



Ore-structure relationships at Sishen Mine, Northern Cape, Republic of South Africa, based on fully-constrained implicit 3D modelling



I.J. Basson^{a,d,*}, C.J. Anthonissen^a, M.J. McCall^a, B. Stoch^a, J. Britz^c, J. Deacon^b, M. Strydom^c, E. Cloete^b, J. Botha^b, M. Bester^c, D. Nel^c

^a Tect Geological Consulting, Unit 3 Metrohm House, Gardner Williams Ave, Somerset West, South Africa

^b Sishen Iron Ore Company (Pty) Ltd., Private Bag X506, Kathu 8446, South Africa

^c Kumba Iron Ore, Corporate Office, Centurion Gate, 124 Akkerboom Road, Centurion, 0157, South Africa

^d Department of Earth Sciences, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa

ARTICLE INFO

Article history:

Received 14 February 2017

Received in revised form 24 March 2017

Accepted 6 April 2017

Available online 8 April 2017

Keywords:

Maremane Dome
Transvaal Supergroup
Sishen
Implicit 3D modelling
Structural control

ABSTRACT

A fully-constrained, implicit, 3D geological model of Sishen Mine reveals the original, pre-mining geometry of ore bodies, host rocks to mineralization and major structures. There are several overlapping controls, at a variety of scales, on the position, depth and geometry of laminated and conglomeratic ore. Most of these controls are structural or may be reconciled with the kinematic history of this part of the Maremane Dome. A series of near-horizontal sections, through the entire 3D model, demonstrates the manner in which these controls overlap and interact. First-order or large-scale controls comprise broad domes, which show preservation of laminated ore around their rims, outside of which conglomeratic ore occurs. Second-order controls comprise grabens and half-grabens, which are often bounded by strike-persistent normal faults, which show fault drag on their western flanks due to inversion, along with preservation of BIF-related supergene ore and conglomeratic ore. A type example is the thick, deep, linear ore to the west of the Sloep Fault. Third-order controls on the preservation of mineralization comprise downthrown blocks to the north of reactivated E-W, SE/ESE- or NE/ENE-trending conjugate faults. Uplift to the south could be attributed to the 1.15–1.0 Ga NNW-directed Lomanian (Namaqua-Natal) Orogeny. Palaeosinkholes comprise fourth-order controls, which are superimposed on higher-order controls. Palaeosinkholes, which form the bulk of current mining, comprise deep, conical depressions with anomalous thicknesses of chert, chert breccia and haematite. Due to their limited size, the steepness of all units and the often chaotic nature of detached and slumped blocks in their centres, these volumes reflect longstanding models on palaeosinkhole development and very local ore control.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

Sishen Mine is the largest iron ore mine in the Republic of South Africa. It is situated on the northern end of a range of hills, with 60 km of strike along the western limit of the Maremane Anticline or Maremane Dome, which contains lithologies of the Transvaal and Olifantshoek Supergroups (Fig. 1). The origin of iron mineralization has been attributed to several processes or models: supergene (Wagner, 1921; Boardman, 1948), “ancient” supergene (Beukes, 1983; Beukes et al., 2002), magmatically-driven mineralization (e.g. De Villiers, 1944) and metasomatic-hydrothermal mineralization with a supergene overprint (Du Preez, 1944; Strauss, 1964; Van Deventer et al., 1986; Beukes et al., 2002). The

bulk of laminated and massive ore and most of the high-grade haematite at Sishen occurs in the Kuruman Formation of the Asbestos Hills Subgroup. This is commonly cited as a Lake Superior-type banded iron formation within the lower parts of the Griqualand West Supergroup. Relatively lower-grade, often conglomeratic or clastic ore of the Gamagara Subgroup overlies this banded iron formation. Very thick intervals of collapsed, brecciated or clastic ore occur locally in deep palaeosinkholes in the karstic topography of Campbell Rand Subgroup dolomite (Carney and Mienie, 2003; Hagemann et al., 2008; Smith and Beukes, 2016).

Despite the size and economic importance of Sishen Mine, publications that address its structural evolution and setting, based on direct observations in operational sub-pits, are limited. Contributions by Van Schalkwyk (1984), Van Schalkwyk and Beukes (1986), Alchin and Botha (2005), Friese and Alchin (2007) and Carney and Mienie (2003) primarily address ore mineralogy, ore

* Corresponding author.

E-mail address: ianbasson@tect.co.za (I.J. Basson).