A 3D GRAVITY MODEL OF THE BOSUMTWI IMPACT STRUCTURE H. Ugalde[1], S. K. Danuor[2] and B. Milkereit[1], [1]Department of Physics, University of Toronto. 60 St George St, Toronto, ON M5H 2C7; ugalde@physics.utoronto.ca , [2]Department of Physics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Introduction: The Bosumtwi impact crater is located in Ghana. It has a rim-to-rim diameter of 10.5 km and is completely filled by Lake Bosumtwi, which has a diameter of 8 km and a maximum depth of 75 m [1]. With an age of 1.07 Ma it is one of the youngest large impact craters with well established age on Earth and within the planetary system [2]. It is well preserved and due to its excavation in early Proterozoic crystalline rock, it is more comparable to lunar and planetary impact craters than other terrestrial craters that were excavated in sedimentary target rocks. The crater was drilled in September-October 2004 as part of the International Continental Drilling Program – ICDP, and therefore a vast amount of geoscience data is available from the pre-site surveys and the actual drilling.

A 3D model was constructed from the integration of gravity, petrophysics and seismic data. The results obtained from the model are compared to the morphometric parameters obtained from numerical modelling [3] and scaling laws.

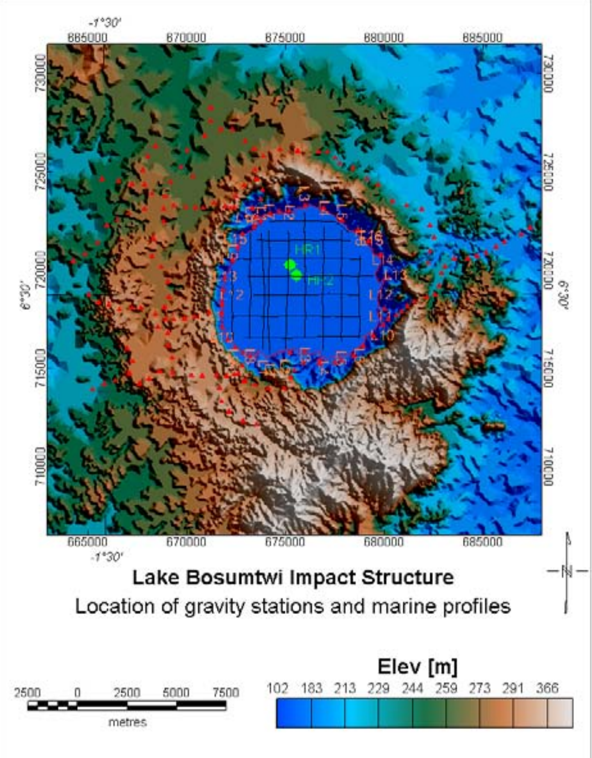

Figure 1: Location of land gravity stations and marine profiles.

Gravity data: New gravity data was acquired at Lake Bosumtwi between 1999-2001 (Figure 1; [4]). In total, 163 land stations and 18 marine profiles allowed the creation of an updated Bouguer gravity anomaly map (Figure 2). The separation between the land gravity stations was 500 m along profiles which ran radially towards the center of the lake. For roads and paths which ran parallel to the lake shore, station distances of 700 – 1000 m were chosen. The marine gravity survey is composed of 18 profiles [4]. The distance between the gravity profiles was about 800 m. Navigation was provided using a Garmin 235 Echo Sounder/GPS, which allowed the acquisition of bathymetric data at the same time. The conventional corrections (latitude, free-air, Bouguer) were applied to both datasets to produce a compiled dataset. In order to do that, the Bouguer correction considered a special term to account for the effect of the body of water [5]).

The anomaly is characterized by a negative with about –15 mGal amplitude and a diameter of about 11 km. The steepest gradients are found within the lake area. The anomaly is elongated in a SW – NE direction in analogy with the bathymetric results. As it is shown lwith the 3D model, the negative anomaly is the addition of the gravity deficiencies caused by the fractured and brecciated rocks in the rim area and below the crater floor, the impact breccias within the crater, and the sedimentary and water infilling of the lake.

Petrophysical data: One of the important outcomes of the ICDP project was the petrophysical data collected both through borehole logging and core scanning. This is of considerable importance to constrain the 3D model of the structure, since otherwise the depth extent of each unit can not be constrained accurately. The borehole logging survey collected gamma, susceptibility, resistivity, Vp sonic, and orientation (azimuth and deviation) of the borehole. Core scanning was accomplished in December in the headquarters of GFZ in Germany. This consisted on gamma-density and magnetic susceptibility. Gamma density was measured at irregular intervals, depending on the availability of suitable samples (regular diameter and flat surfaces); magnetic susceptibility was measured at ~10 cm spacing.

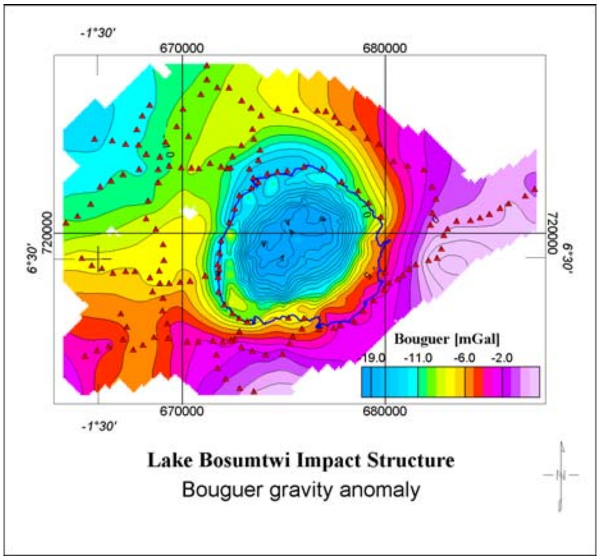

Figure 2: Compiled Bouguer gravity anomaly.

The density and p-wave velocity logs show larger density and P-wave velocity than on Hole 8 (central uplift) compared to Hole 7, located outside. This corroborates the velocity model by [6] and constitutes the base of the porosity-depth analysis that we used as a base for the density model incorporated in the 3D gravity modeling. Because of the different pressure conditions and distinct pore-space filling material in and out of the central uplift, it is expected to have a density contrast between both areas.

Gravity model: The model is composed of a series of 3D polygonal bodies, each with its own density. Together, all the adjacent bodies that share a similar density can construct very complex geological units. Then, the observed data was matched by the computed data from the whole 3D geometry via forward modelling and inversion, ending up with an error < 0.1 mGal (figure 3). The initial model was constructed based on numerical modeling and scaling predictions and is made up of two layers: sediments and impactites. From that base, adjustments were made line by line to reproduce the observed anomalies.

The sediment thickness was constrained by the sedimentary boreholes, and a minimum thickness grid was generated from the available seismic data. A good correlation was obtained between the model and the seismic, with an average thickness of the sediment unit of 140-180 m. This unit has a density of 1.6 g/cm^3, which is the average density of the sedimentary boreholes drilled in the lake (Peck, pers. comm.)

The model supports an impactite unit with a density of 2.3 g/cm^3 and located out of the central uplift, and another impact melt-rich unit located at the central uplift, with a higher density of 2.6 g/cm^3. The density contrast between these two units is supported by the measured density on core Both units have a thickness <300 m.

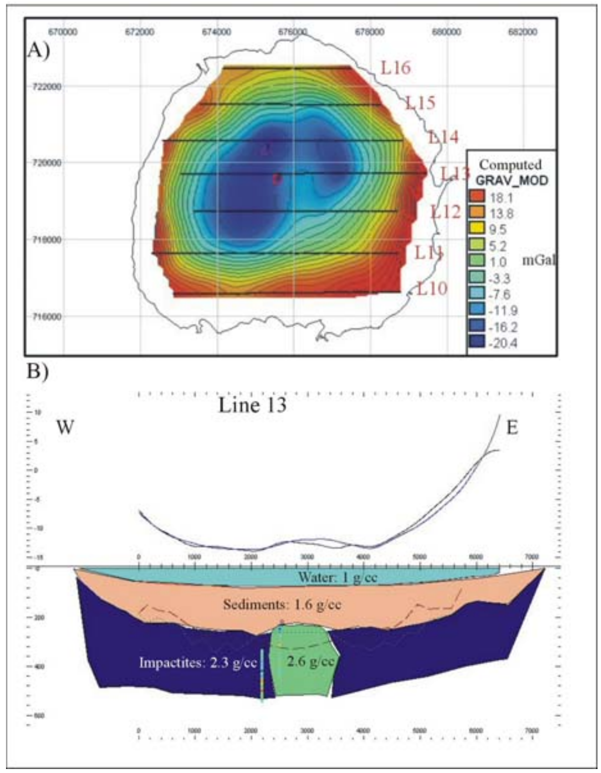

Figure 3: A) Computed gravity model; B) Example of a modeled cross section across the center of the crater.

Conclusions: For the first time a 3D model was constructed over the impact structure, which allows lateral density variations and updates the previous results from the 2.5D model from [4]. Finnally, it was recognized that the different pressure conditions induced by the impact, and the post-impact differential pore-space filling across the structure have an effect on the density distribution. Lateral density variations inside and outside of the central uplift are supported by a previous velocity-depth model [6], porosity-depth analysis, petrophysical data, and by this new 3D model of the structure.

References: [1] Scholz et al. (2002) *Geology, 30,* 939-942. [2] Grieve. et al. (1995) *GSA Today, 5,* 189-196. [3] Artemieva et al. (2004) *G^3, 5,* Q11016, doi:10.1029/2004GC000733. [4] Danuor S. K. (2004) *PhD Thesis*, KNUST, 147p. [5] Ugalde et al. (2006) *Geophysics ,in press*. [6] Karp et al. (2002) *Planetary Space Science*, *50*,735-743.