Paper Number: 5271

3D Geophysical modelling of the Bethlehem Sub-Basin, Free State, South Africa

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The small town of Bethlehem is situated in the Free State Province, South Africa, the area first became of interest during the search for gold-bearing strata below thick Karoo sediments due to a prominent gravity high, known as the "Bethlehem High". The Geology of the Bethlehem region is divided chronologically into the basement Archean granite, overlain by the Witwatersrand Supergroup, the Ventersdorp Supergroup and covered by the Karoo Supergroup [2]. For this study, we considered an area centred on the town of Bethlehem, extending 100 km around the town, which includes the gravity high. Geophysical techniques such as gravity, magnetics, 2D reflection seismic surveys and boreholes were used to search for gold in the Witwatersrand conglomerate bearing horizons within the Bethlehem region. Thus there is a wealth of data that can now be integrated in this study.

Interest in the Bethlehem gravity anomaly was heightened after a dark linear shadow was discovered in the 1970's Landsat images which correlated with the Bethlehem gravity high. The dark linear shadow was said to be caused by rain patterns due to its NW-SE trend [3]. Investigations into the gravity anomaly coincided with an exploration boom for gold and uranium, which continued until the early 1990s. Investigations revealed that the Bethlehem gravity anomaly is due to a sub-basin which was a structurally controlled remnant of a much bigger sedimentary sequence. Unfortunately, investigations also revealed little mining potential and further study in the area was stopped [1].

This study integrates 2D reflection seismic data collected in the 1980's, with gravity, magnetic and borehole data to create and constrain a 3D geological model of the Bethlehem Sub-basin. This integrated approach provides a more accurate representation of the geology and structures below the 1 km thick Karoo Sediments in the Bethlehem region.

The results shows a N-S trending normal fault, which has uplifted the Archean granite basement on the eastern side of the sub-basin, with a maximum throw of 2.5 km. The Archean granite basement is covered by West Rand Group shales and Central Rand Group Quartzites of the Witwatersrand Supergroup; this sequence is overlain by Klipriviersberg lavas of the Ventersdorp Supergroup which is followed by Dwyka and Ecca sandstones and shales of the Karoo Supergroup. The model shows two first order faults which have uplifted the West Rand Group shales, as well as smaller faults which have displaced the Central Rand Group quartzites and Klipriviersberg lavas.

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