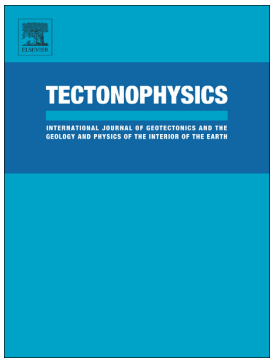

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Resolving the crustal composition paradox by 3.8 billion years of slab failure magmatism and collisional recycling of continental crust

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Abstract:

In the standard paradigm, continental crust is formed mainly by arc magmatism, but because the compositions of magma rising from the mantle are basaltic and continental crust is estimated to contain about 60% SiO_2 and much less MgO than basalt, the two do not match. To resolve this paradox, most researchers argue that large amounts of magmatic fractionation produce residual cumulates at the base of the crust, which because arcs are inferred to have magmatically thickened crust, form eclogites that ultimately founder and sink into the mantle. Not only are there problems with the contrasting bulk compositions, but the standard model also fails because prior to collision most modern arcs do not have thick crust, as documented by their eruption close to sea level, and in cases of ancient arc sequences, their intercalation with marine sedimentary rocks.

Our study of Cretaceous batholiths in the North American Cordillera resolves the crustal composition paradox because we find that most are not arc-derived as commonly believed; but instead formed during the waning stages of collision and consequent slab failure. Because the batholiths typically have silica contents greater than 60% and are derived directly from the mantle, we argue that they are the missing link in the formation of continental crust.

Slab failure magmas worldwide are compositionally similar to tonalite-trondhjemite-granodiorite suites as old as 3.8 Ga, which points to their collective formation by slab failure and long-lived plate tectonics. Our model also provides (1) an alternative solution to interpret compiled detrital zircon arrays, because episodic peaks that coincide with periods of supercontinent amalgamation are easily interpreted to represent collisions with formation of new crust by slab failure; and (2) that models of early whole-earth differentiation are more reasonable than those invoking progressive growth of continental crust.

Keywords: continental crust formation, arc-continent collision, slab failure, Cordilleran batholith, tonalite-trondhjemite-granodiorite (TTG) suite, crustal recycling

1.1 Introduction:

How and when continental crust formed are contentious, long-standing issues among geologists. Most geoscientists believe that continental crust formed principally by water-induced melting of the mantle wedge above subduction zones to produce juvenile basaltic melts, which rise into the crust where they fractionate (Rudnick, 1995; Davidson and Arculus, 2006; Hawkesworth and Kemp, 2006; Tatsumi and Stern, 2006; Lee et al.,