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Long-Term Behavior of Magnesium and Stable Strontium Isotopes in Coastal Aquifers

ANAEL COHEN[1], YAEL KIRO[2] AND NETTA SHALEV[3]

[1]Weizmann Institute of Science, Israel

[2]Lamont-Doherty Earth Observatory, Columbia University

[3]The Hebrew University, Edmond J. Safra Campus - Givat Ram Jerusalem

Presenting Author: anael.cohen@weizmann.ac.il

Groundwater-derived solute and isotope fluxes to the ocean have been shown in recent decades as significant contributors to ocean chemistry. The chemical composition of coastal aquifer groundwaters is affected by mixing between fresh and saline water bodies and by water-rock interactions. The latter also depends on the residence time of the intruding seawater and its flow paths. This study delves into the chemical dynamics of a carbonate-rich silicate aquifer at the Nitzanim Nature Reserve in Israel, unraveling the behavior of magnesium and stable strontium isotopes in the context of groundwater flow and water-rock interactions.

Calcium, potassium, sodium, and strontium concentrations exhibit non-conservative behavior, while magnesium is conservative. The enrichment and depletion seen in the major elements are gradual demonstrating an increase in the enrichment/depletion magnitude along the flow path from the sea into the aquifer. Calculation of the degree of saturation of calcium carbonate, and calculation of the enrichment/depletion of calcium, sodium, and potassium, suggest that the main water-rock interaction processes affecting the major elements are ion exchange and some precipitation of calcium carbonate as the calcium addition increasing the degree of saturation of calcium carbonate. The study employs stable strontium isotopes to deepen our understanding of geochemical processes between water and sediment, thereby enhancing insights into coastal aquifer dynamics. Despite the conservative behavior of magnesium, our $\delta 26$Mg data (ranging from -1.46 to -0.82‰) reveals depletion compared to the conservative mixing line, implying isotope exchange during equilibrium. The $\delta 26$Mg becomes more negative along the saltwater flow path from the sea into the aquifer over a period of around 300 years. A preliminary estimate of the contribution of long-term circulated submarine groundwater discharge to the magnesium isotope budget shows fluxes (-2 Tmol yr-1 · ‰), comparable to rivers (-1.4 Tmol yr-1 · ‰).