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Chemical separation of heavy metals between coexisting vapor and liquid phases during fluid boiling

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Introduction

Fluid boiling is one of the most important processes in the formation of hydrothermal deposits. Many inclusions trapped boiling fluid during mineralization of porphyry-type deposits. In recent years, their analyses have suggested that some metals, such as copper, are strongly fractionated into vapor phase, while ordinary metals are fractionated into brine phase (e.g., [1]). Fluid boiling may have an effect to extract copper from ore-forming fluids in the porphyry environment. Experimental determination of the factor controlling volatility of heavy metals is important to know the detail of this effect.

Synthetic fluid inclusion technique

Synthetic fluid inclusions described by Bodnar and Sterner [2] were used as experimental technique. This technique made it possible to sample high P-T fluid without cooling, and to minimize the change after experiment. Starting materials for syntheses were 1,000-12,000 ppm copper and zinc and 10 or 30 weight percent NaCl. Some solutions contained sulfur or HCl. A cracked quartz core and starting materials were loaded into a gold capsule. The capsule was kept heating in a boiling conditions (400-600ºC, 20-50MPa). After several days, the core was sectioned for observation. Fluid inclusions trapping vapor and liquid respectively are simultaneously synthesized. Liquid inclusions, which contain halite daughter crystal, were heated and measured their halite dissolution temperature. These temperatures are compared with NaCl solubility curve and gave salinity of the inclusions. Obtained values were 59.17-59.39 weight % NaCl when experimental condition was 600ºC and 50MPa. It was close agreement with 58.7±1.1wt%, reported by [3]. It means that these inclusions trap liquid completely, and little vapor mixed. Salinity distribution shows that there are little gradient in composition in the capsule.

SXRF analysis and result

Synchrotron X-ray fluorescence (SXRF) spectra were obtained from hypersaline inclusions using the X-ray microprobe beamline BL-4A at the High Energy Accelerator Research Organization (KEK), Tsukuba, Japan. The X-ray microprobe beam at KEK-PF arises from deflection of a 2.5 GeV electron beam around a bending magnet, yielding a white spectrum with a maximum flux at 25 keV. The beamline 4A consists of beam shaping slits, a Kirkpatric-Baez type sagittal focusing system, an ion chamber for monitoring beam current, an X-Y specimen stage, a combined optical microscope and CCD camera observation system, and a solid-state Si(Li) detector (EDS system) ([4] and [5]). Multilayer-coated mirrors were used to collimate the beam, and incident-beam spot size was 4 x 5 µm. Thin section of quartz was hold by masking tape on an acrylic sample holder. EDS spectra were accumulated in a 1024-channel multi-channel analyzer.

Copper and zinc concentrations were measured and distribution of metals was obtained. These results shows that fluid inclusions synthesized in this study are suitable for clarification of behavior of heavy metals in boiling hydrothermal solutions.

In the case of fluid inclusions synthesized in S-free solutions, neither Zn nor Cu was detected in vapor inclusions, and liquid inclusions contain both Zn and Cu at similar concentration levels. While, liquid inclusions contain ~100 ppm Cu and 3,000-4,000 ppm Zn and vapor inclusions contain ~3,000 ppm Cu and ~100 ppm Zn in fluid inclusions synthesized in solutions containing 1.4 to 1.7 mol/kg sulfur. These results suggest that sulfur plays an important role to fractionate Cu into the vapor phase during fluid boiling. Our experimental results support thio-complex model to transport Cu in high temperature vapor phase proposed by Heinrich et al. [1].

References

[1] C. Heinrich et al., Geology 27, 755 (1999)
[2] R. J. Bodnar and S. M. Sterner, in G. C. Ulmer and H. L. Barnes eds. Hydrothermal Experimental Techniques, 423 (1987).
[3] R. J. Bodnar et al., Geochim. Cosmochim. Acta 49, 1861 (1985).
[4] A. Iida, J. Japan. Soc. Synchrotron Rad. Res. 6, 109 (1993).
[5] A. Iida et al., Rev. Sci. Instrum. 66, 1373 (1995).

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