

**GRAVITY SURVEY OF THE MT. TOONDINA IMPACT STRUCTURE, SOUTH AUSTRALIA:** J. Plescia<sup>1</sup>, E. M. Shoemaker<sup>2</sup>, and C. S. Shoemaker<sup>2</sup>, <sup>1</sup>Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; <sup>2</sup> 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 evaporites beneath the Permian. Recent detailed mapping by Shoemaker et al. [5,] 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 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 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  $1.9 \text{ g cm}^{-3}$ . Data from the 1989 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 that has 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. These gravity data can be interpreted as follows: (1) the positive gravity anomaly at the center corresponds to the central uplift and results from relatively high density material that was drawn upward; (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 (density contrast about  $-0.15 \text{ g cm}^{-3}$ ). This annular thickening appears to have only about 50 m of relief. The east-west seismic reflection profile 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 original impact crater with a diameter of 3-4 km and a shallow floor.

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 S. Aust., **89**, 1965; Freytag, I. B., unpublished S. Aust.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 [5] Shoemaker, E.M. and Roddy, D. J., unpublished geologic mapping, 1988-1989.

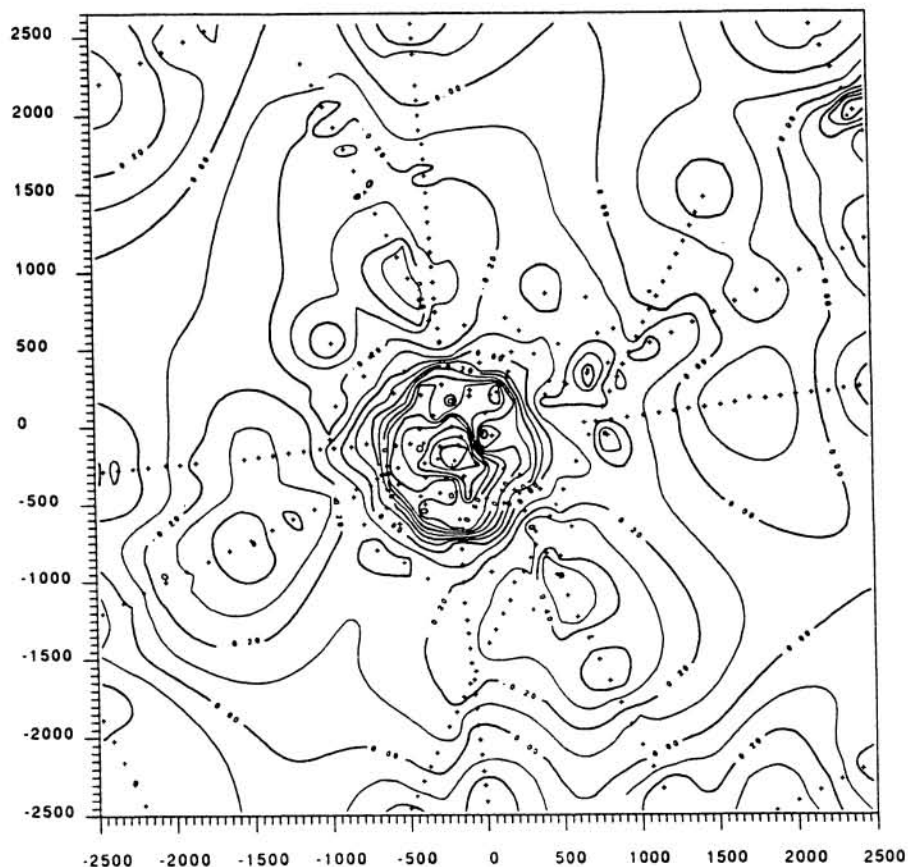


FIGURE 1.

Residual Bouguer gravity map of the Mt. Toondina impact structure.