Spatial variation of the $\delta^{18}O$ and δD isotopic signatures of ore-forming fluids within a Au-bearing vein in the Hishikari deposits, Kagoshima, Japan

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Serial sampling at close distances of about 2.4 meters interval was conducted for the Hosen 8-2 vein at -5 ML in the Hishikari deposits. The horizontal length of the section of the vein studied is about 68 m. The main gangue minerals observed include quartz and adularia with minor calcite, as well as clay minerals (smectite and chlorite-smectite) occurring as minor or trace amounts in some samples. The dominant ore mineral is electrum with occasional galena, sphalerite, pyrite, chalcopyrite, and hessite. The Au grades of bulk samples range from 0.14 to 10809 ppm, with most of the high Au-grade ores (>1,000 ppm) located at the center part of the vein.

The spatial variation of $\delta^{18}O$ of quartz (n = 41), adularia (n = 8), and smectite, chlorite, illite, and chlorite-smectite mixed layer (n = 8), as well as the δD values of smectite, chlorite, illite, and chlorite-smectite mixed layer (n = 8) were systematically analyzed in relation to Au grade. Additionally, fluid inclusion microthermometry was also conducted for all samples with fluid inclusions suitable for observation to calculate the $\delta^{18}O$ of H_2O of the ore-forming fluids. Results show that the modes of homogenization temperatures range from 160 to 240 ˚C, with most samples having the mode of 200 –210 ˚C. The average salinities fall within a narrow range from 2.3 to 3.9 wt. % NaCl eq., with an average of 3.0 wt.% NaCl eq. The $\delta^{18}O$ values of quartz and adularia relative to Vienna Standard Mean Ocean Water (VSMOW) do not vary significantly. The $\delta^{18}O$ of quartz ranges from +6.3 to +9.2 ‰with an average of +7.5 ‰while the $\delta^{18}O$ of adularia ranges from +4.6 to +9.1 ‰with an average of +5.9 ‰. On the other hand, the calculated $\delta^{18}O$ of H_2O of the ore-forming fluids from the early adularia ($\delta^{18}O_{water}$ = -3.7 to +1.2 ‰, average = -2.2 ‰) is slightly higher than that from the later quartz ($\delta^{18}O_{water}$ = -6.8 to -0.8 ‰, average = -3.7 ‰), which suggests a decrease in $\delta^{18}O$ as mineralization progresses, possibly due to the dilution effect of mixing with ^{18}O-depleted meteoric water (e.g. Matsuhisa and Aoki, 1994). The range of $\delta^{18}O$ and δD of H_2O calculated from mixed smectite, chlorite-smectite, and illite in the altered host rock ($\delta^{18}O_{water}$ = +3.6 to +8.9 ‰, δD_{water} = -77 to -62 ‰) are higher than those from smectite and chlorite-smectite in the vein ($\delta^{18}O_{water}$ = +1.3 to +8.5 ‰, δD_{water} = -132 to -92.5 ‰). This may have been due to varying contributions from local meteoric waters (^{18}O-depleted and D-enriched), meteoric waters that reacted with the ^{18}O-enriched and D-depleted sedimentary basement rocks, and contributions from primary magmatic waters (^{18}O- and D-enriched). Another possibility is the lower temperature in hydrothermal alteration than that of vein formation.

Statistical analysis showed that the calculated $\delta^{18}O$ of H_2O of the ore-forming fluids from quartz, adularia, and clay minerals have a positive relationship with Au grade. This is also supported by the distribution of higher $\delta^{18}O$ values (> -2.0 ‰) of the waters located at the high Au-grade zone (> 1,000 ppm) at the center part of the vein. The relatively higher δD values of H_2O (> -110 ‰) were also found in the high Au-grade zone.

References

Matsuhisa, Y. and Aoki, M. (1994) Temperature and oxygen isotope variations during formation of the

Hishikari epithermal gold-silver veins, southern Kyushu, Japan. Economic Geology, 89, 1608-1613.

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