Geophysical Research Abstracts
Vol. 15, EGU2013-13095, 2013
EGU General Assembly 2013

Effects of fault structures on evaporite dissolution

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Uncontrolled subsurface dissolution of evaporites can lead to hazards such as land subsidence. Observed subsidences in a study area of Northwestern Switzerland were mainly due to subsurface dissolution of halite and gypsum.
A set of density-driven flow simulations were conducted to study the effect of the different unknown subsurface parameters on the dissolution process. The study site is represented by an approximately 1000m long, and 200m deep 2D field scale model, which corresponds to a setup of two aquifers connected by subvertical normal fault zones. The mixed finite element method is used to solve the flow equation, coupled with the multipoint flux approximation and the discontinuous Galerkin method to solve the diffusion and the advection parts of the transport equation. Specific concern is given to the heterogeneity of normal fault zones and its role on the dissolution of evaporites. Different fault zones with increased hydraulic conductivity and fault widths ranging from 0.5m to 40m were evaluated. Results show that larger fault thicknesses induce smaller flow velocities, which, theoretically, lead to less salt dissolution. Larger fault zones, however, allow for larger amounts of freshwater to access the salt top. The resulting increase of concentration gradient between the saturated salt top and the subsaturated groundwater accelerates the dissolution process.
Major faults causing significant displacement of sediments typically consist of sets of smaller faults, which can be grouped into one larger fault zone. In order to account for a more realistic approach of heterogeneity within the 40m wide fault zone, the zone is divided into 2, 3 and 6 faults with different combinations of fault widths. Despite that the hydraulically active width of the fault is reduced when the faults number is increased, a substantial increase of dissolved mass is observed when increasing the number of faults. This difference in mass is due to the fact that steady state flow conditions require more time to establish in the case of six thin faults compared to the model with one single wide fault. The presence of conductive vertical zones in a variety of geological settings combined with the typical uncertainty related to the hydraulic characteristics of fractured fault zones suggests that faults play an important role for the dissolution process of evaporites and resulting density-driven transport of solutes.