

Challenges in the Detection of Ruby and Sapphire Treatment in the Thai Market

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Abstract

The detection of treatments in ruby and sapphire remains a critical aspect and has become an increasingly complex issue in the gem trade and laboratories alike. Treatments such as traditional heating, flux-assisted heating, various types of glass filling, lattice diffusion heating using elements from an external source, irradiation, and pressure-assisted heating have been widely applied to enhance colour, clarity, and durability of corundum, directly affecting the stone market values and ethical disclosure. The advancement of these techniques, particularly those designed to evade detection, have outpaced many traditional gem detection methods, necessitating the integration of advanced analytical technologies.

Introduction

The commercial value of ruby and sapphire is closely linked to their natural, untreated or treated state. The treatments, usually common, must be accurately detected and disclosed to ensure transparency and maintain consumer trust. However, as treatment technologies evolve, so do the challenges in their detection. This presentation is aimed at reviewing and updating both traditional and advanced methods for identifying treatments in the ruby and sapphire and discusses the identification challenges, ongoing research and future directions in this field.

Overview of Treatment Methods

Corundum treatments are commonly employed to enhance a gem's appearance, and they can be broadly categorized into heat-involved and non-heat-involved methods (Pisutha-Arnond, 2017). Heat-involved treatments include conventional heating (typically around 1200 – 1700 °C), flux-assisted heating using substances like borax and/or sil-

ica to (partially) assist healing of fissures. In addition, heat treatment combined with diffusion is used, such as shallow surface-diffusion with added colouring agents such as Ti alone or Ti with Be (as well as Ti and Fe in case of synthetic colourless sapphire) to create blue colouration (e.g., Kane *et al.*, 1990, Leelawatanasuk *et al.*, 2014, Pisutha-Arnond *et al.*, 2019), Cr to produce red hue (McClure *et al.*, 1993), and high-temperature beryllium diffusion (above 1700°C) often resulting in yellow colour (e.g., Emmett *et al.*, 2003, Pisutha-Arnond *et al.*, 2004). Other heat treatments of corundum include fracture filling with high-refractive-index glasses (e.g., lead or bismuth-based, colourless or coloured) at rather moderate temperatures and heating under pressure (e.g., Krzemnicki *et al.*, 2019), as well as other low temperature heat treatments. In contrast, non-heat-involved treatments of corundum consist of oil or resin filling to improve clarity, dyeing to enhance or alter colour, and irradiation to induce a change of stone colour (e.g., introducing an unstable yellow hue). Each treatment may produce specific diagnostic features. However, certain corundum treatments - particularly low-temperature heating and recent glass filling – often are challenging for gemologists to accurately identify and properly disclose the treatment of a stone.

Basic and Advanced Techniques for the Detection of Ruby & Sapphire Treatments

- Microscopy: Identification of specific diagnostic features, e.g., altered inclusions, newly healed fissures, presence of flux residue, colour concentration along stone surface and fractures.
- FTIR Spectroscopy: May assist heat treatment detection of corundum, e.g. based on characteristic absorption bands

(e.g., 3232, 3309, 3185 cm⁻¹), though not always conclusive for all samples (Soares *et al.*, 2025, Phlayrahan and Homkhajorn, 2021)

- Raman Spectroscopy: Detects phase transformation of some inclusions (e.g., goethite to hematite). The presence of goethite (or diasporite) in corundum is a strong indication that a corundum sample has not been heated (Krzemnicki *et al.*, 2023)
- EDXRF and LA-ICP-MS: Identify trace elements and diffusion of foreign elements (e.g., Be, Pb, Ba, Bi) associated with specific treatments (Krzemnicki *et al.*, 2004)
- LIBS: Elemental analysis for diffusion treatments, especially Be-diffusion (Krzemnicki *et al.*, 2004)
- Luminescence Analysis: Observes changes in silk inclusions and UV-induced luminescence as indicators of heating, especially in Geuda sapphires (Pluthametwisute *et al.*, 2025)

Key Challenges in Identification

- Low-temperature heat treatment of corundum is often difficult to detect, as it may not alter inclusions significantly or produce clear spectroscopic markers (e.g., Atichat *et al.*, 2011, Hughes *et al.*, 2022)
- Heat treatment detection in corundum from basaltic origins is particularly difficult, as natural heating during ascent in alkali basalt and high iron content—which suppresses diagnostic spectral features—complicate differentiation from heated stones. Accurate trace element

analysis and close inclusion observation are essential. (e.g., Soonthorntantikul *et al.*, 2019).

- Some glass-filled stones may appear highly transparent, masking fractures quite effectively; detection may be supported by chemical analysis (e.g., lead content) and X-ray imaging (see figure 1).
- Surface diffusion treatments create color only on the outer rim, requiring immersion techniques and careful chemical profiling for identification (see figure 2).
- Irradiation treatments can create an unstable (in some cases also stable) yellow colouration, but it could also induce a subtle change of colour that is difficult to distinguish from natural colouration. Currently, only the colour stability of such stones can be checked by a fading test, whereas the irradiation treatment itself cannot be detected up to this day. Recently, advanced spectroscopic and fluorescence techniques are under investigation allowing possibly a reliable detection in the near future (e.g., Wang *et al.*, 2023).
- Detection the presence of oil in ruby and sapphire: especially colourless or low-viscosity oil could be a challenge without the backing of other techniques, such as Raman microprobe, FTIR spectroscopy, and hot point tester.
- Overlapping spectroscopic features in treated and untreated stones complicate detection, but the most reliable results come from combining multiple analytical techniques (Soares *et al.*, 2025, Phlayrahan and Homkhajorn, 2021).

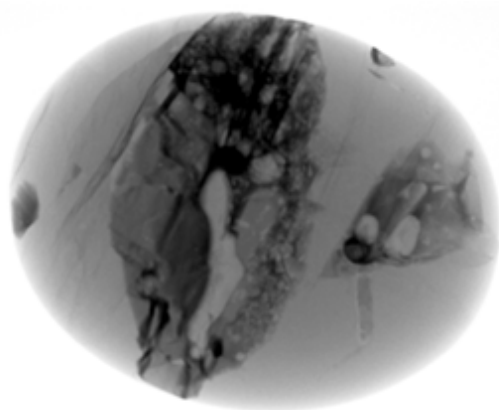


Figure 1. X-ray image of a glass-filled (and heated) ruby showing high density glass along the fractures within the stone. Photo by W. Chongraktrakul; image widths 7.0 mm.

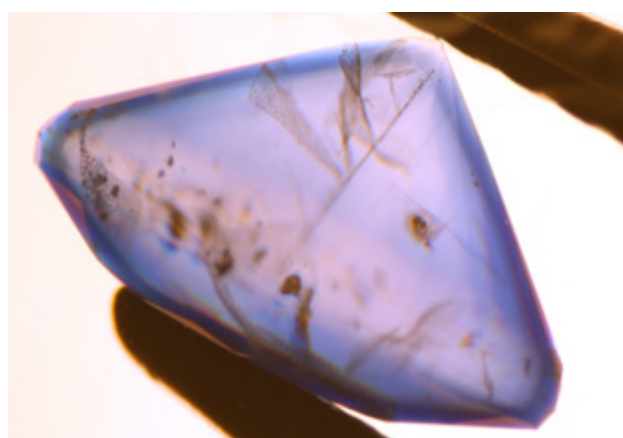


Figure 2. A diffusion-treated sapphire exhibits blue colour concentration along the stone surface, while the interior is noticeably lighter or even colorless. Photomicrograph by S. Promwongnan; image widths 7.0 mm.

Conclusion

The detection of treatments in ruby and sapphire is an ongoing challenge due to the sophistication of modern enhancement techniques. Accurate identification requires a combination of traditional gemological skills and advanced analytical technologies. Continued research, method devel-

opment, and collaboration among laboratories are essential to keep pace with evolving treatment methods. Above all, transparency and full disclosure of treatments are essential to uphold ethical standards and maintain consumer confidence in the gemstone industry.

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