Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37372

Role of water and fO_2 in the stabilization and preservation of lithospheric mantle in continental collision zones: An integrated xenolith and modelling approach

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The liberation and circulation of volatile-bearing fluids at convergent margins profoundly modifies the physical and chemical properties of the lithosphere, such as its viscosity, melting behavior and ability to preconcentrate ore-forming metals. The Xing'an Mongolia Orogenic Belt (XMOB, also known as the eastern part of Central Asian Orogenic Belt), interpreted as representing a transitional stage of cratonization in previous studies, provides a unique perspective for investigating volatile-lithosphere interactions and their role in the long-term stability of continents.

Here we present a comprehensive geochemical and FTIR study of basalt-hosted peridotite xenoliths from the western XMOB. Geothermobarometry suggests significant lithospheric thickening, with the mantle keel locally extending up to ~60 km beyond its inferred initial thickness. Our previous modelling suggests that hydrous re-melting at convergent margins, coupled with the incorporation of ancient refractory lithospheric fragments, regulated the viscosity and buoyancy profile of the newly-formed keel by generating or adding refractory mantle domains, with compositional densities comparable to those of Archean and Proterozoic cratons. Indeed, the limited proportion of low-density mantle components alone appears insufficient to account for the subsequent survival of the lithospheric mantle during post-orogenic extension. Instead, elevated mantle viscosity ranging from 10^{19} to 10^{21} Pa·s, based on reconstructed H_2O contents in olivine of 7-32 ppm, likely becomes a critical factor favoring preservation. It does so by mitigating deformation and inhibiting delamination during later extensional or tectonothermal events, emphasizing the critical role of rheological strength in root preservation. The oxygen fugacity estimated for the spinel peridotites ($\Delta\log fO_2$(FMQ) = −0.6 to +0.6) is consistent with carbonate-stable conditions, and more oxidized relative to models of depleted peridotite, suggesting a subduction fluid-related increase in redox state, with the potential for storage of oxidized carbon in continental subduction zones. High fO_2, on the other hand, may facilitate H_2O uptake in olivine, highlighting the importance of water-fluxed melt removal in generating H_2O-undersaturated conditions and maintaining high lithospheric viscosity.