The longevity of Archean mantle residues in the convecting upper mantle and their role in young continent formation

J. LIU[1], J. SCOTT[2], C. MARTIN[2], D. G. PEARSON[1]

[1] University of Alberta, Canada T6G 2E3
[2] University of Otago, New Zealand 9054

The role played by ancient melt-depleted lithospheric mantle in preserving continental crust through time is critical in understanding how continents are built, disrupted and recycled. While it has become clear that much of the extant Archean crust is underpinned by Archean mantle roots, reports of Proterozoic melt depletion ages for peridotites erupted through Phanerozoic terranes raise the possibility that ancient buoyant lithospheric mantle acts as a "life-raft" for much of the Earth's continental crust. Here we report the largest crust-lithospheric mantle age decoupling (~2.4 Ga) so far observed on Earth and examine the potential cause for such extreme age decoupling [1].

The Phanerozoic (< 300 Ma) continental crust of West Otago, New Zealand, is intruded by Cenozoic diatremes that have erupted cratonic mantle-like highly depleted harzburgites and dunites. These peridotites have rhenium depletion Os model ages that vary from 0.5 to 2.7 Ga, firmly establishing the record of an Archean depletion event. However, the vast range in depletion ages does not correlate with melt depletion or metasomatic tracer indices, providing little support for the presence of a significant volume of ancient mantle root beneath this region. Instead, the chemical and isotopic data are best explained by mixing of relict components of Archean depleted peridotitic mantle residues that have cycled through the asthenosphere over Ga timescales, along with more fertile convecting mantle. Extensive melt depletion associated with the "docking" of these melt residues beneath the young continental crust of the Zealandia continent explains the decoupled age relationship that we observe today. Hence, the newly formed lithospheric root incorporates a mixture of ancient and modern mantle derived from the convecting mantle, cooled and accreted in recent times. This model could account for the large spectrum of ages observed in fertile to moderately depleted peridotites sampled from lithospheric mantle beneath SE Australia, W Antarctica and other locations in Zealandia, as well as the oceanic mantle. Our data confirm the longevity and dispersal of ancient depleted mantle domains in the convecting mantle and their re-appearance beneath young continents.

[1] J. Liu et al., 2015. EPSL 424, 109-118.