Positive gravity anomaly over the Sydney basin

I. R. Qureshi
Department of Applied Geology
University of NSW
Box 1, Kensington
NSW

Abstract

A prominent positive gravity anomaly overlies the Macdonald trough in the Sydney basin. Allowing for isostatic compensation and the effect of sedimentary rocks, the anomaly is determined to have an amplitude of 440 GU (μms^{-2}) and a width of 60 km. The anomaly is smoothed using cubic splines, FFT and IFFT. It is interpreted by a large mafic body of density 2.9 g cm^{-3} underlying the basin to a depth of 13.5 km. A 12 km wide zone with a small positive density contrast underlies the body within the lower crust.

The steep western boundary of the body represents a major basement fault underlying the Lapstone monocline and Kurrajong Fault System.

The anomaly is a member of the Meandarra Gravity Ridge which marks a zone of crustal extension within which dominant nature of intrusion is mafic in character.

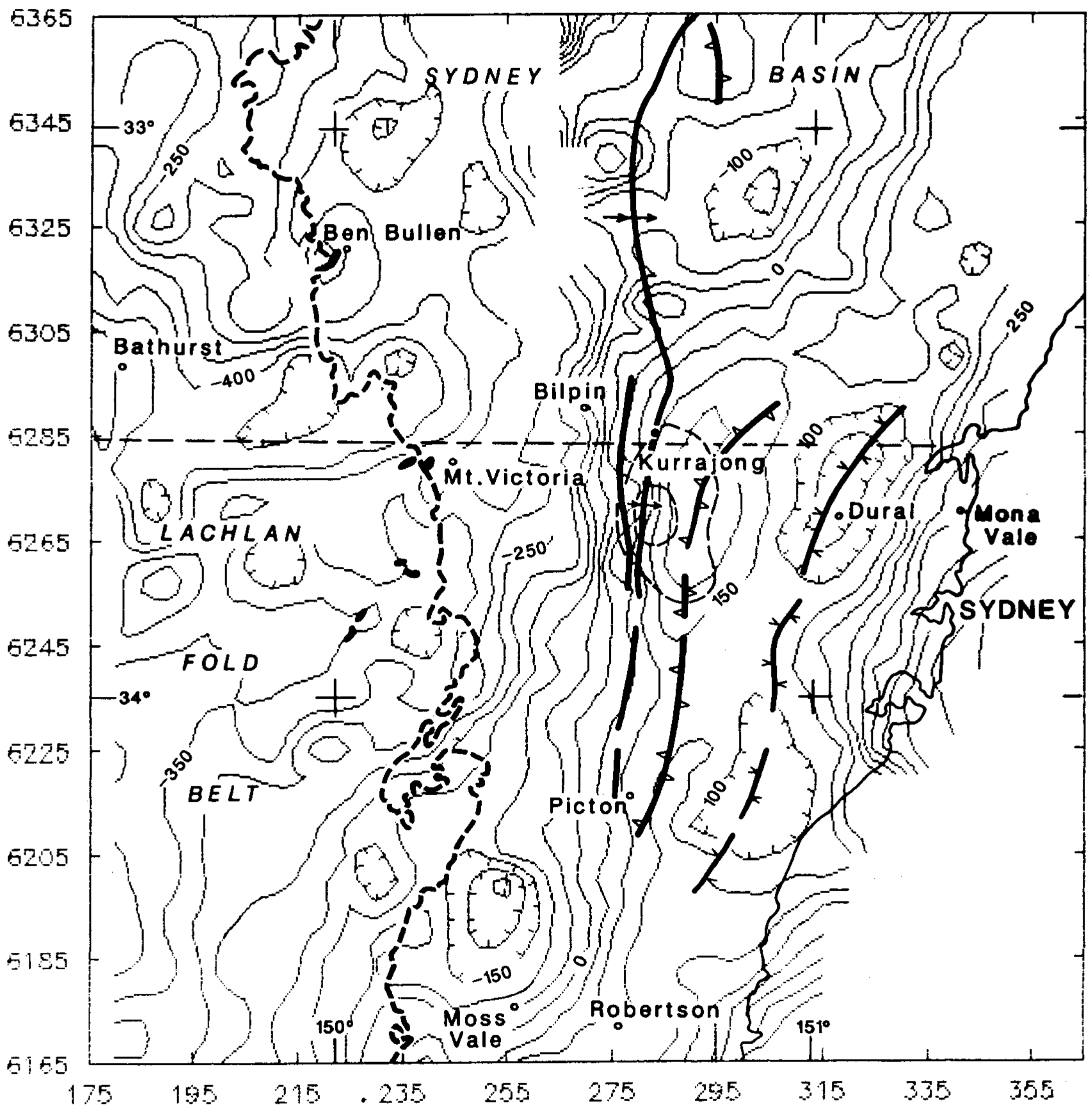

FIGURE 1
A computer plot of the Bouguer anomaly contours (interval: 50 GU). Australian Map Grid in km is shown along the margins. Bouguer reduction is based on a density of 2.5 g cm^{-3} to sea level. An aeromagnetic anomaly high is shown at Kurrajong by two dashed contours of 50 and 100 nT. Lapstone monocline and Kurrajong Fault System are shown in thick lines. Dark patches near Mt. Victoria and Ben Bullen show outcrops of Early Carboniferous mafic intrusions. Axes of a gravity high and a gravity low are marked east of the monocline. E-W broken line marks the position of the interpreted profile.

Key words: gravity anomaly, Sydney Basin, tectonics, crustal structure, basement fault.

Introduction

The Bouguer anomaly map (Figure 1), based on some 750 personal measurements and 1000 of BMR, shows that the anomaly values are generally positive in the Sydney basin. A closed positive anomaly with its apex at +250 GU, lying over the Macdonald trough, forms the most prominent feature of the map. This anomaly is identified as the Central Positive Anomaly. Further east the values drop to +40 GU over the Kulnura anticline before merging with the coastal gradient zone associated with the continental margin.

Seismic and borehole data (Mayne *et al.*, 1974) indicate a thickness of about 3 km of Permo-Triassic sedimentary rocks within the Macdonald trough. The occurrence of a positive anomaly in place of an expected negative anomaly poses a problem.

The Central Positive Anomaly is flanked to the west by the Wollondilly-Blue Mountains Gravity Gradient Zone which has a N-S trend throughout the extent of the map and overlies the Lapstone-Kurrajong Fault System. A gradient zone trending NE branches off the main zone, north of the anomaly.

A narrow gravity ridge of lower amplitude represents a southerly continuation of the positive feature whilst a high at the northern margin of the map (Figure 1) may join up with the Meandarra Gravity Ridge (Figure 2) after suffering westward displacements at the Goulburn River and north of the Liverpool Range. The Central Positive Anomaly assumes a great tectonic significance if it is deemed to be a continuation of this ridge.

Qureshi (1984) selected a 180 km long E-W gravity profile between Mona Vale and Bathurst, (Figure 1) applied an Airy-type isostatic correction for the Blue Mountains and the continental margin, and a correction for the expected gravity effect of the Permo-Triassic rocks of the basin and thus identified an anomaly of 440 GU with a width of 60 km that required an explanation (see Figure 2 in Qureshi, 1984). A preferred model for the interpretation of the gravity anomaly showed a large mafic body underlying the basin within the upper crust.

A magnetic anomaly coincides with the Central Positive Anomaly (Figure 1).

The present study is aimed at a reinterpretation of the anomaly to allow for a link of the mafic body with the mantle (Scheibner, pers. comm.) and to further consider its tectonic implications.

Processing and modelling

The gravity anomaly profile (60 km in length) was composed of corrected values at 36 gravity stations. A smoothing operation was performed by converting the profile into a 256 point profile (at a spacing of 236.5m) through the fitting of cubic splines, transforming the data using an FFT routine, and inverse transforming rejecting all frequencies > 0.031 cycles/data interval. This procedure effectively rejected wavelengths shorter than 7.6 km which were considered to arise from shallow inhomogeneities. From the smoothed data 32 values at an equal spacing of 1.89 km were chosen for two-dimensional modelling (Qureshi and Kumar, 1976).

Sources of uniform density contrast underlying the base of the Sydney Basin and extending in depth to the Moho can reproduce the anomaly but with a rather large RMS difference of 30 GU. Assumption of a uniform density contrast is not realistic and the RMS difference is unacceptably high.

A preferred model (Figure 3) places a source of density contrast 0.2 g cm-3 in the upper crust and a 12 km wide zone with a density contrast of 0.1 g cm-3 provides its link with the

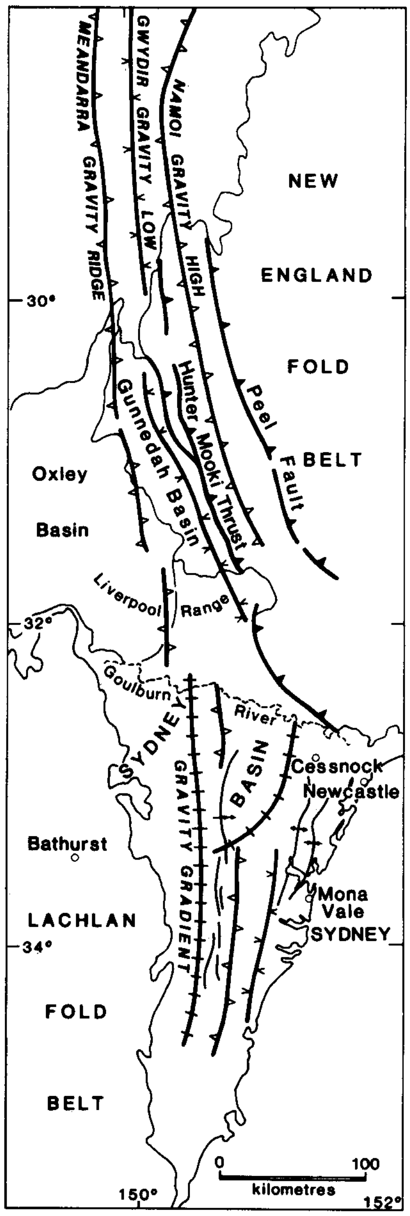

FIGURE 2
The gravity features of the Sydney Basin and the three major linear anomalies to the north. The geology is based upon 1 to 2.5 million Geological Map of Australia. The linear anomalies extend for a distance of 100 km beyond the northern limit of the map.

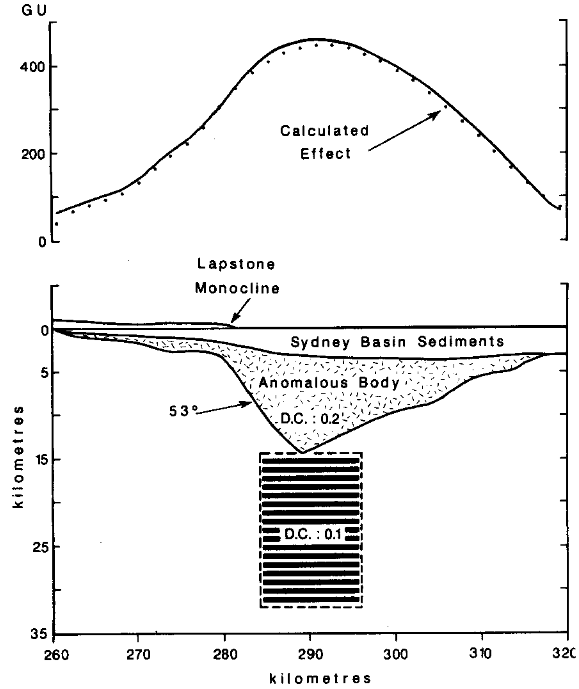

FIGURE 3
The gravity high and its interpreted source on natural scale. Dots represent the calculated effect of the source underlying the Sydney Basin. The western boundary of the source in the upper crust dips at 53° and marks a major basement fault inferred to underlie the Lapstone monocline. A zone of sills with a density contrast (D.C.) of 0.1 g cm^{-3} may form a link to the mantle. The horizontal scale follows the map grid of Figure 1.

mantle. The maximum gravity effect of this link is 134 GU and drops to 48 GU at the edges, thus effectively accounting for about one-fifth of the total anomaly. The model reproduces the given anomaly with an RMS difference of 6 GU.

Discussion

The derived shape of the postulated mafic body shows its western boundary steep enough to be interpreted as a major basement fault underlying the Lapstone Monocline-Kurrajong Fault System. This fault controlled sedimentation during the Permian times (Harrington and Brakel, 1981) and recent earthquakes (Drake, 1976) at Kurrajong, Picton and Robertson (Figure 1) may be caused by small movements along this fault.

Extensive igneous activity during the Carboniferous is recorded in the New England Fold Belt and the eastern part of the Lachlan Fold Belt. Intrusion of large granitic plutons marks this period as one of significant crustal extension (Scheibner, 1973). Whilst most of the granites are less dense than the rocks they intrude and hence produce negative gravity anomalies, there are some small mafic plutons occurring at the western margin of the Sydney Basin that may produce positive anomalies. A recent study (Qureshi and Miller, 1989) has shown a local anomaly of 120 GU to be associated with the Ben Bullen plutonic complex which may be derived from the mantle (Knutson and Flood, 1988). The source of the Central Positive Anomaly is probably of similar nature.

Tadros (1988) has correlated individual gravity highs along the Meandarra Gravity Ridge with sedimentary troughs in the Gunnedah Basin. Although no detailed quantitative interpretation of these anomalies has yet been undertaken, a preliminary study (Bramall and Qureshi, 1984) indicated that large parts of these anomalies must arise from within the basement. The Meandarra Gravity Ridge may thus mark a zone between the two fold belts where the intrusions were mainly mafic in character and probably intraplate in origin (Griffin and Reilly, 1986).

The zone of slightly higher density contrast within the lower crust is envisaged as a zone through which mantle derived magmas moved up and some of which solidified as sills. This is supported by seismic evidence (Finlayson and McCracken, 1981; Drummond and Collins, 1986).

Conclusion

Whilst a small part of the Central Positive Anomaly may arise from within the lower crust, a greater part of the anomaly has its source within the upper crust.

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