有馬型温泉水を含めた温泉水の起源と地殻内上昇過程の制約

Compositional variations of the Arima-type and associated spring waters in the Kinki district, southwest Japan: Implications for origin and upwelling process of deep brine

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Rare earth elements (REEs) of the spring waters upwelling in the non-volcanic fore-arc region of the Kinki district in southwest Japan have been investigated to assess their upwelling processes and deep-seated origins [Nakamura et al., 2014; 2015]. In this study, a principal component analysis of the REE data has identified three principal components (PCs) that cover 89% of the entire sample variance: (1) PC-01, which corresponds to a dilution process by which fluids are introduced at low concentrations, previously represented by major solute binary trends, including $\delta^{18}O$–δD systematics; (2) PC-02, which is a precipitation process of REEs from the brine; and (3) PC-03, which is an incorporation of REEs from country rock by carbonic acidity, although the types of country rocks may also have a significant impact on the spring water compositions. Based on these three PCs, together with the major solute concentrations and hydrogen, oxygen, and helium isotopic compositions determined in previous studies, five distinct types of spring waters in the Arima and Kii areas have been identified: (i) “Tansansen”, (ii) “Kinsen”, (iii) “Ordinary Arima”, (iv) “Ginsen”, and (v) “Eastern Kii”. These five types probably represent (ii) a deep brine, (iii) an evolved deep brine that precipitated REE-bearing minerals, (iv) a mixture of (iii) and meteoric water, (v) a meteoric water carbonated by deep gas derived from (ii), and (i) a spring water similar to (v) with a more significant influence of the country rock constituting the aquifer.
A comparison of the spring waters in the Arima and Kii areas revealed a systematic geographic distribution. The “Ordinary Arima”-type occurs along the Median Tectonic Line, and the “Eastern Kii”-type occurs in the eastern part of the Kii area. The latter seems to upwell in the restricted region where deep low-frequency tremors are observed. We suggest that the geographical distributions are linked to the tectonic setting and/or temporal evolution of fluid upwelling.

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