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Iron isotope cycling in continental sedimentary basin mineralization

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Low δ^{57}Fe values in ferric oxides are an increasingly recognized feature in terrestrial environments and have been interpreted to reflect organically-bound Fe or Fe that has undergone cycles of reduction and oxidation. This work studies Fe-isotope cycling in the Paran Fault adjacent to the Dead Sea Transform, where iron oxide lenses and veins are exposed in the fault and Fe-dolomitization has occurred in Cretaceous limestones adjacent to the fault. The mineralization fluids are thought to have gained metals during topographically-driven basinal brine flow through an underlying clastic sandstone aquifer. This was followed by rise of the Fe(II)-bearing fluids up the fault zone and mineral precipitation. The study was made at two mineralization locations 80 km apart at the eastern Menuha Ridge (MR) and western Haspas-Beroqa (H-B) ends of the fault, respectively. Oxygen isotope fractionations among quartz, Fe-oxides and dolomites indicate temperatures of 50 $\pm$ 25ºC. δ^{57}Fe IRMM values of the Fe-oxides and Fe-dolomites show significant variations, but all are negative: MR: Fe-oxides δ^{57}Fe = -1.08 $\pm$ 0.40 permil, dolomites = -0.87 $\pm$ 0.26 permil; H-B: Fe-oxides δ^{57}Fe = -0.66 $\pm$ 0.47 permil, dolomites = -0.58 $\pm$ 0.31 permil. These values are approximately 1.0 to 1.4 permil lower than the Fe-mineral fraction of the underlying clastic sandstone (δ^{57}Fe = 0.34 $\pm$ 0.19 permil). Fe has thus undergone a cycle of sub-surface reductive dissolution and oxidation. The fact that both ferric oxides and Fe-dolomites have similar δ^{57}Fe values at each location suggests that oxidation to ferric oxides was complete and that the δ^{57}Fe values essentially reflect those of the precursor Fe(II) solutions. A single-stage mass-balance calculation shows that substantial amounts of the source iron were mobilized: a fact possibly reflected by the higher δ^{57}Fe values of the sandstone relative to lithogenic Fe with δ^{57}Fe $\sim$ 0.1 permil.