MORB mantle hosts the missing Eu in the continental crust

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The continental crust (CC) is an important geochemical reservoir whose origin and evolution remains debatable. Estimated bulk CC composition is model dependent. A reliable upper CC composition has been obtained from fine-grained sediments. The upper CC has a negative Eu anomaly (NEuA or Eu/Eu* < 1), 0.65, which points to an unlocated Eu-rich reservoir. The upper CC is < 10 km thick and cannot represent the bulk CC, which has a mean thickness of ~ 36 km. The composition of the deep CC is required, but difficult to estimate. A creative approach combines geochemical data on deep crustal rocks (xenoliths and localized outcrops) with seismic and heat flow data to estimate the average deep CC composition. As some granulites show Eu/Eu* > 1, the missing Eu in the upper CC may all be in the deep CC. Indeed, the NEuA in the upper CC is substantially reduced in model bulk CC compositions: 0.829 - 0.974. *IF* one assumed that mantle derived igneous rocks show no Eu anomaly, the upper CC NEuA would arise from intracrustal processes. For example, the granitic upper CC resulted from anatexis of more mafic rocks in the deep CC with Plag as a residual phase (holding Eu) in the granulite residues. This interpretation is viable, but the protoliths of most of these granulites are underplated mantle melts. The NEuA (~ 0.8) and the more felsic nature of bulk CC composition in eastern China encouraged the suggestion that the more mafic lower CC rocks were tectonically removed. High quality data on 306 fresh MORB glass samples (2-10 wt% MgO) exhibit varying Eu/Eu* (0.68-1.18) and significant correlations: $R_{[MgO\text{-}Eu/Eu^*]}$ = 0.876, $R_{[MgO\text{-}Sr/Sr^*]}$ = 0.809 and $R_{[Eu/Eu^*\text{-}Sr/Sr^*]}$ = 0.875. 148 samples show Eu/Eu* > 1. For Eu/Eu* > 1, MgO > 7.6 wt% or $T_{[liquidus]}$ >1185±10°C. For MORB, Plag begins to crystallize at ~1200±10°C. These observations demonstrate that primitive MORB melts all have *POSITIVE* Eu and Sr anomalies. We interpret these anomalies as inherited from the MORB source. Eu and Sr behave similarly because of the same charge [2+] and ionic radius (~1.31Å for CN = 6). The larger radius may make Eu[2+] more incompatible than the smaller Sm and Gd, but the divalent Eu[2+] goes mostly with Sr into M2 site of Cpx in mantle peridotites, making it more compatible than the trivalent Sm and Gd. If the depleted MORB mantle indeed resulted from bulk CC extraction in the early Earth, then that 'event' would have preferentially extracted the more incompatible trivalent REEs into CC, leaving the divalent Eu[2+] in the MORB mantle. Hence, we suggest MORB mantle hosts at least some of the missing Eu in CC paralleling the situation deduced for the Moon.