An Arc Origin for Archean High MgO "Eclogite" Xenoliths?

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The origin and evolution of Archean continental crust is an important topic in the Earth Sciences. Gaining a more comprehensive understanding of continental crust formation will allow for better tracking of how chemical differentiation and geodynamic processes have evolved on the Earth over billion-year timescales. Suggested mechanisms responsible for Archean crust formation, which are not necessariliy mutually exclusive, include melting of subducted slabs, melting of orogenically thickened basaltic crust, generation of large oceanic plateaus (proto-continents), and arc magmatism. High temperatures are required for the first three scenarios and may be reasonable if the Archean mantle was hotter than today's. Most Phanerozoic continental crust formation, however, tends to be associated with arc magmas formed not by slab melting but by hydrous melting of the peridotitic mantle wedge. The question addressed here is to what extent did Phanerozoic-like arc processes, such as mantle wedge melting, operate in the mid- to late-Archean.

Although there is strong evidence from low MgO eclogite xenoliths that melting of subducted slabs was involved in Archean crust formation, the origins of the Archean high MgO garnet pyroxenite xenoliths is less understood. High MgO "eclogite" xenoliths from the west African, south African, and Siberian cratons were thus the focus of this study. We find that these Archean high MgO xenoliths have compositional systematics remarkably similar to high MgO garnet pyroxenite ("eclogite") xenoliths originating from the lithospheric root underlying the Mesozoic Sierra Nevada continental arc batholith in California. The latter are interpreted to represent cumulates from arc magmas beneath a thick continental arc. Both groups have similarly high Ni and MgO contents, high Mg/(Mg+Fe) ratios (Mg#), and relatively high SiO_2 contents. Such compositions are not represented by typical frozen melts. Uniformly high Mg#s of the Sierran high MgO "eclogites" suggest that they are not melt residues of a basaltic protolith. In addition, no continuous compositional spectrum reflecting varying degrees of melt is observed, suggesting instead a cumulate origin. Given the compositional similarities between the Archean and Sierran high MgO "eclogites," we speculate that the two high MgO "eclogite" xenoliths have a similar origin, implying that at least some Archean crust may have formed by Phanerozoic-like arc processes. Seismic velocities calculated for high MgO "eclogites" reveal considerable overlap with peridotite velocities. This suggests that it may be potentially difficult to seismically detect high MgO "eclogites" within cratonic roots.