GEOPHYSICAL STUDIES OF THE HIGHBURY METEORITE IMPACT STRUCTURE, ZIMBABWE. T. Gumede[1,2], D. J. Robertson[3] and S. Master[4,5], [1]Department of Physics, Univ. of Zimbabwe, Harare, Zimbabwe. [2]Present Address: Prospecting Ventures, P.O.Box ST689, Southerton, Zimbabwe. [3]Dept. of Physics, Univ. of Namibia, Windhoek, Namibia, Djr@unam.na. [4]Dept. of Earth & Planetary Sciences, Harvard University, 20 Oxford St., Cambridge, Mass., 02138, USA, Master@geochemistry. harvard.edu. [5]Permanent Address: EGRU, Univ. Witwatersrand, P.Bag 3, WITS 2050, South Africa, 065sha@cosmos.wits.ac.za.

The 20-km-diameter Highbury meteorite impact structure in northern Zimbabwe, centered on 30°06'55" E, 17°03'53" S, is developed in Paleoproterozoic metasedimentary country rocks of the c. 2.0-1.8 Ga Magondi Belt [1,2] (Fig. 1). The undeformed Munwa Granophyre, believed to be an impact melt-rock, intrusive into shocked, brecciated country rocks, has a zircon U-Pb age of 1034±13 Ma [2]. Ground gravity, magnetic, and resistivity studies of the Highbury structure were carried out in 1995 [3]. The gravity study indicates a central high (with a large offset anomaly coinciding with the granophyre) surrounded by concentric gravity lows. This is interpreted to be the result of a central uplift cored by denser material from the underlying Chinhoyi greenstone belt. Magnetic studies show that a prominent magnetic anomaly is centred on the Munwa Granophyre, while other anomalies are due to dipping mafic dykes. Resistivity studies show the limited extent of the Munwa Granophyre, and support its interpretation as a downwardly-injected impact melt.

Gravity: The gravity survey comprised 62 gravity stations with an average spacing of 1 km, with closer spacing over the Munwa granophyre. Data were obtained with a LaCoste Romberg gravimeter, and gravity values were reduced using Tidal, Terrain, Bouguer, Free air, Latitude and instrumental drift corrections. Elevations were obtained by levelling and differential mode GPS. Relative gravity values were tied into the Zimbabwe National Gravity Station 21M276 in Chinhoyi, and the data was merged with the Leeds and Zimbabwe Geological Survey national gravity grids, to produce the regional gravity field over Highbury. The contoured map of the gravity field shows a gravity high over the (topographically flat) centre of the Highbury Structure, with a large Bouguer anomaly offset to the SW from the centre, corresponding with the position of the Munwa granophyre, and a further prolongation to the SW over Windsock Farm. The Gravity high is surrounded by a roughly concentric gravity low, with an increase in the gravity field corresponding to the edge of the Highbury Structure in the north, but extending for up to 5 km beyond the southern edge. The central gravity high is consistent with being due to a structural uplift, of c. 150 m, of the underlying felsic greenstones of the Chinhoyi greenstone belt, which have a density contrast of 134 kgm^{-3} with the overlying dolomite. The central gravity high cannot be due to a tapering (conical) intrusion of granophyre, since there is no corresponding magnetic signature.

Magnetics: Aeromagnetic data over Highbury were obtained from a 1976 high-resolution (150 m line spacing, 80 m elevation) survey [4], as well as the Zimbabwe National Aeromagnetic survey (1 km line spacing, 305 m elevation) [5] (Fig. 2). The overall magnetic fabric follows the regional structural grain, but there is a circular pattern superposed on this, which is concentric with the edge of the structure, and extends beyond it, especially in the NW and E (Fig. 2). Two major magnetic anomalies are present- one over the Munwa Granophyre, and the other over Windsock Farm 3 km SW of the first. Detailed ground magnetic traverses were made over these anomalies, using a Proton Precession Magnetometer. Modeling of the magnetic anomaly over the Granophyre shows that it is due to the very high magnetic susceptibility of the magnetite-rich granophyre (magnetic susceptibility = $1.6x10^{-3}$ cgs units), and a high Natural Remanent Magnetization (NRM). Combined gravity and magnetic modeling of the Windsock anomaly shows that it is probably due to a N-dipping mafic sill.

Paleomagnetism: Preliminary paleomagnetic studies on a single sample of the Munwa Granophyre showed an NRM with I=-24.65°, D=327.27°, M=328.24 mAm^{-1}. Alternating Frequency step demagnetization in fields from 5 to 70 mAm^{-1} showed 2 components, a soft component with I=20.9°, D=330.9°, M=308.5 mAm^{-1}; and a hard component (primary field), with I=-37.25°, D=16.9°, and M=20.8 mAm^{-1}. The primary component corresponds with a virtual geomagnetic pole at 136.1°E, 73.6°N.

Resistivity: Resisitivity measurements, using Schlumberger soundings (200 m maximum spacing between current electrodes), and Wenner profiles (10 m electrode spacing over 250m-long profiles) immediately E of the outcrop of the Munwa granophyre showed only a 3-layer resitivity pseudosection model interpreted to be due to dry and saturated alluvium, and tremolitic dolomite marble, which crops out on part of the section. The granophyre is not seen in these profiles, indicating its limited lateral extent, as also borne out by the magnetic and gravity data.

The combined gravity, magnetic and resistivity data demonstrate that the Munwa granophyre is not an apophysis from an inferred large regional intrusive batholith that was postulated as being responsible for producing contact-metamorphic "skarns" in the Highbury area [6]. The tremolitic marbles are not skarns, and their origin is related to the impact-generated shock and thermal metamorphism (they contain gries-textured breccias with silicate glass schlieren). The rootless nature of the granophyre supports the interpretation that it is a downwardly-injected meltrock produced during the formation the Highbury impact structure. Concentric gravity and magnetic anomalies extend for up to 5 km beyond the photogeologically-determined edge of the Highbury structure, indicating that the structure may originally have been larger, prior to deep erosion. More detailed gravity work, especially to the NW and SE of the structure is needed to confirm this.

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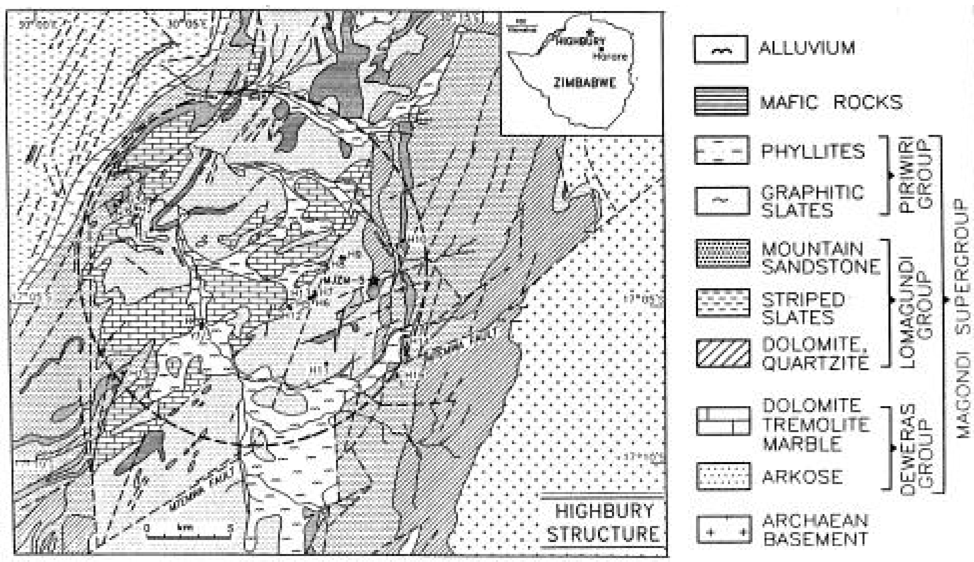

Fig. 1. Geological map of the Highbury impact structure. The circular outline of the structure is defined photogeologically from computer-enhanced Landsat TM imagery and from geology.

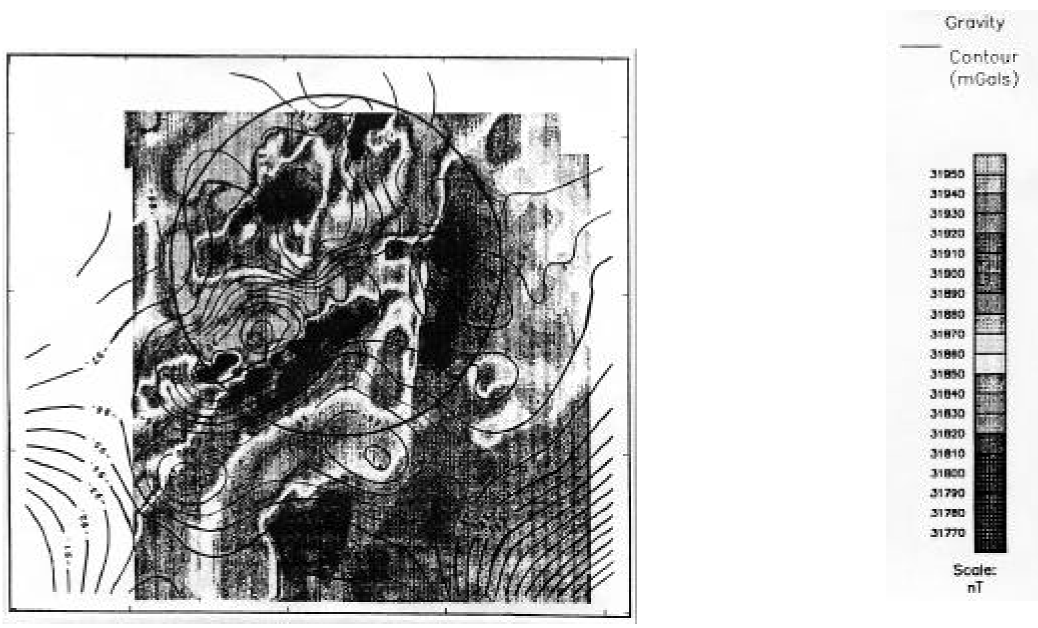

Fig. 2. Shaded Aeromagnetic Map of the region around Highbury, with superposed Gravity contour lines, and the photogeologically-defined outline of the Highbury impact structure.