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Have mantle get crust – consequences of fluid-peridotite interaction for continental crust composition

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The chemical composition of the continental crust is too rich in Ni and Cr to have evolved solely by amalgamation of differentiated magmatic rocks. The upper crustal concentrations of Ni and Cr are 47 ppm and 92 ppm, while average volcanic arc concentrations are 28 ppm (Ni) and 69 ppm (Cr), consistent with the average andesitic crust of the Taylor model of continental crust formation [1]. High concentrations of Ni and Cr are almost exclusively found in undifferentiated ultramafic rock, typically up to 4000 ppm, indicating that transfer of Ni and Cr to the continental crust is incompatible with partial melting of peridotite. In contrast, elevated Ni and Cr concentrations in continental sediments that are used to define the average composition of the continental crust indicate their addition by weathering and erosion processes. Here we show how hydrothermally alteration and weathering of ultramafic rock produces a Cr and Ni -enriched residual that becomes part of the continental crust via erosion and redeposition. The mass-balance indicates that chemical weathering of Ni– and Cr–rich, undifferentiated ultramafic rock equivalent to $\sim$1.3 wt% of today's continental crust compensates for low Ni and Cr in formation models of the continental crust. This estimate is consistent with a flux-balance that considers Ni and Cr solute and particulate transport from the continents to the oceans and addition to the continents by weathering of volcanic arc type rocks and peridotite. Furthermore, fluid-driven ultramafic rock alteration, particularly in the presence of CO_2, also causes a distinct relative enrichment in silica extending to pure quartz (e.g. listvenite, silcretes). In the light of potentially large volumes of ultramafic rock and high atmospheric CO_2 concentrations during the Archean, chemical weathering must therefore have played an important role in forming compositionally evolved components of the early Earth's crust.

[1] Taylor, S. R. & McLennan, S. M. The geochemical evolution of the continental crust. Rev Geophys 33, 241-265 (1995).