Fluid-mobile elements in evolved Archean magmas: Implications for Archean subduction processes

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The role of subduction zone melting in the formation of Archean continental crust is highly debated. In the study of modern mantle-derived magmas, fluid-mobile elements are the most powerful discriminants between subduction zone and other types of magmas. Indeed, the relative abundance of these elements can also be used to differentiate between various types of subduction environments ('hot' vs. 'cold') and fluid and metal sources (sediment, serpentinite, direct eclogite melt). However, surprisingly little coherent data are available for fluid-mobile element systematics in Archean felsic magmas. The main reason for this shortfall appears to be the widely held view that the systematics of these lithophile, relatively large ions are too easily disturbed by later geologic overprint to be of much use.

Here we report a systematic dataset of fluid-mobile and other trace elements in 60 felsic Archean granitoids, 3.8-2.5 Ga in age and representing several cratons. The data-set includes Li, Be, B and As, widely viewed as some of the most useful discrimnants for and against subduction processes.

Comparison of some of the most lithophile elements (e.g. Tl and Rb) between modern arc-derived rocks and the Archean granitoids gives no indication that at least the relative abundance of these elements should be disturbed in the Archean samples. Indeed, the majority of Archean granitoids show a remarkable similarity in all fluid-mobile element features with modern arc derived magmas, strongly suggesting that subduction zone magmatism was operational as far back as 3.6-3.7 Ga.

B/Be and As/Pr and compatible element systematics clearly discriminate between direct Archean slab melts (i.e. adakites) and the much more fluid-mobile element-rich wedge melts. In between these extremes are TTG that share some characteristics with each end-member. They could have formed by melting of underplated basaltic eclogite at the base of the crust, in mantle above (hot) subduction zones where B and As were lost at too shallow depth, or they could represent differentiates from very hydrous basaltic precursors in which garnet and amphibole replace olivine and pyroxene as the earliest crystallizing phases. Geochemical data suggest that TTG formed in different geodynamic environments.

The merits of "recycled oceanic crust-eclogite" lineage in the mantle source of group-I kimberlite melts

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The source of group-I kimberlites, located deep within the upper mantle, remains controversial. Primary melt compositions, so crucial in tracking compositions and melting conditions of possible mantle sources, tend to be obscured by contamination and alteration of kimberlite rocks. At present, group-I kimberlites are thought by many to have a source in "plume"-type, OIB-like mantle. Recently, another type of magma source, recycled oceanic crust (eclogite) has regained favor. Such a source is supported by "dry" carbonate-chloride composition of the primary magma for the unaltered Udachnaya-East kimberlite [1, 2], and by low $^{87}Sr/^{86}Sr$ in magmatic perovskite for this (0.7030 [3]) and other kimberlites (0.7023-0.7033 [4]).

Recycled oceanic crust (eclogite) should be a common component in the deeper mantle as a result of subduction processes. It contains generally unradiogenic Sr (as recorded in kimberltiic perovskite), and, after suitable ageing, would be expected to develop the unique Hf-Nd isotope signatures of many group-I kimberlites. Lithophile trace element contents are ≈ 10x higher than in peridotite, providing the oft-quoted 'pre-enriched' source required for kimberlites. Carbon and chlorine, prominent in unaltered kimberlites, could be inherited from the altered portion of oceanic crust. Volatile-fluxed melting of such a source can proceed at relatively low temperatures to relatively high melt fractions, favorable for melt segregation and ascent. Eclogite garnet remains residual even at high degrees of melting, thus explaining the garnet-signature in kimberlites. Eclogite is olivine-free and must produce melts undersaturated in olivine, as is the case for the primary melts inferred for the Udachnaya-East kimberlite. Finally, the density contrast between primary kimberlitic melt and an eclogite source are greater than for a peridotite source, consistent with inferred high ascent rates of kimberlite magmas and preservation of diamonds.

[1] Kamenetsky *et al.* (2004) *Geology* **32,** 845-848.
[2] Kamenetsky *et al.* (2007) *Chemical Geol* **237,** 384-400.
[3] Maas *et al.* (2007) *Geochim Cosmochim Acta* **71,** A608.
[4] Paton *et al.* (2007) *Geology* **33,** 549-552.