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Salinization processes of continental aquifers during marine transgression

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Saline fluids with moderate concentrations have been sampled in basement aquifers at the regional scale in the Armorican shield (northwestern France). The horizontal and vertical distributions of high chloride concentrations (60-1400mg/L) are in good agreement with altitudinal and spatial limits of three major marine transgressions between the Mio-Pliocene and Pleistocene ages. The current distribution of fresh and "saline" groundwater at depth is the result mostly of processes occurring at geological timescales - seawater intrusion processes followed by fresh groundwater flushing -, and slightly of recent anthropogenic activities. In this abstract, we focus on seawater intrusion mechanisms in continental aquifers to investigate how saline fluids are irreversibly introduced into aquifers after a full transgression cycle. We first show that most of salt water that remains after the end of a marine transgression comes from a destabilization of the salt water wedge. This mainly occurs by gravity instabilities, which develop from salinized rivers or estuaries that penetrate inland on top of fresh groundwater. This downward diapirism is an efficient mechanism to feed deep aquifers with highly saline water at relatively high rates. Series of numerical model (time-dependent, variable-density flow and transport) of free convection have been performed with a permeability model typical of the continental crust (i.e. exponentially decreasing with depth). Salinization has been quantified according to the width of the stream, the properties of the initial perturbation (amplitude and wavelength), the stream salinity and the regional groundwater flow. Simulations allow us to identify the conditions necessary to develop gravity instabilities, and if it does, the rates at which basement aquifers are salinized. We then identify the continental zones, where these conditions are fulfilled and make an estimate of the total volume of salt that can remain in aquifers after a transgression. Eventually we discuss how saline fluids are flushed out by fresh groundwater flows.