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Parental magma composition of the Main Zone of the Bushveld Complex: Evidence from in-situ LA-ICP-MS trace element analysis of silicate minerals in the cumulate rocks

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In-situ trace element analysis of cumulus minerals may provide a clue to the parental magma from which the minerals crystallized. However, this is hampered by effects of the trapped liquid shift (TLS). In the Main Zone (MZ) of the Bushveld Complex, the Ti content in plagioclase grains shows a clear increase from core to rim, whereas most other elements (e.g., rare earth elements (REEs), Zr, Hf, Pb) do not. This is different from the prominent intra-grain variation of all trace elements in silicate minerals in mafic dikes and smaller intrusion, which have a faster cooling rate. We suggest that crystal fractionation of trapped liquid occurred in the MZ of Bushveld and the TLS may have modified the original composition of the cumulus minerals for most trace elements except Ti during slow cooling. Quantitative model calculations suggest that the influence of the TLS depends on the bulk partition coefficient of the element. The effect on highly incompatible elements is clearly more prominent than on moderately incompatible and compatible elements because of different concentration gradients between cores and rims of cumulate minerals. This is supported by the following observations in the MZ of Bushveld: 1) positive correlation between Cr, Ni and Mg# of clinopyroxene and orthopyroxene, 2) negative correlation between moderately incompatible elements (e.g., Mn and Sc in clinopyroxene and orthopyroxene, Sr, Ba, Eu in plagioclase), but 3) poor correlation between highly incompatible elements and Mg# of clinopyroxene and orthopyroxene or An# of plagioclase. Modeling suggests that the extent of the TLS for a trace element is also dependent on the initial fraction of the primary trapped liquid, with strong TLS occurring if the primary trapped liquid fraction is high. This is supported by the positive correlation between highly incompatible trace element abundances in cumulus minerals and whole-rock Zr contents.

We have calculated the composition of the parental magma of the MZ of the Bushveld Complex. The compatible and moderately incompatible element contents of the calculated parental liquid are generally similar to those of the B3 marginal rocks, but different from the B1 and B2 marginal rocks. For the highly incompatible elements, we suggest that the use of the sample with the lowest

whole-rock Zr content and the least degree of TLS is the best approach to obtain the parental magma composition. Based on calculation, we propose that a B3 type liquid is the most likely parental magma to the MZ of the Bushveld Complex.