Geophysical Research Abstracts
Vol. 20, EGU2018-14995, 2018
EGU General Assembly 2018

A multi-tracer study to estimate groundwater ages and upwelling of saline groundwater along conductive normal faults in a carbonate aquifer

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Existing modeling studies of evaporite dissolution showed that conductive subvertical fault zones within carbonates and evaporites may play an important role for both the access of subsaturated groundwater to vulnerable rock salt formations and the transport of the resulting highly saline groundwater into regional aquifers. As a consequence, the intrastratal rock salt karst preferentially develops closer to conductive fault zones. Highest surface subsidence rates are expected above normal fault zones. However, mapping and hydraulic characterization of subsurface fault zones is often not possible due to the lack of sensitive data.

The presented multi-tracer study in a regional Middle Triassic aquifer in Northwestern Switzerland aims at delineating areas, where upwelling of saline waters suggests the presence of conductive subsurface fault zones. Estimation of groundwater ages were used to give insight on the temporal evolution of the dissolution process, and to provide a more general understanding of groundwater dynamics within the regional aquifer. A total of 60 groundwater wells reaching depths between 10m and 270m were sampled for physico–chemical parameters, hydrochemistry (major ions and trace elements), and water isotopes (^{18}O, ^{2}H, ^{3}H, ^{13}C,^{14}C, ^{34}S, ^{87}Sr/^{86}Sr). Methods for groundwater age determination found that large parts of the aquifer have been subjected to mixing between very recently infiltrated rainwater, infiltration of the nearby river Rhine, or artificial recharge of Rhine water, and older Holocene, or Pleistocene groundwater (>10'000 years). Natural occurring mixing is been accelerated by intensive anthropogenic influence of the groundwater flow field due to a past river dam construction, large-scale groundwater pumping, and artificial groundwater recharge. Data of δ^{34}S composition together with SO_4^{2-} concentration were used to distinguish between influences of gypsum/anhydrites aquitards lying either above, or below the regional carbonate aquifer. The combined mapping of the sampled chloride concentrations indicated an area in the central part of the aquifer, where upwelling of highly saline groundwater is more likely to occur.