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3D coexisting modes of thermal convection in the faulted Lower Yarmouk Gorge

Fabien Magri (1,2), Nimrod Inbar (3), Peter Möller (4), Marwan Raggad (5), Tino Rödiger (6), Eliyahu Rosenthal (3), and Christian Siebert (6)

(1) Helmholtz Centre for Environmental Research - UFZ, Department of Environmental Informatics, Leipzig, Germany (fabien.magri@ufz.de), (2) Freie Universität Berlin, Hydrogeology, Berlin, Germany, (3) Tel Aviv University, The Department of Geophysics and Planetary Sciences, Tel Aviv, Israel, (4) GFZ German Research Centre for Geosciences, Potsdam, Germany, (5) University of Jordan, Amman, Jordan, (6) Helmholtz Centre for Environmental Research – UFZ, Dept. Catchment Hydrology, Halle, Germany

Numerical investigations of 3D modes of large-scale convection in faulted aquifers are presented with the aim to infer possible transport mechanisms supporting the formation of thermal springs in the Lower Yarmouk Gorge (LYG), at the border between Israel and Jordan. The transient finite elements models are based on a geological model of the LYG that introduces more realistic structural features of the basin, compared to previous existing models of the area (Magri et al., submitted). The sensitivity analysis of the fault permeability showed that faults cross-cutting the main regional flow direction allow groundwater to be driven laterally by convective forces within the fault planes. Therein thermal waters can either discharge along the fault traces or exit the fault through adjacent permeable aquifers. The location of springs can migrate with time, is not strictly constrained to the damage zones and reflects the interplay between the wavelength of the multicellular regime in the fault zone and the regional flow toward discharge areas in the lowlands.
The results presented here suggest that in the LYG case, crossing flow paths result from the coexistence of fault convection, that can develop for example along NE-SW oriented faults within the Gorge, and additional flow fields that can be induced either by topography N-S gradients, e.g. perpendicular to the major axe of the Gorge, or by local thermal convection in permeable aquifers below Eocene aquiclude. The sensitivity analysis is consistent with the analytical solutions based on viscous-dependent Rayleigh theory. It indicates that in the LYG coexisting transport processes likely occur at fault hydraulic conductivity ranging between 2.3e-7 m/s and 9.3e- 7 m/s (i.e. 7 m/yr and 30 m/yr). The LYG numerical example and the associated Rayleigh analysis can be applied to study the onset of thermal convection and resulting flow patterns of any fractured hydrothermal basin.

References

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