CONSTRAINED MODEL INTERPRETATIONS FROM HAUGHTON CRATER GEOPHYSICAL DATASETS. B. J. Glass[1], S. Domville[1] R. Sanjanwala[1] and P. Lee[2], [1] NASA-Ames Research Center, Moffett Field, CA 94035, USA; [2] SETI Institute, 2035 Landings Drive, Mountain View, CA 94043, USA. (brian.glass@nasa.gov)

Summary: Existing geophysical datasets have been updated and are used as constraints to create a model of the substructure of the Haughton Crater impact structure.

Haughton Crater: The Haughton impact structure is a relatively well-preserved crater, estimated origin at 39 Ma [1, 2], located at 75º 23' N, 89º 39' W in the Canadian Arctic, on Devon Island, Nunavut, Canada with an original rim diameter estimated at about 23 – 24 km [3]. Past studies, in the 1980s, did an initial survey of the Haughton structure, looking at its surface units, exposures, map surface geology, topographic and initial surveys of gravity and magnetic fields in profiles across the impact structure [4]. The impact structure is located in approximately 2 km thickness of carbonate material above a gneissic basement. In the mid to late 1980s initial surveys of the Haughton Impact central crater used geomagnetic field measurements using handheld and surface instruments in transects , which were limited to several 4km ground profiles taken along NW/SE and NE/SW transects in the vicinity of the central local anomaly. At that time, the magnetic survey also lacked a local base station magnetometer to correct for temporal variation of the ambient magnetic field. These early results showed a positive magnetic field anomaly of 700 nT at the central anomaly. At the same time, a fairly detailed gravity survey of the Haughton structure was completed in 1984 with 341 data points and found a large negative Bouguer anomaly of roughly –12 mgal. This central local minimum is characteristic of impact structures. The gravity low and magnetic high were postulated in [4] as likely due to highly shocked and altered sedimentary and crystalline basement rocks in the central uplift area.

Geophysical Measurements: Given the lack of detailed magnetic datasets and gradients covering the same area as the detailed gravity survey, an aeromagnetic survey was conducted over two field seasons (1999 [5] and 2001 [6]) at Haughton Crater. A central magnetic high could be due to uplifts of magnetized basement material or compressed and altered materials at a central uplift with remnant magnetism. But the central gravity low implies a region of lower density material. Figure 1 shows the vertical magnetic gradient over the crater, with a sharp central anomaly.

In July 2003, August 2004 and August 2008 new gravity stations were established and data taken. These stations extended from the central anomaly and were primarily located in the NW quadrant of the crater, and also extended to the west. Additional stations were also located around the annular area where hydrothermal locations had been noted. The existing data from 1984 (published in 1988 [4]) was digitized and merged with the 32 new gravity stations to generate a new combined gravity contour plot, shown here in Figure 2.

The small magnetic gradient anomalies on the north side, given that there is found little to no gravity field variation in the area, would be candidates for correlation with hydrothermal deposits in the faulted and fractured rim zones, as postulated in [2]. The new aeromagnetic and gravity data are consistent with the previous results showing a central magnetic high with bounding lows in the crater, compatible with a subdued central uplift with smaller regional basement anomalies around the crater locale.

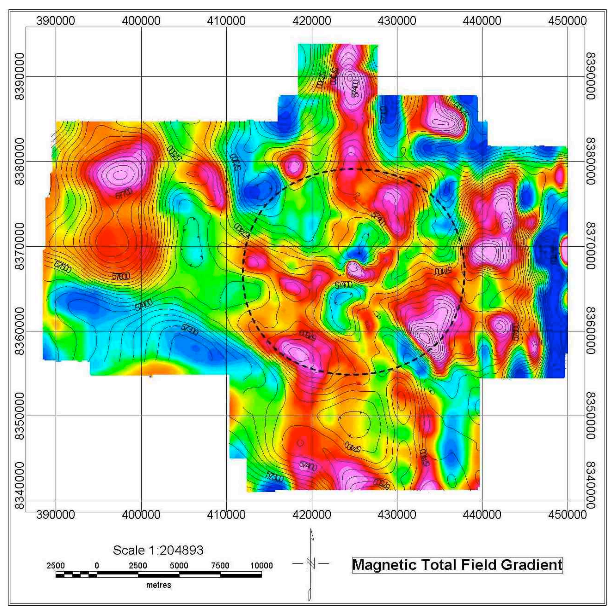

Figure 1. Magnetic total field gradient, with crater rim.

Modeling Approach: The physical landforms and units found at Haughton Crater, together with the new or updated geophysical datasets, provide constraints that allow the development of models of the subsurface. Starting with a idealized crater conical structure sized to the estimated rim diameter, we then subsampled from the sets of flown E-W and N-S survey lines, then adjusted the basement depths and created altered-material zones between the basement and the surface, adjusting the density and magnetic susceptibility of these crater infill zones to fit the gravity and magnetic and magnetic gradient values. Geosoft Profile was used to create and edit these individual 2D models. An example is shown in Figure 3, with the model vs. dataset error estimates shown in red. The grid of N-S and E-W 2D profile models was then used themselves as constraints to create an estimated 3D model of the Haughton Crater subsurface, one that is consistent with the gravity, magnetic, and elevation data as well as known areas of paleohydrothermal activity.

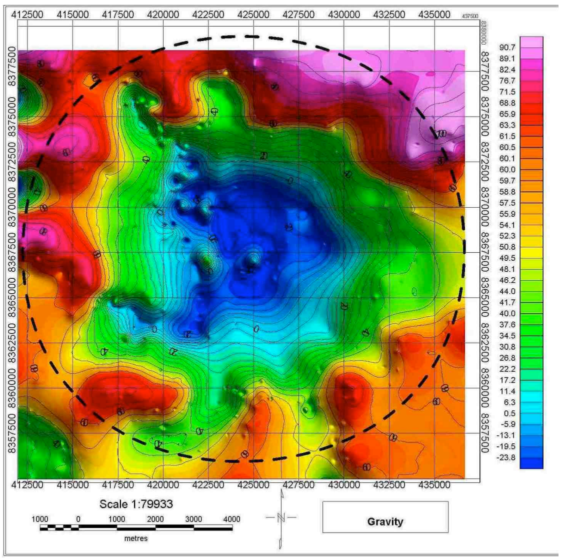

Figure 2. Combined gravity dataset.

Discussion: Fundamentally this is a model that is curve-fit to match the observed geophysical and other data, so there could be multiple valid solutions along one or more of the 2D model lines. Therefore the model as a whole should be considered as a notional best estimate rather than a definitive map. The resulting 2D and 3D models (Figure 4) show three regions within the crater subsurface. Around the central uplift (about 6-8 km radius) the modeled densities are low, below 2.0 g/cc, with a central peak zone with higher magnetic susceptibilities. This correlates with a recent study [7] that found highly-shocked, porous lower-density rocks prevalent near the center. Several of the 2D models also found a collar zone with upturned or raised basement between about 6 – 12 km radius, which compares with similar results from a 2008 numerical modeling study [8]. Zones with increased susceptibilities are used to match the areas with increased magnetic gradient values around the central uplift and around paleohydrothermal areas.

The 3D model unexpectedly shows a basement groove or trough extending to the SW (bearing of 61 degrees, slope of about 25 degrees) extending about 8km radius. It is interesting to speculate whether this could have been created by a relatively low-angle (but >15 degrees, given a circular surface crater) impact path. Using Scotese's Paleomap method [9] to estimate the plate drift and rotation back to roughly the estimate age of the crater (~40 Ma), the adjusted approach bearing of the trough would have been 80 degrees, extending outward WSW from the center.

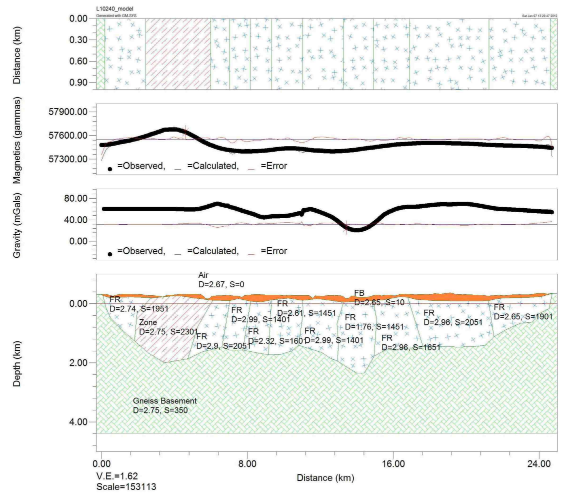

Figure 3. 2D model along a survey line, with palaeohydrothermal zone (left) and reduced densities in center.

References: [1] Jessburger, E.K., (1988) *Meteoritics*, 23, 233-234. [2] Osinski, G. R. and Spray, J. G. (2005) *Meteoritics & Planet. Sci*. [3] Scott, D. and Hainal, Z. (1988) *Meteoritics,* 23, 239-247. [4] Pohl, J. et al., (1988) *Meteoritics,* 23, 235-238. [5] Glass, B.J., and Lee, P. (2001). LPSC XXXII, Abstract 2155. [6] Glass, B.J. et al. (2002). LPSCXXXIII [7] Singleton, A. et al, (2011) *Meteoritics & Planet. Sci*., 46, 1774-1786. [8] Collins, G.S., et al, (2008) *Meteoritics & Planet. Sci*., 43, 1955-1977. [9] Scotese, C., (2008) GSA Joint Meeting, Paper No. 233-3.

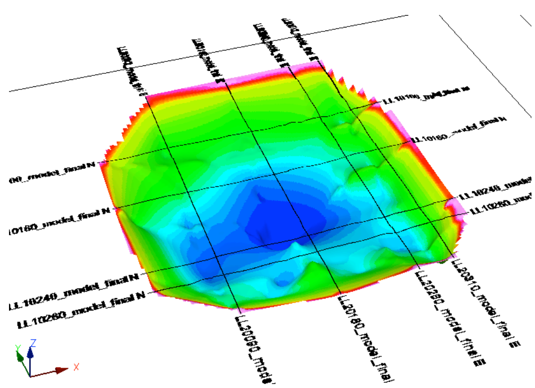

Figure 4. 3D constructed model from grid of 2D models, showing trough to SW.