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Magnesium isotope composition of the altered upper oceanic crust at ODP Holes 504B and 896A, Costa Rica Rift

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Chemical reactions between the oceanic crust and seawater play a major role in regulating the composition of the oceans that, in turn, influence important geochemical cycles (e.g., C, S, Mg). It is well established that alteration of the oceanic crust is the principal sink of Mg in seawater, but the effect of this process on the Mg isotope composition of the oceans remains unclear. Here we present the first measurements of Mg isotopes in altered oceanic crust from ODP Holes 504B and 896A. These holes are located in 5.9 Ma crust located 200 km south of the intermediate spreading rate Costa Rica Rift. Hole 504B penetrates: (i) A volcanic section, consisting of primitive to moderately altered mid-ocean ridge basalt (MORB) that was open to seawater alteration under oxic-suboxic conditions at temperatures <150 °C; (ii) A transition zone that marks the contact between volcanic flows and dikes and is characterised by mixing between upwelling hydrothermal fluids and seawater at temperatures between ∼100 and 350 °C; (iii) A sheeted dike complex consisting of diabase partially altered to greenschist facies minerals. Hole 896A is ∼1 km away from 504B, and penetrates volcanic rocks altered under low temperature (<100 °C) and oxic-suboxic conditions. Samples were selected from each of the different alteration zones and have been well characterized petrographically and geochemically. The overall range in δ26Mg values is -0.52 to -0.12‰ which is significantly greater than the restricted range of the unaltered MORB (0.25 ± 0.06‰ [1]). These values also extend towards significantly lighter compositions than published values for altered oceanic crust (0.25 ± 0.11‰ [2]) from basalts and gabbros recovered from the ODP Site 1256 on 15 Ma EPR crust on the Cocos Plate. Overall, δ26Mg values decrease with depth in the volcanic section in both Holes 504B and 896A, covering the entire range of Mg isotopic compositions. The highest δ26Mg values are found in saponite-bearing basalts at the top (<50 msb) of the volcanic sections of both holes, which can be attributed to the preferential incorporation of heavy Mg isotopes into secondary clays (Mg-saponite). Lower δ26Mg values in the deeper part of the volcanic section may be a result of interaction with evolved light-Mg enriched seawater, or precipitation of carbonates that preferentially incorporate light Mg. The Transition Zone is characterised by relatively high δ26Mg values (∼ -0.15‰ in the chlorite-smectite bearing basalts. The sheeted dike complex yields a narrow range of MORB-like δ26Mg values (-0.22 to -0.30‰ suggesting that limited fractionation occurs during high-temperature alteration and that the fluids have very low Mg concentrations. Consequently, there is no observable change to the Mg isotopic composition of the dikes at bulk rock scale. [1] Teng et al., (2010) GCA 74, 4150-4166. [2] Huang et al., (2015) Lithos 231, 53-61.