CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

This study has addressed two aspects of geomagnetism of the amphibolite-granulite transition in the Vredefort impact crater. The first involved a ground magnetic survey across the transition as well as detailed surveys over small areas within the transition that are characterized by rapid variations in the geomagnetic field. These are areas containing prominent outcrops of banded iron formation and an area of exceptionally steep magnetic gradient in the centre of the study area. The second aspect involved a palaeomagnetic study of the latter area and analysis of these and pre-existing data from the crater. Interpretation of the combined data sets has gone a long way towards meeting the objectives of the project as indicated below.

The results of ground magnetic surveys show that the geomagnetic data delineate the position of the amphibolite-granulite transition as well as the radial and concentric faults that separate the different geological units. While most impact craters are characterised by negative magnetic anomalies over their central regions, aeromagnetic surveys over the Vredefort meteorite impact crater reveal concentric magnetic patterns that have sharp gradients consistent with the near vertical structures observed in the rim. The ~36 km of uplift and the near vertical structures of the central peak, coupled with the concentric magnetic patterns suggest that the Vredefort crater is one of the few multi-ring craters on earth.

Upward continuation of the data shows that they are compatible with the aeromagnetic data, and this suggests that conclusions made from the current study can be extended to the whole basement. Applications of the automatic gain control filter to magnetic data successfully reveal hidden features as well as enhance traceability of known subtle features.

The most pronounced long wavelength negative anomaly coincides with the amphibolite-granulite transition, indicating that this crustal boundary in some way bears upon the magnetic signature of the crater. It is suggested that the transition zone coincides with the Conrad discontinuity that may be present at depths of about 20 km elsewhere in the Kaapvaal Craton.

Analysis of existing models for the negative magnetic anomaly in the Vredefort basement has revealed that they are incompatible with the data from this study and do not pay sufficient attention to the geological constraints. Conventional thermoremanent magnetism is not a plausible explanation because there is no negative anomaly at the centre of the crater where the temperatures should have been highest. A plasma generated field is not realistic because it assumes that randomly generated magnetic vectors will result in a negative magnetic anomaly, whereas randomization of vectors should result in a net zero anomaly. Furthermore, it has not been demonstrated how such a process could work. 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 subsurface 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.

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 AMS were found to coincide with the observed metamorphic fabric which suggests that at least some of the rocks were not heated too high to attain melting at the time of the impact event. This is also in agreement with Carporzen et al. (2006) 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.

Some of the smaller wavelength (20 to 100 m) anomalies measured in this study were found to have magnetic intensities that could not be modelled using the same criteria as the long wavelength anomalies (i.e. using vector moments constrained by those found in impact melts). Further investigation is needed to establish the cause of unusually high magnetization intensities in these areas of the Vredefort basement.

Further work is clearly required to gain a better understanding of the magnetic anomaly of the Vredefort dome. The aeromagnetic data yield regional coverage, but ground surveys provide details, and if this could be achieved across the entire structure it would allow mapping of the lithology and fault structures in the core region of the crater and greatly enhance understanding of its morphology. Holes that penetrate the basement to depths greater than 10 m below surface would permit more definitive palaeomagnetic studies because the samples could not be affected by lightning. Analyses on such samples would establish whether or not the magnetic vectors are indeed randomly orientated, and thus place important constraints on the origin of the magnetic field. In addition, further detailed surveys are required to better understand regions of exceptionally high magnetic intensity and steep magnetic gradient that are present in parts of the transition zone.