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3D reflection seismic data constraints on the timing of faulting in the upper crust: implications for the origin of gold deposits in the Proterozoic Transvaal Supergroup, South Africa

Musa Manzi (1), Raymond Durrheim (1), Glenn Nwaila (1), Kim Hein (1), Hartwig Frimmel (2), Roger Gibson (1), and Nick King (3)

(1) School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa (musa.manzi@wits.ac.za), (2) Bavarian Georesources Centre (BGC), Institute of Geography and Geology, University of Würzburg, Am Hubland, D-97074 Würzburg, Germany, (3) Gold Fields Ltd, South Africa

We have re-processed high-resolution 3D reflection seismic data from the West Wits Line and West Rand goldfields (South Africa) and combined it with underground mapping observations. First-, second-and-third-order-scale fault and dyke structures offset the Black Reef Formation (BRF), a distinct seismic reflector that acts as a marker horizon for the gold-bearing conglomerates that are found at the base of the NeoArchaean-Palaeoroterozoic Transvaal Supergroup. The BRF is of considerable economic and academic interest since it contains payable concentrations of gold, especially in areas where it lies adjacent to the Witwatersrand Supergroup's gold-bearing conglomerates.

The structural mapping resolution was maximized by reprocessing the data using advanced processing techniques (Manzi et al., 2015), enhancing the detection of faults with throws as small as 2-5 m. The results allow us to constrain the timing of tectonic activity affecting the BRF and the intrusion of dykes, which can be used to provide information that may be useful in answering some of the longstanding questions regarding the origin of the gold in the BRF (Phillips and Law, 1994; Frimmel et al., 2005). The BRF dips 5-15° N and is cut by shallowly S-dipping faults with mostly normal dip-slip (up to 30 m), although 10% show reverse-slip (< 5 m). Faults are heterogeneously distributed and locally form networks.

Economic gold concentrations occur almost exclusively in coarse-grained siliciclastic rocks that reflect a variety of fluvial lithofacies. Underground mapping confirms that background gold grades of 5-7 g/t in the BRF are locally enhanced to 25-50 g/t along essentially stratabound quartz-pyrite-gold veins and some dispersion is noted within 1-2 m of faults. Conversely, calcite veining lacks Au mineralisation. The largest faults are characterised by depletion of Au in the BRF, and smaller faults show relatively narrow alteration haloes. The presence of native Au associated with pyrobitumen-uraninite-brannerite nodules in the BRF indicates earlier fluid infiltration. Regional studies provide several possible explanations for this polyphase structural and hydrothermal history. These include (1) a thrust–fold event at ∼ 2.2 Ga (Dankert and Hein, 2010), (2) emplacement of the Bushveld Complex and related mafic sills into the Transvaal Supergroup, with accompanying deformation and metamorphism, at 2.06 Ga, (3) post-Bushveld (∼2.04 Ga) N-verging thin-skinned thrusting and folding (Alexandre et al., 2008), (4) complex deformation and hydrothermal activity linked to the Vredefort impact event at ∼2.02 Ga, and (5) emplacement of the Pilanesberg Complex and dyke swarm (∼1.30–1.10 Ga). Some of these events led to the formation of several post-depositional faults and facture networks, creation of secondary permeability, large fluxes of aqueous fluids and considerable element mobility (Phillips and Law, 1994; Stevens and Preston, 1999; Frimmel et al., 2005). Our results suggest that N-directed thrusting may be related to (1) or (3) and low-angle normal faulting to the formation of the Vredefort crater (4). Ongoing work aims to evaluate the nature of the hydrothermal effects related to the structures and to further constrain the mineralisation model for the BRF.

Keywords. Transvaal Basin, Black Reef Formation, Gold, 3D Seismics