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Cumulative deformation and original geometry of the Bushveld Complex

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ABSTRACT

A structural review and re-interpretation of the Bushveld Complex, based on 254 georeferenced maps from research, technical reports and geophysical surveys, suggests that its current geometry differs markedly from its original geometry. Broadly N–S flattening, left-lateral transpressional shearing along an interconnected fault network, steepening of cumulate layering and 10 km of uplift, to the north of the northern margin of the complex's main chamber, were accompanied by an eastward-verging escape structure (Burgersfort Bulge) and syn-cooling gap areas on its Western Limb. Southward-verging deformation was transmitted from the Villa Nora Fragment, via thrusting in the Rooiberg area, generating 50–70 km of southward displacement, uplift and erosional loss of the Northern Limb's western portion. A string of anomalous occurrences of Bushveld Complex units and dense areas outlined by unconstrained gravity isoshells suggest a further 170 km southward displacement through the center of the main chamber. The Southern Limb underwent predominantly right-lateral, ductile offset from the Western Limb along the Crocodile River and Rustenburg Faults, expressed by an in-line series of NNW-trending magnetic highs to the south of their mapped terminations. Left-lateral shearing and progressive splaying of a NNE-trending dyke swarm, to the west of an inflection point, provides strain markers for this offset and 35° anticlockwise rotation of the Burgersfort Bulge and central parts of the main chamber. Although recent work suggests that the complex cooled within 1 Myr, late-intrusion/syn-cooling, SSE-wards movement of its deeper, ductile, central parts, within at least 5–10 Myr after its initial intrusion, the Transvaalide Fold-and Thrust event and the expulsion of fluids to form the high-Ti igneous suite (HITIS) and related bodies, appear to have closely post-dated the complex's intrusion. Removal of the effects of cumulative strain produces a more equant complex, shortly after its intrusion, occupying an orthogonal network of normal faults and perpendicular, strike-slip, transverse faults.

1. Introduction

The Bushveld Complex has been the subject of an extensive research effort over the last 100 years. The main body of this large, layered igneous complex intruded, possibly due to intracratonic rifting (Eriksson et al., 1991; Eriksson and Reczko, 1995), into the volcano-sedimentary Pretoria Group of the late Archaean to early Proterozoic Transvaal Supergroup (Lenhardt and Eriksson, 2012; Fig. 1), with the complex's Northern Limb in contact with Archaean granite-gneiss basement. It outcrops over an area of > 65,000 km^2 (Cawthorn et al., 2006), has a total thickness of approximately 12,000 m (Eriksson et al., 2001) and is consequently the largest known body of its type. The complex essentially comprises a thick mafic component, the Rustenburg Layered Suite (RLS), a granitic component comprising the Lebowa Granite Suite (LGS) and the Rashoop Granophyre Suite (RGS). It is generally accepted that the complex intruded as a series of flat, sill-like sheets or fingers (Kruger, 2005; Clarke et al., 2009) between the overlying Rooiberg Group volcanics, dated at 2061 ± 2 Ma (Cawthorn and Walraven, 1998; Walraven, 1997) and the underlying Pretoria Group, consisting of a sequence of shales, secondary clastics and subordinate volcanics, and minor banded ironstones. It is only in the Northern Limb that there is a marked transgression across the Transvaal Supergroup (inset, Fig. 1). The Rooiberg Group volcanics, the extrusive component of the complex, are up to 6 km thick and represent one of the largest known provinces of silicic volcanic rocks, comprising a volume comparable to that of the RLS itself.

The complex's mafic component, the RLS, may be subdivided into five zones, from its base upwards, according to compositional changes (Cawthorn et al., 2006) and marker units. The Marginal Zone, with a maximum thickness of 250 m, comprises gabbronorite, norite and various metasediments (Vermaak and Hendricks, 1976; Kruger, 2005) and is considered to be a chill margin containing metasedimentary xenoliths at the complex's base (Kruger, 2005). The overlying Lower Zone shows significant thickness variations, probably due to sub-outcropping

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