Non-uniformitarian continental crust formation

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The composition of the continental crust is a first-order observable that must be satisfied in any crust formation scenario. All published compositional estimates agree, within uncertainty, that the average continental crust has an 'andesitic' bulk composition[1]. This evolved composition requires operation of recycling processes (e.g., density foundering, relamination, chemical weathering with export of Mg to altered oceanic crust) that remove mafic to ultramafic components that are complementary to the present andesitic crust. However, seeking to understand the formation of continental crust from a Lyellian perspective (i.e., the present is the key to the past) may skew our understanding of crust formation processes, given that the majority of continental crust formed by 2.5 Ga[2]. Clearly, the Archean was a critical period for crust formation. Many lines of evidence suggest a fundamental shift in the composition of continental crust between the Archean and younger eons. Using mainly trace element compositions of detrital terrigenous sedimentary rocks, it is well established that mafic to ultramafic rocks were proportionately more abundant in the Archean[3]. A recent estimate for MgO content of land (i.e., crust sitting above sea level and susceptible to chemical weathering and erosion) through time shows that average MgO changed from 15 wt.% in the mid-Archean to ~4 wt.% at the end of the Archean[4]. This chemical transformation suggests significant crustal growth (through addition of granitic rocks), and a fundamental change in the processes of crust formation, which may reflect the onset of widespread subduction (i.e., plate tectonics) as a means of generating voluminous granitic magmas. Armstrong-type models[5] of constant felsic continental crust volume since 4 Ga appear untenable. A corollary is that crust formation processes prior to the mid-Archean were likely very different from those operating today. This shift in crust formation processes may be reflected in the changing composition of Archean TTG, which transitioned from low Mg#, Ni and Cr to high Mg#, Ni and Cr from Early to Late Archean[6], possibly reflecting slab melts interacting with mantle wedge in Late Archean TTGs.

[1],Rudnick & Gao, 2003, ToG; Hacker et al., 2015, *AREPS;* [2]Belousova et al., 2010, *Lithos*; Dhuime et al., 2015, *Nat. Geo.* [3]Taylor & McLennan, 1985; Condie, 1993; *Chem. Geol.*; [4]Tang et al., 2016, *Science*; [5]Armstrong, 1991, *AJES*.[6] Martin & Moyen, 2002, *Geology*.