# Magnetic responses from an iron-rich gossan in a volcanic terrain and a limestone-hosted strata-bound manganese deposit, Central Province, Papua New Guinea


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## SUMMARY

To interpret magnetic responses of different mineral settings in Papua New Guinea, field campaigns were conducted by the Geological Survey Division in two mineral fields in the Rigo District, Central Province.

In December 2011, geological mapping accompanied by a ground magnetic survey was conducted over iron-rich gossan within a volcanic sequence at Kore. In March 2012, an analogous program was undertaken in a sedimentary-hosted manganese field near Kemaea village.

Ground magnetic surveys in both areas comprised a series of north-south magnetic profiles, up to 1km in length separated by 100 m.

The results of the magnetic survey show significantly different responses that are apparently related to the style of mineralisation.

The total magnetic response of a gossan within a volcanic rock unit is characterised by high frequency signals that require extensive filtering to outline the trend of distinct magnetic source. In contrast, the limestone-hosted strata-bound manganese deposit has a well-defined north-westerly structural trend that is easily distinguished by the response in the total magnetic field.

Applying a reduced to magnetic equator algorithm and generating an upward continuation of the magnetic field enhances these structural trends.

The results of the survey demonstrate that background knowledge of mineral systems, including major mineral composition and style of deposit is essential to interpret imagery from ground magnetic surveys of mineral deposits and that different styles of mineralisation generate unique magnetic responses.



**Key words:** Ground magnetic surveys, reduced to equator, upward continuation.


## INTRODUCTION

Ground magnetic surveys data provide a wealth of information on the characteristics and often, the structural setting of a mineral prospect. And different mineral setting is characterised by different responses to the magnetic field. Interpretation of the magnetic data is often difficult. With appropriate filters, accompanied by geological data, it is possible to delineate structures (Giddings et al., 1999) and alteration patterns (Webster and Henley, 1989) that can be used to distinguish areas of mineralisation from the background signature.

In this example we present two case studies conducted in the Central Province of Papua New Guinea (Fig. 1). In one area a ground magnetic survey is conducted over a known iron-rich gossan hosted within a thick volcanic sequence. In the other area a ground magnetic survey is carried out over an area previously mined for its manganese nodules, hosted within a sequence of carbonate unit.

In both areas the ground magnetic survey comprised a series of north-south magnetic profiles. The profiles reached up to 1 km in length and were separated by 100 m.

Results from the magnetic data showed two totally different responses. In the volcanic-hosted gossan area the magnetic response is characterised by high frequency signals that tend to suppress the response from the gossan. In the limestone-hosted manganese deposit there is a distinct signature difference between the host rock and the structure hosting the mineralisation.

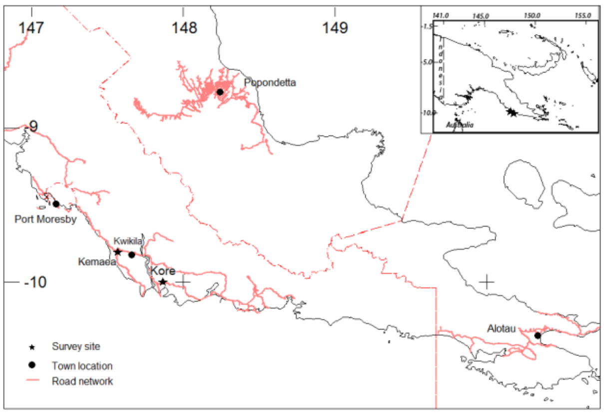


Figure 1. Location map showing study areas.

## METHOD AND RESULTS

Geological mapping accompanied the ground magnetic surveys in the two areas of study, the Kore gossan and the Kemaea manganese fields. The geological mapping included field observations of structures, main rock units and collecting of samples for further analysis using the x-ray fluorescent (XRF) analysis. Magnetic profiles were prepared in the north-south orientation, with stations marked every 50 m. The profiles were separated by a distance of 100 m. A Geonics G859 magnetometer system, set to Auto-record mode, was used for data acquisition. Data was acquired by walking in one direction along one profile and walking back the opposite direction along the next line. During data acquisition the system was "marked" along every 50 m for control purposes. Acquired data was diurnally corrected using the Charters Tower (CTA) geomagnetic observation data for the corresponding dates. All datasets were reduced to magnetic equator (rte). To produce the analytical signals (as), the rte datasets were upward continued by 100 m to filter out high frequency signals before applying the analytical signal filter. All processing was done using Oasis Montaj 7.5.

**Geology**

In the Kore gossan field mapping defined two main rock units; the Kore Volcanics and the Gidobada Limestone, both formerly described by Yates and de Ferranti (1967) and Pieters (1978) respectively. Pieters (1978) indicated that the Kore Volcanics only outcrops between Kore and Kwaipo villages with a smaller exposure 50 km east of Gabone village. Pieters (1978) further suggests that the Kore Volcanics overlie the Port Moresby beds.

Mapping by this project indicate that the Kore Volcanics is mostly composed of porphyritic basaltic breccia that are massive, poorly sorted, matrix supported with sub-angular to sub-rounded phenoclasts (<1 cm) of porphyritic basalts (Mosusu et al., 2012). Deeply weathered and oxidized basalt resembling claystone or mudstone are exposed on the hilltops.

In the Kemaea manganese field, much of the survey area is underlain by Eocene Port Moresby Beds (Rogerson, et al., 1981, Pieters, 1978, Yates and de Ferranti, 1967) and is intruded by the Oligocene Sadowa Gabbro towards the east. The rocks within and around the survey area are faulted and folded with a general north-west trend (Yates and de Ferranti, 1967).

Field mapping shows that the Port Moresby Beds are comprised mostly of (1) siliceous argillite, (ii) Biomicrites and (iii) Calcilutites /fine-grained calcarenites. Biomicrites and argillites occupy most of the survey area whereas the calcilutite/ fine-grained calcarenites is restricted to the eastern and south-eastern end of the study area (Mosusu, et al., 2012).

The siliceous argillite varies in the mode of occurrence from well-exposed isolated boulders/outcrops to poorly exposed small outcrops. They are generally massive and intensely weathered and oxidized with extensive vein stock work. The veins comprise oxides, quartz and calcite with oxide veins, including iron and manganese oxides predominate. These oxides also occur as surface stains or fracture coatings. Manganese and secondary copper mineralisation with gossanous coatings were also observed within porphyritic basaltic breccia. Malachite occurs with the manganese mineralisation and hosted as fissure-filling mineralisation.

| Sample | Easting | Northing | Major Element composition (%) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Fe | Mn | Cu | Zn | Ni |
| Kore100344 | 592173 | 8893972 | 8.640 | 0.228 | 0.005 | 0.006 | 0.007 |
| Kore100346 | 592944 | 8894637 | 8.116 | 0.844 | 0.000 | 0.010 | 0.000 |
| Kore100347 | 593234 | 8893047 | 1.774 | 0.017 | 0.000 | 0.006 | 0.000 |
| Kore100348 | 594283 | 8893817 | 12.585 | 0.063 | 0.013 | 0.007 | 0.000 |
| Kemaea100010 | 563902 | 8916313 | 0.793 | 0.131 | 0.003 | 0.004 | 0.000 |
| Kemaea100011 | 563769 | 8915761 | 3.409 | 2.113 | 0.004 | 0.000 | 0.000 |
| Kemaea100012 | 563119 | 8916158 | 4.176 | 0.07 | 0.008 | 0.016 | 0.006 |
| Kemaea100013 | 562500 | 8915819 | 1.810 | 0.113 | 0.004 | 0.004 | 0.000 |
| Kemaea100014 | 562718 | 8916450 | 0.858 | 3.857 | 0.091 | 0.011 | 0.156 |

Table 1. XRF values of major mineral constituents of samples collected at the two study sites

XRF results show high Fe composition (>8%) with varying Mn composition for the Kore samples. For the Kemaea samples the Fe composition values are variable with up to 4% Mn values.

**Ground magnetics**

Figures 2 and 3 show the reduced to magnetic equator total magnetic intensity maps for Kore and Kemaea respectively. The Kore image (Figure 2) shows a lot more texture in the magnetic signature compared to the Kemaea magnetic signature (Figure 3)

The total magnetic intensity maps were upward-continued to 100 m and passed through an analytical signal filter to produce the images given in Figure 4 and Figure 5.

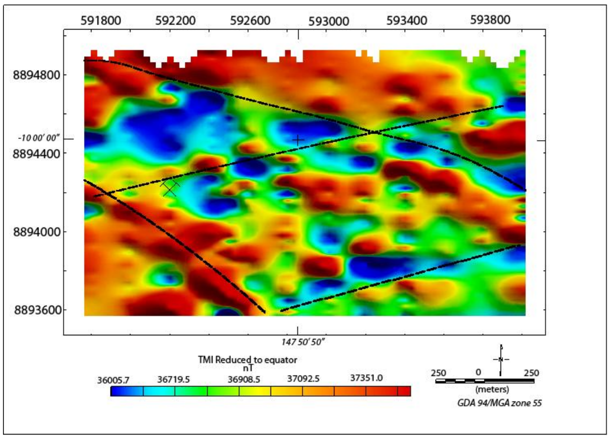


**Figure 2. The total magnetic intensity, reduced to equator, map of the Kore gossan. The crossed geopick sindicates location of the gossan.**

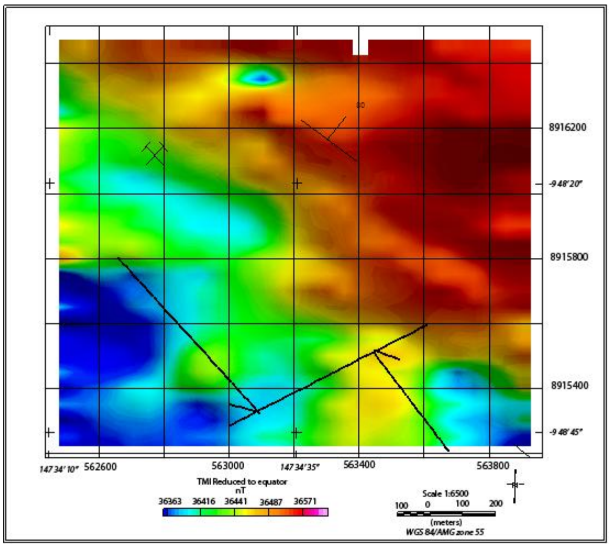


**Figure 3. The reduced to equator total magnetic intensity map of the Kemaea manganese prospect. Crossed geopick indicates location of Mn mined area.**

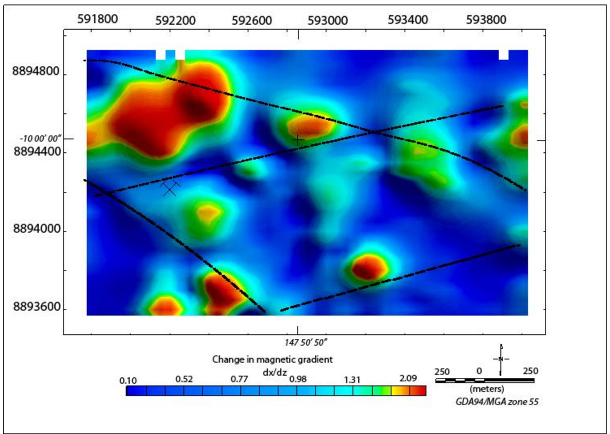


**Figure 4. The analytical signal filter applied on the Kore TMI in an attempt to define accumulation of iron oxides.**

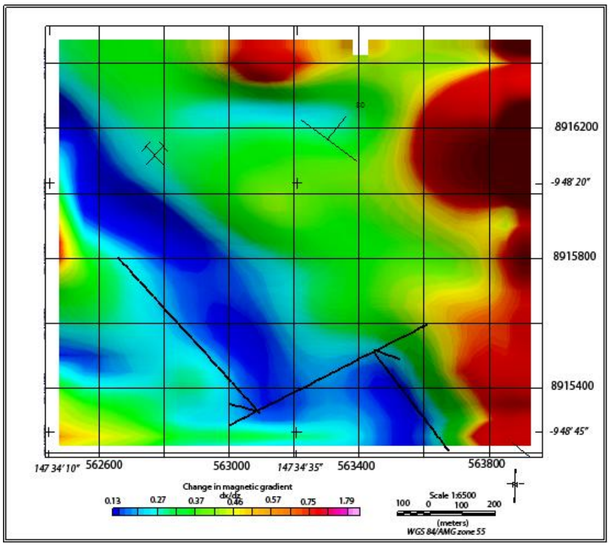


**Figure 5. A structural corridor at Kemaea defined from the application of analytical signal filter on the TMI.**

## CONCLUSIONS

The application of ground magnetics in defining mineralised provinces depends mostly on the magnetic contrast between the surrounding host rock and the mineralised body, often determined by the composition of Fe and Mg. Different types of mineralisation style will therefore have different effect on the magnetic signature derived from the area.

In this study we determined that volcanic cover over an oxide-rich body tends to suppress the magnetic signature of the gossan due to the generally wider distribution of the Fe in the volcanics, producing higher frequency signals. In a carbonate environment, the magnetic signature displays low frequency signals throughout. Applying analytical signal filters on the total magnetic intensity, we were able to enhance contact margins between the rock units. In the volcanic area no visibly significant structures were defined from the analytical signal. However, we were able to show areas that have magnetic gradient, indicating possible contacts. We suggest these high gradient 'blobs' to be possible sources of the iron-rich mineralisation.

In the Kemaea manganese field the analytical image defined a structural corridor, extending in a north-west to south-east direction. Adjacent to this corridor is a former manganese mine. The proximity of the mine to this corridor leads us to presume that Mn mineralisation may be associated with this structural corridor, and we assume there would be several of these north-west trending structures. Outside the study area all other former manganese mines in the area lie in a north-westerly trend (Finlayson and Cussen, 1985).

In conclusion, we are able to say that the application of ground magnetic surveys in mineral application has many implications on the success of the survey being able to properly define a mineral target. These implications may include the style of mineralisation and host rock type. The application of appropriate software filters also is dependent on whether the aim is to define a magnetic structure or just the alteration pattern. Having all these parameters addressed, and combined with good geological information, the best interpretation of the dataset may be obtained.

## ACKNOWLEDGMENTS

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