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Ultra-refractory peridotites in the modern and ancient Earth and their implications for origins of Archean cratonic roots

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Ultra-depleted peridotite residues - those characterised by harzburgitic or dunitic compositions and olivine Fo# of $\geq$ 92 - are quintessential components of Archean mantle lithospheric roots but their tectonic environment of formation is hotly contested. While some form of global subduction is widely accepted to have been active by the end of the Archean, the operation of this process has been pushed back as early as the Late Hadean-Early Archean by some. Such a scenario would have important implications for the creation of early mantle residues and cratonic roots because of the ability of water-fluxed melting to enhance mantle melting. This makes it essential to re-visit the potential role that subduction-driven melting may have played in the origin of Archean cratonic roots.

Ultra-depleted spinel facies mantle peridotites, with clear links to subduction environments, have been increasingly recognised in younger mantle lithospheres over the last decade and provide a chance to compare their characteristics and origin with Archean mantle melting residues. Here, we provide new data major element and isotopic data, combined with recently published studies, to better characterise post-Archean ultra-depleted melting residues created in subduction environments.

The mineralogical properties of these ultra-depleted post-Archean peridotite xenoliths, coupled with experimental melting studies, indicate that these younger rocks are best explained as residues of extensive hydrous melting (F ~ 30 to 40%) i.e., in subduction zones. Combined Re-Os, Lu-Hf and Sm-Nd isotope data confirm that this melting took place in the Phanerozoic Earth. While some aspects of the mineral chemistry, e.g., olivine Mg#, mimic the ranges observed in cratonic peridotites, striking differences are present such as the distinct melting trends defined by spinel and olivine compositions. The Archean mantle residues have distinct bulk rock Fe/Al, and more varied Ca/Al. Bulk rock platinum group element fractionations in the hydrous melting residues are very different to most cratonic peridotites, indicating greater PGE solubility in the higher fO2 melting environments that characterise modern subduction zones.

Overall, the properties of the Archean and post-Archean peridotites show that although ultra-depleted melting residues that share many compositional similarities have formed throughout geological time, these refractory compositions have been achieved via different melting mechanisms. The modern day ultra-depleted rocks represent subduction-related, water-fluxed melting conditions, whereas most cratonic peridotites are best accounted for by anhydrous melting process at various pressures. Combined, these data point to subduction being a minor process in the generation of buoyant viscous lithospheric mantle until the end of the Archean. We will also discuss the global implications of these implications for Archean geodynamics.