Chemical mapping of individual fluid inclusion by synchrotron X-ray fluorescence microprobe

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Introduction

Chemical composition of ore-forming fluid has fundamental importance to discuss the origin and evolution of ore-forming fluid, transport of ore-forming metals, and mechanism of ore mineral precipitation. Several substantial efforts have been made to develop the analytical techniques of individual fluid inclusions [1]. Among them, SXRF (synchrotron X-ray fluorescence microanalysis) requires special facility, and limited number of suitable microprobe beamlines is available (<10 sites worldwide). Applications of SXRF for the analysis of individual fluid inclusion have been previously reported by several researchers [2-7]. All these researches were carried out using synchrotron facilities in USA or UK. In this short report, we first present a preliminary result of SXRF analysis on fluid inclusion obtained by synchrotron source in Japan.

Samples

Doubly-polished thin section of quartz with thickness ~200 μm, commonly used in fluid inclusion study, was prepared in this study. Sample is from a prospect of porphyry copper deposit at Mocha, east of Iquique, northern Chile. Quartz specimen contains large amount of fluid inclusions. They are grouped into 2-phase type, vapor containing liquid inclusion, and polyphase type, solid(s) containing vapor and liquid inclusion. Distribution pattern of inclusions in quartz suggests that polyphase inclusions are primary in origin. Daughter mineral observed in the polyphase inclusions is NaCl, and most polyphase inclusion contains unknown opaque mineral besides NaCl.

Results of heating experiments of polyphase inclusions are summarized as follows. The bubble disappeared at variable temperatures of 254°-351°C ($n = 17$) and NaCl crystal dissolved at 261°-387°C ($n = 16$). The NaCl crystal dissolved after the disappearance of bubble in all cases. The NaCl equivalent salinity calculated from the dissolution temperatures of the halite daughter salt varies between 35.1 and 45.7 %. No significant change was observed on opaque daughter mineral during heating up to 500°C.

Results

The XRF spectrum obtained from a polyphase fluid inclusion that locates ~20 μm depth beneath the surface of quartz reveals the presence of Si, Ca, Ti, Mn, Fe, Ni, Cu, Zn, As, and Br. The background of XRF spectrum was obtained from quartz of fluid inclusion free portion just beside the fluid inclusion analyzed. In addition to silicon, Ti and Ni were detected from host quartz crystal. The fluid inclusion contains elements such as Mn, Fe, Cu, Zn, As and Br. However, many other elements such as Na and Cl are also likely to be present, but were not detected owing to limitations in detector sensitivities coupled with signal loss by absorption of X-rays in the host quartz crystal. In the case where inclusion was located <5 μm from the surface of quartz, small signal generated by Cl was observed. However, SXRF analysis is not an adequate method to analyze light elements especially mass number <Ca [6]. In contrast with this, heavy elements are very sensitive to SXRF. Although bromine content in fluid inclusion is usually much less than that of Cl, it is clearly detected from hypersaline inclusion.

We have succeeded to map the distribution of several elements in single fluid inclusion. During the accumulation of SXRF data, specimen was moved every 2 μm by X-Y stage; images were then composed from a total of 400 point analyses. The map suggests elements except As distribute homogeneously in liquid phase of fluid inclusion. Although this fluid inclusion contains daughter crystal of NaCl, concentrations of Br, Fe, Mn and Zn are not obviously high in solid phase. However, concentration of arsenic in daughter crystal probably in opaque mineral is higher than that in liquid phase. Since effect of absorption of X-ray by host quartz was not known in this stage, quantitative concentrations of elements in the fluid inclusion are unclear. However, SXRF is the powerful tool for research of ore deposits.

References

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