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Geochemical Constraints on the Origins of the Deep Groundwaters Beneath Danshuei at NW Taipei, Taiwan

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Groundwaters at depths of > 1 km are commonly characterized by temperature > 40 degree, depending on geothermal gradient. Their high temperature nature mimics that of hot springs. In recent 5 years, they have been discharged from several community sites in metropolitan Taipei for commercial values. However, the chemical properties of these deep groundwaters have not been investigated. Here, we report major ion abundances and isotope ratios of oxygen (δ18O), hydrogen (δD), and Sr (87Sr/86Sr) for the > 1 km deep groundwaters from Danshuei at NW of the Taipei city to constrain their origins.
The Cl contents in the groundwater samples vary in a large range of 35.7-179 mmol/L with Na/Cl ratio > 1, reflecting contribution from wall-rocks to the Na budget in these groundwaters. If seawater is the only source for Cl, the groundwater samples are mixtures of 6.5–32.9% seawater and 93.5–67.1% meteoric water. In addition, the Danshuei samples deviate from the δ18O–δD meteoric water line (MWL) to higher δ18O values, typical of interaction with wall-rocks. The inverse 1/Sr–87Sr/86Sr correlation of the groundwater samples strengthens the inferences of interaction with wall-rocks and involvement of seawater. Specifically, the high 87Sr/86Sr end of the 1/Sr–87Sr/86Sr trend extends to the 87Sr/86Sr value and Sr concentration of seawater, arguing unambiguously for modern seawater as a mixing end-member. The low 87Sr/86Sr end-member can be modeled as meteoric water incorporating sub-equal proportions of andesitic and sedimentary wall-rocks, consistent with inference from the 1/Sr–87Sr/86Sr correlation of the shallow ($\sim$10 m) groundwater samples. Calculated from the 1/Sr–87Sr/86Sr systematic, the seawater proportion in the hybrid water mass ranges in 10–30%, supporting the estimates from Cl content. The inverse 1/Sr–87Sr/86Sr correlation requires seawater intrusion occurring after meteoric water interacted with wall-rocks. Based on this evolution model, the δ18O and δD values of the meteoric water components are modeled in the ranges respectively of -8 – -6‰ and -35 – -55‰ largely overlapping with that of the shallow groundwaters and meteoric water in this region. The diverse ranges of the δ18O and δD values for the meteoric water components imply isolated water masses for individual deep groundwater sites, in which the meteoric water components have experienced similar extents of interaction with wall rocks as indicated by the 1/Sr–87Sr/86Sr systematic. The timing of seawater intrusion and the duration of meteoric water-wall rock interaction, however, remain to be resolved.
In conclusion, variations in Na and Cl contents and δ18O, δD, and 87Sr/86Sr values of the Danshuei deep groundwaters indicate involvement of seawater and meteoric components. In addition, these groundwater masses are isolated from each other. Continuous discharging may result in changes in the relative proportions of seawater and meteoric water components. Therefore, it is proposed that long-term monitoring the chemical features of the Danshuei deep groundwaters can provide insights into the recharging pattern and form a basis for predicting the consequences of over-discharging these deep groundwaters.