Crustal-Lithospheric Processes Recorded at the 2.06 Ga Bushveld-Molopo Farms Igenous Complex

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Over the past ~3.6 Ga, the Kaapvaal Craton has experienced multiple episodes of crustal growth by extraction of large-volume melts from the mantle. The 2.06 Ga Bushveld Igneous Complex (BIC) comprises ~10^6 km^3 of magmatic materials. Several igneous suites were emplaced contemporaneously across southern Africa, including the Molopo Farms Complex (MFC) in Botswana. By comparing the BIC and MFC, we can explore aspects of Bushveld-age magmatism that have been poorly understood. This study combines petrographic observation and geochemical analysis to investigate the layered mafic suite at Molopo Farms. We find textural and chemical evidence in the uppermost layers for fluxing by a highly evolved residual magma. Thus, the MFC preserves a part of the magmatic process – separation and mobilization of a highly evolved liquid – that has been invoked but is poorly preserved in the BIC. In this aspect, the MFC can be interpreted as an illuminating microcosm of the BIC. Unlike the BIC, however, the MFC lacks extensive sulfide saturation and platinum group element enrichment. Multiple sulfur isotope systematics can provide insight into sources of sulfur in Bushveld-related magmas. Rocks from the BIC display non-zero $\Delta^{33}S$, evidence for incorporation of Archean surface sediments (either directly or in the form of subduction-modified mantle) containing sulfur that underwent mass-independent fractionation in the atmosphere prior to the Great Oxidation Event. Rocks from the MFC have distinctly less mass-independent fractionation of sulfur relative to the BIC, suggesting that the BIC samples a sediment-influenced sulfur source largely unseen by the MFC. Assuming that both the MFC parental magmas and the BIC parental magmas ultimately derive from the same asthenospheric mantle plume, this likely puts the source of Bushveld sulfur enrichment in the lithosphere. Evidence suggests that the source is somewhere other than the Transvaal sediments into which the intrusions were emplaced, possibly the lithospheric mantle or lower crust.