9 EXPLORATION EXAMPLES

9.1 Introduction

Since completion of the initial field trials of the SAMCard-enhanced TM-4, over 2000 line km of commercial SAM surveys have been conducted for the simultaneous acquisition of High Definition, Total Magnetic Intensity (TMI) and Total Field Magnetometric Resistivity (TFMMR). The experience derived from those surveys has contributed greatly to an appreciation of the technique's potential as a geological mapping tool. Of particular importance has been the insight into the interpretational value of the two independent, high definition data sets.

The Sub-Audio Magnetics method is appropriate for use as an exploration tool in geological environments where both magnetic and electrical contrasts are anticipated. The interrelationships which may exist between those physical properties have been found to vary greatly. In some cases, the two data sets were *supplementary*, that is, the TFMMR data provided consistent information which confirmed and extended the interpretation which would have been made had only the magnetics component of the data been available.

In other cases, the TFMMR data exposed new, vital yet contrasting information which, in some instances, resulted in a complete review of exploration strategy. Although the magnetic and TFMMR data may in some situations appear to be contradictory, they must both be consistent with the actual geological structures present. In those situations, the *complementary* nature of the two data sets highlighted the potential interpretational bias which may result from too much dependence on a single data type.

This Chapter presents the results of four exploration examples which serve to illustrate the interrelationships described above. At the time of writing, the exploration leases were still being held and, for reasons of confidentiality, the locations of the survey areas and the details of the geology have not been divulged.

9.2 Supplementary Data Sets

The first examples are from a Banded Iron Formation (BIF) - hosted Archaean gold prospect in Western Australia. Two grids were surveyed in the area and were designated Grid A and Grid B. Grid A was 1200 m x 800 m in dimension with local north orientated at 20° magnetic. The survey was conducted with the electrodes located east and west of the survey area. The current carrying wire was laid out to the south of the grid.

Images of TMI and TFMMR from Grid A are included as Figures 9-1 and 9-2, respectively. The blank area of the images was not surveyed due to the presence of an open-pit gold mine. The main feature of the TMI image is an intense (>4000 nT) northeast-southwest striking anomaly which clearly defines the location of a BIF. The TFMMR image depicts a distinct anomaly coincident with the magnetic anomaly, suggesting that the BIF is also a conductor. A second, more intense, sub-parallel TFMMR anomaly was also detected to the south of the BIF. Clearly, the second conductor is non-magnetic. The high amplitude, high frequency noise to the north of the magnetic anomaly was due to float material which had been eroded from the BIF. The effect of this intense noise is clearly manifest in the TFMMR data in Figure 9-2.

Grid B was 900 m × 650 m in area. Local north was orientated 0.6° magnetic. The electrodes were located to the north and south of the survey area with the wire positioned to the east of the grid. The images of TMI and TFMMR from Grid B are presented as Figures 9-3 and 9-4, respectively. The BIF in this case is aligned more closely with magnetic north. The magnetic anomaly due to the BIF is less intense than that from Grid A with an amplitude of about 2000 nT. A distinct flexure in the anomaly is visible at approximately 14100 mN.

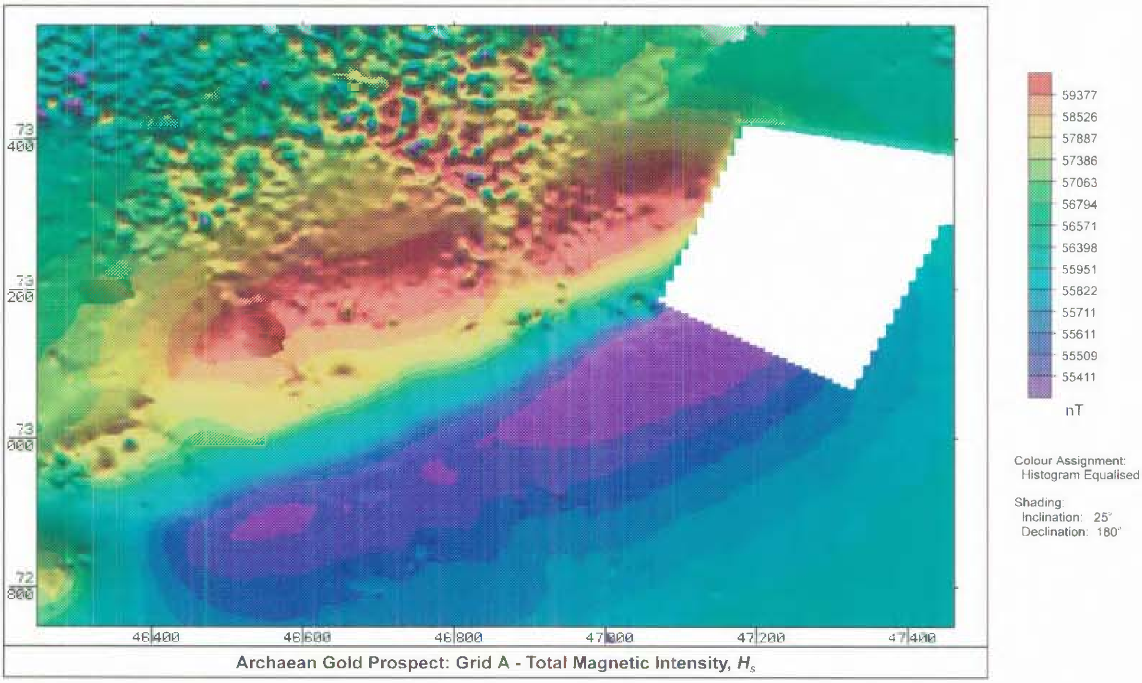

Figure 9-1. Archaean Gold Prospect: Grid A - Total Magnetic Intensity, H_S.

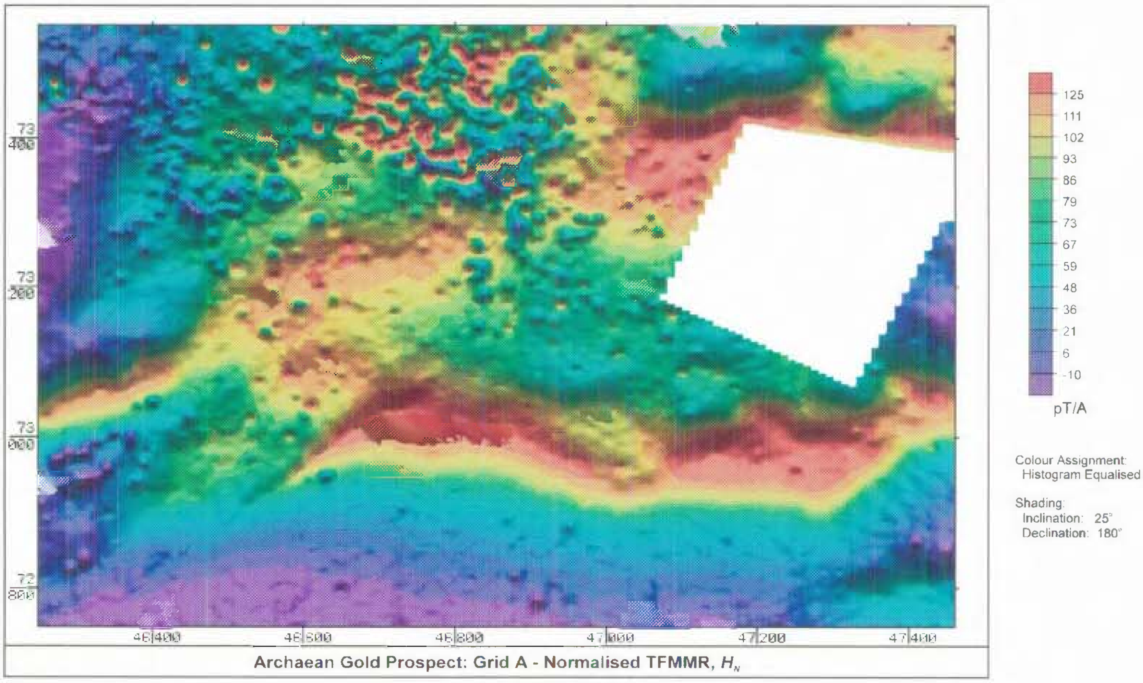

Figure 9-2. Archaean Gold Prospect: Grid A - Normalised TFMMR, H_N.

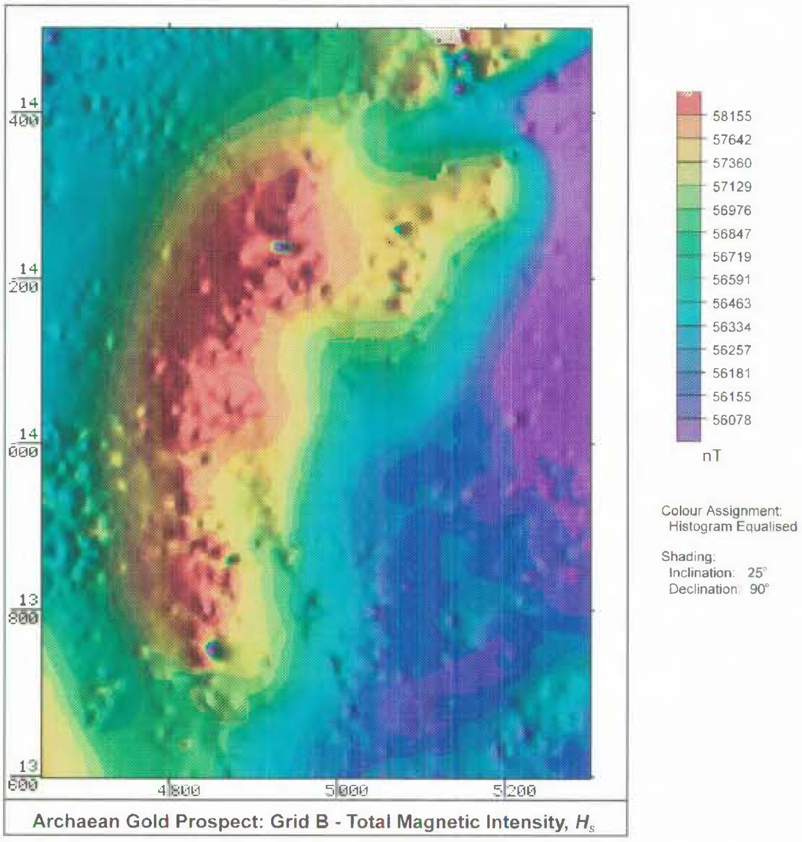

Figure 9-3. Archaean Gold Prospect: Grid B - Total Magnetic Intensity, H_S.

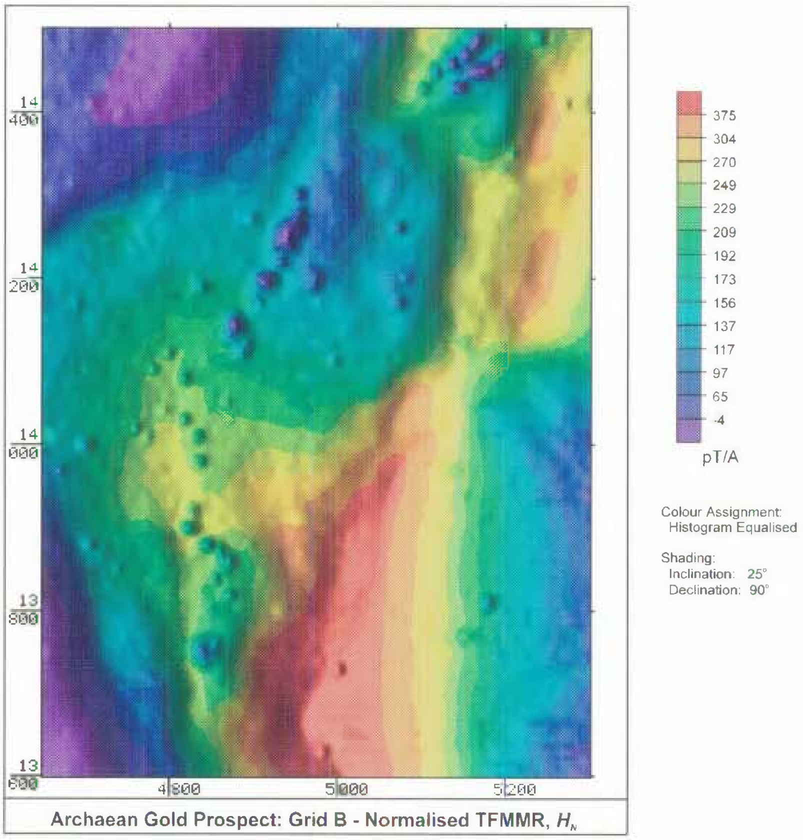

Figure 9-4. Archaean Gold Prospect: Grid B - Normalised TFMMR, H_N.

A coincident TFMMR anomaly in Figure 9-4 again suggests that the BIF is a conductor. As with Grid A, a second, more intense anomaly further to the east is clearly defined in the TFMMR image. Several displacements in the TFMMR anomaly in the north of the survey area suggest faulting.

Both of the above surveys demonstrated how the TMI and TFMMR data sets may complement each other. In each case, the TFMMR data both reinforced and extended the interpretation which would have been made solely from the magnetics information.

9.3 Complementary Data Sets

The next examples are from surveys conducted from a prospect located north of Cloncurry, Qld. The exploration target was a classic Ernest Henry or Osborne style Cu/Au deposit. The general exploration strategy was to look for magnetic "highs" which coincided with anomalous geochemistry.

Prior to the SAM surveys being conducted, the area had been surveyed with conventional ground magnetics and investigation of some of the more intense magnetic anomalies did, in fact, reveal anomalous soil geochemistry. However, it was found that the trend of the geochemical anomalism did not agree with the trend of the magnetics, providing a dilemma for those responsible for the exploration program. An airborne EM survey had detected the presence of a conductor in the area, although follow-up ground surveys had failed to properly define the anomaly.

Two SAM grids were surveyed at the site and, for the sake of this discussion, have been designated Grids C and D. The surveys were conducted with the electrodes positioned north and south of the survey areas. The grids were both orientated with local north aligned with 7.5° magnetic.

Grid C had the dimensions of 1000 m × 1000 m. The current carrying wire was laid out to the west of the survey area. Images of TMI and TFMMR for Grid C are included as Figures 9-5 and 9-6, respectively.

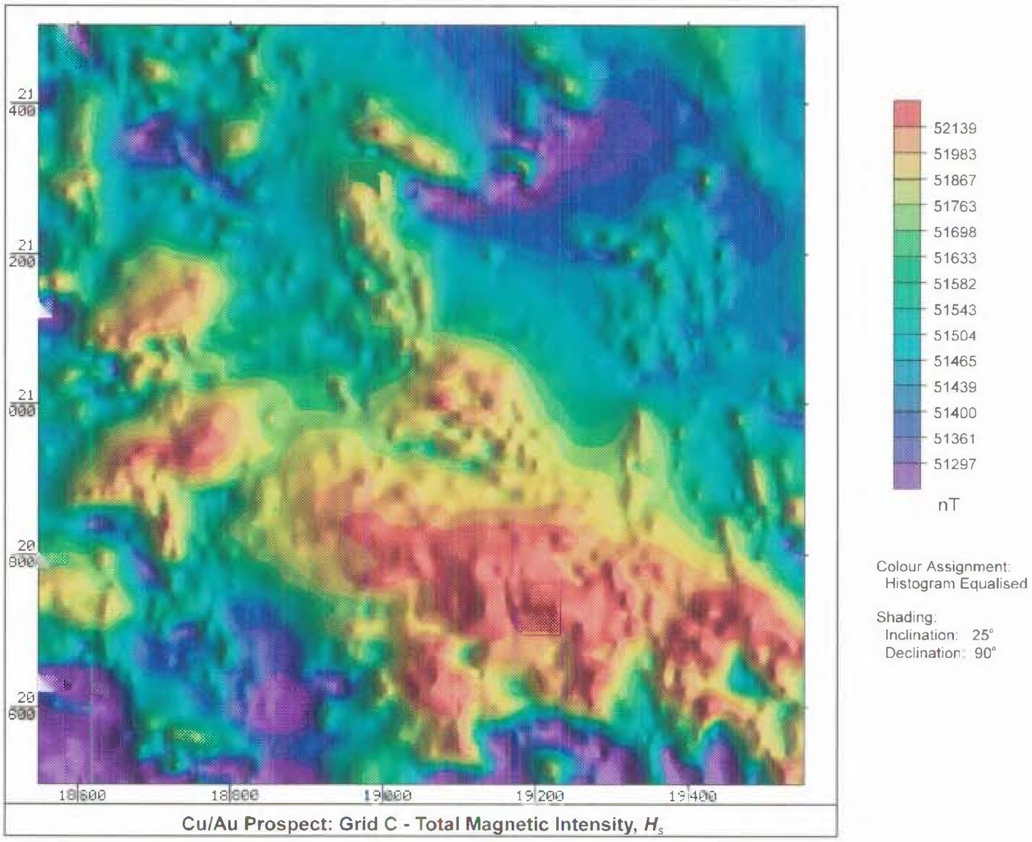

Figure 9-5. Cu/Au Prospect: Grid C - Total Magnetic Intensity, H_S.

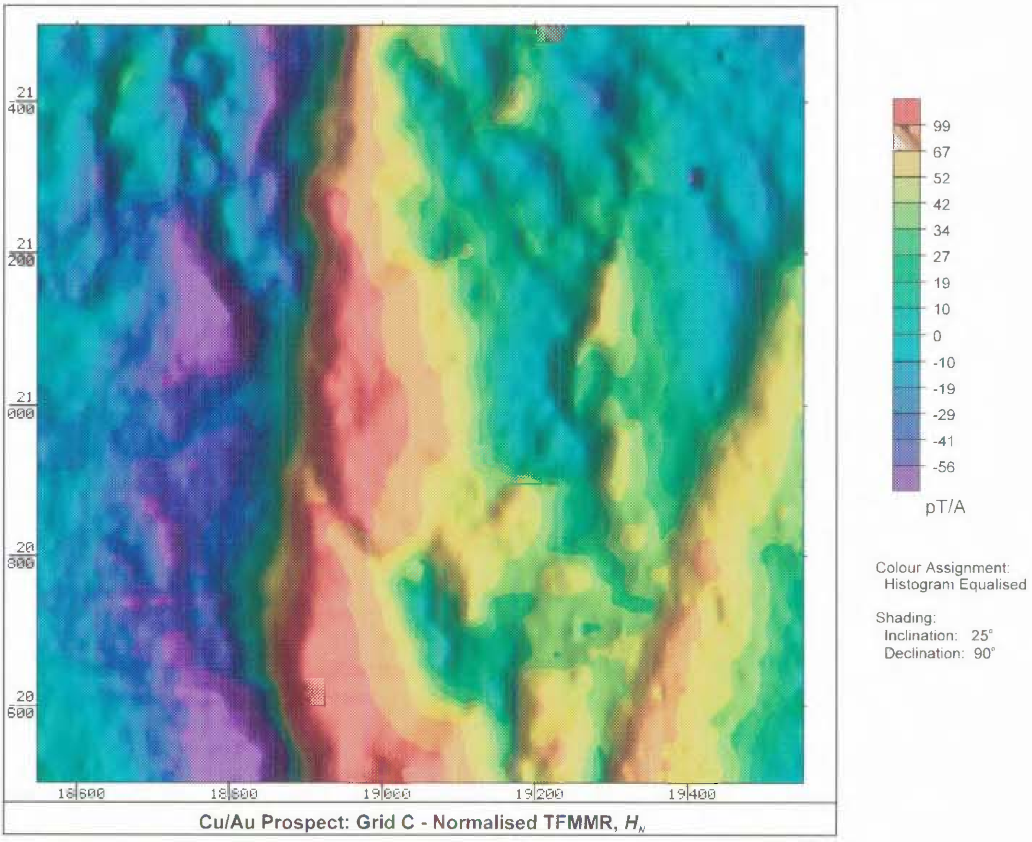

Figure 9-6. Cu/Au Prospect: Grid C - Normalised TFMMR, H_N.

As can be seen from the TMI image, the high spatial resolution magnetics revealed a general trend which was roughly west-northwest. The dynamic range in the data was of the order of 1000 nT. However, the anomalous features showed poor definition. Some finer features which are aligned more north-west to north appear to correlate with the current drainage pattern.

The TFMMR image from Figure 9-6 presents a completely different picture which is dominated by a significant north-south trending anomaly and a second well-defined feature further to the east and trending at about 15-20°. The large conductor is believed to be a shear zone and is coincident with the conductor detected from the airborne EM surveys. A review of the trend of the geochemical anomalism revealed that it coincided more closely with that of the TFMMR anomalies than the trend of the magnetics.

Grid D was smaller than Grid C, having the dimensions of 600 m × 600 m. The grid was located approximately 400 m to the east of Grid C. The wire was laid out to the east of the survey area. Images of TMI and TFMMR are shown in Figures 9-7 and 9-8, respectively. The magnetics is similar to that recorded for Grid C. Again, the main features trend roughly west-northwest.

The TFMMR image in Figure 9-8 is complex and is dominated by two northwest trending linears which appear to be the limbs of a tight fold. Several weaker, sub-parallel anomalies are also in evidence. The TFMMR does not correlate very well with the magnetics. The strike of the TFMMR anomalies is slightly, yet distinctly different from that suggested for the magnetics. The location and trend of the geochemical anomalism detected in the area was found to coincide with the TFMMR anomalies.

The controls on magnetite distribution in the area are not understood. However, it was clear that the TMI and TFMMR data reflected completely different aspects of the geology. The SAM surveys were conducted just prior to completion of the exploration program. It was interesting to note that the geologists responsible for the prospect commented that their interpretation and exploration strategy would have been quite different if the TFMMR data had been available at an earlier stage in the exploration program. It was apparent that the exploration strategy used for the area would need to be reviewed.

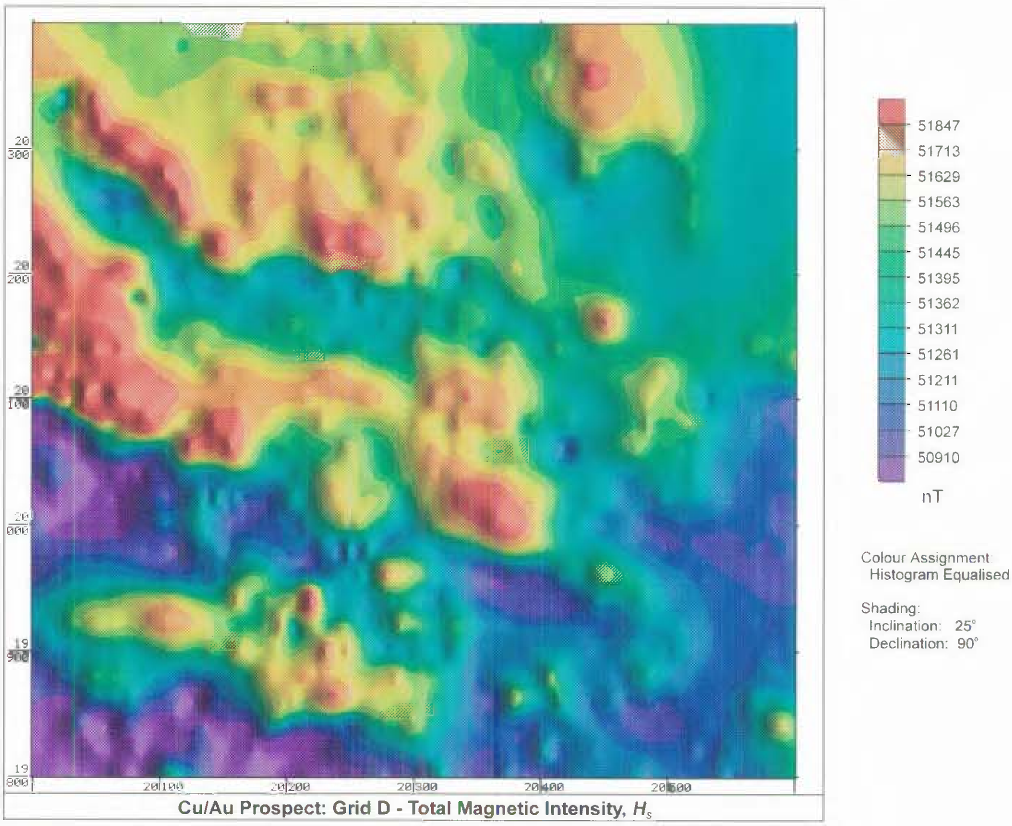

Figure 9-7. Cu/Au Prospect: Grid D - Total Magnetic Intensity, H_S.

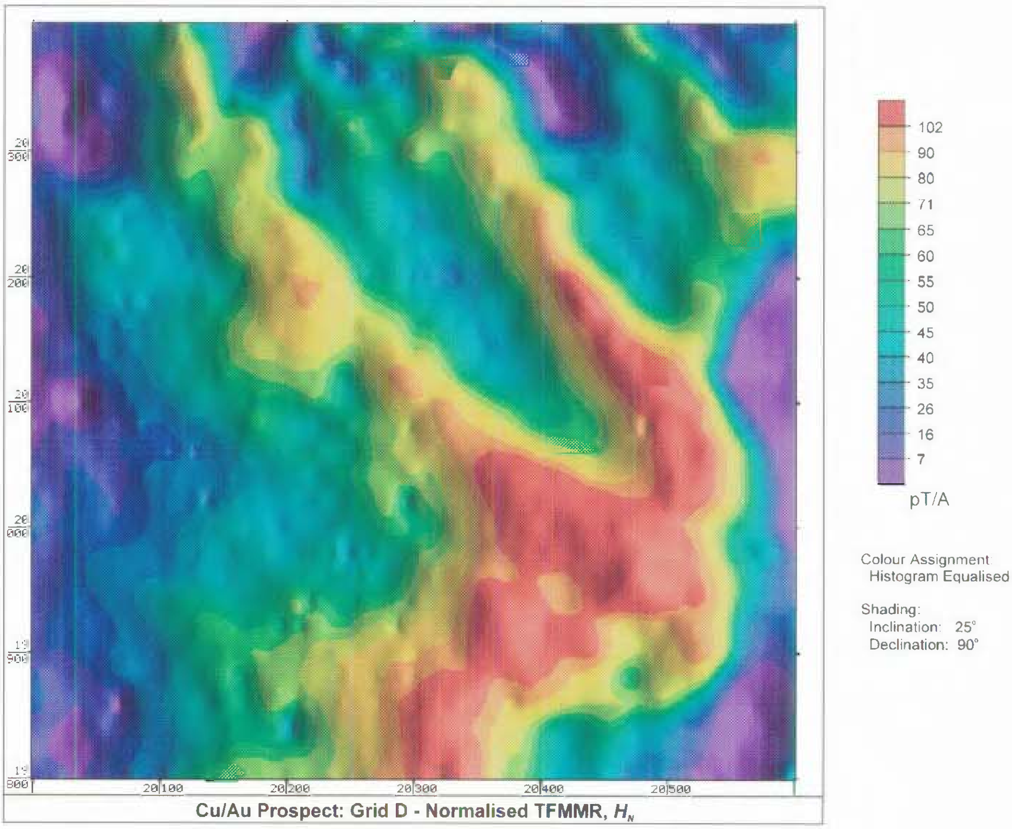

Figure 9-8. Cu/Au Prospect: Grid D - Normalised TFMMR, H_N.

9.4 Discussion

The SAM surveys conducted for the Archaean BIF-hosted gold prospects demonstrated the supplementary relationship which may exist between the TMI and TFMMR data. The data recorded from the Cu/Au prospect in North Qld served to illustrate that those relationships are not always the case and that the two data sets may invoke completely contrary interpretations which are both consistent with the geological structures present. However, each of the exploration examples highlight the potential benefits of having multiple, high quality data sets which reflect independent physical parameters.

Interpretation of geophysical data is often quite complex and must take into account both quantitative and qualitative aspects of the data. In addition, geophysical interpretation usually benefits greatly from prior knowledge of the local geology. Multiple-property data sets can greatly assist interpretation by enabling some means of discrimination between different geological units by classifying them on the basis of their measured geophysical properties.

As a general guide to the interpretative power which can be achieved from multiple-property data sets, the number of classifications which can be achieved will be given by:

$$C = m_1 \times m_2 \times .. m_n \qquad \text{Eqn 9-1}$$

where C = the number of possible classifications (combinations)
m = the number of identifiable states for each property measured
n = the number of properties measured.

For the sake of discussion, if it was assumed that the two properties of interest to SAM surveys are magnetic susceptibility and conductivity and that each property was readily identifiable from the results of the survey as being in one of either two states, then geological units could be classified on the basis of their being:

1) Non-conductive and non-magnetic.

2) Non-conductive and magnetic.

3) Conductive and non-magnetic.

4) Conductive and magnetic.

These are very simple classification criteria which may be extended by including degrees of magnetic susceptibility or conductivity. As can be seen from Equation 9-1, the number of possible classifications will increase dramatically with increases in the number of identifiable states per property as well as the number of properties measured.

Magnetics is one of the most commonly used and probably one of the most valuable geophysical methods available to the explorationist. Recent developments in instrumentation and survey procedure have made high quality data even more accessible and cost-effective and will ensure a vital role for the technique in the future. However, experience with the SAM technique has highlighted an important fact. Because magnetics is so accessible and inexpensive, it is extremely widely used and a great deal of reliance is often placed on the technique. These examples demonstrate how this reliance may be misplaced.

A great benefit of having multiple data sets reflecting independent physical properties is that the interpretational bias may be significantly reduced. In order to achieve that goal, simultaneous acquisition of multiple independent data sets provides a cost-effective means by which successful exploration may be achieved. SAM is a significant step towards accommodating that requirement.

In summary, the exploration examples served to illustrate that:

(i). Much greater interpretative power can be derived from having multiple data sets which reflect independent physical properties, and

(ii). Access to several independent data sets removes much of the interpretational bias which must result from a dependence on a single data type.

(iii). High definition sampling strategies are valuable for all measured properties, not only magnetics.