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Inverse geochemical modeling of groundwater evolution in a granitic Island: a case study from Kinmen Island, Taiwan

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Kinmen is a granitic island covering 150 km2 and lies approximately 200 km from the western coast of Taiwan. Due to the high annual evaporation (∼1661 mm) and low annual precipitation (∼1072 mm), the surface water resources are not able to provide a stable water supply for daily usage of residents and agricultural irrigation. Moreover, the unconsolidated sediment layer is as thin as a few meters and has been seriously overpumped for decades. The groundwater level decreased about 24 cm during the last two years. It is very essential to explore other alternative water resources; and the voluminous granitic rocks have the most potential. Although granitic rocks have lower permeability, the aquifers were recharged with fast infiltration rate through highly fractured zones. The fast infiltration rate in Kinmen Island is demonstrated by the consistency between groundwater stable isotopes and Taiwan's local winter meteoric waterline. It also suggests that the groundwater in granitic aquifer is principally infiltrated in the winter time.

According to the in-situ geochemical well logging, the highly fractured zones were firstly identified in granitic aquifers and ten groundwater samples were collected for the subsequent geochemical analyses. Some samples show very high sulfate content, which may be caused by water-rock interaction during infiltration. The results of factor analysis provide four major factors. The first two factors can be interpreted as seawater salinization but Na and Cl are belong to two different factors. It is mainly caused by additional source of Na from water-rock interaction. In this study, inverse geochemical modeling (NetpathXL) is utilized to evaluate the effect of water-rock interaction on groundwater geochemical evolution. The results show that the water-rock interaction includes three major geochemical processes: (1) gypsum dissolution, (2) albite decomposition into kaolinite and (3) calcite precipitation. In addition, there is no model obtained if pyrite was assumed to be the unique phase to balance the sulfate contents along the flow path. Therefore, gypsum in the top sedimentary aquifer is the major source of sulfate. The inverse geochemical modeling also confirms that albite weathering is the additional source of Na to separate Na and Cl into two factors in factor analysis.