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The metallogenesis of the lithospheric mantle and its bearing on the Bushveld magmatic event: Evidence from lamprophyric dykes and critical metals in mantle xenolith sulphides

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In southern Africa, the geodynamic setting and source(s) of magmas that fed the Bushveld magmatic event remain unresolved – not least the controls on the metallogenic signature of this large igneous province (LIP). The Northern Limb is separated from the rest of the Bushveld Complex by the Thabazimbi-Murchison Lineament (TML), and the differences in the Bushveld metallogenic 'fingerprint' north (low Pt/Pd ratio) versus south (high Pt/Pd ratio) of the TML might signal interplay between a mantle plume and/or significant subcontinental lithospheric mantle (SCLM) melting. The shallow Kaapvaal SCLM keel should record the Bushveld magmatic perturbation and either reveal the SCLM as a major magmatic source itself or as a largely 'passive' lithospheric region which may contribute precious metals to ascending asthenospheric magma(s). The latter has been identified in the North Atlantic Igneous Province [1], and we suggest that this may also be applicable for the Bushveld LIP.

Lamprophyric parental magmas are thought to be produced by low-degree partial melting in the lithospheric mantle. Hence, spatial and temporal changes in lamprophyre composition potentially provide insights into the geochemical evolution of the Kaapvaal SCLM, through which the Bushveld magmas intruded. We present new data for the geochemistry and mineralogy of post-Bushveld lamprophyric dykes and Kaapvaal mantle xenoliths (garnet and spinel peridotites) that pre-date the intrusion, and from different blocks of the craton. Five main types of lamprophyric dyke are recognised based on mineralogical and textural differences. All dykes show a consistent terrane-scale trace element and metallogenic signature, closely resembling that of the Bushveld Complex itself and adjacent kimberlites. Critical metal ratios, such as Pt/Pd, are typically > 1 for lamprophyres from the Western Bushveld south of the TML, with a mean ratio of 1.79 ± 1.04 (2σ). This is significant in light of the Bushveld Pt/Pd range of 1.60 to 2.76 (south of the TML) and we suggest that this metallogenic signature is inherent to the SCLM itself. Hence, there appears to be an intrinsic link between the metallogeny of Bushveld LIP and the Kaapvaal SCLM underlying it.

Sulphides located at grain boundaries are likely to contribute significantly to partial melts formed in or passing through the SCLM [1]. By directly studying sulphides in mantle xenoliths suites from across southern Africa (including localities in proximity to the Bushveld Complex), we complement our lamprophyric study and holistically gauge the geochemical and metallogenic 'fingerprint' of this region. We observe that different mantle sulphide populations have distinctive critical metal abundances. For example, xenoliths from the Limpopo Belt contain sulphides strongly enriched in cobalt compared to other areas. This may be indicative of an oceanic subduction signature that 'pre-conditioned' the Limpopo SCLM during orogenesis c. 2.7-2.5 Ga (i.e., analogous to Co-enriched SCLM in southern Scotland [2]). This Co-rich SCLM was then remobilised during the Bushveld LIP, as indicated by high-Co sulphides in the Phalaborwa carbonatites [3]. We hope to gain a broader perspective for the spatial and temporal changes recorded by the lithospheric mantle, and thereby assess the causes for geochemical features pertaining to the 'pre-conditioning' of critical metals in certain geodynamic environments, later inherited by intracontinental LIPs such as the Bushveld magmatic event.

References:

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