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Structural Analysis and Implicit 3D Modelling of High-Grade Host Rocks to the Venetia Kimberlite Diatremes, Central Zone, Limpopo Belt, South Africa

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10 11 Abstract

12 The Beit Bridge Complex of the Central Zone (CZ) of the Limpopo Belt hosts the 519±6 Ma Venetia kimberlite
13 diatremes. Deformed shelf- or platform-type supracrustal sequences include the Mount Dowe, Malala Drift
14 and Gumbu Groups, comprising quartzofeldspathic units, biotite-bearing gneiss, quartzite, metapelite,
15 metacalcisilicate and ortho- and para-amphibolite. Previous studies define tectonometamorphic events at 3.3-
16 3.1 Ga, 2.7-2.5 Ga and 2.04 Ga. Detailed structural mapping over 10 years highlights four deformation events
17 at Venetia. Rules-based implicit 3D modelling in Leapfrog Geo™ provides an unprecedented insight into CZ
18 ductile deformation and sheath folding. D₁ juxtaposed gneisses against metasediments. D₂ produced a
19 pervasive axial planar foliation (S₂) to isoclinal F₂ folds. Sheared lithological contacts and S₂ were refolded into
20 regional, open, predominantly southward-verging, E-W trending F₃ folds. Intrusion of a hornblendite protolith
21 occurred at high angles to incipient S₂. Constrictional-prolate D₄ shows moderately NE-plunging azimuths
22 defined by elongated hornblendite lenses, andalusite crystals in metapelite, crenulations in fuchsitic quartzite
23 and sheath folding. D₄ overlaps with a: 1) 2.03-2.01 Ga regional M₃ metamorphic overprint; b) transpressional
24 deformation at 2.2-1.9 Ga and c) 2.03 Ga transpressional, dextral shearing and thrusting around the CZ and d)
25 formation of the Avoca, Bellavue and Baklykraal sheath folds and parallel lineations.

26
27 *Keywords: Venetia Mine; Limpopo Belt; Central Zone; High Grade; Implicit; 3D modelling*

28 Introduction

29 Venetia Mine, in production since 1992, is situated 75km west of Messina in the Limpopo Belt of
30 South Africa and is currently in open pit operation with pit base expected at approximately 500m,
31 after which the mine will commence with underground mining. The ca. 520 Ma Venetia kimberlite
32 diatremes of the Limpopo Province of South Africa have been the focus of intense research,
33 particularly since the commencement of full-scale mining in the early 1990's (e.g. Allsopp *et al.*,
34 1995; Phillips *et al.*, 1999; Smith and Barton, 1995; Seggie *et al.*, 1999; Kurszlaukis and Barnett, 2003;
35 Brown *et al.*, 2009; Richardson *et al.*, 2009). Regional geological mapping has established the
36 framework of metamorphic and structural events of the Central Zone of the Limpopo Belt (Brandl,
37 2000, 2002; Klemd *et al.*, 2003; van Reenen *et al.*, 2004; Rigby *et al.*, 2011) which form the context
38 for mine-based studies (e.g. Barnett, 2003; Doorgapershad *et al.*, 2003; Barton *et al.*, 2003).

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