



3D Fabric analysis of Venetia Mine, South Africa: Using structural measurements and implicitly-modelled surfaces for improved pit slope design and risk management

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ABSTRACT

The geometry and structural history of high-grade granite-gneiss units, which host the Venetia diatremes in South Africa, have been modelled in 3D using an implicit, rules-based, conditional geometrical technique. The volume contains a pervasive, dominant foliation, which forms the main plane of strength anisotropy in ongoing design and mining of the Venetia pit, which has a planned final depth of approximately 465 m below surface. The well-developed S_2 foliation is a continuous feature that was locally re-oriented during D_3 and D_4 and localised ‘wrapping’ around competent amphibolite/hornblende lenses or boudins. These local variations have important implications for pit design and operational risk management, particularly where they dip adversely out of the slope, or occur at the base of bench stacks, or in inter-ramp areas. These structures, when undercut by dips steeper than their friction angle, may result in planar sliding, presenting an operational safety risk. Best practice requires early identification of these occurrences, to make design adjustments where warranted. Lithological contacts, which have been transposed into parallelism with the S_2 foliation, and a robust set of structural data collected over the last 10 years, are analysed to quantify and represent the variable orientation of S_2 in 3D space. This contribution describes several methods, using leading software packages such as Leapfrog Geo™, Micromine™ and Python, to generate representative S_2 form surfaces and anisotropy block models, both of which are used for downstream geotechnical engineering analysis. Outputs are also translated into apparent dip “heat” maps that show the angular interaction between S_2 foliation and a pit design surface. These methods augment, and lessen the dependence on, typical 2D wedge-shaped design sectors that are commonly employed in pit design. This approach has important safety and economic benefits. As the rock mass fabric is characterised, it supports quick identification of potentially higher-risk areas (e.g. adverse undercut fabric with greater likelihood of slope instability) in current mine plans, which justifies more detailed analysis and/or additional monitoring controls to ensure safe and efficient mining. It also allows rapid mine design optimisation.

1. Introduction

Venetia is a large open pit diamond mine that has been in production since 1992. It is situated 75 km west of Messina in the Limpopo Province of South Africa (Fig. 1). Pit base is expected at approximately 465 m below surface (mbs) with concomitant development of under-

ground infrastructure. For much of its earlier development, Venetia underwent numerous design and mining phases, each based on traditional geotechnical approaches that relied on explicitly-built, geometrical models (e.g. Barnett, 2003). In a standard slope design process, data from geological, structural, rock mass and hydrogeological models are used to formulate and populate a geotechnical model or a series of

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