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GRAVITY SURVEY OF THE MT. TOONDINA IMPACT STRUCTURE, SOUTH AUSTRALIA: J. Plescia[1], E. M. Shoemaker[2], and C. Shoemaker[2], [1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; [2] U. S. Geological Survey, Flagstaff, AZ 86001.

The Mt. Toondina impact structure [1] is located in northern South Australia, about 45 km south of the town of Oodnadatta at 27° 57'S, 135° 22'E.. Only the central uplift is exposed. It was first mapped by Freytag [2] who described beds of early Permian age that have been brought to the surface in the core of the uplift. Youles [3] suggested the structure was of impact origin; his suggestion was promptly rebutted by Wopfner [4] who thought the structure was related to the presence of evaporite beneath the Permian. Recent detailed mapping by Shoemaker et al. [5,6] has shown that the style of deformation of the exposed beds is consistent with an impact origin.

The outcrops at Mt. Toondina reveal a remarkable structural anomaly surrounded by a broad expanse of nearly flat-lying beds of the Bulldog Shale of Early Cretaceous age. Highly deformed beds of the Permian Mt. Toondina Formation, the Jurassic (?) Algebuckina Sandstone, and the Early Cretaceous Cadna-Owie Formation rise to the surface in the central uplift. On the basis of a seismic reflection profile through the center of the structure the top of the Permian rises about 350 m from the axis of a shallow structural depression that surrounds the uplift. The maximum structural relief near the center of the uplift is estimated to be between 400 and 500 m. The structure dies out at depth; the base of the structurally disturbed zone is near the base of the Permian section at about 1 km depth. Although numerous diapirs of late Precambrian evaporites occur in the region, no diapir is present beneath the Permian beds at Mt. Toondina.

A gravity survey was undertaken in 1989 to to determine the diameter of the impact structure, define the form of the central uplift, and understand the local crustal structure. Data were collected along a two orthogonal lines trending N5°W and N85°E across the structure and extending about 4 km from the central uplift. The east- and a northeast-trending lines were run along seismic reflection profiles. In addition to the profiles, a significant number of measurements were made on and around the central uplift. The 1989 gravity data combined with 1963 gravity data (by J. McG Hall) provided by the South Australia Geological Survey and the seismic reflection data provides an excellent data base to interpret the subsurface structure of the Mt. Toondina feature.

Data from both surveys were reduced using a density of 1.9 g cm^{-3}. Data from the 1988 survey were reduced using the USGS Bouguer Gravity Reduction Program which computes Free Air, Curvature, Latitude, and Bouguer Corrections. No terrain corrections were made to the data because of the lack of significant topography. Data for the 1963 survey were available only in the form of reduced Bouguer gravity.

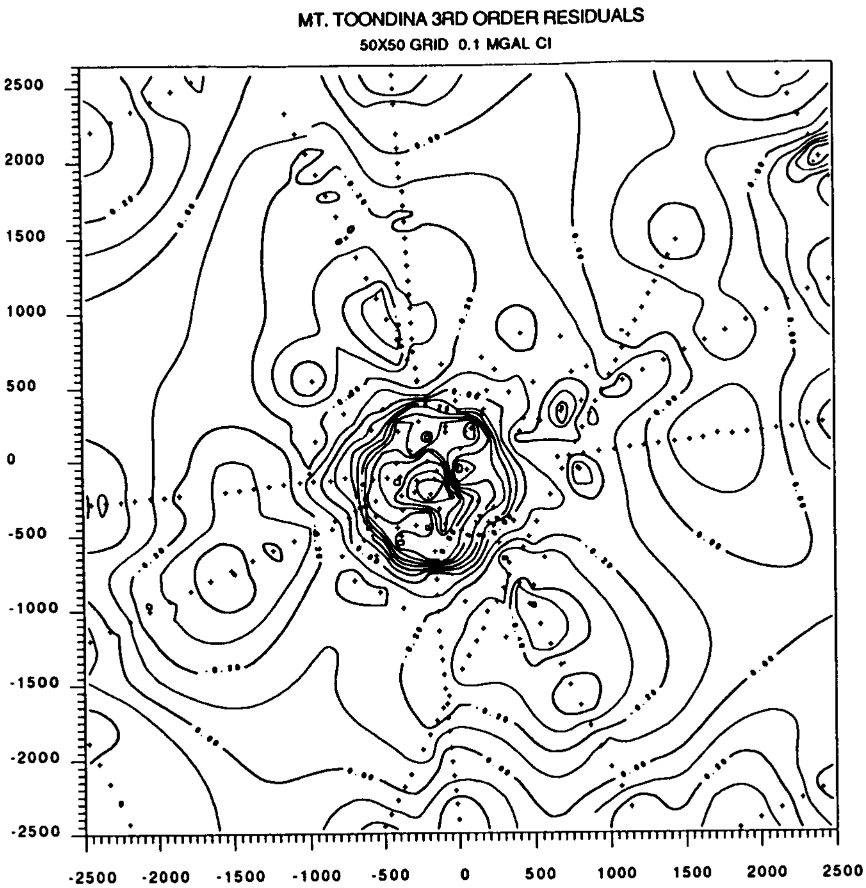
The region around Mt. Toondina is marked by a significant gravity gradient resulting from regional structure. In the area of the impact, the regional gravity gradient is about 1.8 mGal/km, decreasing to the northwest. To isolate the anomalies associated with the feature itself, the regional trend of the data was removed by calculating a variable order polynomial surface and determining residuals. A third order polynomial was chosen as a good approximation of the regional data (accounting for about 97% of the total variation). The residual values were then gridded and contoured. Figure 1 illustrates the residual Bouguer gravity for a region within 2.5 km of the central uplift contoured from a 50x50 grid (100 m grid spacing) with a 0.1 mGal contour interval.

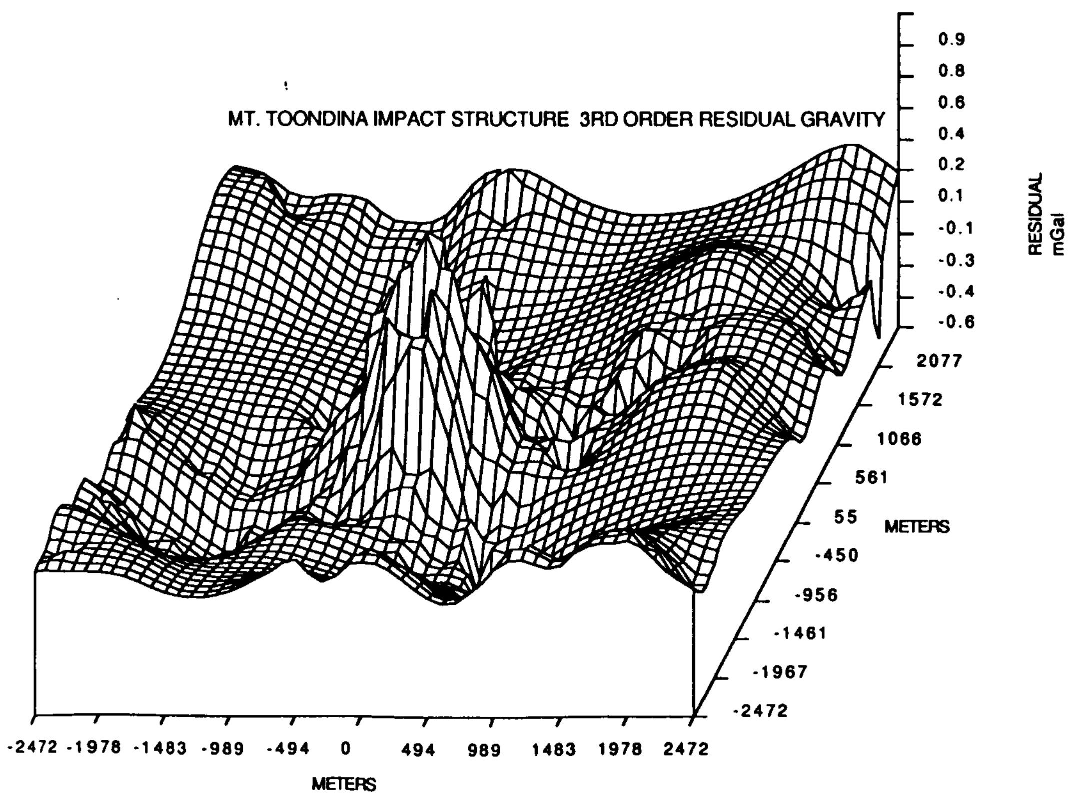
The regional gravity field is dominated by an approximately northwest-trending low displaying in excess of 1 mGal of relief. This linear low is the result of a northwest trending syncline in Precambrian rocks. This regional structure is well-defined by numerous seismic reflection lines crossing the area. Higher order polynomials remove this aspect of the field and define a central gravity high coincident with the central peak and an annular low surrounding the uplift.

The impact structure is dominated in the residual gravity by a prominent positive anomaly centered over the central uplift. The anomaly has about 1 mGal of positive relief relative to the surrounding areas and is about 1 km in diameter (an attribute noted by [1]). Around the high, residual gravity gradients of 2.5 mGal/km are observed. The central high is surrounded on all sides by a low.beginning about 750 m from the central peak and extending out to a radius of about 1.5 km. This gravity data can be interpreted as: (1) the positive gravity anomaly at the center corresponds to the central uplift and resulting from relatively high density material having been drawn upward; and (2) surrounding the central uplift is an annular low resulting from thickening of the low density Bulldog Shale due to drawdown. The Bulldog shale has a relatively low density (about -0.15 g cm^{-3}). This annular thickening appears to have only about 50 m of relief. The east-west reflection line defines a disturbed zone about 3-4 km in diameter, with deformation extending to a depth of approximately 1 km. Together, the gravity and seismic data indicate an impact crater with a diameter of 3-4 km and a shallow structure.

References: **[1]** Shoemaker, E. M., and Shoemaker, C. S., 19??, Abstracts 19th Lunar Planet. Sci. Conf., 1079-1080. **[2]** Freytag, I. B., Trans. Roy. Soc. S. Aust., **89**, 1965; Freytag, I. B., unpublished So. Aust. Dept. Mines Report, 1964. **[3]** Youles, I., Quat. Geol. Notes, Geol. Sur. So. Aust., No. 60, 10-12,1976. [4] Wopfner, H., Quat. Geol. Notes, Geol. Sur. So. Aust., No. 62, 21-24,1977. **[5]** Shoemaker, E.M., Shoemaker C. S., and Roddy , D. J., unpublished mapping, 1988. **[6]** Shoemaker, E.M., Shoemaker C. S., and Roddy , D. J., unpublished mapping, 1989.

Figure Caption: Upper panel shows the residual Bouguer gravity field over the Mt. Toondina impact structure. A 3rd order polynomial was fit to the data and removed to produce the residual contoured here. Contour interval is 0.1 mGal. Crosses indicate station locations. Lower panel shows the same 3rd order residual field in an oblique view from the southeast. The high associated with the central peak and the surrounding low are well illustrated by this perspective.


MT. TOONDINA 3RD ORDER RESIDUALS
50X50 GRID 0.1 MGAL CI
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
-2500 -2000 -1500 -1000 -500 0 500 1000 1500 2000 2500


MT. TOONDINA IMPACT STRUCTURE 3RD ORDER RESIDUAL GRAVITY
0.9
0.8
0.6
0.4
0.2
0.1
-0.1
-0.3
-0.4
-0.6
RESIDUAL
mGal
2077
1572
1066
561
55
-450
-956
-1461
-1967
-2472
METERS
-2472 -1978 -1483 -989 -494 0 494 989 1483 1978 2472
METERS