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The structural, metamorphic and temporal evolution of the country rocks surrounding Venetia Mine, Limpopo Belt, South Africa: Evidence for a single palaeoproterozoic tectono-metamorphic event with implications for a tectonic model

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ABSTRACT

This paper presents the results of a detailed and fully integrated pressure–temperature–time-deformation (P–T–t-D) study of the country rocks around Venetia Mine in the Central Zone of the Limpopo Belt, South Africa. Detailed structural mapping around Venetia Mine delineates four deformation events (D_1–D_4). Relict S_1 comprises quartzofeldspathic bands in biotite gneiss and amphibolite. S_2, defined by biotite in biotite schist, gneissic banding in biotite gneiss, long axes of quartzofeldspathic augen, and the long axes of amphibolite lenses/boudins, is axial planar to F_2. F_3 occurs predominantly at the contacts between biotite gneiss and biotite schist, forming open to closed, upright to inclined, E-W- to ENE-trending, shallowly plunging folds. D_4, which was constrictional-prolate in nature, refolded S_1, S_2, F_2 and F_3. F_4 folds and an L_4 mineral lineation, defined predominantly by sillimanite in metapelitic schist, plunge moderately NE to NNE and overprint all previous fabrics. Poles to refolded S_2 foliations show a characteristic great circle distribution. In turn, the pole to this great circle coincides with the orientation of L_4. Such patterns are also found in the Avoca, Bellevue and Ha-Tshansi sheath folds in the Central Zone, albeit that the plunge of the lineations at Venetia are predominantly NE-wards, rather than SW-wards. The moderately NE- to NNE-plunging F_4 sheath folds and L_4 lineations accord with the NE-SW trend of sheath folds and associated mineral elongation lineations observed elsewhere in the Central Zone. However, PbSL dating of syntectonic garnets constrain the minimum and maximum age of D_2 and D_4 structures respectively to c. 2037–2040 +/− 22 Ma. The metamorphism developed in metapelitic lithologies is characterized by peak amphibolite facies conditions of ~6.5 kbar and 680 °C. Pseudosection modelling of growth zoning in garnet provides evidence of a prograde pressure and temperature increase from ~5 kbar at 600 °C to ~6–6.5 kbar at 650–680 °C, which is interpreted to be a consequence of tectonic thickening. Collectively, the integrated P–T–t-D data unequivocally demonstrates that the country rocks around Venetia experienced a structural–metamorphic event in the palaeoproterozoic. Coupled with published data we suggest a simple two-fold tectonic model, which involves the Central Zone as separate terrane docking with the Kaapvaal during the Neoarchean and later, during the Palaeoproterozoic this Central Zone-Kaapvaal amalgam collides with the Zimbabwe Craton.

1. Introduction

The construction of detailed and well-constrained pressure–temperature–time (P–T–t) paths is crucial in deciphering the tectonic evolution of orogenic belts. In complexly deformed and potentially polymetamorphic Precambrian terranes the interpretation of P–T–t data is often fraught with difficulty (Van Reenen et al., 2008; Eriksson et al., 2010). This is exemplified primarily by the Limpopo Belt of southern Africa, which has a long and protracted magmatic and metamorphic evolution extending from ~3.2 Ga to 2.0 Ga (Rigby et al., 2008a). The major events affecting the Central Zone of the Limpopo Belt include the formation and subsequent anatexis of the Sand River Gneiss at 3.24–3.12 Ga (Zeh et al., 2007; Gerdes and Zeh, 2009; Zeh et al., 2009), structural, metamorphic and magmatic events at

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