Mixing of meteoric water and thermal water inferred from helium isotopes and its application to groundwater residence time

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Helium isotope and concentration in groundwater are used for estimating the groundwater age and flow dynamics. The dating of groundwater using ^{4}He concentration, however, has generally not been successful because of the uncertainty of the He flux from the continental crust and/or groundwater mixing.

In this work, we investigate the mixing of groundwater in the light of helium isotopes and geological settings. As a case study for this objective, we have undertaken helium and stable isotopic study for groundwater from Kobe-Hanshin area. The Kobe-Hanshin area is one of the sedimentary basins in southwest Japan overlaid with deep-seated Quaternary sediments and accompanying many faults. This area has unique characteristics of well out high-temperature and -chlorine thermal water in spite of non-volcanic region (Arima Spa). Arima Spa has also unusual characteristic in point of high ^{3}He/^{4}He ratio up to $1x10^{-5}$ and large hydrogen and oxygen isotopic shifts from meteoric line in this region.

Hydrogen and oxygen isotope ratios indicate that all samples except one we collected in this study show no significant incorporation of Arima-type thermal water. Helium isotope signature gives different information. Several samples from deep well show high ^{3}He/^{4}He ratios ($3.6\text{-}7.7 \times 10^{-6}$) relative to the air-saturated water but is significantly less than that of Arima Spa. The sample, shifted towards hydrogen and oxygen isotopes of Arima type thermal water, has similar high ^{3}He/^{4}He ratio. These observations indicate that many of groundwaters from the deep well in this region contain small or no amount of Arima type thermal water but significant incorporation of helium. Observed ^{3}He/^{4}He ratio reflects the flux of helium originated from Arima type thermal water and groundwater residence time because radiogenic He concentration in groundwater increases with increasing groundwater residence time.

Apatite-rich layer in the Finero phlogopite-peridotite massif: metasomatism and its timing

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The Finero phlogopite-peridotite massif in the western Italian Alps is famous for highly metasomatised mantle peridotites (e.g., Zanetti et al., 1999). We recently found an apatite concentration (up to 10 modal % locally) in a thin fine-grained layer (< 1 cm in thickness) from the massif. The thin layer is divided into two parts; apatite-rich and apaptite-poor. Apatite-rich part is richer in amphibole and carbonate minerals than apatite-poor part, suggesting that an alkali- and phosphate-rich carbonatitic metasomatising agent locally existed and involved in formation of the thin layer. On the other hand, film-shaped tiny orthopyroxenes, which are low in Al_2O_3, Cr_2O_3 and CaO contents, occur at grain boundaries of olivine in the thin layer, suggesting a silica-rich metsomatising agent was also involved. These two distinctive metasomatising agents were caused by the immiscibility of a silica-rich metasomatising agent which had been already evolved from an parent metasomatising agent to be high in CO_2/H_2O due to interactions with host peridotite.

The age of the metasomatism in the phlogopite peridotite is at present controversial. An in-situ ion microprobe U-Th-Pb dating of apatite using the sensitive high-resolution ion microprobe (SHRIMP) at Hiroshima University (Sano et al., 1999) was applied for the studied rock. Thirteen spot analyses on small apatite grains indicate a Tera-Wasserburg concordia (Sano et al., 2000) constrained linear three-dimensional isochron age of 215 ± 35 Ma in the ^{238}U/^{206}Pb-^{207}Pb/^{206}Pb-^{204}Pb/^{206}Pb diagram. Preservation of chemical heterogeneity of orthopyroxene indicates that the interaction between peridotites and the two distinctive metasomatising agents was quenched by continuous decreasing of temperature. This age is, therefore, interpreted as representing both the metasomatism and cooling of the Finero massif.

References

Sano Y., Oyama T., Terada K. and Hidaka H. (1999). Chem. Geol., **153,** 249-258.

Sano Y., Terada K., Takkeno S., Taylor L. A. and McSween H. Y. (2000), Meteo. Planet. Sci., **35,** 341-346.

Zanetti A., Mazzucchelli M., Rivalenti G. and Vannucci R. (1999). Contrib. Mineral. Petrol., **134,** 107-122.