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Fluid circulation within a volcanotectonic system inferred from numerical hydrothermal modelling: application to the Ghoubbet-Asal Rift (Djibouti, East Africa).

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Asal Rift (Republic of Djibouti, East Africa) represents the westward propagation of the Aden ridge within the Afar depression. It is a typical accretion center, with the Fieale volcano at the center of two extensional systems, the oceanic Ghoubbet Strait to the East and the Asal Lake (at 155 meters below sea level) to the West.
The Asal Rift is an active system submitted to a relative insurrection of its northern part (Doubre et al., Geology, 2007). Asal Lake is composed of evaporitic deposits and is fed by superficial circulation of sea water through the rift faults. Fluid circulation is governed by a westward pressure gradient of approximately 1.5 MPa. Drillings and hot springs outline the existence of deeper and hotter fluid reservoirs whose origin is unknown.
Our objectives are to estimate the permeability and to characterize its spatial and temporal variation through the Asal faulted crust by taking into account both tectonics (fault locations, seismic cycle), hydrology and boundary constraints of the system.
To this purpose, we made some numerical models computed with the Comsol MultiphysicsTM finite-element software where heat equation is coupled with the Darcy law and where the permeability was depth- and time-dependent.
Our hydrothermal models notably show the enhancement of sea water upward circulation by a thermal flow incoming from the subjacent Fieale magma chamber through convection cells. The horizontal water flow is slowed down, the convection cells acts as a barrier to westward fluid exchange.
We also outline the important control of the seismic cycle in fluid redistribution within the upper crust.
These results are relevant to understand how tectonics interacts with fluid circulation and also to propose a mechanism for the formation of evaporitic deposits on an oceanic crust.

Key words: Asal Rift, Gulf of Aden, hydrothermal circulation, numerical modelling, permeability, evaporitic deposits.