

# The Role of Secondary Fluid Inclusions in Detecting Heat Treatment

John I. Koivula  
GIA Laboratory, Carlsbad, California (April 30, 2009)

---

Since the mid-1980s, it has been established that the presence of large, intact primary fluid inclusions provides proof of natural color and the absence of heat treatment in corundum. Heat treatment experiments conducted by this author have shown that the same is also true of other gems such as quartz, spinel, and topaz (figures 1A and 1B show an intact primary fluid inclusion in an unheated spinel).



Figures 1A and 1B. Containing a mobile gaseous phase suspended in an aqueous fluid, with numerous graphite platelets also present as solid phases, this intact 1.86-mm-long primary fluid inclusion clearly shows that the host spinel could not have been heat treated. Photomicrographs by John I. Koivula.

While larger primary fluid inclusions have become useful tools to gemologists around the world in recognizing the absence of heat treatment, virtually no work has been done on secondary fluid inclusions, also referred to as “fingerprints.”

So-called fingerprint inclusions are essentially composed of minute fluid inclusions, often (but not always) interlinked by equally minute tubes known as “communication” or “equalization” tubes, which balance the pressure between the interconnected fluid inclusion islands. Laboratory gemologists readily recognize large-scale, heat-induced damage to “fingerprints” when they rupture as a collective unit, since this produces mirror-like fractures that are visible at low magnifications (see figure 2).



Figure 2. While it is not possible with current gemological microscopes to resolve the interior of any of the fluid inclusion islands in this “fingerprint,” the glassy fringe of microcracks along the edge provides evidence of high-temperature heat treatment. Such obvious visual information is not always present, however. Photomicrographs by John I. Koivula. Horizontal field of view is approximately 4 mm.

But what happens within the individual fluid inclusion islands at extreme temperatures should, from a logical standpoint, be just as telling as what happens to primary fluid inclusions. During heat treatment, fluid contents are lost and daughter crystals are damaged or visibly altered. One apparent difference is that while primary fluid inclusions clearly rupture, and in doing so visibly crack the host, the minute fluid inclusions in a fingerprint sometimes seem to bleed out their fluid contents without visibly cracking the surrounding host gem. This appears to result from the small volume of fluid present, as well as the type(s) of fluid. But even if no actual cracking occurs, the changes in the interior of these minute fluid inclusion chambers are still very indicative of high-temperature heat treatment, most notably in natural sapphires and rubies.

Presently, what we are lacking to fully pursue this type of project is a research-grade microscope with high optical quality and clear resolution in the 400×–1000× region.

There are times when all that is present in a sapphire, aside from a few small particles and some growth zoning, is a single small fingerprint inclusion. If

laboratories had the capability to clearly resolve the individual fluid inclusion islands within fingerprints, we would have another useful weapon in our arsenal for detecting high-temperature heat treatment. This researcher has examined minute fluid inclusions in the past and feels strongly that a project of this nature would be useful to gemology.

### **References**

- Koivula J. I. (1980) Fluid inclusions: Hidden trouble for the jeweler and lapidary. *Gems & Gemology*, Vol. 16, No. 8, pp. 273–276.
- Koivula J. I. (1986) Carbon dioxide fluid inclusions as proof of natural-colored corundum, *Gems & Gemology*, Vol. 22, No. 3, pp. 152–155.