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A GRAVITY SURVEY OF WOY WOY DISTRICT AND ITS LOCAL AND REGIONAL GEOLOGICAL SIGNIFICANCE

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A detailed gravity survey of the Woy Woy district, south of Gosford, New South Wales, was undertaken in order to determine the thickness of young, unconsolidated sediments overlying the Gosford Formation belonging to the Narrabeen Group of the Triassic. The district is situated within a valley which has a maximum width of 5 km, south of the Blackwall Mountain (Fig. 1). The valley is cut into the sandstone of the Gosford Formation by the Brisbane Water which occupies the valley almost entirely to the north. Near Woy Woy, the water channel bifurcates about St. Hubert's Island and further south it narrows down to a width of only 300 m near Bucher Bay (point D in Fig. 1). Near Ocean Beach at the southern boundary of the district, the channel widens again and joins up with the Broken Bay. The sides of the valley formed by the sandstone are generally steep and the valley floor in Woy Woy quite flat except for the intervention of the Blackwall Mountain, a monadnock over 115 m high.

Some 500 gravity stations were measured at a spacing of about 100 m, along most streets of the township and St. Hubert's Island and along roads in neighbouring districts (Fig. 1). An average station density of 12.5/km^2. Observations were made using a Worden Master gravimeter (No. 935). A local base station was established and connected to the BMR isogal station at Wahroonga. Station elevations were determined relative to bench marks using an automatic precision level with an accuracy of about 10 cm. Tidal and drift corrections were applied and observations reduced to Bouguer Anomalies using the 1978 International Gravity Formula. Topographical corrections were applied manually up to Hammer Zone F and thereafter to a radius of 20 km using a computer method. Overall accuracy of Bouguer anomaly for most stations is estimated at about 1 GU but for some stations close to steep topography it may be about 2 GU.

A steady eastward increase in anomalies from 338 GU in the west to 457 GU in the east is observed and shows the dominance of a regional gradient largely associated with the continental margin. A first degree trend surface analysis of the anomalies gives a trend of 16.4 GU/km along 107.5° with a correlation coefficient of 97.7%. Because the continental slope locally trends along 122° there is an obvious discrepancy between the two trends. An explanation of this discrepancy is proposed in the gravitational influence of the northward dip of the base of the Permian rocks in the region; this dip is indicated from the results of the seismic refraction studies of the Sydney Basin.

The residual anomalies, resulting from the removal of the first degree trend are shown in Fig. 1. They outline a broad low running north-south in the central part of the district. The values on the western flank rise to 9 to 11 GU and on the eastern flank in the vicinity of the Blackwall Mountain they approach similar magnitudes while along the trough they fall to – 6 to – 9 GU. A maximum drop of about 20 GU occurs along the low. Lows of smaller magnitude occur over St. Hubert's Island and further east in the vicinity of the Empire Bay. The locations and trends of these lows associate them quite firmly with the development of young sediments in these districts.

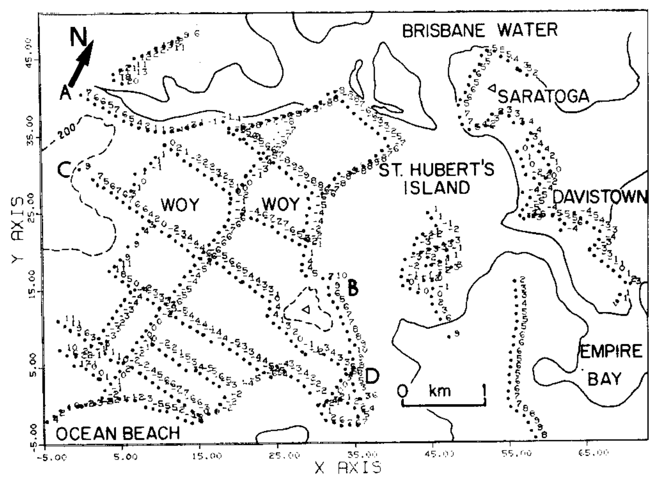

FIGURE 1

Location of gravity stations and residual anomalies (after the removal of first degree regional) in GU based on a computer plot. Continuous line shows land-water boundary (the line is not drawn on the eastern and southern boundaries of Woy Woy as stations follow these boundaries closely). Broken lines show 200 ft (61m) contours on the western scarp and on the Blackwall Mountain near point B.

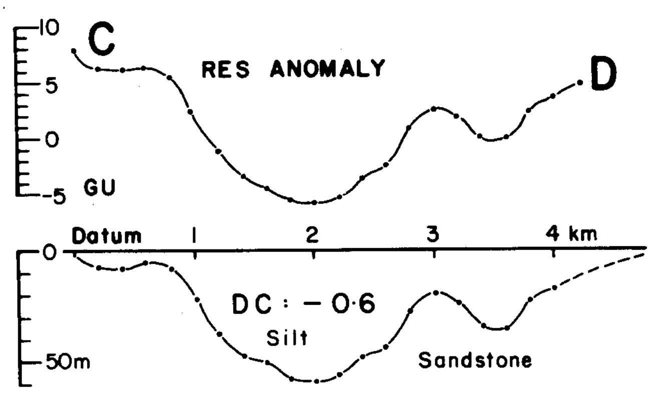

FIGURE 2

Smoothed residual anomalies along profile CD (see Fig. 1). Alternate points (1, 3, . . . 43) and a density contrast of –0.6 tonne m^{-3} were used in an iterative programme to obtain a distribution of young sediments. The RMS difference of the smoothed and calculated values was 0.06 GU.

Some 30 specimens of the sandstone collected within the area yield an average density of 2.31 tonne m^{-3} for the Gosford Formation. Six specimens of soil (mainly fine silt) give an average density of 1.36 tonne m^{-3}. This value is considered to be very low and a value of 1.7 tonne m^{-3} may be more realistic bulk density of compacted sediments. A density contrast of 0.6 tonne m^{-3} is thus chosen in quantitative interpretations.

A quantitative interpretation has been carried out along two profiles AB and CD, one of which is described here. Forty six stations along and close to profile CD were used in obtaining 44 interpolated values at a constant spacing of 100 m along the line. The mean and RMS values of the original anomalies were 0.88 and 4.41 GU respectively and these statistics for the equispaced values were 0.88 and 4.36 GU respectively. A three point Hamming filter (weights: 0.23 0.54 0.23) was applied to the latter values and end points were saved by assigning to a single neighbour, the weight for two neighbours. The mean and RMS values of the smoothed anomalies were 0.87 and 4.30 GU respectively. These smoothed anomalies are shown in Fig. 2.

An interpretation of the anomalies using a density contrast of 0.6 tonne m^{-3} between the young sediments and the Gosford Formation is carried out with the application of an iterative computer programme and shown in Fig. 2. The maximum inferred thickness of sediments is 58.3 m under point 21 at the base of the gravity low. It should be noted that the vertical exaggeration of the section is about 20 and the dip of the floor does not exceed 5° anywhere along the section. While small scale step faulting at the flanks of the valley cannot be entirely excluded, the low dip is indicative of the erosional processes responsible for the carving out of the valley floor and later filling in of the depression by young sediments. The prominent ridge on the valley floor occurs in the vicinity of the Blackwall Mountain. Point D occurs close to the rip at Bucher Bay where bedrock is at shallow depth.

Uncertainty in the value of chosen density contrast is probably the biggest source of uncertainty of the quantitative interpretation of the anomalies. While this interpretation needs to be corroborated perhaps with a few boreholes, the present study does show the applicability of the gravity method in a built-up area where many other geophysical methods cannot be applied. It also shows that a detailed gravity survey of a small area can make a significant contribution both to local and regional geology. While contribution in the local case is largely confined to a shallow depth, it may be possible to extract some deeper information as well.

CASE HISTORY EXAMPLES COMPARING DIPOLE-DIPOLE INDUCED POLARIZATION AND DUAL HORIZONTAL LOOP TRANSIENT ELECTROMAGNETIC SURVEYS IN AUSTRALIA

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This paper presents a selection of geophysical results across various conductive and/or chargeable targets encountered in routine base metal exploration. Its main purpose is to allow immediate visual comparison between the effectiveness of dipole-dipole IP and the Crone Pulse EM (PEM) transient EM system in a variety of differing contexts.

Example 1:

A vertical sheet of massive copper-zinc-lead mineralization in the Lachlan Geosyncline shows a classic response which gives a symmetric slowly decaying PEM anomaly and symmetric triangular shaped apparent resistivity low and chargeability high. The deposit responds well to SP, is not magnetic and gives a definite but extremely low amplitude INPUT response.

Example 2:

In many ways this example from the Pilbara region of Western Australia gives similar responses to the mineralization of Example 1, except the source of the anomalies is magnetic. Drilling encountered relatively small amounts of low grade pyrrhotite which conductivity studies showed to have a similar conductivity thickness product to the more abundant mineralization of Example 1 and even with the commercial Woodlawn ore body. Small amounts of pyrrhotite, whose existence is indicated by magnetic anomalies, can give deceptively intense IP and PEM anomalies.

Example 3:

A sheet of disseminated sulphide in the Pilbara region gives distinct dipole-dipole IP and magnetic induced polarization (MIP) responses. The apparent resistivity data recorded with the IP data shows that this mineralization is not conductive. The PEM basically does not respond to this zone although rapidly decaying early channel perturbations which correlate with features on adjacent lines are probably an associated response.

Example 4:

Various geophysical methods were tried over this target in the Lachlan Geosyncline which was originally identified as an INPUT conductor. Turam and PEM surveys located the conductor on the ground but the strange forms and extreme variability of the anomalies suggested that it was not a classic massive sulphide body. An IP survey showed that no chargeable material was present. The dipole-dipole resistivity low results had the form caused by a horizontal conductive body. The source of the anomalies was identified as a buried channel containing conductive ground waters and clays.

Example 5:

Areas with lateral changes of conductivity can cause interpretation problems because of spurious anomalies caused by edge effects. A study from the Yilgarn Block of Western Australia illustrates these points. INPUT defines different conductive bodies but lacks the resolution necessary to determine their form. PEM and dipole-dipole resistivity data must be interpreted carefully to decide if anomalies are due to mineralization or merely conductivity boundaries. Gradient array apparent resistivity data is extremely useful as it provides a simple reflection of the resistivities of underlying rocks. Despite complexities with conductivity changes IP results indicate the lack of sulphides in an area by simply not showing any anomalies.