Helium and CO_2 systematics of the San Andreas Fault System

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Leakage of volatiles from the mantle to the surface in faulted regions of the crust can be recognised and quantified using He-isotopes [1]. Here, we report He-isotope and abundance results of 2 new regional surveys of groundwaters and geothermal fluids along the San Andreas Fault System (SAFS) targeting (a) southern California (Coachella Valley, San Bernardino and the Salton Sea) and (b) central California, between Hollister and Parkfield. Together with prior results from Big Bend [2], we now have extensive coverage of the SAFS over segments of the fault characterised by different slip rates. All He data are accompanied by CO_2 data ($\delta^{13}C$ and abundances) enabling calculation of mantle CO_2 fluxes to the surface.

The highest $^3He/^4He$ values in southern California obtained in close proximity (± 5 km) to the fault trace are 2.2R_A (Salton Sea), 1.7R_A (San Bernardino) and 0.97 R_A (Coachella) whereas the highest value in central California is 1.3 R_A. The $CO_2/^3He$ ratios at all locations are generally $> 10^{11}$, with $\delta^{13}C$ being variable, from -7 to -16 ‰ (vs. VPDB). All fluids are supersaturated in He and CO_2.

The coupled He-CO_2 systematics reveal that mantle-derived volatiles are emitted throughout the strike of the SAFS. Mantle-derived CO_2 constitutes 0.5-1.5% of the total CO_2 whereas up to 25% of the total He is mantle-derived. Using the approach of Kennedy et al. [3], we calculate mantle fluxes of both species. In southern California, CO_2 and ^3He fluxes (in mol/yr/km) at all fault segments are low: < 200 and < 0.3, respectively, in comparison to the Big Bend and the Hollister and Parkfield segments. However, there is an intriguing positive correlation between mantle CO_2 and ^3He fluxes and fault activity, as gauged by slip rate, particularly for the southern segment of the SAFS. We discuss the possibility that super hydrostatic pressure at depth along the fault – maintained by high CO_2 fluxes – increases permeability which, in turn, influences the variations in seismicity seen along the strike of the fault.

[1] Hilton, Science, 2007; [2] Kulongoski *et al Chem. Geol.,* 2013; [3] Kennedy *et al* Science, 1997.