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Hydrochemical effects of saltwater intrusion in a limestone and dolomitic limestone aquifer in Lebanon

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Abstract

This study demonstrates groundwater quality differences between a limestone and a dolomitic limestone, (sub)oxic coastal aquifer in the Eastern Mediterranean (Lebanon), with and without ongoing moderate salinization since the last decades. For this purpose, 8 major and 50 trace elements (TEs) were analyzed in 80 water and 65 rock samples, and interpreted with a quad-fold approach utilizing: (1) nonparametric statistical tests, (2) concentration deviations from ideal conservative freshwater–seawater mixing lines, (3) a new parameter called Mixing Enrichment Factor to assess the mobility of chemical constituents under salinizing conditions, and (4) 1-D dual porosity flow path modeling with PHREEQC. Dissolution/precipitation of $Ca_xMg_ySr_zCO_3$ and cation exchange were the main disclosed hydrogeochemical processes besides minor signs of organic matter oxidation. In the dolomitic limestone aquifer, less carbonate dissolved as compared to the limestone aquifer, partly because of lower pCO_2 in addition to seawater inflow triggering Mg-calcite precipitation by cation exchange. Saltwater intrusion led to mobilization of As, Ba, Cu, Ni, Rb, Sr and U in both aquifers, sometimes likely by cation exchange (e.g. Ba and Sr). Some of these TEs (notably Cu and Ni) recorded higher concentrations in the dolomitic limestone regardless of salinization. Other elements like Al, Be, Ce, Cr, Nb, Pb, V, Y and Zr revealed no or a low mobilization tendency. The concentration of all TEs in groundwater remained below drinking water limits notwithstanding moderate salinization. This classifies carbonate rocks as a weak geogenic source of TEs, whereas encroaching seawater appears to be a more important source.

Keywords (dolomitic) limestone aquifer; hydro(geo)chemistry; trace elements; reactive transport model; Lebanon.

1 Introduction

Coastal aquifers are known for their complex hydrochemical nature due to (1) different inputs from precipitation, infiltrating rivers, intruding seawater, irrigation return flow, and wastewater infiltration