Geofluid leakage along an active plate boundary, southern California

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ABSTRACT
Faults have profound controls on fluid migrations at all depths in the Earth's crust. Faults affect regional groundwater flow, sediment diagenesis, brine and petroleum migration, and the movement of the deepest hydrothermal-metamorphic-magmatic fluids. Fluids lubricate fault zones, and fluid pressures modulate stress/deformation. In southern California the vertical migration of petroleum and noble gases can be used to constrain fault permeability in a seismically active plate boundary. In the offshore Santa Barbara basin, ocean tidal signals and rates of vertical petroleum leakage can be used to constrain an intrinsic permeability ~30 millidarcys for the South Ellwood Fault. In the Los Angeles Basin, large faults formed a lateral barrier for petroleum migration, which resulted in the vertical stacking of oil reservoirs to produce the world's richest petroleum field along the Newport-Inglewood Fault zone (NIFZ). Mantle-derived helium along the NIFZ is a significant component of the helium casing gas from deep production wells, as high as 5.3 Ra, indicating up to 66% mantle contribution (Boles et al., 2015). Using basic theory for reactive fluid flow, one can calculate a maximum inter-seismic Darcy flow rate ~ 2.2 cm yr^{-1} and vertically-averaged permeability of ~160 microdarcys (1.6×10^{-16} m^2). Based on the Peclet number and numerical modeling of the basin, regional fluid flow is still too slow to perturb the local heat flow around the NIFZ. Although heat flow data are sparse, there generally doesn't appear to be any clear association of anomalous heat flow with the large strike-slip faults of southern California, suggesting that neither the effects of Tóthian regional flow nor frictional heating alter the mostly conductive temperature regime.

Reference:
Boles, J.R., G. Garven, G., H. Camacho, and J.E. Lupton (2015), Mantle helium along the Newport-Inglewood fault zone, Los Angeles basin, California: A leaking paleo-subduction zone, Geochem. Geophys, Geosyst., 16, 2364-2381.