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Structural analysis and implicit 3D modelling of Jwaneng Mine: Insights into deformation of the Transvaal Supergroup in SE Botswana

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ABSTRACT

Country rock at Jwaneng Diamond Mine provides a rare insight into the deformational history of the Transvaal Supergroup in southern Botswana. The ca. 235 Ma kimberlite diatremes intruded into late Archaean to Early Proterozoic, mixed, siliciclastic-carbonate sediments, that were subjected to at least three deformational events. The first deformational event (D_1), caused by NW-SE directed compression, is responsible for NE-trending, open folds (F_1) with associated diverging, fanning, axial planar cleavage. The second deformational event (D_2) is probably progressive, involving a clockwise rotation of the principal stress to NE-SW trends. Early D_2, which was N-S directed, involved left-lateral, oblique shearing along cleavage planes that developed around F_1 folds, along with the development of antithetic structures. Progressive clockwise rotation of far-field forces saw the development of NW-trending folds (F_2) and its associated, weak, axial planar cleavage. D_3 is an extensional event in which normal faulting, along pre-existing cleavage planes, created a series of rhomboid-shaped, fault-bounded blocks. Normal faults, which bound these blocks, are the dominant structures at Jwaneng Mine. Combined with block rotation and NW-dipping bedding, a horst-like structure on the northwestern limb of a broad, gentle, NE-trending anticline is indicated. The early compressional and subsequent extensional events are consistent throughout the Jwaneng-Ramotswa-Lobatse-Thabazimbi area, suggesting that a large area records the same fault geometry and, consequently, deformational history. It is proposed that Jwaneng Mine is at or near the northernmost limit of the initial, northwards-directed compressional event.

1. Introduction

Jwaneng Mine is host to at least four kimberlite diatremes that currently contain the single largest in-situ concentration of diamonds worldwide. The mine, located in south-central Botswana, approximately 120 km west of Gaborone (Fig. 1), contributes over 50% of the country's income. An understanding of the structural setting and deformational history of the Late Archaean to Early Proterozoic sedimentary succession that hosts the diatremes, is essential for safe, economic mining. This requires the construction of fully-constrained, 3D geological models of country rock surrounding the diatremes, which in turn require a robust structural interpretation that is based on pit mapping, geotechnical drilling and geophysical data. The resultant, detailed 3D model also provides a rare insight into the tectonic evolution of this part of Botswana and its similarities to mapped areas along-strike, at the Ramotswa-Lobatse area in Botswana and the Thabazimbi area in South Africa. This is particularly significant as the area is covered by deep, laterally-extensive clay and calcrete of the Kalahari Group, which does not permit surface mapping.

2. Regional geology

The country rocks in which Jwaneng Mine is hosted are late Archaean to Early Proterozoic, mixed siliciclastic-carbonate sediments of the Transvaal Supergroup. The Transvaal Supergroup is preserved within three structurally-constrained basins on the Kaapvaal craton of southern Africa: the Transvaal and Griqualand West Basins in South Africa and the Kanye Basin in Botswana (Altermann and Wotherspoon, 1995; Eriksson and Altermann,

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