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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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The highly deformed Beit Bridge Complex of the Central Zone of the Limpopo Belt forms the host rocks to the ca. 519±6 Ma Venetia kimberlite pipes. The complex locally consists of a highly deformed shelf- or platform-type supracrustal sequence, subdivided into the Mount Dowe, Malala Drift and Gumbu Groups. These groups contain varying proportions of interlayered quartzofeldspathic units, biotite-bearing gneiss, quartzite, metapelite, metacalcsilicate and ortho- and para-amphibolite. The Central Zone underwent metamorphic events at approximately 3.3-3.1 Ga, 2.7-2.5 Ga and 2.04 Ga. Detailed structural mapping and analysis of the Venetia Mine over a total of ten years suggests that there are at least four major deformation events which may be correlated with regional events in the Central Zone, terminating in the development of sheath folds and a strong prolate fabric. The first deformation event is poorly constrained, but probably involved the tectonic juxtaposition of a suite of gneisses against a metasedimentary succession. The second deformation event involved the development of a pervasive axial planar foliation (S_2) to isoclinal F_2 folds throughout the volume of interest. Sheared lithological contacts and S_2 were subsequently refolded into regional-scale, open, predominantly southward-verging, E-W trending F_3 folds, which are accompanied by sporadic development of an S_3 axial planar fabric. The intrusion of the protolith to amphibolite/hornblendite occurred during D_1-D_3, at a high or obtuse angle to the incipient S_2 fabric. The final deformation event or D_4 is constrictional or prolate in nature, with a moderately NE-plunging azimuth. This formed elongated amphibolite and hornblendite lenses, aligned andalusite crystals in metapelite, a strong crenulation in fuchsitic quartzite and sheath folding, similar to the Avoca, Bellevue and Baklykraal sheath folds. The robust set of mapping data, along with diamond drilling, has allowed the definition of distinct domains, each with their own structural geometry and dominant lithologies. Application of rules-based implicit modelling (Leapfrog Geo™) to this comprehensive data set accurately reproduces the 3D geometry of these upper-amphibolite to granulite facies, complexly-deformed country rocks and provides a rare insight into the nature of ductile deformation and sheath folding in the Central Zone. This 3D model has been subsequently used for slope design and pit analysis for the creation of a super-pit and for forthcoming underground development.