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XGT

The Power of Micro-XRF in Gemology – Part 1: Small Garnet Characterization

Application Note

Gemology
XGT30

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Abstract: Elemental composition of a garnet stone is an important parameter for the color. It is also important to identify the origin. We analyzed a small garnet stone using a HORIBA XGT-9000 X-ray Analytical Microscope, and the elemental composition result suggested that it was close to the chrome poor pyrope from Monte Suímo, Portugal.

Keywords: Gemology, gemstone, garnet, characterization, EDXRF, micro-XRF

Introduction

Garnet is a famous gemstone as a birthday stone of January. The most popular color of garnet is red, but there are more various kinds of colors of garnets and the color variety is known to be derived from the variety of elemental composition of the matrix and the impurities.[1,2] Therefore, elemental analysis is an important approach for garnet characterization.

Energy dispersive X-ray fluorescence is an elemental analysis method which is widely used for gemstone characterization because of the non-destructive approach and less sample pretreatment. We analyzed a commercial small garnet stone for characterization using the HORIBA XGT-9000 X-ray Analytical Microscope (micro-XRF) in this application note.

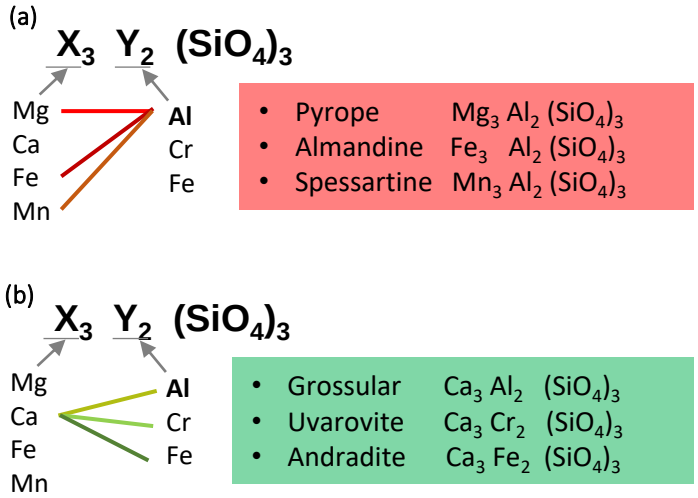

Figure 1. Garnet characterization [1]
(a) Pyralspite (Red-type) (b) Ugrandite (Green-type)

The 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 an upper irradiation with multiple-spot size selection including a 100 µm ultra-high intensity probe.

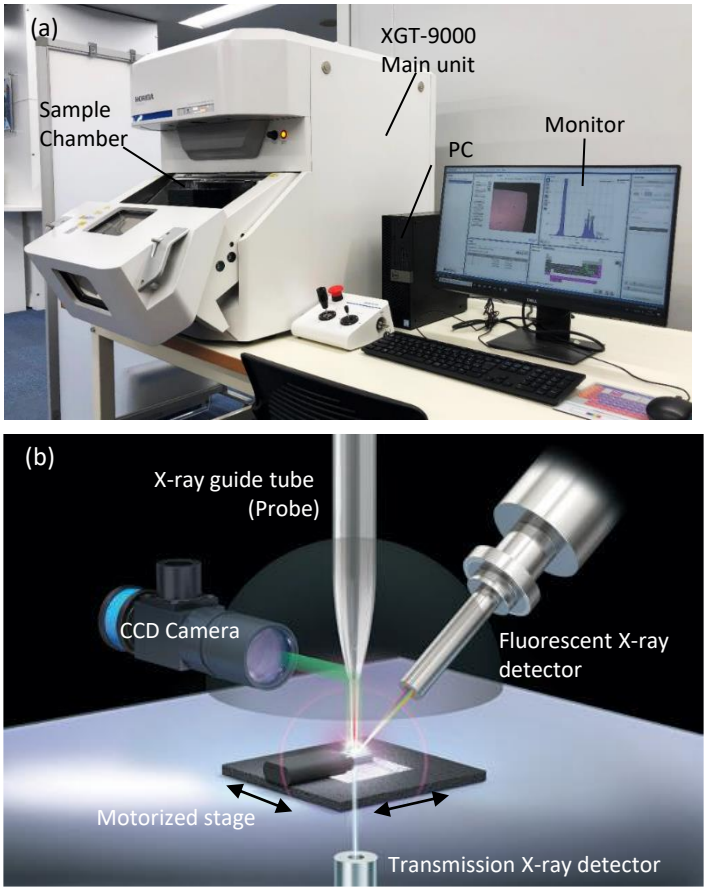

Figure 2. (a) The installation setup of XGT-9000 X-ray analytical microscope (b) Schematic diagram of the optics of the XGT-9000.

Sample information

We prepared a small garnet stone which we purchased at an online shop of a Jewelry brand. (Figure 3a).

Measurement & Result

We placed the garnet stone in the sample chamber of the XGT-9000 without any sample pretreatment. We analyzed it under full vacuum condition. Because of the small sample size, we used a 100 µm ultra-high intensity probe.

Figure 3b shows a spectrum result of the garnet stone, which showed the peaks of Si, Mg, Al, Si, Ca, Ti, Mg, and Fe, which are the elements reported by Pion et al. (2020)[3]. Figure 3c shows the quantitative result of the garnet stone. Compared with the categories reported by Pion et al. (2020) as shown in Table 1, it suggested that the garnet stone's composition was closest to the Type IV, chrome poor pyrope from Monte Suímo, Portugal.

Conclusion

The XGT-9000 is HORIBA's latest micro-XRF system, equipped with a high sensitivity detector and a micro spot size. It allowed composition analysis even on a small gemstone and covered the range from tens of percent to sub percent without any standard samples and sample pretreatment. Thus, we could show the value of micro-XRF analysis for garnet characterization.

Table 1. The comparison of elemental composition between a previous research result[3] and our result.

	Pion et al. (2020)				The garnet in this analysis
	TypeI	TypeII	Type IV	Type V	
SiO_2	36.0	37.3	41.2	41.5	**41.11**
FeO	37.5	32.1	12.7	8.9	**12.53**
Al_2O_3	20.8	21.5	23.1	21.6	**22.19**
MgO	4.4	6.2	16.3	19.8	**17.13**
CaO	0.7	1.4	5.4	4.3	**6.23**
MnO	0.4	1.2	0.4	0.3	**0.35**
Cr_2O_3	0.0	0.06	0.0	2.2	**0.00**
TiO_2	0.0	0.0	0.4	0.45	**0.40**

References

[1] Central Gem Laboratory, Gemmy 136, Lab topics "Garnet". (https://www.cgl.co.jp/latest_jewel/gemmy/136/34.html) Viewed on December 8th, 2023.

[2] Gemological institute of America, Gem Encyclopedia Garnet (https://www.gia.edu/garnet) Viewed on December 8th 2023.

[3] C. Pion et al. (**2020**) Bead and Garnet Trade between the Merovingian, Mediterranean, and Indian Worlds. In *The Oxford Handbook of The Merovingian World*; Effros, B., Moreira, I., Eds.; Oxford University Press: Oxford, UK; pp. 819–859.

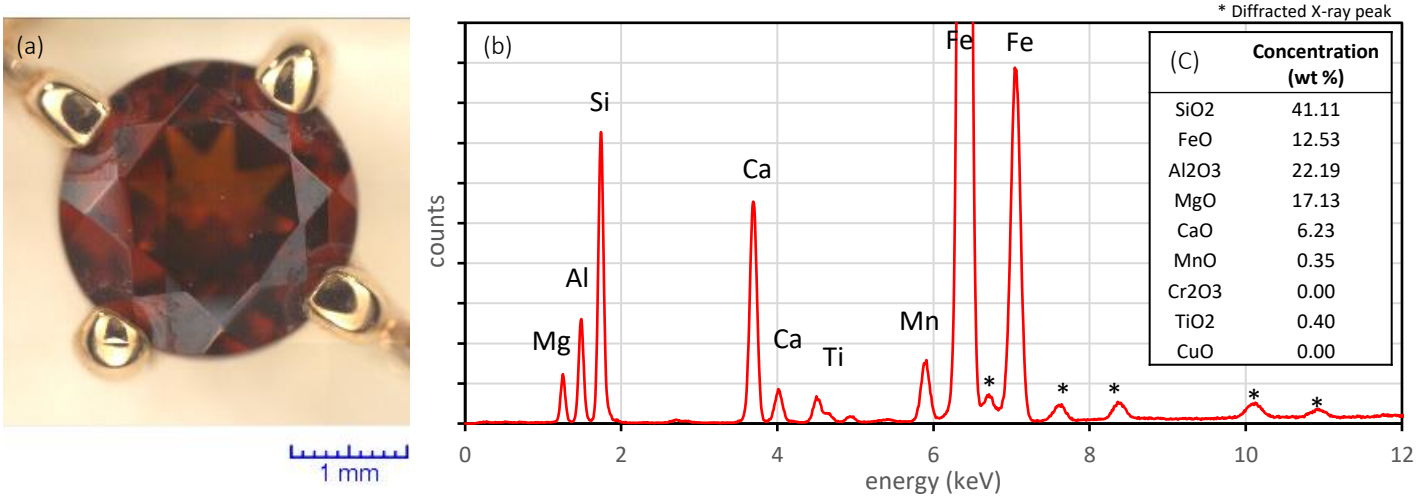

Figure 3. (a) The optical image and (b) An XRF spectra of the garnet stone using the XGT-9000. (C) Quantitative result.
Condition: XGT-9000 with a light element detector, 50 kV, 500 µA, None Filter, Process time 5, 100µm ultra-high intensity probe, 30 seconds.

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