FTIR in Gem Testing • A Pink Sapphire Lesson
紅外光譜 (FTIR) 技術在寶石檢測的應用 • 粉紅藍寶石的檢測


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作者通過對粉紅藍寶石的檢測討論了DRIFTS與光束聚光鏡FTIR的關係。通常DRIFTS在揭示紅寶石和藍寶石的熱處理方面功能要強得多。

A discussion of DRIFTS vs the Beam Condenser FTIR attachment in the testing of pink sapphire. The DRIFTS accessory is generally much better at unmasking heat treatment in ruby and sapphire.

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In January 2020, a pair of earrings was brought to Lotus Gemology's Bangkok lab for testing. We were asked to test the pink sapphire at the centre of each earring (Fig. 1).

Fig. 1 The pink sapphire earrings that are the subject of this article. While the stone at left showed clear evidence of heat treatment, the right earring did not. As a result, we asked the client to unmount the stone for testing. *Photo © Wimon Manorotkul; earrings courtesy of VPGemstones Co., Ltd., Bangkok*
粉紅藍寶石耳環是本文的主題。儘管左邊的寶石清楚地顯示了熱處理的跡象，但右邊的耳環卻沒有。結果，我們要求客戶卸下寶石，以便檢測。

The first gem tested showed inclusion evidence suggesting it had been subjected to heat treatment. But in the second gem, the inclusion evidence was inconclusive and partially obscured by the mounting.

Under the normal testing protocol at Lotus Gemology, all corundums will have their infrared spectra measured using a Bruker Tensor 27 FTIR unit with a Pike EasyDiff™ diffused reflectance (DRIFTS) collection device.

Due to the mounting, we were forced to use a Pike 4x beam condenser attachment to measure the infrared spectrum. The result was the spectrum shown in Fig. 2.

Because the inclusion and spectral evidence was inconclusive regarding heat treatment, we requested that the client to unmount the stone. After unmounting, we again measured the infrared spectrum, this time using the DRIFTS attachment. The resulting spectrum is shown in Fig. 3, where both the 3309 cm^{-1} and key peak at 3232 cm^{-1} rise above the noise floor. This clearly demonstrates why DRIFTS is the better choice for measuring the infrared spectra of most gems.

Discussion

Over the years, gemmologists have measured the infrared spectra of tens of thousands of rubies and sapphires. The appearance of a peak at 3232 cm^{-1} has proven to be an extremely strong indicator of heat treatment (Atichat et al., 2011). Crystals by definition display directional properties, and their spectra are no exception. Because the DRIFTS attachment samples light moving through the gem in a variety of directions,

it is more likely to reveal information such as the key 3232 cm^{-1} peak (Hughes et al., 2007). Thus, it should be the first choice for gemmologists measuring infrared spectra.

The basalt caveat

It is important to note that when using the infrared spectrum as a tool to unmask heat treatment, caution should be taken when

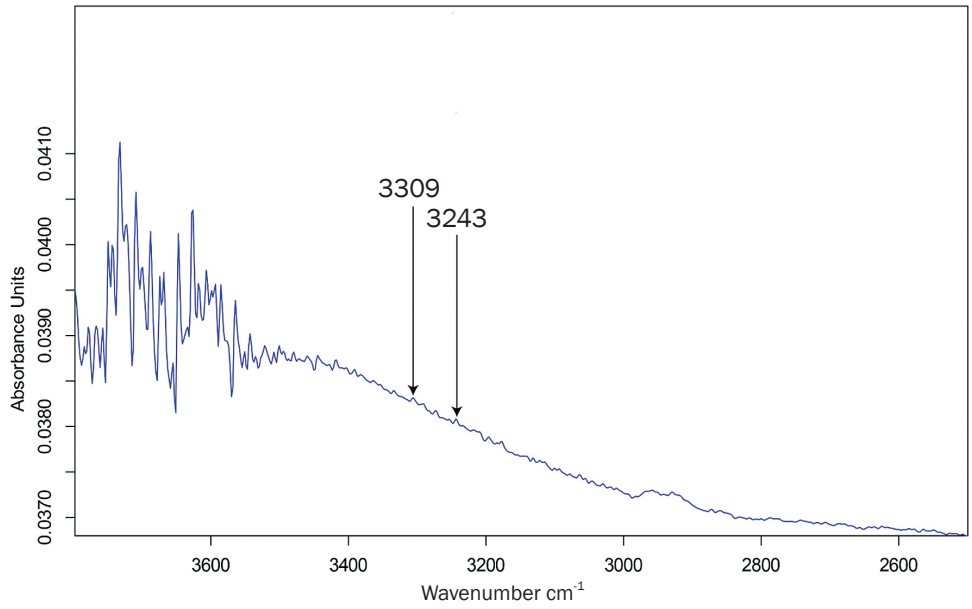

Fig. 2 Infrared spectrum of a Madagascar pink sapphire using the Pike 4x beam condenser collection attachment. This sends a narrow beam through the gem. Using this technique, the 3309 cm^{-1} was at the noise floor, while the 3232 cm^{-1} peak was not visible at all.
使用Pike 4x光束聚光器收集的馬達加斯加粉紅藍寶石的紅外光譜。通過寶石發出一束特定波長的窄小光束。使用此技術，3309 cm^{-1} 處於雜訊水平 ，而根本未能看到3232 cm^{-1}峰。

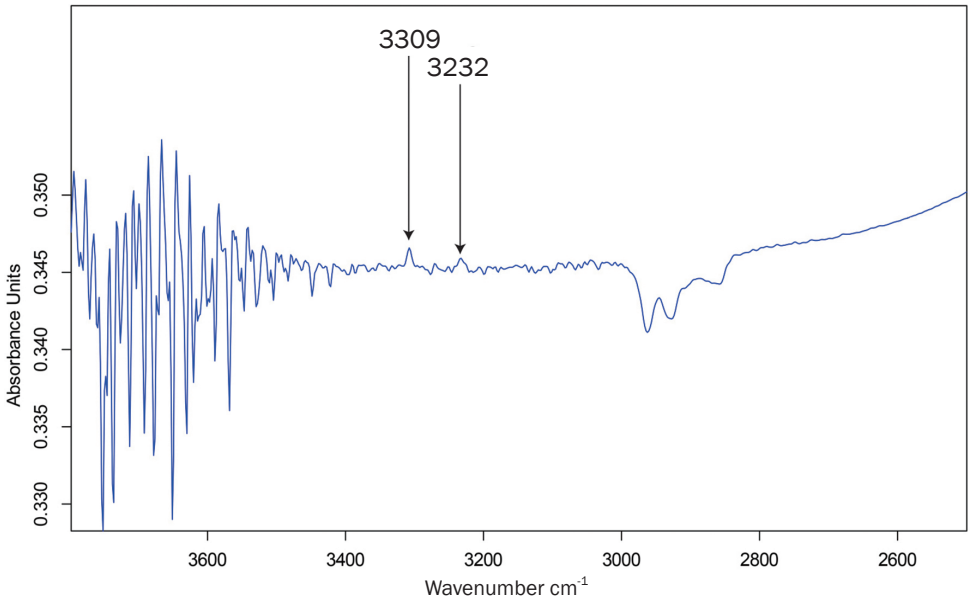

Fig. 3 Infrared spectrum of the same Madagascar pink sapphire using the DRIFTS (diffuse reflectance) attachment. This bounces the beam through the gem from a variety of directions. Using this technique, the 3309 cm^{-1} rises well above the noise floor. In addition, the peak at 3232 cm^{-1} rises above the noise floor, proving that the gem had been subjected to artificial heat treatment.
使用DRIFTS（漫反射）連接的，同一顆馬達加斯加粉紅藍寶石的紅外光譜。這會從各個方向反射穿過寶石的光束。使用此技術，3309 cm^{-1}會上升到高於雜訊水平。此外，在3232 cm^{-1}處的峰則上升到雜訊水平之上，證明該寶石已經過人工加熱處理。

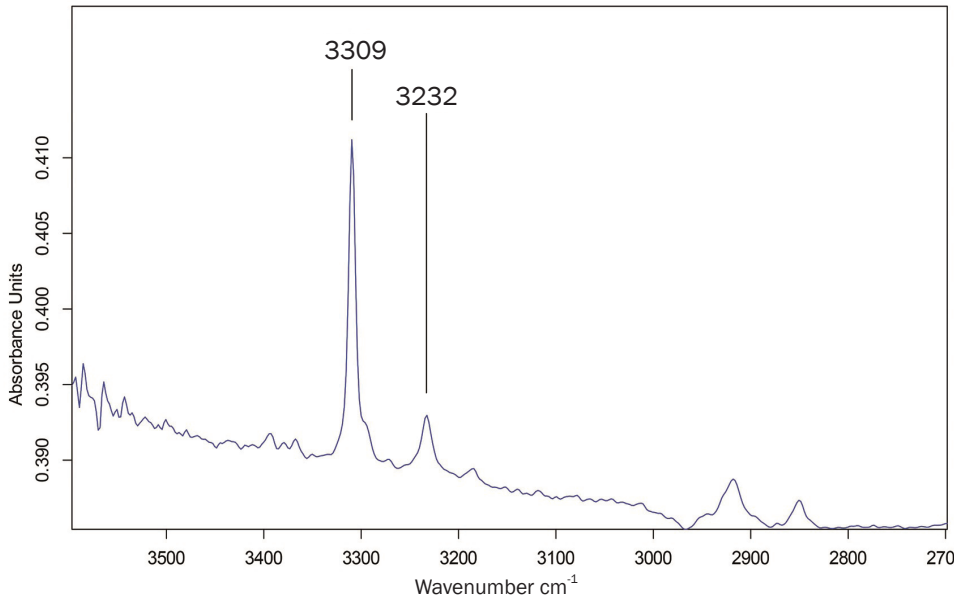

Fig. 4. Due to the heat of the magma that brought them to the surface, basalt-related corundums may show the 3232 peak even without being artificially heat treated.
由於將岩漿被帶到表面的熱量，即使未曾進行人工加熱處理的、與玄武岩有關的剛玉也可能會顯示3232峰。

the ruby or sapphire is believed to have been produced from a magmatic source such as a basalt. In both ruby and sapphire from basaltic sources, while the gems may have formed deeper in the ground through metamorphic processes, they are transported to the surface in volcanic rocks such as basalts. The heat from these volcanic rocks can produce inclusions, UV fluorescence and spectral features in the infrared that closely resemble stones that have been artificially heat treated (Fig. 4). This includes the important 3232 cm^{-1} peak (Soonthorntanikul et al., 2019). Basalt-related sapphires come from around the world, including Australia, Cambodia, Cameroon, China, Ethiopia, France, Kenya, Laos, Madagascar (far north), Nigeria, Rwanda, Scotland, Thailand and Vietnam.

Conclusion

The FTIR spectrum has proven to be an essential technique in unmasking heat treatment in both ruby and sapphire. But like any tool, it requires a skilled operator to extract its full potential. Part of that skill is the choice of the collection device (DRIFTS vs. beam condenser). In addition, it is crucial that clients be warned about the perils of testing gems while mounted. Mountings severely restrict the types of tests that can be performed, as well as the information gathered by those tests. All gems tested by Lotus Gemology in the mounted state feature the following warning on the report: “Mounted gems are tested only to the degree permitted by the mounting. Results may change following unmounting.”

About the Authors

Richard Hughes met Wimon Manorotkul in 1979, when she signed him up for his first gemmology class. Since then they have explored gems, life and love together. In 2014 they founded Lotus Gemology with their daughter, Billie. Their Bangkok lab is devoted to issuing reports on ruby, sapphire, spinel, jade and other coloured gemstones.

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