Low Temperature Heat Treatment of Madagascar Sapphire

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One of the challenges facing gemologists today is the detection of low temperature (below 1200°C) heat treatment in corundum (Hughes *et al*., 2017). At these temperatures, the color of ruby and sapphire can be altered, but some common features such as rutile silk may remain intact.

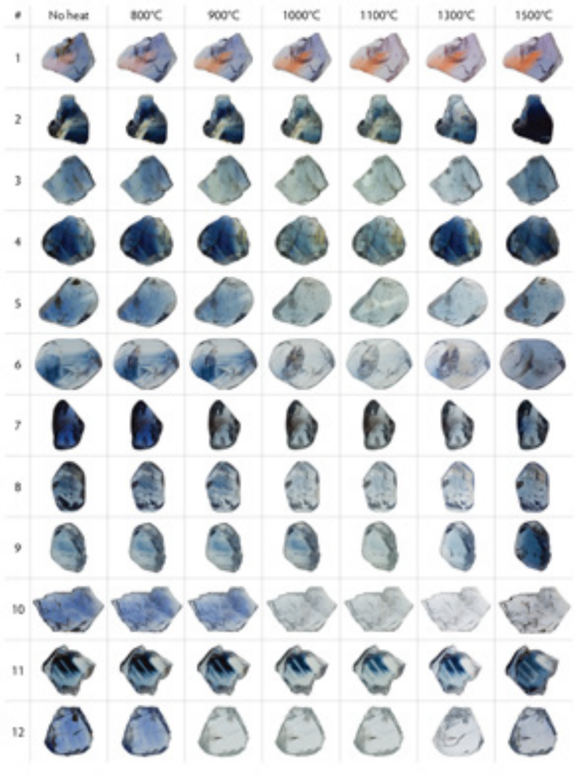


Figure 1. Madagascar sapphire before and after heating the 12 samples, shown before and after heating to each temperature. Most of the samples began to lighten significantly after heating to about 900–1000°C and started to deepen in color again around 1300°C. After heating to 1500°C, many pieces became significantly deeper in color. Photos not to scale. Photos by Rosey Perkins and Sora-at Manorotkul.

To aid in detection, the authors heated Madagascar sapphires at a range of temperatures from 800°C to 1500°C. The samples were documented using macrophotography in the untreated state and after heat treatment at elevated temperatures (figure 1), photomicrography of inclusions (figure 2), ultraviolet fluorescence imaging (figure 3), and spectroscopic analysis (ultraviolet/visible/near infrared and infrared) to record any changes, with a focus on features that could help detect heat treatment.

Results showed that a combination of inclusion studies, infrared spectroscopy, and observation of fluorescence could help detect treatment. We also noticed a fascinating change in UV-Vis-NIR spectra that can have implications for origin determination of blue sapphire (figure 4) (Schmetzer and Bank, 1980 and Emmett and Douthit, 1993). Many of the samples developed a peak at 880 nm after heat treatment. This can make it challenging to separate heated metamorphic sapphires from Madagascar from the basalt related material.

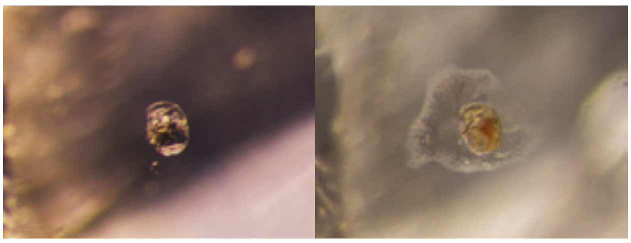


Figure 2.
Left: A small, flat crystal is pictured in sample 10 before heat treatment.
Right: After the first heating to 800°C, a reflective fissure begins to appear around the crystal. By 1100°C (pictured), the fissure has begun to heal at the edges.

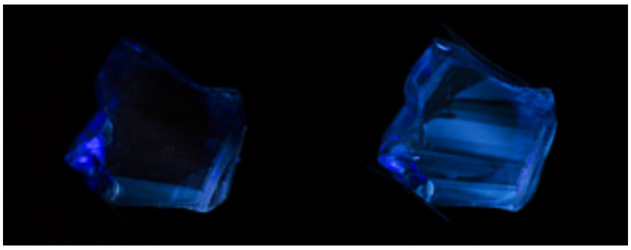
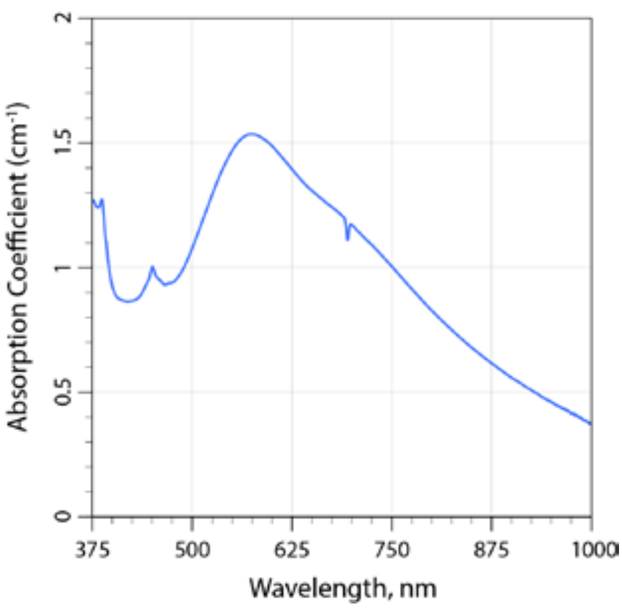


Figure 3. Short-wave UV fluorescence reaction of a Madagascar sapphire during heating
Left: Sample 11 began to show a short-wave fluorescence reaction after heating to 1000°C. This was mainly limited to one side of the stone, where a chalky blue band can be seen.
Right: After heating to 1100°C, the chalky blue reaction became stronger and more widespread, with chalky blue bands across the stone.



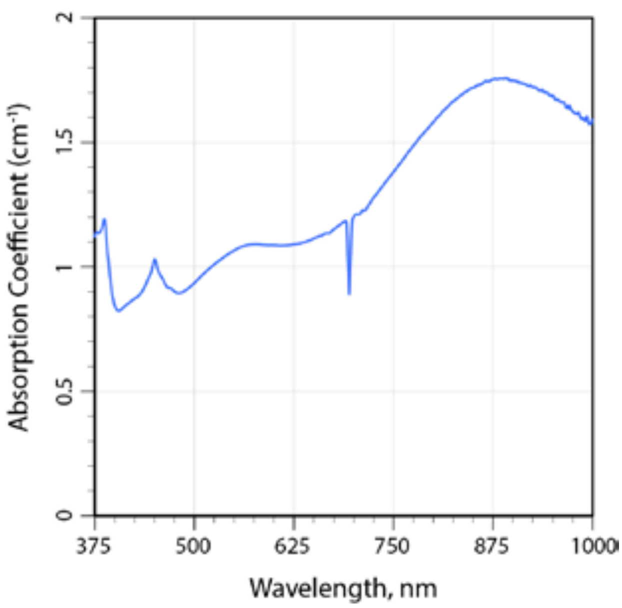


Figure 4. UV-Vis-NIR spectrum of a Madagascar sapphire before and after heating
Left: The UV-Vis-NIR spectrum of sample 7 before heat treatment. Note that the most prominent feature is the absorbance between 500 and 600 nm, as well as a small Fe-related peak around 450 nm.
Right: The UV-Vis-NIR spectrum of sample 7 after heating to 900°C. Note the development of a large peak at ~880 nm.

References:

- Emmett J., Douthit T. (1993) Heat treating the sapphires of Rock Creek, Montana. Gems & Gemology, Vol. 29, No. 4, pp. 250–272.
- Hughes R.W., Manorotkul W., Hughes E.B. (2017) Ruby & Sapphire: A Gemologist's Guide. RWH Publishing/Lotus Publishing, Bangkok, 816 pp.
- Schmetzer, K. and Bank, H., 1980, Explanation of the absorption spectra of natural and synthetic Fe- and Ti containing corundums, Neues Jahrbuch für Mineralogie, Abhandlungen, Vol. 139, No. 2, pp. 216–225.