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The isotopic and chemical heterogeneity of komatiite mantle sources: insights into geodynamic evolution from the Hadean to the Phanerozoic

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The heterogeneity of the Earth's modern mantle, including chemical, mineralogical, and isotopic differences, is well documented. Cenozoic mantle-derived magmas offer valuable insights into the mantle's composition. However, data on the heterogeneity of the ancient mantle, especially from the Archean, remain limited *(1)*. A major challenge is the significant post-magmatic alteration of these ancient rocks, complicating the use of sensitive isotope systems such as Rb-Sr and hampering measurement of highly informative mobile elements such as U and Pb. Fortunately, melt inclusions protected by host olivine from external alteration provide unique opportunities to analyze these elements *in situ*.

We analyze Sr isotopes and trace elements using split-stream LA-ICP-MS on melt inclusions, and oxygen isotopes via SIMS in host olivines from various komatiites and picrites, including those from Barberton (3.27 Ga), Belingwe (2.69 Ga), Song Da (Emeishan LIP, 260 Ma), Gorgona (90 Ma, Caribbean LIP), and Mauna Loa, Hawaii (1 Ka). Our results reveal that the mantle sources of komatiites and Hawaiian picrites are heterogeneous, with components of varying ages and compositions. The unradiogenic Sr signature in Paleoarchean komatiites suggests extensive continental crust formation during the Hadean, likely driven by a mobile-lid regime with active subduction initiated by mantle plumes. The detection of continental crust formation indicators in unaltered, mantle-derived melts implies that the modern plate tectonic system possibly originated in the late Archean, either contemporaneously with or after the continental emergence.

Cambrian basalts and serpentinites that have been altered by seawater and subsequently dehydrated during subduction are present in the mantle sources of Phanerozoic komatiites and the Hawaiian plume (*3, 4*). This indicates a widespread presence of recycled early Paleozoic oceanic crust, with recycling rates exceeding 1-2 cm per year.

References:

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