XRF

The Power of Micro-XRF in Gemology – Part 6: Verifying Copper in a Small Paraiba Tourmaline Gemstone

Application Note

Gemology XGT44

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Abstract: Verifying the presence of copper in a Paraiba tourmaline is an important approach to separate it from other similar color tourmalines. This application note introduces the feasibility of non-destructive copper detection inside a small Paraiba tourmaline gemstone using HORIBA's micro-XRF XGT-9000 X-ray Analytical Microscope.

Keywords: Gemology, gemstone, Paraiba tourmaline, EDXRF, micro-XRF

Introduction

Tourmalines, one of the birthstones for October, have a wide variety of colors and compositions[1]. Paraiba tourmaline is one of the most famous and precious tourmalines for their vivid hues, higher color saturation and greater rarity[2]. Elemental analysis using an analytical instrument is important to identify Paraíba tourmaline by verifying the presence of copper inside[3].

In this application note, we introduce HORIBA's XGT-9000 micro-XRF analyzer, as a non-destructive elemental analysis technique for copper verification in a small Paraiba tourmaline gemstone.

Sample information

We prepared a small Paraiba tourmaline gemstone (0.11 ct) from a reputable gemstone dealer for this application note. It is reported as being from Brazil (Figure 1).

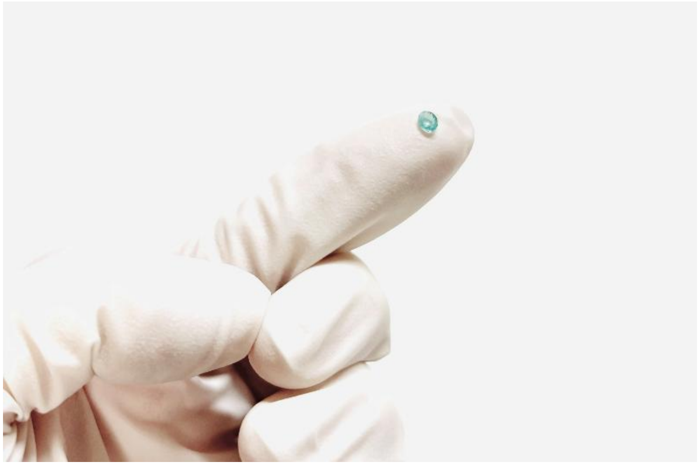

Figure 1. A small Paraiba tourmaline gemstone we analyzed.

XGT-9000 X-ray Analytical Microscope

The XGT-9000 X-ray Analytical Microscope (Figure 2) is an energy dispersive X-ray fluorescence microscope (micro-XRF) with multiple key features for gemological applications, including an upper irradiation with micro-spot size[4], motorized stage for scanning[5], and dual types of detectors for transmission X-ray and fluorescent X-rays[6].

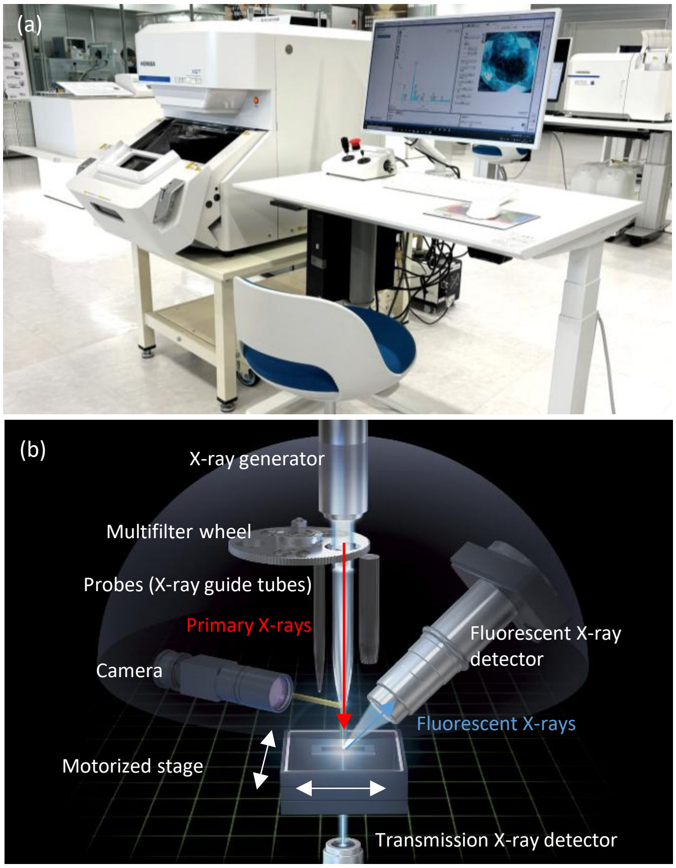

Figure 2. (a) XGT-9000 instrument setup (b) internal structure.

STEP 1: Scanning to check the possible inclusions that might affect our spectrum analysis

First, we quickly scanned over the surface using the XGT-9000's simultaneous imaging of transmission X-rays and fluorescent X-rays to check for the possible presence of inclusions that might affect to spectrum analysis.

Figure 3 shows a transmission X-ray image with the contrast based on the density differences, and also fluorescent X-ray images with the contrast of individual elements' presence. As shown in Figure 3. we could find a small dark spot (higher density) in the transmission X-ray image which indicates the presence of an inclusion inside. On the other hand, there were no hot spots in the elemental distribution images. The findings indicate that the inclusion location is deep enough that it won't affect our spectrum analysis.

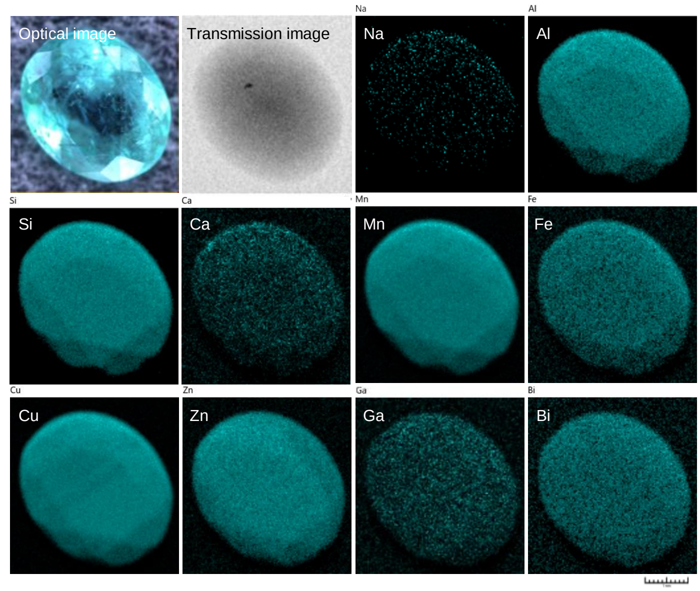

Figure 3. Quick scan result on the Paraiba tourmaline: an optical image, a transmission X-ray image, elemental map images obtained in 6 minutes by the XGT-9000.

STEP 2: Spectrum analysis to find the presence of copper as a marker element of Paraiba tourmaline

We carried out spectrum analysis using a 100 µm ultra-high intensity probe to hit the limited surface without compromising the X-ray beam intensity. Also, gemstones generally have a crystalline structure, which might cause diffracted X-rays, and could lead to undesired spectral interference with fluorescent X-ray peaks in a spectrum. For this reason, we used primary X-ray filters to reduce the undesired phenomenon.

Figure 4 shows an optical image and XRF spectrum result obtained by the XGT-9000. As shown in Figure 4, we could successfully verify the presence of Cu.

We could also find the presence of some other unique elements reported in Paraiba tourmalines[7,8,9] such as Mn, Zn, Ga, and Bi, in addition to O, Na, Al, and Si, which are in the typical main composition of a Paraiba tourmaline as an elbaite ($Na(Al_{1.5},Li_{1.5})Al_6(Si_6O_{18})(BO_3)_3(OH)_3(OH)$).

Conclusion

We demonstrated that the HORIBA XGT-9000 can non-destructively verify the presence of copper, even in a small Paraíba tourmaline gemstone.

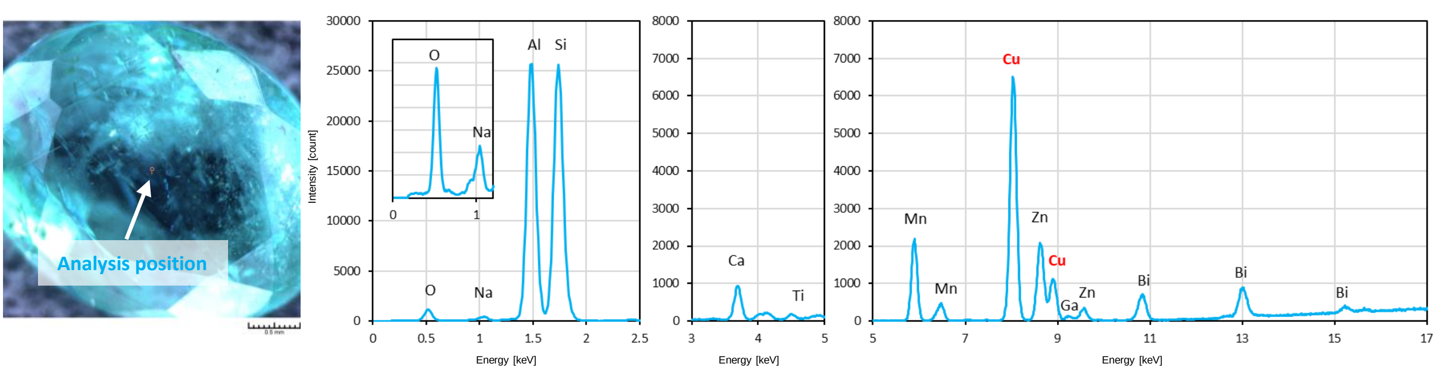

Figure 4. Spectrum analysis result obtained by the XGT-9000 to check the presence of copper in the Paraiba tourmaline.
(Condition: XGT-9000 Expert, whole vacuum, a 100 µm ultra-high intensity probe, multiple filters, 60 seconds per condition)

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