Geophysical Research Abstracts
Vol. 16, EGU2014-6620, 2014
EGU General Assembly 2014

Gravitational fractionation of solutes and isotopes

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In a stagnant pore fluid, dissolved heavy components tend to gravitate downwards, while light components concentrate towards the top of the reservoir. This gravitational gravitation (Bons & Gomez-Rivas, 2013) is counteracted by Fickian diffusion, which strives to equalize concentrations of all components. Numerical simulations show that gravitational fractionation can be significant in crustal fluid reservoirs, provided the fluid is stagnant for prolonged periods of times (tens of millions of years) and that the vertical connectivity of the pores extends over at least a few kilometres. In that case, up to double digit shifts in hydrogen and oxygen isotopic signatures can develop and, for example, Cl/Br ratios can be modified by more than a factor of two.

Stagnant fluid reservoirs can be expected in basement rocks under unconformities, such as the Variscan basement in Western Europe during the Mesozoic. Published fluid ages based on halogen isotopes confirm that basement fluids can be tens of millions of years old (e.g. Fehn & Snyder, 2005). Considering that fluid compositions (isotopic signatures, halogen ratios, etc.) are commonly used to determine origin of fluids and the processes that may have modified them, recognizing the potential modification of fluid signatures by gravitational fractionation is of importance in models for crustal fluid flow and ore formation.

Bons, P.D., Gomez-Rivas, E. 2013. Gravitational fractionation of isotopes and dissolved components as a first-order process in hydrothermal crustal fluids. Economic Geology 108, 1195-120.

Fehn, U., and Snyder, G.T. 2005. Residence times and source ages of deep crustal fluids: interpretation of 129I and 36Cl results from the KTB-VB drill site, Germany. Geofluids 5, 42-51.