

Identification of sources of nitrate in the coastal aquifer of Israel: New insights from nitrogen and oxygen isotope measurements

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Nitrate pollution is a major environmental problem in the Mediterranean coastal aquifer of Israel. Concentrations and isotope compositions of nitrate were determined in order to delineate its sources. We collected and analyzed 97 groundwater samples from ten nitrate plumes (>85 mg/l) in different parts of the aquifer. $\delta^{15}\text{N}_{\text{NO}_3}$ ranged from +3‰ to +16‰ (mean = +6.8‰) and $\delta^{18}\text{O}_{\text{NO}_3}$ values varied from -8‰ to +10‰ (mean = +1.9‰). High $\delta^{15}\text{N}_{\text{NO}_3}$ values (>8‰) are attributed to sewage pollution. We found a positive relationship between the dissolved HCO_3^- concentrations and $\delta^{15}\text{N}_{\text{NO}_3}$ values, implying degradation of organic matter derived from a sewage source. However, most of the nitrate contaminated groundwater had $\delta^{15}\text{N}_{\text{NO}_3}$ values between +3‰ to +8‰. This range suggests that the nitrate pollution can be derived by either mineralization or subsequent nitrification of soil organic nitrogen induced by cultivation or from application of synthetic fertilizers over the aquifer. The relatively low $\delta^{15}\text{N}$ values of synthetic fertilizers (typically 0-2‰) can be modified by isotopic fractionation induced during ammonia volatilization followed by nitrification in the unsaturated zone. The nitrogen and oxygen isotopic data show that nitrate in most of the contaminated groundwater is presumably derived from mineralization and nitrification of soil organic nitrogen and/or from synthetic fertilizers application. It appears that sewage pollution and/or irrigation with treated wastewater have only a minor impact on the overall on the current nitrate problem in the Israeli coastal aquifer.

Microbial precipitation of dolomite in groundwater

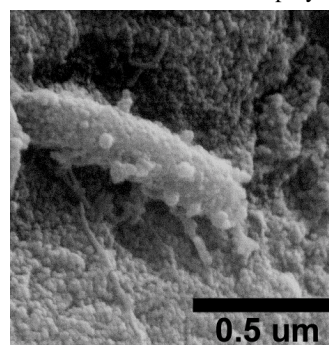
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Despite prevalence of dolomite in the rock record, formation of dolomite in the lab under low temperature, earth-surface conditions is difficult at best, and is the subject of many investigations. A link between dolomite formation and microbial processes such as sulfate reduction has long been suspected based on geochemical evidence and the only laboratory synthesis of dolomite was associated with microbial sulfate reduction (Vasconcelos et al., 1995; Warthmann et al., 2000) in high sulfate saline systems.

Biomining by bacteria has also been documented in a wide range of environments and is now recognized as a fundamental geologic process, with bacteria precipitating sulfides, phosphates, oxyhydroxides, clays, and carbonates (Ghiorse and Ehrlich, 1992). In some cases microbial metabolism drives precipitation by changing bulk water chemistry. Microbes can also precipitate minerals by concentrating metals and nucleating crystals on their cell membranes and associated exopolysaccharides.



We report here on freshwater nucleation and precipitation of dolomite directly influenced by microorganisms. This process was observed in field studies and confirmed in controlled laboratory experiments.

Geochemical and microscopic data indicate that well-ordered dolomite forms on microbial cell walls under methanogenic conditions (Figure 1).

Unlike other modern examples of low temperature dolomite formation, this dolomite is precipitating from solutions that are close to equilibrium with respect to dolomite and have relatively low Mg/Ca ratios (<1).

References

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