



# Mineral Resources Tasmania

## REPORT 1994/22

### A geophysical interpretation of the Balfour–Waratah area, northwest Tasmania

by R. G. Richardson

#### Abstract

New aeromagnetic and radiometric data, when combined with pre-existing data, prove an effective tool for geological mapping. The Arthur Lineament consists of a series of narrow near-vertical magnetic units that dip to the east at the southeastern side of the lineament. A northeast-trending fault with a strike extent in excess of 40 km passes obliquely through the lineament. The Roger River Fault, in the Smithton Trough, is marked by a strong magnetic anomaly on the eastern side. In the Balfour area a pyrrhotitic siltstone unit extends over 20 km in strike.

The residual gravity field is dominated by a strong positive anomaly associated with the Arthur Lineament and Heazlewood Ultramafic Complex in the east and a strong negative anomaly produced by the Pieman Granite and Cowrie Siltstone in the west. Known mineralisation is predominantly within these features and the northern margin of the Meredith Granite.

The areas of highest prospectivity are the Arthur Lineament, Pieman Granite and the northern margin of the Meredith Granite. In the first two areas the data show that extensions of mineralised units, or units in similar environments, exist but are only poorly exposed. Existing data do not sufficiently define the margin of the Meredith Granite to allow the prospectivity to be properly assessed but the presence of both the Cleveland and Mt Bischoff mineralisation means that the prospectivity should be evaluated in detail.

#### INTRODUCTION

The study area lies within the Rocky Cape Block of Williams (1976) and includes the southern part of the Smithton Trough. The Arthur Lineament, which is distinguished by positive gravity and magnetic anomalies, and the Heazlewood Ultramafic Complex also fall within the study area. Figure 1 shows the generalised geology of northwest Tasmania; the following description is from Turner (1990).

The Arthur Lineament transects the Rocky Cape region and divides the eastern, relatively unmetamorphosed, turbiditic association from a western, relatively unmetamorphosed, shallow to deep-water association. Metamorphosed equivalents of the eastern, and probably the western, associations are present in the Arthur Metamorphic Complex together with a relatively extensive volcano

sedimentary association. In the Smithton district the sedimentary associations of the Rocky Cape region are overlain by similar successions consisting of shallow-water siliceous clastic deposits and dolomite followed by mafic volcanic rocks interbedded with turbiditic volcanoclastic lithicwacke and mudstone. There are scattered areas of granitoids, Tertiary basalt and Jurassic dolerite.

The aeromagnetic coverage is complete (fig. 2) with a 500 m flight line spacing. The 1981 Department of Mines (now Mineral Resources Tasmania) fixed-wing survey of Western Tasmania recorded magnetic data only. The 1985 Bureau of Mineral Resources (now Australian Geological Survey Organisation) survey recorded both magnetic data and the usual four channels of radiometric data. In 1993 Mineral Resources Tasmania flew a helicopter survey, with 200 m flight line spacing, over the Arthur Lineament between Savage River and Meunna. Both magnetic and radiometric data were acquired. All three surveys had east-west flight lines.

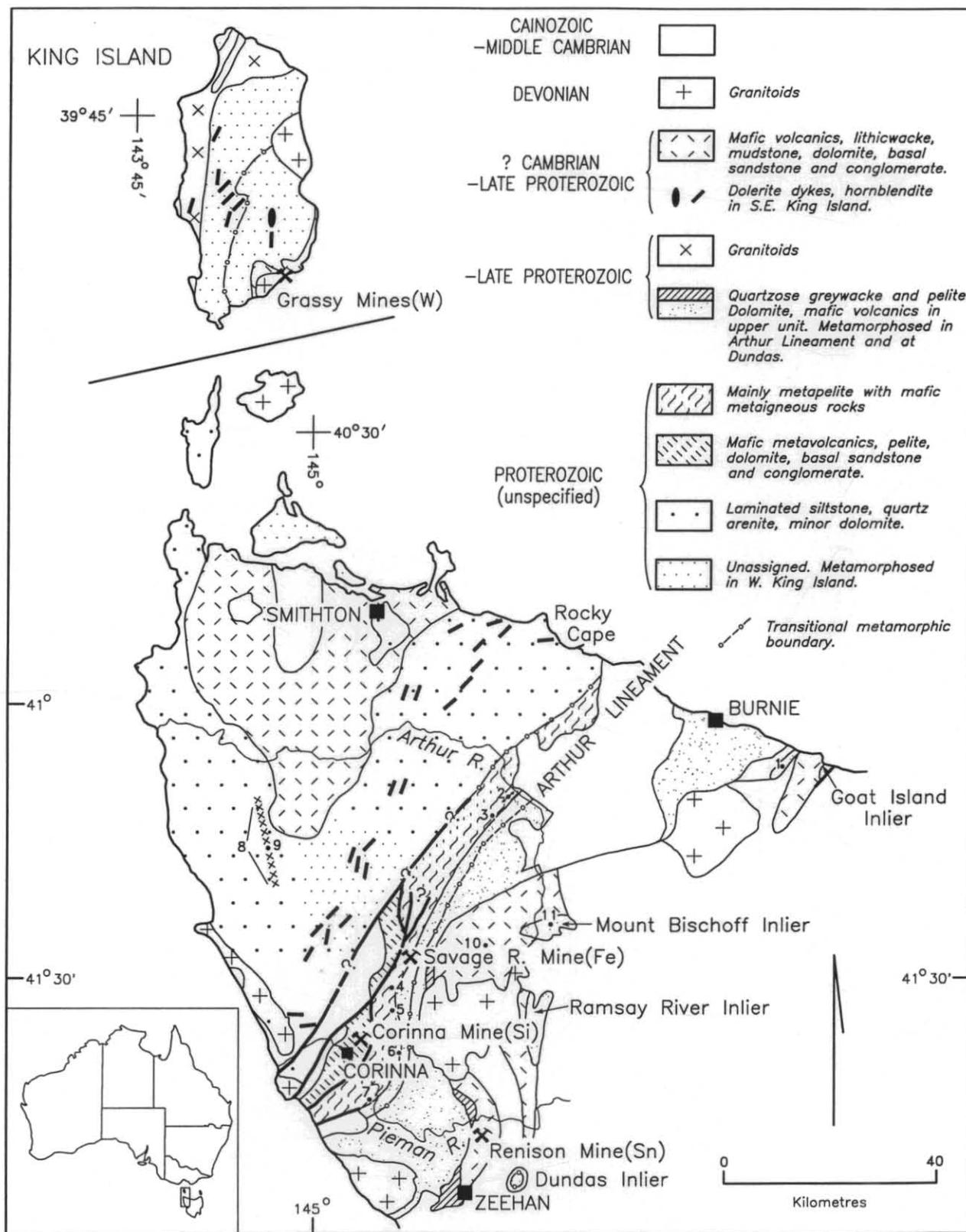
The gravity coverage (fig. 3) varies from a station density of about one per square kilometre in the Balfour–Sandy Cape and Waratah–Meunna areas to one station per hundred square kilometres north of Savage River. All gravity data are fully corrected (including terrain corrections) and are presented in this report in residual anomaly form calculated using the 1991 version of the Tasmanian regional gravity field (MANTLE91) of Leaman and Richardson (1989a). The utility of the gravity data is severely restricted in areas of low station density.

#### REGIONAL OVERVIEW

##### *Gravity Field*

At a regional scale the residual gravity field (fig. 4) is dominated by negative anomalies in the southwest and southeast, corresponding to the Pieman and Meredith Granites respectively, and a strongly positive anomaly over the Heazlewood Ultramafic Complex. This positive anomaly is bounded to the north and west by the Arthur Lineament but extends to the east and northeast. A negative anomaly extends NNE from the Pieman Granite towards Rocky Cape.

The eastern margin of the Pieman Granite was initially interpreted to dip steeply to the east (Leaman and Richardson, 1989b) but additional data acquired south of



**Figure 1**  
Northwest Tasmanian geology (from Turner, 1990)

5 cm

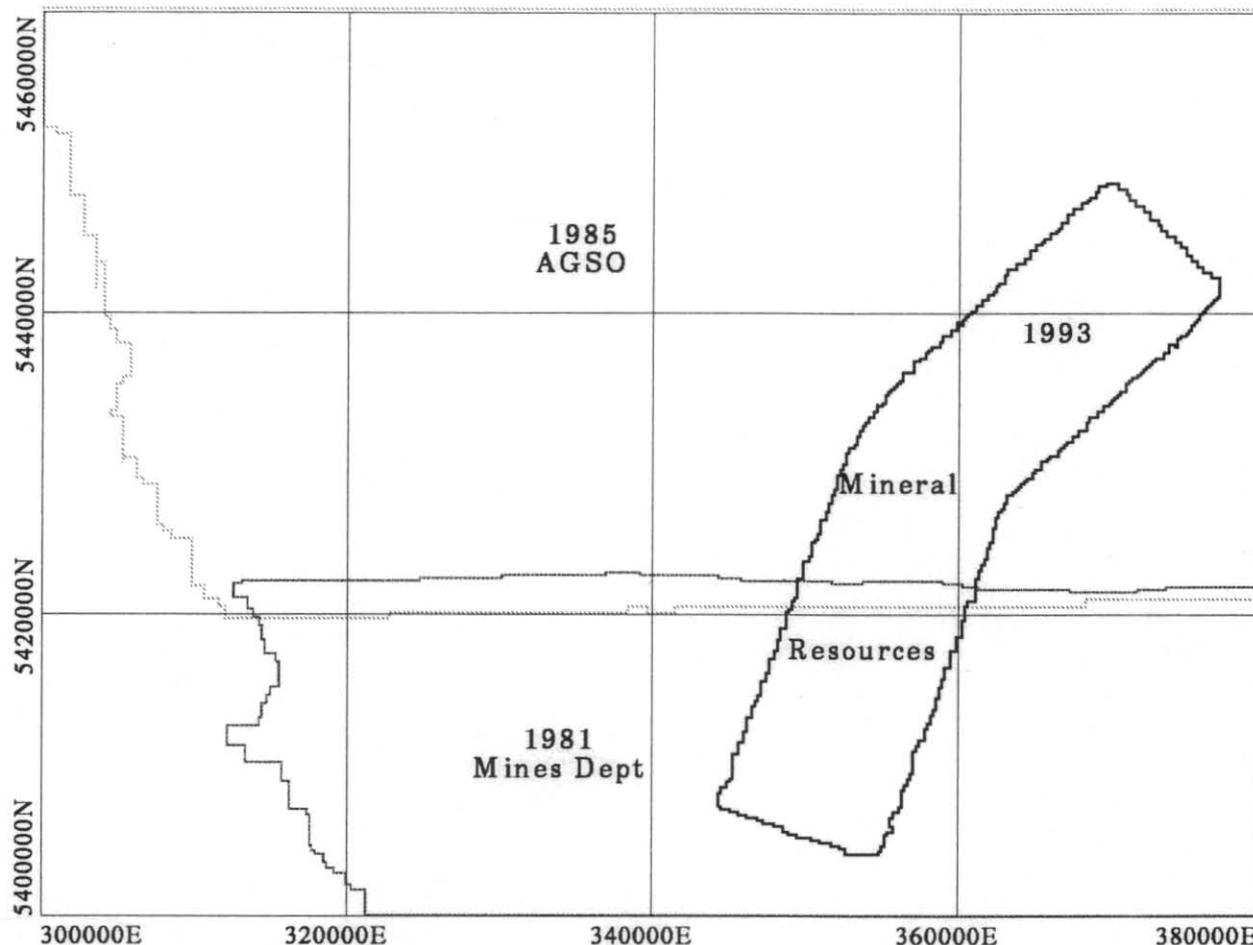


Figure 2  
Aeromagnetic coverage

Balfour, and included in Figure 4, show that the eastern margin dips shallowly and that the granite extends at least as far north as Balfour (Leaman, 1990). The negative anomaly trending NNE from the granite represents low density ( $2.65\text{--}2.67\text{ t/m}^3$ ) Rocky Cape Group rocks west of the Arthur Lineament with the thickness increasing to the north of the area. The southeastern margin of the Smithton Trough extends into the area of this anomaly. North of Balfour the materials of the Smithton Trough produce a positive anomaly which decreases to the west, with a negative axis at 316 000 mE, before increasing to the west. Leaman (1990) has interpreted this increase, which is in an area mapped as Rocky Cape Group, as being sourced by Smithton Trough materials that have been overthrust by the Rocky Cape Group.

**Magnetic Field**

The combined aeromagnetic data set (fig. 5) is dominated by strongly positive anomalies in the east of the area and generally low values elsewhere. The Rocky Cape Group has variably low magnetisation with a zone of slightly elevated values NNW of Balfour. Areas of Tertiary basalt are generally marked by low-amplitude positive anomalies, through which the larger regional anomalies can be traced, and negative anomalies indicating reverse remanant magnetisation.

Figure 6 is a magnetic domain map produced by on-screen interpretation of both the total field image and a number of

processed images. It provides fine detail of the major anomalies and enhances subtle features such as the dyke-like features, presumed to be intrusive, in the Rocky Cape Group. This map should be viewed in conjunction with Figure 5.

The following magnetic features are identified on Figure 5.

- Feature 1** This linear feature within the Rocky Cape Group correlates with a pyrrhotitic siltstone at Balfour (N. J. Turner, pers. comm.). Although data quality is poor, offsets and changes of direction are inferred at 5 431 000 mN and 5 437 000 mN. The magnetic source dips very steeply to the east.
- Feature 2** This linear feature marks the western boundary of the Smithton Trough and corresponds to a slightly magnetic source.
- Feature 3** The Meredith Granite is non-magnetic.
- Feature 4** A zone of alteration, probably skarns, and Tertiary basalt, on the northern margin of the Meredith Granite.
- Feature 5** Basalts of the Smithton Trough on the eastern side of the Roger River Fault.

- Feature 6** The Heazlewood Ultramafic Complex. This consists of a number of physically distinct magnetic sources. It extends to the north under non-magnetic cover.
- Feature 7** An area of Cambrian basalt extending under both Tertiary basalt and Permian sediments.
- Feature 8** The western part of this circular feature is mapped as Jurassic dolerite and shows the expected high-frequency response. The eastern part of this anomaly represents a large deep feature and lies in an area of Permian sediments. The possible sources include Jurassic dolerite (possibly a feeder), Cambrian basalt or ultramafic rocks. The northern part of the Arthur Lineament is distorted around this feature and the northeast-southwest fault cutting through the lineament also cuts through this feature.
- Feature 9** This is the magnetic expression of the Arthur Lineament. A large number of narrow, steeply-dipping magnetic sources combine to produce an area of positive anomalies. The strike direction varies from NNW to northeast within the area under discussion. A major fault can be traced southwest from feature 8 for about 35 km and shows a dextral offset of two kilometres. Splaying of the magnetic units within the lineament is suggestive of variable stress directions during deformation. Between 5 425 000 mN and 5 443 000 mN there is a slightly magnetic unit about 3 km wide along the southeastern side of the lineament. The main magnetic features are still readily observed in the areas covered by Tertiary basalt.
- Feature 10** This is a steeply-dipping magnetic source mapped as Cambrian basalt. The southeastern extension of this is parallel to a postulated fault through the Balfour area that offsets the pyrrhotitic siltstone.

### Radiometrics

The radiometric total count image (fig. 7) shows a region of high total counts over the Cowrie Siltstone and generally low counts from the Arthur Lineament area. Care must be used in interpreting this image as vegetation changes, cultural effects (such as clearing, gravel pits, roads) and surface moisture may effect the total count rate measured. There is an indication from Figure 7 that higher count rates may be related to drainage but the large extent of some of these features suggests that the geology is the controlling influence. Figure 8 is a classified total count image and was produced by selecting four total count classes. It highlights structural trends such as the strike direction within the Cowrie Siltstone. Areas of Tertiary basalt show as low total counts.

The following features are identified on Figure 7.

- Feature 1** The Cowrie Siltstone. The high frequency features reflect the dominantly north to NNE strike.

- Feature 2** An area of low total counts corresponding to a magnetic high and mapped as Cambrian basalt.
- Feature 3** An area of low total counts with no corresponding magnetic anomaly. This is either limestone, quartz or chert.
- Feature 4** An area of very low total counts and low magnetic field mapped as chert.
- Feature 5** The Heazlewood Ultramafic Complex.
- Feature 6** A northwest-trending feature with elevated total counts and magnetic field at the western margin of the Smithton Trough.
- Feature 7** An area of very low total counts wrapping round a core of high total counts. There are no corresponding magnetic anomalies, suggesting a lithological source to the total count anomaly with the central core being more pelitic.
- Feature 8** An area of Permian sediments.
- Feature 9** An area mapped as pelitic phyllite.

Tertiary basalt cover obscures most of the rocks in the Arthur Lineament.

The radiometric 3-colour composite (fig. 9) shows variations in both count rates and elemental composition. The Arthur Lineament, despite being of generally low count rate, is K-rich from about 5 435 000 mN south. The Tertiary basalt cover on the lineament is also K-rich in this region but becomes slightly enriched in U at about this northing and is high in Th and U in the northeast corner of the area. In the Smithton Trough the chert units are very low in counts but the Cambrian basalts are slightly higher in counts, although depleted in K. The quartzite unit against the western boundary of the trough shows clearly.

### Linear Features

By combining different magnetic and radiometric interpretations a plan showing the main linears in the area was prepared (fig. 10). Because of levelling problems with the 1981 and 1985 surveys, east-west features have not been indicated in this interpretation. The strike directions already noted predominate in this presentation. In the western part of the area strikes are predominantly northwest-southeast. In the Smithton Trough southeast-trending strikes become more east trending before terminating against the Roger River Fault. To the east of the Roger River Fault strikes trend north to northeast. There are a number of features with strike lengths of 10 km or more and these frequently truncate or offset other linears. Because they are predominantly defined magnetically they may not be defined at the surface, and therefore represent the projection at depth of mapped faults or linear structures. The longer structures trend NNE to northeast or east to southeast.

### DISTRIBUTION OF KNOWN MINERALISATION

The MIRLOCH database was searched for primary (not alluvial or placer) mineralisation containing gold, copper, tin or all minerals.

Gold mineralisation was predominantly in close proximity to the magnetic anomalies associated with the Arthur Lineament and Heazlewood Ultramafic Complex (fig. 11). The three locations near 352 000 mE, 5 412 000 mN lie in a magnetic feature that extends some 15 km to the NNE.

The copper mineralisation is predominantly in the Balfour area along the magnetic anomaly associated with the pyrrhotitic siltstone (fig. 12). There are also several occurrences on the eastern edge of the Arthur Lineament near 367 000 mE, 5 436 000 mN.

The tin mineralisation is in two areas (fig. 13). One area is near Balfour and lies near the magnetic anomaly associated with the pyrrhotitic siltstone, and the other is near Mt Bischoff above the northeastern extension of the Meredith Granite.

When the distribution of all mineralisation is viewed (fig. 14 and 15) three separate groupings are apparent.

#### (a) *The Balfour Area*

The mineralisation lies along the magnetic expression of the pyrrhotitic siltstone which is above a ridge of the Pieman Granite as far north as 5 430 000 mN and then offsets to the east. It then lies along the eastern side of the negative residual gravity anomaly. This means either that the mineralisation is not immediately above the granite ridge in this area or that the mineralisation lies in a zone of generally higher density.

#### (b) *The Meredith Granite*

The northern margin of the Meredith Granite is marked by a number of mineral deposits including those at Luina and Mt Bischoff. Two-dimensional modelling (Leaman and Richardson, 1989b) shows that the granite margin dips steeply to the north in the Luina area but shelves gently towards Mt Bischoff. The depth to granite under the known mineralisation is less than six kilometres.

#### (c) *Arthur Lineament*

Mineralisation in the Arthur Lineament area (fig. 14) lies within distinct magnetic domains. These domains are part of the main magnetic anomaly pattern of the Lineament and can be traced under the Tertiary basalt-covered areas. There are no other anomalies of the Savage River type in the Lineament north of the Savage River deposits. In the Savage River area known mineralisation (of all kinds) extends over a strike length of 10 km in a magnetic unit 2–3 km wide that exhibits a high-frequency anomaly pattern. At 366 000 mE, 5 436 000 mN the mineralisation extends northeast along a narrow magnetic unit for approximately six kilometres.

### QUANTITATIVE INTERPRETATION

To provide some indication of structure in areas of interest three sections were produced using two-dimensional gravity and magnetic modelling software. The section locations are shown on Figures 14 and 15.

#### (a) *Arthur Lineament (fig. 16)*

This section is along the line modelled by Leaman *et al.* (1994) and results in a similar model. The new aeromagnetic data have a much higher resolution than the previously available data and show that what was

previously regarded as one anomaly comprises three distinct anomalies.

The section shows that the base of the Rocky Cape Group dips to the northwest over the western part of the Arthur Lineament. The units of the Lineament dip vertically in the west and progressively dip more shallowly to the east along the section. The slightly magnetised materials required to source the magnetic lows appear to have little continuity with depth but may be between the magnetic units as disconnected slivers. A magnetic source is required below both the Rocky Cape Group and the Burnie Formation to match the long-wavelength magnetic anomalies. The Rocky Cape Group is thrust over the lineament on the western side.

#### (b) *Heazlewood Ultramafic Complex (fig. 17)*

This north-south section shows that the Heazlewood Ultramafic Complex dips shallowly to the north and is truncated by the Meredith Granite to the south. Possible variable magnetic properties have been accommodated within the one body by shape variations rather than by using a composite body.

#### (c) *Balfour area (fig. 18)*

There is little geological data available for the Balfour area. The section line also covers the southern end of the Smithton Trough and cannot be considered strictly two-dimensional. Leaman (1990) produced a model section suggesting that there are Smithton Trough-type materials at depth west of Balfour.

The section presented here assumes that denser (2.75 t/m<sup>3</sup>) and slightly magnetic Precambrian rocks similar to those northwest of Balfour also occur west of Balfour. A narrow spine of the Pieman Granite, at a depth of approximately 2 km, is modelled as lying below and slightly to the west of the pyrrhotitic siltstone. Other solutions are also possible but have not been explored fully in the absence of geological controls.

### PROSPECTIVITY

The area under review has a history of mineral production and contains three major mines (Mt Bischoff, Cleveland and Savage River) and a large number of smaller mines and prospects. The residual gravity anomaly image (fig. 13) shows that there are three main zones of known mineralisation:

- the negative anomaly associated with the Pieman Granite;
- the northern and northeastern margins of the Meredith Granite;
- the positive anomalies of the Heazlewood Ultramafic Complex and the Arthur Lineament.

Based on the geophysical data presented here the following prospectivity assessment is proposed.

#### (i) *Arthur Lineament*

The known mineralisation is within or close to well-defined magnetic units. These units extend under the Tertiary basalt and are readily tracked magnetically, implying that the basalt cover is thin. There is further

potential for mineralisation along these units which have less than one half of the strike length exposed. The circular feature (Feature 8, fig. 5) at the northern end of the lineament distorts the strike of the lineament and may represent either a potential mineralisation source or host. There is no evidence of magnetite bodies of large size north of the Savage River mine.

#### (ii) Meredith Granite

The northern margin of this granite is poorly defined by the existing gravity data. Potential exists for further tin and copper mineralisation which could be targeted by a program of detailed gravity and magnetic surveys.

#### (iii) Heazlewood Ultramafic Complex

This complex has a number of small occurrences of known mineralisation. The extension below cover on the northern flank of the complex offers potential for further mineralisation.

#### (iv) Pieman Granite

Known mineralisation in this area is along a gravity low adjacent to or within small magnetic anomalies. It also coincides with the edge of a zone of low radiometric counts (fig. 9). There are a number of other parts of this area matching these criteria.

#### (v) Rocky Cape Group

Geophysically the area of Rocky Cape Group rocks extending NNE from the Pieman Granite has little relief. There are a number of subtle magnetic features which may represent either dykes or magnetic units. There is only sparse gravity data coverage. There is no known mineralisation but a close examination of the magnetic features should be carried out to determine if there is a possibility of associated mineralisation.

## CONCLUSIONS

The Balfour–Waratah area may be divided into six major geophysical blocks. These are:

- (i) The Meredith Granite which has associated tin and copper mineralisation.
- (ii) The Heazlewood Ultramafic Complex and the Arthur Lineament which contain mineralisation including the magnetite ore at the Savage River mine.
- (iii) The Smithton Trough which has no known mineralisation.
- (iv) The Cowrie Siltstone (Rocky Cape Group) which has a negative residual gravity anomaly.
- (v) The Pieman Granite which has associated tin and copper mineralisation.
- (vi) The area of Rocky Cape Group rocks NNW of Balfour which has a positive residual gravity anomaly.

The magnetic and radiometric data provide an effective tool for surface geological mapping and determining detail of the geological structures. The main feature is the Arthur Lineament, which consists of a series of near-vertical magnetic units that wedge and dip to the southeast on the eastern side of the lineament. The lineament is generally low in radiometric counts but is potassium rich. The major magnetic units are readily traced under the Tertiary basalt. The composite nature of the Heazlewood Ultramafic Complex is clearly seen and the complex extends to the north under non-magnetic near-surface rocks. The Tertiary basalt is generally thin. The Arthur Lineament has been overthrust by the Rocky Cape Group from the west.

In the west the Pieman Granite shelves gently to the east. There are numerous small occurrences of mineralisation associated with magnetic anomalies. In the Balfour area these anomalies are attributed to a pyrrhotitic siltstone.

Linear features show predominantly northwest-southwest trending strikes in the western part of the area with strikes in the Smithton Trough becoming more east trending before terminating against the Roger River Fault. East of the Roger River Fault strikes trend north to northeast. There are a number of features having strike lengths of tens of kilometres and these represent either faults or lines of structural control.

The regions of highest prospectivity are the Arthur Lineament, the northern margin of the Meredith Granite, and the Pieman Granite area. In the Arthur Lineament magnetic units with known near-surface mineralisation are exposed for less than half the strike length. The northern margin of the Meredith Granite is poorly defined because of sparse gravity data and could have further cupolas or spines. Known mineralisation in the Pieman Granite area occurs in or near magnetic units adjacent to radiometric count lows and there are a large number of similar targets.

## REFERENCES

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[12 October 1994]

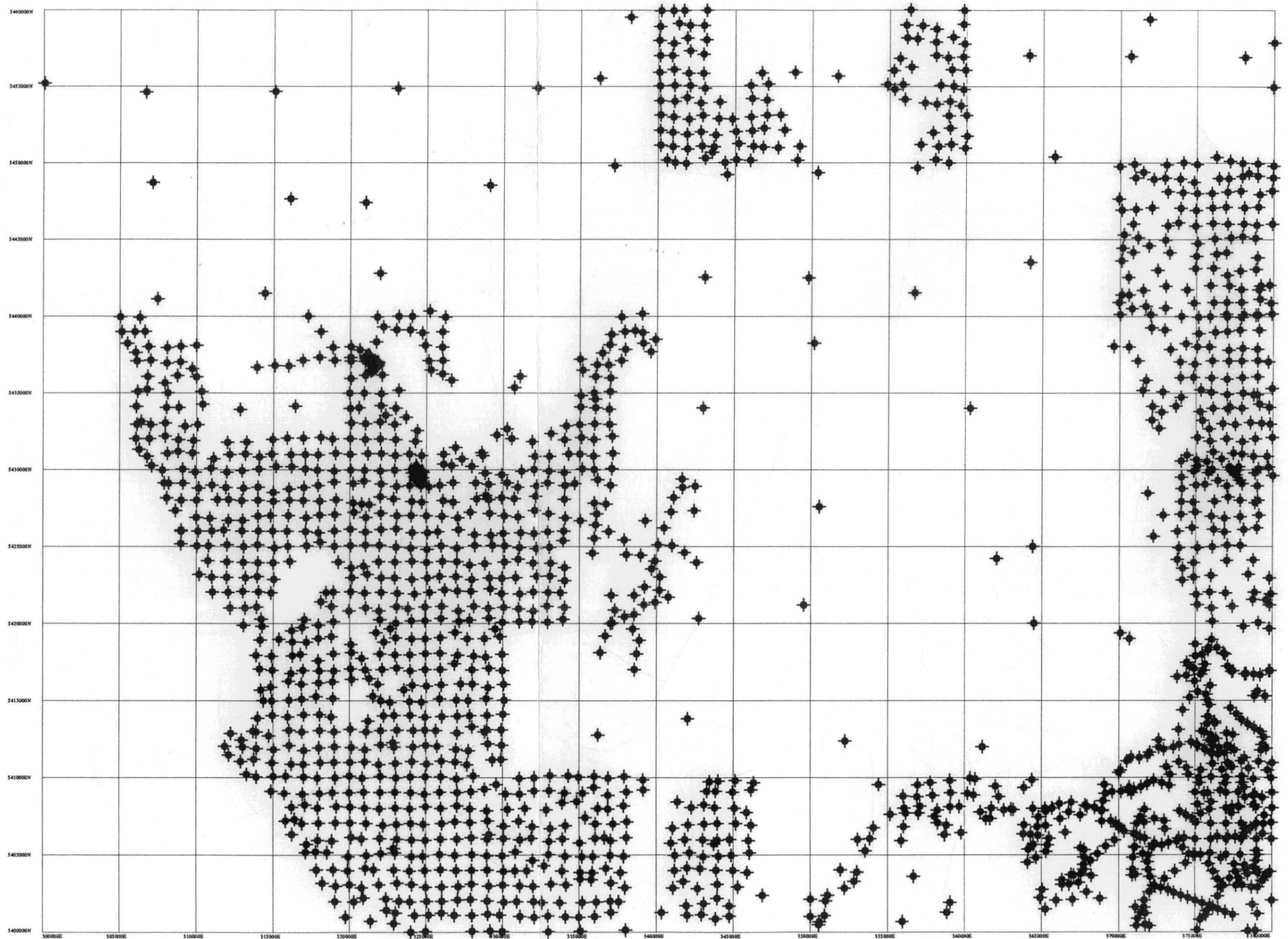
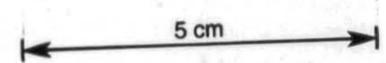
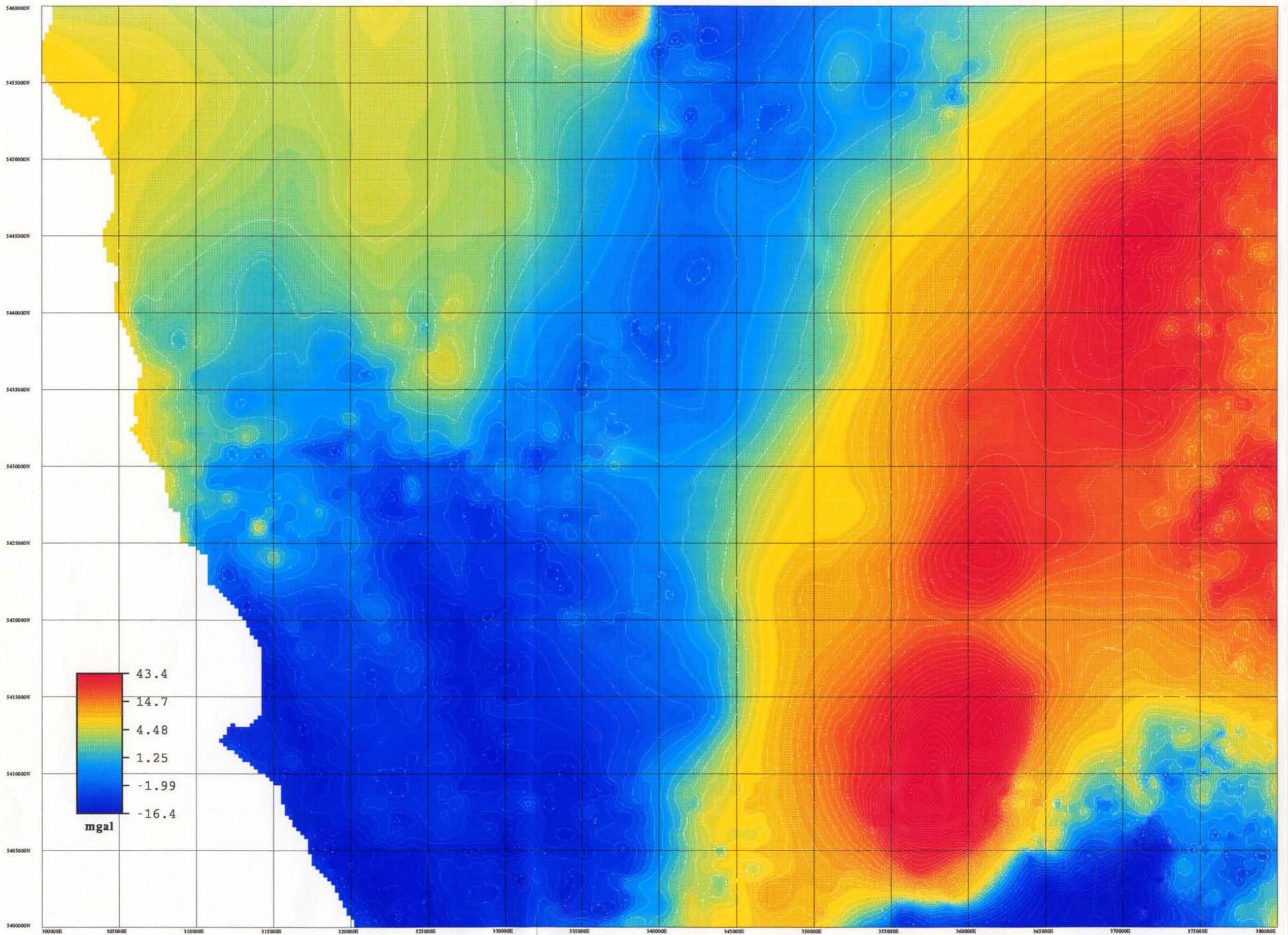


Figure 3  
Gravity station locations.





**Figure 4**  
Residual gravity anomaly.

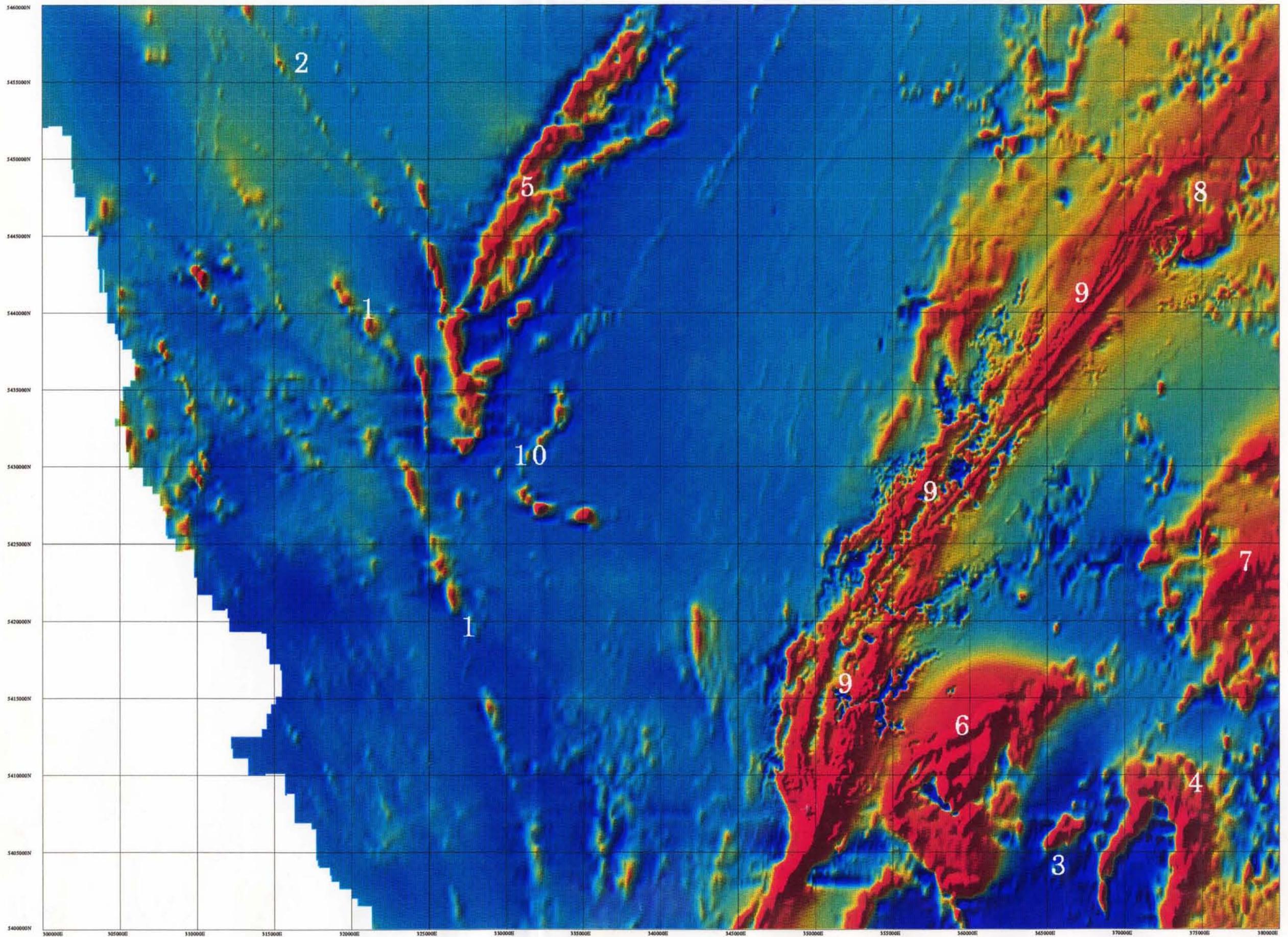
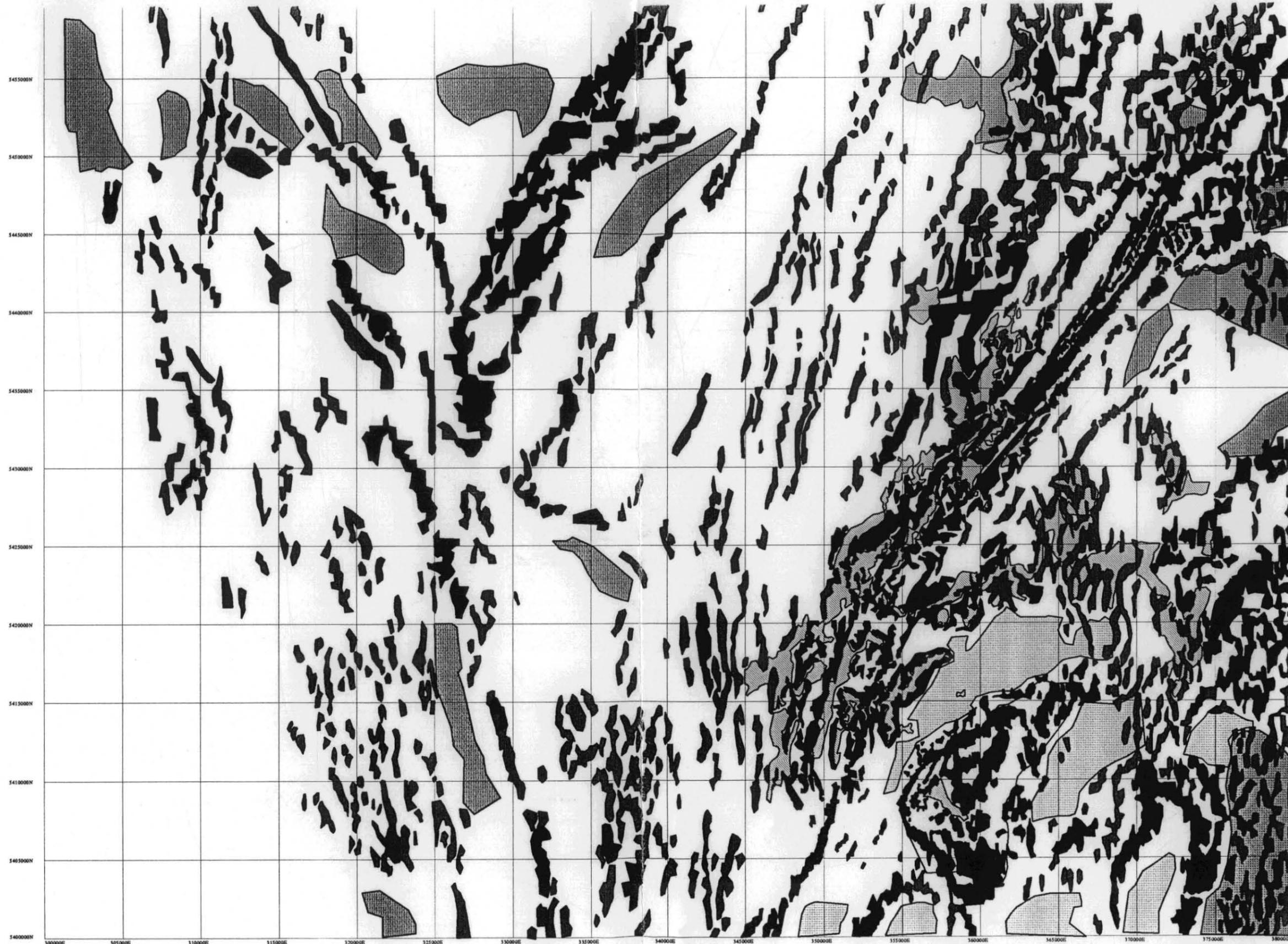


Figure 5

Aeromagnetic data (data from AGSO, MRT).

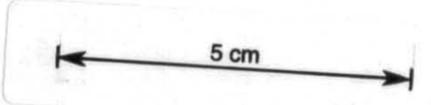


□ Heazlewood complex  
 ▨ Reversely magnetised - probably basalt  
 ▩ Normally magnetised - probably basalt

■ High amplitude features  
 ▨ Areas of moderate near surface magnetisation

■ Low-medium amplitude features  
 □ Areas of little near surface magnetisation

Figure 6 Magnetic domains.



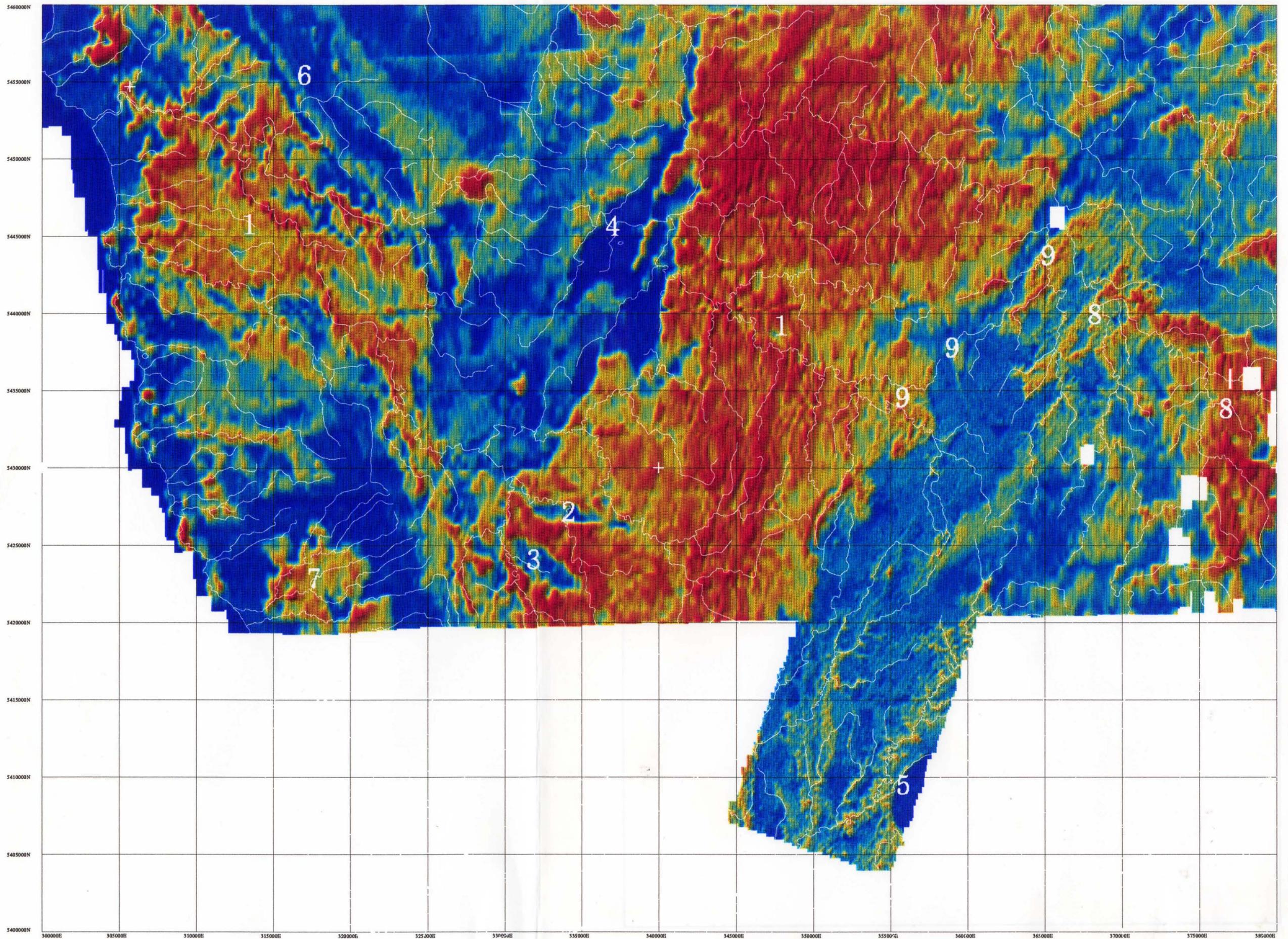
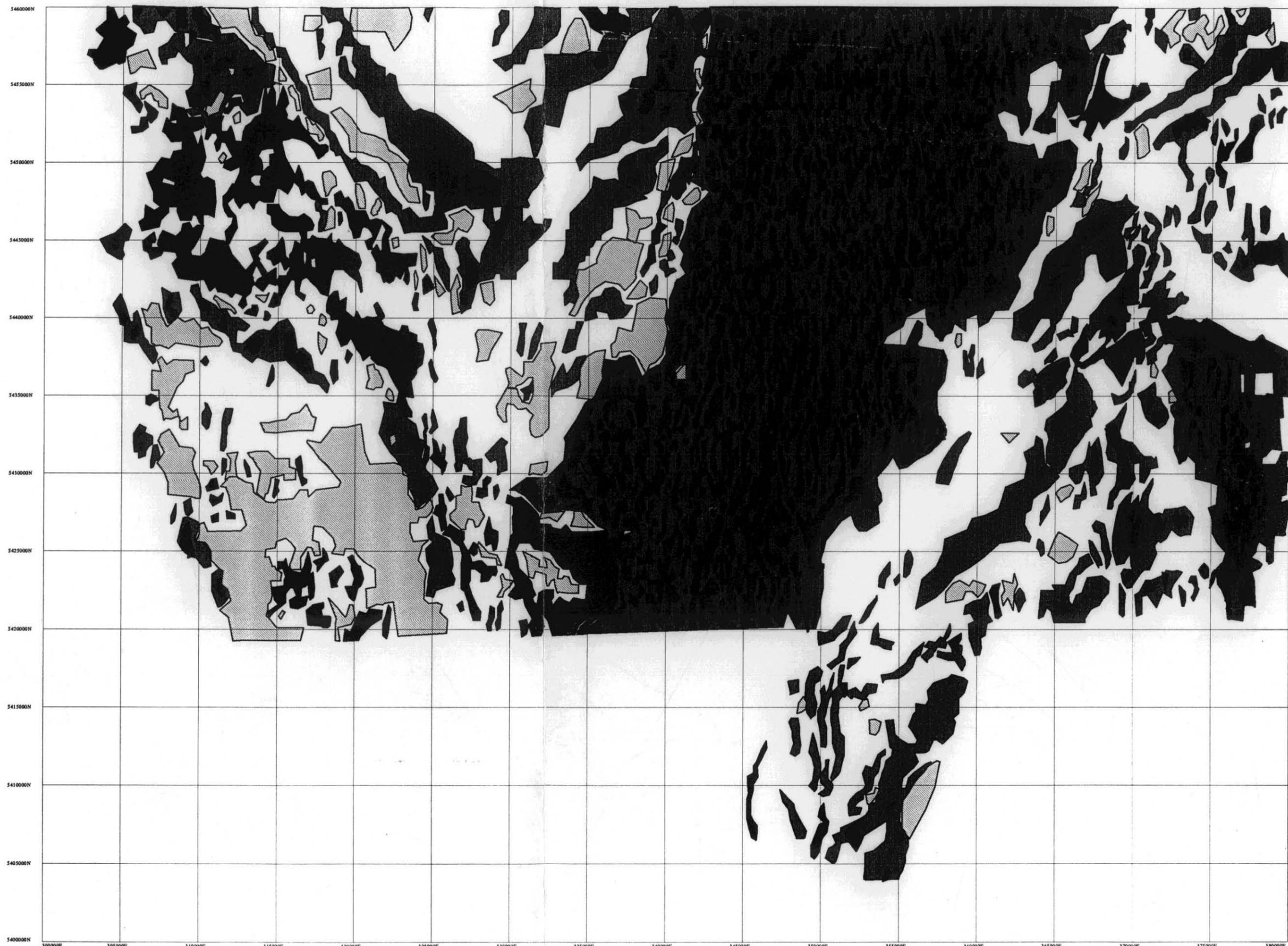


Figure 7

Radiometric total counts (data from AGSO, MRT).

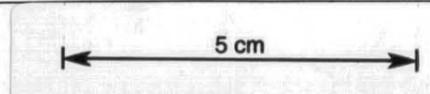


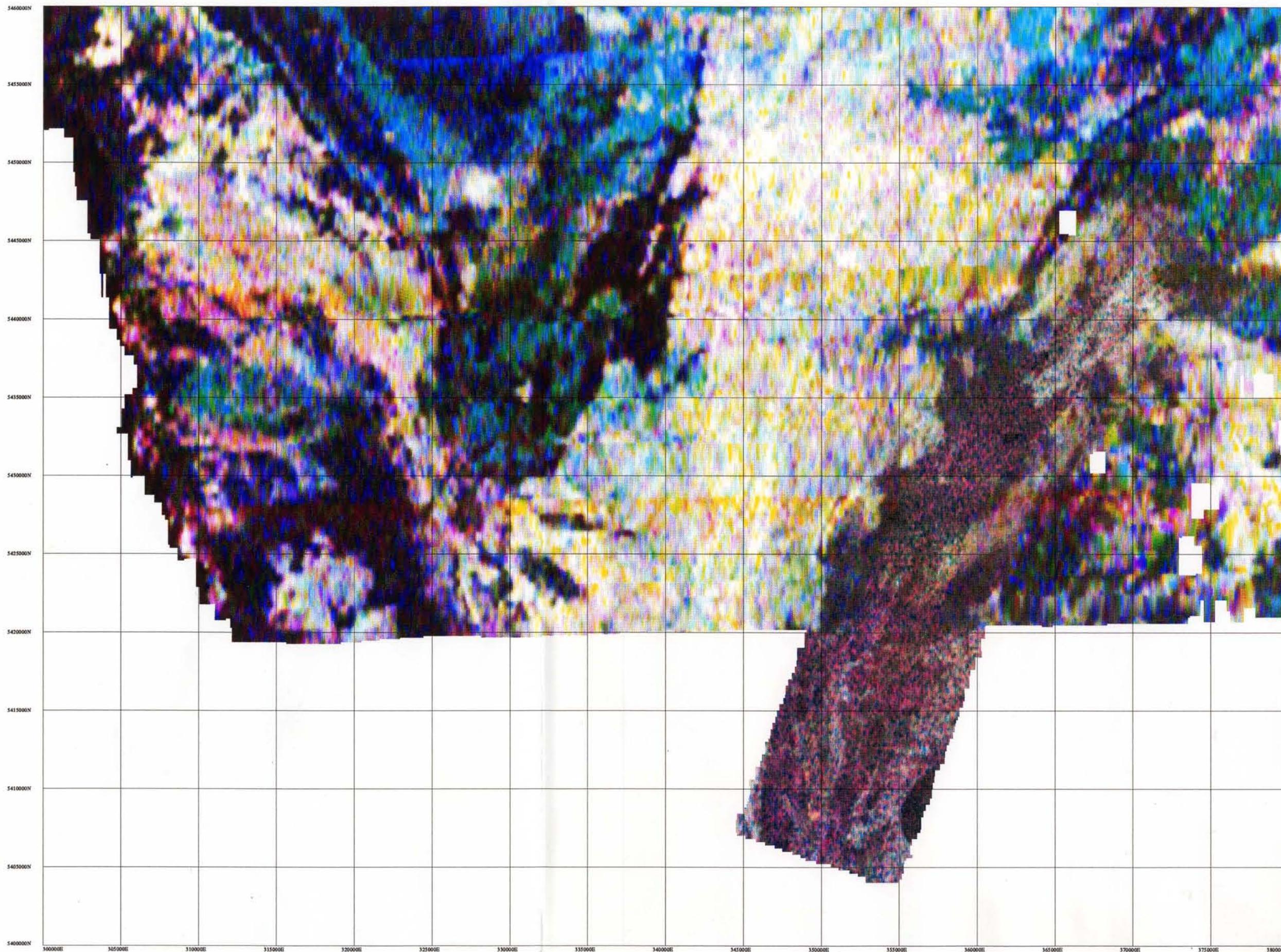
Very Low Total Counts

Slightly Elevated Total Counts

Very High Total Counts

Figure 8 Radiometric total count classes.





**Figure 9**

Radiometric three-colour composite; K = red, Th = green, U = blue.  
Smoothed with a  $3 \times 3$  average.

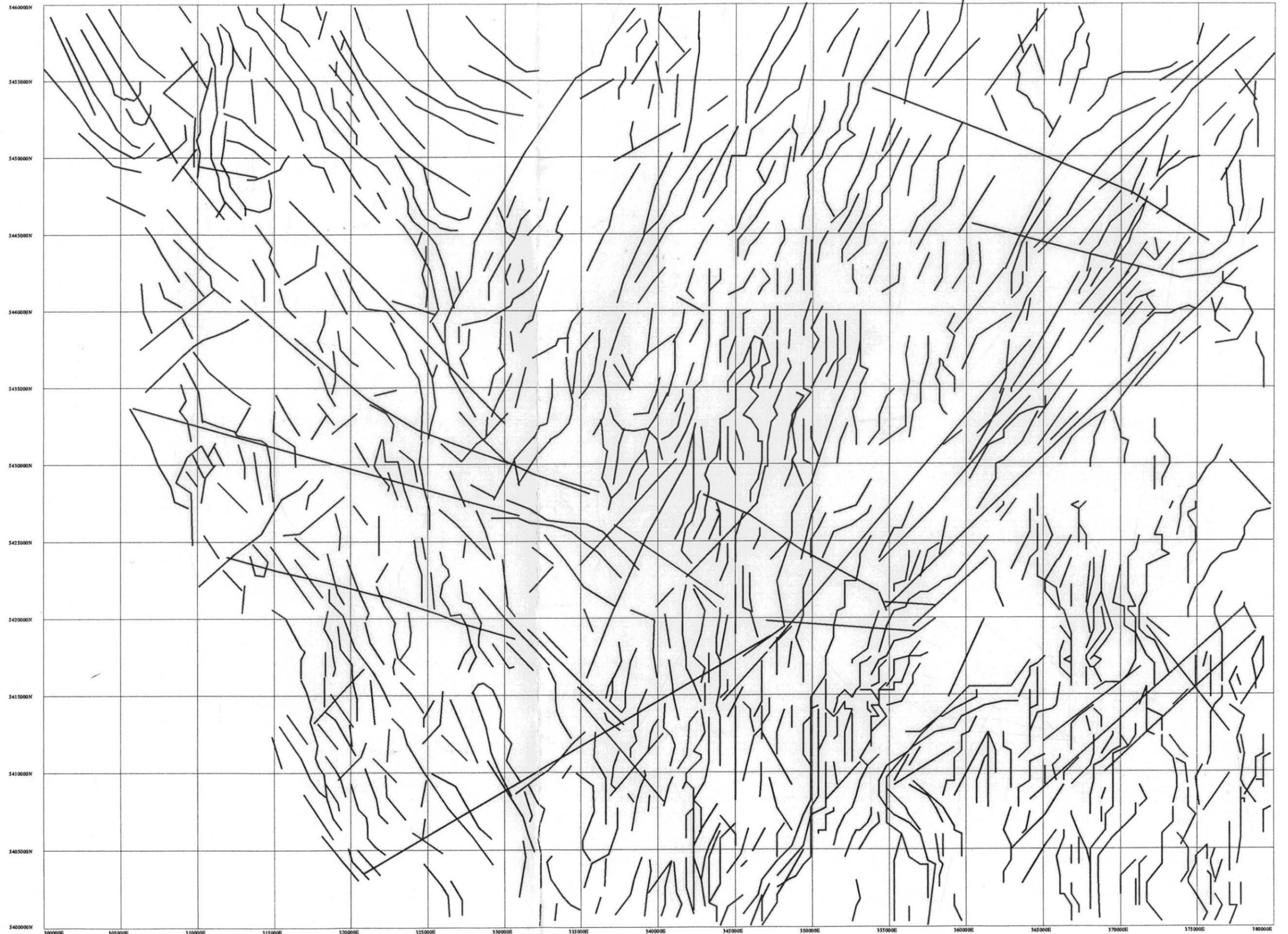
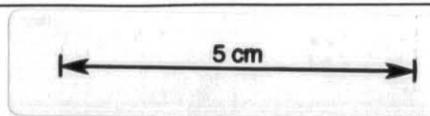


Figure 10

Linear features derived from the magnetic and radiometric data.



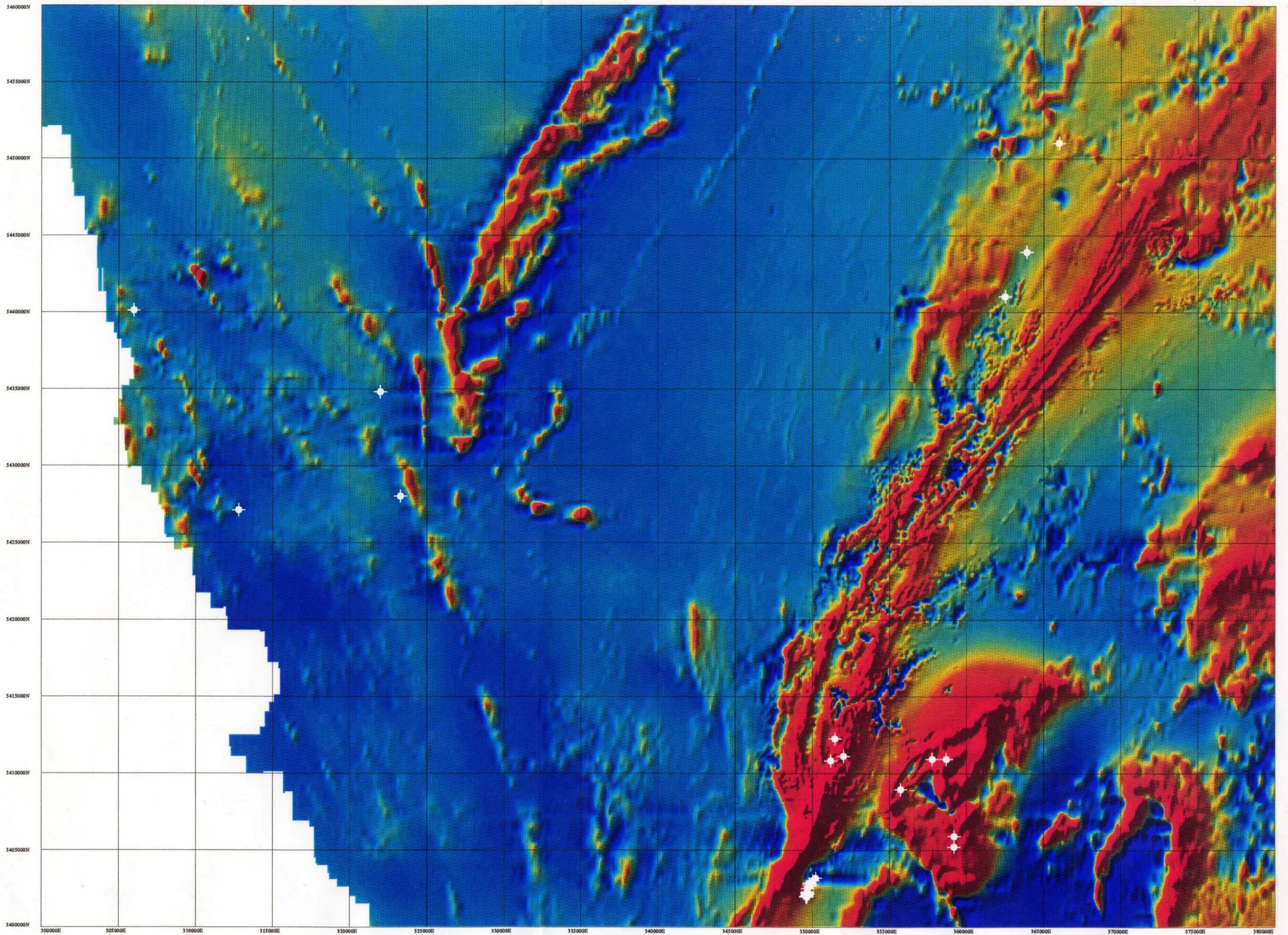


Figure 11

Aeromagnetic data and gold mineralisation.

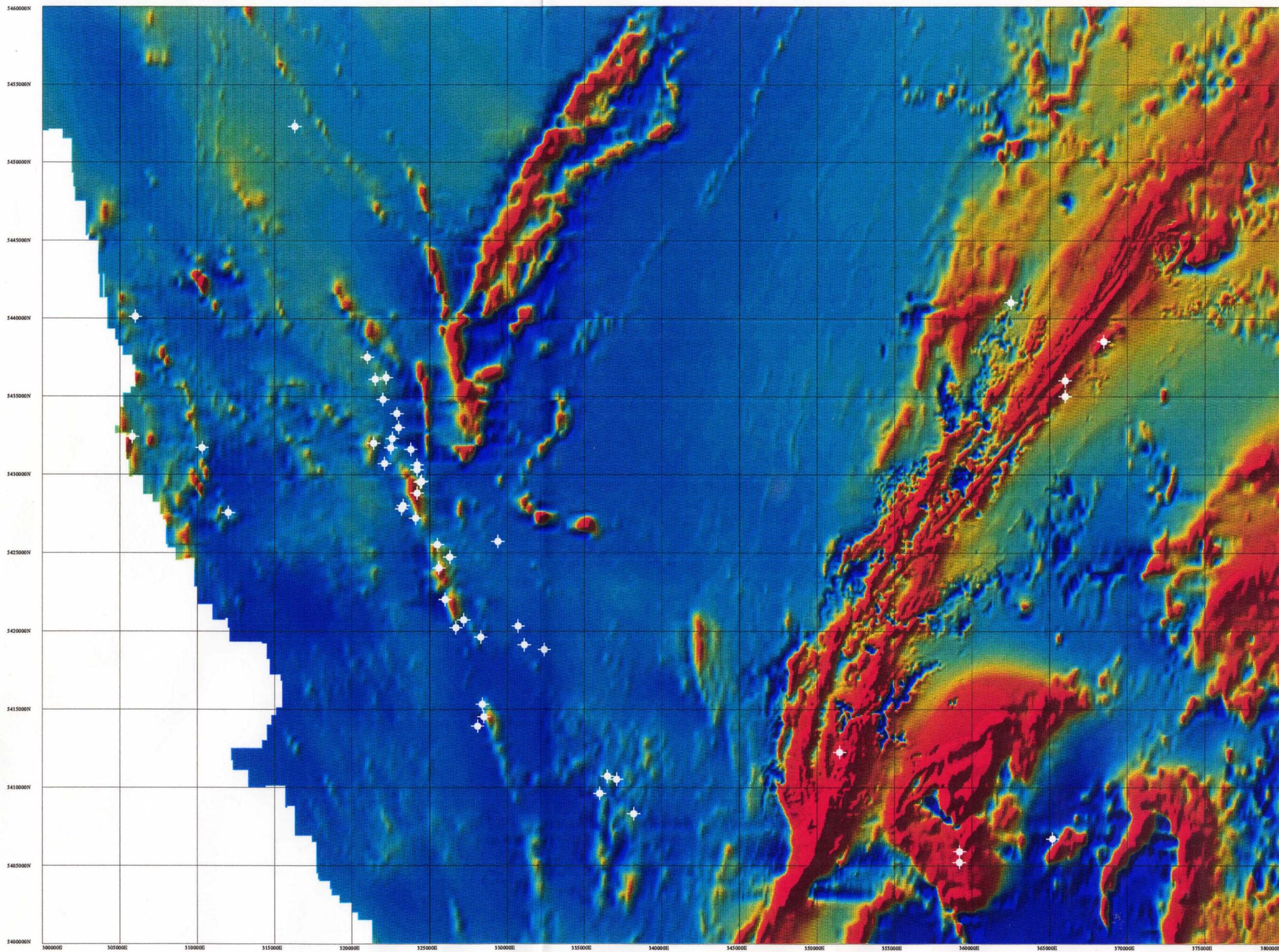


Figure 12

Aeromagnetic data and copper mineralisation.

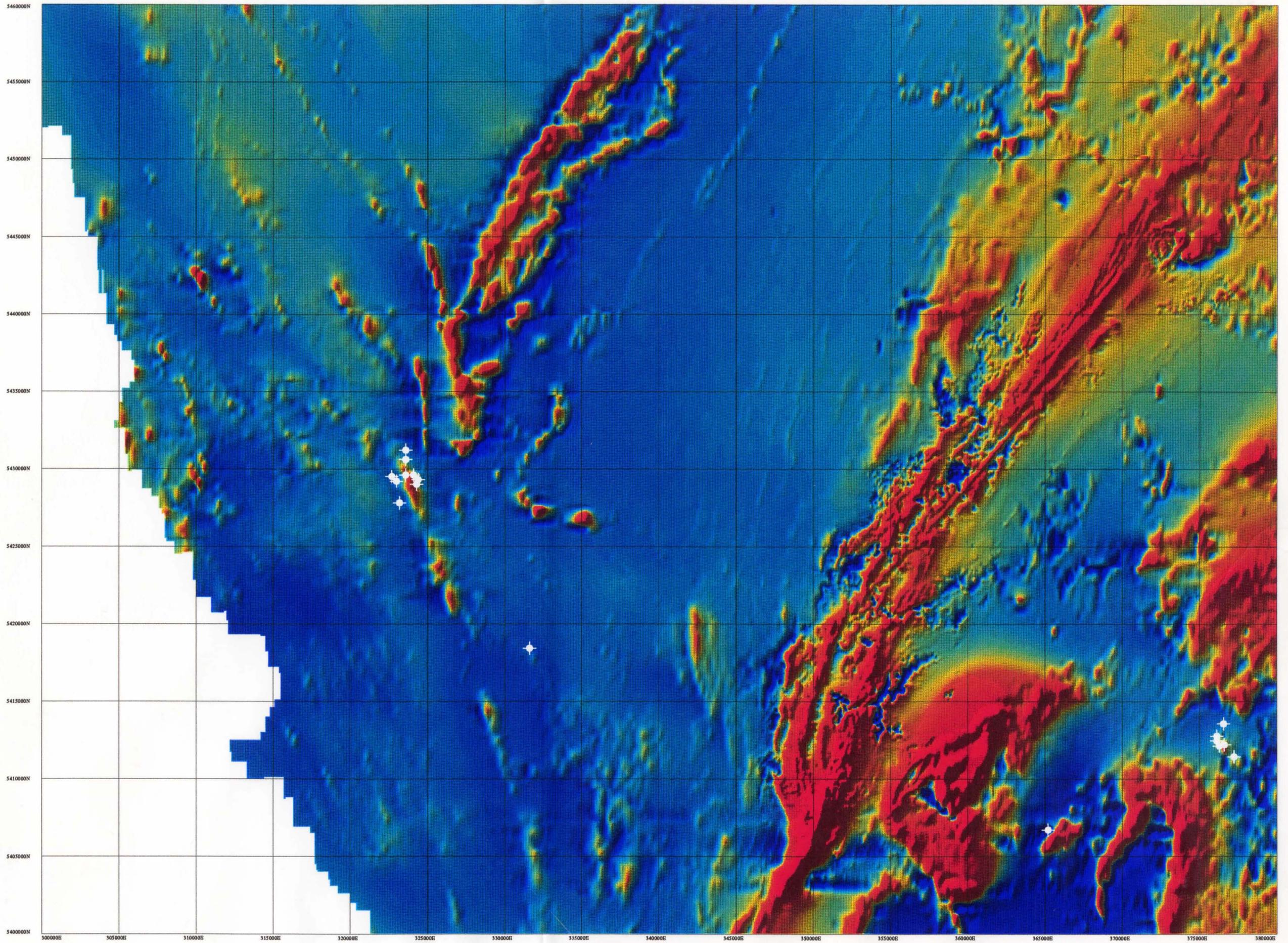
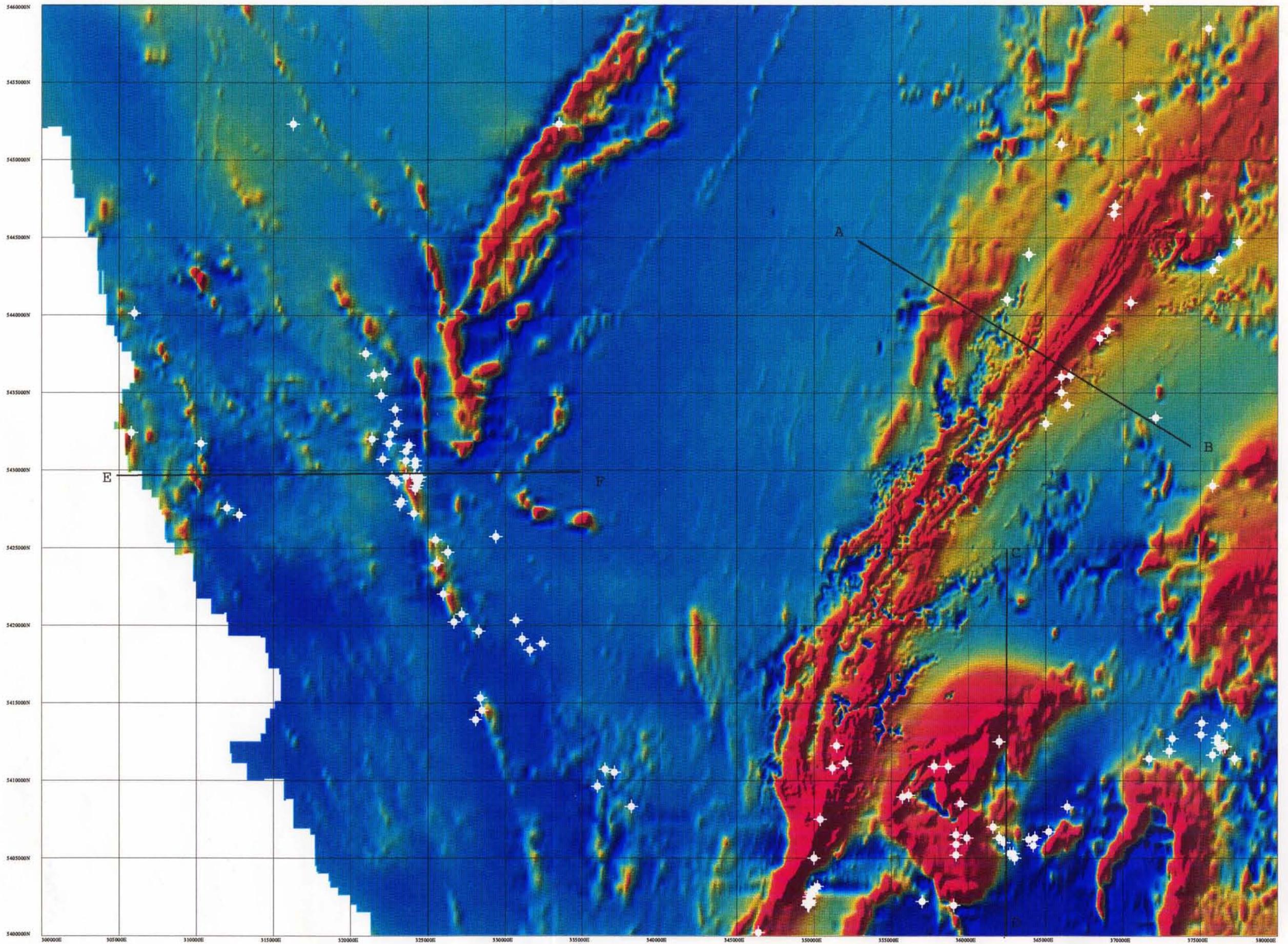


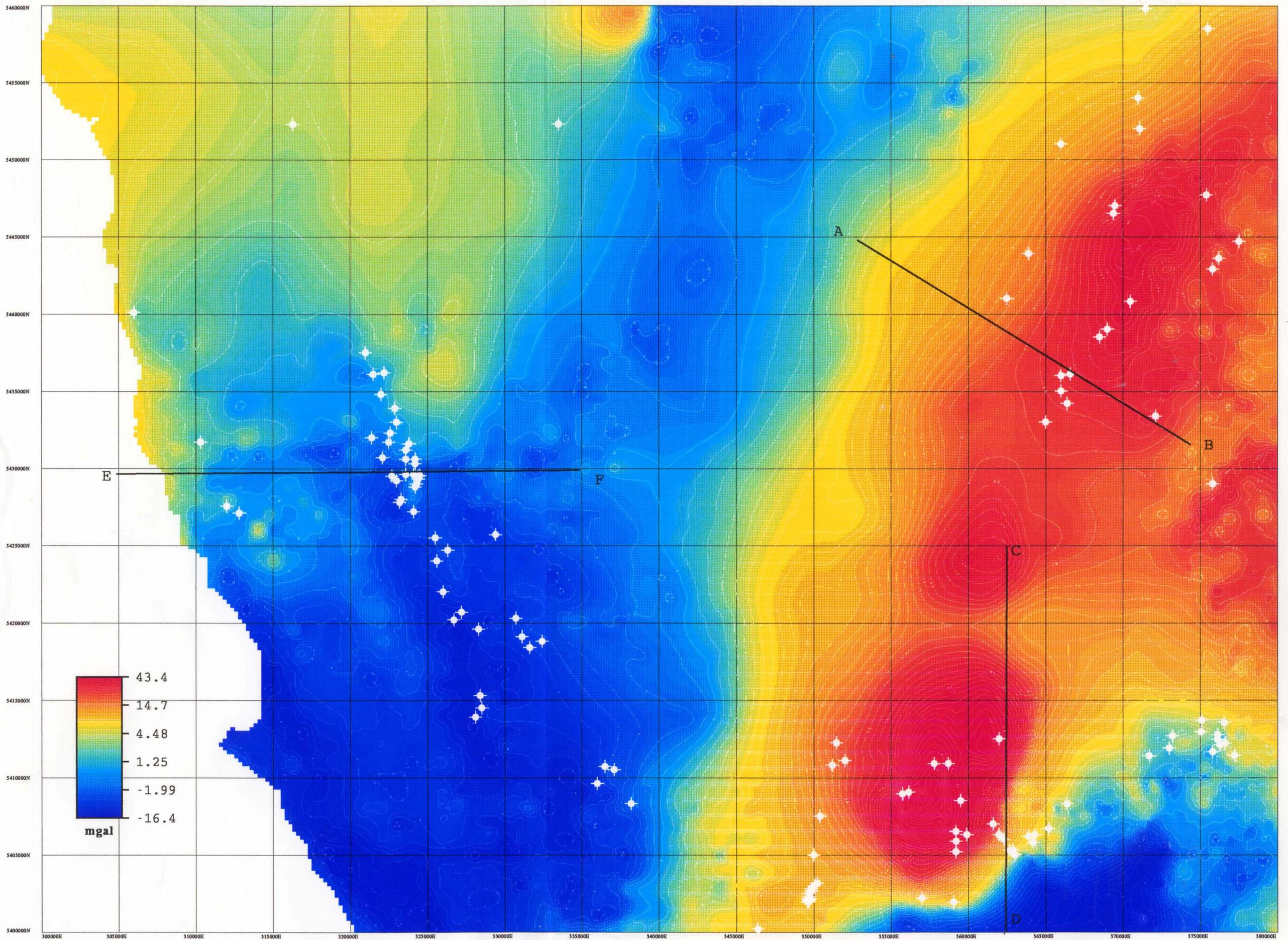
Figure 13

Aeromagnetic data and tin mineralisation.



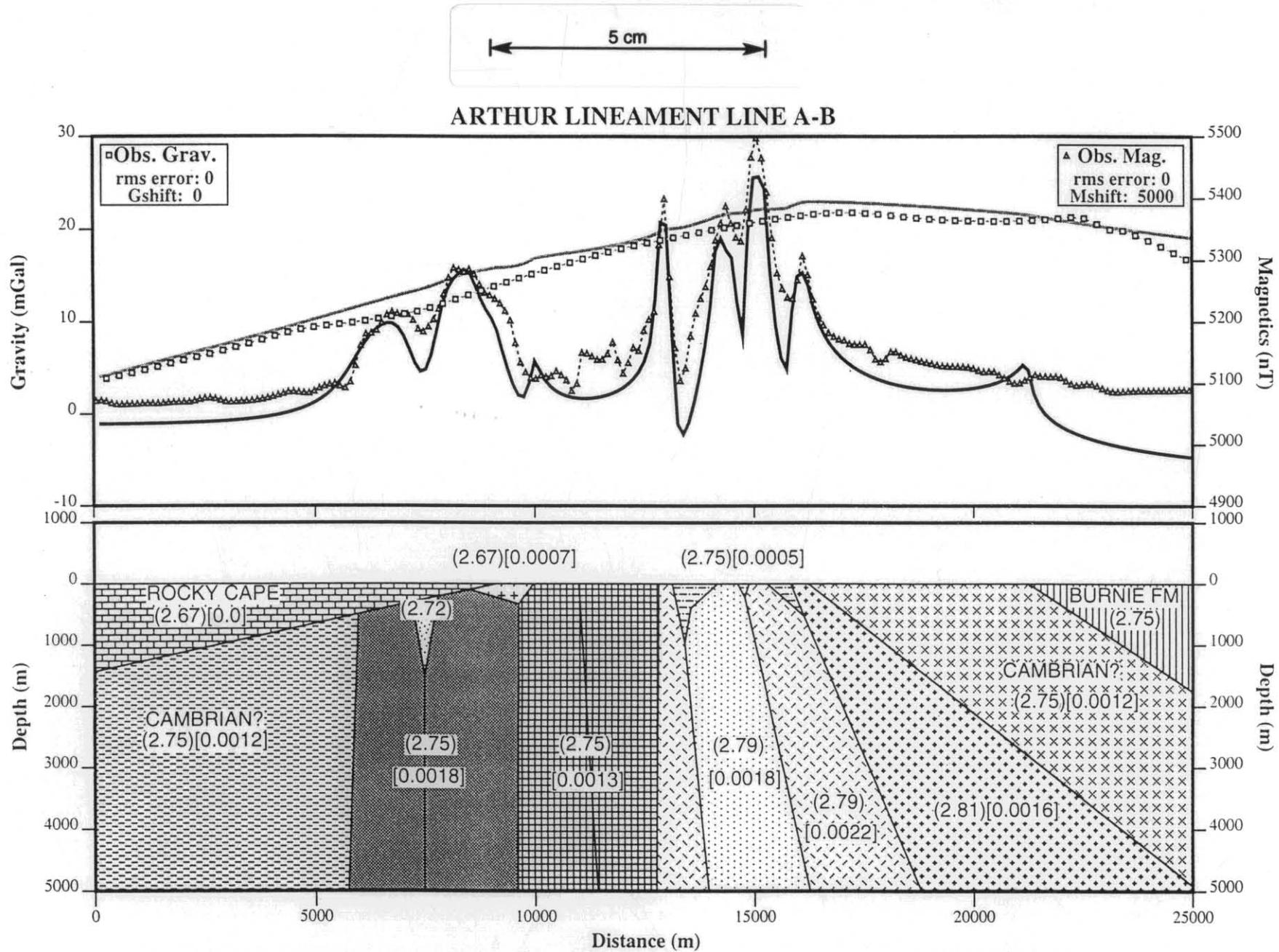
**Figure 14**

Aeromagnetic data and mineralisation (not alluvial or placer)  
(section lines marked).



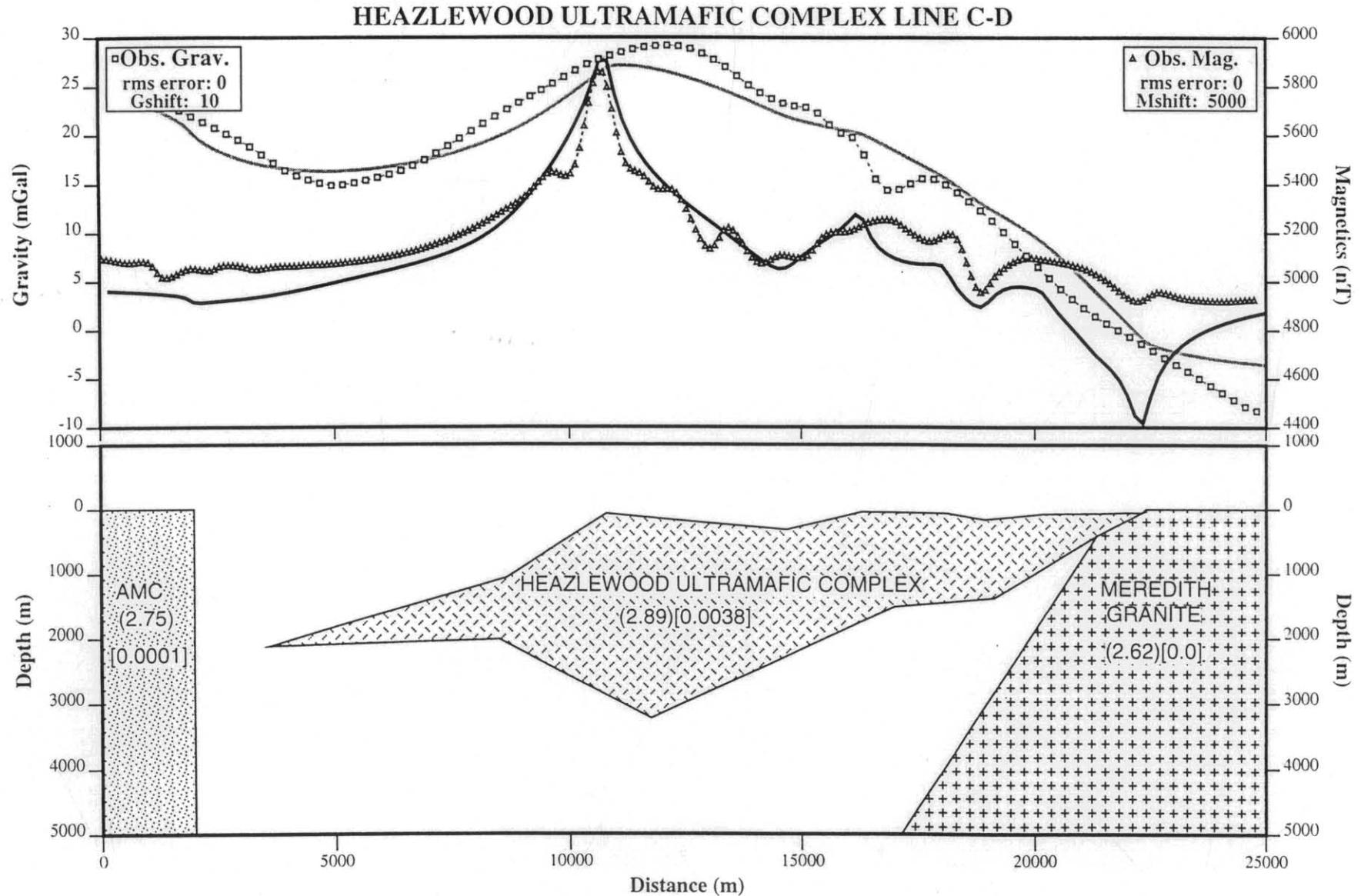
**Figure 15**

Residual gravity data and mineralisation (not alluvial or placer)  
(section lines marked).



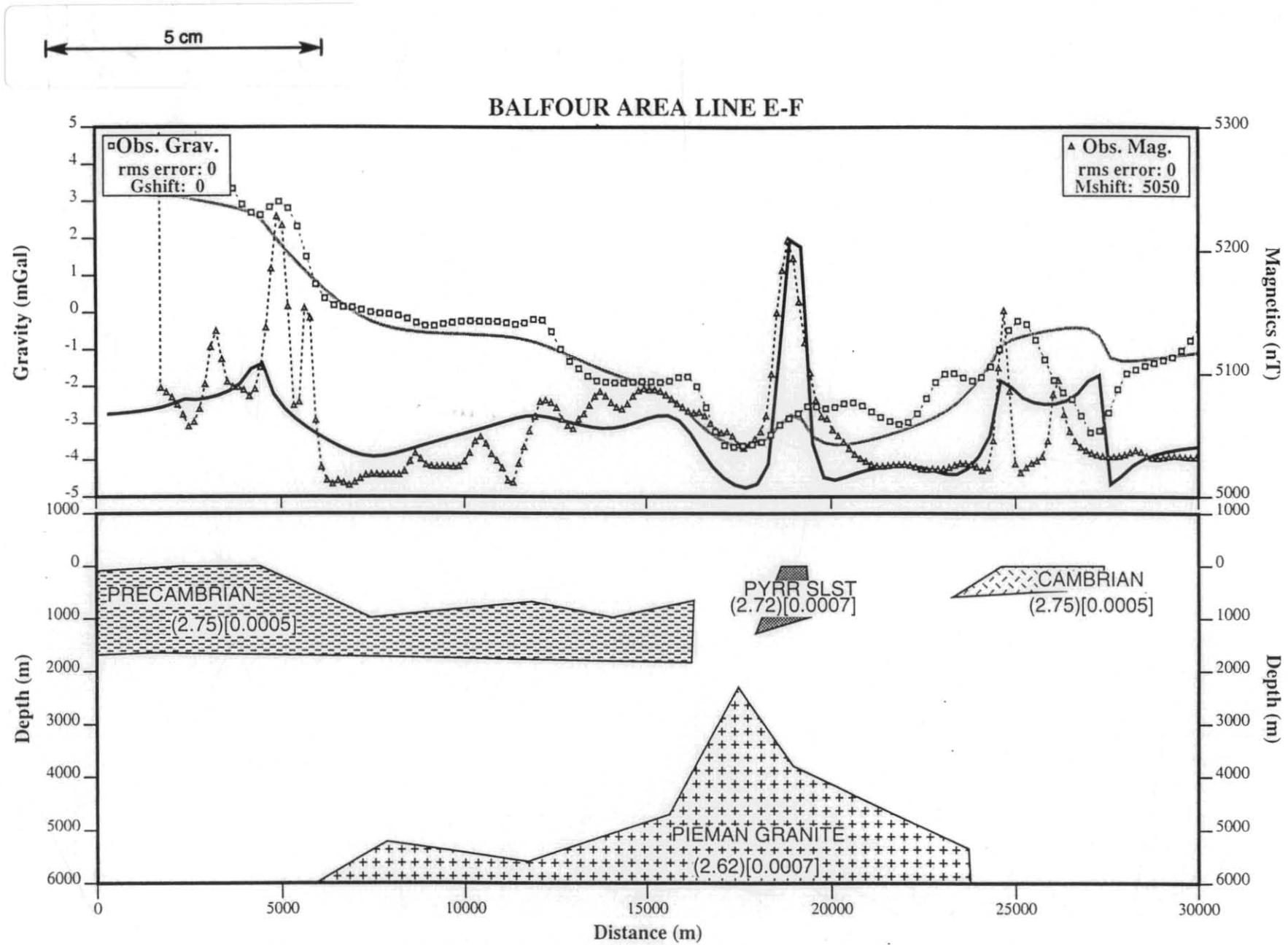
Model File:ARTLIN.MOD Obs. Gravity:LINGRAV.OBS Obs. Magnetic:LINMAG.OBS Date:09-29-1994 Time:14:15:00

**Figure 16.** Two-dimensional gravity and magnetic model across the Arthur Lineament. Values in curved brackets are densities ( $t/m^3$ ); values in square brackets are magnetic susceptibilities [cgs].



Model File:HEAZLE.MOD Obs. Gravity:HEAZGRAV.OBS Obs. Magnetic:HEAZMAG.OBS Date:09-29-1994 Time:15:18:06

**Figure 17.** Two-dimensional gravity and magnetic model of the Heazlewood Ultramafic Complex. Values in curved brackets are densities ( $t/m^3$ ); values in square brackets are magnetic susceptibilities [cgs].



Model File:PIEMAN1.MOD Obs. Gravity:PIEGRAV.OBS Obs. Magnetic:PIEMAG.OBS Date:09-29-1994 Time:17:33:22

**Figure 18.** Two-dimensional gravity and magnetic model of the Balfour area.  
Values in curved brackets are densities ( $t/m^3$ ); values in square brackets are magnetic susceptibilities [cgs].