An Apatite to Unravel Magma Chamber Dynamics, Mantle Sources and Metallogenesis in the Bushveld Complex

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The metallogenesis, magmas and mantle sources responsible for the formation of the Rustenburg Layered Suite (RLS) of the Large Igneous Province (BLIP) remain exceptionally controversial despite decades of research. Recent work using zircon and bulk-rock Lu-Hf isotope data show variations in isotopes and suggests that the BLIP intrusions were produced by the melting of several distinct reservoirs. We present systematic in situ Sr-Nd isotopic compositions, major (Cl, F, OH) and trace element abundances in apatite, from the coeval satellite intrusions, which include the Phalaborwa Complex, Marble Hall, Lindeques Drift, Roodekraal intrusions, Molopo Farms Complex and Uitkomst Complex. Understanding the geochemical properties of these intrusions is essential in providing insights into the metallogenesis of the BLIP. Advances in LA-MC-ICP-MS technology now enable detailed analysis of apatite geochemistry, providing new insights into magmatic processes. Apatite is capable of retaining important geochemical information and is a repository of REES. We provide a comprehensive in-situ data set for apatite from the BLIP using LA-MC-ICP-MS, Electron Microprobe, and a Tescan Integrated Mineral Analyser. Major element compositions show that Molopo Farm Complex is Cl-rich, while the Roodekraal intrusions, Marble Hall, Uitkomst Complex, Lindeques Drift and Phalaborwa Complex show variable F-rich apatite compositions. Trace element data, although variable for these intrusions, generally show a negative slope suggestive of LREEs enrichment consistent with the apatite trace element trends that have been previously reported for carbonatites and mafic-ultramafic rocks. Our in-situ Sr-Nd isotopes show that apatite from the different intrusions record variable initial isotopic compositions at 2.06 Ga for 87Sr/86Sr (0.7030 to 0.7130) and εNd (-10.2 to -2.5). The apatite data provide evidence of in situ Sr-Nd isotopic variability for these intrusions. On the basis of this new isotopic data, we provide insights into the magmatic processes involved in forming the BLIP.