DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for degree or examination in any other University.

Signed

________________________
Manfriedt Muundjua

___________ day of ____________ 2008
While most impact craters are characterised by negative magnetic anomalies over their central regions, aeromagnetic surveys over the Vredefort meteorite impact crater reveal multiple concentric magnetic patterns with no significant anomaly at its centre. In the rim, the patterns reflect the different sedimentary strata of the Witwatersrand Basin and the intense anomalies in the rim are clearly related to iron rich shales. About halfway into the basement there is a prominent negative magnetic anomaly that extends in a broad semicircular belt around most of the basement core. The anomaly in the basement is more pronounced in the northwest part of the basement.

A ground geomagnetic survey was conducted across a portion of the negative magnetic anomaly identified from the aeromagnetic data, which coincides with the amphibolite-granulite facies transition zone. The reasons for choosing the area was two fold, firstly to understand the relationship between the magnetic anomalies and the geology and secondly to compare the ground survey with aeromagnetic data. In addition to the main survey, a more detailed geomagnetic survey was conducted over a small area (9 m x 9 m, this being the total area) of intense magnetic field variation to help constrain magnetization over shorter wavelengths. The latter part also included a palaeomagnetic study and analysis of these and pre-existing data from the crater.

The data were analysed using two geophysical filters (upward-continuation and automatic gain control) which were successful in comparing data from this study with existing aeromagnetic data and in enhancing subtle features for comparison with the geological map. Inverse modelling was conducted on the main magnetic study area as well as on the 9 m x 9 m grid, which was characterized by very variable magnetic field, in an attempt to constrain the magnetization and depth of source bodies.

Magnetic anomalies defined by the data are most often negative and occur over a wide range of wavelengths. The longest wavelength negative anomaly coincides well with the
aeromagnetic data. This feature is centered over the amphibolite to granulite metamorphic facies transition exposed in the basement. The upward continued map coincides very well with the aeromagnetic data in that the amplitude and shape of the long wavelength anomaly obtained in this study is similar to that seen in the aeromagnetic data.

On the basis of the modelling conducted in this study it is concluded that the long wavelength negative anomalies in the basement are due to Archaean basement rocks with coherent vectors, that have been remagnetised as a result of temperature, pressure and phase transitions at amphibolite-granulite transition at the time of the 2.0 Ga impact event. Petrographic evidence shows that there is a marked increase in the intensity of the impact related thermal and shock metamorphism (including the formation of single domain magnetite) across the transition. The author suggests that this and the magnetic anomaly are explained by focusing and defocusing of shock waves at a rheologic interface.

On the other hand, negative anomalies occurring over smaller (20 to 100 m) wavelengths often do not coincide with the surface geology. These features require a body below the surface with very high magnetization intensities and thus cannot be modelled using the same criteria as that for the long wavelength anomaly. Further, the magnetizations determined from inversion over the smaller anomalies are not compatible with conventional thermoremanent magnetism.

The scattered pattern displayed by the natural remanent magnetism data strongly suggests that lightning strikes are the cause. The observed patterns displayed by the anisotropy of magnetic susceptibility data could not have survived the plasma fields, and this is a strong negation that the plasma fields were responsible for the random orientations of natural remanent magnetism as postulated by others.

In this study the principal directions of the anisotropy of magnetic susceptibility were found to coincide with the observed metamorphic fabric which suggests that at least some
of the rocks were not heated that high to attain melting at the time of the impact event. This is also in agreement with Verwey transition measurements in the basement rocks that suggest that the basement rocks were not wholly heated above the Curie temperature during or since the time of impact.
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