

# Characterising water-rock interaction in a mixed carbonate-evaporite karstified aquifer system, Qatar

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Qatar is an arid country, most of the rainfall (80 mm/yr) occurring during intense storms. Surface runoff is endorheic and recharge is facilitated by karst features developed over an extended (c.30 Ma) period of exposure of the carbonate bedrock. In December 2016, we sampled a rare intense rainfall event (41 mm over 3 days), after which waters ponded within low-relief terminal depressions prior to infiltration. We compare the chemistry of these recharge waters with that of ground waters from 76 wells distributed across Qatar to understand the nature and spatial distribution of water-rock interaction. Using  $\text{Cl}^-$  as a conservative tracer for seawater mixing, we calculate concentrations of rock-derived  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{SO}_4^{2-}$ .

During surface detention, rain chemistry is modified by evaporation and interaction with clays and the surface bedrock over days to weeks. However, groundwater chemistry is dominated by subsurface interaction between recharge waters and the karstified Tertiary aquifers. These include the largely dolomitic Paleocene to Lower Eocene Umm er Radhuma (UER) and overlying Lower Eocene Rus, with the Middle Eocene Abarug limestone forming a locally important aquifer in the south west. Away from coastal areas which show clear evidence of salinisation, TDS of groundwaters in the interior of the peninsula increases from north to south. All groundwaters are significantly enriched in  $\text{SO}_4^{2-}$ , but this enrichment is marked greater in the south. This likely reflects the presence of a unit of middle Rus gypsum that in the south of the country confines the Lower Rus and UER aquifers, whilst in the north either gypsum was not deposited or has been dissolved. Waters in the Abarug limestone show limited sulfate enrichment and a 1:1 molar ratio of rock-derived  $\text{SO}_4^{2-}:\text{Ca}^{2+}$ , but across much of the country both  $\text{SO}_4^{2-}$  enrichment and  $\text{SO}_4^{2-}:\text{Ca}^{2+}$  molar ratio are significantly higher, the latter reaching 2:1 and suggesting an additional sink for  $\text{Ca}^{2+}$ . The dolomite aquifer waters are also enriched in  $\text{Mg}^{2+}$ , indicating replacement of dolomite by calcite (dedolomitization), driven by the release of  $\text{Ca}^{2+}$  from gypsum dissolution. Whilst current rates of gypsum dissolution and dedolomitization may be limited by the arid climate, this process is likely to have been more active during pluvial periods and to have played a role in karst development.

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