A Question Concerning Heat-Treated Blue Sapphires

John I. Koivula and Alethea Inns
GIA Laboratory, Carlsbad

Over the past several years, we have noted a curious pattern of gemological characteristics related to certain heat-treated blue sapphires. While this pattern seems consistent, we do not know why it occurs. We present it here in the hope that the ideas of others and additional forms of analysis beyond micro-observation, UV luminescence, and FTIR spectrometry might shed light on why this happens and if this pattern of characteristics is, in fact, verifiable and consistent.

In heat-treated blue sapphires showing clear evidence of high-temperature heat treatment in the form of rutile exsolution–patterned "ink spot" internal diffusion (see figure 1), no shortwave ultraviolet (SWUV) luminescence is observed. Additionally, it has been noted that such stones do not show a 3309 cm^{-1} feature in their infrared absorption spectrum, which is caused by traces of a structurally bonded hydrogen impurity.

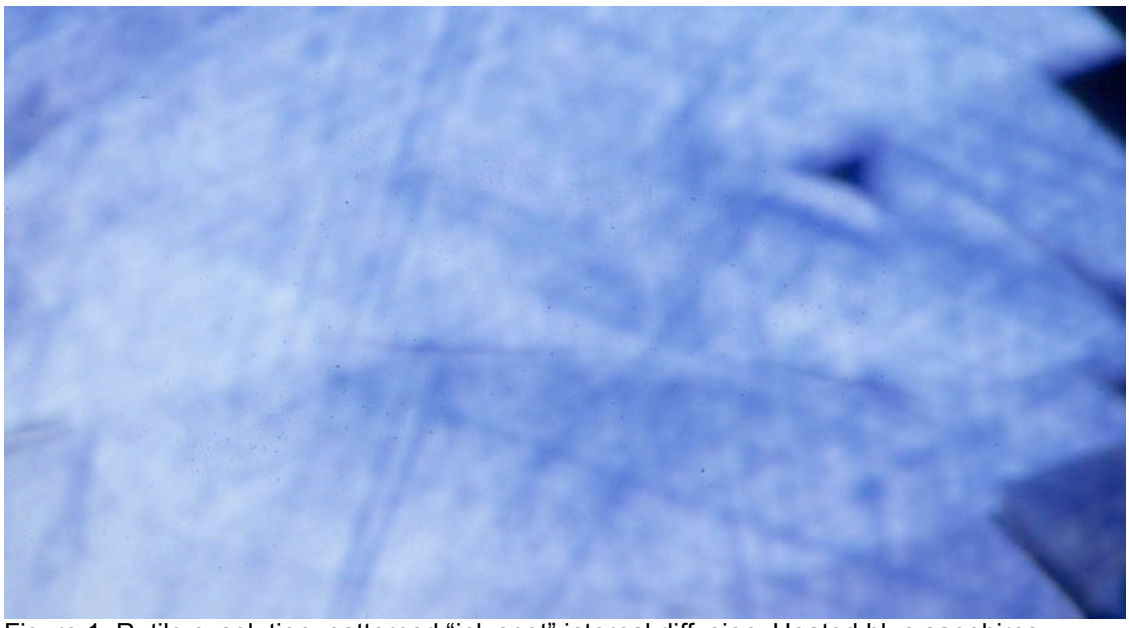

Figure 1. Rutile exsolution–patterned "ink spot" internal diffusion. Heated blue sapphires displaying this type of internal diffusion do *not* exhibit 3309 cm^{-1} absorption features or SWUV fluorescence.

This trend seems to be so consistent in heated blue sapphire that when you see a pattern of internal diffusion that follows typical rutile exsolution, you can

immediately predict that no 3309 cm^{-1} will be present in the FTIR scan and that no SWUV reaction will be observed.

Conversely, heat-treated blue sapphires that show clear evidence of heat treatment, such as melted solid inclusions and discoid fractures, but do not show exsolution-patterned internal diffusion, often display prominent 3309 cm^{-1} features in their FTIR patterns as well as obvious chalky bluish to greenish reactions to SWUV radiation.

It should be stated that we have not yet observed a heated blue sapphire that shows a 3309 cm^{-1} feature and no SWUV reaction, or vice versa. Yet we cannot think of any reason why such a stone would not exist. Perhaps this is because we have just started looking for stones that possess this pattern of identifying characteristics.

Also significant is the fact that this pattern does not hold true for samples that show internal diffusion halos surrounding large rutile inclusions (figure 2) . . .

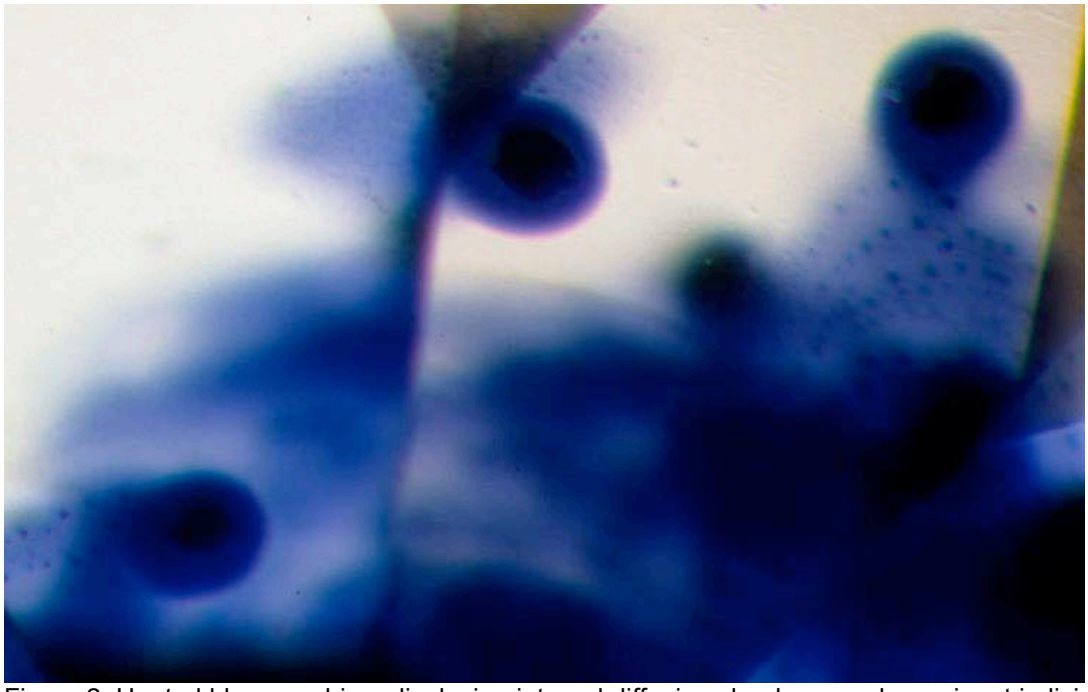

Figure 2. Heated blue sapphires displaying internal diffusion clouds around prominent individual rutile inclusions can have both a 3309 cm^{-1} absorption feature and an SWUV reaction.

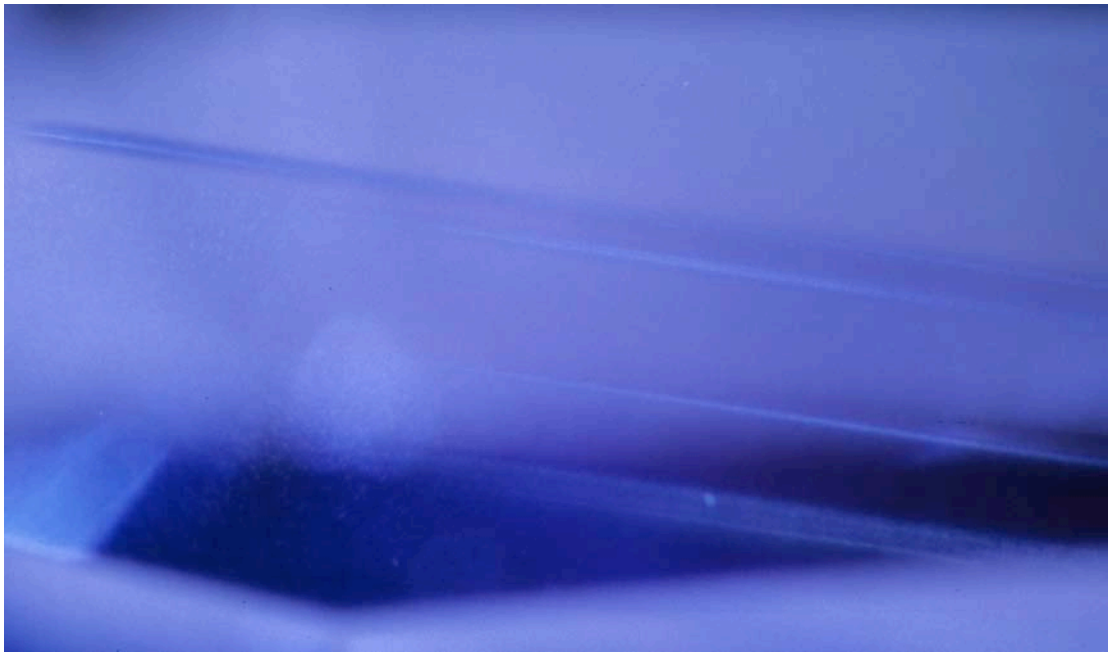

Figure 3. Internal diffusion in distinct color bands does not follow the sapphire-rutile exsolution pattern. Such sapphires can display both 3309 cm^{-1} absorption and SWUV chalkiness.

. . . or for those displaying internal diffusion in distinct color bands, as pictured in figure 3. Such heated sapphires can and do have 3309 cm^{-1} absorption features and SWUV luminescence.

The predictable lack of a 3309 cm^{-1} feature and SWUV chalky reaction only seems to hold true in those sapphires displaying rutile exsolution–related "ink spot" internal diffusion.

While we suspect that this must have something to do with the original growth environment, growth conditions of unheated sapphires are relatively easy to determine. When sapphires are heated to temperatures above 1500^{o}C in atmospheres that do not match those where growth originally occurred, and with no compensating external pressure, then the distinction between natural growth environments becomes somewhat blurred. In view of this, the lack of both a 3309 cm^{-1} peak and SWUV chalky reaction in heated blue sapphires that clearly show rutile exsolution–patterned internal diffusion is interesting.

Your ideas, comments, and observations concerning this pattern of gemological features in heated blue sapphires are most welcome.