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# The Bushveld Complex: an overview of its structure, concepts on its origin, age and outstanding controversial issues

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The Bushveld Complex in South Africa is the world's largest mafic/ultramafic layered intrusion containing vast resources of platinum, chromium and vanadium. It has been the subject of intense studies over the past 100 years and in spite of major advances in the understanding of the intrusion many old and new questions remain unanswered. In this talk we will attempt to provide a general overview of the mafic rocks of the Bushveld Complex, including their extent, stratigraphy and mineralization. Focus will be on the enigmas and recent developments in the understanding of the Bushveld Complex and controversies that have arisen.

The Bushveld Complex is an association of three main components: the felsic (and some mafic) lavas of the Rooiberg Suite, the mafic Rustenburg Layered Suite (RLS) and the Lebowa Granite Suite. Within the error of measurement all are of the same age, 2.05 Ga. The mafic and ultramafic rocks occur as five main lobes (probably interconnected) that extend for over 300 km in all directions, and together with outlying associated bodies extending as far as Botswana constitute at least 1 million $km^3$. Recent precise U-Pb ages determined on zircons show that the RLS was emplaced, solidified and cooled in less than 1 million years. While such a time-scale effectively rules out subduction-related models it raises the question of how such vast amounts of magmas with highly disparate compositions were produced in a very short time. The earliest magmas produced olivine and orthopyroxene compositions up to mg# 92 that are clearly indicative of a highly magnesian, chromian-rich and siliceous magma. Conventional modelling of high initial Sr and oxygen isotope ratios seem to require excessively large proportions of crustal assimilation, also in accord with trace element ratios. It is also likely that the initial emplacement events started as a series of separate magma compartments which merged at higher levels as the chambers filled.

One debate concerns whether emplacement occurred by way of crystal-rich slurries derived from depth (or even cascading from distant walls of the intrusion) or as essentially liquid. In the first model, grains were sorted and accumulated during horizontal flow, whereas the second model suggests grain growth within the chamber with either settling or in situ formation. Some extremely high-Mg olivines were probably emplaced as crystal slurries derived from the feeder conduits. Some packages of monomineralic layers show constant compositions, whereas most other units show clear evidence of systematic fractionation and episodes of magma replenishment. The lateral continuity of individual distinctive layers (such as chromitites, magnetitites and the platiniferous Merensky Reef) of near constant thickness and metal grade over hundreds of km is difficult to envisage in a slurry model requiring lateral flow.

Other pertinent questions relate to the amount of metal (specifically Cr and PGE) present throughout the RLS in relation to the volume of magma now preserved as mafic cumulates. This has necessitated the concepts of either a large eruptive volcanic component from the Bushveld magma chamber for which no evidence exists, or erosion of laterally more evolved rocks within the main body itself.

However, all such models depend crucially upon the (unknown) three-dimensional shape of the body (modelled as a planar sheet but more likely a wide cone). A third possibility is that large amounts of dense mafic cumulates at the base of the magma chamber may have foundered and subsided into the lower crust or upper mantle (see Arndt et al, 35th IGC Conference Abstracts).