

Magnesium isotopes behavior in coastal aquifers

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Although it has long been assumed that groundwater-derived solute and isotope fluxes to the ocean are static and subordinate to riverine fluxes, it has recently been shown that they do play a significant role in ocean chemistry. The chemical composition of these coastal aquifer groundwaters is affected by mixing between fresh and saline water bodies and by water-rock interactions. The latter also depend on the residence time of the intruding seawater and its flow paths. This study attempts to determine the behavior of magnesium isotopes in the context of groundwater flow and water-rock interaction time-scales using a carbonate-rich silicate aquifer at the Nitzanim Nature Reserve in Israel. Calcium, potassium, sodium and strontium concentrations in the groundwater typically show a non-conservative behavior, while magnesium is usually conservative.

Our $\delta^{26}\text{Mg}$ data (which ranges from -1.46 to -0.82‰) is mostly depleted compared to the conservative mixing line. It shows values similar to seawater near the coast, becoming more negative away from the shoreline along the salt water flow path from the sea into the aquifer.

In order to estimate the contribution of the long-term circulated SGD to the isotopic budget of magnesium in the ocean, we used an estimated volumetric flux of $600 \text{ km}^3 \text{ yr}^{-1}$ (estimated independently on groundwater flow models and ocean budgets) and the average magnesium concentration of seawater (47mM) to get the magnesium flux of long-term circulated SGD. Next, we multiplied the magnesium flux of the different sources (5.5 Tmol yr^{-1} for rivers and $28.2 \text{ Tmol yr}^{-1}$ for long-term circulated SGD) by the difference between the isotopic composition of each source (-1.09‰ for rivers and -0.9‰ for long-term circulated SGD) and the isotopic composition of sea water (-0.83‰). The resulting contribution of long-term circulated SGD ($-2 \text{ Tmol yr}^{-1} \cdot \text{‰}$) to the magnesium isotope budget is at the same order of magnitude as rivers ($-1.4 \text{ Tmol yr}^{-1} \cdot \text{‰}$). Thus, our study demonstrates the importance of water rock interaction and residence time in the coastal aquifers in determining the isotopic composition of terrestrially-derived solute fluxes to the ocean.