Geophysical Research Abstracts
Vol. 18, EGU2016-9107, 2016
EGU General Assembly 2016

Early warning of freshwater salinization due to upward brine displacement by species transport simulations combined with a hydrochemical genesis model

Maria Langer and Michael Kühn

GFZ German Research Centre for Geosciences, Section 3.4 - Fluid Systems Modelling, Potsdam, Germany (mkuehn@gfz-potsdam.de)

Shallow groundwater resources could be possibly affected by intruding brines, which are displaced along hydraulically conductive faults as result of subsurface activities like CO_2 injection. To avoid salinization of potable freshwater aquifers an early detection of intruding saline water is necessary, especially in regions where an initial geogenic salinization already exists. Our study is based on work of Tillner et al. [1] and Langer et al. [2] who investigated the influence of permeable fault systems on brine displacement for the prospective storage site Beeskow-Birkholz in the Northeast German Basin. With a 3D regional scale model considering the deep groundwater system, they demonstrated that the existence of hydraulically conductive faults is not necessarily an exclusion criterion for potential injection sites, because salinization of shallower aquifers strongly depends on the effective damage zone volume, the initial salinity distribution and overlying reservoirs [2], while permeability of fault zones does not influence salinization of shallower aquifers significantly [1].
Here we extracted a 2D cross section regarding the upper 220 m of the study area mainly represented by shallow freshwater aquifers, but also considering an initial geogenic salinization [3]. We took flow rates of the intruding brines from the previous studies [2] and implemented species transport simulations with the program code SHEMAT [4]. Results are investigated and interpreted with the hydrochemical genesis model GEBAH [5] which has been already applied as early warning of saltwater intrusions into freshwater aquifers and surface water [6]. GEBAH allows a categorization of groundwater by the ion ratios of the dissolved components and offers a first indicative determination for an existence and the intensity of saline water intrusion in shallow groundwater aquifer, independent of the concentration of the solution. With our model we investigated the migration of saline water through a fault or an erosional channel which both allows an exchange between the shallow freshwater and the deeper saline water complex. The salinization potential of a drinking water well in vicinity to the brine source was determined for different scenarios.

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