Lamprophyric dykes in the Bushveld Complex: The lithospheric mantle and its metallogenic bearing on the Bushveld LIP

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In Southern Africa, the geodynamic setting and source(s) of magmas that fed the Bushveld Complex remain unresolved – not least the controls on the metallogenic signature of this large igneous province (e.g., Pt/Pd ratio) between Northern, Western and Eastern Limbs of the complex. The Northern Limb is separated from the rest of the Bushveld Complex by the Thabazimbi-Murchison Lineament (TML), and the differences in Bushveld metallogenic 'fingerprint' N *vs.* S of the TML might signal interplay between a mantle plume (asthenospheric-derived magmas) and/or significant subcontinental lithospheric mantle (SCLM) melting. We predict that the shallow Kaapvaal SCLM keel should record the Bushveld magmatic perturbation and either reveal the SCLM as a major magmatic source or as a largely 'passive' lithospheric region which may contribute precious metals to ascending asthenospheric magma(s).

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 provide insights into the geochemical evolution of the SCLM below the Kaapvaal Craton, through which the Bushveld Complex intruded. In the Western Limb, lamprophyric dykes regionally trend NE-SW to NW-SE and range in thickness from millimetres to > 20 metres. So far we have identified five main types of lamprophyric dyke but there is huge textural variation across these groups.

Lamprophyric dykes show a clear terrane-scale trace element and metallogenic signature, closely resembling that of the Bushveld Complex itself and adjacent kimberlites. For example, Pt/Pd ratios of lamprophyric samples are typically > 1, with a mean ratio of 1.79 ± 1.04 (2σ). This is significant in light of the Western Bushveld Pt/Pd range of 1.60 to 2.76. We suggest that this metallogenic signature is inherent to the SCLM source of parental magmas of the lamprophyres. Hence, there appears to be an intrinsic link between the Kaapvaal SCLM (per constituent block) and Bushveld magmatism.

On a practical level, lamprophyric dykes represent a major hazard to mining excavations and underground developments across various portions of the Bushveld Complex, particularly the Western Limb. Once exposed during operations, dykes frequently 'rot' within 24-48 hours, and this has led to multiple incidences of falls of ground and underground collapse. In addition, catastrophic blow-outs and wall rock failures caused by highly pressurised gas pockets have been documented in association with the dykes, resulting in serious injury and fatalities of mineworkers. The cause of lamprophyre decomposition is unclear although we would predict that it could reflect a specific vulnerability of certain mineral species to dissolution (e.g., carbonates or salts) or oxidation. By understanding the mineralogy and composition of the lamprophyric dykes we aim to identify the process(s) involved in their disintegration and thereby mitigate these dangerous working conditions.