

Chemical analysis of individual fluid inclusion by SXRF: application to hydrothermal ore deposits

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Information on chemical composition of ore-forming fluid is significant when discuss the origin and evolution of ore-forming fluid, dissolution and transportation mechanisms of heavy metals and precipitation mechanisms of ore minerals. Salinity of fluid inclusion has been extensively reported, however data of heavy metals is scarce. Chemical compositions of individual fluid inclusion are measured recently with a development of micro-analytical techniques. Examples of SXRF analysis of individual fluid inclusion are described.

Chemical compositions of ore-forming fluid responsible for vein-type W deposit at the Takatori mine was measured. Four mineralization stages are distinguished at the deposit, such as early wolframite-fluorite-topaz-muscovite-lepidolite, middle sulfide-fluorite, late carbonate-cassiterite and final carbonate-clay mineral stages. Quartz is accompanied in all these stages. Pseudosecondary fluid inclusions hosted in quartz are selected for chemical analyses. Temporal relation of these inclusions is determined from cross-cut nature of trails that accompany fluid inclusions. SXRF analyses suggest compositions of ore-forming fluid as follows. Metal concentrations in early stage fluid are very high as 1400-3700 ppm W, 4100-6200 ppm Fe, 1000-1800 ppm Mn, 1500-3000 ppm Cu and 1800-2900 ppm Zn. Middle to late stage fluids contains 300-600 ppm Fe, 100-300 ppm Mn, 50-100 ppm Cu and 50-100 ppm Zn with less than detection limit of W. Concentrations of ore-forming metals in fluid decreased remarkably with mineralization.

Vapor-liquid partitioning coefficients for Cu and Zn in aqueous fluid were determined under boiling conditions at 500-650 °C and 35-100 MPa in sulfur-bearing and sulfur-free systems. A synthetic fluid inclusion technique was used to sample the experimental system coexisting vapor-rich and liquid-rich fluid inclusions, with the Cu and Zn concentrations in individual fluid inclusions then analyzed by SXRF. The vapor-liquid distribution constant of Cu ($K_D = m_{Cu(vapor)}/m_{Cu(liquid)}$) is found to be strongly dependent on the sulfur content in the experimental solutions. In sulfur-bearing systems, Cu preferentially partitions into the vapor phase, whereas Zn preferentially fractionates into the hypersaline liquid. The K_D values for Cu and Zn obtained in this study correspond well with those obtained from natural fluid inclusions in hydrothermal ore deposits. The results suggest that differential volatility of metals is an important factor affecting the enrichment of certain metals in different hydrothermal ore deposits.

Keywords: fluid inclusion, SXRF, chemical analysis, ore-forming fluid