Cu-containing Thin Sheet Inclusion in Cu-bearing Tourmaline from Brazil

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Cu-bearing tourmaline was first discovered in 1987 in granitic pegmatites in Paraíba state in Brazil. It immediately became one of the most sought-after tourmaline species in the gem trade, thanks to its attractive vivid blue (to green) colour, also described as "neon" or "electric" blue. Depending on its chemical composition, Cu-bearing tourmaline can be found in a range of colours, from blue to green to even purple and pink.
Our study focusses on a green Cu-bearing tourmaline sample (Fig. 1) from Brazil, containing oriented metallic-looking thin sheet inclusions. This rarely-seen inclusion has been reported previously in a few studies (Fritsch et al. 1990, Brandstätter et al. 1994, Hartley 2018) and was suggested to be native Cu and tenorite (CuO) formed during epigenetic exsolution (Koivula et al 1992).

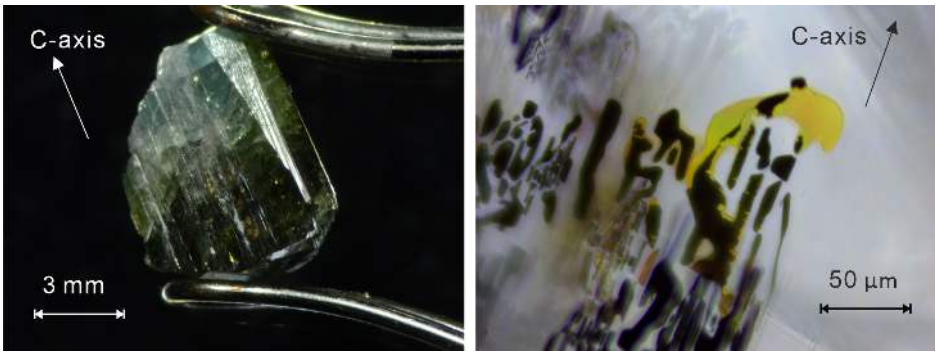

Figure 1. Left: Cu-bearing tourmaline from Brazil containing a rare type of highly reflective inclusions investigated in this study. Crystal width is about 5 mm. Right: Microphoto of the thin sheet inclusion in transmitted light, revealing two clearly separated phases (black and yellow).

In our sample, the inclusion planes are aligned parallel to the C axis direction of the host tourmaline. We used a focused ion beam (FIB) in combination with scanning electron microscope (SEM) to cut the sample and image the cross-section of the inclusion. Detailed SEM pictures showed that the inclusion is about 150 nm in thickness (Fig. 2). A chemical profile across the cross-section was carried out by energy dispersive spectroscopy (SEM-EDS). In the profile, the Cu signal increased at the position of the inclusion, while no elevated S signal was observed. In contrast to Brandstätter & Niedermayr (1994), in our sample we did not see an obvious decrease of Cu in the tourmaline host on each side of this thin sheet inclusion.

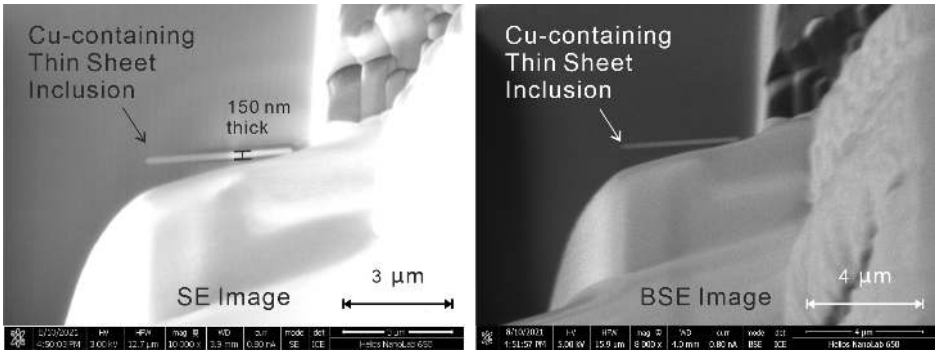

Figure 2. Left: Secondary electron image (SE) of a thin sheet inclusion in Cu-bearing tourmaline revealing a thickness of about 150 nm. Right: Backscattered electron image (BSE) of the same inclusion showing brighter color than the host tourmaline, indicating the presence of high Z elements in the inclusion compared to the tourmaline host.

Using micro-FTIR, we noticed a small shift in the OH absorption peak positions (around 3000-4000 cm^{-1}) in the thin sheet inclusion region compared to the nearby tourmaline host. Raman spectra showed extra peaks in the tourmaline host in the inclusion region than in the tourmaline host further away from the inclusion, which may indicate species of tourmaline other than elbaite being present near the thin-sheet inclusion. Subsequently, we focused on investigation of the inclusion by spatially resolved Synchrotron Radiation X-ray absorption spectroscopy (XAS). The result showed that Cu is probably present as a metal phase (zero oxidation state) in the thin sheet inclusion.

Based on our preliminary observation, the Cu-containing thin sheet inclusions are probably Cu metal. Nevertheless, the hypothesis that these inclusions form due to epigenetic exsolution from the Cu-bearing tourmaline host is in debate. Definitely, more analyses are required to better understand the nature and formation of these inclusions. The outcome may provide crucial information on the oxidation conditions during the formation of Cu-bearing tourmaline from Brazil.

References

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