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Title: ARCHEAN, PROTEROZOIC AND PHANEROZOIC LITHOSPHERES: PRESERVATION, MODIFICATION OR DELAMINATION?

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Abstract: The composition of the subcontinental lithospheric mantle (SCLM) varies broadly with the age of the last major tectonothermal event in the overlying crust. Archean SCLM is highly depleted in basaltic components, commonly is strongly stratified, and has low Fe/Al compared to younger SCLM. Phanerozoic terrains are generally underlain by fertile mantle, and most Proterozoic SCLM is intermediate between these extremes. Archean SCLM >120 km thick is buoyant relative to the asthenosphere; it cannot be “delaminated”, and will persist through time. Phanerozoic SCLM is buoyant when hot, but on cooling to typical Phanerozoic conductive geotherms it becomes susceptible to delamination. This instability is reflected in the evolution of major orogens such as the Central Asian Orogenic Belt.

The secular evolution in SCLM composition has been interpreted as reflecting changes in the mechanisms that produce SCLM, related to evolution of Earth’s internal dynamics. However, this may be only part of the story. Detailed studies show that the protoliths of many orogenic peridotite massifs (e.g., Western Norway, Lherz, Ronda) were highly depleted dunite/harzburgites, and that metasomatic refertilisation by infiltrating melts has led to the production of more "fertile" lherzolites, mirroring the secular evolution of the SCLM.

Seismic tomography shows high-Vs roots, which require both depleted compositions and low geotherms, under most Archean cratons. However, most "typical" Archean mantle xenoliths come from kimberlites intruded along the margins of these high-Vs roots, where lower seismic velocities reflect more fertile compositions. This sampling bias suggests that the dominant rock type of the Archean roots is dunite/harzburgite, rather than lherzolite.

Hf-isotope data on zircons show that much Proterozoic crust, especially in shield areas, has Archean protoliths, suggesting that the underlying SCLM also is originally Archean, and many of these areas also have moderately high-Vs roots. These observations suggest that much of the secular evolution in SCLM composition reflects the progressive refertilisation of Archean SCLM, rather than production of progressively less depleted SCLM through time. Modern processes produce SCLM that is only mildly depleted relative to the Primitive Mantle compositions.

The Archean may represent an interlude between the Hadean and a more modern Earth, during which "primitive" dunites/harzburgites formed as restites/cumulates from high-degree melting in ascending plumes. This uniquely Archean regime may have coexisted with a more modern plate-tectonic regime, producing weakly depleted residues similar to Phanerozoic SCLM and more easily recycled. Seismic tomography suggests that approximately 50% of existing continental crust is underlain by relict Archean SCLM, modified to varying degrees. This implies a much larger volume of originally Archean crust than currently accepted, and hence very high early crustal growth rates.