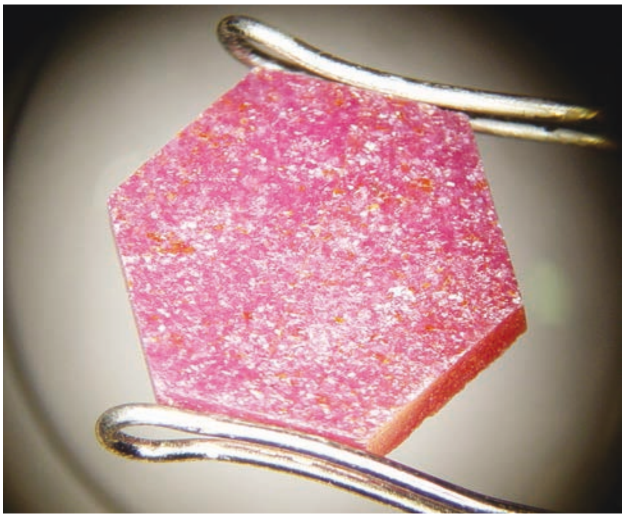

Figure 23: Seen here in oblique lighting, the 3.32 ct ruby shows a granular texture with orangey red domains corresponding to rutile inclusions. Photo by B. Williams.

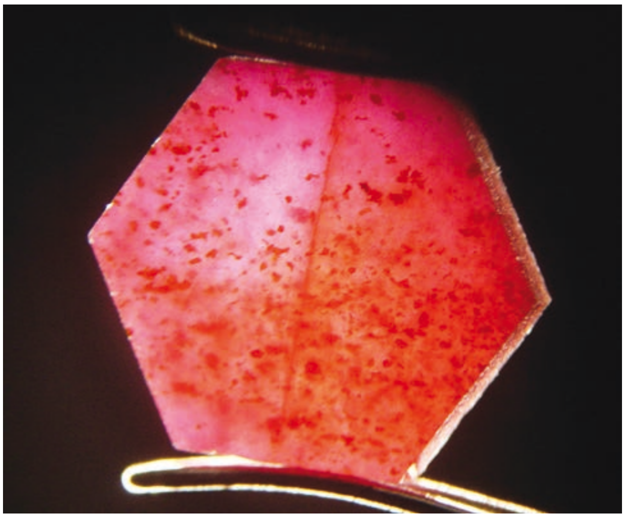

Figure 24: Viewing the 3.32 ct ruby with transmitted light highlights the presence of a partially healed fissure and abundant orangey red inclusions (rutile crystals). Photo by B. Williams.

translucency. Although the hexagonal slice had a shape reminiscent of a cross-section from a corundum crystal, the stone gave a polycrystalline reaction between crossed polarizers, remaining bright throughout a full rotation. Microscopic observation revealed a granular appearance with most individual grains appearing pinkish red, while a few were orangey red (Figure 23). While this might be suggestive of ruby dichroism, the orangey red domains proved to consist of inclusions. Transmitted light revealed numerous translucent, deep orangey red, blocky, crystalline inclusions that were randomly oriented, as well as one partially healed fissure running through the centre of the stone (Figure 24). No other inclusions were observed. RI measurements of the sample yielded a single, weak shadow edge near 1.763. Specific gravity was measured as 3.81; this relatively low value is possibly due to the corundum's polycrystalline structure. The stone was inert to both long- and short-wave UV excitation. Raman analysis with a GemmoRaman-SG instrument confirmed it to be corundum.

It is the sparkly appearance that makes this ruby intriguing. Under magnification, numerous micro-reflections were seen emanating from the polycrystalline grain boundaries, as well as from the inclusions mentioned above. Several of the surface-reaching inclusions were identified as rutile by an Enwave 785 micro-Raman spectrometer. The presence of abundant rutile inclusions is consistent with the elevated Ti content obtained for the sample with an Amptek X123-SDD EDXRF spectrometer. The chemical analysis also revealed the Cr and Fe that are presumed responsible for the red colour of the ruby and lack of fluorescence, respectively.

While ruby with rutile needles is commonly encountered, this material in unusual for having rutile present as reflective grains mixed with polycrystalline ruby.

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Yellow Sapphire with Unstable Colour—in Reverse

Irradiated yellow sapphires are rarely encountered in today's market. Although it is possible to irradiate a colourless sapphire to turn it yellow, this treatment is highly unstable and readily fades to colourless upon exposure to light (Nassau and Valente, 1987). We were therefore surprised to learn about a yellow sapphire with unstable colour—in reverse. Harold Dupuy FGA of Stuller

Figure 25: This 1.07 ct sapphire shows an unusual 'reverse' colour change. The more stable yellow state fades to colourless after low-temperature heating, and the yellow colour can be restored by exposure to long-wave UV radiation or daylight. Photos by B. Williams.

Inc., Lafayette, Louisiana, USA, reported that they sold a 1.07 ct white sapphire to a retailer who returned the stone after it turned yellow. The client mounted the white sapphire into a ring, and sold it to a consumer who wore the ring for a few months before returning it to the retailer. Stuller immediately exchanged the stone for another comparable white sapphire, but the question remained of how and why the change in coloration occurred.

The sapphire was sent to Stone Group Laboratories for testing. Upon receipt, the stone was yellow (Figure 25, left). The refractometer showed the expected RI values of 1.76–1.77 and Raman spectroscopy confirmed it was corundum. Detailed microscopic examination and FTIR spectroscopy revealed the absence of thermal enhancement in this metamorphic sapphire. With Dupuy's permission, various experiments were performed to test the colour stability of the stone.

First the sapphire was subjected to low-temperature heating of 260°C for one hour, which rendered it colourless (e.g. Figure 25, right). Then it was exposed to a 4 W long-wave UV lamp for 30 minutes, after which it again appeared light yellow. Reheating as before returned it to colourless. Such reversible coloration is commonly related to energy-induced trapped hole centres, which can vary in their stability (Nassau and Valente, 1987). A reversible colour change also has been observed by the present authors in some blue zircons that exhibit brown-to-green tints upon exposure to strong UV radiation, then revert to their previous (heated) blue colour over a period of days when exposed to a broad-spectrum visible light (cf. Renfro, 2013), or more quickly revert to blue with slight heating.

Jay Boyle (Jay Boyle Co., Fairfield, Iowa, USA), who has been dealing in untreated yellow and white sapphires for 35 years, says he has encountered a small number of yellow stones that exhibited this colour behaviour. He believes it to be observed only in approximately 1 in 3,000 yellow sapphires. In such cases, the yellow colour is more stable, and fades to colourless when exposed to heat (such as during the jewellery-making process), but reverts to the original yellow upon exposure to sunlight for a few days.

In the present sapphire, ultraviolet-visible-near infrared (UV-Vis-NIR) spectroscopy showed a small absorption at 450 nm in both colour states that is indicative of iron (not responsible for the colour phenomenon). The spectra also revealed a very subtle difference between colour states in the form of a broad absorption band in the 460–480 nm range for the yellow state, which was most likely related to the observed change in coloration.

All of the conditions that were found capable of altering the colour of this sapphire are commonly experienced by gem materials in general. Long-wave UV radiation is encountered in the laboratory environment as well as in tanning beds. Of course, sunlight is an even more common source of long-wave UV wavelengths. Heating to a temperature of 260°C is comparatively mild, such that it may be produced by typical kitchen ovens, and jewellery processes can often expose gems to much higher temperatures. Heating of this sapphire to 260°C did not induce a 3309 cm^{-1} band in the FTIR spectra, such as seen in heated corundum. More research is required to understand the coloration of this sapphire, which is best described as containing a rare but unstable energy-activated colour centre.

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References

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