WETUMPKA IMPACT STRUCTRE, ALABAMA: GRAVITY SURVEY. J. B. Plescia[1], [1]Applied Physics Laboratory, The Johns Hopkins University, 11100 Johns Hopkins Road, MP3-E169, Laurel MD 20723, jeffrey.plescia@jhuapl.edu..

Introduction: The Wetumpka Structure is an ~7-8 km diameter impact in Alabama of Late Cretaceous (80-83 Ma) age. The structure was originally reported by [1-2]; subsequent work including drilling has been discussed by [3-10]. An earlier gravity survey [11] indicated that the structure exhibited an annular gravity high gravity over the crystalline rock ridge and low gravity within the interior and total gravity relief of about 10 mGal. Here, a more comprehensive gravity survey of the structure is reported.

Geology: Presently, the structure consists of a horseshoe-shaped topographic ridge composed of Appalachian piedmont schist and gneiss that is open to the southwest west, and an inner zone of undulating topography composed of deformed Upper Cretaceous sedimentary rocks [1,3]. The target geology at the time of the impact included weakly consolidated Upper Cretaceous strata overlying pre-Cretaceous crystalline basement. Two cores have been drilled into the eastern flank of the structure [3-4]. Both holes were drilled to about 190 m and both penetrated steeply dipping Upper Cretaceous units in the upper 64 m and then interbedded impactite units below 64 m to the bottom of the hole (≥130 m thick). PDF features were observed in shocked quartz grains recovered from the core, confirming the impact origin of the feature [3].

Previous Work: Gravity data were collected in 1994 along an approximately east-west profile across the Wetumpka structure. Analysis of those data was reported by [11] and the profile is illustrated in Figure 1. The field exhibits an eastward decreasing gravity of about 1.0 to 1.5 mGal km^{-1}. A central low and flanking highs are observed on the profile with a maximum gravity relief of about 10 mGal. The high gravity corresponds to the circular ridge of crystalline rock and the low gravity is associated with the interior area of deformed sedimentary rocks. The western side of the interior low exhibits more complex gravity in the profile because the westerns portion of the profile is composed of three offset segments; thus, different portions of the structure are being sampled by the profile.

New Data: In order to more completely define the gravity field associated with the Wetumpka impact structure additional gravity data were collected in 1999 and 2006. Gravity readings were made using a LaCoste Romberg gravity meter and are tied to the absolute gravity base at Auburn University. A local base station was reoccupied every few hours to correct for meter drift. Position information was derived from both differentially corrected GPS and from the USGS 1:24,000 map sheets. For the GPS established positions, the signal was integrated for 10 minutes; vertical precision is typically of the order 10 cm (except in a few cases of poor satellite distribution). A base station set up within the structure was used for the differential correction. For stations whose locations were derived from the 1:24,000 map sheets, only locations with defined elevations (e.g., intersections, spot elevations) were used. These stations have vertical precision of ~30 cm. Bouguer reduction was done using a density of 2.67 g cm^{-3}. Terrain corrections have not been applied to the data.

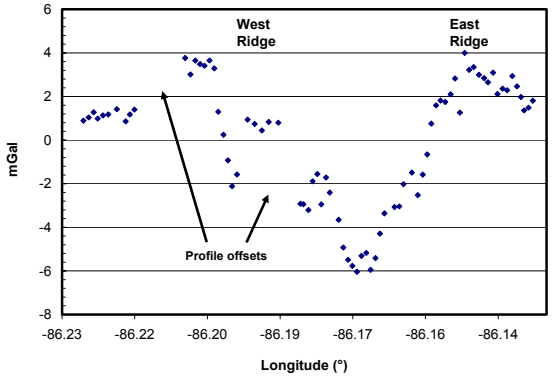

Figure 1. East-west trending residual gravity profile across the Wetumpka structure. The eastward decreasing regional gradient has been removed. The data have been projected onto a single line of latitude.

Data were contoured using the Oasis Montaj software. Gridding was done with grids of 300 x 300 points using a minimum curvature method. Residual gravity values were calculated by removing a variable order best-fit polynomial surface to the original data. Data distribution are somewhat uneven with more stations across the northern half of the structure.

Discussion: The simple Bouguer gravity map for the region is illustrated in Figure 2. The low associated with the interior of the structure is well defined and set in a northeast decreasing field. The long wavelength gradient of the field is about 1.1 mGal km^{-1}. A northeastward decrease in gravity is consistent with the increasing depth to crystalline bedrock (Figure 3 in [1]).

To focus on the specific anomaly associated with the Wetumpka structure, a residual gravity map was

created by removing a 2nd order polynomial surface and is illustrated in Figure 3.

The residual data show a well-defined simple circular anomaly composed of a central gravity low and an annular gravity high. The minimum gravity in the center is –5.75 mGal and the maximum values on the annular high are +2.2 to 2.5 mGal. Maximum gravity relief is about 8 mGal. This value is lower than reported in [11], the difference most likely due to inaccurate removal of the regional field in the earlier study.

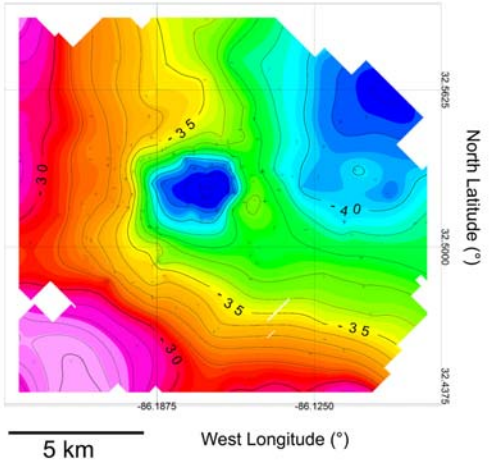

Figure 2. Regional Bouguer gravity field over the Wetumpka impact structure. Even in the observed field, the low associated with the center of the structure is evident.

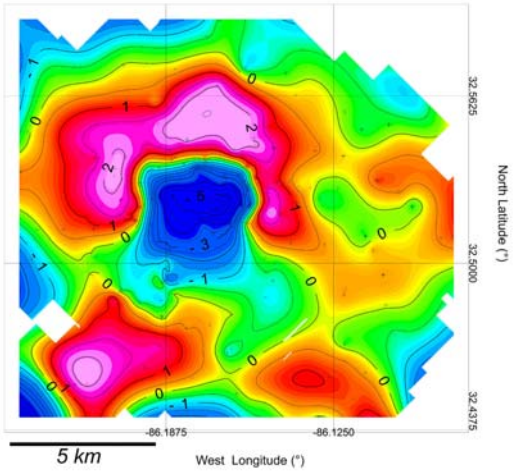

Figure 3. Residual Bouguer gravity of the Wetumpka impact structure. Central low and annular gravity high are well defined.

The variability in the amplitude of the annular high is real and not an artifact of data distribution, although the details may not be completely resolved. The high is well defined from the west around the north and thence to the east side. On the southeast side, the high is not present. On the southwest margin, control is sparse, but the high appears to be displaced to southwest of its expected position. This is also the region where the crystalline bedrock ridge is not present and in which the 'extra-structural terrain' of [2] occurs.

The gravity data suggest that the rocks within the interior of the structure (inside of the annular high) are relatively homogenous – at least from a density-contrast perspective. A homogenous density contrast suggests that a significant central uplift or a terracing of the inner margin of the crystalline basement do not occur.

Johnson *et al*. [10] and King *et al*. [9] suggest in an interpretive geologic cross-section (as part of a comparison to the Chesapeake Bay Impact Structure) that Wetumpka has a central uplift (although it is not exposed). The gravity data do not support the presence of an central uplift of high-density crystalline rock.

Summary: A gravity survey over the Wetumpka, Alabama Impact Structure reveals a relatively simple gravity anomaly. A central low (-5.75 mGal relative to the exterior) is surrounded by a gravity high (+2.5 mGal relative to the exterior). Total gravity relief is about 8 mGal. The gravity high corresponds to outcrops of crystalline rock that forms a horseshoe-shaped ridge open to the southwest. The gravity low is associated with the deformed Late Cretaceous rocks that fill the interior. The low is simple and there is no suggestion of a buried central uplift.

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