APPLICATION OF GRAVITY DATA TO UNDERSTANDING IMPACT MECHANICS. J. B. Plescia, U. S. Geological Survey, 2255 N. Gemini Drive, Flagstaff AZ 86001, jplescia@usgs.gov..

Introduction: Gravity data provide important constraints on morphometry of impact structures and on the crustal response to the impact process [1-3]. Such data can provide insight that may not be obtainable from surface geologic mapping and may not be quickly or cheaply obtained by other geophysical means. The gravity data can be used to constrain the dimensions of a completely to partly buried structure (e.g., diameter, central uplift, etc.) and can provide information on the subsurface character of both exposed and buried structures. Gravity data can also be used to reject some structures as being of impact origin.

Morphometry: The most direct use of gravity data is establish morphometric properties of partly to completely buried structures. Gravity data have been used at several structures in Australia to establish the nature of these impacts. Mulkarra was proposed [4] to be a 9 km diameter simple crater in a sedimentary section. Gravity data [5], however, reveal positive and negative anomalies that indicate the structure is actually an 18-20 km complex structure with an 8 km central peak or peak ring. At Kelly West [6], gravity data have been used to study the central uplift area. Those data (a low surrounded by a high associated with the central uplift) suggest the central uplift is a small central peak-ring filled with breccia rather than a solid central peak. At the Manson impact [7] gravity data show that the central uplift is probably an incipient peak ring and that the zone of low density material (breccia) extends to a depth of 3 km.

Deep Crustal Effects: Gravity data can be used to provide constraints on the depth of crustal deformation. Impacts produce shock effects which reduce the effective density of rocks at depths greater than the transient cavity filled with the breccia lens. At Meteor Crater the breccia lens is 220 m thick, yet the zone of low density persists to a depth of 800 m [8]. Shock waves from the impact event had sufficient energy to significantly fracture the basement for distances of 500-600 m below the crater floor, thus providing a constraint on the energy decay rate. The breccia and the shattered basement contribute to the total 0.6 mGal anomaly [9].

Upheaval Dome is a deeply eroded complex crater in Utah [10], although apparently not everyone agrees with this interpretation [11]. Detailed geologic mapping show that the normal faults that are exposed around the margin of the structure and which cut the Navajo, Kayenta and Wingate units flatten at depth. From the attitudes of the exposed faults, the faults probably flatten into a decollement within the deeper Cutler Group. Such a geometry would imply that the deformation was restricted to levels above the Culter. Gravity data collected over the structure show that there is no gravity anomaly. The absence of an anomaly is explained in that at the current structural level deformation is entirely associated with slip along faults translating different sandstone blocks. Simple translation does not produce a density contrast. Erosion is at such a level that the breccia lens has been removed. These data indicate the shock did not have substantial influence below the level of the decollement.

The gravity data for an impact structure can also be used to model the nature of the central uplift. The Connolly structure in Australia [12] is a 9 km diameter complex crater. Gravity data reveal the presence of a high over the central uplift surrounded by an annular lower amplitude high over the crater interior. The central gravity high is due to uplift of deeper sandstones from a depth of ~1 km. These sandstone are of higher density than the surrounding rock and have shed relatively high density material into the crater interior causing the annular high.

Summary: These examples serve to illustrate that gravity can provide information on the deep structure of impacts. Such data place constraints on the cratering process by providing insight into how the crust responds to the impact: how deep the effects of the shock extend, how much structural uplift occurs, the shape of the central uplift with depth, etc.

References: [1] Grieve, R. A. F., and Pilkington, M. (1996) AGSO J., 16, 399-420. [2] Pilkington, M. and Grieve, R. A. F. (1992) Rev. Geophys., 30, 161-181. [3] Plado, J. et al. (1999) GSA Special Paper 229-239. [4] Flynn, M. (1989) The Cooper and Eromanga Basins Australia, 431-439. [5] Plescia, J. B. (1999) *Berichte zur Polarforschung, 343*, 74-78. [6] Shoemaker, E. M. and Shoemaker, C. S. (1996) *AGSO J.*, 16, 379-398. [7] Plescia, J. B. (1996) *GSA Special Paper 302*, 89-104. [8] Ackerman, H. D., et al. (1975) *JGR, 80*, 765-775. [9] Regan, R. D. and Hinze, W. J. (1975) *JGR, 80*, 776-788. [10] Kriens B. J. et al. (1999) *JGR, 104*, 18867-18887. [11] Jackson, M. P. A. et al. (1998) *GSA Bull., 110*, 1547-1573. [12] Shoemaker, E. M. et al. (1989) LPSC 20th, 1010-1011.