The age and evolution of the SCLM

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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, commonly is strongly stratified, and contains rock types that are essentially absent in younger SCLM. Its composition reflects processes that do not operate today. Phanerozoic terrains are generally underlain by fertile mantle, and most Proterozoic SCLM is intermediate between these two extremes. This secular evolution in SCLM composition implies quasi-contemporaneous formation (or modification) of the crust and its underlying mantle root.

Most "typical" Archean xenoliths have experienced repeated metasomatism, leading to a progression from dunite/harzburgite through "depleted" lherzolite to "fertile" lherzolite, which mirrors the secular evolution of the SCLM as a whole. Similar refertilisation processes are observed in peridotite massifs (eg Western Norway), where the dominant Archean protoliths are highly magnesian dunite/harzburgites, poorly represented in the published xenolith record. Melt-modelling exercises that treat "typical" Archean peridotites as simple residues are invalid, and cannot be used to support "lithosphere stacking" models for SCLM formation.

Hf-isotope data on zircons show that much Proterozoic crust, especially in cratonic areas, has Archean protoliths, suggesting that the underlying SCLM also is originally Archean. Seismic tomography shows high-Vs roots, which require depleted compositions and low geotherms, under many of these areas; clearly juvenile Proterozoic belts (eg SW Scandinavia) do not have such roots. These observations suggest that much of the observed secular evolution in SCLM composition reflects progressive reworking of buoyant Archean SCLM, rather than secular changes in the mechanisms of SCLM production.

In situ Re-Os data from sulfides in massif peridotites and SCLM xenoliths give older depletion ages than most whole-rock analyses, but none >3.9 Ga have yet been found; there appear to be no samples of Hadean SCLM. The Archean may represent a specific tectonic regime that formed an interlude between the Hadean and a more modern Earth. The "primitive" Archean dunites/harzburgites are best modelled as restites/cumulates from high-degree melting at 3-6 GPa, in ascending plumes/mantle overturns. This uniquely Archean regime may have coexisted with a more modern plate-tectonic regime, which produced weakly depleted residues similar to Phanerozoic SCLM. This "modern" SCLM would be inherently unstable and easily recycled. Seismic tomography suggests that 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.