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Data integration for structural interpretation in the Bushveld Complex

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Introduction

Structure appears to be of secondary importance to the Bushveld Complex when viewed from a distance. However, a closer look already reveals that large fault zones bound the Bushveld Complex. These fault zones are deep-seated crustal lineaments of continental magnitude such as the Thabazimbi-Murchison Lineament, the Johannesburg-Barberton Lineament, the Palala Fault zone and the Rustenburg fault. Furthermore, the Bushveld Complex is transected by large faults such as the Vlakfontein Fault, visible in the Pilanesberg, the Steelport Fault and the Laersdfrift Fault in the Eastern Bushveld, the Brits Graben, and a multitude of dyke generations (Figure 1).

When pursuing structures on a project scale, the lack of outcrop, particularly in the western part of the Bushveld, is of no help for the exploration geologist. Consequently, the first dataset that needs to be considered is the Landsat imagery. Older Landsat TM 5 or newer Landsat ETM 7 will immediately reveal areas of outcrop for field visits, and, after further processing, indicate the geological units, in particular the platiniferous Critical and the Main Zone of the Rustenburg Layered Suite (Figure 2).

Airborne magnetic surveys are the subsequent dataset necessary for any decent interpretation of the geology under the 'Black Turf' cover. Currently Anglo Platinum acquires aeromagnetic surveys with a flight height of 20 m and a line spacing of 50 m. These result in high-resolution imagery absolutely crucial for dyke delineation and dip modelling, stratigraphic layer detection, IRUP detection and possibly pothole discovery and fault delineation (Figures 3 and 4).

However, the aeromagnetic surveys and the Landsat imagery reveal structures very much confined to the surface and may be hundreds of metres above the platiniferous reef horizons. This may lead to inaccuracies.

When determining the underground structures for shaft sinking and mine planning, a 3D seismic survey is advisable. Too many shafts have been sunk in the Witwatersrand Basin for gold and in the Bushveld for platinum without sufficient information of the structure beneath. Recent 3D seismic surveys in the Bushveld have proven the technology and visualized the reef horizons and led to an interpretation of the underground structure (Figures 5 and 6).

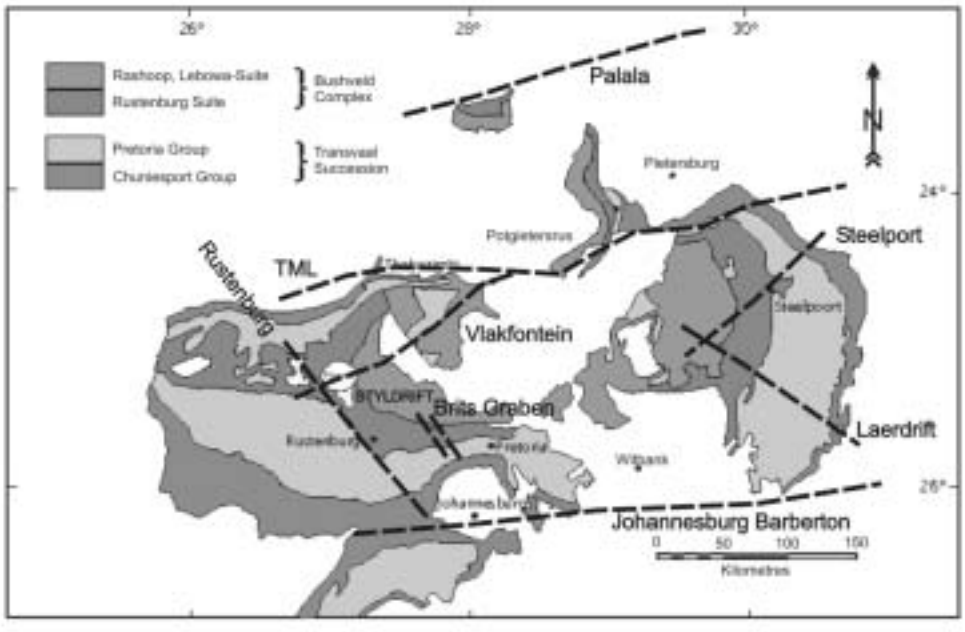

Figure 1. Map showing the Bushveld Complex and the major faults bounding and transecting it

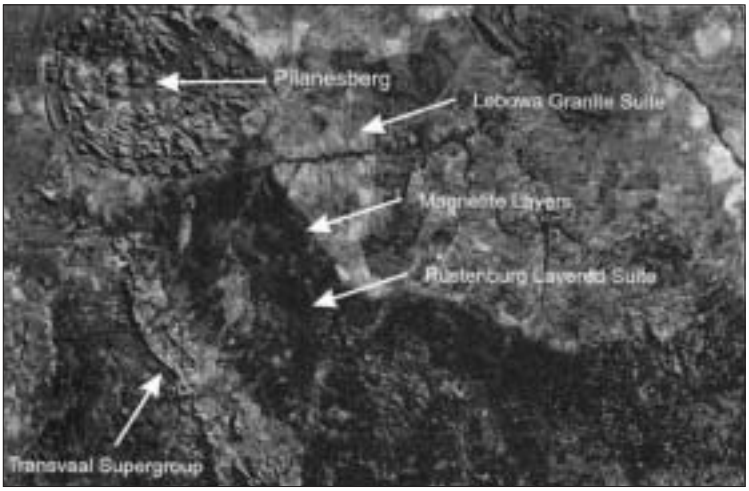

Figure 2. Landsat imagery over the southwestern Bushveld Complex. Geological mapping utilizing Landsat:

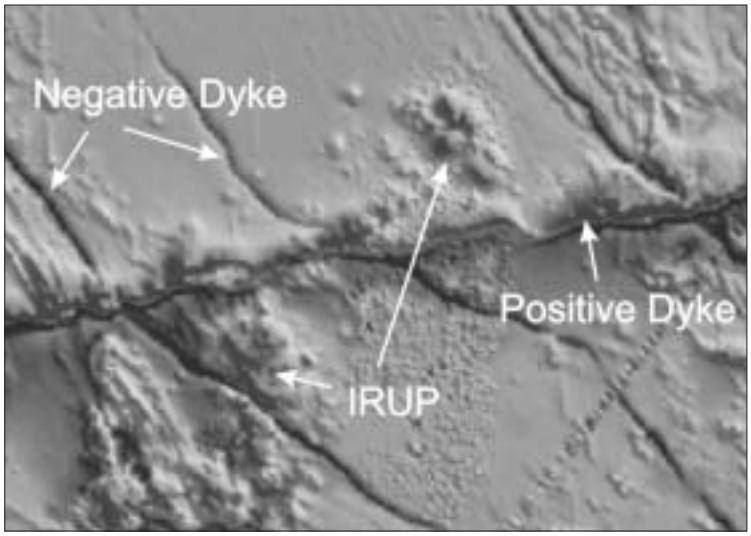

Figure 3. Total Field Magnetics displaying positive and negative dykes, and Fe-rich ultramafic replacement pegmatoids (IRUPs)

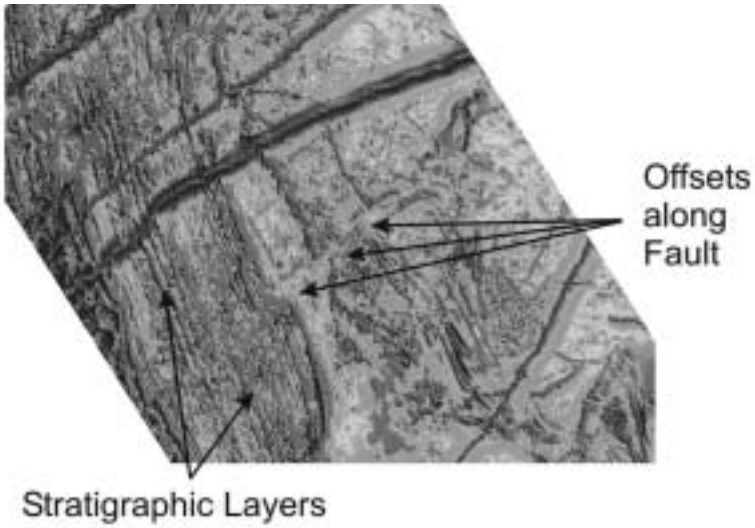

Figure 4. Different stratigraphic layers display different magnetic susceptibility. The layers strike NW-SE and are clearly offset by a NE-SW striking fault

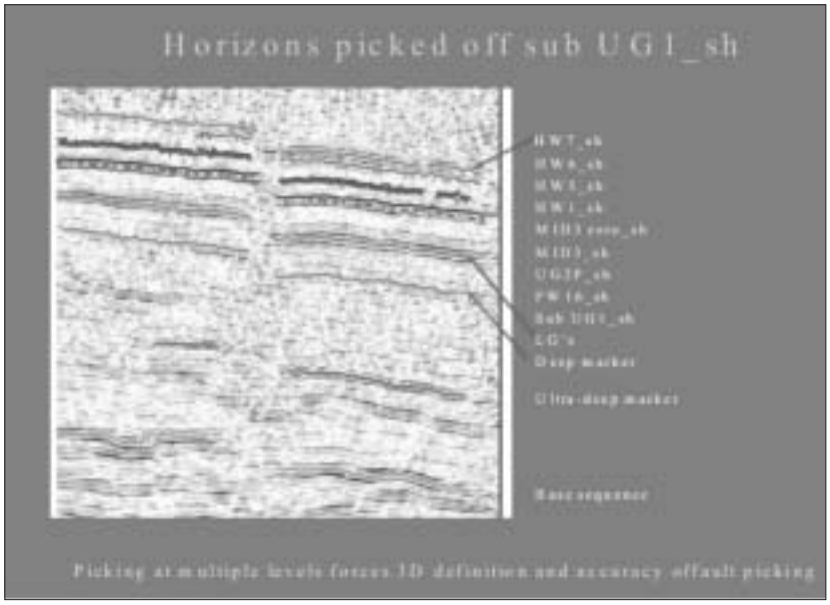

Figure 5. A seismic section with a number of identified horizons traced

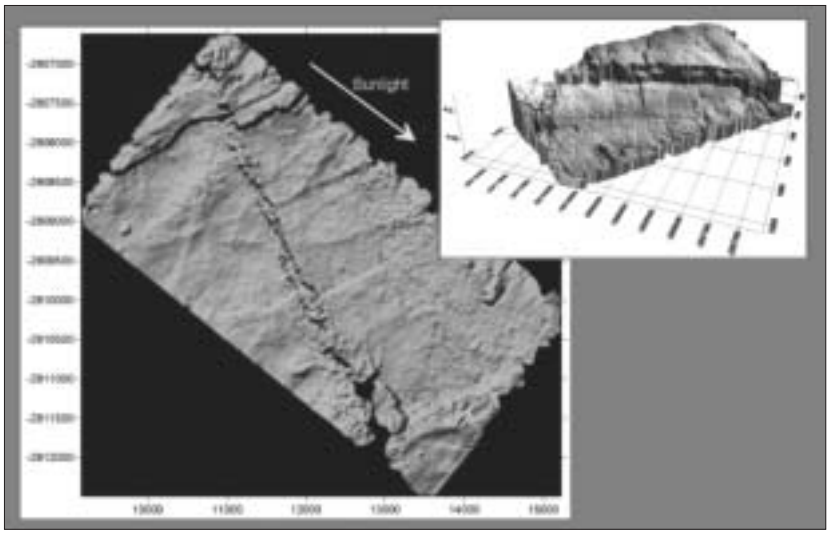

Figure 6. Sunshaded 3D model of the UG2 horizon. Clearly visible is a 100 m downthrow fault

The interpretation of the 3D seismic dataset has to be integrated with the interpretations of the aeromagnetic and Landsat derived information. Seismic data visualizes the tabular horizon underground, but cannot directly image steep faults and dykes. These need to be complemented from the previous datasets mentioned above (Figures 7 and 8).

The final result is a structural orebody model, displaying reef elevations, fault planes, dykes, IRUPs and possibly potholes in 3D. This model will then be tested by diamond drilling and verified by field observations on fault and dyke outcrops, where measurements will confirm or disprove the geophysically derived interpretations. The final model will then be utilized to place shafts correctly (safely) and plan the mining of the orebody over its entire life-of-mine.

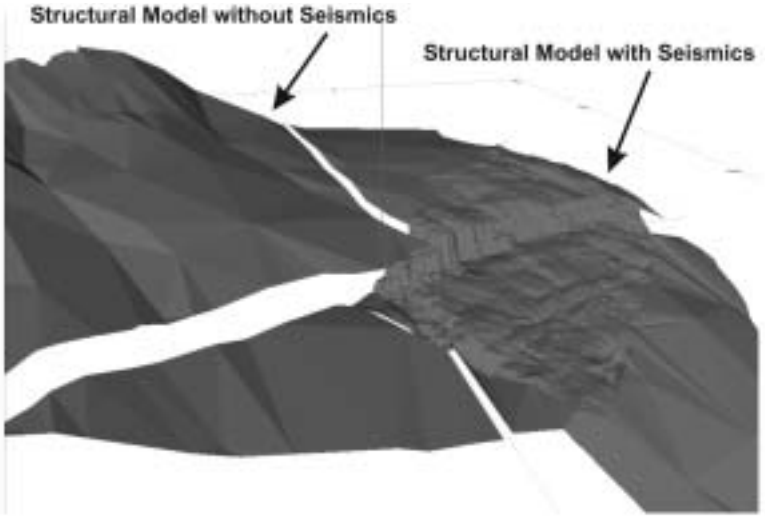

Figure 7. 3D target horizon model with and without seismic data. Huge resolution contrast in favour of seismic data

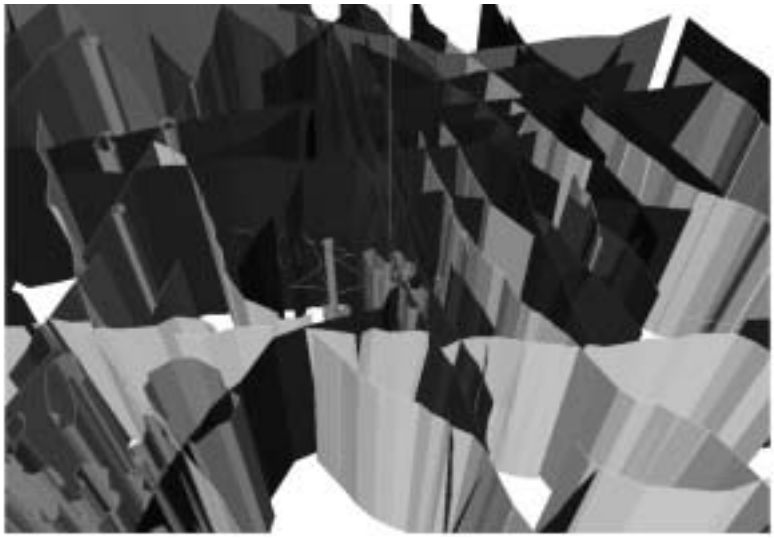

Figure 8. 3D structural model with faults (dark grey), dykes (light grey) and IRUPs (grey) modelled from surface down to the reef horizon