Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25756

Variable mantle redox states driven by deeply subducted carbon

MINGDI GAO[1], YU WANG[1], STEPHEN F. FOLEY[2] AND YIGANG XU[1]

[1]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
[2]Australian National University

Subduction processes transport significant amounts of carbonates into the reduced, Fe^0-bearing sublithospheric mantle (> 250 km), profoundly affecting mantle redox states and contributing to the formation of sublithospheric diamonds beneath cratons. Mantle redox states recorded in these diamonds are highly heterogeneous, whereas the driving force of the variation remains contentious. Here, we report high-pressure high-temperature reaction experiments conducted on slab-derived carbonatite melt and Fe^0-bearing peridotite at 9-21 GPa and 1450-1780°C under various redox conditions. By comparing experimental results with data from sublithospheric diamond inclusions, we infer that majorite and ferropericlase inclusions from the Amazonia Craton reflect a mixed oxidized to reduced, non-plume mantle environment, whereas majorite inclusions from the Kaapvaal Craton indicate a completely oxidized plume setting. In non-plume settings, carbonatite melts released from subducting slabs at depths of ~300-700 km are progressively consumed by redox freezing reactions with the Fe^0-bearing mantle during ascent, finally resulting in their fully reduction to diamond and Fe-C metal. Attachment of these reduced materials to the cratonic keel by mantle upwelling forms a carbon reservoir in the keel and enhances craton stability. In plume environments, carbonatite melts from subducting slabs induce reactive melting of the ambient mantle, surpassing the redox buffering capacity of Fe^0 and leading to a fully oxidized, CO_2-rich melt-bearing mantle that extends to the asthenosphere-lithosphere boundary. Impregnation of these melts into the lithosphere weakens the cratonic keel, resulting in lithosphere delamination, surface uplift, widespread volcanisms and CO_2 emission.