorless to pale brown hue in that direction.

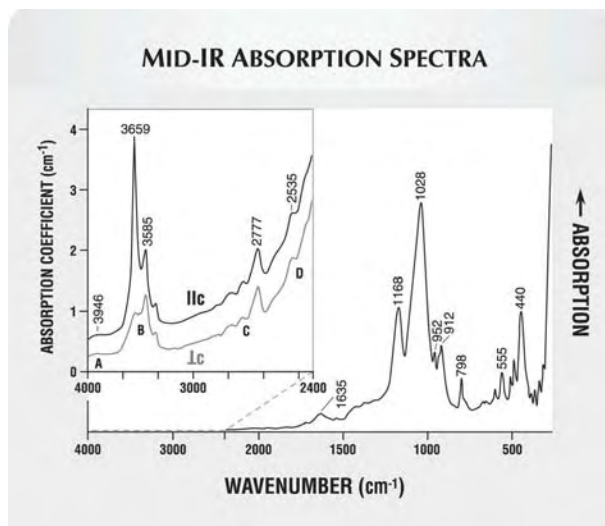
intense purple-pink color concentration was present in approximately two-thirds of the stone. No significant growth structures were visible in this highly saturated region. The boundary of this color zone was very irregular but distinct, in that it was closely paralleled by a very narrow, essentially colorless zone. The area of growth adjacent to that zone consisted of a series of planar and angular growth structures that did not repeat the irregular contours of the other two growth zones. These growth planes were oriented parallel to prism faces and consisted of alternating near-colorless and pale purple-pink bands. No twinning or other growth structures were observed.

X-ray Crystallography. A powder diffraction analysis resulted in a distinct pattern of 29 clearly resolved X-ray reflections. The three dominant “lines” are at 5.12, 3.26, and 2.82 Å. The complete X-ray powder diffraction pattern is virtually identical to the type material from Quebec. The unit-cell parameters were refined to be $a = 10.245 (2) \text{ \AA}$ and $c = 13.466 (5) \text{ \AA}$.

Advanced Analytical Techniques. UV-Vis-NIR Spectroscopy. The polarized optical absorption spectra of the poudretteite (figure 8) revealed a very strong, wide band centered at approximately 530 nm for the “ordinary ray” (light vibration perpendicular to the optic axis). In contrast, the “extraordinary ray” (light vibration parallel to the optic axis) showed no 530 nm band but an absorption continuum gradually decreasing from the UV region to the NIR. The 530 nm band is the main color-causing absorption in the visible range of the spectrum. In the near-infrared region (750–2500 nm), we recorded a sharp absorption structure consisting of four bands, with the main band located at 1903.8 nm and very weak side bands at 1898, 1909, and 1911 nm for the ordinary ray. The extraordinary ray did not show any absorption bands in this area. As a result of these different absorption behaviors, the poudretteite displays strong dichroism.

In the UV region, the poudretteite specimen revealed an unfamiliar degree of transparency below 300 nm. Even at 200 nm, the poudretteite

Figure 9. The mid-infrared spectrum of a microsample (<0.001 ct) of poudretteite in a KBr pellet shows the characteristic pattern of poudretteite. The spectral region of approximately $3700\text{--}2300 \text{ cm}^{-1}$ was corrected for artifacts due to water adsorbed by the KBr pellet and an organic impurity. In the inset, the spectra were recorded with a beam direction parallel and perpendicular to the optic axis of the faceted sample, and show a single absorption band A and the series of bands B, C, and D. The 3659 and 3585 cm^{-1} bands are the only ones to exhibit anisotropic behavior and suggest OH stretching modes.



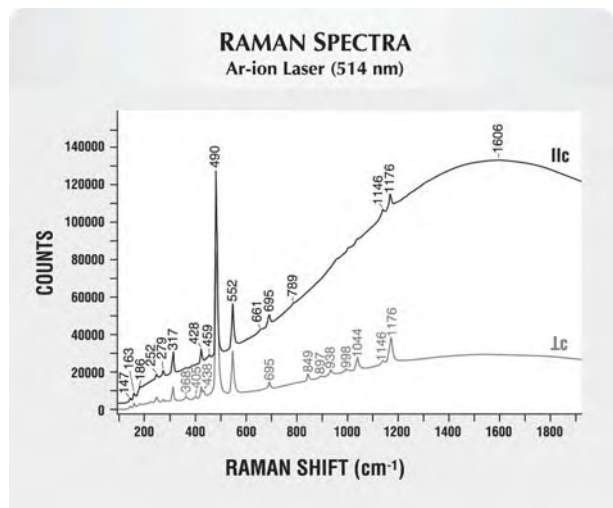


Figure 10. Raman spectra taken with 514 nm laser excitation showed variations in the relative intensities of the three dominant bands present, as well as in some subordinate bands. The dominant peaks for the spectrum taken with the beam direction parallel to the *c*-axis are at 490, 552, and 317 cm^{-1} ; a broad, overlying photoluminescence band centered at about 1500–1600 cm^{-1} masks some of the weaker Raman bands. These weaker bands are clearly seen in the spectrum taken perpendicular to the *c*-axis, which has dominant peaks at 490, 552, and 1176 cm^{-1} .

only reached a moderate absorption level but not total absorption.

Mid-Infrared Spectroscopy. The mid-infrared spectrum of poudretteite recorded for the KBr pellet revealed eight dominant bands, as labeled in figure 9, as well as several weaker bands.

Mid-infrared spectra also were recorded for the 3 ct gem with its optic axis oriented as closely parallel and then perpendicular to the infrared beam as possible. Figure 9 (inset) shows the 4000–2400 cm^{-1} region, which is a continuation of the spectra presented in figure 8. A single absorption band and three series of bands were recorded in both spectra, located at (A) 3940 cm^{-1} , (B) 3659, 3630, 3585, 3512 cm^{-1} , (C) 3455, 3380, 3265, 3175, 3080, 2975, 2890, 2777 cm^{-1} , and (D) 2535, 2435 cm^{-1} . The intensity of the bands A, C, and D did not reveal any dependence on the direction of the transmitted IR beam. In contrast, the bands at 3659 and 3585 cm^{-1} in group B exhibited a pronounced anisotropy.

Raman Analysis. In general, the same Raman peaks were present in both spectra recorded with the two

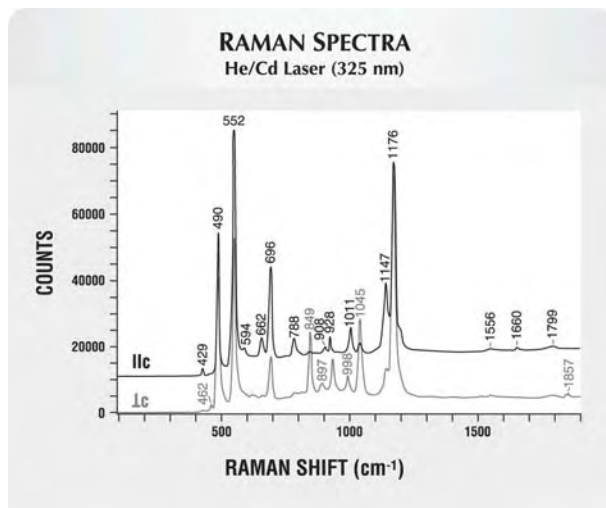


Figure 11. Raman spectra taken with 325 nm laser excitation also showed a change in the relative intensities of the dominant and subordinate bands, with dominant peaks at 552, 1176, and 696 cm^{-1} with the beam direction parallel to the *c*-axis and at 1176, 490, and 552 cm^{-1} perpendicular to *c*.

lasers. However, their relative intensities varied and, in the case of the spectrum taken with the Ar-ion laser parallel to the *c*-axis, some Raman bands were masked by a dominant overlying photoluminescence band.

The Raman bands recorded at ambient temperature with the Ar-ion laser are illustrated in figure 10. The three dominant bands (in descending order of intensity) are: 490, 552, and 317 cm^{-1} $\parallel c$ and 490, 552, and 1176 cm^{-1} $\perp c$. The Raman bands recorded with the He/Cd laser are illustrated in figure 11. The three dominant bands are 552, 1176, and 696 cm^{-1} $\parallel c$ and 1176, 490, and 552 cm^{-1} $\perp c$.

Chemical Analysis. Of the four analyses taken, two were performed in the highly saturated region and two in the colorless to near-colorless region. Statistically, all analyses were highly consistent with regard to major elements: SiO_2 (78.99 wt.%), B_2O_3 (10.53–11.03 wt.%), Na_2O (6.20–6.53 wt.%), and K_2O (3.45–4.09 wt.%). These major-element concentrations are in good agreement with the data obtained by Grice et al. (1987): SiO_2 (77.7 wt.%), B_2O_3 (11.4 wt.%), Na_2O (6.2 wt.%), K_2O (5.2 wt.%). In addition, more than 30 other elements were measured (ranging from Li to U). Of these, 21 trace elements were detected at the ppm (parts per million) level. Two of these trace elements displayed a consistently higher concentration in the saturated

region as compared to the near-colorless one: Li (14 ppm and 9–10 ppm, respectively) and Mn (49–52 ppm and 16–21 ppm). Others revealed an opposite correlation: Ca (32–55 ppm and 79–132 ppm, respectively), Rb (83–86 ppm and 112–114 ppm), and Cs (8 ppm and 9–10 ppm). Be, Mg, Al, Ti, V, Cr, Fe, Ni, Cu, Zn, Ga, Sr, Zr, Sn, Pb, and Bi revealed a high degree of variability but no apparent correlation between the different color regions.

DISCUSSION AND SUMMARY

It is likely that few gemologists will ever encounter a faceted poudretteite. The combination of refractive indices and specific gravity will readily separate it from amethyst, which is probably the only major commercially available gem material that it might be confused with. However, the visual appearance/color of poudretteite is also significantly different from that of amethyst. Poudretteite might also be confused with sugilite, some of which is translucent (as opposed to the typically encountered opaque material) and has been polished *en cabochon* and even rarely faceted (Shigley et al., 1987). Although the color of these two materials is more similar, poudretteite is a transparent mineral, while sugilite is, even in its best quality, translucent. In addition, the refractive index (approximately 1.60) and specific gravity (ranging from 2.74 to 2.80) of sugilite are significantly higher than that of poudretteite.

The main color-causing absorption centered at 530 nm is not yet fully understood and requires further analytical investigation. However, we can discuss potential mechanisms based on the trace-element composition. Manganese is the primary color-causing element of the similarly colored member of the osumilite/milarite group, sugilite, which has a dominant broad absorption band at approximately 556 nm (see, e.g., Shigley et al., 1987). It is not surprising that there was considerable variation in Mn concentration between the near-colorless and highly saturated areas of the poudretteite (averaging 16–21 ppm and 49–52 ppm, respectively, although this is surprisingly low for so intense a color). Substitution of cations by divalent and trivalent transition metal ions is the most frequent cause of color in silicates. Manganese (as Mn^{2+} or Mn^{3+}) is a common cause of pink to red and purple coloration in a variety of other gem-quality silicate minerals, such as red beryl and tourmaline, as well as the carbonate rhodochrosite

(see, e.g., Fritsch and Rossman, 1987, 1988). However, other trace elements or possibly color centers may also have an influence in producing the intense purple coloration.

The intensity of the group B peaks in the mid-infrared region (again, see figure 9 inset) differ when recorded parallel and perpendicular to the optic axis. This indicates that the 3659 and 3585 cm^{-1} bands are anisotropic. These bands suggest OH stretching. In addition, the 1635 cm^{-1} band indicates H_2O bending, and the band structure centered at 1903.8 nm (5253 cm^{-1}) represents the combination of these stretching and bending modes (E. Libowitzky, pers. comm., 2003). Within poudretteite, H_2O molecules are likely to be positioned in the channels of the ring silicate structure.

As would be expected for a uniaxial mineral, the Raman spectra of poudretteite are polarized parallel and perpendicular to the c-axis. This includes a change in the relative intensities of the three dominant bands, as well as variations in several subordinate bands. In addition, depending on which laser was used to obtain the Raman signal, distinct differences in the three dominant peaks were identified when measurements were taken parallel to the c-axis direction, whereas only slight variations in relative peak intensities were noted for the measurements taken perpendicular to the c-axis.

The chemical composition determined by LA-ICP-MS for the study sample is in good agreement with previous chemical data reported by Grice et al. (1987). However, the list of elements has been significantly extended by several trace elements present at concentrations as low as 1 ppm.

Not unlike the unique alkali gabbro-syenite geology of the Mont Saint-Hilaire region, the complex geology of the Mogok Stone Tract has also produced a special environment for the prolific growth of minerals of sufficient size and transparency that they can be considered gem quality. Contact and regional metamorphism in the Mogok area is well known for providing the geologic environment for rare gems to form (e.g., painite), and the region plays host to a wide variety of gem materials, including many silicates.

CONCLUSION

Gemologists continue to be excited by the discovery of minerals that have never before been seen in a transparency and size suitable for faceting (see, e.g., McClure, 2002; Schmetzer et al., 2003). When such

rarities are encountered, they present unique opportunities to expand the science of gemology and mineralogy. Such is the case with the recent identification of the faceted 3.00 ct intense purple-pink specimen of poudretteite from Myanmar. Prior to this find, the seven crystals of poudretteite known to exist were small, pale in color, and came from a single quarry in Quebec, Canada, during the 1960s.

The data obtained during this study are in agreement with those documented by past researchers for poudretteite from Canada. In addition to confirming the standard physical/gemological properties of this mineral, analysis of this gemstone also permitted the authors to significantly expand the documentation of poudretteite, specifically in terms of its spectral characterization and chemical composition.

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ACKNOWLEDGMENTS

The authors thank Federico Barlocher, Lugano, Switzerland, for submitting the 3.00 ct poudretteite for identification and permitting us to publish the results of our research. The following kindly provided fruitful discussions: Dr. A. A. Levinson of the University of Calgary, Canada; Prof. Eugen Libowitzky of the University of Vienna, Austria; and Dr. Joel Grice, research scientist, Canadian Museum of Nature, Ottawa, Canada.

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THE FIRST TRANSPARENT FACETED GRANDIDIERITE, FROM SRI LANKA

By Karl Schmetzer, Murray Burford, Lore Kiefert, and Heinz-Jürgen Bernhardt

Gemological, chemical, and spectroscopic properties are presented for the first known transparent faceted grandidierite. This jewelry-quality 0.29 ct stone was fashioned from rough reportedly found in the Kolonne area of Sri Lanka. The greenish blue borosilicate has refractive indices of 1.583 to 1.622, which correlate to a low iron content of 1.71 wt.% FeO and readily separate it from the gem material closest in properties, lazulite.

Grandidierite, a magnesium-aluminum borosilicate, $MgAl_3BSiO_9$, is mentioned only rarely as a “possible” blue gemstone (Ostwald, 1964), although the existence of faceted stones has been reported occasionally in the gemological literature (see, e.g., Mitchell, 1977). However, the samples available to date as faceted stones or cabochons, all originating from southern Madagascar, are opaque—never transparent—or at best translucent (Arem, 1987). This article describes the first transparent faceted grandidierite, which is also the first faceted grandidierite reported from Sri Lanka.

Grandidierite occurs in pegmatites, contact metamorphic rocks (hornfelses), and high-grade (granulite facies) metamorphic rocks; worldwide about 40 localities are known (Grew, 1996). Grandidierite was first discovered in a pegmatitic environment at Andrahomana near Taolanaro (formerly Fort Dauphin) in southeastern Madagascar (Lacroix, 1902, 1904). The orthorhombic mineral was named by Lacroix after Alfred Grandidier, one of the French explorers of Madagascar. Lacroix described the nontransparent material as both massive (1902) and forming crystals as long as 8 cm (1904). The color of grandidierite from

different localities is described as blue, greenish blue, blue-green, and bluish green.

The Kolonne area of Sri Lanka, which is located approximately 8 km south-southeast of Rakwana, near Ratnapura, has become known for some rare gem materials such as sapphirine (Harding and Zoysa, 1990), olivine with a high iron content (Burford and Gunasekera, 2000), and—most recently—the Ca-Mg-Al borosilicate serendibite (Schmetzer et al., 2002). In 2000 while in Ratnapura, one of the authors (MB) purchased the grandidierite described in this article, reportedly from the Kolonne area, as an 0.85 ct crystal fragment. After faceting, the rough yielded a 0.29 ct greenish blue transparent gemstone (figure 1).

The Sri Lankan seller offered the rough gem (on the basis of its color) as a “possible serendibite.” The original flat, tabular crystal did not appear to be water worn. Probably it was mined from a primary deposit, as is the case for most sapphirine from high-grade metamorphic host rocks in the Kolonne area (see again Harding and Zoysa, 1990). Based on some initial testing, the owner believed that the stone might be the rare gem mineral grandidierite and sent it to the senior author (KS) for additional tests and confirmation.

MATERIALS AND METHODS

The faceted grandidierite was tested by standard gemological methods for refractive indices, optic character, specific gravity, and fluorescence to long- and short-wave ultraviolet radiation, as well as the

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GEMS & GEMOLOGY, Vol. 39, No. 1, pp. 32–37.

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spectrum seen with a handheld spectroscope. We also used standard microscopic techniques to examine the internal features under different lighting conditions, both with and without immersion liquids. After some experimentation with the immersion microscope, we were able to orient the sample in such a way that, when it was rotated, we could observe the interference figures along both optic axes. This enabled direct measurement of the $2V$ angle and determination of the orientation of the indicatrix within the cut gemstone, especially relative to the table facet, which was necessary for the determination of maximum pleochroism.

To confirm the identification indicated by the gemological properties, we scraped a minute amount of material from the girdle to conduct X-ray powder diffraction analysis with a Gandolfi camera. Given the rarity of this material, we also examined the powder pattern of a known non-gem-quality sample from Madagascar to ensure the accuracy of the pattern in the data base. To further characterize the sample, we performed quantitative chemical analysis using a Cameca Camebax SX 50 electron microprobe to obtain 15 point analyses from a traverse across the table of the gemstone.

In addition, polarized UV-Vis (300–800 nm) absorption spectra were recorded using a Cary 500 Scan spectrophotometer. Infrared spectroscopy was performed with a PU 9800 Fourier-transform infrared (FTIR) spectrophotometer using a diffuse reflectance device. In addition, we analyzed the sample and its solid inclusion by laser Raman microspectrometry using a Renishaw 1000 system.

RESULTS

Gemological Properties. The gemological properties of the 0.29 ct faceted sample (table 1) were consistent with grandidierite. Unlike most known grandidierites, however, this greenish blue stone was transparent with only a few inclusions. On the basis of interference figures, the optic axes were found to be at inclinations of about 5° and 20° , respectively, to the girdle of the stone. Consequently, with the known orientation of the indicatrix in grandidierite ($a = X$, $b = Z$, $c = Y$), it was established that the table is roughly parallel to the crystallographic (010) plane. Given this established orientation, the pleochroic colors of both X (greenish blue) and Y (very pale yellow, almost colorless) can be observed in a view perpendicular to the table facet, while the Z color (blue-green) is visible parallel to the table of the stone (that



Figure 1. This 0.29 ct grandidierite is the first known transparent faceted sample of this material and the first gem-quality sample from Sri Lanka. Photo by Maha Tannous.

is, along the girdle). The measured optic axis angle $2V_x$ is in good agreement with the value we calculated from the measured refractive indices.

TABLE 1. Gemological properties of the 0.29 ct transparent faceted grandidierite from Sri Lanka.

Property	Description
Weight	0.29 ct
Size	4.82 × 4.63 × 2.23 mm
Clarity	Transparent
Color	Greenish blue
Pleochroism (strong)	
X	Greenish blue
Y	Very pale yellow, almost colorless
Z	Blue-green
Refractive indices	
n_x	1.583 ± 0.002
n_y	1.620 ± 0.002
n_z	1.622 ± 0.002
Birefringence	0.039
Optic character	Biaxial negative
Optic axis angle	
$2V_x$ (meas.)	$25^\circ \pm 3^\circ$
$2V_x$ (calc.)	25.7°
Specific gravity	2.96 ± 0.02
UV fluorescence	
long-wave	Inert
short-wave	Inert
Handheld spectroscope	Line at 479 nm
Microscopic features	Parallel growth planes in two directions; needle-like channel, partly filled with polycrystalline, birefringent matter; small fractures



Figure 2. This needle-like channel in the faceted grandidierite from Sri Lanka is filled with a polycrystalline material. Unfortunately, there was not a sufficient amount of this polycrystalline material to identify it by Raman analysis. Note also, to the left, one of two fractures seen in the stone. Photomicrograph by H. A. Hänni; magnified 40 \times .

Features Observed with the Microscope. The sample revealed two series of parallel growth planes, but no distinct color zoning was associated with this growth pattern. The grandidierite was slightly included: One needle-like channel, partly filled with a polycrystalline birefringent material (figure 2), was observed, as were two unhealed fractures (see, e.g., figure 2). Raman analysis provided no identification for the polycrystalline material.

X-ray Diffraction Analysis. The X-ray powder diffraction pattern of the faceted stone was consistent with the published pattern for grandidierite (see, e.g., McKie, 1965) and the pattern of our own control sample from Madagascar.

Chemical Composition. The electron microprobe results are averaged in table 2; no chemical zoning was evident from the 15 points analyzed. Only 1.71 wt.% FeO (average) was measured, and traces of chromium also were present.

Spectroscopic Properties. UV-Visible. Due to the crystallographic orientation of the faceted grandidierite, we could record polarized spectra only perpendicular to the table facet. With this orientation, we obtained spectra parallel to X (greenish blue) and Y (very pale yellow), as illustrated in figure 3. The

spectrum parallel to X reveals a strong absorption band in the red at about 737 nm and an increasing absorption from the greenish blue minimum to the UV range. The Y spectrum consists of an increasing absorption from the red to the blue and ultraviolet range. In both spectra, as labeled in figure 3, several small absorption bands are found in the visible and ultraviolet range, with the most distinctive band at 479 nm in the Y spectrum, which also can be seen with a handheld spectroscope.

Infrared and Raman. The nonpolarized infrared spectrum showed several absorption maxima in the 4000–2000 cm^{-1} range (figure 4). Below 2000 cm^{-1} , the general absorption was too strong to record a spectrum of usable quality. The Raman spectrum consisted of numerous lines in the 200–1200 cm^{-1} range, the strongest of which occurred at 492, 659, 717, 868, 952, 982, and 993 cm^{-1} (figure 5).

DISCUSSION

The chemical composition of our faceted sample from Sri Lanka is consistent with the theoretical

TABLE 2. Chemical composition of a gem-quality grandidierite from Sri Lanka.

Oxides (wt.%) ^a	
SiO ₂	20.20
TiO ₂	0.01
Al ₂ O ₃	52.64
B ₂ O ₃ ^b	11.91
Cr ₂ O ₃	0.07
V ₂ O ₃	0.01
FeO ^c	1.71
MnO	0.03
MgO	12.85
CaO	0.01
Total	99.44
Cations per 9 oxygens	
Si	0.983
Ti	—
Al	3.017
B	1.000
Cr	0.002
V	—
Fe	0.070
Mn	0.001
Mg	0.932
Ca	0.001

^a Electron microprobe analysis, average of 15 point analyses.

^b Calculated for B = 1.000, according to the theoretical formula MgAl₃BSiO₉.

^c Total iron as FeO.

formula for grandidierite, $MgAl_3BSiO_9$, or $(Mg, Fe^{2+})Al_3BSiO_9$. The analytical data for this sample (again see table 2), as has been reported for translucent low-iron-bearing grandidierite from Madagascar (see table 3), indicate some replacement of magnesium by iron. In this mineral, only smaller fractions of its iron content are found as Fe^{2+} in Al sites, with minor Fe^{3+} also present in the Mg and/or Al sites (Stephenson and Moore, 1968; Seifert and Olesch, 1977; Qiu et al., 1990; Farges, 2001; Wilke et al., 2001).

The refractive indices of grandidierite and ominelite ($Fe^{2+}, MgAl_3BSiO_9$ —the recently described Fe analogue of grandidierite (Hiroi et al., 2002)—are closely related to the iron content; with increasing Fe, the R.I. also increases (table 3). With increasing iron values, specific gravity in grandidierite also increases, from 2.91 to 2.99 (Olesch and Seifert,

Figure 3. Absorption spectra of the grandidierite in the UV-Vis range parallel to X (greenish blue) and Y (very pale yellow) show a strongly polarized absorption band in the red and several other weak absorption bands.

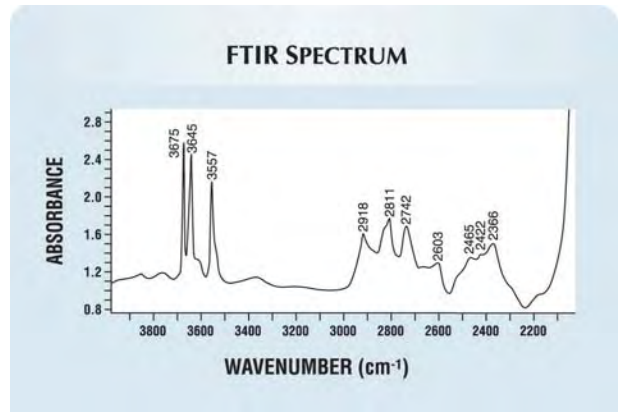
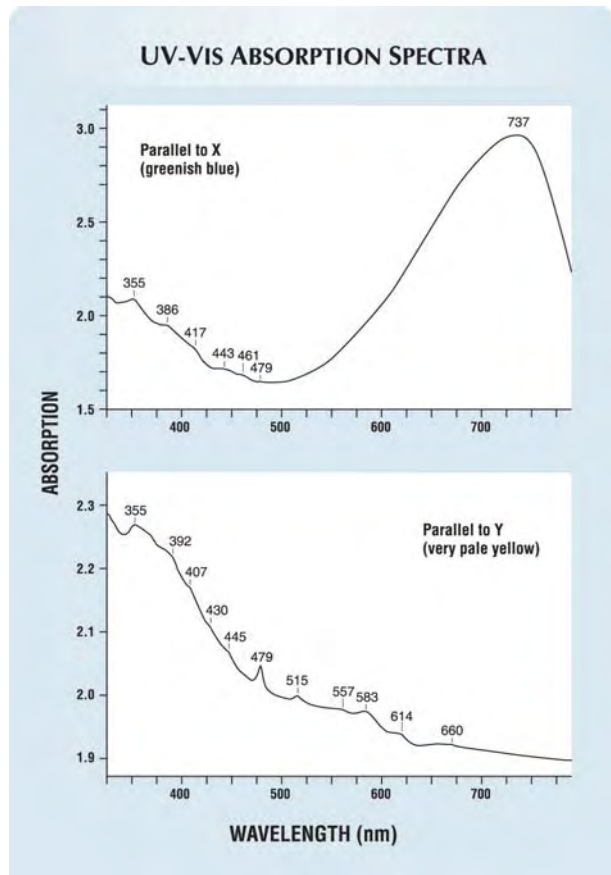
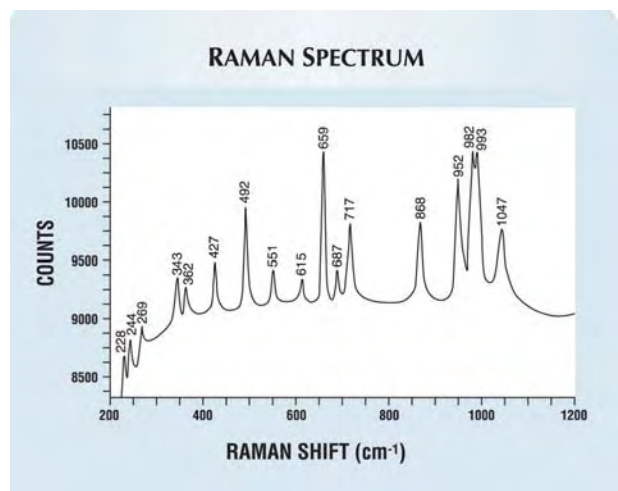


Figure 4. The nonpolarized infrared spectrum of the grandidierite shows numerous bands that are characteristic of this mineral.

1976). The properties of our faceted sample fit within this trend.

The material described by Lacroix was relatively rich in iron (with FeO above 10 wt.%) and had refractive indices of n_x 1.6018 and n_z 1.6385. Grandidierite samples from other localities in southern Madagascar, on the other hand, had lower iron contents (1–5 wt.% FeO) and, accordingly, lower refractive indices of n_x 1.580–1.590 and n_z 1.620–1.629 (McKie, 1965; von Knorring et al., 1969; Black, 1970). These data are more consistent with the values mentioned for the semitransparent gem material reported to date (Mitchell, 1977; Arem, 1987; see also Farges, 2001).

Figure 5. The Raman spectrum of the transparent grandidierite from Sri Lanka also revealed several bands that appear to be characteristic of this rare gem material.



The pleochroism of grandidierite is described in numerous papers (see, e.g., the references cited in table 3) as X = blue, greenish blue, or blue-green; Y = colorless; and Z = greenish blue, blue-green, or green. The pleochroism of our faceted sample is consistent with this general description, except that Y, which is colorless in thin section, appears pale yellow in thicker samples such as ours.

Rossmann and Taran (2001) described polarized absorption spectra in the visible-to-infrared range for grandidierite from Metroka, Madagascar, that contained 1.10 wt.% FeO. Four strongly polarized absorption bands in the visible and near-infrared regions were measured and assigned to Fe²⁺ in five-fold magnesium coordination. Two of the three spectra illustrated in that article are identical to the two spectra recorded on our Sri Lankan sample: Our X spectrum (greenish blue) is identical to the a spectrum, and our Y spectrum (slightly yellowish) is identical to the g spectrum in the article cited. (According to G. Rossmann [pers. comm., 2002], the labels for b and g were inadvertently transposed in that article; thus, our Y spectrum is identical to the spectrum he and Taran recorded for b. Corrected spectra appear at <http://minerals.gps.caltech.edu/files/visible/grandidierite>.)

No detailed assignment of the smaller absorption bands was possible, but as discussed above they most likely are caused by Fe²⁺ or Fe³⁺ in the Mg and/or Al sites of the grandidierite structure.

Infrared spectra in the 1500–400 cm⁻¹ range for

grandidierite were described by von Knorring et al. (1969) and Povarennykh (1970). At present, however, no detailed interpretation of our spectra in the 4000–2000 cm⁻¹ range is available, although there is always the possibility of impurities in the stone and small amounts of water in the structure.

The strongest lines in our Raman spectrum resemble the most characteristic lines in the Raman spectrum pictured by Maestrati (1989) for a grandidierite sample from Madagascar, but no detailed assignment of Raman bands was performed in that article. However, reference to both types of spectra, infrared and Raman, may be helpful for the identification of grandidierite.

There is almost no gem material known to date that might be mistaken for grandidierite. The closest—in terms of color, optical properties, and specific gravity—is low-iron-bearing lazulite, but this gem material always has somewhat higher refractive indices, with n_x above 1.600.

The Kolonne area in Sri Lanka is known to contain high-grade metamorphic rocks (Harding and Zoysa, 1990). Serendibite was also recently described from Kolonne as a new gem material (Schmetzer et al., 2002), and is another mineral typically formed in high-grade (granulite facies) metamorphic rocks. Previously, these two boron-bearing silicates were found in the same geographic area at only three localities (two in the U.S. and one in Madagascar: Grew et al., 1990, 1991; Nicollet, 1990). However,

TABLE 3. Refractive indices and iron content of grandidierite and ominelite from various localities.^a

Locality	n _x	n _y	n _z	(n _x +n _y +n _z)/3 ^b	FeO ^c (wt.%)	Reference
Synthetic	nr	nr	nr	1.603	0	Olesch and Seifert (1976)
Fort Dauphin, Madagascar	1.580	1.619	1.620	1.606	1.0	von Knorring et al. (1969)
Vohiboly, Madagascar	1.587	1.618	1.622	1.609	1.1	Black (1970)
Kolonne, Sri Lanka	1.583	1.620	1.622	1.608	1.71	This study
Sakatelo, Madagascar	1.590	1.618	1.623	1.610	3.59	McKie (1965)
Cuvier Island, New Zealand	1.590	1.624	1.628	1.614	4.7	Black (1970)
Ampamatoa, Madagascar	1.590	1.626	1.629	1.615	5.0	Black (1970)
Cuvier Island, New Zealand	1.593	1.628	1.633	1.618	6.7	Black (1970)
Rhodesia	nr	nr	nr	1.622	6.93	Olesch and Seifert (1976); Seifert and Olesch (1977)
Mt. Amiata, Italy	1.5982	1.6290	1.6346	1.621	7.75	Van Bergen (1980)
Andrahomana, Madagascar	1.6018	1.6360	1.6385	1.625	10.80	Lacroix (1904)
Tenkawa, Japan	1.631	1.654	1.656	1.647	19.37	Hiroi et al. (2002)

^a All data are for grandidierite, (Mg, Fe²⁺)Al₃BSiO₉, except Hiroi et al. (2002) for ominelite, (Fe²⁺, Mg)Al₃BSiO₉, the Fe analogue of grandidierite. Abbreviation: nr = not reported.

^b Calculated average refractive index; see also Olesch and Seifert (1976).

^c Total iron calculated as FeO.

the two minerals occur together in the same rock at only one locality (Adirondack Mountains, Russell, New York; Grew et al., 1990).

CONCLUSION

The first known transparent faceted grandidierite, reportedly from the Kolonne area of Sri Lanka, is

characterized with regard to gemological, chemical, and spectroscopic properties. The relatively low refractive indices (1.583–1.622) are related to the relatively low iron content of the sample (1.71 wt.% FeO). Previously, only semitransparent material from Madagascar had been described in gemological publications. With the data presented, this material is readily identifiable by standard gemological methods.

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ACKNOWLEDGMENTS: The authors are grateful to Dr. O. Medenbach of Ruhr-University, Bochum, Germany, for performing X-ray diffraction, and to P. Giese of SSEF for his assistance recording various spectra. Dr. H. A. Hänni of SSEF critically reviewed the original manuscript.

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DIAMOND

With Fracture Filling to Alter Color

The two nonpermanent diamond enhancements seen most often in the laboratory are surface coating and fracture filling. Surface coating is used to improve or alter the color of a gem. One particularly noteworthy example we reported on years ago was a 10.88 ct light yellow emerald-cut diamond that was coated with pink fingernail polish so it could masquerade as a natural-color pink diamond that had been stolen (see Summer 1983 Lab Notes, pp. 112–113). While fracture filling is used to improve apparent clarity, in some instances it will have

Figure 1. This 0.20 ct “pink” diamond shows uneven color distribution. With strong direct lighting (inset), the pink hue seems to be confined to the two eye-visible fractures, whereas the rest of the stone appears to be near colorless.



the additional effect of improving color appearance. For example, in the Winter 1997 Lab Notes (pp. 294–295), we reported on a 1.39 ct Fancy Intense pink square emerald cut that had been fracture filled several times, which reduced the “whiteness” of the fractures and resulted in a more saturated color appearance. However, we had not seen a diamond that was fracture filled for the sole purpose of altering its color—with no attempt to improve apparent clarity—until the 0.20 ct “pink” round brilliant shown in figure 1 was submitted to the East Coast laboratory for origin of color and identification.

An unusual, uneven color distribution was first noticed during color grading. While it is not uncommon for pink diamonds to have uneven color distribution (see J. M. King et al., “Characterization and grading of natural-color pink diamonds,” Summer 2002 *Gems & Gemology*, pp. 128–147), in this particular diamond it appeared that the pink color was confined to the eye-visible fractures, whereas the rest of the diamond was near colorless (again, see figure 1). Magnification revealed that the pink color was in fact strictly confined to the fractures, with areas of concentrated color in a fluid-like pattern or “beads” (figure 2). This appearance, not unlike that seen in some clarity-enhanced diamonds, suggested that the diamond was filled with a fluid that subsequently hardened.

However, there apparently had been no effort to enhance clarity in



Figure 2. The pink coloring agent is not fully absorbed into the feather and has formed small “beaded” areas of concentrated pink color. Such beaded areas are often seen in clarity-enhanced diamonds. Magnified 45x.

this diamond, as the fractures remained quite obvious, with very high relief. The low refractive index of the filling material, along with its inherent color, suggested that it was not designed to match the refractive index of diamond. There also was no flash effect, as is commonly seen in clarity-enhanced diamonds. We can only assume that this filling was done solely to change the color of the diamond. Unfortunately, we were unable

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Gems & Gemology, Vol. 39, No. 1, pp. 38–46

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to identify the substance in the fractures. Following our practice of not issuing grading reports on filled diamonds, we returned the diamond to the client with an identification report declaring the treatment.

*Siau Fung Yeung and
Thomas Gelb*

Intensely Colored Type IIa, with Substantial Nitrogen- Related Defects

It is widely accepted that type IIa diamonds contain little if any nitrogen impurities. These diamonds are generally near colorless to colorless, or they are brown to pink, possibly due to plastic deformation. If a type IIa diamond is a color other than brown, the color is usually low in saturation. The East Coast laboratory recently examined two intensely colored type IIa diamonds (see figure 3), both of which displayed a substantial amount of nitrogen-related defects in the visible spectrum, but showed essentially no nitrogen-related absorption in the mid-infrared region.

A working definition of type II diamonds are those that do not show any appreciable absorption in the mid-infrared range from 1400 to 800 cm^{-1} when their spectra are plotted to give a maximum reading of 15 cm^{-1} in absorption coefficient (J. Wilks and E. Wilks, *Properties and Applications of Diamond*, Butterworth-Heinemann, Oxford, 1994, pp. 76–77). On this scale, the limit of detection is $\sim 0.1 \text{ cm}^{-1}$, which corresponds to a nitrogen concentration of 1–2 parts per million (ppm).

In nature, after being incorporated during diamond growth, the nitrogen impurities in most diamonds go through a complex aggregation process that involves both the isolated nitrogen atoms as well as other point defects such as vacancies. As a result, a large variety of nitrogen-related point defects and extended defects are possible; however, not all of them are infrared active (i.e., a diamond may contain nitrogen-bearing defects, but not display any absorption features in



Figure 3. These two intensely colored type IIa diamonds revealed unusual spectroscopic properties. The HPHT-annealed diamond on the left weighs 1.15 ct and was color graded Fancy Intense green-yellow. The natural-color diamond on the right weighs 4.15 ct and was color graded Fancy Vivid pinkish orange.

the mid-infrared range). Such defects include N3 (three nitrogen atoms around a vacancy), H3 (two nitrogen atoms plus a vacancy), H4 (four nitrogen atoms plus two vacancies), and N-V (one nitrogen atom plus a vacancy) centers. While it is theoretically possible that a type IIa diamond could contain enough IR-inactive nitrogen to significantly affect its color appearance, no such diamond has been recognized thus far, to the best of our knowledge. The two diamonds studied here could help provide additional information on type and color of diamond.

The first diamond (figure 3, left) was a 1.15 ct pear-shaped brilliant cut that had been subjected to high pressure/high temperature (HPHT) annealing. It was color graded Fancy Intense green-yellow. This diamond was also a “green transmitter,” that is, it showed very strong green luminescence to visible light. Diamonds that are HPHT annealed to this color typically are type Ia (see, e.g., I. M. Reinitz et al., “Identification of HPHT-treated yellow to green diamonds,” Summer 2000 *Gems & Gemology*, pp. 128–137). However, the infrared absorption spectrum of this diamond (figure 4, top) showed only a very weak absorption peak at

1344 cm^{-1} from isolated nitrogen (0.01 cm^{-1} in absorption coefficient). This corresponds to approximately 0.25 ppm of nitrogen, which fulfills the criterion for a type IIa diamond. In addition, the UV-Vis absorption spectrum (figure 5, top) showed a strong N3 absorption at 415 nm, and a strong H3 absorption at 503 nm with its side band centered around 470 nm. Both N3 and H3 are nitrogen-related defects. A relatively strong and broad absorption around 270 nm due to isolated nitrogen, and some sharp peaks related to H3 (364, 369, 374 nm) and isolated nitrogen (271 nm), were also observed.

A second type IIa diamond (figure 3, right), submitted shortly after the first, revealed similar infrared spectroscopic properties. However, this Fancy Vivid pinkish orange diamond, which weighed 4.15 ct, proved to be natural color. This cushion-shaped modified brilliant was one of the more strongly colored diamonds in this hue that the GIA laboratory has examined. This diamond showed no nitrogen-related absorption in the mid-infrared range (figure 4, bottom), which is consistent with the definition of type IIa. However, the UV-Vis absorption spectrum did reveal some unusual features

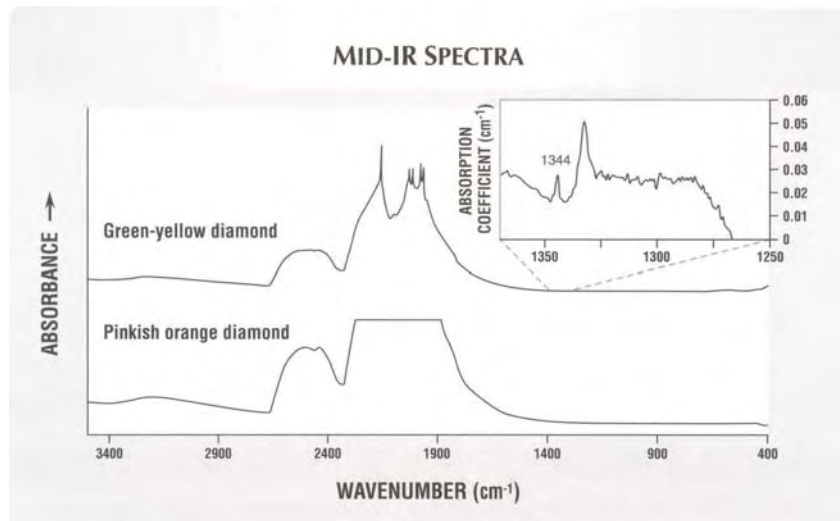
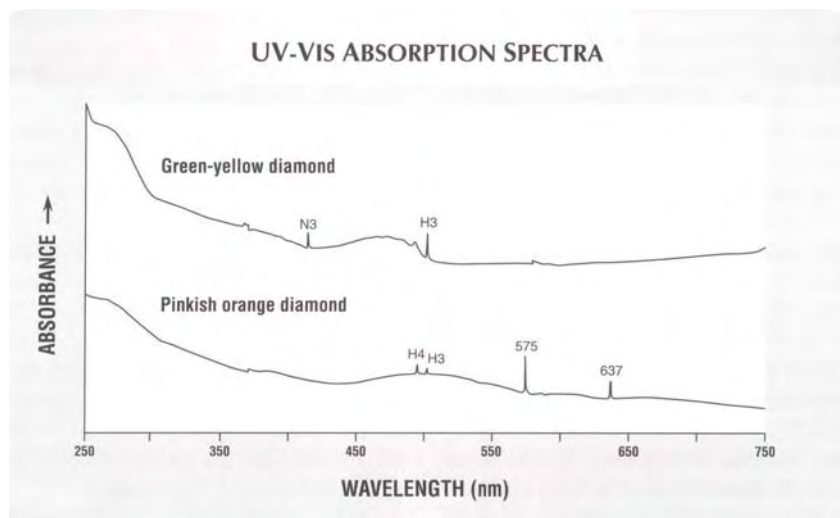


Figure 4. The infrared absorption spectra of the two intensely colored diamonds show no evident absorption in the 1400–800 cm^{-1} range, so both diamonds are type IIa. The 1344 cm^{-1} peak is shown in the inset. The absorption coefficient in the inset was calculated using the two-phonon absorption band of the diamond.

(figure 5, bottom): strong absorption by N-V centers at 637 nm and 575 nm, moderate absorption by H3 (503 nm) and H4 (496 nm), and a weak absorption by N3. A weak but broad band around 270 nm, due to trace amounts of isolated nitrogen, also was

detected. Obviously the concentration of isolated nitrogen was above the detection limit of the infrared spectrometer. The most outstanding feature was a strong, broad absorption band centered at 507 nm, which we believe was the side band of the

Figure 5. The UV-Vis absorption spectra of the two type IIa diamonds show strong absorption of N3 and H3 nitrogen-related defects in the green-yellow diamond, and a broad and strong band at 507 nm, plus H4, H3, 575 nm, and 637 nm peaks, in the pinkish orange diamond.



vibronic 575 nm center.

Strong H3 and H4 absorptions, in particular those detectable by UV-Vis spectroscopy, usually do not occur in a type IIa diamond. N3 and N-V centers occur in some type IIa diamonds, but generally they are very weak. In addition, these N-bearing defects in type IIa diamond usually do not affect the body color. The green-yellow diamond is unusual because its N3 and H3 defects are so strong that they significantly affect the color appearance. The green hue is mainly caused by luminescence of the H3 center, which absorbs blue and violet and emits green light. Unfortunately, we do not have spectra on this stone before it was HPHT-processed. Nevertheless, it is reasonable to speculate that the original diamond may have contained some A form nitrogen (i.e., pairs of nitrogen atoms) that combined with vacancies during HPHT treatment to create H3 centers. Furthermore, some of the A centers may have disaggregated to isolated nitrogen during the HPHT annealing, while the N3 defects mostly survived the treatment. An HPHT-annealed diamond with these spectroscopic properties is quite rare.

In the pinkish orange diamond, the broad 507 nm side band to the 575 nm vibronic center is comparable to the ~550 nm broad band that is responsible for brown, pink, red, and purple coloration in some diamonds. With a shift in this broad absorption to higher energy, a pinkish orange coloration results. The strong 637 nm absorption and its side band at 580–620 nm could also contribute to the pink color to some extent. In terms of color origin, it is very rare to attribute an intense color to the 575 nm center in natural diamond (E. Fritsch, "The nature of color in diamonds," in G. E. Harlow, Ed., *The Nature of Diamonds*, Cambridge University Press, 1998, pp. 23–47). Since both stones are faceted, we do not know the exact path length through the stone during the UV-visible spectroscopic analysis. For this reason, the concentration of nitrogen in

these infrared-inactive defects could not be quantitatively determined.

Most diamonds that possess nitrogen-related point defects in the visible region typically show appreciable nitrogen-related absorption between 1400 and 800 cm^{-1} in the mid-infrared. However, in this rare case, both of these intensely colored diamonds are type IIa. These diamonds not only show interesting spectroscopic features, but they also reinforce the need to carefully document both natural- and treated-color diamonds to better understand the range of characteristics that may occur in each.

Wuyi Wang, Matt Hall, and TMM

With Unusual Overgrowth

Within the earth's mantle, it is not uncommon for diamond with different physical and chemical features to grow over a pre-existing diamond crystal. Such diamonds have been discovered in mines all over the world. Typically, the overgrowth layer and the pre-existing crystal are both crystallographically and spatially continuous, although there is usually a sharp, clear boundary between a heavily included overgrowth layer and a gem-quality inner portion (see, e.g., O. Navon et al., "Mantle-derived fluids in diamond micro-inclusions," *Nature*, Vol. 335, 1988, pp. 784–789). Recently Marc Verboven, of GIA in Antwerp, brought a special diamond of this type to our attention (figure 6). This diamond displayed these two episodes of growth; however, the overgrowth layer and the inner core were not continuous. Instead, for the most part they were separated by a distance of 0.5–1.0 mm.

The diamond was originally cubic in shape, about 8 mm on each side. Both {100} and {110} faces were well developed, similar to the cuboid diamonds commonly found in Zaire. Diamonds of such low quality and reasonably large size are commonly used to "open up" new and refurbished polishing discs, or to prepare

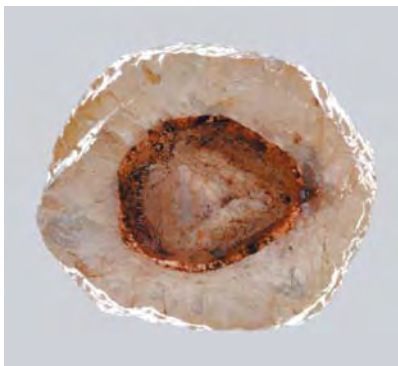


Figure 6. This milky white cuboid diamond, about 8 mm on each side, cleaved along the {111} face and exposed an interesting core while it was being used to "open up" a polishing disc.

the discs for polishing when new grit is applied. This stone cleaved along the {111} direction while being used to open up a disc, thereby exposing the interesting core. As shown in figures 6 and 7, the inner core and the outer overgrowth layer were not in direct contact, and the surface of the interior was covered by a dark brown material, very likely Fe-rich oxides.

After we removed the dark brown material by boiling the sample in sulfuric acid, careful microscopic observation revealed that the core diamond was octahedral in shape, with rounded edges. It was transparent, and contained a colorless macro inclusion (very likely olivine or enstatite) similar to inclusions seen in most "regular" rough diamonds. The surface of the core octahedron was pristine, showing many growth pits with flat ends. The overgrowth layer seems to have protected it from magmatic dissolution during transportation from the mantle to the earth's surface. In contrast, the overgrowth layer was milky white and contained numerous tiny inclusions, with evidence of dissolution on the surface.

Observation of the margin between the core and the overgrowth layer revealed regrowth connecting the octahedral core to the overgrowth on the {111} faces. This regrowth



Figure 7. After the dark brown material at the interfaces was removed by boiling the diamond in acid, it became clear that the inner core was an octahedral diamond crystal, most of which was spatially separated from the overgrowth layer. Analyses showed that the inner core and the outside overgrowth have very different physical and chemical properties.

served as a frame that supported the overgrowth layer during its formation. It is reasonable to assume that the margin was originally occupied by Fe-bearing mantle minerals (such as olivine). The components of these minerals (except for the postulated Fe-rich oxide) could have been removed by subsequent alteration at the earth's surface. As shown in figure 7, the {111} face of the core diamond is parallel to the {111} cleavage face of the overgrowth layer, indicating that the two parts of the crystal are crystallographically continuous. Spectroscopic analyses showed that the diamond contains substantial amounts of nitrogen, and the microscopic inclusions in the overgrowth layer are rich in H_2O and calcite. They also revealed that the inner core contains many more point and extended defects than the overgrowth layer, which supports formation of the diamond by two separate processes.

Further study of this special crystal may supply some important information about the environment and growth of diamond.

Wuyi Wang and TMM



Figure 8. This beautiful mineral specimen was identified as consisting of light greenish blue euclase crystals (largest approximately $13.20 \times 9.40 \times 4.00$ mm), near-colorless to white feldspar, and pink apatite.

EUCLASE Specimen, with Apatite and Feldspar

Generally, the laboratory is asked to identify fashioned stones for use in jewelry, as well as carvings and small statues. We were quite interested, therefore, to receive the mineral specimen shown in figure 8 at the East Coast lab. Reported to be from a mine in Brazil, it was submitted for identification of its transparent light greenish blue crystals.

These crystals were numerous and well formed, with natural striations along their length. They pro-

truded from a base of transparent to semi-transparent near-colorless to white crystals. Similar white crystals also formed a small cluster at the top of the specimen. Three small, transparent, light pink crystals were present as well, with one prominently visible in figure 8.

At first glance, the greenish blue color suggested that these crystals were aquamarine, but closer examination revealed that the crystals were monoclinic, not hexagonal like beryl. Standard gemological testing (a spot R.I. reading of approximately 1.65, double refraction detected via polar-

iscope, pleochroism, and lack of fluorescence to UV radiation) indicated that these crystals were euclase. This identification was confirmed by Raman analysis. Euclase is often described as "having a pale aquamarine color" (see, e.g., R. Webster, *Gems: Their Sources, Descriptions and Identification*, 5th ed., Butterworth-Heinemann, London, 1994, p. 336), and material of this color is known to originate from the Brazilian state of Minas Gerais.

The same client also submitted a transparent to semi-transparent light pink crystal measuring approximately $15.65 \times 19.60 \times 7.70$ mm, which reportedly was from the same deposit. This crystal was identified via standard gemological testing as apatite (R.I. of 1.630–1.634, S.G. of 3.21, uniaxial, a 580 nm doublet and a 520 nm line in the desk-model spectroscope, and weak-moderate and moderate fluorescence to long- and short-wave UV, respectively). The specimen contained liquid fingerprints and numerous two-phase (fluid and gas) inclusions. Although Brazil is a known source of apatite, references in the literature (see, e.g., R. Webster, cited above, and R. T. Liddicoat, Jr., *Handbook of Gem Identification*, 12th ed., GIA, Santa Monica, 1989, p. 173) most often describe it as blue, yellow, green, or violet, rather than pink.

Once this identification was made, our curiosity was piqued to see if the light pink crystals on the euclase specimen were also apatite. Although their size and placement made standard gemological testing impossible, Raman analysis proved that they were indeed apatite. Raman also identified the near-colorless to white crystals as feldspar. The association of euclase, apatite, and feldspar is consistent with a pegmatitic origin.

Wendi M. Mayerson

"Cherry Quartz" GLASS Imitation

Walking by the many bead vendors at the Tucson gem shows this past February, this contributor could not

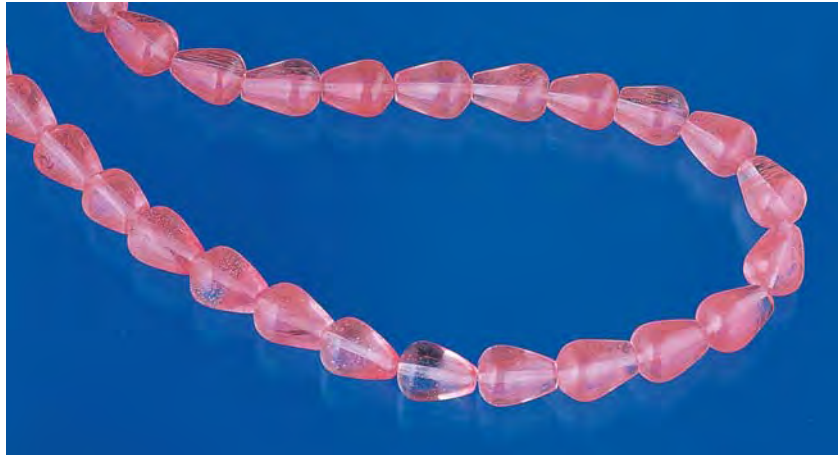


Figure 9. This strand of approximately 8-mm-long “cherry quartz” beads, purchased at one of the Tucson gem shows, proved to be a manufactured glass product.

help but notice large quantities of a transparent to translucent pink material that was reminiscent of strawberry quartz. Offered in various sizes and shapes, these beads appeared to be very popular and were selling rapidly.

On closer inspection with the naked eye, however, the material did not appear to be strawberry quartz after all. The vendor stated that it was “cherry quartz.” When asked what that was, he explained that it was heat-treated quartz from China. The same claim was repeated by numerous other vendors elsewhere in the city. This somewhat unusual treatment and provenance connected with a heretofore-unknown gem material prompted

inspection with a loupe. Immediately visible were numerous spherical gas bubbles, which suggested that the material was not quartz at all, but rather some kind of glass.

A strand of these beads was purchased and brought back to the West Coast laboratory for closer inspection (figure 9). Microscopic examination revealed not only arrays of spherical gas bubbles, which were often arranged in planes, but also irregular parallel colorless to dark pink bands (figure 10) and clouds of a somewhat reflective “copper”-colored material (figure 11). Gemological testing showed the material to be singly refractive with an R.I. of 1.460, an

Figure 10. Planes of spherical gas bubbles and irregular pink and colorless banding were clearly visible in this glass bead. Magnified 15 \times .



Figure 11. Somewhat reflective “copper”-colored clouds of unknown composition were also common in these glass beads. Magnified 15 \times .



S.G. of 2.18, and a varied reaction to UV radiation, ranging from inert to moderate orange in long-wave, and from weak to moderate greenish blue or weak to very strong yellow in short-wave. All of these properties confirmed the identification of these beads as glass.

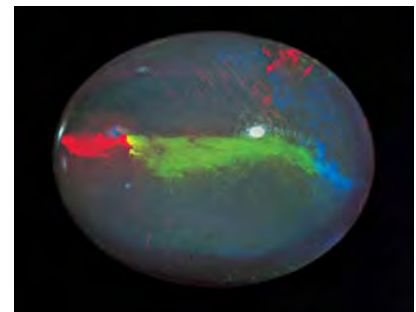
Glass imitations of gems date to antiquity, but in a day and age where the focus is on full disclosure, it is unfortunate that this type of misrepresentation continues to occur. *SFM*

Cat’s-eye OPAL

Most cat’s-eye opal seen on the market is a fibrous material that does not exhibit play-of-color. The cause of the cat’s-eye in such opals is the same as for many other chatoyant gems: reflection of light from the densely packed parallel fibers.

However, opal occasionally displays chatoyancy that is somewhat different in nature and appearance. Some opals will exhibit a cat’s-eye composed entirely of play-of-color, which often seems to be caused by a closely spaced lamellar structure within the opal. This phenomenon is not common, and the stones typically show a weakly developed or indistinct eye (see, e.g., Winter 1990 Gem News, p. 304). Fine examples that show a strong chatoyant band made of play-of-color are much rarer, but just such a stone (figure 12) was recently submit-

Figure 12. This unusual 4.59 ct cat’s-eye opal displayed rainbow-colored chatoyancy when viewed in the right orientation.



ted for examination to the West Coast laboratory by Kerry Massari of St. Petersburg, Florida.

This 4.59 ct oval cabochon was translucent and had a gray body color; the back of the stone was gray common opal ("potch"), which is often seen in opals from Australia. The gemological properties were typical for opal.

One of the most interesting things about this opal, in addition to the strength of the eye, was the fact that in the right position the eye displayed a full range of spectral colors, in effect showing a rainbow across the top of the stone.

SFM

"Blue" QUARTZ

Color in most gems is caused by chromophoric elements that are either a necessary part of the gem's chemical composition, as with peridot and turquoise (*idiochromatic* gems), or not essential to the identity of the mineral, as with corundum and beryl (*allochromatic* gems). However, some gem materials gain apparent color from the presence of inclusions. Examples are the reddish orange color of some sunstone feldspars and so-called bloodshot iolite, which is attributed to the presence of ultra-thin inclusions of red hematite, or the dark brown color of some star beryls and brown-to-black star sapphires, which results from numerous tiny, skeletal gray-brown ilmenite inclusions. While these inclusion-colored gems are relatively common, others, such as natural blue quartz, are much more unusual.

As thus far reported, blue color in natural quartz has always been the result of inclusions; ajoite, chryso-colla, dumortierite, elbaite, lazulite, and papagoite have all been identified as causes of such a color appearance. Of these, dumortierite is by far the most common. Blue elbaite tourmaline, also known as indicolite, is rarely encountered, as the vast majority of tourmaline inclusions in



Figure 13. The blue color in both the 30.58 mm crystal group and the polished cabochons of rock crystal quartz (21.76 and 6.96 ct) is caused by inclusions of indicolite.

quartz are black to very dark brown.

Two well-polished grayish blue cabochons from Minas Gerais, Brazil, were recently sent for examination to the West Coast laboratory by gem dealer Elaine Rohrbach of Pittstown, New Jersey. They were easily identified as quartz by their refractive index and the presence of a uniaxial "bull's-eye" optic figure. As shown in figure 13, the larger was a 21.76 ct oval cabochon (19.50 × 14.89 × 10.19 mm), while the smaller was a 6.96 ct round gem (11.66–11.83 × 6.64 mm).

Magnification revealed that the blue color came from numerous thick-to-thin, randomly scattered, euhedral fibers and rods of what appeared to be indicolite (figure 14). These inclusions showed strong dichroism, from virtually colorless to dark blue (depending on the thickness of each), which

was also indicative of indicolite.

As a confirmatory test, Raman analysis was used to support the optical identification. The reference

Figure 14. Thick to thin in diameter, and randomly scattered, these deep grayish blue indicolite inclusions are responsible for the apparent blue color of their quartz host. Magnified 10×.



standard for this test was a sample of indicolite-colored blue quartz crystals from the Morro Redondo mine, near Araçuaí, Minas Gerais (again, see figure 13). Studying gems colored by inclusions is always interesting, particularly so when the inclusion-host combination is both beautiful and unusual.

JIK and Maha Tannous

RUBY, Heat Treated with a Large Glass-Filled Cavity

The purplish red gemstone shown in figure 15 was submitted to the West Coast laboratory by a client who had purchased it as a natural ruby. While examining the stone with a microscope, however, the client noticed prominent gas bubbles and inclusions that he described as “fingerprints.” Because the appearance of those inclusions was quite different from what he had encountered previously in unheated or heat-treated rubies, he asked us to verify that the stone was natural and, if enhanced, determine the type of treatment.

Standard gemological tests confirmed that the 2.50 ct stone was indeed natural corundum. When we examined the ruby with 10× magnification, we recognized immediately—from the altered appearance of numerous inclusions—that the stone had been subjected to heat treatment. The ruby showed a series of fractures that had all been partially healed; such healed fractures often resemble the fingerprint-like inclusions found in unheated natural gems. However, we also noticed some opaque dark brown rounded particles. Those particles were remnants of crystals that had exploded and the pieces subsequently melted down into rounded “balls” due to the thermal treatment (see figure 16).

Deep in the pavilion, around the culet, we also saw a series of large gas bubbles. Focusing on these bubbles from the pavilion, we could see that they were confined to an area very close to the surface. Further examina-

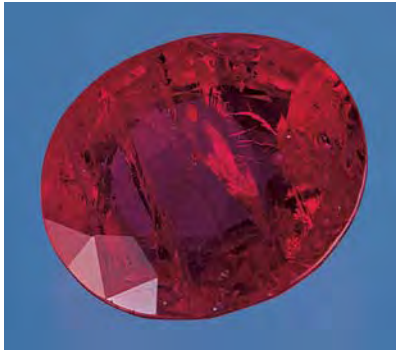


Figure 15. This 2.50 ct ruby contained a glass-filled cavity large enough to yield a separate R.I. value and to entail the loss of a significant amount of weight if the stone was recut to remove it.

tion with overhead illumination revealed very fine separations in three of the pavilion facets adjacent to the culet and a distinct difference in luster in those facets (see, e.g., figure 17). This area of lower luster was large enough that we were able to obtain a single R.I. reading of 1.51, which indicates that it was not corundum but rather a type of glass. We advised our client that this ruby had undergone heat treatment and also had been surface repaired with a foreign material.

Over the course of the last two decades, we have reported on a number of rubies with evidence of foreign “fillers” both on the surface and in surface-reaching fractures (see, e.g., Fall 1984 Gem News, pp. 174–175; R. E. Kane, “Natural rubies with glass-filled cavities,” Winter 1984 *Gems & Gemology*, pp. 187–199; and Fall 2000 Lab Notes, pp. 257–259). Only on a few occasions have we encountered filled cavities large enough to measure the R.I. We also determined that if this stone was recut to remove the cavity, it would likely lose significant weight and a “size”; that is, it would be less than 2 ct. While such fillings are less prevalent today than they were a decade ago, one still needs to be careful to inspect the surfaces of rubies

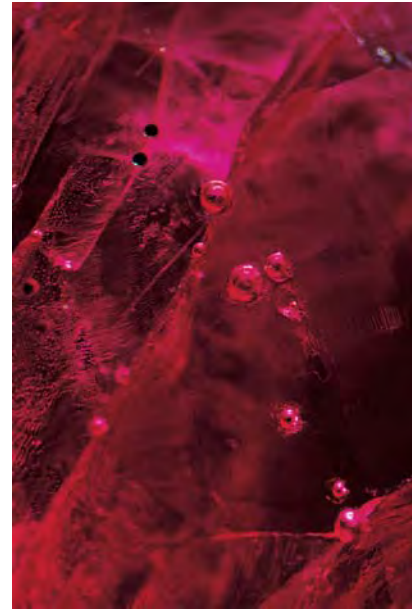


Figure 16. Seen here at 15× magnification are remnants of exploded crystals (brown “balls”), portions of healed fractures, and large gas bubbles—proof that the ruby shown in figure 15 had undergone heat treatment and glass filling.

for such a treatment. In this case, too, someone viewing the stone through the table could have interpreted the gas bubbles as indicating that it was a melt synthetic.

KNH and TM

Figure 17. Seen here in reflected light, distinct differences in luster separate the corundum and the glass filling on this pavilion facet; note also the gas bubbles in the filled area on the lower right. Magnified 15×.

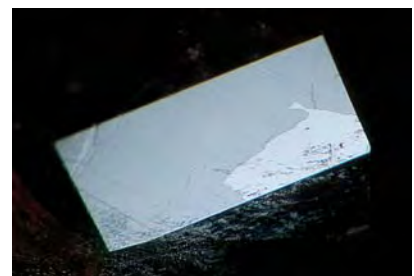




Figure 18. This 1.79 ct green metamict zircon shows striking play-of-color that changes as the gem or light source is moved.

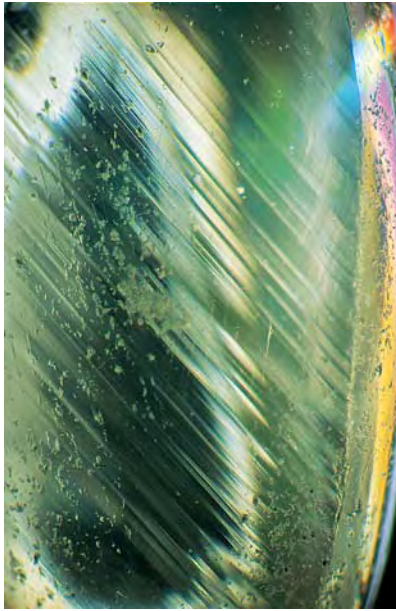


Figure 19. The extremely fine lamellar structure of the metamict zircon in figure 18 is responsible for its unusual play-of-color. Magnified 30×.

Play-of-Color ZIRCON

Green metamict zircons from Sri Lanka are relatively well known in the gem trade, and compared to other colors of zircon they are also relatively common. Occasionally, however, we do see less typical, phenomenal green metamict zircons. For the most part, these show sparkling aventurescence, which is caused by the presence of tiny discoid fractures that develop during their metamict breakdown (see E. J. Gübelin, *Internal World of Gemstones: Documents from Space and Time*, ABC Edition, Zurich, 1979, p. 193).

Very recently, the West Coast laboratory had the opportunity to examine another, even more unusual type of phenomenal metamict green zir-

con, which was also submitted by gem dealer Elaine Rohrbach, who provided the blue quartz described above. This oval double cabochon weighed 1.79 ct and measured $8.07 \times 5.02 \times 4.11$ mm. It was identified as zircon by its absorption spectrum, “over-the-limits” refractive index, and specific gravity. What made this gem stand out was that in both sun and incandescent light it showed a bright play-of-color (figure 18), very similar to what one would expect to see in transparent crystal opal. As also seen with opal, when the gem and/or the light source was moved, the play-of-color pattern changed. Even with fluorescent lighting, the colorful effect was still visible,

although—just as with opal—it was much more subdued.

Observation with a gemological microscope revealed that an extremely fine lamellar structure (figure 19) was responsible for the bright spectral color phenomenon. The structure appeared to act as a diffraction grating, breaking the entering white light into its component colors. The zircon’s high transparency and general absence of light-blocking inclusions also greatly added to its fascinating appearance.

In the past, we have seen only two other zircons that showed such interesting color effects. The first was a faceted green Sri Lankan zircon described as iridescent in the Spring 1990 Gem News section (p. 108). The cause of this phenomenon was also stated to be structural, but the colors observed were much more subtle than the play-of-color seen in the present sample. The second stone, described in the Summer 1997 Lab Notes section (p. 141), was a very dark brown cabochon that showed patches of red and green “play-of-color” of unknown cause.

Note that play-of-color is a light-interference phenomenon that is not by definition confined to opal. Nevertheless, this is the first zircon we have seen that clearly showed the cause of its bright play-of-color.

JIK and Maha Tannous

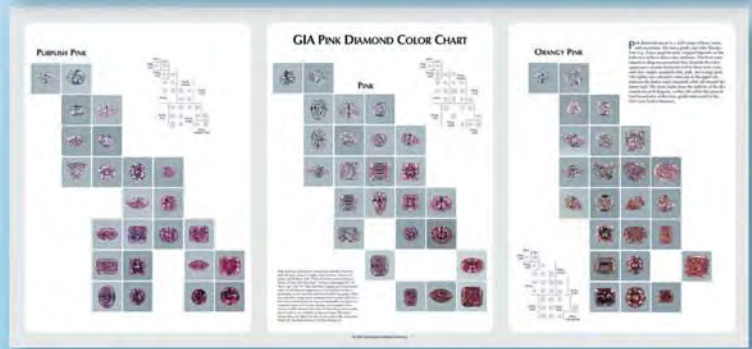
PHOTO CREDITS

Elizabeth Schrader—figures 1, 3, 4, 5, and 8; Vincent Cracco—figures 1 (inset) and 2; Marc Verboven—figures 6 and 7; Maha Tannous—figures 9, 12, 13, 15, 16, and 17; Shane F. McClure—figures 10 and 11; John I. Koivula—figures 14, 18, and 19.

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T u c s o n 2003

In January-February 2003, the gem and mineral shows in Tucson, Arizona, bustled with activity despite the slow U.S. economy. Although this year revealed fewer novel gem materials or new localities than previously, there were still numerous interesting items on display. Among the highlights was a 44.11 ct intense greenish blue tourmaline that was reportedly from the São José da Batalha mine in Paraíba, Brazil (figure 1). This may be the largest faceted tourmaline from this famous deposit. Of great curiosity was an unusual 18K white gold ring set with calibrated princess-cut jeremejevites from

Namibia (see Fall 2002 Gem News International, pp. 264–265), in a range of color from near colorless through shades of blue and violet (figure 2). Another unique piece was shown to us by Edward Johnson of GIA London: a tie pin fashioned into a horse head that made creative use of an unusually shaped diamond crystal (figure 3). Additional items are described in more detail below, and others will appear in the Summer 2003 GNI section. *G&G* thanks our many friends who shared material with us this year.

Figure 1. This 44.11 ct tourmaline is reportedly from Paraíba, Brazil. Courtesy of Sergio Martins, Stone World, São Paulo, Brazil; photo by Robert Weldon.



Figure 2. The calibrated jeremejevites (2.5 and 3 mm) in this ring are from the Erongo Mountains of Namibia. Courtesy of Chris Johnston, Johnston-Namibia C.C., Omaruru, Namibia; photo by Robert Weldon.





Figure 3. The natural diamond crystal (1.5 cm long) in this tie pin, which was manufactured by Manfred Wild of Idar-Oberstein, bears an uncanny resemblance to a horse head. Courtesy of Andreas Guhr, Mineralien Zentrum, Germany; photo by Maha Tannous.

COLORED STONES AND ORGANIC MATERIALS

Dyed “landscape” agate. At the AGTA show, William Heher of Rare Earth Mining Co., Trumbull, Connecticut, had some distinctive landscape agate. The agates showed attractive scenes (figure 4), portions of which were created using a proprietary process to add new colors. Approximately 600 pieces were available, in sizes from 12 × 20 mm to over 50 mm. Mr. Heher reported that he purchased the starting material from two old collections in Idar-Oberstein that had been mined years ago in Brazil. Blue colors were created with cobalt salts, and the greens with copper sulfates and other chemicals. The natural landscapes in the agates are sometimes enhanced by heat to improve their appearance (e.g., to improve saturation or change the color from yellow to more reddish hues), depending on the amount of iron staining and the starting color.

Thomas W. Overton (tom.overton@gia.edu)
GIA, Carlsbad

Carved Brazilian bicolored beryl and Nigerian tourmaline. At the AGTA show, gem carver Michael M. Dyber of Rumney, New Hampshire, displayed a collection of carved bicolored

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GEMS & GEMOLOGY, Vol. 39, No. 1, pp. 48–64
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Figure 4. The scenes in these “landscape” agate cabochons (23 mm long) were enhanced by the addition of cobalt salts to create areas of blue “sky.” Courtesy of William Heher; photo by Maha Tannous.

beryl from Minas Gerais, Brazil, titled “Optic Art” (see, e.g., figure 5). This collection was created from a parcel of 25 crystals weighing a total of 666 grams, which he purchased from Haissam Elawar, K. Elawar Ltd., Minas Gerais. According to Mr. Elawar, the beryl was mined in 1998 from a pegmatite at the São João mine near Padre Paraíso, Minas Gerais. The production included an unusual variety of beryl colors, from yellow to green to blue. Of the approximately 40 kg of bicolored crystals, about half were gem quality.

Bicolored beryl, mostly from Minas Gerais, has been reported in the past (see, e.g., Winter 1985 Lab Notes, p. 232; Winter 1986 Gem News, p. 246; and A. R. Kampf and C. A. Francis, “Beryl gem nodules from the Bananal mine, Minas Gerais, Brazil,” Spring 1989 *Gems & Gemology*, pp. 25–29) but facet-grade material is uncommon, and most of

Figure 5. Unusual bicolored beryls from Minas Gerais have been fashioned into attractive gem carvings. Shown here are a 67.50 ct aquamarine/green beryl carving and a 261.1 ct (11.1 × 3.75 cm) bicolored beryl crystal from Brazil. Photo © Sena Dyber, 2003.



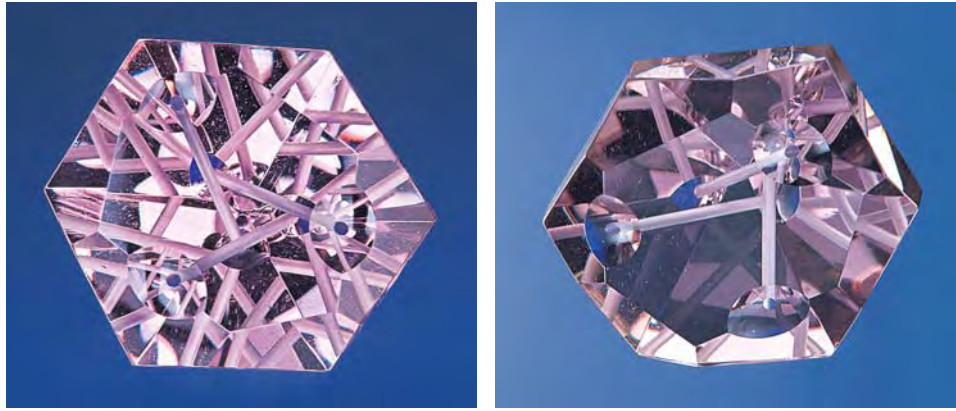


Figure 6. Careful arrangement of facets and tubes in this 89.40 ct carved Nigerian tourmaline produces a clever optical illusion. In the face-up view (left), facet reflections create the appearance of dozens of internal tubes; from the back (right), the true nature of the carving—a mere three tubes—is seen. Courtesy of Michael Dyber; photos by Maha Tannous.

the reported discoveries have been morganite/aquamarine or a combination of colorless beryl (goshenite) with another variety. Aquamarine/green beryl and green beryl/heliodor combinations such as those from the São João mine appear to be considerably rarer. Rains in 2000 collapsed some of the tunnels, but Mr. Elawar reported that there have been recent attempts to reopen this mine, so more of this material may become available in the future.

Also on display at Mr. Dyber's booth was a carving he called "Pink Snowflake," an 89.40 ct Nigerian tourmaline that showed a remarkable optic effect. Viewed through the table (figure 6, left), this carving created a snowflake-like illusion of numerous small tubes intersecting throughout the piece. When viewed from the back (figure 6, right), the true nature became apparent: Only three 1-mm wide tubes had been drilled into the stone, and careful alignment of the tubes and facets created the illusion of many more. The even dimensions and frosted polish of the tubes, called "Luminares" (see Spring 1999 Gem News, pp. 57–58) were achieved through a proprietary

process that Mr. Dyber developed after years of research and experimentation.

Thomas W. Overton

A new saturated purplish pink Cs-"beryl" from Madagascar: Preliminary analyses. One of the most exciting materials to debut at Tucson this year was deep purplish pink "beryl" from a new find in Madagascar. In addition to its color, this material was particularly interesting because it showed anomalous properties for beryl (e.g., higher refractive indices than previously known), which were attributed to very high concentrations of cesium (Cs). The primary suppliers were Polychrome (Laurent Thomas, Chambray-les-Tours, France), Le Minéral Brut (Denis Gravier and Fabrice Danet, Saint-Jean-le-Vieux, France), and MJ3 Inc. (Marc Jobin, New York). The material was sold as "red beryl," "raspberyl," and "hot pink-red beryl." Combined, these dealers had about 5 kg of rough and a small number of faceted stones and cabochons at Tucson, although additional pieces were cut during the show. The largest supplier of rough was Mr.

Figure 7. In mid-November 2002, an usual Cs-"beryl" showing a deep purplish pink color was found at this mine, located near the village of Mandrosonoro in central Madagascar. The underground workings are located to the lower left of the photo. Photo by Laurent Thomas.



Thomas, who had approximately 0.5 kg for cutting faceted gemstones or cat's-eye cabochons, 2 kg that were carving quality, and 1 kg of crystal specimens. The material is referred to here as "beryl" in quotation marks, because work is still in progress to determine its mineralogical identity (see below).

GIA was first notified about this unusual new material by Tom Cushman (Allerton Cushman & Co., Sun Valley, Idaho), who obtained a crystal during a buying trip to Madagascar in December 2002 and subsequently donated it for research. According to Dr. Federico Pezzotta (Natural History Museum, Milan, Italy) and Mr. Thomas, both of whom were in Madagascar during the discovery, the deep pink "beryl" was mined in mid-November 2002 from a pegmatite located a few kilometers south of the village of Mandrosonoro, which is 140 km by dirt road west of Ambatofinandrahana in central Madagascar (figure 7). Mr. Thomas visited the mine soon after the pocket was discovered, but he had to flee the area when he drew gunfire. It is not surprising that foreigners are not welcome there, since Mandrosonoro is considered to be among the most dangerous areas in Madagascar.

The almost vertical pegmatite, which measures about 4–6 m thick and over 200 m long, was originally explored by French colonists for tourmaline. Recent mining by local people resulted in the discovery of the pink "beryl" about 6 m below the surface. It was recovered from a single large pocket containing mostly smoky quartz, multi-colored tourmaline, and pink or yellow-green spodumene; amazonite, cleavelandite (albite), lepidolite, and danburite also were found in this pocket.

The "beryl" has been seen to occur in three different morphologies: (1) large flattened masses (up to 8 cm in diameter) of irregular shape that grew interstitially to other minerals in the pocket; (2) well-formed tabular hexagonal crystals up to 6–7 cm in diameter, occasionally in aggregates (figure 8); and (3) euhedral, small (up to a few

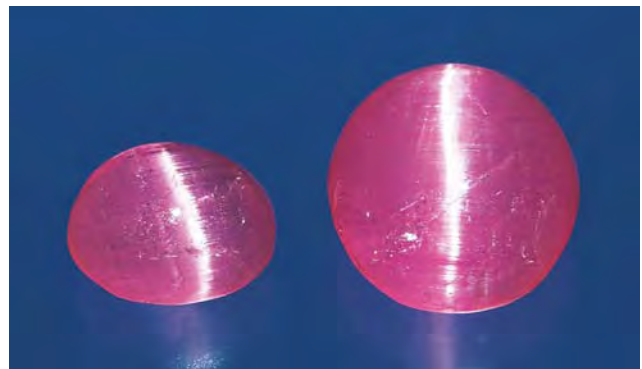


Figure 8. Well-formed tabular crystals and aggregates of pink Cs-“beryl” (here, up to 3 cm) created excitement at the 2003 Tucson gem shows. Courtesy of Stuart Wilensky and Irv Brown; photo © Jeff Scovil.

millimeters in diameter), tabular-to-elongate crystals on the faces of large tourmaline crystals. The unusual elongate crystals formed by parallel intergrowth of numerous tabular crystals.

According to Dr. Pezzotta, the production of deep pink "beryl" amounted to 40 kg of crystals and fragments of variable quality, and many tens of kilograms of low-quality fragments and deeply corroded crystals. Gemmy portions in crystals are rare and very limited in size, so faceted stones are typically small and/or contain eye-visible inclusions (figure 9, left). Some of the material is of carving quality, and a small proportion contains microscopic tubes parallel to the c-axis in sufficient abundance to yield attractive chatoyant gems (figure 9, right). The color is similar to pink tourmaline, and in fact one piece of tourmaline was discovered in a parcel of samples that GIA obtained for research.

Figure 9. Faceted examples of the Cs-“beryl” are uncommon, since much of the rough is heavily included. The samples on the left (0.89–1.02 ct, courtesy of Mark Kaufman) show characteristic growth tubes, fractures, and fluid inclusions. The cabochons on the right show attractive chatoyancy; they are courtesy of Mark Kaufman (1.84 ct) and Herb Obodda (4.11 ct). Photos by Maha Tannous.



Six samples were gemologically characterized by contributors SFM and EPQ: two faceted stones (0.89 and 1.02 ct), two cat's-eye cabochons (1.84 and 4.11 ct), one crystal specimen (7.5 grams), and one partially polished crystal fragment (1.64 ct). The properties are reported in table 1. The R.I. and S.G. values are significantly higher than those reported for morganite (e.g., $n_o=1.578-1.600$, $n_e=1.572-1.592$, and S.G.=2.80–2.90; R. Webster, *Gems*, 5th ed., revised by P. Read, Butterworth-Heinemann, Oxford, England, 1994, p. 128), as well as other beryl varieties. In addition, morganite has no characteristic absorption spectrum (Webster, 1994). Although the dealers who supplied the samples were not aware of any clarity enhancement, all samples showed fractures of low relief, some of which contained air bubbles that contracted when exposed to a thermal reaction tester, indicating the presence of a filling substance. Subsequently we learned from Dudley Blauwet (Dudley Blauwet Gems, Louisville, Colorado) that all of the purplish pink "beryl" rough he had purchased was oiled by the local Madagascar dealers. He reported that the oiling enables them to see into the rough more easily (because of the slight etching on most of the crystal surfaces), and it appears to be done with mineral oil that is manually applied rather than pressure injected.

On a separate crystal (5 mm in diameter; figure 10) that was donated by Mr. Thomas to the University of New Orleans, WBS obtained refractive indices of $n_o=1.616$ and $n_e=1.608$ by immersion in Cargille oils (in white light, Na corrected). A measured density of 2.97 was obtained with a Berman density balance, and a calculated density of 3.012 was obtained using unit-cell dimensions (from powder X-ray diffraction analysis) and the average chemical composition of the core (from electron microprobe analysis; see below). The relatively low density of this sample, compared to those examined above, is probably due to the presence of numerous fluid inclusions.

Preliminary chemical analyses of two samples with energy-dispersive spectrometry (performed by Dr. Alessandro Guastoni of the Natural History Museum, Milan) revealed high concentrations of Cs, with the strongest enrichment in the rims of the crystals. Quantitative chemical analysis with an electron microprobe at the University of New Orleans was performed by WBS and AUF on the 5-mm-diameter crystal mentioned above. This sample had a purplish pink core and a pale pinkish orange rim that were separated by a sharp boundary (again, see figure 10). Several point analyses of a slice taken perpendicular to the c-axis revealed an average of 13.57 wt.% Cs_2O in the core and 15.33 wt.% Cs_2O in the rim (table 2). This is significantly more Cs than previously reported in beryl (11.3 wt.% Cs_2O in morganite from Antsirabe, Madagascar; see H. T. Evans and M. E. Mrose, "Crystal chemical studies of cesium beryl," *Program @ Abstracts*, Geological Society of America Annual Meeting, San Francisco, 1966, p. 63). Minor amounts of Rb, Na, and K also were detected. Inductively coupled plasma (ICP) analysis of a portion of the crystal showed 2.16 wt.% Li_2O . The water

content, obtained by the LOI (loss on ignition) method, is 1.72 wt.%. Some of the water, as well as the 0.30 wt.% B_2O_3 measured by ICP, is attributed to the presence of abundant fluid inclusions.

Structural refinement of four samples by FCH showed that the Cs resides (and is dominant) in the 2a site in the channel of the mineral's structure. Cs substitutes for a vacancy in the channel, and electroneutrality is maintained by an accompanying substitution of Li for Be at the tetrahedrally coordinated beryllium site. Minor Na occupies the 2b channel site. The end-member composition could therefore be represented as $Cs[Be_2Li]Al_2Si_6O_{18}$. As such, this interesting gem material has been submitted to the International Mineralogical Association as a new mineral of the beryl group (along with beryl, bazzite, and stoppaniite).

Vis-NIR spectroscopy by GRR showed bands centered at 494 and 563 nm when the beam was polarized perpendicular to the c-axis (figure 11). The maximum transmission was seen near 630 nm (orangy red) and 400 nm (deep violet), which provided the pink-orange color in this direction. When the polarization was parallel to the c-axis, the spectrum was dominated by a band centered at 572 nm. Transmissions in the red and blue-to-violet regions of the spectrum combined to produce the purplish pink color for light polarized in this direction. These absorption characteristics are consistent with Mn^{3+} and are similar to the spectra of pink beryls that have been interpreted in terms of Mn^{3+} (see A. N. Platonov et al., "On two colour types of Mn^{3+} -bearing beryls," *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 38, 1989, pp. 147–154).

TABLE 1. Properties of six samples of purplish pink Cs-"beryl" from Madagascar.

Property	Description
Color	Purplish pink with moderate dichroism: pink-orange (w ray) and purplish pink to pinkish purple (e ray)
R.I.	$n_o=1.616-1.617$, $n_e=1.608$; spot reading = 1.61 (cabochons)
Birefringence	0.008–0.009
Optic character	Uniaxial negative, with two samples showing anomalous biaxial optics, possibly due to strain
S.G.	3.04–3.14, with most values near 3.10
Chelsea filter reaction	Orangy pink to pink
UV fluorescence	Inert to long- and short-wave UV radiation
Absorption spectra	With the desk-model spectroscope, all samples showed an absorption band at approximately 485–500 nm, and five samples showed weak lines at 465 and 477 nm and a weak band at 550–580 nm
Internal features	Growth tubes, fractures, "fingerprints," and fluid inclusions; two samples contained low-relief, birefringent inclusions

In heating experiments by GRR, crystal fragments heated at 250°C and 350°C for two hours maintained their color. A fragment heated at 450°C for 2 hours suffered near total loss of color. The sample regained nearly all its pink color upon irradiation with 6 megarads of Cs-137 gamma rays. This sensitivity to heating and irradiation suggests that the color is caused by radiation-induced color centers involving Mn³⁺. However, the color and optical spectrum of the new Cs-“beryl” are different from those of the red beryl from Utah, which is also colored by Mn³⁺ (Platonov et al., 1989).

Raman spectrometry of the Cs-“beryl” showed shifts in some peak positions and intensities when compared to morganite and near-colorless beryl from Brazil. Likewise, some of the bands in the infrared spectrum were shifted in comparison to morganite and near-colorless beryl. The powder X-ray diffraction pattern was unique, with missing peaks and slight shifts in peak positions, as compared to the beryl pattern. Evans and Mrose (1966) also documented intensity differences in the X-ray diffraction patterns of Cs-rich beryl. Likewise, Cs has been shown to increase R.I. values (P. Černý and F. C. Hawthorne, “Refractive indices



Figure 10. This crystal of Cs-“beryl” displays a pale pinkish orange overgrowth over a purplish pink core. Electron-microprobe analyses showed slightly more Cs in the rim. Courtesy of Laurent Thomas; photo by W. Simmons.

TABLE 2. Chemical analyses of a Cs-“beryl” from Mandrosonoro, Madagascar, with a purplish pink core and a pale pinkish orange rim.^a

Chemical composition	Core	Rim
Oxide (wt.%)		
SiO ₂	56.52	55.99
Al ₂ O ₃	15.60	15.68
Sc ₂ O ₃	0.03	0.03
BeO calc	8.05	7.99
MnO	0.09	0.06
Li ₂ O ^a	2.16	2.16
Na ₂ O	0.52	0.46
K ₂ O	0.15	0.03
Rb ₂ O	0.76	0.68
Cs ₂ O	13.57	15.33
H ₂ O ^a	1.72	1.72
Total	99.17	100.13
Ions^b		
Si	6.050	6.024
Al	1.968	1.988
Sc	0.003	0.003
Be	2.070	2.065
Mn	0.008	0.006
Li	0.930	0.935
Na	0.107	0.097
K	0.021	0.004
Rb	0.052	0.047
Cs	0.619	0.703

^a Except for Li and H₂O (one bulk analysis each, by ICP and LOI, respectively), data represent averages of nine analyses of the core and eight analyses of the rim, by electron microprobe. Below detection limits (in wt.%) were TiO₂ (0.002), FeO (0.02), MgO (0.01), and CaO (0.07).

^b Calculated per 18 oxygens (water excluded, Be+Li=3).

versus alkali contents in beryl: General limitations and applications to some pegmatitic types,” *Canadian Mineralogist*, Vol. 14, 1976, pp. 491–497). Since Cs is a relatively heavy element, high concentrations of it would also be expected to increase S.G. values, as recorded in the samples we examined. Further information on this Cs-“beryl” is being prepared by these researchers for publication in the mineralogical and gemological literature.

Figure 11. Vis-NIR spectra of a 5.08-mm-thick slice of Cs-“beryl” were dominated by bands centered at 494 and 563 nm when polarized perpendicular (⊥) to the c-axis, and a band centered at 572 nm when polarized parallel (∥) to c. The difference in these absorptions accounts for the moderate dichroism in purplish pink (ε ray) and pink-orange (ω ray).

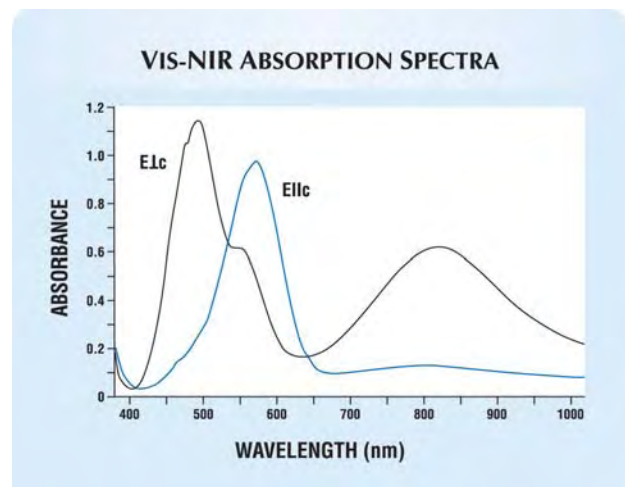




Figure 12. Bill Larson (left) and Nicolai Kuznetsov examine some of the demantoid rough that was recently recovered from the Kladovka mine in Russia's Ural Mountains. Photo © Jeff Scovil.

Figure 13. These rough nodules (up to 4+ grams) and faceted stones (3.31 and 4.21 ct) show the range of color of demantoid from the Kladovka mine. Photo © Jeff Scovil.



Acknowledgments: The contributors thank the following for loaning and/or donating research specimens: Mark Kaufman, Kaufman Enterprises, San Diego; Dudley Blauwet; Laurent Thomas; Denis Gravier and Fabrice Danet; Tom Cushman; Alain Andrianjafy, Antananarivo, Madagascar; Marc Jobin; Herb Obodda, H. Obodda, Short Hills, New Jersey; Stuart Wilensky, Stuart and Donna Wilensky Fine Minerals, Wurtsboro, New York; and Irv Brown, Irv Brown Fine Minerals, Fallbrook, California.

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BML

A new find of demantoid at a historic site in Kladovka, Russia. At the AGTA show, Bill Larson of Pala International, Fallbrook, California, had large quantities of rough and fine cut demantoid garnets from a recently rediscovered primary deposit in the historic Sissertsk district in the Ural Mountains (figure 12). The Kladovka mine is located about 10 km from the city of Kladovka, which is a two-hour drive south of Ekaterinburg. In the past, primary deposits in this area produced mostly mineral specimens, while nearby placers yielded significant amounts of gem rough (W. R. Phillips and A. S. Talantsev, "Russian demantoid, czar of the garnet family," Summer 1996 *Gems & Gemology*, pp. 100–111).

Mr. Larson and his partner, Nicolai Kuznetsov of Moscow-based Stone Flower Co., helped fund an Ekaterinburg team of prospectors who began exploring the area in May 2002 after researching the historic localities of this czarist gem, first discovered in Russia in the mid-19th century. By July 2002, the prospectors were on the verge of abandoning their search in the heavily forested area when they rediscovered an old mining pit and exposed a "vein" containing demantoid. The garnets formed rounded nodules and aggregates along this vertical horizon in the sheared serpentinite host rock, which varied from a few centimeters up to 50 cm wide.

According to Mr. Larson, Pala International has obtained 8.3 kg of rough of variable color, from yellowish or brownish green to bright green. Approximately 600 grams is of top cutting grade. A significant portion will cut stones exceeding 1 ct each; however, gems over three carats (see, e.g., figure 13) are very rare. The largest gem faceted so far weighed 6.71 ct. "Horsetail" inclusions are present in some of the material.

The demantoid was produced from a pit measuring about 500 × 200 m and up to 12 m deep, which was excavated from the low hillside using backhoes and manual labor. A pump is used to remove water from the pit. The mining season lasts just four to six months, and as many as six miners worked the pit this past summer. Depending on the weather, this year's season should start in May.

Mr. Larson indicated that unlike the demantoid from the Karkodino mine (also in the Ural Mountains)—much of which is treated by a simple heating process to remove the brownish color component—the material from Kladovka has not been treated in any way. For more information on the Kladovka demantoid, visit the Web site www.palagems.com/demantoid_garnet.htm.

BML

Fire opal from Juniper Ridge, Oregon. At the GLDA show, Terry Clark and Don Buford of Dust Devil Mining Co., Cloverdale, Oregon, showed one of these contributors (BML) some attractive faceted fire opal from the Juniper Ridge deposit in southern Oregon. The samples were provided to them by Ken Newnham of Klamath Falls, Oregon, who is one of the claim owners. The diggings (figure 14) are located on the border of Klamath and Lake Counties, south of Quartz Mountain, at an elevation of about 6,000 feet (1,830 m).

According to Mr. Newnham, who has worked the deposit since the late 1990s, the opal forms as seams and nodules within a volcanic host rock (figure 15). The largest nodule found so far weighed about 12 pounds (5.4 kg), and fist-size pieces are common (figure 16). Transparent colors range from very light “lemon” yellow



Figure 14. At Juniper Ridge, in southern Oregon, fire opal is mined from a shallow pit. Here, fee diggers are extracting opal with simple hand tools. Photo by Ken Newnham.

to a saturated brownish orange, and translucent-to-opaque material is white to brown and black. The distribution by diaphaneity is 32% opaque, 40% cabochon grade, 20% “commercial” facet grade, and 8% fine facet grade. Some of the material contains attractive dendritic inclusions.

Not until 2002, when about 1,000 pounds (454 kg) of

Figure 15. The Juniper Ridge fire opal commonly forms large nodules in the volcanic host rock. Photo by Ken Newnham.



Figure 16. Fist-size pieces of fire opal are common at Juniper Ridge. Photo by Ken Newnham.





Figure 17. These fire opals (1.39–5.48 ct) show the range of color of transparent material from the Juniper Ridge deposit. Courtesy of John Bailey; photo by Maha Tannous.

rough fire opal were recovered, did the mine prove to be a commercial source. Most of this material was produced via fee digging (again, see figure 14), and Mr. Newnham estimates that the mine owners and fee-dig patrons have faceted about 1,000 stones and cut a few hundred cabochons over the past two years.

To date, most of the mining has been done with hand tools and jackhammers. The mine owners plan to use an excavator during the upcoming mining season, which typically runs from June to October. Mr. Newnham reported that crazing of the opal is not problematic, but as a precaution the rough is cut into pieces and “cured” for at least one year in the dry atmosphere of Klamath Falls before it

Figure 18. This “Diamond in a Pearl™” pendant and the matching earrings were created from black freshwater cultured pearls (8–9 mm in diameter), each set with diamonds weighing 0.04 ct that are mounted in 14K white gold. Photo by Maha Tannous.



is fashioned. A damp cloth or damp sand is positioned nearby to buffer the drying process. The material is not treated in any way.

Mr. Newnham and his colleague John Bailey (also of Klamath Falls) donated several rough and faceted samples of the fire opal to GIA. Six faceted stones (figure 17), which weighed from 1.39 to 5.48 ct and represented the range of color from this locality, were selected for gemological examination by one of us (EPQ). The following properties were obtained: color—reddish brown-orange, brownish orange, and brownish yellow; R.I.—1.459 to 1.462; singly refractive with weak to strong anomalous double refraction; S.G.—2.15 to 2.18; the brownish yellow opals were inert to long-wave and had only a very weak chalky green fluorescence to short-wave UV radiation, and all the other samples were inert to both wavelengths. Microscopic examination revealed a hazy appearance, fluid inclusions, crystals (near colorless and birefringent), a flow-like structure, and color zoning. Two of the stones contained interesting black opaque plumelike dendrites.

BML and
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Cultured pearls with diamond insets. Jewelry designer Chi H. Galatea of San Dimas, California, has developed a new procedure for setting small diamonds into cultured pearls (figure 18). The “Diamond in a Pearl™” jewelry (patent pending) was shown at the Galatea booth at the AGTA show. The process involves setting small (up to 0.20 ct) diamonds into a drilled hole in a cultured pearl using a gold or platinum sleeve. Both freshwater and Tahitian cultured pearls are used. Some of the Tahitian cultured pearls are further enhanced by carving into fanciful designs. The resulting gems have been used for rings, earrings, and pendants.

Thomas W. Overton

Effect of cutting on the appearance of spinel. At the AGTA show, David Clay Zava of Zava Master-Cut Gems, Fallbrook, California, had a parcel of 13 red spinels that were all cut from a single piece of rough. The waterworn crystal weighed approximately 300 grams and was mined from He An, Vietnam. Although fractured, it appeared to be of homogenous color before cutting. The faceted stones ranged from 1.41 to 7.94 ct, with a total weight of 59.25 carats. The shapes included pear, shield, cushion, oval, trillion, round, rectangle, and parallelogram.

As seen in figure 19, the stones show some significant variations in color and overall face-up appearance. This suite provides an interesting example of what a single, homogeneous spinel crystal can produce when various faceting shapes are used for the different sizes.

BML

INSTRUMENTS AND TECHNIQUES

Gemewizard™ gem communication and trading software. This new computer program was unveiled at the International Colored Gemstone Association (ICA) Congress in January 2003; hands-on demonstrations were later provided in Tucson by Gemewizard Ltd. (Ramat Gan, Israel) and Stuller Inc. (Lafayette, Louisiana) at the GJX and AGTA shows, respectively. Developed by Menahem Sevdermish of Advanced Quality (Ramat Gan), this patent-pending system is designed to assist jewelers and gem dealers in communicating gem colors, managing their inventories of gemstones, and special ordering loose diamonds and colored stones for their customers. It is being distributed in the U.S. by Stuller Inc.

Mr. Sevdermish reported that Gemewizard's gem color communication scheme is based on the colored stone grading system taught in GIA's Graduate Gemology program, and was developed from a database of more than 11,000 digital gem images. It is capable of displaying 1,296 gem colors and nearly 20,000 recreated gem images, directly on a laptop or desktop computer screen. Although the developers recognize that colors may appear different from one monitor to the next, they feel that newer LCD monitors (developed over the last two years) provide good consistency of color across most computers.

According to the company's Web site (www.gemewizard.com), the program can operate in two different modes: Gememode for colored stones (see figure 20) and Diamond Mode for diamonds. Gememode has two separate color selection systems. Using the first, Gemesquare (see figure 21), users can specify hue, tone, saturation, and shape from "sliding rulers," and then search for these parameters among gems in their inventory or the inventories of various suppliers. Using Base Square (Stuller Square in the U.S.), users can display the color spectrum of gemstones available in a supplier's inventory. Base Square can adjust pricing to reflect a jeweler's markup. Information on individual stones can be called up as needed, including measurements, quality of cut, and an image of the actual stone, in addition to gem lore that can assist in the selling process.

Diamond Mode allows the selection of diamonds with various combinations of the "4 Cs." The user can also search based on the presence of a report from a specific laboratory.

The program is intended to serve as a merchandising and marketing tool at the point of sale or over the Internet, allowing users to integrate their own inventories with those of their suppliers for display to customers. Pricing can be shown per carat or per stone. Also available is a gem and diamond market price guide based on actual wholesale transactions. Although the program is a stand-alone system capable of performing most activities without being connected to the Internet, current inventory and pricing information can be automatically updated each day over an Internet connection.

According to Mr. Sevdermish, four versions of

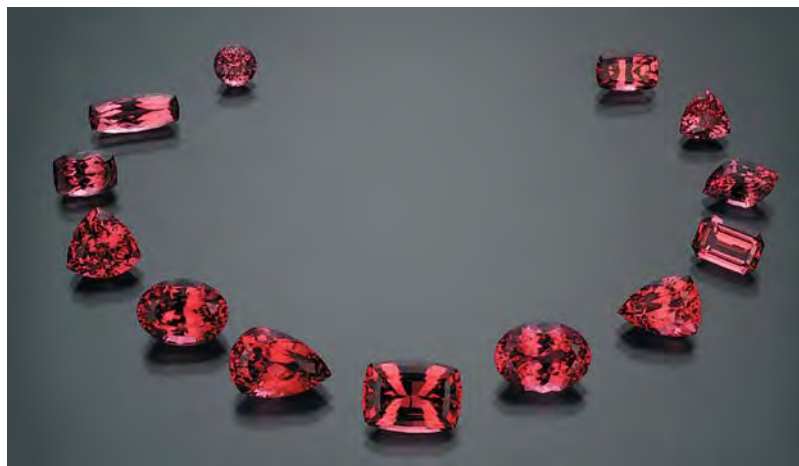
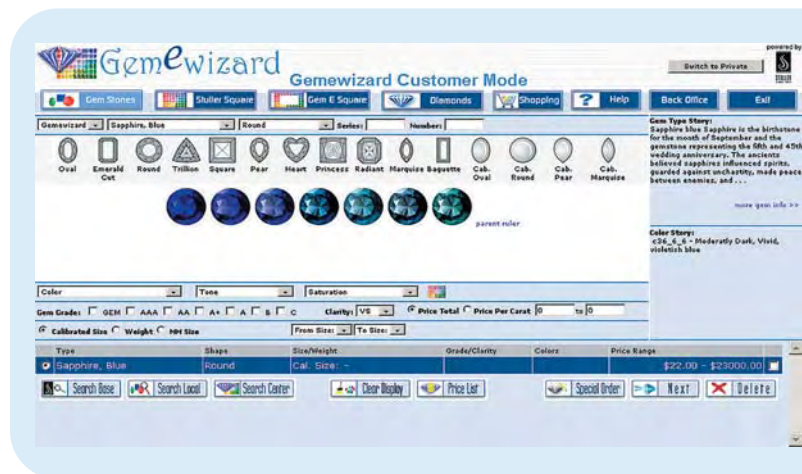


Figure 19. These spinels from Vietnam (1.41–7.94 ct) were all cut from the same piece of rough. The differences in appearance are due to variations in the size and shape of the faceted gems. Courtesy of Zava Master-Cut Gems; photo by Robert Weldon.

Gemewizard will become available. The Jeweler's Pro, intended to be used by retailers, is currently being released. The Dealer's Pro, intended for colored stone and diamond dealers, will include enhanced inventory-management capabilities, and is scheduled to be released by the end of April 2003. These Pro versions will be sold only to members of the trade; a monthly subscription from the Gemewizard Support Center will give the user access to updated price lists, inventory information, upgrades, enhancements, proprietary gem color rulers, and new program functions. The Education version, set for release in

Figure 20. Using Gemewizard's color selection systems, gem dealers and retailers can search for colored stones in their own and their suppliers' inventories. The software can be used to specify gem properties and display color options. Courtesy of Gemewizard Ltd.



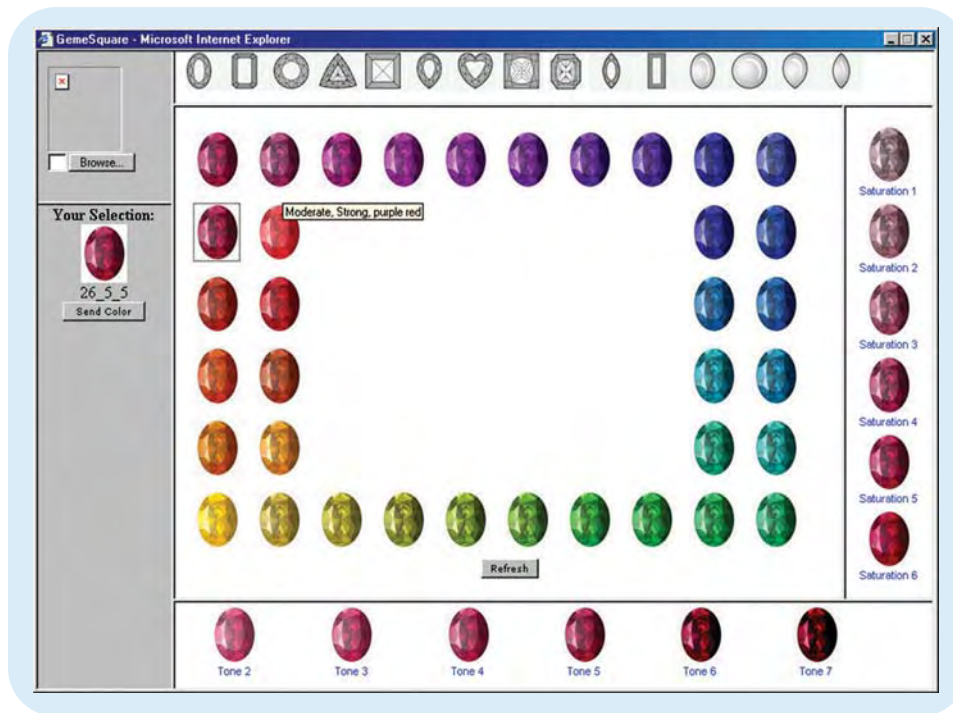


Figure 21. The Gemesquare function provides a comprehensive color communication system that allows users to specify tone and saturation for 36 possible hues. The color nomenclature is based on the colored stone grading system taught at GIA. Courtesy of Gemewizard Ltd.

June 2003, will be tailored to students in gemology. This version will have an enhanced tutorial and gemological section, but with fewer trading capabilities (e.g., it cannot trade gems over the Internet). Finally, the Lab version, scheduled for release in July-August 2003, is planned to offer a more comprehensive and detailed color system.

Thomas W. Overton and BML

CONFERENCE REPORTS

AGTA corundum panel. On February 7, the American Gem Trade Association hosted the panel session "Beryllium Diffusion Coloration of Sapphire—A Summary of Recent Research," which was moderated by Kenneth Scarratt of the AGTA Gemological Testing Center, New York. The panel focused on the controversial bulk diffusion treatment of corundum.

Richard Hughes, of Pala International, Fallbrook, California, recounted the history of the beryllium treatment controversy, saying that dealers and laboratories in the U.S. became suspicious in fall 2001, when large quantities of orange corundum appeared on the market. He added that some of these treated goods had already been sold in Japan undetected.

Dr. Dietmar Schwarz, of the Gübelin Gem Lab, Lucerne, Switzerland, announced that bulk diffusion-treated blue sapphires have now entered the gem trade. These stones are particularly challenging to identify because the diffusion-induced color penetrates the entire stone. The blue color, he said, can resemble that of fine Sri Lankan sapphires. Dr. Schwarz also reported that the treaters are now trying many other types of additives, such as lithium, to create various colors, and warned that the diffi-

cult-to-detect blue material could undermine the market for sapphires.

Tom Moses, of the GIA Gem Trade Laboratory in New York, reported that bulk-diffused rubies have also appeared on the market. Clues to this new treatment process include the unusual color (resembling red spinel), the presence of inclusions that have been significantly altered by the treatment process, and—most importantly—by a shallow orange color zone along the outline of the stone.

Mr. Moses stressed that the terms *bulk* or *lattice* diffusion had been established long before this corundum came to market at the end of 2001. "Labs did not invent these terms. They simply are the scientific terms used to describe the process."

Dr. John Emmett, of Crystal Chemistry, Brush Prairie, Washington, said that currently the only reliable test to identify bulk diffusion treatment in those sapphires where the treatment penetrates the entire stone is chemical analysis using methods such as secondary ion mass spectrometry (SIMS). If beryllium or other elements not found in natural corundum are detected, this proves that the stone has been diffusion treated. While this test is 100% accurate, it is too expensive—at least \$500 per stone, Mr. Scarratt pointed out—to be practical for the general run of commercial material.

Mr. Scarratt also noted that some of the corundum is subjected to a second heat treatment after the bulk diffusion process, which helps create the attractive blue color. He reported that treaters now have access to very sophisticated furnaces for heating stones, which can tightly control the temperatures to better regulate the treatment process. He also pointed out that some of the treated corundum shows traces of a synthetic overgrowth that formed

during the high-temperature heating process.

Shane McClure, of the GIA Gem Trade Laboratory in Carlsbad, told the audience that it is “unacceptable” for treaters to try to legitimize a new treatment process by attempting to pass it unnoticed through laboratories. “Even if they do get through at first, we will find out eventually.”

Terry Coldham, of Sapphex, Sydney, Australia, said that the treaters were experts in particular types of corundum, and could process rough in such a way as to make detection of the treatment very difficult.

At a press conference held the next day, Douglas Hucker, of AGTA, Dallas, Texas, reported that the Jewelers of America, Jewelers Vigilance Committee, American Gem Society, and AGTA were issuing a five-point communiqué regarding this treatment. This communiqué (1) confirmed that the corundum is being subjected to a bulk/lattice diffusion treatment that creates new colors or alters existing colors; (2) maintained that this treatment must be disclosed at all levels of the trade, per Federal Trade Commission Guidelines and industry practices; (3) warned that recutting some of the treated stones could affect their color; (4) rec-

ommended that buyers consider establishing written vendor agreements stipulating terms of disclosure; and (5) affirmed that U.S. laboratories would continue efforts to identify the treatment, support the trade, and protect the consumer.

The following week, the Chanthaburi Gem & Jewelry Association (CGA), comprised of some of the biggest players in heat treatment, agreed to disclose the use of beryllium to enhance the color of some types of corundum. The action was welcomed by the gem trade worldwide. The 60 association members present unanimously agreed that:

- Chrysoberyl is being intentionally added to the crucible during the new heat treatment as a source of beryllium to enhance color in corundum.
- All association members are obligated to disclose and differentiate the new treatment to customers. The CGA agreed to add the code letter “A” to invoices of such treated material.

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GNI Regular Features

DIAMONDS

European Commission approves the De Beers Supplier of Choice initiative. The European Commission (EC) granted formal approval of the De Beers Diamond Trading Company’s (DTC) Supplier of Choice initiative on January 16, 2003. This confers a legal stamp of approval on De Beers’s marketing and distribution system for rough diamonds.

However, the EC registered an objection to the DTC’s five-year agreement with Alrosa, Russia’s principal diamond mining and marketing operation, to sell \$800 million worth of rough diamonds on the Russians’ behalf.

The DTC has begun preparing for the formal implementation of the Supplier of Choice initiative in July 2003. It is surveying current and potential clients to determine their distribution and marketing programs, especially with the view of having them commit more funds and resources toward helping downstream retailers and jewelry manufacturers increase diamond sales. Clients are also required to sign a series of “Best Practice Principles,” which ban trading in conflict diamonds altogether and trading in treated diamonds without proper disclosure.

Once the questionnaires are completed, the DTC will assess each client’s position in the market, effectiveness in serving that market, and ability to increase diamond sales. The company will use that information to determine future diamond allocations for existing clients, to possibly drop some clients from its active list, and to appoint new clients now on the potentials list. The DTC must give six months’ notice to clients it drops from its active list. In

turn, the DTC agrees to tailor diamond allocations more closely to clients’ actual needs.

Disputes between clients and the DTC will be handled by an ombudsman, appointed by the DTC and approved by the EC. If no agreement is reached within 25 days, the matter will be determined by arbitration in London.

The EC objected to the DTC agreement with Russia because the DTC’s 50% share of Russian production would enable the company “to maintain its dominant share of the diamond market.” Russia and De Beers have begun talks to alter their marketing agreement to address EC objections. In this regard, *Idex Magazine* and Russian press sources say that the DTC would scale down its Russian purchases by 25%.

Russell Shor

A type IaB diamond showing a “tatami” strain pattern.

The SSEF Swiss Gemmological Institute recently examined an unusual type IaB diamond. During the initial grading process, observation of this colorless 3.54 ct stone with the SSEF Diamond Spotter revealed that it was transparent to short-wave UV radiation. UV transparency is characteristic of both type II and type IaB diamonds. While type II diamonds do not contain enough nitrogen to be detectable with an infrared spectrometer, type IaB diamonds contain a variable concentration of nitrogen atoms (clustered in so-called B aggregates), with a major infrared absorption centered at 1175 cm^{-1} . FTIR spectroscopy of this diamond confirmed that it was type IaB with a low nitrogen concentration—less than 10 ppm. This nitrogen estimate was determined from the absorption coefficient value at 1282



Figure 22. In cross-polarized light, a tatami strain pattern was observed in this 3.54 ct type IaB diamond with a low nitrogen concentration. Photomicrograph by J.-P. Chalain, © SSEF.

cm^{-1} (see S. R. Boyd et al., "Infrared absorption by the B nitrogen aggregate in diamond," *Philosophical Magazine B*, Vol. 72, No. 3, 1995, pp. 351–361).

Microscopic observation of the diamond between crossed polarizing filters showed a crosshatched or "tatami" strain pattern (figure 22). This pattern was described by R. E. Kane more than two decades ago ("The elusive nature of graining in gem quality diamonds," Summer 1980 *Gems & Gemology*, pp. 294–314). More recently, T. M. Moses et al. documented this particular strain pattern in a large population of HPHT-treated diamonds ("Observation of GE-processed diamonds: A photographic record," Fall 1999 *Gems & Gemology*, pp. 14–22). In a subsequent article, C. P. Smith et al. underlined that the tatami pattern is not necessarily indicative of HPHT treatment ("GE POL diamonds: Before and after," Fall 2000 *Gems & Gemology*, pp. 192–215).

Like colorless type II diamonds, colorless type IaB diamonds may be HPHT treated (see B. Deljanin and E. Fritsch, "Another diamond type is susceptible to HPHT: Rare type IaB diamonds are targeted," *Professional Jeweler*, October 2001, pp. 26–29). Therefore, before grading the diamond, low-temperature analysis (at approximately -120°C) was performed to establish the origin of its color. UV-Vis spectroscopy showed features typical of type IaB diamonds: total absorption at 225 nm and a triplet absorption feature with two major peaks at 230 and 236 nm. Photoluminescence spectrometry, together with the data collected in the infrared and UV-Vis regions, proved the diamond to be naturally colorless.

The continuous, three-dimensional propagation of strain through a diamond crystal is hampered by the presence of nitrogen (see Chapter 3 of R. Berman, Ed., *Physical Properties of Diamond*, Clarendon Press, Oxford, 1965). Thus, most type II diamonds, with almost no nitrogen, show "tatami" strain, which extends throughout the sample with approximately the same magnitude in all direc-

tions. In contrast, type Ia diamonds usually show banded strain, with one direction strongly dominating the strain distribution. The 3.54 ct diamond reported here had enough nitrogen to show that it is grouped in B aggregates (as evidenced by the FTIR spectrum), but not enough to disturb the strain distribution significantly, if at all (as shown by the tatami pattern). Moreover, in the past SSEF examined a type IaAB diamond that showed both a weak tatami strain pattern and a slight short-wave UV transparency (as seen with the SSEF Diamond Spotter). From the FTIR spectrum, the total nitrogen content was estimated at 14 ppm. Therefore, that type IaAB diamond also contained very little nitrogen and likewise showed a tatami strain pattern.

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COLORED STONES AND ORGANIC MATERIALS

Poldervaartite from South Africa. Poldervaartite, a very rare Ca-Mn-silicate, was described as a new mineral from the Wessels mine in South Africa nearly a decade ago (Y. Dai et al., "Poldervaartite, $\text{Ca}(\text{Ca}_{0.5}\text{Mn}_{0.5})(\text{SiO}_3\text{OH})(\text{OH}) \dots$," *American Mineralogist*, Vol. 78, 1993, pp. 1082–1087). Few examples were known until recently, when approximately 5,000 specimens were recovered during the mining of manganese ore at the nearby N'Chwaning II mine, from October 2001 to February 2002 (B. Cairncross and J. Gutzmer, "Spektakulärer Neufund. . .," *Lapis*, Vol. 27, No. 5, 2002, pp. 30–34). No additional specimens have been found since then. In the vast majority of specimens, the poldervaartite occurs as druses of "creamy" white opaque crystals. The best poldervaartite specimens form ball-like aggregates of "amber" yellow, pink, or nearly red crystals on a dark brown matrix; the translucent-to-semi-transparent material can yield interesting, if rare, cut gems (figure 23).

Six faceted stones (0.57–6.06 ct, all cut from one spherical aggregate) were examined for this study. They showed a distinct color change—brownish yellow in day light, pinkish orange in fluorescent light, and orange in incandescent light—with very weak pleochroism. The smaller stones (under 1 ct) were semitransparent, whereas the larger stones were translucent (again, see figure 23). They were biaxial, with measured refractive indices of 1.670–1.690. However, considerably lower R.I.'s— $n_x=1.634$, $n_y=1.640$, and $n_z=1.656$ —were given by Dai et al. (1993). Specific gravity, measured hydrostatically, was 3.03–3.12; this range is much higher than the original description (2.91). In a polariscope, these samples had the appearance typical of anisotropic aggregates, due to the fibrous structure of the spheres. All of the stones fluoresced deep red to short-wave UV radiation, but were inert to long-wave UV. No absorption lines were observed with a hand-held spectroscope.

Because the R.I. and S.G. values of this material were



Figure 23. Poldervaartite from the N'Chwaning II mine in South Africa forms attractive spherical aggregates (here, up to 2.1 cm in diameter); photo by Jeff Scovil. A small number of translucent to semitransparent gems have been cut from this material, as shown in the inset (6.06 and 0.78 ct). Inset photo by Jaroslav Hyrsl; daylight-equivalent illumination.

somewhat different from the reported values, one of the faceted samples was analyzed further by Dr. William B. (Skip) Simmons at the University of New Orleans. EDXRF spectrometry showed a composition that was consistent with poldervaartite, and powder X-ray diffrac-

tion yielded a pattern that was very similar to the reference spectrum for this mineral.

Because of its low hardness (5 on the Mohs scale), it is unlikely that much of this material will be faceted, especially since high-quality poldervaartite specimens are prized by collectors. However, the attractive color, distinct color change, and fluorescence of poldervaartite make it a very interesting collector's gemstone.

Jaroslav Hyrsl (hyrsl@kuryr.cz)
Kolin, Czech Republic

Triphylite inclusions in quartz from Brazil. Phosphates are quite common in many granitic pegmatites, but only rarely do they form eye-visible inclusions in quartz. Recently J. Koivula described large (up to 10.5 mm long) mica-like inclusions of lithiophilite in quartz (see "Unusual inclusions in quartz," *Australian Gemmologist*, Vol. 20, No. 11, 2000, pp. 481–482). The locality was given as Madagascar, but this contributor knows of similar material from Brazil. Other phosphates that have been found in quartz include blue lazulite (Madagascar) and apatite and triploidite (Brazil).

Four samples of faceted quartz with some unusual inclusions were purchased by this contributor in Brazil in July 2002 (see, e.g., figure 24). The samples contained sharp, elongated crystals up to 8 mm long and about 1 mm wide. These crystals were pointed on one end, but flat on the other, and had a lozenge-shaped cross-section. They appeared colorless, but when viewed down the c-axis they were pale green in daylight and red-brown in incandescent light. The inclusions had good cleavage perpendicular to their length.

One crystal near the surface was removed and analyzed by X-ray diffraction. Surprisingly, it proved to be a member of the triphylite (LiFePO₄)–lithiophilite (LiMnPO₄) series, but closer to triphylite. This is the first occurrence of triphylite in quartz known to this contributor. Gem-quality triphylite (see, e.g., Fall 1988 Lab Notes, p. 174) is known from several pegmatites in the vicinity of Galiléia (east of Governador Valadares) in Minas Gerais, Brazil. Rough material found about three years ago at the Cigana mine near Galiléia yielded about 500 carats of faceted triphylite

Figure 24. The 58.00 ct faceted quartz on the left contains some unusual eye-visible inclusions that proved to be triphylite. On the right, note the cleavage breaks perpendicular to the length of this 8 mm long triphylite inclusion. Photos by Jaroslav Hyrsl.



in sizes up to approximately 10 ct; these stones were greenish brown in day and fluorescent light but appeared red in incandescent light. The quartz sample reported here may have come from the same region.

Jaroslav Hyrsl

SYNTHETICS AND SIMULANTS

LifeGem synthetic diamonds. Synthetic diamonds created from the remains of a deceased loved one have been offered since May 2002 by LifeGem of Elk Grove Village, Illinois. This patent-pending product is intended as a more personal and individualized memorial than traditional burial and cremation methods, and is available for both people and pets.

The production process requires that the remains be cremated at a funeral home equipped with LifeGem's proprietary technology, which collects organic carbon normally lost in cremation. According to the LifeGem Web site (www.mylifegem.com), about halfway through the standard cremation process, the carbonized matter is captured in a unique "carbon curing" container. Typically, enough carbon can be collected from the average human body to make at least ten 1 ct synthetic diamonds. The carbon is purified and converted to graphite, although traces of many elements found in the body (particularly boron) are not entirely removed during the purification.

Diamond synthesis is carried out by Lucent Diamonds of Lakewood, Colorado, which has the worldwide exclusive production rights. This company has grown synthetic diamonds (formerly sold as Ultimate Created Diamonds) for

several years (see Spring 1999 Gem News, pp. 47–48). According to Lucent Diamonds president Alex Grizenko, the synthesis process uses presses designed by a team of scientists in Russia, and employs the temperature gradient method using a flux solution of iron alloys. Synthesis occurs in the range 5.0–6.0 GPa and 1,600–2,000°C. Because of the presence of trace amounts of boron in the recovered carbon, the synthetic diamonds are type IIb. Currently, faceted sizes up to 1 ct with a light to medium blue color are being produced.

LifeGem and Lucent Diamonds are constructing a production facility outside of Denver, Colorado, that is scheduled to open in 2004. This center will have 15 presses in its first phase, with plans to expand significantly over the next several years.

Permission was obtained from family members for GIA to examine two LifeGem synthetic diamonds (see, e.g., figure 25). According to Shane McClure at the GIA Gem Trade Laboratory in Carlsbad, these blue type IIb samples, 0.23 and 0.25 ct, had properties that were consistent with those reported for other synthetic blue diamonds (see, e.g., M.-L. T. Rooney et al., "De Beers near colorless-to-blue experimental gem-quality synthetic diamonds," Spring 1993 *Gems & Gemology*, pp. 38–45; Spring 2000 Lab Notes, p. 62). Both contained metallic inclusions (from the solvent) and were attracted to a magnet. EDXRF spectrometry of the 0.23 ct sample by senior research associate Sam Muhlmeister showed only traces of iron (boron cannot be detected with our instrument). At the present time, the Laboratory does not know of any nondestructive method to identify the source of the carbon in synthetic diamonds.

BML and Thomas W. Overton

Figure 25. This 0.23 ct LifeGem synthetic diamond was grown using purified carbon that was derived from human remains during cremation. Courtesy of LifeGem; photo by Maha Tannous.



CONFERENCE REPORTS

SME 2003 annual meeting. A session on "Diamonds and Other Gem Minerals" was part of the technical program of the 2003 Annual Meeting of the Society of Mining, Metallurgy, and Exploration (SME), which was held in Cincinnati, Ohio, from February 24 to 26. **Howard Coopersmith** of Great Western Diamond Company, Fort Collins, Colorado, began the session with a review of numerous diamond exploration projects ongoing in both Canada and the U.S. Although North America contains the largest area of diamond potential in the world, this continent was largely overlooked by geologists until recently. Diamonds from Canadian mines that are either in operation or in the final stages of development will soon represent over 10% of the world's production. **Dr. Roger Mitchell** of Lakehead University, Thunder Bay, Ontario, Canada, described in general terms the geology of lamproite diamond deposits in Australia, India, and the U.S., and discussed in more detail the evaluation of potentially diamondiferous lamproites adjacent to the famous Prairie Creek (or Crater of Diamonds) deposit in the Murfreesboro District of Arkansas. **This GNI contributor** discussed the

importance of accurate gem identification and complete information disclosure for ensuring consumer confidence in the gem marketplace. Also described were some current challenges in the identification of diamonds and other gemstones, with particular focus on how gemologists recognize synthetic and treated diamonds and simulants.

Kimberley Scully of SGS Lakefield Research Ltd., Lakefield, Ontario, discussed the importance of quality assurance for mineral testing laboratories that support diamond exploration efforts. Such attention to detail will minimize the possibility of mineral contaminants or the loss of crucial grains of indicator minerals from a collected sample, which could cause a diamond area under investigation to be mistakenly overvalued or not recognized. In the final presentation, **Leigh Freeman** of Downing Teal Inc., Denver, Colorado, described current operations to recover and market blue sapphires from the famous Yogo Gulch deposit in Montana, which is the largest *in situ* source of sapphires in the Western Hemisphere. Since its discovery just over a century ago, this deposit has produced more than 20 million carats of blue sapphires, of which more than 3 million carats were gem quality. The strong attendance (75+) at this session reflects the interest of mining geologists in the occurrence and exploitation of gem deposits. *JES*

ANNOUNCEMENTS

AGTA Spectrum Awards competition. The AGTA Spectrum Awards recognize outstanding natural-color gemstone and cultured pearl jewelry designs from North America, as well as achievements in the lapidary arts. The deadline for entering this year's competition is September 22. Winning entries will be displayed and award recipients honored at the 2004 AGTA GemFair in Tucson and the 2004 JCK GemFair in Las Vegas. As there have been changes in the Cutting Edge Awards for the lapidary arts, entrants are urged to review the new guidelines on the AGTA web site. For entry forms and more information, visit www.agta.org or call 800-972-1162.

Exhibits

GIA Museum exhibits in Carlsbad. "From the Vault," an exhibition of notable gifts to the GIA collection, will be displayed in the Rotunda Gallery May 5–November 5, 2003. In the Tasaki Gallery, the exhibit "Opal and the Dinosaur—Discover the Link" featuring opalized fossils and other opal from Australia concludes May 17. The Gallery will reopen with "All Natural, Organically Grown—Gems from Plants and Animals," from July 7 through June 2004, and will feature pearls, shell, amber, ivory, jet, tortoise shell, and coral. Educational displays will cover how these materials form, where they are found, and how they have been used in jewelry, as well as related environmental and endangered-species issues.

Contact Alexander Angelle at 800-421-7250, ext. 4112 (or 760-603-4112), or e-mail alex.angelle@gia.edu.

Gems at the Bowers Museum extended—again. The highly popular run of "Gems! The Art and Nature of Precious Stones" at the Bowers Museum in Santa Ana, California (announced in Winter 2001 *Gems & Gemology*, p. 342), has been held over, to August 31, 2003. Visit www.bowers.org or call 714-567-3600.

Fabergé at the Walters Art Museum. "The Fabergé Menagerie," featuring more than 100 miniature animal sculptures created by the firm of Carl Fabergé from various gem materials, will be on display at the Walters Art Museum, Baltimore, Maryland, through July 27, 2003. Visit www.thewalters.org, call 410-547-9000, or e-mail info@thewalters.org.

Conferences

CIM Montreal 2003. This mining conference and exhibition will take place May 4–7, 2003, in Montreal, Canada. The technical program will include sessions on Canadian diamonds and rare-element mineralization in granitic pegmatites. There will also be a workshop on diamond exploration. Visit www.cim.org/MCE/montreal2003.

GIA GemFests 2003. Save the date for these informative sessions at the following locations: Italy—Vicenza Fair, June 8; Thailand—Bangkok Gems and Jewelry Fair, September 11; Hong Kong—Hong Kong Jewellery and Watch Fair, September 20; U.S.—Dallas Fine Jewelry Show, Texas, September 20. Contact Jan Tilton at jtilton@gia.edu.

Field Symposium in Urumqi. Titled "Paleozoic Geodynamic Processes and Metallogeny of Chinese Altay and Tianshan," this meeting will be held August 9–21, 2003, in northern Xinjiang, China. Included in the 11-day field excursion will be a visit to the Keketuohai No. 3 pegmatite, a source of gem-quality tourmaline and aquamarine. Visit www.nhm.ac.uk/mineralogy/cercams/activities/2nd%20Circular%20Final.doc or e-mail jingwenmao@263.net.

13th V. M. Goldschmidt Conference. Held in Kurashiki, Japan, September 7–12, 2003, this conference will host a symposium titled "Geochemistry of diamond, a window to the deep earth," featuring recent progress on the mineralogy of diamond and its inclusions, HPHT experiments to investigate diamond formation, and the isotopic geochemistry and physical properties of diamond. Fax 81-3-3263-7537, visit www.ics-inc.co.jp/gold2003, or e-mail gold2003@ics-inc.co.jp.

JCK Show – Las Vegas. Held at the Sands Expo & Convention Center May 30–June 3, this international gem and jewelry trade show will also host a comprehensive

educational program beginning May 28. Scheduled seminars will cover sales and marketing strategies, industry trends, and developments in gemology. To register or for further information, call 800-257-3626 or 203-840-5684, or visit <http://jck.expoplanner.com/vegas.html>.

The AGTA GemFair, Cultured Pearl & Jewelry Pavilion will be held as part of JCK Las Vegas from May 29 to June 2 at the Venetian Hotel. AGTA will be offering educational seminars and gemological testing. For more information or to register, call 800-972-1162 or visit www.agta.org/consumer/tradeshows/jckvegas.htm.

Faceters Symposium 2003. Held in Ventura, California, June 6–8, this conference will feature speakers on various aspects of gem faceting and a three-level faceting competition. For information, contact Glenn Klein at glennklein@yahoo.com.

Jewelry 2003: Honoring the Sataloffs. The 24th Annual Antique & Period Jewelry and Gemstone Conference will be held July 12–17 in Hempstead, New York. The program will cover such topics as hands-on jewelry examination techniques, methods of construction, understanding materials used throughout history, and the constantly changing marketplace. Jewelry collectors Ruth and Dr. Joe Sataloff, founders of the original Antique Jewelry Course in Orono, Maine, will also be honored. Visit www.jewelrystcamp.org, call 212-535-2479, or e-mail jwlrystcamp@aol.com.

FIPP 2003. The 13th International Gemstones Show will take place August 19–22 in Teófilo Otoni, Minas Gerais, Brazil. Seminars and excursions to local gem mines will be offered. Visit www.geabrasil.com or e-mail geabr@geabrasil.com.

Diamond 2003. The 14th European Conference on Diamond, Diamond-like Materials, Carbon Nanotubes, Nitrides & Silicon Carbide will take place September 7–12 in Salzburg, Austria. Sessions will include diamond growth, optical properties, and mechanical applications and properties of diamond and other superhard materials. Contact April Williams at 44-0-1865-843089 (phone), 44-0-1865-843958 (fax), e-mail a.williams@elsevier.com, or visit www.diamond-conference.com.

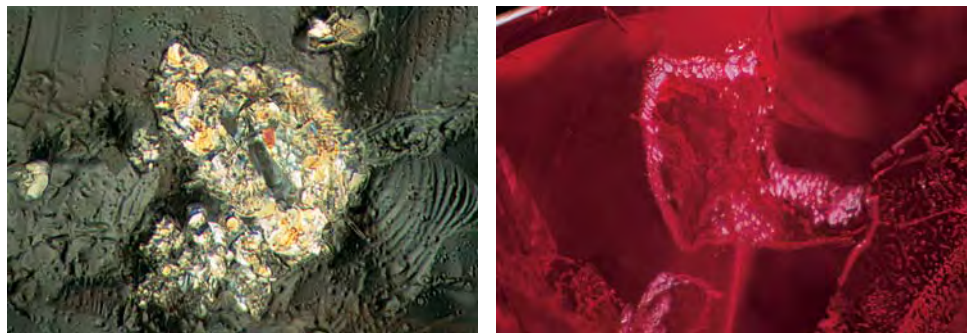


Figure 26. On the left is a kibatama ojime bead carved from a mammal tooth; on the right is a hornbill “ivory” ojime. Photos by Robert K. Liu; courtesy of and © 1977 Ornament magazine.

ERRATA

1. In the Letters section of the Winter 2002 issue (p. 292), the photos of the hornbill ivory and kibatama mammal tooth ojime were inadvertently transposed (corrected in figure 26). *Gems & Gemology* regrets the error.
2. In the Winter 2002 issue, the entry for the Zoë Diamond Cut™ in the appendix to “Legal Protection for Proprietary Diamond Cut” (p. 323) incorrectly indicated that ownership of the design was shared between Gabi Tolokowsky and Suberi Brothers. In fact, the design and name are wholly owned by Mr. Tolokowsky, and the stones are cut exclusively by Mr. Tolokowsky’s company in Antwerp. *Gems & Gemology* thanks Mr. Tolokowsky for bringing this to our attention.
Elsewhere in the appendix, the entry for the Elara cut diamond describes the design as “probably patented.” The patent for this design is in fact J. D’Haene, *Gemstone*, U.S. patent D338,851, issued August 31, 1993. *Gems & Gemology* thanks Howard B. Rockman of Chicago, Illinois, for the information.
Last, U.S. adoption of the Madrid Protocol, discussed on pp. 315–316, was signed into law by President Bush in November 2002. The changes will be implemented by the U.S. Patent and Trademark Office over the next year.
3. Also in the Winter 2002 issue, on p. 296 of the article “Chart of Commercially Available Gem Treatments,” the two photomicrographs in figure 2 were inadvertently transposed (see corrected placement in figure 27). *Gems & Gemology* regrets the error.

Figure 27. On the left (magnified 33×), platelets of synthetic corundum formed on the surface of a sapphire treated by a Be-diffusion process. On the right (40×), small platelets of synthetic corundum line the bottom of a glass-filled cavity in a Mong Hsu ruby. Photomicrographs by Shane F. McClure.



The Dr. Edward J. Gübelin MOST VALUABLE ARTICLE AWARD

In an issue where we are honoring the award's namesake, we are especially pleased to announce the winners of this year's Dr. Edward J. Gübelin Most Valuable Article Award. We extend our sincerest thanks to all the subscribers who participated in the voting.

The first-place article was "Chart of Commercially Available Gem Treatments" (Winter 2002), which provided a comprehensive guide to the most frequently encountered treatments in the industry. Receiving second place was "Characterization and Grading of Natural-Color Pink Diamonds" (Summer 2002), a study of almost 1,500 pink diamonds examined in the GIA Gem Trade Laboratory. Third place was awarded to "Diamonds in Canada" (Fall 2002), an in-depth review of exploration, mining, and production in one of the industry's most exciting new sources.

The authors of these three articles will share cash prizes of \$2,000, \$1,000, and \$500, respectively. Following are photographs and brief biographies of the winning authors.

Congratulations also to John Fuhrbach of Amarillo, Texas, whose ballot was drawn from the many entries to win a three-year subscription to *Gems & Gemology* and a laminated Gem Treatments Chart.

● FIRST PLACE

CHART OF COMMERCIALY AVAILABLE GEM TREATMENTS

Christopher P. Smith and Shane F. McClure

Christopher Smith is director of the Gübelin Gem Lab Ltd. in Lucerne, Switzerland. A prolific author, Mr. Smith is also a member of the *Gems & Gemology* Editorial Review Board and a contributing editor of the journal's Gem News International section. **Shane McClure** is director of West Coast Identification Services at the GIA Gem Laboratory in Carlsbad. With over 20 years of laboratory experience, Mr. McClure is well known for his articles on gem identification. He is also an editor of the Gem Trade Lab Notes section.



Christopher P. Smith



Shane F. McClure



John M. King



James E. Shigley and Scott S. Guhin



Thomas H. Gelb



Matthew Hall

● SECOND PLACE

CHARACTERIZATION AND GRADING OF NATURAL-COLOR PINK DIAMONDS

John M. King, James E. Shigley, Scott S. Guhin, Thomas H. Gelb, and Matthew Hall

John King is laboratory projects officer at the GIA Gem Trade Laboratory in New York. Mr. King received his Master of Fine Arts degree from Hunter College, City University of New York. With over 20 years of laboratory experience, he frequently lectures on colored diamonds and laboratory grading procedures. **James Shigley** is director of research at GIA in Carlsbad. Prior to joining the Institute in 1982, Dr. Shigley received his bachelor's degree in geology from the University of California, Berkeley, and his doctorate in geology from Stanford University. He is the author of numerous articles on diamonds and other gemstones, contributing editor of *G&G*, and a well-known speaker on gemological topics. **Scott Guhin** is manager of GIA's West Coast Grading Laboratory in Carlsbad. Mr. Guhin came to GIA in 1990 with an extensive background in retail jewelry. He holds a bachelor's degree in art from San Diego State University. **Thomas Gelb** is a staff gemologist at the GIA Gem Trade Laboratory in New York. A graduate of the University of Massachusetts, Mr. Gelb has 10 years' experience in diamond grading and gem identification. **Matthew Hall** is the supervisor of analytical equipment for GIA Research and Identification in New York. He holds a bachelor's degree in geology from Franklin and Marshall College and a master's in geology and geochemistry from the University of Maryland.

● THIRD PLACE

DIAMONDS IN CANADA

B. A. Kjarsgaard and A. A. Levinson



B. A. Kjarsgaard



A. A. Levinson

Bruce Kjarsgaard is a research scientist in the Mineral Resources Division of the Geological Survey of Canada in Ottawa. Dr. Kjarsgaard received his bachelor's degree in earth science from the University of Guelph and his Ph.D. in geology from the University of Manchester. **Alfred A. Levinson** is professor emeritus in the Department of Geology and Geophysics at the University of Calgary. Dr. Levinson, who has written and edited a number of books in geochemistry, serves on the *G&G* Editorial Review Board and as editor of the journal's Gemological Abstracts section. He holds a Ph.D. in mineralogy from the University of Michigan.

GEMS & GEMOLOGY Challenge 2003

Gems & Gemology Challenge 2003 Gems & Gemology Challenge 2003 Gems & Gemology Challenge 2003 Gems & Gemology Challenge 2003 Gems & Gemology Challenge 2003
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The following 25 questions are based on information from the four 2002 issues of *Gems & Gemology*. Refer to the feature articles and “Notes and New Techniques” in those issues to find the **single best answer** for each question; then mark your choice on the response card provided in this issue. (Sorry, no photocopies or facsimiles will be accepted; contact the Subscriptions Department—dortiz@gia.edu—if you wish to purchase additional copies of this issue.) Mail the card so that we receive it no later than **Monday, August 4, 2003**. Please include your name and address. All entries will be

acknowledged with a letter and an answer key **after the due date**.

Score 75% or better, and you will receive a GIA Continuing Education Certificate. If you are a member of the GIA Alumni Association, you will earn 10 Carat Points toward GIA’s Circle of Achievement. (Be sure to include your GIA Alumni membership number on your answer card and submit your Carat card for credit.) Earn a perfect score, and your name will also be featured in the Fall 2003 issue of *Gems & Gemology*. Good luck!

- Economic diamond deposits discovered in Canada thus far have generally been
 - high in ore grade and large in size.
 - low in ore grade but large in size.
 - low in ore grade and small in size.
 - high in ore grade but small in size.
- Dyeing of gem materials
 - cannot be detected in some materials or with certain dyes.
 - can always be detected with magnification.
 - can always be detected with EDXRF, UV-Vis-NIR, or Raman analysis.
 - always mimics hues that occur in nature.
- Richard Liddicoat’s _____ is one of the most widely used textbooks ever published in gemology.
 - Diamond Dictionary*
 - Handbook of Gem Identification*
 - Jewelers’ Manual*
 - Jewelers Pocket Reference Book*
- Of the two types of hand-held spectrometers available, the advantage of the prism spectrometer over the diffraction-grating spectrometer is its
 - portability.
 - even distribution of the visible color range.
 - greater availability of published spectra.
 - clearer absorption lines in the red region.
- The coloration of natural-color yellow rhodizite-londonite is
 - stable.
 - unstable to heat.
 - unstable to sunlight.
 - less stable than irradiated yellow rhodizite-londonite.
- The principal source of liddicoatite tourmaline is
 - Brazil.
 - Madagascar.
 - Mozambique.
 - California.
- The grant of a right to prevent others from making, using, selling, or importing an invention, such as a diamond cut design, is known as a
 - trademark.
 - patent.
 - trade secret.
 - copyright.

8. Type II pink diamonds tend to be _____ than type I pink diamonds.
- more heavily included
 - less heavily included
 - deeper in color
 - more strongly color zoned
9. Diamonds such as the Star of the South are classified as type IIa based on the relative absence of _____-related features in the infrared region of the spectrum.
- argon
 - boron
 - hydrogen
 - nitrogen
10. All of the yellow Gemesis laboratory-created diamonds examined proved to be type ____ diamonds, based on their infrared spectra.
- Ia
 - IaB
 - Ib
 - IIa
11. An absorption feature at 700 nm can be used to help separate yellow cultured pearls of the *Pinctada margaritifera* oyster from those produced in the South Seas by the
- Pinctada maxima*.
 - Pinctada fucata martensii*.
 - Pteria sterna*.
 - Haliotis iris*.
12. The optical properties and specific gravity of serendibite completely overlap with those of
- zoisite.
 - diopside.
 - sapphire.
 - spinel.
13. A record \$926,316-per-carat price was paid for a _____ diamond at auction in 1987.
- Fancy blue
 - Fancy pink
 - Fancy purplish red
 - Fancy Deep red
14. The brownish purple-red garnets from Tranoroa, Madagascar, are members of the _____ series.
- malaia
 - andradite-grossular
 - grossular-hydrogrossular
 - pyrope-spessartine
15. Early diamond exploration in Canada was frustrated by misunderstandings about
- permafrost.
 - glacial geology.
 - local culture.
 - kimberlite genesis.
16. Synthetic ruby overgrowth on natural corundum can best be distinguished from red diffusion treatment by
- aligned inclusions along a boundary plane.
 - surface morphology of the corundum crystal.
 - chalky white X-ray fluorescence.
 - EDXRF chemical analysis.
17. Irradiation of gem materials
- generally is not detectable.
 - sometimes can be detected with advanced techniques such as EDXRF or SEM-EDS chemical analysis.
 - sometimes can be detected with microscopic examination or advanced techniques such as UV-Vis-NIR or Raman photoluminescence spectrometry
 - both A and C.
18. Working in conjunction with the University of Florida, Gemesis has developed a synthetic diamond growth process based on a modification of the
- floating zone method used in Japan.
 - BARS apparatus used in Russia.
 - BARS apparatus used in Japan.
 - HPHT process developed in Russia.
19. To reveal the beautiful color zoning of multicolored liddicoatite, most of this material is fashioned as
- cabochons.
 - step cuts.
 - polished slices.
 - freeform polished stones.
20. Once a diamond manufacturer has registered its brand name as a trademark, that trademark
- is permanent.
 - must be used in commerce to remain in force.
 - need not be used in commerce to remain in force.
 - prevents anyone else from using the brand name in commerce.
21. Londonite was recognized as a mineral in
- 1834.
 - 1910.
 - 1934.
 - 1999.
22. When methylene iodide is not available as an immersion medium in the field, one author recommends the use of water or even
- olive oil.
 - alcohol.
 - saturated salt solution.
 - acetone.
23. Atypical absorption features, particularly in the _____ region of the spectrum, can be used to identify color treatment in "golden" South Sea cultured pearls.
- red
 - yellow
 - orange
 - blue
24. The Star of the South, a historic 128 ct diamond, was discovered in 1853 in
- Brazil.
 - South Africa.
 - German SW Africa (Namibia).
 - Australia.
25. The best method for separating red diffusion treatment from a synthetic overgrowth on natural corundum is
- Raman spectrometry.
 - microscopic examination.
 - EDXRF chemical analysis.
 - infrared spectroscopy.

EDITORS

Susan B. Johnson
Jana E. Miyahira-Smith
Stuart Overlin

Elizabeth Taylor: My Love Affair with Jewelry

By Elizabeth Taylor, 239 pp., illus.,
publ. by Simon & Schuster, New
York, 2002. US\$39.95*

Elizabeth Taylor is a living legend, and her magnificent jewels are almost as legendary. As the head of Christie's Jewelry Department, François Curiel, says in his introduction, "Elizabeth Taylor's name is synonymous with jewels. . . ." Immensely entertaining, this book will appeal to a wide range of audiences. Jewelry and gem lovers will enjoy the book because it features numerous pieces of exceptional quality from famous design houses such as Boucheron, Bulgari, Cartier, Chopard, Tiffany & Co., and Van Cleef & Arpels. Taylor fans will enjoy the amusing anecdotes that accompany many of the jewels (including the famous story of the puppy and the pearl), and history buffs will appreciate the descriptions of historically important jewelry in her collection, among them the Taj Mahal diamond and the pearl known as La Peregrina. Her knowledge of the provenances behind these items is quite impressive.

The text contains both the expected—chapters on jewelry given to her by husbands Michael Todd and Richard Burton—and the unexpected: a chapter devoted to her collection of charm bracelets and another highlighting her animal-themed jewels. The book is filled with top-notch photographs of Ms. Taylor's jewelry as well as photos that document her amazing career, many of which show her wearing jewelry featured in the book. Also included is an index of

jewelry with detailed descriptions of each item.

Beautiful and interesting, this book belongs on almost anyone's "to read" list.

JANA E. MIYAHIRA-SMITH
Gemological Institute of America
Carlsbad, California

Cameos: Old and New, 3rd Ed.

By Anna M. Miller, 274 pp., illus.,
publ. by Gemstone Press,
Woodstock, VT, 2002. \$19.95*

One might think that a third edition on the same topic would be redundant—not so with *Cameos*. Whether contemporary or antique, cameos are among the most sentimental and easily recognizable jewelry items. Yet they are often the least understood.

Did you ever wonder why the woman in that classical profile was wearing a winged helmet? Or why cherubs wear two types of wings—butterfly and angel? The story behind cameos is incomplete without the symbolism, myths, historical events, and legends, but this work lays it all out in an uncomplicated manner. A source of confusion for many is the overlapping Greek and Roman influences (e.g., the Greek god Eros and his Roman counterpart Cupid), but the chart on Greek and Roman divinities sorts it out, with a list of mythological figures frequently found on cameos, including 20 other pairings.

One of the important new sections in this edition is "Estimating Cameo Value: Quality Ranking Cameos," information that should be in the

notebook of every auction jewelry specialist and independent appraiser. To determine the quality of a cameo, the jewelry consultant must combine research with hands-on examination. Basic elements such as composition, design, craftsmanship, subject, material, signature, and authentication are used as a guide to determine quality rankings. While this valuation process may sound complex, the clear explanations make it easy to follow.

A new section on buying and selling offers many pieces of solid advice. The one that resonated most for this reviewer was that collectors and dealers should compile their own price guide of auction sales results, which should include notes about conditions that might have affected the final sales price, such as location, time of year, weather, holidays, and publicity.

Anna Miller's considerable expertise in cameos expands the wealth of information provided by this affordable third edition. It will prove very valuable even to those who have read the previous two.

GAIL BRETT LEVINE, G.G.
Publisher, Auction Market Resource
Rego Park, New York

Beryllium-Treated Rubies and Sapphires

By Ted Themelis, 48 pp., illus.,
publ. by Gemlab Inc. (e-mail:
ted@themelis.com), Bangkok, 2003.
US\$20.00.

Gemologist Ted Themelis has written a very timely and informative booklet on the controversial subject of berylli-

um-diffused sapphire. Ever since stones treated by this new method were first recognized by Ken Scarratt of the AGTA Gemological Testing Center in January 2002, the sapphire community has been in turmoil trying to understand the process and define it for the trade. Initially, Thai processors denied that beryllium was responsible for the color enhancements, arguing that so many different colors could not be caused by a single element. Subsequently, the use of beryllium was proved to be true, and the process is now disclosed by the Chanthaburi Gem and Jewelry Association.

However, very few people in the colored stone community have had a chance to actually *see* what happens to a wide variety of sapphires when subjected to beryllium diffusion. It is in exploring this subject that Themelis's booklet is of significant value. The great majority of the more than 129 color photographs illustrate various types of corundum that have been treated by beryllium diffusion. It is in these photos that the value lies, more so than in the text. The photos clearly show the many different colors produced in various starting materials by diffusion of the single element beryllium.

It should be stated that this is not a technical work, in that no attempt is made to explain the physical processes involved in the treatment. Nor does it attempt to recognize other work being conducted contemporaneously, and its representation of the history of understanding and duplicating this new Thai process is less than global. Its strength (and weakness) lies in the fact that it simply documents, with numerous color photographs, one man's experiments with beryllium diffusion into a wide variety of corundum samples.

I would recommend this booklet to anyone dealing in ruby and sapphire, as it clearly shows those types and colors of sapphire that should receive close scrutiny.

JOHN L. EMMETT
Crystal Chemistry
Brush Prairie, Washington

Jewelry & Gems at Auction

*By Antoinette Matlins, 309 pp., illus., publ. by Gemstone Press, Woodstock, VT, 2002. US\$19.95**

This is the seventh in a series of consumer-friendly books by Ms. Matlins. The gem and jewelry auction is an event that can cause great intimidation and yet offers great possibilities for both buyer and seller. The pages of this book are sprinkled with numerous firsthand experiences, both the positive and the disappointing.

With an in-depth discussion of the various layers of auction procedure and what to expect, Ms. Matlins addresses the contrasts between the traditional auction gallery and the modern Internet auction, including opportunities and risks alike. She recommends a two-step approach to using any auction venue: (1) learn the auction process, and (2) acquire a useful knowledge of gemstones. To help with the first step, she not only explains basic auction terminology in terms a layperson can understand, but she also devotes an enormous number of pages to describing the intricate relationship between the pre-sale estimate and the reserve, how this affects sold vs. not-sold pieces, and ultimately the impact on auction house revenue and profits.

The mantra echoed throughout is *do not bid* on any major gem or piece of jewelry unless you have seen the item. While this is not easily accomplished on the Internet, Ms. Matlins explains that it can be done by employing the services of a "Gemologist Consultant" (as Ms. Matlins refers to this individual) for confirmation and verification of Internet purchases. Gemologist Consultants can help the online buyer or seller avoid costly mistakes, teach good-better-best in gemstones and jewelry, and confirm lab documentation. Concerns about on-site auction gallery condition reports, catalog descriptions, catalog photos, and laboratory reports can be addressed by an experienced Gemologist Consultant as well. Becoming a Gemologist Consultant is a great career move for gemologist appraisers.

Ms. Matlins also provides criteria for selecting a credentialed appraiser and contact information on appraisal organizations. In this regard, it would have been helpful to have Web site addresses listed, because many of these organizations have their member directories online. It also was unfortunate that an important appraisal organization (the International Society of Appraisers), as well as two prominent gem laboratories (the International Gemological Institute and the European Gemological Laboratory), were left out of the listing.

The book includes excellent photos of some extraordinary items of antique and contemporary jewelry, complete with final hammer price, gallery, and location. Regrettably, there are no dates of sale, which would have been useful as time-in-place valuations.

Online and onsite auctions are not for the faint of heart, but Ms. Matlins's book provides common-sense suggestions and clear steps one should take to minimize risks and maximize success.

GAIL BRETT LEVINE, G.G.

Gemstone Buying Guide, 2nd Ed.

*By Renee Newman, 156 pp., illus., publ. by International Jewelry Publications, Los Angeles, 2003 US\$19.95**

Is it a reference manual for gemologists, a source of product knowledge for jewelry salespeople, or a guidebook for gemstone buyers? In many respects, this book is a combination of all three.

With almost 280 color photos and dozens of line drawings and charts, the author shows us the variety of gems and gem-set jewelry available in the market today. From common and inexpensive stones to one-of-a-kind designer pieces, the reader will see a full range of items to appeal to most tastes and budgets.

The book begins with a 10-page preview of the most important gem materials covered and the factors that affect price. The remaining chapters

discuss cutting styles; color; judging clarity, transparency, and cut quality; evaluating stars and cat's-eyes; treatments; synthetics; deceptive practices; and caring for gems. The author covers these subjects in a clear and easy-to-understand manner, although a few line drawings and photos are either mislabeled or ambiguously labeled.

The author provides detailed descriptions for over 100 trade names and varieties, many of which are illustrated in color. The written descriptions often include information on history, lore, sources, appearance of fine qualities, and retail price ranges. There are gem property charts for each species, with optical properties, physical properties, care tips, and treatments.

Gemologists, jewelry salespeople, and gemstone buyers would all benefit by adding this book to their libraries.

DOUGLAS KENNEDY

*Gemological Institute of America
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Mogok, Myanmar

By Roland Schlüssel, 280 pp., illus., publ. by Christian Weise Verlag, Munich, 2002 (in German). € 100.00

This is not simply a book about Mogok and rubies. Nor is it just a travel account. Instead, it is a combination of both—and more. The author, a gem expert with the Swiss retailer Bucherer, takes the reader from his arrival at Yangon (Rangoon), to Mandalay, and finally Mogok, combining the description of his adventures with plenty of background color and information.

The opening chapter provides a general introduction to the geography of Myanmar, its history, its role as a melting pot of cultures, and its civilization, which is deeply rooted in Buddhism. Throughout, Schlüssel stresses the importance of gems (especially rubies and jadeite) in Myanmar society, from the gem trade that goes on across the country to the Gem Emporium in the capital.

Next is a history and description of Mogok itself, its cocktail of peoples, the

mining activities, and the customs and procedures that control the gem trade. The author carries the reader through his visits to several ruby mines and his difficult and delicate negotiations to acquire some exceptional rubies.

From the fourth chapter on, the gemological aspect of the book prevails over the "touristic." Chapter 4 mainly details the geologic setting of Myanmar in general and Mogok in particular. The collision of the Indian and Eurasian plates created several microplates, with subsequent regional metamorphism causing the enormous profusion of gems in the Mogok Stone Tract. This chapter also includes a description of other gem varieties found in Mogok, including danburite and some absolute rarities: painite, johachidolite, periclase, and thortite.

A chapter on the gemology of ruby and sapphire describes the gemological properties of corundums from Mogok, with a special focus on inclusions and treatments. It also discusses certificates and pricing.

Next, the author traces the gem trade routes from ancient times to the present. He then discusses the characteristics, symbolic value, and meaning of colors (especially terms such as *pigeon blood red*, *cornflower blue*, and *padparadscha*), rubies and sapphires in auctions, star sapphires and rubies, the role of spinels and peridots, and quality criteria for gems. He also describes the provenance of some important and historic rubies and sapphires (including the 1,734 ct "Sun of Mogok" ruby crystal).

The final chapter is dedicated to corundum cutting and its challenges, as well as the creation of jewelry. Here, the author allows himself some (pardonable) promotion for Bucherer's "Mogok Collections."

This volume, which is written mainly for the general reader, concludes with a nine-page glossary of gemological terms and Burmese expressions, and two pages of references. It contains a number of interesting maps, lists, and other graphical illustrations, as well as some stunning photographs of people and pagodas,

pits and painites, peridots and precious rubies, mostly taken by the author. In short, the volume is sheer beauty combined with thorough information—a lot of fun to leaf through and to read.

ROLF TATJE
Duisburg, Germany

Crystals: Their Growth, Morphology, and Imperfections

By Ichiro Sunagawa, 304 pp., illus., publ. by Kyoritsu Publications Corp., Tokyo, 2003 (in Japanese). ¥7,500

The many forms in which crystals can occur raise many questions, even for experienced mineralogists and gemologists. Why does a mineral show a particular crystal habit? How do the internal imperfections form? What is the relationship of these imperfections to the crystal morphology and growth mechanism?

With this book, world-renowned mineralogist, gemologist, and crystal-growth scientist Prof. Ichiro Sunagawa provides answers to these and other questions related to crystals. The 14 chapters are divided into two parts: The first describes the fundamentals of crystal morphology, crystal growth theory, and lattice defects; the second addresses how these fundamentals apply to different gem minerals, in particular diamond, quartz, pyrite, and calcite. For example, the quartz chapter describes formation mechanisms of various silica minerals with different imperfections, such as twins, growth bands, and dislocations. The pyrite and calcite chapter summarizes variations in the crystal habit of these minerals, while the final chapter discusses the biomineralization origin of several crystals such as apatite, calcite, and magnetite.

This insightful book represents a summary of the author's 50 years of studies in mineralogy, gemology, and crystal growth.

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Gemological ABSTRACTS

2003

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COLORED STONES AND ORGANIC MATERIALS

Aquamarin & Co. *extraLapis*, No. 23, 2002 [in German].

This issue is dedicated to all beryls except emerald. It begins with etymological discussions by C. Behmenburg and M. Glas on the word *beryl* and other words derived from it, such as the German *Brille* (eyeglasses) and the French *briller* (to shine). These authors then discuss Nikolaus von Kues's *De beryllo*, wherein beryl is described as "shining, white, and transparent." This and other considerations lead to the conclusion that eyeglasses possibly were not made of beryl, as was often claimed, but other materials, most likely rock crystal.

R. Hochleitner and K. Schmetzer briefly outline the mineralogy and crystallography of beryl and describe its varieties—goshenite, aquamarine, heliodor, morganite, emerald, and red beryl. This is followed by R. Hochleitner's 23-page summary of beryl occurrences worldwide.

The beryl and bazzite (the scandium analog of beryl) occurrences of the Alps, which are rare specialties for rock hunters, are described by S. Weiß. J. Kanis relates the story of the Baboon Hill mine in Zimbabwe, which produced small, but fine, golden beryls (up to 12 ct), and E. Petsch and K. Schmetzer describe the aquamarine occurrence at Marijao, Madagascar, which yielded 28 aquamarine crystals that weighed more than 100 kg each. The "Beryll-Galerie" contains 17 pages of stunning photographs of outstanding beryl specimens.

The volume concludes with three articles on various topics: K. Schmetzer on synthetic beryls, especially hydrothermal synthetics from Russia; K. E. Wild and K. Schmetzer on gem beryls, including market and pricing trends; and M. Huber on the use of beryllium in science and technology. As is customary for the *extraLapis* series, this volume is lavishly illustrated. *RT*

This section is designed to provide as complete a record as practical of the recent literature on gems and gemology. Articles are selected for abstracting solely at the discretion of the G&G editors and the reviewers, and space limitations may require that we include only those articles that we feel will be of greatest interest to our readership.

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The reviewer of each article is identified by his or her initials at the end of each abstract. Guest reviewers are identified by their full names. Opinions expressed in an abstract belong to the abstractor and in no way reflect the position of Gems & Gemology or GIA.
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Cathode-luminescence texture of jadeite jade and its gemological significance. Y. Zhou, *Journal of Gems and Gemmology*, Vol. 4, No. 3, 2002, pp. 31–35 [in Chinese with English abstract].

The textures of jadeite from Myanmar have been extensively studied by polarized microscopy of thin sections. In this article, jadeite textures are described based on images obtained by cathodoluminescence microscopy. Five distinct types of textures were identified: crystalloblastic, zonal, cataclastic, metasomatic, and artificially treated.

The crystalloblastic texture is characterized by clear grains of varying sizes. The zonal texture shows regular (near rectangular or diamond shaped) or irregular-shaped zones with different luminescence colors; these zones may relate to variations in the distribution of impurities within the jadeite. The cataclastic texture displays recrystallization features developed during certain geologic processes, such as those that mechanically deform rock. The metasomatic texture is characterized by mineral replacement features (e.g., jadeite grains that are partly replaced by albite). The artificially treated texture, as seen in “B-jade,” has net-like micro-fractures with or without filling materials.

TL

Manganese accommodation in fossilised mastodon ivory and heat-induced colour transformation: Evidence by EXAFS. I. Reiche, G. Morin, C. Brouder, V. A. Solé, P.-E. Petit, C. Vignaud, T. Calligaro, and M. Menu, *European Journal of Mineralogy*, Vol. 14, No. 6, 2002, pp. 1069–1073.

The color of odontolite, or bone turquoise, a “turquoise”-blue heat-treated mastodon ivory or bone, can be ascribed to traces of Mn^{5+} (220–650 ppm Mn) in a tetrahedral environment of four oxygen atoms in an apatite matrix. Extended X-ray absorption fine structure (EXAFS) confirmed the presence of Mn^{2+} , Mn^{3+} , or Mn^{4+} before, and Mn^{5+} after, thermal treatment of fossilized ivory.

RAH

Microstructural studies on cultured saltwater pearls from Fangcheng, Guangxi. B. Kong, J. Zou, J. Cheng, and Y. Liao, *Journal of Guilin Institute of Technology*, Vol. 22, No. 2, 2002, pp. 119–122 [in Chinese with English abstract].

Chinese Akoya cultured pearls produced in Fangcheng, Guangxi Province, have been classified into three types based on optical microscopy, scanning electron microscopy, and X-ray diffraction studies of their internal structures: (1) nacre with a layered structure, (2) prismatic layered structure, and (3) complex layered structure. About 55%–60% are of the first type; percentages are not given for the other types.

The nacre with a layered structure consists mainly of minute (3–5 μm long, 2–3 μm wide, 0.3–0.5 μm thick)

aragonite platelets with hexagonal or irregular forms. These platelets are cemented together by conchiolin (in layers 0.015–0.1 mm thick) and overlap, giving rise to a regular array of concentric layers. The prismatic layered structure is located very close to a nucleus and composed mainly of relatively large (0.02–0.1 mm long, 0.02–0.04 mm wide) calcite crystals with a prismatic habit. These calcite crystals, also cemented with conchiolin (in layers 0.2–10 μm thick), are either in a parallel arrangement or in radial lines. The complex layered structure is found in low-quality cultured pearls and is usually a mixture of crystallites with irregular forms, water, gas, and other materials. The exact nature of this material is unclear.

TL

On the problem of dispersed bunsenite (NiO) in chrysoprase. K. Dyrek, Z. Sojka, W. Zabinski, and F. Bozon-Verduraz, *Mineralogia Polonica*, Vol. 32, No. 2, 2001, pp. 3–8.

UV-Vis-NIR spectroscopy of chrysoprase of differing crystallinity is interpreted as confirming that the Ni^{2+} ions are grafted to the finely crystalline SiO_2 matrix in extra-framework positions of distorted octahedral symmetry. The coordination sphere of Ni^{2+} ions, being partly formed by water molecules, is labile and easily affected by thermal treatment. The green color of the chrysoprase is determined by absorption in the red (654 nm) and blue (389 nm) regions of the visible spectrum. The presence of dispersed bunsenite in the samples studied has been ruled out because of the absence of the corresponding charge-transfer band.

RAH

The origin of colour of chrysoprase from Szklary (Poland) and Sarykul Boldy (Kazakhstan). M. Sachanbiński, J. Janeczek, A. Platonov, and F. J. M. Rietmeijer, *Neues Jahrbuch für Mineralogie, Abhandlungen*, Vol. 177, No. 1, 2001, pp. 61–76.

Chrysoprase samples from two major sources, Szklary in southwestern Poland (the “type” locality) and Sarykul Boldy in Kazakhstan, were studied by electron microscopy and optical and infrared (IR) spectroscopy to determine the origin of the unique green color. The results show that the color originates from nano-size inclusions of layer-silicates—nickel-bearing kerolite (a variety of talc) and pimelite (a variety of serpentine?). Bunsenite (NiO) was not detected in these samples, and therefore it cannot be the coloring agent as was previously suggested in the literature.

The presence of mineral inclusions containing Fe^{3+} ions causes a yellowish hue. Light scattering on microdefects (e.g., silica globules, minute mineral inclusions, gas-liquid inclusions) in the chalcedony matrix causes a bluish hue. IR spectroscopy indicates that there is no relationship between the degree of crystallinity and the intensity of the green color.

KSM

DIAMONDS

Coesite inclusions in rounded diamonds from placers of the northeastern Siberian Platform. A. L. Ragozin, V. S. Shatsky, G. M. Rylov, and S. V. Goryainov, *Doklady Earth Sciences*, Vol. 384, No. 4, 2002, pp. 385–389.

Rounded dark gray to black diamonds with characteristic inclusions are typical of placers in the northeastern Siberian Platform. Known kimberlites in the area are either barren or poorly diamondiferous, and the morphology and inclusions of diamonds from the known pipes differ markedly from those in the placers.

The dark colors of the diamonds are attributed to abundant fluid inclusions with the walls coated by a "graphite-type carbon." Some inclusions contained both CO₂ and hydrocarbons, suggesting that the crystallizing solutions were oversaturated with respect to carbon. The nitrogen content of the diamonds ranged from 929 to 2,243 ppm; the N aggregation state was high. Colorless euhedral crystals of coesite (a high-pressure form of quartz) also were detected in the diamonds, which constrains their origin to an eclogitic source (confirmed by $\delta^{13}\text{C}$ isotopic data from the diamonds). All factors considered, these alluvial Siberian diamonds probably formed in carbon-containing subducted crustal rocks. They remained in the upper mantle for a long time after crystallization before being brought to the surface by an unspecified mechanism at an unknown location. AAL

Crystal morphology as an indicator of redox conditions of natural diamond dissolution at the mantle PT parameters. A. F. Khokhryakov, Y. N. Pal'yanov, and N. V. Sobolev, *Doklady Earth Sciences*, Vol. 385, No. 5, 2002, pp. 534–537.

Small (0.3–0.8 mm), flat-faced octahedral diamonds from the Udachnaya kimberlite pipe in Russia were subjected to a wide range of reducing and oxidizing (redox) conditions, in the presence of a C-O-H fluid of variable composition, at a pressure of 5.7 GPa and a temperature of 1,400°C. The object was to investigate the effect of such conditions, which simulate those in the earth's mantle, on the dissolution morphology of natural diamonds.

With these experimental conditions, three principal forms of diamond dissolution developed. In the most oxidizing environment (Na₂O₃ melt with Fe₂O₃), trisectahedroids with curved faces were formed, with normally triangular etch pits present on the {111} faces. In moderately oxidizing conditions (Na₂CO₃ melt with H₂O), diamond dissolution developed along ditrigonal layers with the formation of inversely oriented etch pits on the {111} faces. Highly reducing conditions (MgO melt with titanium) resulted in the formation of flat-faced trisectahedrons that were sculptured by striations parallel to [011] and very low-angle triangular etch pits on the octahedral faces. These results show how redox conditions in the earth's upper mantle may control some of the

morphological characteristics of diamonds, via their interaction with melts and fluids within the diamond stability field. AAL

Industrial diamonds gather strength. E. J. Lerner, *Industrial Physicist*, Vol. 8, No. 4, 2002, pp. 8–11.

Diamond has the highest atomic density (i.e., number of atoms per unit volume) of any known substance, leading to its hard and chemically inert nature as well as to its high R.I. (2.42). Its short and extremely strong bonds make it an excellent insulator and thermal conductor, as well as a semi-conductor (under certain conditions). Diamond is transparent to a wide range of the electromagnetic spectrum, from ultraviolet to microwaves. These remarkable properties have been harnessed by industry for many purposes, and have encouraged the manufacture of high-quality synthetic diamonds, including some for the gem trade.

Diamonds were first synthesized by Sweden's ASEA and General Electric in the mid-1950s using massive (1,000 ton) presses to generate the required high pressures and temperatures. Since then, the process has become faster and more economic due to the efforts of Russian and American researchers; for example, current presses are about the size of a washing machine. Numerous sources are now producing large gem-quality synthetic stones. For example, one Florida-based firm is synthesizing and selling rough yellow synthetic diamonds up to 3 ct that are grown in about four days. It is uncertain what impact increased production of gem-quality synthetic diamonds will have on the market for natural diamonds.

Low-pressure techniques yield chemical-vapor-deposition (CVD) diamond films. These techniques are progressing rapidly as researchers improve film quality and increase growth rate. The article describes a wide range of industrial applications for CVD films. CT

Laser-aided separation of diamonds. S. E. Avdeev et al., *Proceedings of the International Society for Optical Engineering*, Vol. 4900, No. 2, 2002, pp. 946–951.

The separation of diamonds from ore has been achieved with X-ray luminescence, laser luminescence, and photoabsorption techniques. Among the drawbacks of the first two methods is the possible loss of high-quality stones, since many such diamonds do not luminesce. Photoabsorption is somewhat inefficient in separating diamonds from ore where there are significant differences in the color and size of the diamonds. These authors propose a new, efficient, low-cost technology for separating diamonds from ore using the specific characteristics of Rayleigh and Raman light scattering in a two-stage separator. In the first stage (based on Rayleigh scattering), all transparent minerals in the ore are concentrated. In the second stage (based on Raman scattering), the diamonds are concentrated. MT

Mining at any cost. E. Blauer, *New York Diamonds*, January 2003, pp. 40–47.

De Beers's diamond mines in South Africa's Namaqualand are nearing the end of their production, after more than 70 years of operation. De Beers, however, is bringing in new equipment to extend the life of these mines by several years. The key: digging deeper.

Namaqualand's alluvial diamond deposits are found over a large area centered around the cities of Kleinsee and Koingnaas. Last year, 800,000 carats of high-quality diamonds were produced from De Beers's Namaqualand mines, but the fact that they account for only 1.5% of the company's total production while requiring 10% of its work force meant that the operation would have become uneconomic by 2006. However, closing the mining operations would have laid off more than 2,000 people, affecting 8,000 additional dependants in a desolate area where there is no other industry.

The plan to extend the mine life is based on reworking previously mined areas at much deeper levels. Until recently, De Beers's drilling equipment could work down to 40 m, and all estimates of mine life were calculated using that limit. However, new equipment allows excavation to 110 m, where an estimated reserve of 41 million carats was identified in 2002. De Beers's concession covers 444 km², and mining is expected to continue until at least 2008. *RS*

Regolith and diamond deposits around Tortiya, Ivory Coast, West Africa. R. M. Teeuw, *Catena*, Vol. 46, No. 1–2, 2002, pp. 111–127.

The placer (i.e., alluvial) diamond deposits in the Tortiya area of the Ivory Coast are in a region that has experienced prolonged and extensive weathering and erosion under humid tropical conditions. This has resulted in the formation of a regolith (loose, unconsolidated surficial materials resting on bedrock) that consists primarily of laterite ("ferricrete") with minor bauxite. Sedimentological studies (e.g., gravel petrology and particle size distribution) of the regolith were undertaken to better understand the processes of both regolith formation and diamond concentration under such climatic conditions.

Two concentrations of placer diamonds are recognized. The bulk of the diamonds (0.2–2.5 mm) come from colluvial placers <10 m thick of probable Quaternary age (between 1.6 million years and the present) that were formed by re-concentration of earlier (exact age not known) placer deposits lower in the regolith sequence. The richest deposits occur toward the base of ferruginized (iron-containing) mudflows. Regolith-forming processes included the transfer of clays and iron-oxide minerals, quartz disintegration, and colluvial inputs. Diamond concentration was influenced by fluvial and mudflow processes, slope wash, desiccation cracks, and ferricrete dissolution. *CT*

Tectonic controls on kimberlite location, southern Africa. S. Vearncombe and J. R. Vearncombe, *Journal of Structural Geology*, Vol. 24, No. 10, 2002, pp. 1619–1625.

The correlation between diamond-bearing kimberlites and Archean cratons is well established worldwide. However, the relationship between the location of the kimberlites and major structures on the Archean cratons is controversial, yet of great exploration significance. This article considers the ascent paths of southern African kimberlite magmas from mantle depths (>150 km) to the surface. It relates their spatial distribution to the "crustal architecture" (i.e., the geometry of major geologic boundaries, including faults, within the crust) in an attempt to find the link between kimberlite location and major geologic structures. The spatial distribution is analyzed geometrically using computer software (SpaDiS™).

The results of the spatial analysis show that kimberlites are located in corridors that are parallel to, but not within, prominent shear zones and crustal faults. These kimberlite corridors occur within domains (i.e., specific areas) with relatively homogeneous, strong crustal rocks that are capable of maintaining the very high CO₂ pressures necessary for rapid emplacement. *AAL*

GEM LOCALITIES

Gem and rare-element pegmatites of southern California. J. Fisher, *Mineralogical Record*, Vol. 33, No. 5, 2002, pp. 363–407.

Pegmatite mining in southern California throughout the 20th century has yielded a wealth of gem and mineral specimens for the collector, museums, and the academic community. The mines were most active between 1902 and 1912 and from the late 1950s to the early 1990s. Fine specimens of elbaite, kunzite, morganite, and other pegmatite minerals from this area can be found in both public and private collections worldwide. The study of these pegmatites has produced a wealth of scientific information and contributed greatly to the current understanding of how and why complex granitic pegmatites form.

Mining activities are slow at present because of the depletion of the near-surface portions of many productive pegmatites. Thus, the cost of future mining will increase dramatically because exploitation must occur at much deeper levels. Mining also faces environmental regulation and property ownership issues, especially on Native American tribal lands; in addition, encroaching human development, particularly in the Ramona area, presents problems. If some of these issues are resolved, then mines such as the Stewart, White Queen, and Little Three have the potential to produce a large number of specimens. If gem prices increase, then the Himalaya, Pala Chief, and Tourmaline Queen, which have been extensively mined in the past, could be re-opened on a commercial scale. Although future prospects for pegmatite mining in southern California may seem limited, the province is considered one of the most productive and well-studied gem and rare-element pegmatite regions in the world, surpassed only by those of Brazil and Afghanistan. *MT*

Gemmological study of corundum from Madagascar. J. Shida, *Australian Gemmologist*, Vol. 21, No. 6, 2002, pp. 247–252.

Techniques and observations by which Madagascar rubies and sapphires can be distinguished from similar stones from other localities worldwide are described. Methods for discriminating between natural-color and heat-treated Madagascar corundum are also presented. The usefulness of argon-ion laser tomography in these discriminatory tests is stressed. Padparadscha sapphires from Madagascar may have zircon inclusions that are altered by heat treatment. The resulting changes in their Raman spectra allow this treatment to be readily identified. RAH

Infrared microspectrometric characterizations and thermoluminescent properties from natural quartz slices. T. Hashimoto, Y. Yanagawa, and T. Yamaguchi, *Bunseki Kagaku*, Vol. 51, No. 7, 2002, pp. 527–532 [in Japanese with English abstract].

Infrared spectroscopy of thin (0.5 mm) slices of natural quartz crystals from Brazil and Madagascar were used to investigate the relationships between blue thermoluminescence (BTL), OH impurities, Al-hole centers, and gamma-ray irradiation. Infrared absorption spectra were obtained in the range 3,800–2,800 cm^{-1} under varying conditions (e.g., room temperature, liquid-nitrogen temperature, following irradiation with ^{60}Co). BTL was observed between 80 and 320°C. A proportional relationship was found between the intensity of the BTL and Al impurities. In the Brazilian quartz, there was a relatively homogeneous distribution of Al-OH and BTL, whereas in the Madagascar quartz heterogeneous growth patterns of Al-OH and Li-dependent Al-OH impurity contents were found. The Al-hole centers are influenced by active hydrogen radicals. These results suggest that mobile hydrogen atoms or hydrogen radicals, produced from the radiolysis of the Al-OH, could operate as a quencher of Al-hole centers for radiation-induced phenomena in quartz. TL

Louisiana opal. G. Brown, *Australian Gemmologist*, Vol. 21, No. 6, 2002, pp. 244–246.

Louisiana opal is a light- to dark-colored sandstone cemented by opal, some of which shows play-of-color. It occurs in central western Louisiana but has not been mined since the early 1990s. Access to the deposit (the Hidden Fire mine) is no longer possible, as it lies in a commercial pine forest. RAH

Mexican gem opals: Nano- and micro-structure, origin of colour, comparison with other common opals of gemmological significance. E. Fritsch, M. Ostrooumov, B. Rondeau, A. Barreau, D. Albertini, A.-M. Marie, B. Lasnier, and J. Wery, *Australian Gemmologist*, Vol. 21, No. 6, 2002, pp. 230–233.

The elementary building blocks of volcanic opals, mostly Mexican examples, are shown to be small silica grains,

~20–40 nm in diameter. They often occur grouped as fibers or as blades in lepispheres (micron-sized spheroidal bodies). The body color of these Mexican opals is generally attributable to inclusions, sometimes submicroscopic. Orange-to-brown Mexican fire opal, in particular, is colored by nanometer-size fibers of an iron-bearing compound.

RAH

Mined in America. G. Roskin, *JCK*, Vol. 174, No. 2, 2003, pp. 110–119.

While most gems are generally regarded as coming from exotic locales, the U.S. and Canada quietly produce many varieties, often of very high quality. This report, categorized by gemstone type, begins with diamond, recounting the operations in Canada's Northwest Territories as well as in Arkansas's Crater of Diamonds National Park. Examples of colored stones follow.

Sapphires have been mined in Montana for many years, though mainly in smaller (2–6 mm) sizes; the blue sapphires from Yogo Gulch are not heat enhanced. Emerald from Hiddenite, North Carolina, can be of high quality, but production remains limited. Beautiful red beryl is mined in Utah, whereas morganite is produced in Maine and California. Various types of garnet (spessartine, andradite/demantoid, pyrope) are mined in Arizona, as is peridot. Red chrome pyrope garnets produced there have "super saturated" colors. Tourmaline is mined in California (mostly pink) and Maine (blue and green). Pink tourmaline from California is often irradiated to enhance the color. Turquoise is produced in Arizona and New Mexico, with the Sleeping Beauty mine in the former state noted for some of the world's finest material. North America also boasts gem-quality occurrences of amazonite, Ammolite, benitoite, fossil ivory, jade (mostly nephrite), obsidian, and numerous varieties of quartz.

Columbia Gem House, of Vancouver, Washington, is spearheading an effort to promote American gemstones. The past year has seen a rise in interest in domestically mined gems, but consumers need assurances that both the stone and the jewelry are produced in the U.S. RS

Mineralogical and geochemical study of the Regal Ridge emerald showing, southeastern Yukon. L. A. Groat et al., *Canadian Mineralogist*, Vol. 40, 2002, pp. 1313–1338.

In 1998, emerald and green beryl were discovered at Regal Ridge, Finlayson Lake district, Yukon Territory, in both float and outcrop. A small quantity of the emeralds have been faceted and cut *en cabochon* (up to ~0.1 ct and ~2 ct, respectively). Although small, the faceted stones have excellent clarity and color with no zonation.

Emerald formed where quartz veins (0.5–1.0 m wide) cut mica-rich layers in schist. These veins are surrounded by extensive concentrations of dark tourmaline that host most of the emerald and green beryl; only rarely do they occur in the quartz veins. Cr (average 3,208 ppm) is the

predominant chromophore of the emeralds. The authors suggest that crystallization occurred ~109 million years ago, at temperatures of ~365–498°C and pressures of 1.0–2.5 kbar, and at depths of 3.0–7.7 km.

The Regal Ridge occurrence is in metamorphosed volcanic rocks near a contact with a granite pluton. The close proximity of the granite suggests that it is the source of the Be; the Cr comes from the schist. Additional exploration work (e.g., trenching and bulk sampling) will be required to determine the economic potential of the occurrence, and whether this could become Canada's first emerald mine. AAL

Mineralogy, age, and fluid geochemistry of the Rila emerald deposit, Bulgaria. P. Alexandrov, G. Giuliani, and J. L. Zimmermann, *Economic Geology*, Vol. 96, No. 6, 2001, pp. 1469–1476.

Emerald occurs in association with the Rila granitic pegmatite (20 m long and 2.5 m wide) in southwestern Bulgaria. The pegmatite contains coarse-grained plagioclase (with or without quartz), columbite, native bismuth, and molybdenite, and is located at the contact between biotite gneiss and talc schist of Precambrian age. Emerald crystals (up to 6 mm wide and 15 mm long) formed within the metasomatic zone between the pegmatite and talc schist; associated minerals include phlogopite, tremolite, and chlorite. The chromophore, Cr, was likely derived from the associated metamorphosed mafic or ultramafic (e.g., talc schist) rocks.

Two types of fluid inclusions (in the H₂O-CO₂-NaCl system) have been identified in the emeralds. Primary (type 1) inclusions are CO₂-bearing aqueous inclusions, which occur as either negative crystals or long thin tubes, oriented parallel to the c-axis. Both two-phase (CO₂ liquid + H₂O liquid) or three-phase (CO₂ liquid + H₂O liquid + vapor) varieties are found. Secondary (type 2) inclusions form along healed fractures. They are typically CO₂-bearing aqueous inclusions, but they also may be two- or three-phase inclusions with 40%–50% vapor. Both type 1 and type 2 inclusions may contain solid inclusions (e.g., phlogopite). KSM

Natural amethyst from the Caxarai mine, Brazil, with a spectrum containing an absorption peak at 3543 cm⁻¹. H. Kitawaki, *Journal of Gemmology*, Vol. 28, No. 2, 2002, pp. 101–108.

Natural amethyst from the Caxarai mine, Rondônia State, Brazil, has several unusual features that distinguish it from amethyst of other localities. The color zoning is unusual in that the *z* {0111} sectors have deeper color than the *r* {1011} sectors, and the dark and light purple banding in the *z* sectors is quite distinct. One of the pleochroic colors is often a strong bluish purple that is frequently associated with synthetic amethyst.

Amethyst from the Caxarai mine also shows very little Brazil-law twinning, and what is present resembles the conically shaped zones currently associated with synthetic

amethyst. Most significant is that amethyst from this mine has an infrared absorption peak at 3543 cm⁻¹, which is considered the most diagnostic characteristic of synthetic amethyst. Thus, the above features so closely resemble those of synthetic amethyst that natural material from the Caxarai mine may be misidentified as synthetic unless thorough investigations are made. Inclusions, when present, remain the key to separating natural from synthetic amethyst. WMM

Occurrence and genesis of thunder eggs containing plume and moss agate from the Del Norte area, Saguache County, Colorado. D. E. Kile, *Rocks & Minerals*, Vol. 77, No. 4, 2002, pp. 252–268.

This article provides a comprehensive and carefully documented review of the history, occurrence, internal and external characteristics, mineralogy, and genesis of thunder eggs. These spherical nodules are typically 4–6 inches (~10–15 cm) in diameter, and filled primarily with chalcedony, and in some cases with colorful agate exhibiting three-dimensional banding and “plume” (feather-like) structures and “moss” inclusions. They are found throughout the western U.S., where they weather out of high-silica extrusive rocks (rhyolites and welded tuffs). They are particularly well known from Oregon, but emphasis in this article is on the exceptionally beautiful thunder eggs found near Del Norte, Colorado.

Various theories have been proposed for the origin of thunder eggs, each of which has contested components. Any theory must explain five particular characteristics. First, they are found only in rhyolites (or welded tuffs) of Tertiary or younger age and usually in a single stratigraphic horizon at each locality. Second, they have a rhyolite shell that has a higher silica content than does the host rhyolite. Third, they have a central cavity for which the origin is particularly contentious (an “expansion mechanism” from an initial vapor bubble is most widely accepted). Fourth, a mechanism is needed for the deposition of chalcedony in the central cavity (the favored mechanism is silica-rich, late-stage hydrothermal solutions derived from the host rock, transportation by groundwater, and crystallization under low temperature and pressure conditions). Last, the formation of the plume and moss inclusions within the agate, from the cavity walls inward, is problematic; for example, even the nature of the silica solutions (whether a gel or a nonviscous silica solution) is not presently known. AAL

The pegmatites of the Nova Era-Itabira-Ferros pegmatite district and the emerald mineralisation of Capoeirana and Belmont (Minas Gerais, Brazil): Geochemistry and Rb-Sr dating. C. Preinfalk, Y. Kostitsyn, and G. Morteani, *Journal of South American Earth Sciences*, Vol. 14, No. 8, 2002, pp. 867–887.

The authors studied rocks (mainly granitic gneiss, and pegmatites with and without emeralds) and minerals (e.g.,

various micas, feldspar) from localities in and around the emerald deposits of Capoeirana and Belmont, as well as in the Nova Era-Itabira-Ferros pegmatite district. Age dating and chemical analysis for both major and trace elements were performed to relate emerald genesis to igneous and metamorphic events in the area. Two generations of emerald formation are recognized. The main formation (as at Belmont and Capoeirana) occurred 1.9 million years (My) ago in schists, associated with a high-grade metamorphic event that was accompanied by the introduction of Be-rich pegmatites that interacted with Cr-bearing ultrabasic rocks. The second, represented by unmetamorphosed pegmatites (only some of which are emerald-bearing) primarily in the Nova Era-Itabira-Ferros pegmatite district, occurred about 477 My ago.

Trace-element plots of Cs vs. K/Rb from K-feldspars and muscovite were used to differentiate between emerald-bearing and emerald-barren pegmatites; however, the technique gave misleading results in some cases. No data on the quality or gemological properties of the emeralds, or production data, are presented. *KAM*

Spectroscopic properties of Mõng Hsu ruby. S. Siripaisarnpipat, T. Pattharakorn, S. Pattharakorn, S. Sanguanruang, N. Koonsaeng, S. Achiwawanich, M. Promsurin, and P. Hanmungthum, *Australian Gemmologist*, Vol. 21, No. 6, 2002, pp. 236–241.

The spectroscopic examination of 140 Mõng Hsu rubies in the 200–1100 nm region showed no significant changes that could be attributed to heat treatment. All spectra showed a fluorescence peak at 693 nm. In the infrared spectra of those rubies that had been heat treated, the peaks at 2000–1900 cm^{-1} disappeared, and a series of sharp peaks replaced the broad band at 3500–3200 cm^{-1} . *RAH*

Successful application of ground-penetrating radar in the exploration of gem tourmaline pegmatites of southern California. J. E. Patterson and F. A. Cook, *Geophysical Prospecting*, Vol. 50, No. 2, 2002, pp. 107–117.

Ground-penetrating radar (GPR), a technique usually associated with archaeology and engineering, was successfully used to locate gem-bearing zones within pegmatite at the Himalaya mine, Mesa Grande district, southern California. Images were obtained showing cavity geometry and location, which enabled more accurate placement of mining explosives, thus minimizing blasting damage to the fragile gem crystals.

Mining activities in pegmatites in this area are often guided by the assumptions that most gem-bearing pockets will have a specific shape (flattened bladder-like spaces) parallel to dike contacts, and that specific mineralogical changes occur in the vicinity of the pockets (e.g., the occurrence of pods of fine-grained lepidolite or schorl crystals that flare toward the center of the dike); the mineralogical changes can be used as indicators that a potentially produc-

tive zone is being approached. In many areas, however, the indicators are either nonexistent or too subtle, and the pocket may be missed. When GPR data are properly recorded and processed, and calibrated with geologic information under appropriate conditions, resolution of features (pockets and vugs) as small as a few centimeters within ~2 m, or tens of centimeters within ~5 m, of a wall surface may be achieved. It is also possible to determine if the pocket is air-filled or clay-filled. The re-examination by GPR of pegmatites that are no longer being mined is justified based on these positive findings. *LT*

INSTRUMENTS AND TECHNIQUES

Inclusions in gemstones: Their cathodoluminescence (CL) and CL spectra. J. Ponahlo, *Journal of Gemmology*, Vol. 28, No. 2, 2002, pp. 85–100.

Rapid, nondestructive cold-cathode (which is distinct from the more common “hot-cathode”) cathodoluminescence (CL) microscopy and microspectrophotometry techniques were used to study 10 gem samples (topaz, garnet, kyanite, tourmaline, kornepurine, plagioclase, calcite, dolomite, and two spinels) containing a variety of inclusions (apatite, dolomite, quartz, fluorite, rutile, diopside, zircon, ruby, albite, and pargasite) with different degrees of luminescence. Even small colorless inclusions that may otherwise escape detection, such as apatite, fluorite, or diopside, can easily be detected if they luminesce strongly.

CL spectra of both host gems and inclusions (which must intersect the facet surface of the host for CL testing) and photomicrographs are presented to support several basic conclusions: (1) Host and inclusions are most easily studied when the CL of each is strong and distinctly colored or when the host is less luminescent than the inclusion; (2) should strong luminescence of the host mask strong luminescence of an inclusion, CL microspectrophotometry is recommended; and (3) should the host luminesce or remain inert while the inclusion is inert, the spectral range up to 950 nm should be searched for CL bands, as the bands may have shifted into the near infrared. *CT*

Light emitting diodes as light sources in portable gemmological instruments. C. Lamarre, *Journal of Gemmology*, Vol. 28, No. 3, 2002, pp. 169–174.

Luminescence from light-emitting diodes (LEDs; i.e., solid-state lamps capable of emitting light from the ultraviolet [370 nm] to the near infrared [950 nm]) is being used as an alternative light source for incandescent bulbs in portable gem instruments. Although LEDs have been available since the 1960s, only in the past decade have technical advances enabled these devices to display bright, full colors in broad daylight. The current generation of LEDs has many other advantages. They are small and durable, have low power consumption and are heat resistant, and their lifespan exceeds 100,000 hours.

A yellow 590 nm (near-monochromatic) and a white LED used as light sources for a refractometer and a polariscope, respectively, are shown to yield excellent results and are superior to incandescent light bulbs. A blue 472 nm light source was successfully used with a red filter to observe red fluorescence in a chromium-bearing gem. LEDs are available that produce white light similar to that produced by a fluorescent tube. This is accomplished with a blue LED coated with YAG, which is fluorescent; the blue emission stimulates the YAG coating to produce fluorescent white light. MW

Measurement of small birefringence in sapphire and quartz plates. D. H. Goldstein, L. L. Deibler, and B. B. Wang, *Proceedings of SPIE—The International Society for Optical Engineering*, July 9–11, 2002, Seattle, Washington, Vol. 4819, pp. 20–27.

Laser polarimetry measurements were made of the low-level birefringence, and the crystallographic dependence of the birefringence, in plates of synthetic sapphire and quartz. Two different systems, Mueller and Exicor, were used. The light source in both was an He-Ne gas laser with a wavelength of 632.8 nm.

Anomalous birefringence was observed in the samples by both optical instruments, even though none was expected on theoretical grounds. It is postulated that this may be due to the quality of the synthetic crystals and the manufacturing process. These instruments do not currently have any direct gemological application for the study of faceted gemstones; however, the Mueller instrument has potential value in obtaining quantitative measurements of low-level birefringence in gem materials. TL

JEWELRY MANUFACTURING

A model approach. G. Todd, *American Jewelry Manufacturer*, Vol. 47, No. 8, 2002, pp. 31–36.

A model maker works within the limits of casting to produce a model that both looks like the intended design and is useful for production purposes. Whether models are directly fabricated, cast, or a blend of both, shrinkage from the master model to the finished piece usually ranges from 6% to 12%. Shrinkage varies because of the type of mold, wax, and metal used; the temperatures of the mold and metal; and the method of casting. It is particularly important to allow for additional shrinkage in those models designed for stones to be set with tight tolerances, or those expected to seat stones of a specific size or weight.

A bright polish lengthens the lifetime of a mold by protecting it from tearing and memory loss, as the reduction in surface resistance that accompanies a bright polish allows easy release of distortion-free patterns from the mold. Surface finishes (e.g., matte) need not be present when the pattern is made, as they can be added during the finishing process. Outside dimensions are reduced during

polishing, so extremities and interior corners should be made slightly thicker to compensate for uneven metal removal. Most model makers prefer the greater control metal offers for executing detail; however, a skilled carver can place 90%–95% of the detail in wax and the remainder in metal, thus completing the master more quickly. Using white gold rather than sterling silver (the most popular metal for molds) increases the cost of a master but proves more cost effective over time as the expense of repair is negligible. CT

JEWELRY RETAILING

The dish on the newest diamond diva: A chat with Reema Pachachi, creative director of De Beers LV. B. Kasha, *Modern Jeweler*, Vol. 101, No. 11, 2002, pp. 9–10.

Reema Pachachi is the chief jewelry designer for the new De Beers LV (venture between De Beers and Louis Vuitton Moët Hennessy) retail operation, which opened in London in December 2002. The Circle Collection she created for De Beers LV draws cues from today's lifestyles and fashions, instead of looking to the past. Her ambition is "to make classics of the future." She believes that most jewelry on the market today has no relevance to what women are wearing. The design should also reflect the "uplifting experience" of buying and wearing jewelry. This, she says, is what will set De Beers LV apart from other competitors in the luxury jewelry market. RS

Friedman's targets 3000 stores using strip center strategy. G. A. Beres, *National Jeweler*, Vol. 97, No. 4, February 16, 2003, pp. 1, 33.

Friedman's Jewelers, a Savannah, Georgia-based chain of 660 stores, the third largest retail jeweler in the U.S., is considering an aggressive expansion by opening stores in strip mall centers near Wal-Mart outlets.

While most retail jewelry chains locate their stores in major shopping malls, two-thirds of the Friedman's stores are located in strip centers and experience significantly lower costs and higher returns on sales than its mall operations. Statistics show that retail sales have shifted "dramatically" from mall-based department stores to discount stores and other mass merchants. Wal-Mart has 1,700 stores in the 20 states in which Friedman's operates and 900 stores in other states, representing an additional 2,600 potential locations. "Following Wal-Mart" is compatible with Friedman's policy of targeting "value-conscious" consumers. In the past decade, Friedman's has seen a 10-fold expansion by opening 60–90 stores a year. RS

The pretenders. J. Heebner, *JCK*, Vol. 174, No. 2, 2003, pp. 98–102.

The Jewelers Security Alliance (JSA), reporting an increase in the number of jewelry store robberies by criminals

using impersonation as a distraction, has compiled examples of this tactic.

One robbery attempt cited was in Lebanon, Pennsylvania, during Halloween 2001, in which a man entered the store wearing a clown costume with full make-up. A sales associate became suspicious and asked the man for his ID. The man left, but returned a few minutes later and tried to smash one of the showcases. Another incident in Williamsville, New York, is described where a man, posing as a utility company meter reader, gained access to the store and robbed it. Other incidents around the world are recounted where robbers have posed as Saudi royalty and ministers.

Suspicious signs and activities include: outfits that hide faces, persons checking exits and security cameras, customers who want to avoid touching counters for fear of leaving fingerprints, inappropriate questions about opening and closing hours, and excessive talk that may be a ruse to distract jewelers. The JSA advises retailers to challenge anyone who looks suspicious by asking for ID. *RS*

SYNTHETICS AND SIMULANTS

Growth rate of high-quality large diamond crystals. H. Sumiya, N. Toda, and S. Satoh, *Journal of Crystal Growth*, Vol. 237–239, No. 2, 2002, pp. 1281–1285.

The most effective way to grow large synthetic diamond crystals is to use the temperature gradient method under high pressure and high temperature. In this article, scientists from the Itami Research Laboratories of Sumitomo Electric Industries report the use of an improved modification of the temperature gradient technique to successfully grow at much higher growth rates large (7–8 ct, or about 10 mm across), colorless, type IIa synthetic diamond crystals with no visible inclusions. A growth rate of 6–7 mg/hour (in 100 hours, a 3.0–3.5 ct synthetic diamond would be grown) was achieved by the prolonged maintenance of a high-precision temperature control (with less than $\pm 5^\circ\text{C}$ deviation), along with a selection of appropriate solvent metals (iron and cobalt) and other additives (titanium and copper). *James E. Shigley*

Imaging Ni segregation in synthetic diamond using ionoluminescence (IL) and particle induced X-ray emission (PIXE). A. A. Bettio, C. G. Ryan, D. N. Jamieson, and S. Praver, *Nuclear Instruments and Methods in Physics Research B*, Vol. 181, No. 1–4, 2001, pp. 225–230.

The spatial distribution of impurities incorporated during the growth of two synthetic diamonds using a nickel catalyst were imaged and measured by ionoluminescence (IL; performed with a nuclear microprobe) and particle-induced X-ray emission (PIXE) spectroscopy. Distinct growth patterns were observed in the four corner regions (i.e., the $\langle 111 \rangle$ growth sectors) of both samples. The growth sectors contained Ni in concentrations ranging

from a few ppm to ~ 25 ppm. This study showed that for the analysis of optically active Ni impurities in synthetic diamond, IL is significantly more sensitive than PIXE. However, the former technique is only effective in detecting optically active impurities. *AI*

New imitation gemstones from Australia. G. Brown and T. Linton, *Australian Gemmologist*, Vol. 21, No. 7, 2002, pp. 283–287.

Brisbane (Australia)-based Australian Crystallization Technology (Pty) Ltd. has begun commercial production of a range of visually effective semitranslucent-to-opaque imitations of jadeite, chrysoprase, and turquoise, as well as transparent colorless to attractively colored ornamental materials. These simulants are manufactured by a proprietary process that produces “supercooled siliceous melts of specific compositions.” The manufacturer uses “a controlled crystal growth process involving the nucleation of complex metal oxide crystals within a prepared base material (melt) of chrysoprase and other proprietary ingredients in a powdered form.” The workability of the simulants resembles that of their natural counterparts. The materials display the classic features of supercooled melts (e.g., spherical gas bubbles, masses of undissolved additives), which make it easy to identify them as imitations. Gemological properties of 20 of these imitations are presented. *CT*

Recent observations of composite stones. U. Henn, *Australian Gemmologist*, Vol. 21, No. 6, 2002, pp. 253–257.

Five types of composite (assembled) stones are currently encountered in Germany:

1. Doublets and triplets used as simulants of classical gems such as diamond, emerald, ruby, and sapphire. Classified within this type are numerous varieties of soudé (triplet with a layer of colored glass) stones; one German company manufactures soudé stones in 25 different colors to imitate tanzanite, aquamarine, peridot, etc.
2. Doublets and triplets as simulants of gems with trendy colors and/or new gem materials (e.g., doublets with a crown of colorless tourmaline and a “neon”-blue glass pavilion to simulate Paraíba tourmaline).
3. Composite stones manufactured to protect soft gem materials with a hard protective cover (e.g., a slice of Ammolite protected by a dome of colorless glass or synthetic spinel).
4. Composite stones designed to cover gem materials that generally occur in thin layers (e.g., opal doublets and triplets).
5. Composite stones in which the gem material is attractive only in thin layers (e.g., a doublet consisting of a thin crystal section of zoned tourmaline backed by colorless glass).

Unusual composite stones include: a crown of beryl

and a pavilion of chalcedony to simulate cat's-eye aquamarine; and doublets manufactured by cementing a rock crystal crown to an orthoclase feldspar pavilion to imitate the adularescence of moonstone. MT

Research on the growth habit of hydrothermal emerald crystal. Z. Chen, J. Zheg, W. Zhong, and H. Shen, *Journal of Synthetic Crystals*, Vol. 31, No. 2, 2002, pp. 94–98 [in Chinese with English abstract].

The results of a study on the variables (e.g., growth rate, shape, and orientation of seed crystals) that determine the morphology of hydrothermal synthetic emerald crystals grown by a major producer in Guilin, China, are reported. Spherical (6 mm diameter) and platy seed crystals cut from natural beryl crystals were used, and the syntheses were conducted at 500–600°C and 1.5–2.0 kbar in an autoclave for periods of 3, 6, and 9 days. The hydrothermal solutions contained $\text{Al}(\text{OH})_3$ (16%–19%), SiO_2 (63%–67%), Cr_2O_3 (1%–3%), and BeO (13%–15%). Spherical seed crystals were used to determine the development sequence of the various crystal faces during crystal growth, while platy seed crystals with various orientations were used to obtain synthetic emerald crystals that gave the highest yield of gem-quality material.

All the crystal faces that occur on natural emerald crystals were observed on the hydrothermal synthetic emerald crystals (e.g., prisms m $\{10\bar{1}0\}$ and a $\{11\bar{2}0\}$, and basal faces c $\{0001\}$). Also observed were t $\{50\bar{5}1\}$ dipyrarnidal faces, which are not found on natural emerald crystals. The growth rates of the m and a prism faces were very similar. The growth rates of three dipyrarnidal faces decreased in a sequence of u $\{20\bar{2}1\} \rightarrow s$ $\{11\bar{2}1\} \rightarrow p$ $\{10\bar{1}1\}$. The basal faces c were always present during the growth process. The growth rates of the main faces increased in the sequence $m \rightarrow c \rightarrow p \rightarrow a \rightarrow s \rightarrow u$. The highest yield (23%–26%) of gem-quality material was obtained when platy seed plates were inclined 20°–25° to the c -axis of the synthetic crystals. Both platy and columnar synthetic emerald crystals were grown. TL

A review of developments in shaped crystal growth of sapphire by the Stepanov and related techniques. P.

I. Antonov and V. N. Kurlov, *Progress in Crystal Growth and Characterization of Materials*, Vol. 44, No. 2, 2002, pp. 63–122.

The Stepanov method is a specialized technique for growing crystals from a melt. Compared to other melt processes, such as the Czochralski or “pulling” method, its major advantage is that the shape (cross-section) of a crystal can be gradually changed during growth. The basic requirement is that a melt column with a defined shape be formed, which is accomplished with the aid of a special “shaper.” Liquid melt columns with various shapes can be made by properly applying a high-frequency electromagnetic field.

Since the initial work by Stepanov in 1938, progress in developing the method has proceeded along two lines: (1) development of technology for producing single crystals of a

desired shape, and (2) understanding the physical phenomena involved in the formation of the shaped crystals. Synthetic sapphire crystals with various defined shapes, primarily for industrial use, have been successfully grown using this technique. For example, synthetic sapphire tubes up to 85 mm in diameter and ribbons 120 mm wide have been grown and used for their optical properties. Sapphire rods with various shapes have also been grown. Microvoids and gas bubbles are the main defects found in such crystals. TL

Solubility of emerald in H_2SO_4 aqueous solution under hydrothermal conditions. Z. Chen, G. Zhang, H. Shen, and C. Huang, *Journal of Crystal Growth*, Vol. 244, No. 3–4, 2002, pp. 339–341.

Hydrothermal synthetic emeralds have been grown traditionally from NH_4F , NH_4OH , NH_4Cl , and HCl solutions. This article reports the growth of good-quality synthetic emerald crystals from 1.1 mol H_2SO_4 solutions, using synthetic emerald seed crystals. Experimental conditions are: $T=500\text{--}600^\circ\text{C}$; $P=1.5\text{--}2.0$ kbar; autoclaves ~60% full. These temperatures and pressures are relatively low compared to those used in growing synthetic emeralds from an HCl solution. CT

Some aspects of precious opal synthesis. S. V. Filin, A. I. Puzynin, and V. N. Samoilov, *Australian Gemmologist*, Vol. 21, No. 7, 2002, pp. 278–282.

The development of the method and the basic steps involved in synthesizing pure silica opal at the Center for Applied Research in Dubna, Russia, are outlined. This process involves four stages: (1) synthesis of monodisperse particles of silica in alcohol-based sols; (2) precipitation of a “raw” opal precursor by spontaneous sedimentation or centrifuging; (3) drying of the precursor opal to remove liquid from its pores; and (4) filling these pores with silica gel, and then sintering the samples at 825°C. The physical, chemical, and gemological properties of synthetic opal produced by this method are reported as identical to those of natural opal. The total time involved in the synthesis is around 10 months, which the authors compare to that of Gilson (12+ months) and Chatham (about 18 months). RAH

TREATMENTS

Black diamond treatment by “internal” graphitization. F. Notari, *Revue de Gemmologie*, No. 145/146, 2002, pp. 42–60 [in French with English abstract].

In the last three years, large quantities of treated black diamonds (with their color resulting from internal graphitization) have appeared on the market. The graphitization is induced in four ways, all of which require the application of heat to low-quality diamonds that have a large number of fractures and cavities, so the heat-induced graphites can be isolated from oxygen. Two of the methods apply heat to rough and cut diamonds under various conditions of pres-

sure and environment. In the third method, small cut stones develop graphitic products as a result of the high temperatures induced during fashioning. The fourth method subjects larger diamonds to ion beam techniques, usually accompanied by heating. All these processes may produce glassy deposits in fractures and cavities on the diamonds, as well as synthetic carbons, frequently as films, on the surface.

These treatments can be identified by conventional microscopy combined with strong lighting or luminescence. Raman spectrometry is helpful in identifying the different types of carbon in these diamonds. Diamonds with graphite on the surface can be recognized with the aid of a thermal-type diamond tester. *MT*

Change of colour produced in natural brown diamonds by HPHT-processing. V. G. Vins, *Proceedings of the Russian Mineralogical Society*, Vol. 131, No. 4, 2002, pp. 111–117 [in Russian with English abstract].

The change in color produced by high pressure–high temperature (HPHT) processing of natural brown diamonds at 5.0–6.0 GPa and 2,100–2,300 K has been investigated by absorption spectroscopy in the UV, visible, and IR ranges. Such treatment of type IIa brown diamonds makes them colorless, but occasionally they acquire a light pink color. Type Ia brown diamonds change to bright yellow-green of various tints. The depth of color, as well as the relative strength of the yellow and green hues, depends on the absorption intensity of N3, H4, H3, and H2 nitrogen-vacancy centers formed during the HPHT treatment. It is concluded that annealing of plastic deformation takes place during the HPHT treatment and thus the density of dislocations decreases. The energy activating the dislocation movement via plastic deformation is 6.4 eV. Models of the color-center transformations are discussed, and color photos of diamonds faceted after HPHT processing are presented. *RAH*

Change of colour produced in synthetic diamonds by β HHT-processing. V. Vins, *Gemological Bulletin (Gemological Society of Russia)*, No. 5, 2002, pp. 26–32.

Changes in types IIa and Ib, and subtypes IaB and IbA, synthetic diamonds on β HHT-processing (exposure to fast-electron irradiation and subsequent high-temperature annealing) are described. Some observations about synthetic diamonds subjected to this treatment include: A lower growth rate results in fewer impurity defects; synthetic diamonds grown at various temperatures display different optically active defects, including color centers; an increase in growth temperature results in a gradual change of the synthetic diamond type (Ib \rightarrow IaB \rightarrow IbA \rightarrow IaA) and sharp color zoning in the synthetic diamond crystal; nitrogen–nickel–vacancy defect formation (and sometimes resultant photoluminescence) may be induced in synthetic diamonds by HPHT processing.

[*Editor's note:* An earlier paper on β HHT-processing of natural diamonds by the same author, including details of the process, was abstracted in Fall 2002 *Gems & Gemology*, p. 288.] *CT*

Investigation of radiation-induced yellow color in tourmaline by magnetic resonance. K. Krambrock, M. V. B. Pinheiro, S. M. Medeiros, K. J. Guedes, S. Schweizer, and J.-M. Spaeth, *Nuclear Instruments and Methods in Physics Research B*, Vol. 191, No. 1–4, 2002, pp. 241–245.

The cause of the yellow color produced by γ -irradiation of colorless Li-bearing tourmaline (elbaite) from Minas Gerais, Brazil, was determined by electron paramagnetic resonance (EPR) and electron nuclear double resonance (ENDOR) techniques.

Two paramagnetic centers (I and II) are present. Center II is identified as an H⁰ electron trap. The identification of center I is not as direct and is proposed to be an Al–O⁻–Al hole trap. Both centers are stable up to 250°C. It is suggested that the O⁻ hole trap is responsible for the yellow color, with an optical absorption band centered around 3.4 eV and a tail extending into the visible range of the spectrum. *AI*

MISCELLANEOUS

Closing the gender gap. R. Bates, *JCK*, Vol. 173, No. 8, 2002, pp. 65–66.

It is ironic that even though most of the products of the jewelry trade are bought and worn by women, the industry is dominated by men. However, this is changing. Women have a large and growing presence in certain sectors of the industry, namely retail, design and fashion, and public relations. Conversely, men dominate the watch, gemstone, and manufacturing sectors, and there is relatively little female involvement in the diamond trade, which is the most tradition-bound branch of the industry.

Much of the credit for the increased visibility and advancement of women in the jewelry trade deservedly goes to the Women's Jewelry Association (WJA). It was organized in the early 1980s mainly to give women a place to network but also as a response, in part, to the fact that other organizations in the industry were male dominated. WJA has since grown to more than 1,000 members and now welcomes men as full-fledged members.

Even with recent advances, some feel that the trade is still significantly behind the times when it comes to gender equality. But the once-homogenous (i.e., overwhelmingly male) industry is moving inexorably forward with respect to gender issues. Recent demographics show that more women are interested in entering the trade than men; for example, 60% of the resident students at GIA are women. Eventually this will result in a closing of the gender gap, as it has in many other industries and professions where ability and performance are the main criteria for success.

AAL