

Lab Notes

Editors

Shane F. McClure | Sally Eaton-Magaña | Artitaya Homkrajae

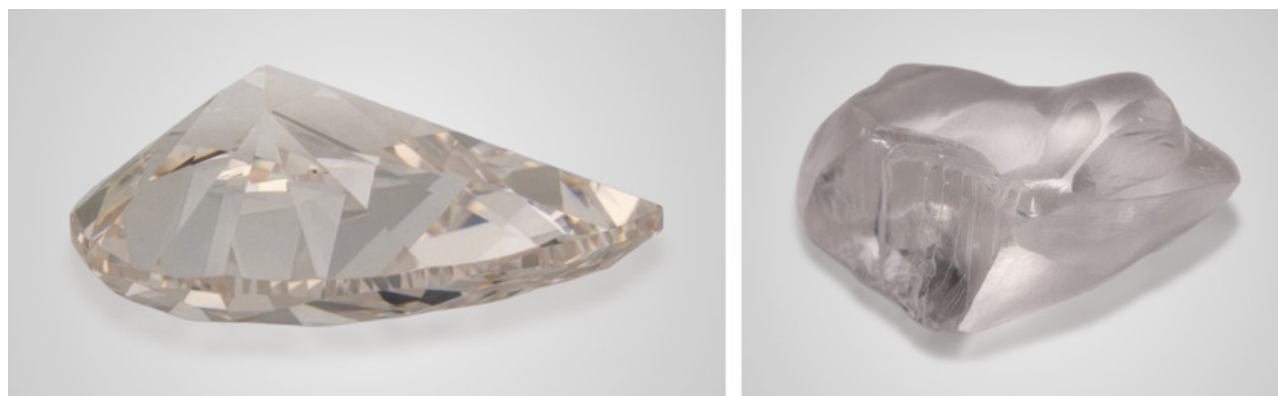


Figure 1. The 5.22 ct very light pinkish brown pear brilliant diamond (left) and the originally submitted 11.07 ct rough (right).

DIAMONDS

Atypical Color Center in Natural Pinkish Brown Diamond

GIA's New York laboratory received a 5.22 ct natural type IaAB pear brilliant diamond, graded as very light pinkish brown (figure 1, left). The finished diamond was matched to its previously submitted 11.07 ct rough (figure 1, right) through identical ultraviolet/visible and mid-infrared spectra.

An atypical absorption band centered at 525 nm and a triplet feature at 600, 608, and 618 nm were detected in the visible/near-infrared (Vis-NIR) absorption spectrum (figure 2). These spectral features are distinct from the typical broad 550 nm absorption band associated with pink coloration from plastic deformation of the diamond structure. The N3 center (415 nm), a defect involving three nitrogen atoms and a vacancy (3N+V), was also present. Mid-infrared spectra showed a natural type IaAB diamond in the

one-phonon region ($\sim 1332\text{--}400\text{ cm}^{-1}$), revealing nitrogen aggregation from prolonged residence at high mantle temperatures. The A-center (1282 cm^{-1}) results from two adjacent substitutional nitrogen atoms (N-N), and the B-center (1175 cm^{-1}) from four adjacent substitutional nitrogen atoms surrounding a vacancy (4N+V).

Microscopic observation revealed a cloud composed of needle-like inclusions, transparent internal graining, and color zoning caused by plastic deformation of the crystal structure. Mottled strain patterns were observed with high interference colors under cross-polarized light (figure 3, left), indicative of internal stress and crystal structure distortion during natural diamond formation. DiamondView fluorescence showed crystal growth patterns and blue emission caused by the presence of the N3 center in the crystal structure (figure 3, right). Gemological testing supported a natural diamond and natural color origin, with no evidence of surface coating, treatment, or laboratory growth.

The cause of the 525 nm absorption band and triplet feature at 600, 608, and 618 nm remains unknown. A prior study of a pink diamond with a 525 nm absorption band found high concentrations of nickel- and hydrogen-related defects (S. Caplan and W. Wang, "Natural pink diamond colored by the 525 nm absorption band," *GSA Abstracts with Programs*, Vol. 54, No. 5, 2022). However, no such

Editors' note: All items were written by staff members of GIA laboratories.

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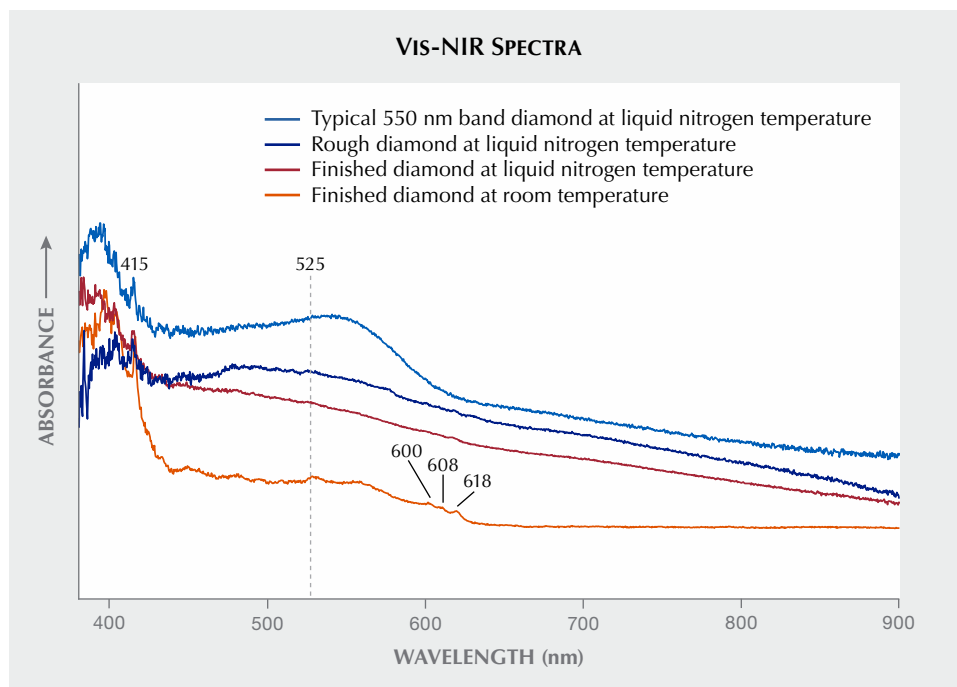


Figure 2. Overlay of the natural rough and finished diamond Vis-NIR spectra verifies matching absorption features. These spectra show the 415 nm peak, an atypical 525 nm band, and triplet at 600, 608, and 618 nm. The room temperature spectrum of the finished diamond shows more resolved features due to a higher signal-to-noise ratio. The typical broad 550 nm band from a different pinkish brown diamond is shown for comparison, highlighting the atypical absorption features. Spectra are offset vertically for clarity.

impurities were detected in this diamond, suggesting that the 525 nm absorption band, to the author's knowledge, has not been previously documented. Weak 600 and 609 nm peaks appear more prominently in type IIa and low nitrogen pink diamonds colored by the 550 nm band (S. Eaton-Magaña et al., "Comparison of gemological and spectroscopic features in type IIa and Ia natural pink diamonds," *Diamond and Related Materials*, Vol. 105, 2020, article no. 107784), possibly originating from

unidentified point defects in the diamond structure, which differ from the spectral features seen in this diamond. The 525 nm band and triplet feature observed in this diamond are likely an atypical naturally occurring previously undocumented color center. These atypical absorption spectral features demonstrate the complexity of diamond color origin and the need for further research into natural diamond color centers.

Erica Watts

Figure 3. Left: Mottled strain patterns with high interference colors observed under cross-polarized light. Photomicrograph by Christopher Vendrell; field of view 7.19 mm. Right: DiamondView fluorescence image showing crystal growth patterns and the blue color commonly observed in type IaAB diamonds.





Figure 4. This piece, a diamond cut into the shape of a panther face and set with two natural Zambian emeralds, has a total weight of 67.18 ct. Photo by Gourav Bera.

Carved Natural Diamond Panther Face

Recently, the Mumbai laboratory received an intriguing submission for an identification report. The opaque gray stone was carved and faceted to resemble a panther's face, with two green marquise mixed-cut stones for eyes (figure 4). The piece weighed 67.18 ct and measured $28.45 \times 24.17 \times 11.37$ mm.

Microscopic examination revealed no major surface-reaching features in the heavily included gem. The item, analyzed using Fourier-transform infrared absorption and photoluminescence (PL) spectroscopy at room temperature with 405 nm excitation, exhibited absorption features

typical of a type Ia diamond, along with the presence of a hydrogen-related 3107 cm^{-1} peak. The PL spectroscopy showed emissions associated with the N3 defect.

According to the client, the finished piece, titled "Jade Fang," took nearly a year of dedicated craftsmanship to complete. The diamond initially weighed 113 carats and required the use of advanced cutting tools due to its heavy inclusions. Two natural Zambian emeralds weighing 0.29 ct and 0.27 ct, previously submitted to GIA, were added to finish the panther's face.

Unlike traditional cuts designed to maximize brilliance through symmetry, unique shapes such as this one challenge the cutter. This piece reminds us that the true value of a diamond lies not just in its gemological characteristics but also in the artistry that brings it to life.

Roxane Bhot Jain and Manisha Bhoir

PEARLS

Large South Sea Bead Cultured Pearl with Mille-Feuille Structure

An extraordinarily large undrilled light gray pearl (figure 5) was recently examined at GIA's New York laboratory. Despite its impressive size (76.79 ct and $42.97 \times 33.43 \times 31.00$ mm), the pearl exhibited an unexpectedly light heft, suggesting the presence of a hollow interior. Real-time X-ray microradiography (RTX) imaging revealed an unusual internal structure for a bead cultured pearl characterized by widely spaced concentric nacre layers separated by translucent veil-like organic material (figure 6), rather than



Figure 5. The South Sea bead cultured pearl measuring $42.97 \times 33.43 \times 31.00$ mm and a large chicken egg (57×43 mm). Photo by Sood Oil (Judy) Chia.

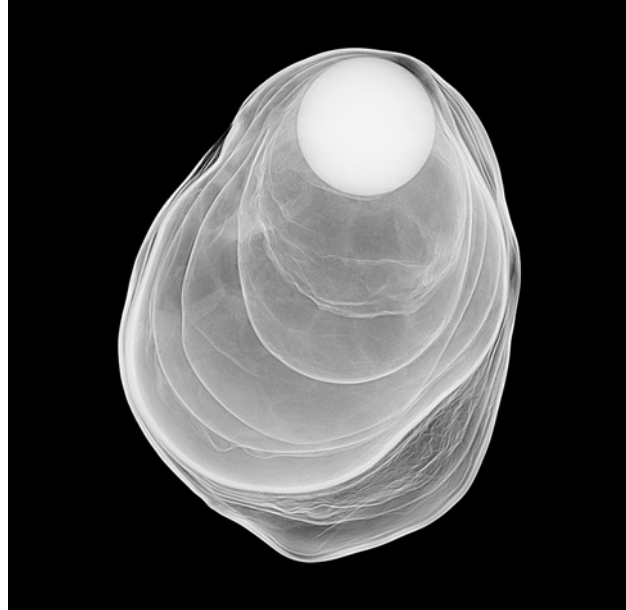


Figure 6. RTX image showing concentric nacre layers separated by translucent organic material.

the compact, continuous nacre typically observed in solid bead cultured pearls. The bead measured approximately 11 mm in diameter and was securely attached at one end of the pearl, with no internal movement or rattling detected when gently shaken. The thin nacre, measuring approximately 0.5 mm at its thickest portion, and hollow internal structure made the pearl extremely fragile.

Based on the gemological examination and the size of the pearl and the bead, the sample was identified as a South Sea bead cultured pearl. Patchy, uneven gray to brown material present underneath the surface appeared to be associated with an organic-rich internal structure; these features contributed to the pearl's bodycolor. While some South Sea pearls may be cultured with organic or inorganic

materials to intentionally produce larger baroque-shaped pearls, this was not the case for this sample (L.E. Cartier and M.S. Krzemnicki, "New developments in cultured pearl production: Use of organic and baroque shell nuclei," *Australian Gemmologist*, Vol. 25, No. 1, 2013, pp. 6–13). In this instance, the mollusk may have been affected by unknown environmental or health factors, causing the pearl sac to inflate irregularly by gas or fluid accumulation, trapping organic materials between layers of nacre, ultimately creating a *mille-feuille*-like internal structure similar to a puff pastry layered with cream (L. Otter et al., "A look inside a remarkably large beaded South Sea cultured pearl," Spring 2014 *G&G*, pp. 58–62).

While average sizes of South Sea bead cultured pearls range between 10 mm and 13 mm, exceptional examples may occasionally exceed 20 mm. This remarkable South Sea bead cultured pearl, with its extraordinary size and uncommon structures, provides interesting insights into a highly unusual growth pattern.

Emiko Yazawa

Microscopic Marine Organisms in South Sea Cultured Pearls

GIA's Bangkok laboratory recently received five pearls ranging from cream to orangy yellow, weighing between 2.33 and 5.54 ct and measuring approximately 0.96×0.64 mm to 1.03×0.83 mm (figure 7). The pearls appeared similar to South Sea cultured pearls produced from *Pinctada maxima* mollusks. X-ray fluorescence imaging was used to confirm their saltwater origin; all samples

Figure 7. Five cream to orangy yellow South Sea cultured pearls (*Pinctada maxima*), ranging from 0.96×0.64 mm to 1.03×0.83 mm. Photo by Nuttapol Kitdee.



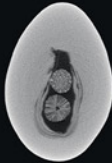
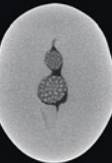
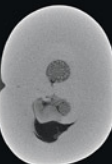
Weight (ct)	Macro	RTX	μ-CT
2.33			
2.97			
3.90			
4.51			
5.54			

Figure 8. RTX and μ-CT images reveal varying forms of elongated void or linear features associated with one or two microscopic spheres of marine organisms. The spheres measure from 1.23 to 2.28 mm in diameter.

were inert when exposed to X-rays, resulting from the absence of, or a very low level of, manganese, characteristic of saltwater pearls. The four orangy yellow pearls exhibited typical ultraviolet/visible/near-infrared reflectance spectra of natural color yellow South Sea pearls (S. Jin et al., "Application of UV-Vis-NIR spectroscopy to gemology," Winter 2024 *G&G*, pp. 456–473).

Real-time X-ray microradiography (RTX) analysis revealed that each sample contained one or two intriguing spherical radial objects in the center, positioned along the length of the pearl (figure 8). The objects were associated with varying forms of elongated void or linear features known to be diagnostic growth structures commonly found in South Sea non-bead cultured (NBC) pearls (A. Homkrajae et al., "Internal structures of known *Pinctada*

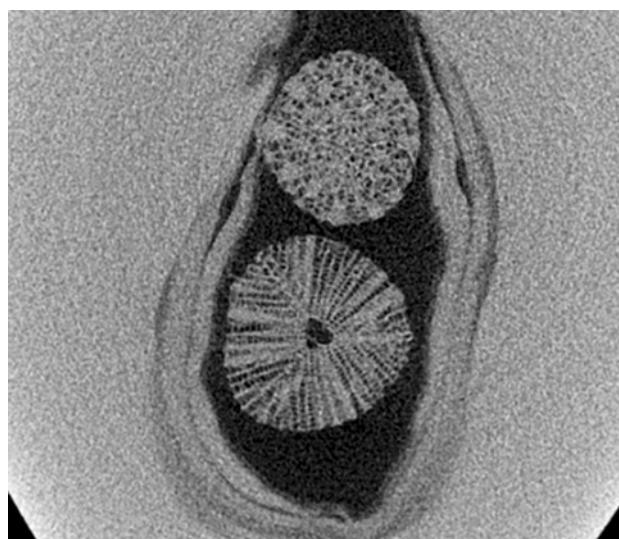


Figure 9. A distinctive porous and radial structure extends outward from the chamber central core of the two white microscopic marine organisms within the elongated dark gray void of the 2.33 ct pearl.

maxima pearls: Cultured pearls from operated marine mollusks," Fall 2021 *G&G*, pp. 186–205). The pearls were further analyzed using X-ray computed microtomography (μ-CT) to enhance image resolution, which provided a more comprehensive understanding of the internal structures.

The spherical objects, along with the typical void and linear structures, were clearly visible in the μ-CT analysis. The 3D images revealed that each sphere possessed a distinctive porous and radial structure extending outward from the central core (figure 9; see video at www.gia.edu/gems-gemology/summer-2026-lab-notes-marine-organisms-in-cultured-pearls). Their morphology closely resembled foraminifera spheres found in a natural pearl previously examined at GIA's Bangkok laboratory (Winter 2015 Lab Notes, pp. 434–436). RTX analysis was used to obtain measurements of all the spherical objects, ranging from 1.23 to 2.28 mm in diameter, which are consistent with the size of previously reported microorganisms. However, the previously studied natural pearl exhibited dark organic- and conchiolin-rich growth layers around the rounded microorganism's central core and growth arcs within the surrounding nacre, a structural characteristic comparable with the formation of natural pearls. Conversely, all five studied pearls displayed a tight structure or minimal growth arcs in the surrounding nacre, consistent with NBC pearls and the so-called "atypical bead cultured pearls" previously studied ("Atypical 'beading' in the production of cultured pearls from Australian *Pinctada maxima*," *GIA Research News*, February 13, 2017).

Although previously reported microscopic marine organisms found within pearls were related to natural formations, the internal void and linear features of these studied samples, as well as their close resemblance to

South Sea cultured pearls, indicated that these were likely of cultured origin. Moreover, it is very unusual to encounter similar-looking pearls with identical internal structures of microorganisms rarely found inside pearls. These findings indicated that microorganisms were intentionally inserted into the host mollusk as bead nuclei for culturing. The use of these organisms may be intended to imitate natural pearl formation; thus, gemologists must take caution when interpreting organic materials as evidence of natural origin, and comprehensive analysis is needed for identification. This is the first reported discovery of microscopic marine organisms in South Sea cultured pearls at GIA's laboratories.

Kwanreun Lawanwong

Reversible Photochromism in a Heat-Treated Sri Lankan SAPPHIRE

A 2.38 ct very light blue gemstone was recently submitted to GIA's Bangkok laboratory for identification and geographic origin determination. Standard and advanced gemological testing results were consistent with a Sri Lankan sapphire that had undergone high-temperature heat treatment.

During routine gemological examination, an unexpected color change was observed. After approximately 30 to 40 seconds of exposure to short-wave (254 nm) ultraviolet radiation, the stone's bodycolor changed from an initial very light blue to a light yellow color. Given the unusual nature of this observation, the stone was subsequently subjected to fade testing under GIA color-stability testing conditions using a 150W halogen lamp. After approximately six hours, the yellow color gradually faded, and the bodycolor returned

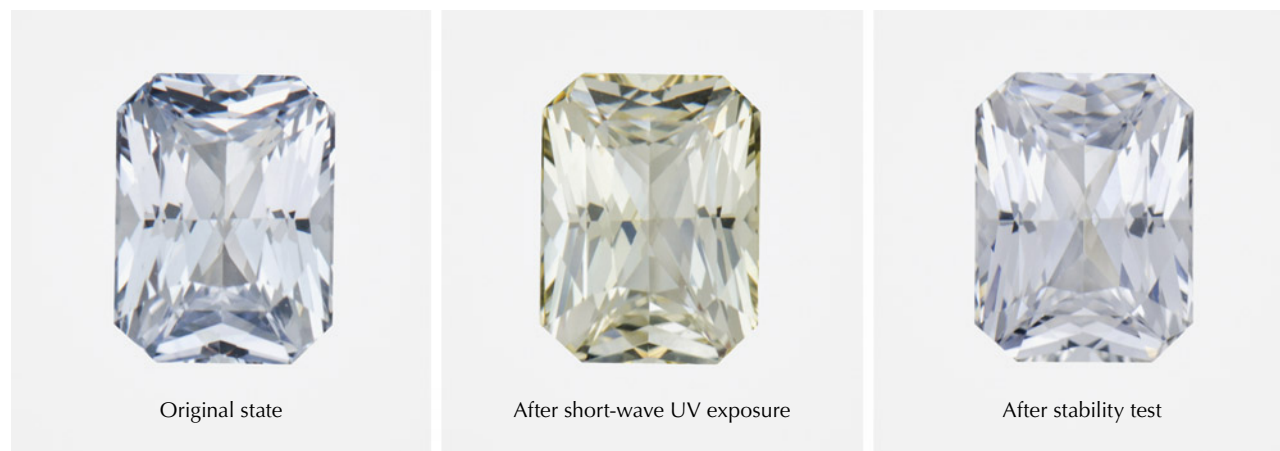
to an appearance similar to its original very light blue coloration (figure 10), confirming that the color change was temporary and reversible.

This behavior is consistent with activation of an unstable trapped-hole color center that can exist in either an inactive (ground) state or an activated state following exposure to ultraviolet radiation (K. Nassau and G.K. Valente, "The seven types of yellow sapphire and their stability to light," Winter 1987 *G&G*, pp. 222–231). In this case, short-wave UV radiation provided sufficient energy to activate the color center and produce a temporary yellow color. However, the induced color was not stable and gradually returned to its inactive state over time or under incandescent illumination. Color descriptions should be based on the color observed after color-stability testing.

Although color-stability testing is not routinely performed for sapphires in this color range, this behavior is consistent with previously documented examples of sapphires containing unstable color centers, particularly some Sri Lankan material. Similar reversible color changes have been reported in sapphires with color influenced by trapped-hole color centers, including yellow, orange, and pinkish orange to orangy pink sapphires ("An update on sapphires with unstable color," *GIA Research News*, December 12, 2022).

Ultraviolet/visible/near-infrared spectroscopic data support this interpretation. Before UV exposure, the stone showed spectral features typical of metamorphic blue sapphire; absorption in the 380–390 nm region (associated with Fe^{3+}) was relatively weak, consistent with low iron content, while a distinct absorption peak at 450 nm (attributed to Fe^{3+} - Fe^{3+} pair interactions) was observed, together with an $\text{Fe}^{2+}/\text{Ti}^{4+}$ intervalence charge-transfer band

Figure 10. Reversible photochromism in a 2.38 ct heat-treated Sri Lankan sapphire. Exposure to short-wave ultraviolet radiation for 30 to 40 seconds produced a temporary yellow color. After approximately six hours under GIA color-stability testing conditions, the stone returned to an appearance similar to its original very light blue coloration. Photos by Lhapsin Nillapat.



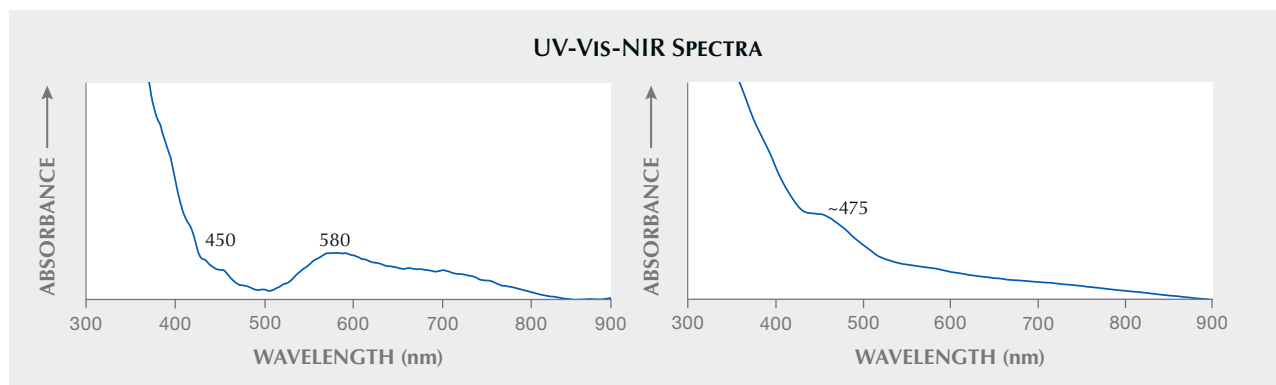


Figure 11. Left: The original state (before UV exposure) shows spectral features typical of metamorphic blue sapphire, including an $\text{Fe}^{3+}\text{-Fe}^{3+}$ pair-related absorption peak at 450 nm and an $\text{Fe}^{2+}/\text{Ti}^{4+}$ intervalence charge-transfer band near 580 nm. Right: After short-wave UV exposure, the spectrum is dominated by an absorption band centered near 475 nm, attributed to the activation of Fe^{3+} -related trapped-hole color centers. Different y-axis scales are used to better highlight the spectral changes following UV exposure.

near 580 nm. After short-wave UV exposure, the 580 nm absorption feature was no longer resolved, and the spectrum became dominated by an absorption band centered near 475 nm, consistent with the activation of Fe^{3+} -related trapped-hole color centers (figure 11) (E.V. Dubinsky et al., “A quantitative description of the causes of color in corundum,” *Spring 2020 G&G*, pp. 2–28). After fading, the spectrum returned to its original state.

Importantly, this UV-activated and reversible color change is unrelated to the stone’s high-temperature heat treatment. Previous studies have shown that heating does not stabilize color derived from unstable color centers (C.P. Smith et al., “Heated sapphires with unstable colour centres,” *Journal of Gemmology*, Vol. 36, No. 7, 2019, pp. 602–604). The observations in this case, therefore, are consistent with established theoretical models and previously documented examples of unstable color-center behavior in Sri Lankan corundum.

Aprisara Semapongpan

Heat-Treated Red SPINEL

The Hong Kong laboratory recently received a 3.37 ct transparent purplish red oval mixed cut for identification (figure 12). Although the stone was submitted as a ruby, subsequent testing suggested a different identity. Standard gemological testing revealed a single refractive index (RI) of 1.717, consistent with spinel rather than doubly refractive ruby (1.760–1.768). Additionally, ruby and red spinel exhibit distinct absorption spectra. Ruby is characterized by a bright chromium fluorescent emission line at 693 nm, along with two fine dark lines in the blue portion of the spectrum at 468 nm and 476 nm. In the blue region where ruby shows distinct doublet lines, spinel typically shows a broad, featureless absorption band and lacks the sharp 476 nm line.

Microscopic examination revealed several features: altered crystal inclusions with discoidal fractures (figure 13), whitish healed fissures, and the presence of exogenous

materials within surface-reaching fractures and cavities. Based on the combination of RI, specific gravity, absorption spectrum, and observed natural inclusion features, as well as laser ablation–inductively coupled plasma–mass spectrometry chemistry, the stone was identified as a natural spinel. Additionally, certain cavities displayed a granular texture with lower luster, indicative of filler material, suggesting artificial treatment (figure 14).

Heat treatment of spinel is considerably less common than that of ruby; however, heat-treated spinel does exist in the marketplace. For spinel specimens with exceptional clarity, microscopic examination alone is generally insufficient to detect evidence of heating. All spinel samples submitted to GIA are analyzed using photoluminescence (PL) spectroscopy as a primary method for evaluating potential heat treatment. The spectrum of the unheated reference spinel shows the peak with the highest counts positioned at 685.5 nm, with a full

Figure 12. This 3.37 ct purplish red oval mixed cut was submitted as a ruby. Photo by Tony Leung Yik Hang.



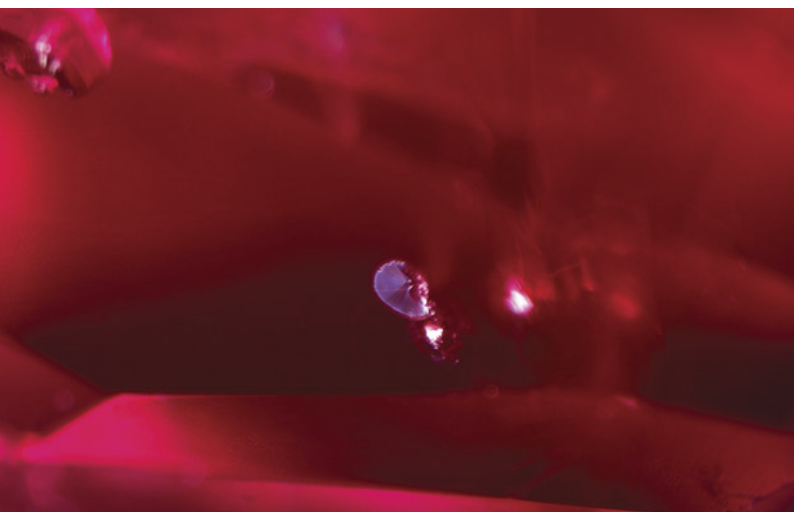


Figure 13. Heat-altered crystal inclusions surrounded by a discoid fracture, proving that the spinel underwent high-temperature treatment. Photomicrograph by Tsz Wing Lai; field of view 2.40 mm.

width at half maximum (FWHM) of 0.88 nm (figure 15). In contrast, the sample spectrum exhibits a peak shifted to 687.5 nm, with a significantly broader FWHM of 4.10 nm. This peak broadening and wavelength shift are consistent with characteristics typically observed in heated spinel spectra (S. Saeseaw et al., "Distinguishing heated spinels from unheated natural spinels and from synthetic spinels," *GIA Research News*, April 2, 2009). Raman spectroscopic analysis further characterized the studied stone's filler as glass.

Historical evidence demonstrates that reliance on stone color alone can result in misclassification, underscoring the necessity of comprehensive analytical approaches for

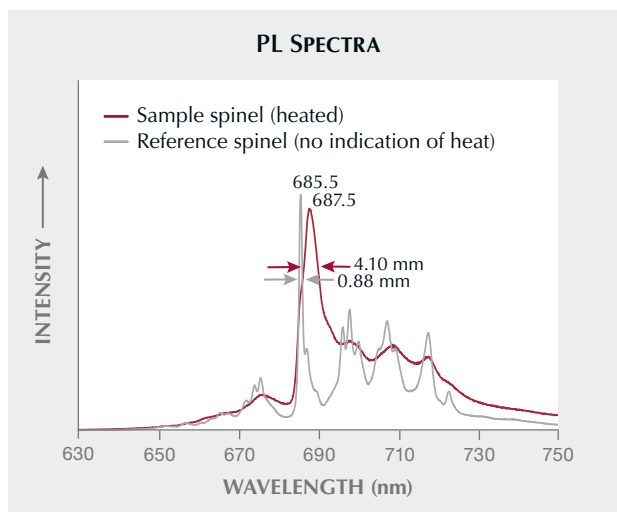


Figure 15. Comparison of the sample's PL spectrum to that of a natural unheated spinel proves that the sample is a heat-treated spinel.

accurate gemstone identification. Red spinel has been the ultimate "imposter," famously misidentified as ruby for centuries. The most notable example is the Black Prince's Ruby set in the British Imperial State Crown.

The submitted spinel appears to have undergone unusually aggressive heating, possibly because it was misidentified as ruby prior to treatment. Such a scenario in the studied sample could explain the presence of glassy surface material and severely damaged inclusions, features atypical of heated spinel. While speculative, this possibility highlights the importance of accurate identification before treatment and the role of advanced spectroscopic methods in detecting such interventions.

Tsz Wing Lai and Amy Cooper

Figure 14. By manipulating different light sources, the filler material is uncovered. While standard lighting shows dull, low-luster patches in the filled cavities (left), fiber-optic illumination reveals a whitish granular texture (right). Photomicrographs by Tsz Wing Lai; fields of view 4.00 mm (left) and 1.50 mm (right).

