Figure 32. Thermal enhancement and unusual inclusions were detected in this 2.05 ct blue sapphire, measuring 7.07 × 6.55 × 4.99 mm. Photo by Kaiyin Deng.

either a black or white bodycolor and a variety of colors in the play-of-color areas. For those who love opal, this attractive material could offer a cost-effective alternative to natural material while retaining the allure of the play-of-color phenomenon.

Nathan Renfro

TREATMENTS

Dendritic inclusions of thorianite in heated blue sapphire. Recently, a 2.05 ct blue sapphire was sent to Guild Gem Laboratories for identification (figure 32). Standard gemological testing confirmed it was corundum, with a refractive index of 1.762–1.770 and specific gravity of 4.00. Under microscopic observation, cloudy particles and diffuse straight color zoning were seen, as well as fingerprint-like fluid inclusions as shown in figure 33, indicating that this stone had undergone thermal enhancement. This sapphire exhibited chalky greenish fluorescence around the girdle under short-wave (254 nm) ultraviolet fluorescence light. Further UV-Vis spectroscopic testing suggested a metamorphic origin, while FTIR spectra (figure 34) showed a distinct 3309 series at 3185, 3232, 3309, and 3367 cm^{-1}, confirming heat treatment. Energy-dispersive X-ray fluorescence (EDXRF) showed an Fe content around 300–500 ppm. Neither U nor Th was detected.

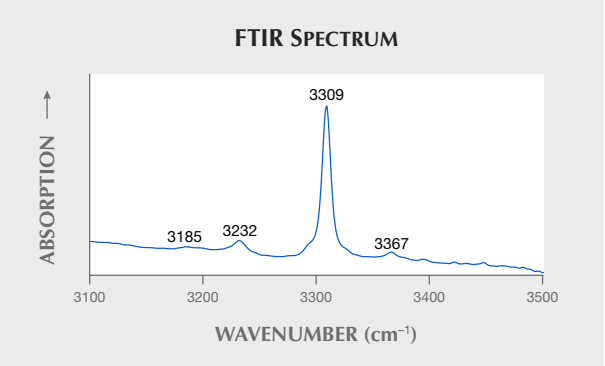
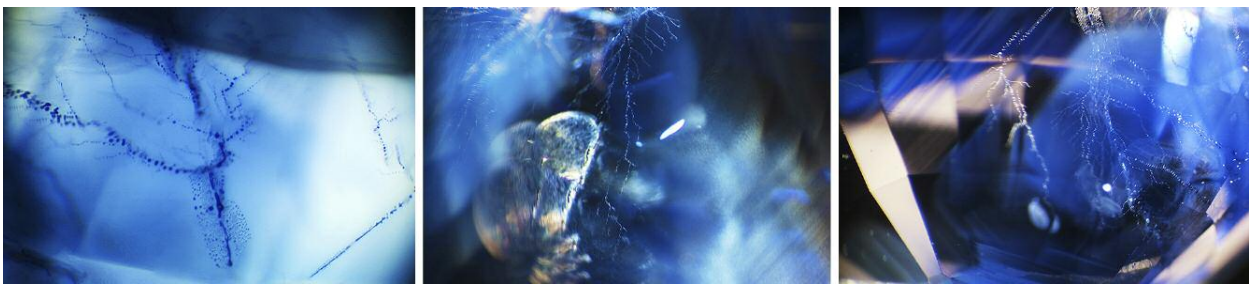


Figure 34. The sapphire's FTIR spectrum exhibited a distinct 3309 series at 3185, 3232, 3309, and 3367 cm^{-1}.

Also observed were interesting dendritic inclusions, which are not very common in sapphire. These inclusions showed relatively strong metallic luster under reflected light, and they appeared to be opaque under transmitted light. Lines of small dots were seen under higher magnification. These dot-like inclusions exhibited a blurred surface and a rounded shape. Raman analysis at the National Gemstone Testing Center (NGTC) using a 473 nm laser showed three distinct peaks at 466, 552, and 607 cm^{-1}, matched very well with thorianite, according to the RRUFF online database (rruff.info), as shown in figure 35. Thorianite (ThO_2) is an oxide mineral mainly composed of Th and O, first found in an alluvial deposit in Sri Lanka (D.

Figure 33. Left: Dendritic inclusions consisted of dot-like minerals showing a "melted and diffused" appearance. Photo by Yujie Gao; field of view 2.68 mm. Center: Resembling a tree root, these dendritic inclusions showed relatively strong metallic luster under reflected light. Photo by Yizhi Zhao; field of view 2.52 mm. Right: Dendritic inclusions coupled with blurred blue color zoning. Photo by Yujie Gao; field of view 9.73 mm.



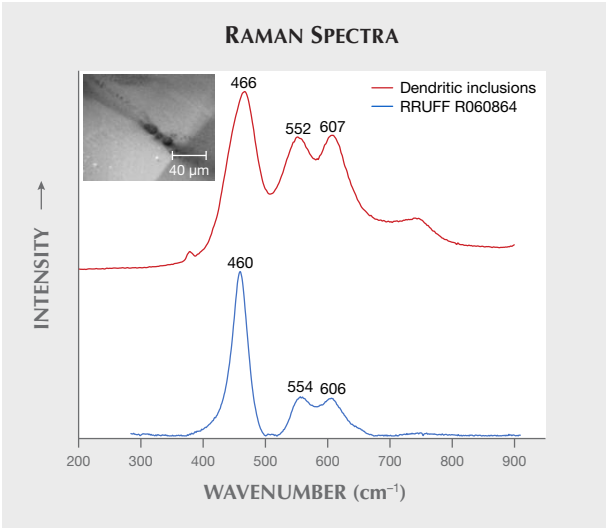


Figure 35. Raman spectra of the sapphire's dendritic inclusions matched with thorianite (ThO_2).

Wyndham, "The occurrence of thorium in Ceylon," *Nature*, Vol. 69, 1904, pp. 510–511). A melted appearance of a mineral inclusion and/or unnatural-looking discoid fractures around inclusions can be indicative of heat treatment in corundum. Such phenomena are normally attributed to the breakdown of mineral inclusions at high temperature. However, the thorianite inclusions here did not have the typical appearance of inclusions that have been altered by high-temperature heat treatment. The diffuse appearance of thorianite is unlikely to be an indicator of heat treatment. Further experiments and tests on thorianite in unheated sapphire would give us more clues in the future.

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Recrystallization of baddeleyite as an indicator of PHT ("HPHT") treatment in sapphire. PHT ("HPHT") treatment in sapphire has been a controversial topic the last few years. Recently, Guild Gem Laboratories in Shenzhen received a 7.11 ct blue sapphire (figure 36) for identification. The refractive index of 1.762–1.770 and hydrostatic specific gravity of 4.00 confirmed the stone's identity. It was inert under long-wave and short-wave UV. Microscopic examination revealed several distinct features, such as diffuse color bands and melted white solid mineral inclusions surrounded by discoid fractures, indicating that this stone had undergone thermal enhancement (figure 37).

Further UV-Vis spectroscopic testing specified a metamorphic geological origin, while energy-dispersive X-ray fluorescence (EDXRF) analysis revealed low Fe content around 400–600 ppm. FTIR spectra (figure 38) showed a

Figure 36. This 7.11 ct oval blue sapphire, measuring 11.66 × 10.44 × 7.38 mm, exhibits eye-visible white mineral inclusions. Photo by Yizhi Zhao.

distinct 3309 cm^{-1} series at 3181 and 3373 cm^{-1}, consistent with heated metamorphic sapphire. We also noticed a broad band centered at 3042 cm^{-1}, accompanied by peaks at 2627, 2412, 2349, 2319, and 2096 cm^{-1}. According to previous reports (S.-K. Kim et al., "Gem Notes: HPHT-treated blue sapphire: An update," *Journal of Gemmology*, Vol. 35, No. 3, 2016, pp. 208–210; A. Peretti et al., "Identification and characteristics of PHT ('HPHT') - treated sapphires – An update of the GRS research progress," 2018, http://gemresearch.ch/hpht-update), the ~3042 cm^{-1} series band is diagnostic of sapphire treated by a high-pressure, high-temperature process.

As shown in figure 39, the mineral inclusions melted and solidified within the surrounding discoid fractures, exhibiting a dendritic appearance. Micro-Raman spectra analysis on the white mineral and recrystallized dendritic

Figure 37. Blurred blue color zoning and melted white solid mineral inclusions surrounded by discoid fractures. Photomicrograph by Yujie Gao; field of view 5.26 mm.