3D Geometry of the Xade Complex

Inferred from Gravity and Magnetic Data

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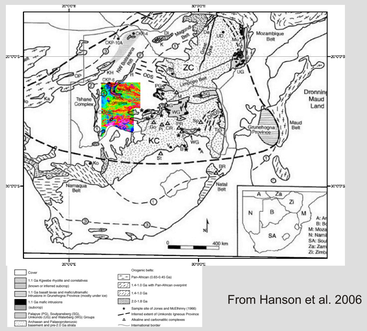
Exploration07

Abstract

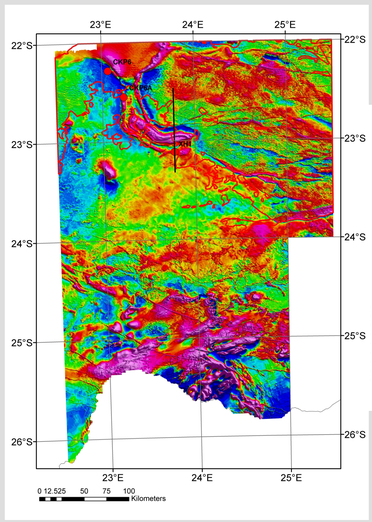
The Xade complex is an unexposed Y-shaped body, approximately 100 km long and 25km wide, located close to the western margin of the Kaapvaal craton in Botswana. The complex is characterized by large coincident magnetic and gravity anomalies. It is completely covered by varying thicknesses of Kalahari sediments as well as by Karoo strata, which means that detailed analysis of high resolution airborne magnetic data, ground gravity data and limited seismic data are essential in interpreting the internal configuration of the complex. An earlier interpretation of the first airborne magnetic survey of Botswana (*Reeves*, 1978) coupled with subsequent drilling discovered the Xade complex and showed that it is made up of mafic and ultramafic rocks. However, the limited amount of drilling did not provide sufficient information to either interpret in detail its geology or to fully assess its mineral potential (*Meixner & Peart*, 1984), in particular for Noril'sk-type Nickel-Palladium mineralisation. New 2D and 3D gravity and magnetic modelling have constrained the geometry of the complex as a syncline defined by folded mafic lavas with a potential feeder zone along a major fault that defines the western margin of the Kaapvaal craton.



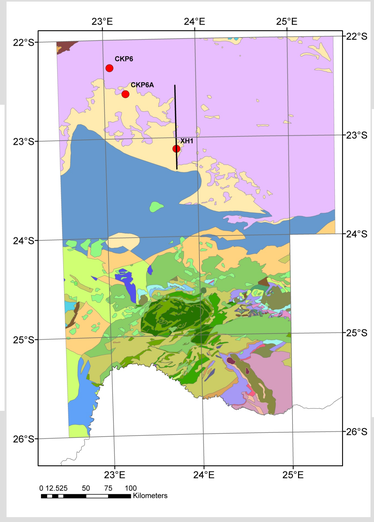
From Hanson et al. 2006

Regional Setting

1



Magnetic Anomaly Reduced to the Pole



Geological Map

XH1_borehole
Karoo Volcanics
Fault
Lineament
Dyke

3 2D Modelling

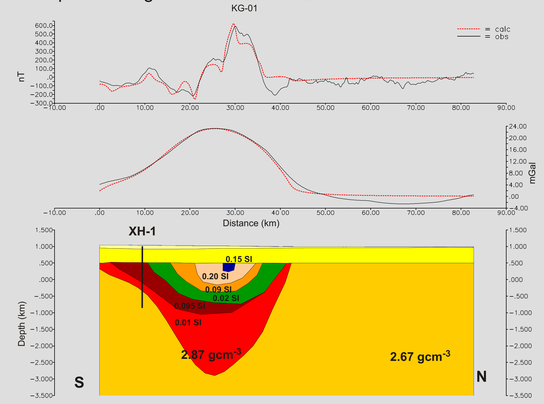
Only 2 boreholes have been drilled to intersect this body. Borehole XH1 penetrated through Kalahari sediments and sub horizontal Karoo strata before intersecting lavas at 621m. Shales assigned to the Palaeoproterozoic Waterberg Group were intersected at 1351 m to indicate a total lava thickness of 730 m. Borehole, CKP-6A, drilled on the western edge of the Xade complex, intersected dolerite at 419m Gabbronorite recovered in the borehole CKP-6 have been date at 1109.0±1.3 Ma by U-Pb on zircons.

Depth (m)	Lithology
0-119	Kalahari beds
119-470	Ecca Group strata
470-555	Mafic sheet
555-580	Ecca Group strata
580-621	Dwyka Group glacigenic strata
621-1140	Mafic lavas (Xade complex)
1140-1351	Mafic sheet (Xade complex)
1351-1741	Waterberg Group shales

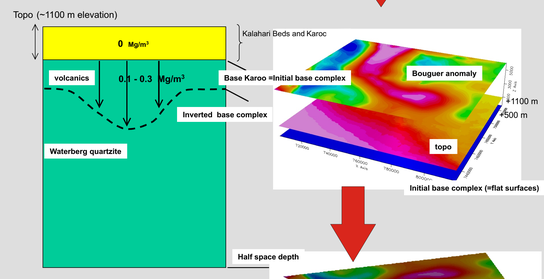
XH1 borehole summary log. (Borehole located at 23º 46' 29" E 23º 06' 00" S). Drilled by Anglo American in 1997.
The Ecca and Dwyka formations are part of the Karoo Supergroup.

Physical property measurements on samples from this borehole indicate that the lavas have a magnetic susceptibility of 0.1 - 0.45 SI, a remanent intensity of 0.6 up to 64 A/m and densities of 2.7 gcm^{-3} - 3.0 gcm^{-3}.

2D gravity and magnetic responses of the complex have been computed along the seismic line KG01.



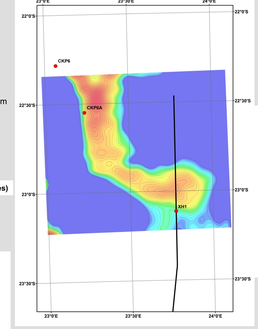
4 3D Modelling



3D Modelling Approach

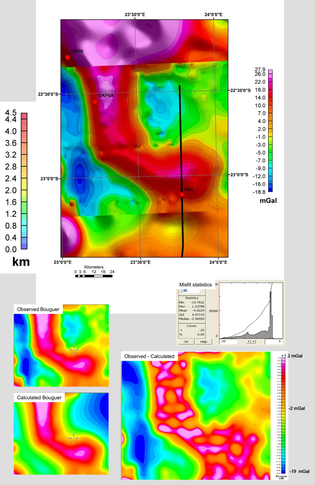
Initial geometry and parameters used for the structural inversion of the Bouguer anomaly.
Three density contrasts have been use for the inversion: 0.1, 0.2 and 0.3 g.cm^{-3}

Computed Depth of the Syncline

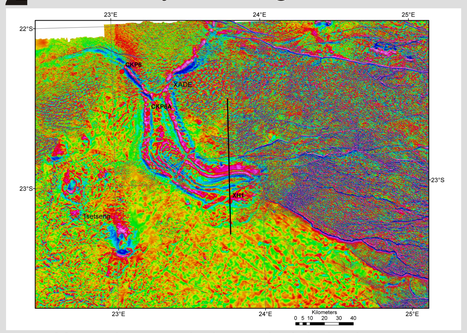


Depth of the Xade complex below datum (in km, positive down) using a density contrast of + 0.2 gcm^{-3} for the gravity inversion. The top of the complex lies at 500 m above datum.

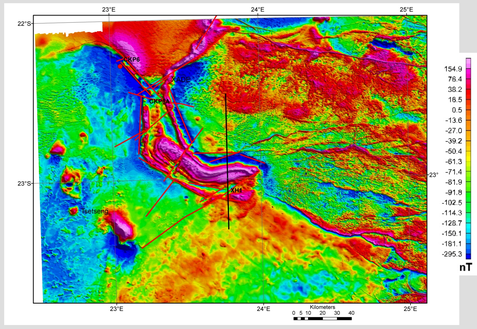
Observed Bouguer Anomaly



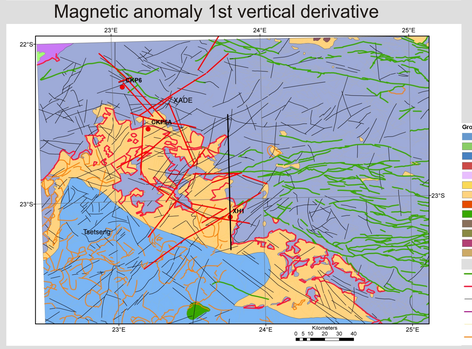
2 Gravity and Magnetic anomalies over the Xade Complex



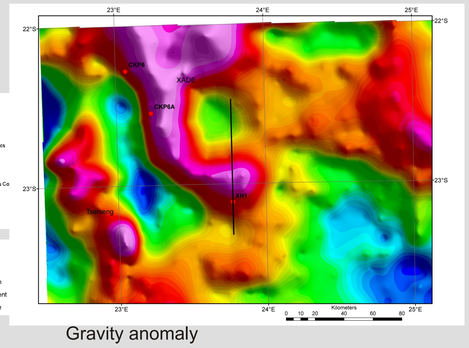
Magnetic anomaly 1st vertical derivative



Total Magnetic Intensity (RTP)



Geological map and magnetic anomaly interpretation



Gravity anomaly

References:

Hanson, RE. 2003. Proterozoic geochronology and tectonic evolution of southern Africa. In, Proterozoic East Gondwana: Supercontinent Assembly and Breakup. (eds: M Yoshida, BF Windley & S Dasgupta). Geological Society, London, Special Publications, 206, 427-463.

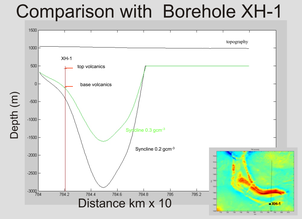
Meixner, HM & Peart, RJ. 1984. The Kalahari Drilling Project. Bulletin, Geological Survey of Botswana, 27, 224pp.

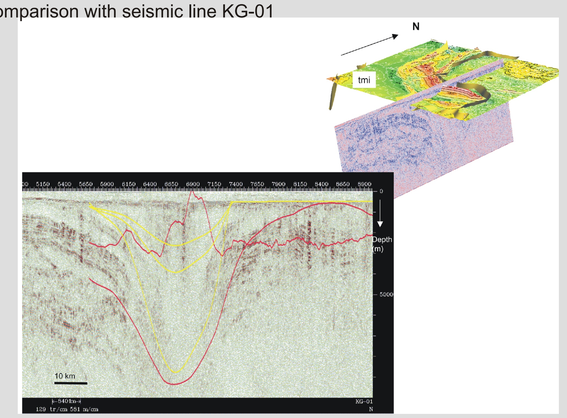
Reeves, CV 1978. The reconnaissance aeromagnetic survey of Botswana, 1975-1977. Final Interpretation Report. Terra Surveys Ltd., Geological Survey of Botswana, 315pp.

5 Geometry of the Xade complex: comparison with seismic line KG-01

Syncline shape from Bouguer anomaly structural inversion (in yellow). Increasing depths are obtained for decreasing density contrast (respectively for 0.3, 0.2 and 0.1 gcm^{-3} from top to bottom). The TMI and Bouguer anomaly (inverted in the figure) have been overlaid in red.

Comparison with Borehole XH-1





Conclusion

Despite the lack of distinct seismic signature of the complex, probably due to the scattering and attenuation in the thickest part of the igneous sequence, it is possible to identify the most appropriate density contrast on the basis of the match between the modelled flanks of the complex and the seismic imaging of underlying structure. This comparison suggests that a contrast of between +0.2 gcm^{-3} and +0.3 gcm^{-3} is most appropriate. Results of inversions suggest a depth extent of approximately 3 kms for the complex.

This is compatible with the results of the XH1 borehole, although the densities of samples from that borehole suggest a contrast towards the lower end of the range. The model indicates that the complex has three approximately linear components with N-S, NW-SE and E-W trends respectively, and that it is thickest in the northern part of the N-S component. This may represent the feeder zone for the mafic lavas along the western bounding fault of the Kaapvaal Craton.

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