The Significance of In Situ Sr-Nd in Apatite for Constraining Magma Sources and the Origin of Platinum Mineralisation in the Bushveld, South Africa

Peace Zowa, Ben Hayes, Grant M. Bybee
University of the Witwatersrand, Johannesburg, South Africa

The magma source(s), mode of magma emplacement, and metallogenesis of the Rustenburg Layered Suite (RLS) of the Bushveld Complex remain controversial despite decades of research. There is an agreement, however, that the RLS was formed through (1) the mixing of multiple pulses of magma in a chemically evolving magma chamber and (2) there was significant pre-emplacement crustal and/or lithospheric mantle contamination of the parent magmas. This is evident in bulk rock variations in Sr-Nd isotopes. On the other hand, Lu-Hf isotopes of accessory zircon show a limited range in εHf (at 2.06 Ga) of -8.6 ± 1.2 throughout the entire RLS. These homogeneous εHf isotopic values indicate decoupling between the major rock-forming silicates and the accessory minerals. The bulk rock Sr-Nd isotopic data therefore provide only a partial story about the solidification history of the RLS. Competing models have been suggested to explain the homogeneous εHf isotopic signature, including melting/contamination of asthenosphere-derived Bushveld magmas by the sub-continental lithospheric mantle and high-level crustal contamination of the RLS by fluids derived from the Transvaal Supergroup. Apatite is also an accessory mineral in the RLS that crystallised in close association with zircon. We analysed Sr-Nd isotopes in apatite using LA-MC-ICP-MS and show that apatite records homogeneous isotopic compositions (average initial $^{87}Sr/^{86}Sr$ of 0.7088 and εNd of ~-7 ± 1.4 at 2.06 Ga). Our Sr-Nd isotopic data in apatite corroborate the existence of isotopic decoupling in the RLS cumulates. We speculate on the origin of the isotopic decoupling with hypotheses including (i) melt percolation in the crystal mush that led to isotopic homogenisation of the trapped melt from which zircon and apatite crystallised and (ii) the emplacement of isotopically distinct cargoes of silicate crystals in an isotopically homogeneous carrier liquid during the emplacement of magmas into the RLS chamber.