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^{186}Os-^{187}Os and platinum group element evolution of the world's largest igneous intrusion

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Layered mafic-ultramafic rocks of the 2.05 Ga Bushveld Complex, South Africa, known collectively as the Rustenburg Layered Suite (RLS), represent the world's largest intrusion and currently provide 75% of platinum to the global economy. High-precision $^{186}Os/^{188}Os$, $^{187}Os/^{188}Os$, isotope dilution Re, platinum group element (Pd, Pt, Ru, Ir, Os) and major- and trace-element abundances are presented for ores of the RLS, namely the Merensky Reef (Impala Mine) and the lower, middle and upper chromitite horizons of the critical zone (Longmin, Impala, Tharisa and Zandfontein mines). The Merensky Reef has high total PGE contents (10 to 62 ppm) with weighted Pt/Pd of 6, and radiogenic measured $^{187}Os/^{188}Os$ (0.1704-0.1883) and $^{186}Os/^{188}Os$ (0.119902-0.120210). Critical zone chromitites have lower mean total PGE contents (~2.5 ppm), weighted Pt/Pd of 7.9, and generally less radiogenic measured $^{187}Os/^{188}Os$ (0.1202-0.1898) and $^{186}Os/^{188}Os$ (0.119832-0.120035). The new Re+PGE abundance and $^{187}Os/^{188}Os$ data confirm significant PGE abundance variations within the critical zone, and the general trend to more radiogenic $^{187}Os/^{188}Os$ up stratigraphy (e.g., [1]). The new $^{186}Os/^{188}Os$ data presented here represent the first bulk rock measurements for the Bushveld Complex. The generally radiogenic compositions of both the Merensky Reef and the critical zone chromitites reflect contributions from high-Pt/Os source(s) to their parental magmas, and do not require extremely low $^{186}Os/^{188}Os$ initials for RLS melts [2]. Instead, it is possible to explain the variations in ^{186}Os-^{187}Os in the Bushveld Complex in a similar way to the Stillwater, Muskox and Rum layered intrusions using calculated Os isotope crustal evolution growth models [3]. Limited and variable contributions from ancient high Pt/Os crust can explain the composition of high PGE rocks. These observations imply that significant PGE – and particularly Pt – enrichment in the Bushveld intrusion was driven by crustal contributions during the emplacement of the complex, and that these processes can lead to significant PGE fractionation within ores in layered intrusions, from high Pt/Pd in the RLS to low Pt/Pd in the Stillwater Layered Igneous Complex.

[1] Schoenberg, R., et al. (1999) EPSL, 172, 49-64; [2] Coggon, J.A., et al. (2012) Chem. Geol., 302, 48-60; [3] Day, J.M.D., O'Driscoll, B. (2019) EPSL, 519, 101-108.