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# Rare Earth Elements as Hydrologic Tracers in water from Tatun Volcanoes, Taiwan

Yu-Shao Lai and Hsueh-yu Lu
National Chung-cheng University,Taiwan

The geochemical properties of hydrothermal waters are generally characterized by the water-rock interaction due to high water temperature. Therefore, the hydrochemical evolution through flow path can be an excellent indicator for hydrologic research. Generally, the evolution of major components in waters is complicated by multiple sources and considerable mass transfer due to mineral precipitation/dissolution. On the contrary, trace elements are dissolved into waters from specific minerals and are generally modified by limited geochemical processes. In this study, rare earth elements (REEs) are applied as the natural tracers to depict the hydrologic system of Tatung Volcano, Taiwan. Tatung Volcano is not active since late Pleistocene but the post-volcanic activities, such as hot spring and sulfur gas, still widespread around the volcano province. Huanghsi River is the main watershed system in Tatung Volcano. According to the results of ICP-MS analysis, the stream water shows considerable abundance of REE. The normalized REE pattern is slightly depleted in light REEs (LREE) and becomes flat for heavy REEs (HREE). In addition, the pattern is very similar to those of local andesites in the watershed. These results demonstrate that REEs in Huanghsi River and hot springs inherit from local andesites due to water-rock interaction. Because the water samples with high abundance of REEs are all located in the upstream area, it is plausible that Huanghsi River is recharged with low-REE water along the main channel. Once the river leaves the mountain area, the abundances of REEs in the river keep roughly constant around 3.64 ppb, which means that there is no considerable recharge in the plain area. Heavy REEs show no or only very weak fractionation and are utilized to calculate the amount of recharge with two-end-member system of REEs. The results demonstrate that the ratio of precipitation with low REE to hot spring with high REE is about 1.43 in the upstream area and gets lower to 0.52 at the point where river leaves the mountain area. The calculated recharge ratios can also be confirmed by the PHREEQC geochemical modeling. These results demonstrate that the trace elements in waters can be used as natural tracers.