Iron isotope systematics of the Bushveld Complex, South Africa

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Iron isotopes show systematic changes in igneous rocks that have been ascribed to fractional crystallization, partial melting, as well as, diffusion effects. Layered mafic intrusions, such as the Paleoproterozoic Bushveld Complex, are ideally suited to investigate stable isotope fractionation arising principally by fractional crystallization. The upper 2.1km of the Bushveld Complex (Upper and Upper Main Zone, UUMZ) crystallized from a basaltic magma produced by a major recharge event, building up a sequence of Fe-rich-gabbroic cumulate rocks that display systematic variations in mineralogy and mineral compositions consistent with fractional crystallization of a tholeiitic magma. Here, we present iron isotope measurements of bulk cumulate rocks, including (olivine) gabbros and gabbronorites, anorthosites and oxide-rich cumulates from the Bierkraal drill core of the UUMZ of the western limb. For a subset of the sample suite, pyroxene, olivine, magnetite, ilmenite and plagioclase separates were prepared and analyzed as well. Iron was chemically separated from its matrix and analyzed for δ^{56}Fe (relative to IRMM-014) with a Nu plasma MC-ICPMS at the University of California, Davis, using (pseudo-) high resolution and sample-standard bracketing. The δ^{56}Fe values of Bushveld cumulates span a range from 0.03 to 0.27 with the highest values corresponding to anorthosites and magnetite-rich cumulates, whereas most pyroxene-rich rocks have δ^{56}Fe values between 0.05 and 0.12. Preliminary results for mineral separates yield δ^{56}Fe values of 0.17 to 0.49 for magnetite, -0.02 to -0.28 for ilmenite, 0.00 to 0.13 for clinopyroxene, -0.02 to 0.12 for orthopyroxene, ~0.02 for olivine and ~0.40 for plagioclase, consistent with positive mineral – melt fractionation factors for magnetite and plagioclase, and near-zero to negative for pyroxenes, olivine and ilmenite. Consequently, variations in bulk rock δ^{56}Fe correlate strongly with modal mineralogy masking potentially systematic changes in δ^{56}Fe arising from fractionation crystallization. We present a forward model for the liquid line of decent of the Bushveld Complex that accounts for these observations.