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Decoupling of Major and Trace Elements During the Intrusion of new Magma: The Main Zone of the Western Bushveld Complex

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The mafic rocks of the Bushveld Complex form a 6 km thick intrusion, and have been divided into the Marginal, Lower, Critical, Main and Upper Zones although their exact boundaries have been the subject of much debate. The >3000 m thick Main has occasional layered packages, although layering is not as spectacularly developed as in the other Zones. Towards the top of the Main Zone, just below the level of the Pyroxenite Marker (PM), a reversal in mineral compositions and initial Sr isotope ratio occurs which is considered to reflect the addition of new magma (Cawthorn et al., 1991; Kruger, 1994) This is perhaps the least equivocal case of magma addition within the entire Bushveld Complex, and as such has been investigated geochemically to constrain the timing of the magma influx and to investigate concurrent chamber processes. New whole-rock and mineral data from two profiles in the western Bushveld have been integrated with previous data to investigate lateral variation within the magma chamber during the magma influx.

Reversals in mineral composition from all sections show no significant lateral variation over a strike length of 80 km, with most evolved compositions being plagioclase An 62.0-63,6 and orthopyroxene Mg# 59.0-61.8, approximately 80 to 100 m below the PM. Ensuing least evolved compositions above the PM are 70.4-72.0 (An in plagioclase) and 66.9-70.7 (Mg# in orthopyroxene). Of specific interest is the difference between the Mg# of the pyroxene and the An in coexisting plagioclase. In a fractionating system with Fe- and Na- enrichment this difference should remain constant or reflect a gradual change, as is observed throughout most of the Main Zone and has been observed in other layered intrusions (Ashwal, 1993). For the western Bushveld, a relatively sharp break occurs in this number, changing from +3 to -5 over an interval of approximately 250 m, concurrent with the reversal in mineral composition. This break is consistent for all sections studied and again mitigates against any significant lateral variation over this strike length.

Reversals in certain trace-element whole-rock abundance are decoupled from, and occur some 40 m below the mineral reversal. For example whole rock Zr and Cr increase and K_2O is decreases with height, a change also reflected in Cr in ortho- and clinopyroxene. This decoupling of major- and trace- element geochemistry has not been recorded from the Main Zone of the Bushveld Complex before.

The major- and trace-element variations reflect the nature of the incoming magma which had lower Sr isotope ratios, and contains relatively more Zr, Cr and less K_2O than the residual magma within the chamber. The difficulty lies in explaining why effects of the incoming of magma as reflected by reversals in mineral composition and trace-element abundances occur at different stratigraphic levels. Because the rocks are all gabbronorites with adcumulate textures and modal proportions reflecting cotectic crystallisation mechanical redistribution of crystals is unlikely. This feature also argues against the entrainment of significant quantities non-cotectic proportions of crystals within the new magma as this would result in layering. Selective migration of trace-elements over 40 m is a possibility although why this should affect certain chemical components of a magma and not others is unclear.

A comparison between the eastern and western Bushveld reveals some differences. In the eastern Bushveld vertical profiles of the difference between the Mg# in orthopyroxene and the An in plagioclase are laterally more variable, although in most instances an increase in this value is seen close to the Pyroxenite Marker rather than the decrease observed in the western Bushveld.

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