Quantifying the roles of igneous differentiation and chemical weathering on the formation of continental crust

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The continental crust is too Si-rich and Mg-poor to have derived directly from mantle melting, which generates basaltic rather than felsic magmas. Converting basaltic magmas to the more evolved felsic compositions of the continental crust requires intracrustal differentiation processes that preferentially remove Mg, Ca, and Fe from the continents, leaving behind a Si-rich residue. One mechanism is by re-melting of basaltic crust or by direct crystallization of basaltic magmas to generate Mg-rich residues/cumulates, which then delaminate into the mantle. Another mechanism is via chemical weathering, which preferentially dissolves mafic minerals, leaving behind more felsic minerals in the crust. Mg is transported in solution to the ocean, and then sequestered in the oceanic lithosphere during hydrothermal alteration. The Si-rich soil residue is then transported to continental margins as detrital sediments, and then re-digested in continental arcs.

To quantify the relative contributions of igneous and weathering differentiation processes in crust formation, we investigated Li/Nb and $^{26}Mg/^{24}Mg$ isotopic systematics of the Peninsular Ranges batholith in southern California, USA, plutonic remnants of a late Cretaceous continental arc emplaced through the margin of the North American continent. Plutons containing a component of pre-existing continental crust (high initial $^{87}Sr/^{86}Sr$) have anomalously low Li/Nb compared to juvenile island arcs, suggesting a deficit in the Li content of continental crust. $^{26}Mg/^{24}Mg$ correlates positively with $^{87}Sr/^{86}Sr$ and $^{18}O/^{16}O$, and is best explained by coupled fractional crystallization and assimilation of pre-existing country rock. We show that the low Li/Nb and Mg-depleted nature of the assimilated country rock must be due to prior chemical weathering losses. These observations show that chemical weathering plays an important role in modulating the composition of the continents. The possibility of weathering modulating crustal growth will be explored.

The formation and differentiation of the howardites based on ^{182}Hf-^{182}W chronometry

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Howardites are the H class of the HED clan meteorites, and probably originated from the asteroid 4 Vesta. It consists of eucrite and diogenite clasts welded together by mineral dust. To know precisely when 4 Vesta formed is critical to the understanding of the accretion and differentiation history of all planetary bodies. The ^{182}Hf-^{182}W system, $t_{1/2}$ = 9 myr, has been successfully applied to the studies of formation and evolution history for various achondrites, including eucrites and diogenites [1-4]. It has been shown that both eucrites and diogenites yield identical Hf-W ages [4]. As a result, precise Hf-W isochron ages for howardites is necessary to understand whether if HED meteorites were indeed co-genetic.

Six howardites have been studied in order to check if internal Hf-W isochron age can be resolved. Preliminary data show that ε_w of the metal fractions vary from +4 to +13, and the ε_w varies from +20 to +26 and +17 to +25 for the silicates and the whole rocks, respectively. In general, the Hf-W data of the howardites studied here are consistent with that of eucrites and diogenites [3,4]. The Hf-W data for each sample are generally scattered within an isochron plot for most of the howardites studied here. However, two samples do exhibit internal isochrons, and the slopes are consistent with an $^{182}Hf/^{180}Hf$ initial of ~ 8.9×10^{-5} and 3.8×10^{-5}, equivalent to an apparent age of 2.4 and 13.3 myrs post-CAI, and the ages are consistent with that of eucrites [3], and diogenites [4]. If these isochron ages truly reflect the formation ages of howardites, they suggest that the formation of HED clans were contemporaneous. It is also possible that the isochron ages were inherited from the eucrites and/or diogenites. More precise Hf-W data, combined with the geochemical data for the different silicate fractions analyzed for the Hf-W system may provide further constraints about the formation and evolution of the HED clan meteorites.

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