Deep Crustal Studies Based on the Analysis of Potential Field Data in Southern Australia

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INTRODUCTION

The Middle Proterozoic rocks of the Willyama Block that are the host to the Broken Hill ore body have been the subject of highly detailed geological and geophysical studies over the last 25 years. Because of the quality of collection and assessment of the geological and geophysical data, this small region provides an excellent situation in which to test results obtained from crustal probings to depths of 10 to 20 km based on the application of energy spectral analysis to aeromagnetic data.

Aeromagnetic surveys were flown by MESA, Mineral Resources NSW and AGSO at 70 m above ground level with a line spacing of 100 m over the areas where the rocks of Proterozoic age outcrop and at 400 m over those areas where the Proterozoic rocks are beneath cover. Beyond this, older analog TMI data was digitised and is available from surveys flown with lines spaced at 1.5 km.

DATA PROCESSING— ENERGY SPECTRA ANALYSIS OF TMI

The systematic analysis of the data (TMI Map shown in Figure 3) was then undertaken between 137°E to 144°35′E and 30°S to 33°S (see Figure 1). The first concern in any data analysis is the quality of the data. The data from surveys flown since 1994 are of very high quality. The weakest aspect of the whole data set is the combination of separate data sets which, if not done for this specific type of analysis, introduce minor flaws which may be interpreted as structures within the crust.

The TMI data were processed twice, first with a spectral window of 50 × 50 km (125 × 125 grid cells with one grid cell 400 × 400 m) at 25-km centres which produces an overlap of 50% in both a north-south and east-west direction, and then a second time using a spectral window of 20 × 20 km (125 × 125 grid cells with an extension window of 256 × 256 grid cells, with one grid cell 200 × 200 m) at 10-km centres with 50% overlap in both directions to provide better resolution.

The interpretation is based on the depths that were calculated on centres which are 10 km apart in a north-south and an east-west direction. Future work intended to provide more information about the shallower structures will use a smaller window, a grid cell of 100 × 100 m and centres at which the depth is calculated, closer spaced than 10 km, to show greater detail about the shallower structure.

INTERPRETATION

It is the normal practice in a geophysical interpretation to progress from the known to the unknown. The problem in the Willyama Block at Broken Hill is that although much fresh very detailed structural mapping has been carried out over the last 20 years the structures are best understood in the top few kilometres, and there is little known about the rocks and structures at greater depths to which the results of the present analysis can be related.

An outline of the geology of the area is provided by a section of the AGSO 1:2 500 000 geological map of Australia (Figure 2), showing the main elements of the geology of the area. Passing from west to east on this map there are Middle Proterozoic rocks of the Gawler Craton which form the basement to the Adelaidian rocks of Late Proterozoic age; at the centre of the map the older metamorphic Middle Proterozoic rocks of the Willyama Block outcrop; to the east of this are Paleozoic rocks in the Balcannia and Menindee Troughs. In much of the northern, eastern and southern part of the area the older rocks are totally obscured by a cover of Tertiary and Recent sediments.

The most relevant interpretation at this stage has been to relate the structures discovered by the map based on the deepest of the magnetic interfaces determined energy spectrum analysis using a 20-km^2 moving window. This provides over 2000 depth values, and the results are presented in this paper in the form of a depth colour image with superimposed contours, Figure 4. In this map we find six significant structures which correspond to known major features on the geological map, from which it may be concluded that these structures extend to depths of the order of 10 km or greater into the upper part of the crust.

These structures are labelled from (a) to (f) on Figure 5 as follows:

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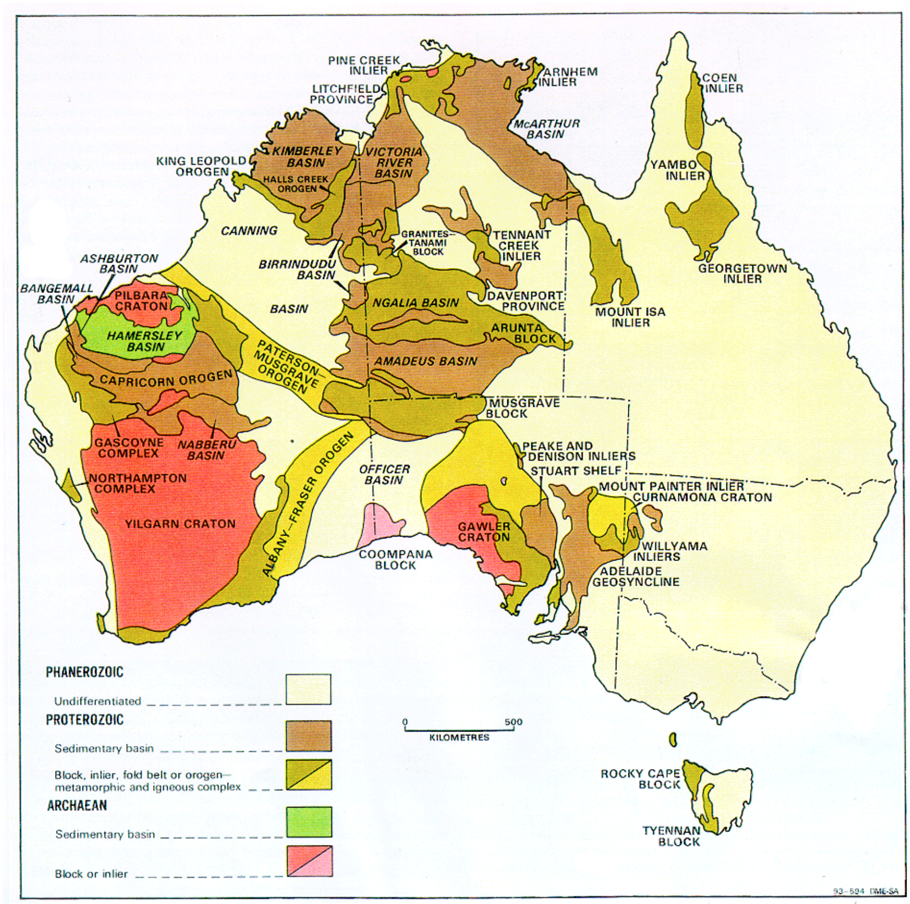

Figure 1: *General geology of Australia.*

(a) This boundary marks the Torrens Hinge Zone the complex structural edge of the Gawler Craton which is the basement of Middle Proterozoic age to the overlying Adelaidian sediments of Late Proterozoic age.

(b) There is a deeper section on the depth map that occurs within the limits of the Adelaide Geosyncline. This boundary has no very clear expression on maps of the Adelaide Geosyncline but it does lie on the extension of the Ardrossan Fault which is a major structure south of the area studied.

(c) This north-northeast-striking gradient in which the magnetic surface is shallower by between 3 and 4 km on the western side, corresponds to the position of the Mundi Mundi Fault, one of the major boundaries in the Willyama Block.

(d) This east-northeast-trending gradient between a shallower magnetic surface to the north and a deeper one to the south corresponds to the Thackaringa Pinnacles Shear Zone, which is another of the major geological structures in the area.

(e) The deeper surface that lies to the east of this line corresponds to the edge of the Balcannia Trough, a rift which is filled with sediments of Paleozoic age. It appears from the image (Figure 4), that the structure may continue farther to the south than it has been followed by geological mapping.

(f) The shallow values marked 'f' coincide with an area in which there are intrusions of granitic rock. It has been observed that in the Gawler Craton to the west, where granite intrusions occur, that the depths recorded in the analysis are noticeably shallower than they are in the adjacent areas and it was considered possible that this difference in depth was the result of a reorientation of the structure as a result of the formation of the granitic bodies.

In addition to structures recognised from the image of the magnetic surface there are some other features which may be significant in the understanding of the area. These are marked A to D and are as follows:

(A) This short northwest-striking line of greater depths may indicate a major structure in the Gawler Craton, showing greater continuity than some of the other features on the image which have not been described here.

(B) This long narrow region of shallower depths of the magnetic surface with a west-northwest strike is one of the most prominent features on this image. It appears to be a boundary separating areas of different character on the north and south sides. This feature crosses the South Australian/New South Wales border and is in line with the Stephens Creek Shear Zone, a major structure in the Willyama Block.

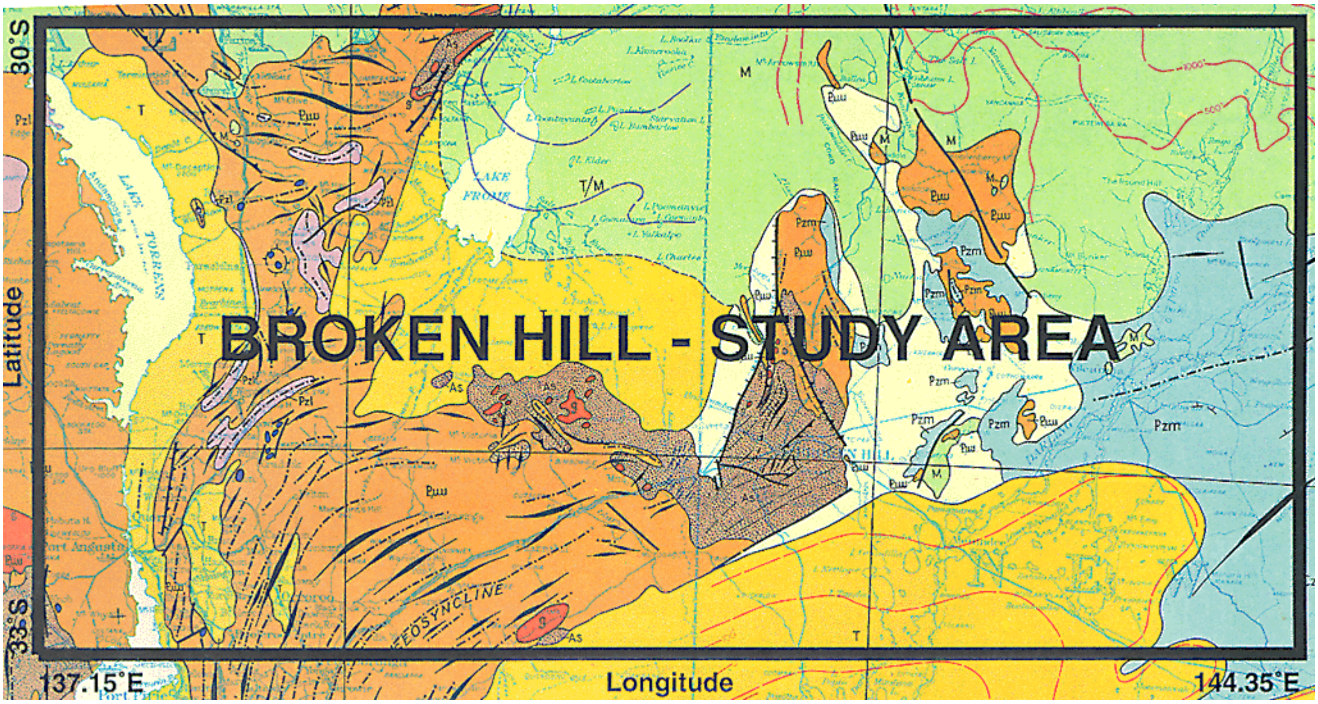

Figure 2: *Geology of study area.*

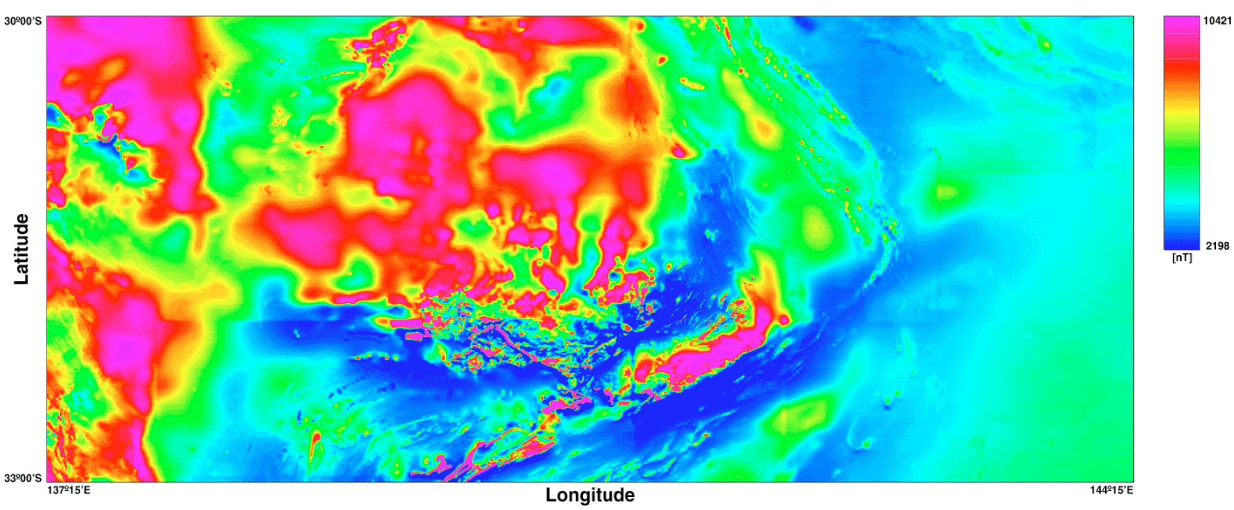

Figure 3: *Total magnetic intensity of study area.*

(C) This line of shallower depths of the magnetic surface is a continuation of the Thackaringa Pinnacles Shear Zone and may mark an extension of it.

(D) Depths on the eastern side of this line are noticeably greater than those to the west. This may indicate a major boundary, but as outcrops of basement rocks do not occur in this area it is not possible to identify the cause of this change with certainty.

There is little evidence available from the known geology to account for structures 'A' to 'D'.

CONCLUSIONS

New information about the structure of the upper part of the crust can be obtained at relatively small cost in areas where high quality regional total magnetic intensity data are available, by analysing the energy spectrum.

It is important that the levelling and matching of adjacent component surveys is properly carried out, as what may be considered to be minor errors in the process will produce false long wavelength magnetic anomalies that could be interpreted as due to structures within the crust.

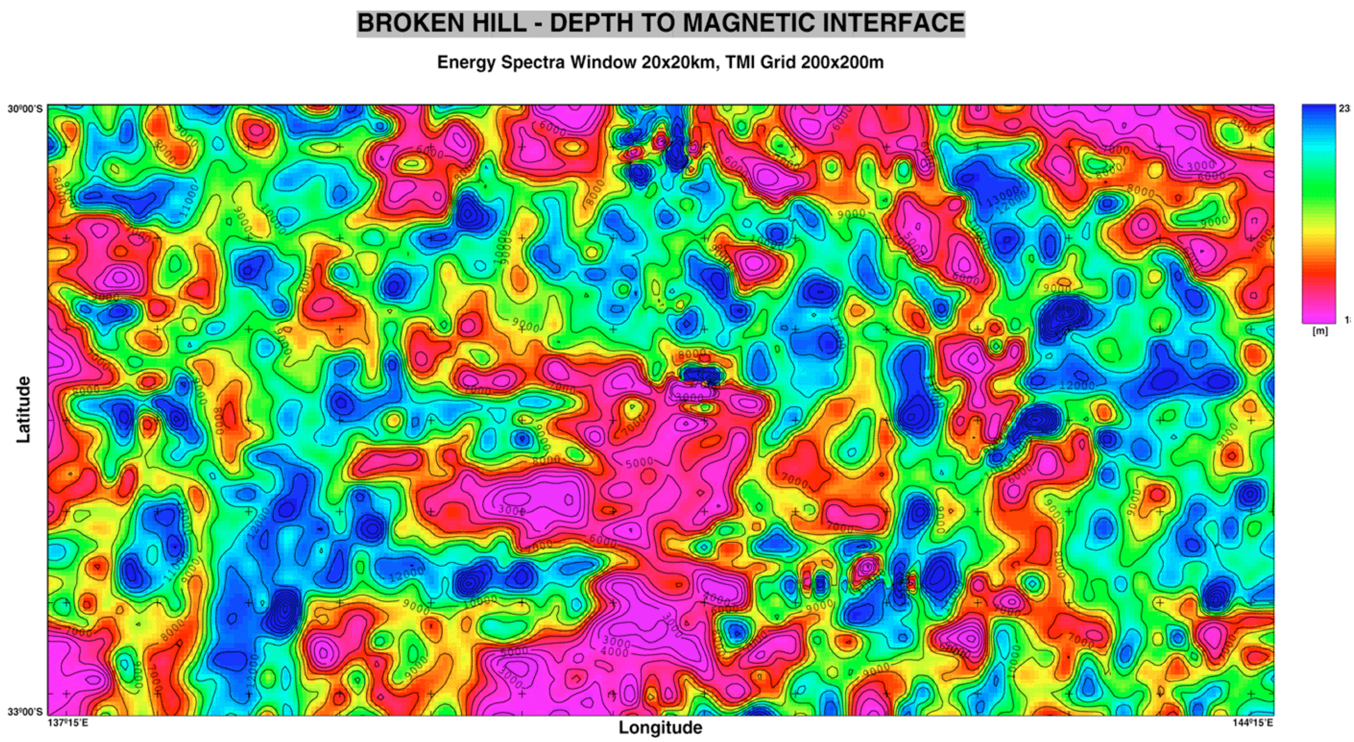

Figure 4: *Calculated depth to the magnetic interface of the study area.*

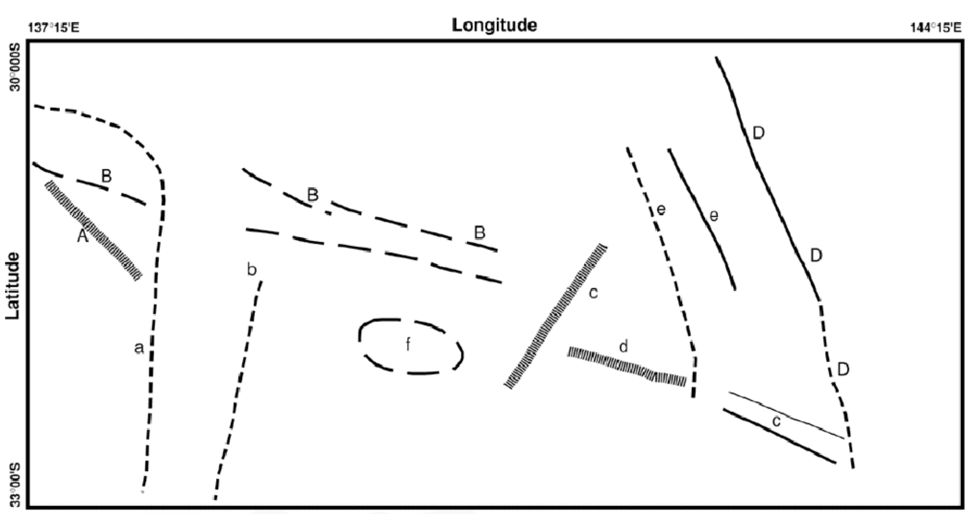

Figure 5: *Magnetic structures discussed in text.*

ACKNOWLEDGEMENTS

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