MODELLING THE GRAVITY AND MAGNETIC FIELD ANOMALIES OF THE CHICXULUB CRATER, C. Ortiz Aleman, Instituto de Geofisica, Ciudad Universitaria, Delgacion de Coyoacan, Codigo 04510, Mexico, D.F., Mexico; M. Pilkington, A.R. Hildebrand, W.R. Roest, R.A.F. Grieve and P. Keating, Geophysics Division, Geological Survey of Canada, 1 Observatory Crescent, Bldg. 3, Ottawa, Canada K1A 0Y3

The ~180-km-diameter Chicxulub crater lies buried by ~1 km of sediment on the northwestern corner of the Yucatán Peninsula, Mexico. Geophysical, stratigraphic and petrologic evidence support an impact origin for the structure and biostratigraphy suggests that a K/T age is possible for the impact (1). The crater's location is in agreement with constraints derived from proximal K/T impact-wave and ejecta deposits and its melt-rock is similar in composition to the K/T tektites. Radiometric dating of the melt rock reveals an age identical to that of the K/T tektites (2,3). The impact which produced the Chicxulub crater probably produced the K/T extinctions and understanding the now-buried crater will provide constraints on the impact's lethal effects. The outstanding preservation of the crater, the availability of detailed gravity and magnetic data sets, and the two-component target of carbonate/evaporites overlying silicate basement allow application of geophysical modelling techniques to explore the crater under most favourable circumstances. We have found that the main features of the gravity and magnetic field anomalies may be produced by the crater lithologies.

A cross section through the center of the Chicxulub crater was constructed for modelling purposes based on information from drill holes within the crater, seismic reflection profiles, the magnetic and gravity field anomalies and scaling from structural relations derived from other terrestrial craters. Density contrasts were assigned based in part on measurements on samples recovered from the crater. The resulting 2-dimensional field anomalies were calculated by interactive forward modelling using a program developed by W. Roest.

Figure 1 shows one modelled Bouguer gravity anomaly profile together with the observed anomaly. The density elements are based on the fallback breccia which includes a peak ring to account for the inner gravity low, an ~3-km-thick melt pool, megabreccia and a structural uplift underlying the melt pool, and an ejecta breccia on top of slumped blocks in the outer zone of collapse. This model uses geometry to account for the decrease in magnitude of the gravity anomaly towards the rim but this effect is more likely the consequence of decreasing density contrast with distance from the impact point due to decreased fracturing from the shock wave and/or decreased slumping. The model is non unique and even the handful of currently available density measurements are useful to constrain the results. A significant uplift of greater-density lower crust within the crater is precluded by the data although a weakly positive density contrast is permitted.

Figure 2 shows one modelled total magnetic field profile together with the observed anomaly. The magnetic elements are based on the structural uplift and the upper margins of the melt pool. The magnetic field anomaly is assumed to be due to remanence. The melt-pool anomalies are assigned a magnetization inclination of -41° and declination of 163°E based on the paleopole position and Yucatán Peninsula position at K/T time. This inclination is consistent with that reported in (3). The structural uplift is assumed to have a magnetization declination of ~90° E and inclination of ~30° based on the observed field. The ~80-km-diameter high-amplitude magnetic anomaly zone (Zone 1 of (4)) may be divided into two concentric zones. This distinction is clearer if the magnetic-field data are plotted after reduction to the pole.

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References: (1) Hildebrand et al., 1991, Geology, 19: 867-871; (2) Swisher, C.C. et al., 1992, Science, 257: 954-958; (3) Sharpton et al., 1992, Nature, 359: 819-821; (4) Penfield and Camargo, 1981, SEG abs. 37-38; (5) Perrier and Quiblier, 1974, AAPGB 58: 507-528.

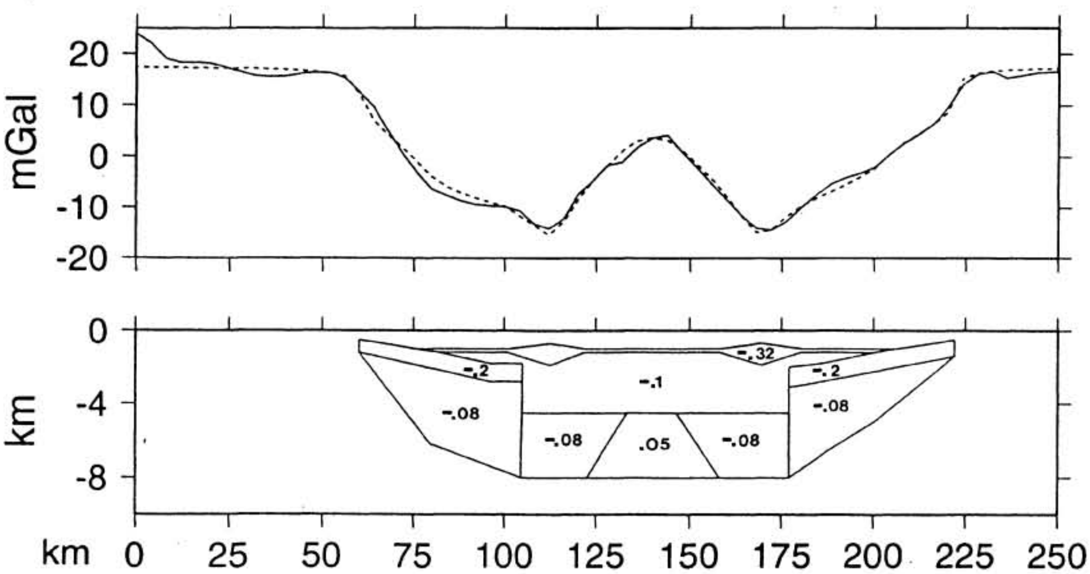

Figure 1: Bouguer gravity anomaly model of Chicxulub crater. Upper portion of diagram shows observed Bouguer anomaly along a near-central profile parallel to coastline with a regional gradient removed (Southernmost profile of two located on Figure 1 of Hildebrand et al. (1)). Solid line is observed anomaly; dashed line is calculated anomaly. Lower portion of diagram shows density elements chosen for Chicxulub crater together with density contrasts in g/cm^3. An 8 km depth limit was chosen for density contrasts based on assuming that lithostatic pressure would close porosity at this level (5). Note vertical exaggeration.

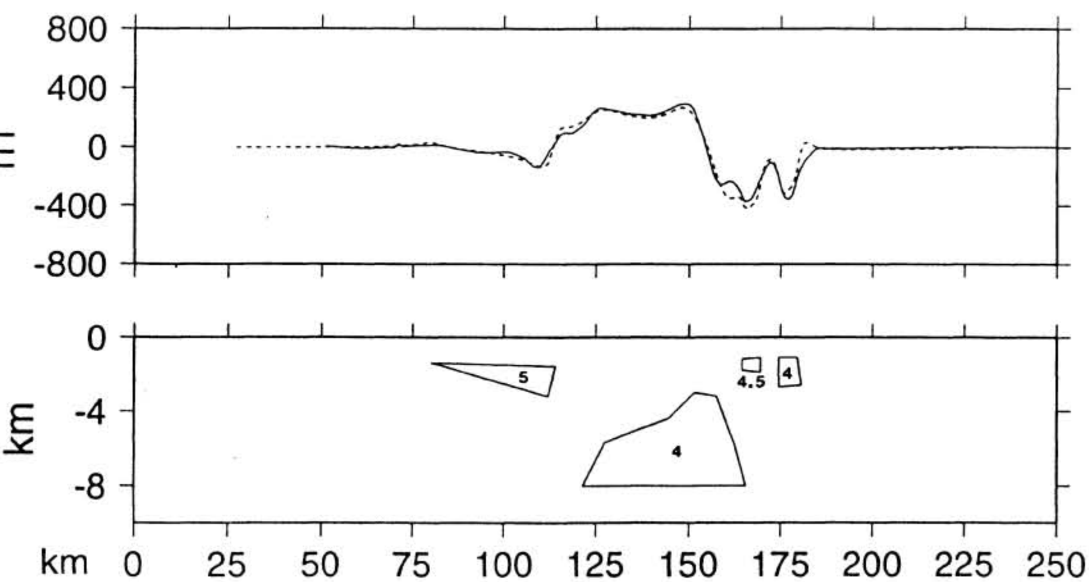

Figure 2: Total field magnetic anomaly model of Chicxulub crater. Upper portion of diagram shows observed magnetic field along same profile as in Figure 1. Solid line is observed field; dashed line is calculated anomaly. Lower portion of diagram shows magnetic bodies chosen for Chicxulub crater together with magnetization contrasts in A/m. Shallower bodies correspond to melt pool and deeper body to central structural uplift. Note vertical exaggeration.