SIMS microanalysis of pyrite for gold and arsenic concentrations and sulfur isotope ratios

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Microbeam techniques have been increasingly applied to investigate minerals associated with gold deposits. We have determined gold and arsenic concentrations in pyrite grains of ore samples from the Hishikari deposit by secondary ion mass spectrometry (SIMS) and electron probe microanalysis (EPMA). The Hishikari epithermal gold deposit, located in the southern part of Kyushu, is the largest gold deposit in Japan. Most high-grade veins are hosted by Cretaceous basement sedimentary rocks.

Pyrite samples were analyzed by EPMA for Fe, S, As, Cu, Co and Ni. Then we determined Au and As concentrations in the same analyzed area of pyrite by SIMS. A defocused Cs^{+} primary beam was restricted to 15 um in diameter by a circular aperture to obtain a homogeneous primary beam of about 0.1 nA. Negative secondary ions of Au^{-} were detected using a total impact energy of 20 kV. A square field aperture of 300 um by 300 um was introduced into the secondary ion optics, limiting the analyzed area of the sample surface to a central square measuring 3 um by 3 um. No energy filtering was used since isobaric interference on ^{197}Au from $^{133}Cs^{32}S_2$ was eliminated by a high mass resolving power of 3300.

Microanalyses of arsenian pyrite from the Hishikari gold deposit by SIMS revealed that gold concentrations of 0.1 to 2600 ppm are positively correlated with arsenic concentrations on a um scale. Depth profiles that show precise depth variations in Au and As are the most splendid feature of SIMS measurements. Samples analyzed are from the Honko, Sanjin, and Yamada ore zones, which have general characteristics in gold-arsenic relationship though they locally differ in veins and depths. The high Au/As ratios are found in the Sanjin and Honko ore zones that occur in the basement sedimentary rocks, while the low ratios are found in the Yamada ore zone that occurs in the overlying andesitic rocks. Au concentrations generally correlate with As concentrations of arsenian pyrite, but arsenian pyrite does not always show high Au values. It is apparent that the As-rich ore fluids are not invariably gold-bearing. The Au variation in SIMS depth profiles does not suggest a constraint in the crystal structural coordination.

Sulfur isotopic studies on ore deposits are useful to investigate the genesis of hydrothermal fluids. Sulfur isotope ratios are measured on the same analyzed area of the SIMS gold analysis using two Faraday cups of the SIMS multi-collection system. Although a sulfur isotope ratio has no simple correlation with gold and arsenic concentrations, it seems to change in accordance with the ore fluid evolution. Thus it is deduced that sulfur isotope ratios with Au and As concentrations on a um scale may give a convincing argument for the genesis of the high-grade gold deposit.