Application News

EPMA-1720HT Electron Probe Microanalyzer

Elemental Mapping of Epidote

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User Benefits

- Metamorphic processes of rock-forming minerals can be analyzed from physical and chemical information obtained by elemental mapping.
- The information of minerals used in jewelry can be obtained for use in gem identification.

■ Introduction

The minerals contained in a rock record the physical and chemical information of the rock when it was formed. Furthermore, it is also known that the metamorphic process that the rock altered after its formation is preserved as the distribution and structure of the elements.

The minerals are also used for ornamental purposes such as in the production of jewelry and garden stones. The compositional analysis of minerals can determine the distribution of elements in gemstones and analyze trace elements, and the information obtained can be used for gem appraisal, geographic origin determination, etc.

To study the two-dimensional distribution of elements in rocks and minerals, EPMA is effective. In this article, we used an EPMA™, Electron Probe Microanalyzer (EPMA-1720HT) to perform elemental mapping of commercially available stones believed to contain epidote (hereafter, epidote containing stones). We also conducted phase analysis to identify the minerals in rocks and visualized their distribution.

■ Elemental Mapping of Epidote Containing Stones

Epidote has a chemical composition of $Ca_2(Al,Fe^{3+})_3Si_3O_{12}(OH)$. Also, natural epidote takes a composition between Clinozoisite ($Ca_2Al_3Si_3O_{12}(OH)$) and Pistacite ($Ca_2Al_2Fe^{3+}Si_3O_{12}(OH)$) due to the substitution of Al by Fe^{3+}. Natural epidote is widely found in metamorphic rocks metamorphosed at relatively low temperatures, such as greenschist, epidote-amphibolite, and glaucophane schist. Greenschist is well known for its use as a stone material and garden stone.

In this study, an epidote containing stone was pretreated by embedding it in resin, followed by polishing and carbon deposition. Fig. 1 shows the results of wide-field mapping analysis using EPMA. The concentration was determined as weight % of the oxide of each element. The results showed that there were agglomeration and non-uniformities of certain elements in some minerals, as well as structures where the chemical composition changed toward the rim.

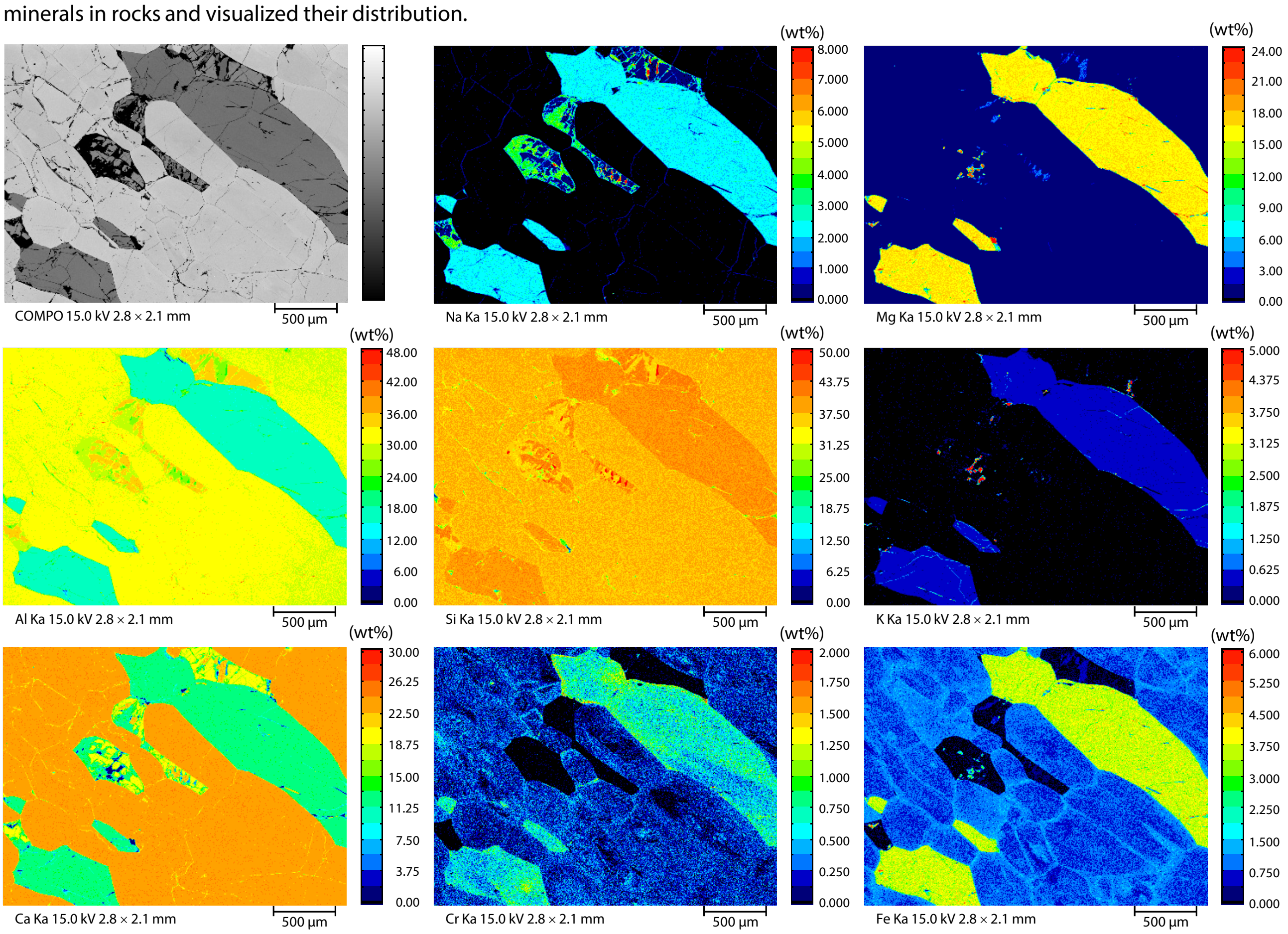

Fig. 1 Wide-Field Elemental Mapping of Epidote Containing Stones

■ Phase Analysis

A phase analysis was carried out based on the results of the elemental mapping of the stones. Fig. 2 shows the scatter plots created by selecting two or three elements (the wt% of their oxides).

Clusters were observed in each scatter plot. These clusters could be classified as epidote from the scatter plot of the two variables FeO-Al_2O_3, hornblende from that of the three variables CaO-MgO-FeO, and plagioclase and K-feldspar from that of the three variables K_2O-Na_2O-CaO. In the plagioclase cluster, there was a further cluster of Ca-rich components. Fig. 3 shows the phase diagram obtained from these results. From these elemental mapping and phase analysis results, it was found that the epidote has low Fe concentration in the core of each crystal and higher Fe concentration at the boundary or rim of the crystals. Furthermore, plagioclase was found to have more Ca-rich components mixed inside. As this analysis shows, the distribution of minerals in a rock can be easily visualized through phase analysis.

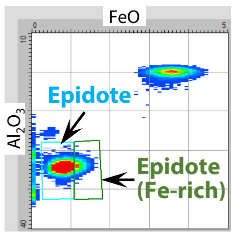

Fig. 2-1 Two-Variable Scatter Plot of FeO-Al_2O_3

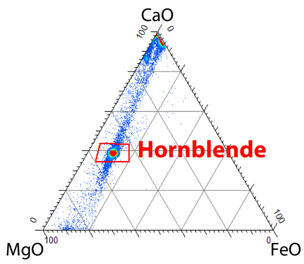

Fig. 2-2 Three-Variable Scatter Plot of CaO-MgO-FeO

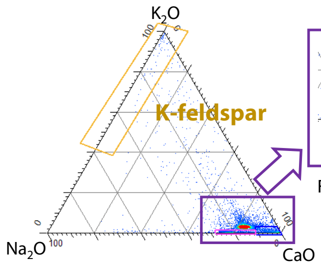

Fig. 2-3 Three-Variable Scatter Plot of K_2O-Na_2O-CaO

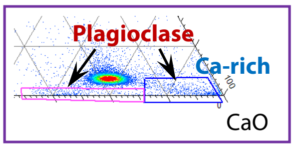

Fig. 2-4 Enlarged Section in Fig. 2-3

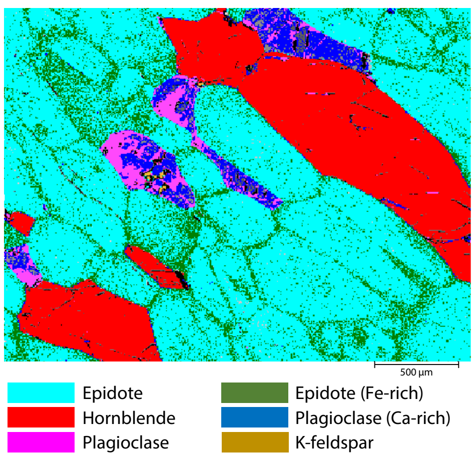

Fig. 3 Phase Diagram

■ Mapping of Fe and Trace Cr in Epidote and Hornblende

Mapping analysis was carried out for Fe and Cr in epidote and hornblende, which are present in epidote containing stones. The concentrations were obtained as weight % of the oxide of each element, as above. Fig. 4 shows the results. The concentration of Fe in epidote was higher at the rim and boundary of the crystals, while the concentration of Cr was higher in areas with less Fe and at the boundary. Furthermore, Fe distribution in hornblende was found to be almost homogeneous, while Cr was heterogeneous in relatively large crystals, with higher concentrations in the center area. However, in some fragmental hornblende, the concentration of Cr was higher at the rim and boundary.

It is known that epidote is produced in metamorphic rocks and that the amount of Fe^{3+} increases with higher metamorphic temperatures, suggesting that the reactions proceeded at the boundary and rim of the crystals during metamorphism. It can also be assumed that hornblende assimilated some Cr-rich substances during metamorphic process, or came into contact with Cr-rich components in case abundant Cr was found at the boundary.

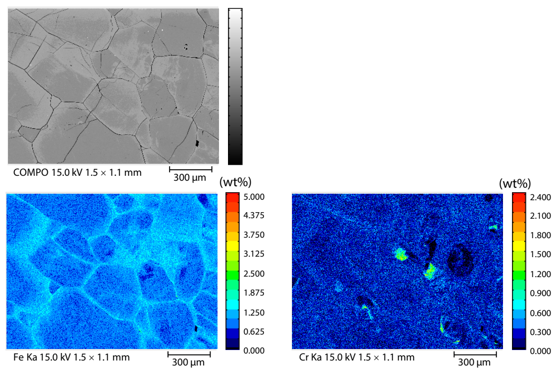

Fig. 4-1 Detailed Elemental Mapping of Epidote

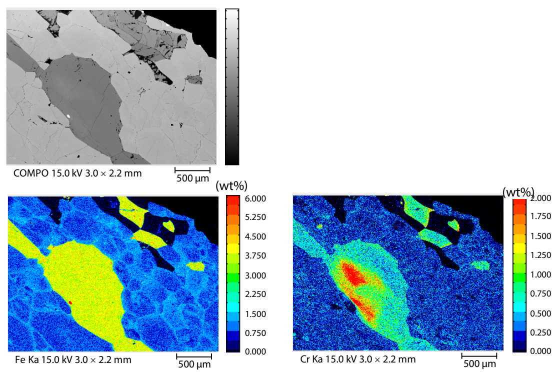

Fig. 4-2 Detailed Elemental Mapping of Epidote

■ Conclusion

Elemental mapping of rocks can reveal the physical and chemical processes of crystal growth and metamorphism of contained minerals. Furthermore, the combination of elemental mapping and phase analysis is effective for identifying minerals. With these methods, it is possible to evaluate gemstones and precious stones in jewelry and even to identify their geographic origin.

<References>

- Y. Kuroda and K. Suwa: Polarizing Microscope and Rock Minerals(Second Edition), Kyoritsu Shuppan (1983)
- A. Miyashiro and I. Kushiro: Petrology I: Polarizing Microscope and Rock-forming Minerals, Kyoritsu Shuppan (1972).

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