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SUMMARY

All public domain geophysical data available for Northeast Tasmania have been reviewed in order to determine whether any distinctive correlations may be found with sites known to be gold-bearing and hence to predict the general location of comparable sites, or allow, based on the balance of structures and orientations involved, the likely scale and ranking of potentially productive areas.

An array of gradient-based variants, coupled with aspect and residual methods, has been applied to regional gravity data and the Netgold aeromagnetic compilation. Some of these procedures have not been used previously.

Although there are deficiencies in the gravity coverage, and it has been inspected only for regional information, aspect and slope processing of the crust-corrected Bouguer anomalies suggests that very few zones contain projections of gross crustal architecture. Predominant regional trends are ENE, ESE and to a much lesser extent NE, N-S and NNW. No fundamental NNW grain, nor any primary structure with this orientations, is supported.

The enhanced magnetic presentations support these trend conclusions. AGC, aspect and slope maps show that there are some distinctive pattern changes within the region but the known mineralised sites are associated with these only where a regional gravity (crustal) element is superimposed. Shallow source fracture and trend patterns appear to reflect deeper systems and many critical or apparently anomalous igneous or structural junctions mapped geologically can be linked to the same systems.

All the known mineralised sites tend to have an intimate association between a N-S structure and intersections of the regional grain (sub E-W). In the Branxholm-Warrentina region the N-S element appears to have been disrupted, possibly at the time of intrusion of the batholith. Relatively few sites display this conjunction of features and the established sites may be ranked Whiskey Creek, Forester, South Lyndhurst in terms of the elements present. Only a few other possible sites have been noted. Large scale, low grade alteration may also be focussed at these sites but overlooked by vein searches. Much of the area is not anomalous. Two possible conjunctions have been inferred in the Mt Cameron area even though no gold has been reported from these areas.

It is suggested that limited areas about the nominated conjunctions of structures be examined structurally, geochemically and perhaps more efficiently by detailed ground magnetics surveys. If previous experience in the Alberton field is a true guide then such surveys could define and rank local alteration and targets.

INTRODUCTION

Herald Resources Limited hold four licence areas in the northern part of the NE Tasmania gold province. These areas are

EL 23/94 Great Forester River
EL 24/94 Boobyalla
EL 25/94 Warrentina
EL 45/94 Mt Cameron

and are shown in Figure 1.

Some gold has been extracted from the first three of these areas but the total amount has been very small; perhaps 200 kg.

The geology of the region is dominated by at least two families of granitoids which have intruded apparently monotonous suites of Lower Palaeozoic metasediments which range from shales to slates and sandstones to quartzites. This suite is known as the Mathinna Beds. The wider region of NE Tasmania is noted for its tin and gold mineralisation. Gold has either been recovered from vein systems or alluvial deposits. No bulk alteration resource has been located or worked. The much sought vein systems are located within the Mathinna Beds although productive veins have been found within granodiorites. The background levels, or discovery of anomalous levels, of gold within the Mathinna Beds, especially, have rarely been tested but most of the rare determinations indicate gold levels below detection limits for the analytical method of the time. This exploration option has yet to be properly tested.

Most exploration has taken the form of pan and vein testing with an increase in geochemical sampling in the past two decades. Geophysical techniques have been underemployed for the simple reason that few explorers have seen how to apply them usefully. Exploration and research in the last decade has, however, demonstrated that simple geophysical methods and data sets may provide both the means to focus upon, or select, a small area for further work - including ranking of previously known and worked sites - as well as define some potentially critical aspects of local structure and alteration.

In the case of the present review three issues arise:

- i) Can any regional signature pattern be identified which might rank sites in the licence areas?
- ii) Do any of the known deposits possess a situation or character comparable with any established large producers?
- iii) Can any significant local structural controls be defined or suggested?

This report considers extant geophysical data, outlines its limitations, suggests its implications and its ability to resolve these issues. The review seeks to establish whether any critical structural elements occur in the licence areas and thereby to recommend which small areas might repay concentrated exploration.

NOTES ON PREVIOUS EXPLORATION

No simple geological, geochemical or geophysical technique has yet proven diagnostic for gold exploration in the NE Tasmania environment. This reflects limited exposure and a consequent inability to define structural controls or locate bearing quartz by normal geological means; the use of geochemical indicators such as arsenic which are notoriously mobile and not primarily diagnostic nor unique; and limited geophysical application.

The first research to suggest that geophysical methods may provide a means to define gross architecture of the region and its relationship to gold-bearing sites and also provide a primary site review of small areas designated of interest either by geochemistry, previous working or gross structure has been reproduced as Appendices 1 and 2.

All previous geophysical studies had failed to develop any satisfactory approaches due either to use of inappropriate techniques, inadequate technology or coarse data sets. A major reason for the lack of application may be simply stated; there was no obvious method which could respond to quartz veins and this was perceived to be a crucial need. This direct demand-signature approach ignored the possible setting, targetting and resolution/separation of site applications. Or assessment of bulk alteration.

The work reported in the appendices is now a little dated since it effectively represented the status of knowledge which could be reported freely in 1991 when the documents were prepared. The appendices summarise experience up to about 1989 and did not include what had been learnt since. All the surveys described were reviewed and many aspects of the preliminary interpretations were tested or improved at that time.

This early work implied that ubiquitous, low cost magnetic methods may map many aspects of structure and lithology within the region, trace vein systems, identify anomalous alteration and, when coupled with gravity data, suggest crustal fracture architecture.

The experiences of three small explorers led the Tasmanian Government to upgrade the quality and coverage of both magnetic and gravity data as the cornerstones of its NETGOLD project. Results from this project were released in April 1994.

To appreciate the specifications and application it is necessary to reflect on the history of these explorers. All references are included in the Appendices.

Placeco Australia acquired high resolution data in two areas (Gladstone and Lyndhurst) in 1987. These remain the finest surveys completed in Tasmania in terms of conventional survey specifications. The results revolutionised attitudes to the mapping value of the magnetic method in a region where rocks which are deeply weathered and presumed to be non magnetic (App. 1, Fig 2; App 2, Fig 2). Ground follow-up indicated that vein and alteration systems might also be mappable given adequate sampling (App 1, Fig 4; App 2, Fig 5). The company was unable to develop its breakthrough due to the stock market collapse of that year.

The Lyndhurst survey or area was never evaluated in any detail by Placeco but a basic interpretation of the mineralised sites and their relationships to the surrounding granitoids was completed several years later. The early interpretation suggests that a set of ENE and ESE trends may be associated with the mineralisation and that many of the obvious anomalies in this very subtle data set could be generated either at the limit of thermal alteration around the western granitoid (Figure 4) and also at the contact with the quite different eastern granitoid (Figure 5). The large regional effect which dominates the Lyndhurst region was separately assessed to suggest that it may be related to a major granitoid complex west of Scottsdale. Only granodiorites are known in this region. The regional modelling is crude since very little data was available in 1991 and the treatment does not over interpret (Figure 6). It suggests that a variation in granitoid composition may encircle the primary core and that gold may be linked with the boundaries of this variant. The 1991 research used as a basis for the papers reproduced in the appendices indicated that this type of association and variation could be related to *all* gold-bearing regions. The link at Lisle is far less tenuous (see App 1, Figs 3, 7; App 2, Fig 3).

It should be noted that more recent evaluation of the large anomaly west of Lyndhurst has suggested an explanation involving a deeply buried slice of ultramafics which may be traced to exposure at Beaconsfield (Richardson & Roach, 1994). Pending further work these two solutions (granodiorite complex, ultramafic sheet) must be considered viable alternatives.

Pegasus Australia Pty Ltd., developed the magnetic approach trialled experimentally by Placeco. This company acquired the best magnetic data set available within Tasmania given the difficult terrain of the important Mathinna-Mangana zone. The specifications were unconventional and required a much higher proportion of tie lines than normal such that either line set can be used to generate a quality compilation. The nodes in the survey were used to constrain and correct all clearance misfits and the results were contoured at 0.5 nT. This precision was necessary to extract the fine detail required to assess mineralised sites and define lithologies (see App 1, Fig 8). The survey drew attention to local concentrations of ENE and ESE alignments which were normal to the general strike of the units within the Mathinna Beds.

Ground follow up was restricted to the region of Tower Hill and the Tower Hill Mine near the centre of the survey. Magnetic surveys using standard magnetometers and an observation interval of about 1 m were able to define a sub circular zone about the mine which was presumed to reflect oxide destructive alteration. A section is shown in App. 1, Fig 5.

These surveys also confirmed that simple methods could locate quartz veins, or at least their wall-rock alteration. Close examination of veins and localised host alteration/oxidation has shown that the spikes observed are compound; two spikes are actually generated but are not observed unless the observation interval is reduced. These reflect up to three orders of magnitude variation in the magnetisation of the host Mathinna Beds adjacent to the quartz where

fracturing, oxidation and fluid passage has altered the material.

Oceania Pty. Ltd., explored the Alberton mineralised zone on a very small budget using very high resolution ground magnetic methods. This survey produced a stunning result in the zone of significant past production (Figure 3). The map, expressed only as stacked profiles, shows that there are several magnetically distinctive blocks in the belt and that each of these is defined by an arcuate limit which curls from ENE to ESE; the two trends so often seen upon close examination but never obvious in primary features. All significant past production can be correlated with the anomalous zones.

This effect has never been properly researched nor explained but it is probably due to alteration controlled by a local structure and stress field. The direct application of the observations, until proven otherwise, is obvious; the magnetic method can selectively define productive volumes.

This result was confidential, but known, when the material presented as appendices here was prepared in 1991.

The very high resolution approach using a vapour magnetometer and a sample interval of 20 cm is clearly effective but may not be cost effective since very careful conventional ground surveys may achieve a similar result. Until this had been tried I could not be sure what might be achieved and what might be resolved. The company was very satisfied with the results even though the exact origin of the effects is still not fully understood.

The only large company to attempt a magnetic survey was Billiton Australia near Lisle. This survey, completed in 1982, was a much more conventional mineral-type survey and lacked the quality of the Placeco and Pegasus surveys. The terrain clearance was more than 150 m and the line spacing more than three times at 400+ m. It was still classed as confidential and unknown to me when I specified the other surveys in 1987-8. The Lisle survey does, however, draw attention to quite anomalous variations within the Mathinna Beds; why for example is the magnetic character terminated on an NE-SW axis when all units strike continuously to the NW? (see App 1, Fig 3).

All these surveys demonstrated that magnetic methods can reveal structural and lithological features within the host Mathinna Beds sequences and also provide definition of some highly anomalous aspects in a regional context. Ground surveys are also able to define these features and appear able to focus upon quite small areas which are worth detailed exploration. In each case where the method has been applied to range from regional to local focus in association with geochemical methods it has proven far more site specific.

At the time of writing, however, there are too few case histories available to ensure this is a truly general conclusion. This status partly reflects the bias, even within a willing Placeco and Pegasus, to base their programmes upon, and emphasise, a geochemical approach while commencing experiments with more radical geophysical concepts. Many of the ideas developed from these limited data sets, and the more general coverage of western Tasmania, have evolved to suggest that stress, vein and crustal patterns affect other mineralisation styles and are more widely applicable across Tasmania than has been

realised.

The learning curve described above was appreciated by Mineral Resources Tasmania and used by them to find an economic compromise for specification of the NETGOLD surveys of 1993-4. The government budget could not allow regional specification to the Placeco or Pegasus standard and it was decided to employ the half Pegasus standard but retain the low terrain clearance of these fine surveys. The new surveys represent a major improvement in coverage and general quality but their restriction only to large areas of Mathinna Beds, and omission of granitic areas, has restricted their regional value. The Netgold data project also included substantial infilling of the gravity coverage of NE Tasmania but unfortunately all detailed infilling was restricted to the area south of Branxholm. The survey coverage north of Warrentina remains much as compiled in 1977 and is in need of some detailing.

Results and ideas have been accumulated from treatments in this and other provinces (including Leonora, WA; Tennant Creek, NT; Anakie and Isa inliers, Qld; Central Victoria) and it is clear that major structural and crustal controls must be involved and appraised. It is also clear that the application of these controls, or formation of the fundamental structure, is never recent in terms of the deposit history or formation. The structures are ancient, rejuvenated or transformed, and remained active during and after the mineralising episode. If this is a valid history then these structures must also distort tectonic and intrusion evolution and we should expect higher crustal structures to reflect these deeper features which may extend into the mantle. Even when high level disturbance effects dominate the surface or apparent geology these underlying elements may be unmoved and still able to feed or control fluids. This crustal fixation of fundamental alteration paths renders them accessible to regional assessment techniques such as gravity and magnetics.

Inspection of available geological maps allows identification of complex intrusion junctions, abrupt trend or structural changes, and other distortions. These unusual elements may define the nominal position of the fundamental structure and its projections into the evolving upper crustal geology. Flower structures provide well known examples of this class of feature. Figure 7 suggests the position of such points (dots of varying weight) and indicates some possible alignments. This may be called the PASS technique - Plot of Anomalous Structural Sites. The alignments shown reflect the identified points and some linkages suggested by the data presented in the MRT NETGOLD package of April 1994. Figure 7 was prepared in May 1994 and was based solely on the data and formats included in the package. Not all correlations are certain due to the mixed map scales and limited processing options provided by the package. Even so, the new data compilations have generally confirmed the previously implied ENE trend system as well as showing that an ESE set may be even more marked. Both these orientations are subtly displayed in all data sets and are often swamped by other trend systems or responses related to unit boundaries or contacts which commonly trend sub N-S; this is also true of western Tasmania. The best regional compilations, coupled with PASS points, suggest that these deep crustal patterns

are gross and extensive and form a deep fracture net. All known mineralised zones can be linked to the approximate nodal positions. This association is particularly pronounced for sites such as Mangana, Alberton, Mathinna, Lisle and Lefroy - and probably Beaconsfield.

Figure 7, as drawn, suggests that the Warrentina area may also be important and anomalous but is less clear about the Lyndhurst and Forester areas. This may reflect lack of PASS information, limited data review and other regional constraints. Consideration of existing information does suggest that a line from Bridport to Ansons Bay may have a basis in PASS information regionally; such an orientation would intersect with the South Gladstone-Forester trend just SE of Forester. This would suggest that the mineralised sites in this region are not randomly located either.

Are there other sites?

Can closer examination and better data integration or processing allow a closer focus and better definition? Are the zones between these major systems unimportant and relatively unprospective?

This report considers these questions in order to resolve the objectives stated in the introduction.

An additional topic must also be reviewed.

There is a commonly held view that the greatest gold potential in the region lies along a general NNW-trending axis from Mangana to Lyndhurst (see App 1, Fig 1). This view is based on the apparent regional alignment of deposits. There is however no systematic association of vein orientations or sites along this axis and many of the more productive sites are up to 2 km off the inferred alignment. As Maps 1 to 6 show, some groups of sites do appear aligned locally but there is no overall alignment and the fragments are almost never aligned NNW. Nor are the actual veins within the mineralised regions. This common emphasis on this zonal structure also ignores the indisputable fact that three quarters of the region's past production was won elsewhere - mainly at Beaconsfield, Lefroy and Lisle.

Does any primary structure exist along this axis? Previous geophysical research south of Alberton would suggest not.

Other geophysical methods have been tested with rather impractical findings (e.g., Leaman, 1974). Thermal and piezo-electric methods may be effective but further research is necessary and the equipment is not readily available.

DATA AND PRESENTATION

Each data set has been inspected in an array of raw and processed forms. The use of each version is constrained by the observation density and the type of processing. Many of the variants discussed represent experimental versions; no wide scan of options has been attempted previously as far as is known.

The magnetics data base provides the highest quality regional data available even though it covers only areas of significant exposures of the Mathinna Beds. The line spacing is variable, ranging from 125 to 500 m. Terrain clearance varies, from 60 to 150 m nominal minimum, but the bulk of the coverage is at about 80 m. Sampling varies from 8 to 30 m. These variations in specification do affect presentation, detail and noise levels after integration. All data, regardless of its origin, has been coherently corrected, tied and adjusted to allow the best possible combination. This integration was undertaken as part of the NETGOLD process and the reader is referred to Richardson (1994). The reader should beware of character differences related to survey edges or joins when dealing with gradient or other amplifications.

The integrated data set prepared by Mineral Resources Tasmania under supervision of Dr. Richardson has been processed to the writer's specifications for this review; many of the variations had never been tested on any Tasmanian data set.

Some processed versions proved to be of limited use and have not been reproduced in this report. All versions have been listed and commented, however.

The raw data map of total magnetic field intensity, after removal of the IGRF, is the standard presentation of magnetic data. This presentation tends to be diffuse in image format and is not able to clearly reproduce all fine texture due to the dynamic range in the data. Contoured maps cope with this problem but are more difficult to inspect.

Although the raw compilation is a residual presentation an alternative version was produced in order to enhance the subtleties in the data set. Previous experience has shown that anomalies of 1 to 10 nT may be important and that delicate gradients may be associated with these. The raw IGRF version includes some very large responses which tend to swamp such fine detail. These large regional effects have been removed by upward continuation to 1500 m, in order to remove all subtleties, and then subtraction of the continued field from the observed field. This process results in removal of most long wavelength features with considerable enhancement of small anomalies. This is a simple, well defined filter procedure but it may be imperfect and introduce modest curvature into the results depending on the wavelength-height balance. This version has been called the continuation residual. Versions are given in Maps 1, 2 and 3.

The horizontal gradient has been prepared from the grid nodes and represents the maximum value of the gradient in the region of each set of four nodes. All grid calculations are based on a 50 m mesh. This process enhances local effects and can focus on the location of

source boundaries and shallow effects.

The 3D analytical signal is a formulation which combines the vertical and horizontal gradients and is able to define the location of sources. The reduction-to-the-pole process is related to this function by direct integration. The analytical signal function enhances shallow effects but can isolate some aspects of source geometry or dip. All calculations are grid based.

Two versions of the analytic signal function have been used - filtered and unfiltered. Since gradient amplitudes can be large any function which changes their exponent can lead to instability in the resulting combination since very large dynamic ranges and imbalances can result between components. Some parts of the data set generated clear line effects and others large spikes. While these features were recognisable their contribution does destroy some of the value of the process. Filtering was attempted in order to minimise these effects and improve resolution of larger scale or deeper contributions but this is always a risky process which may damage the outcome for the entire set in unexpected ways. It was found best to use the unfiltered version in this case.

Automatic gain control (AGC) was also applied. This process applies a decaying amplitude function to the grid mesh which effectively amplifies subtleties and diminishes long wavelength effects regardless of original amplitude. The process is comparable in many ways to gradient calculation but is scaled and normalised. In this way the results display the changes observed without distortion by their actual amplitude or interaction (see Map 4).

Aspect of the data set considers the slope direction within the grid mesh and is able to display subtle changes in sense within the magnetic field. The result is equivalent to the definition of kinks in a much smoother surface. This process can enhance regional aspect of fine grain whether along or across strike (Map 5).

The radiometric data have only been examined in two formats; total counts (image and contours) and superimposed uranium, thorium and potassium channels (image). The superimposed version can be used to separate lithological or alteration characteristics while the former can be used to suggest structural texture. It must be noted that the method depends on shallow source distributions and a relationship between soil content and underlying rock masses. Recent sand blankets destroy much of the value of the data in large parts of NE Tasmania but it is still often possible to suggest important aspects of structural, or erosional, grain.

The coverage and quality specifications for this data set are identical to those noted for magnetics.

The gravity data set is much more variable and more difficult to process and appraise. Station spacings vary from about 250 m in parts of the Gladstone and Mathinna areas to an average of 1 to 1.5 km over large tracts of central NE Tasmania. There are, however, substantial areas, especially east of Lyndhurst and Forester, where the station spacing may exceed 5 km. The variability of coverage does not pose serious problems for coarse regional reviews but focussed assessments of the type attempted here require much more uniformity and a spacing of no more than 1.5 to 2 km.

In order to force the data set and the processing parameters to display as much information as possible the gravity field has only been considered at scales of 1:250 000 and above. This provides a much truer representation of the resolving power.

This loss of detail has been found to be unfortunate since this data set could refine assessments in several important areas. The data have been used to suggest zone rankings rather than provide specific site definition.

The gravity data have been inspected in several formats.

The raw Bouguer anomalies have not been reviewed since these contain a mixture of large distortions and regional fields related to continental margin, Bass Basin and the Blue Tier Batholithic complex. The interference effects from these sources completely disguises all fine detail.

This problem was solved some years ago by creating a model of the mantle and oceanic crust, and water, which acts as an equivalent source (Leaman & Richardson, 1989). This means that it can fully explain all the long wavelength characteristics of the gravity field in the Tasmania region (from abyssal plain to abyssal plain). As an equivalent source it does not matter whether it is geologically valid or a true solution since its effect is predictable and can be subtracted from the actual observed Bouguer anomalies. This process generates a residual field which reflects the near surface geology faithfully and which can itself be processed and amplified.

This type of regional-residual separation process yields a true residual free of any mathematical artifacts as shown by Roach *et al* (1994). Although the model has been described above as an equivalent source it was in fact based on all existing factual information on the crust-mantle and ocean floor interfaces and is probably a very reasonable three dimensional representation of the base of the crust.

This work represents the first time that the TASGRAV data base has been taken to derivatives, analytical signal or aspect. One of these presentations seems so fundamental and useful that its value should be rapidly appreciated before competitors become aware of it (Map 8). The processing train has meaning only when applied to the residual form of the data set and very few other workers or companies have acquired the data in this most useful form.

This examination of NE Tasmania has used the gravity data base in the basic residual format and some processed forms.

The residual format represents the conventional gravity map.

The slope format represents a plot of maximum horizontal slope based on the grid nodes (mesh 250 m). This is a very effective and detailed form of presentation (Map 6).

E-W and N-S gradients have also been examined based on the grid nodes taken in each direction. Each is able to provide some focus on particular orientations. It was found that the E-W gradient was poorly constrained in many areas and subject to breakup and grid patterns.

The vertical derivative represents the change in gradient away from the surface. Due to the variability in coverage and range in values this function tended to be very spiky. Filters were tested. It was

found that a filter with effective 1000 m radius produced the best result by retaining all gross features and smoothing large spikes. This type of processing, like all gradient forms, tends to enhance shallow source character and reduce large regional effects. Treatments of this type have been used to diminish the contribution due to the various granitoids and plutons in the region.

The 3D analytical signal function was calculated from the combined gradients and filtered (2000 m filter) as in the magnetic case.

The aspect was also calculated. The result was variable due to the range of station spacings but this was an impressive map (below)(Map 7).

The slope and aspect maps were also calculated at state scale so that gross elements might be assessed (e.g. Map 8).

OBSERVATIONS AND DISCUSSION

The various data and processing formats have been reviewed for any pattern or trend styles. No attempt has been made to describe particular, individual anomalies since most are of direct lithological origin and not relevant to a ranking of areas within the large tracts of licences.

The review has considered both the general patterns displayed in the region and the particular patterns which can be defined or assessed in the vicinity of known mineralisation. The descriptions are as objective and pragmatic as possible in order to establish whether any features can be associated with mineralised sites and determine if those features occur systematically across the region. Recognition of any patterns would, of course, allow predictions and assessment of zones not previously known to be mineralised or perhaps disguised by thick weathering or Recent cover.

TREND CHARACTER

Each data set, or version of it, yields some consistent and common elements and some additional aspects.

An attempt has been made to present the varied contributions from each version of the magnetic data set in the Branxholm-Lyndhurst region in Figure 8.

The raw data is not particularly useful since all features are of low amplitude in this zone but the continuation residual does provide the general skeleton of sources. These vary in orientation along the belt. The horizontal gradient slope map contributes some features not obvious in the magnetic field but all presentations tend to define the granite or aureole contacts. Many strike extended features, especially near Lyndhurst, or spot features elsewhere are related to these contacts. Much of the field is flat.

Greatest detail is provided by the AGC version and the compilation depends on this presentation since it clearly displays an array of fine details. The least successful presentation was the analytical signal which contributed very little not seen in other displays.

The aspect map was also very useful and was able to contribute grain within sub zones as well as suggestions about those sites where the grain varies.

The structural character shown in Figure 8 is not influenced by the component surveys south of Lyndhurst but the much coarser flight pattern north of Lyndhurst may affect conclusions and most of these inferences have been omitted from the diagram.

The figure also shows the approximate location of the three principal groups of mineralised sites; from north to south, Lyndhurst, Forester, Warrentina-Branxholm.

The trend patterns are generally systematic and reproduce consistent orientations although the balance of orientations differs across the area examined.

Several sub zones may be identified; the general Lyndhurst area north of 5465 000 mN, the Forester zone about 5455 000 mN, the Branxholm

zone at about 5445 000 mN and the intervals between. The nominated zones have a N-S extent of about 5 km and each is marked by an increase in structures and, more significantly, disruption of trends and orientation patterns. This effect is particularly marked in the north Branhholm area (Whiskey and New Find Creek zones) and just south of the Forester group of old mines. The Lyndhurst region is also more complex than the belt to the immediate south but it does not display the trend shifts evident at the other two sites.

The diagram also suggests the approximate location of major trend alignments evident in the gravity data set. The orientation of these features does match many of the more detailed elements determined magnetically but the largest features intersect near Branhholm, just south of Forester and north of Lyndhurst; the very zones where the greatest disturbance in shallow structural trends is noted. A clear correlation between deep structures, defined gravimetrically, and shallower features, defined magnetically, is established.

Figure 9 presents a revised version of Figure 7. This presentation incorporates all the implications of the varied processing of the gravity data set. Some trends previously inferred have been confirmed and some additional features have been recognised.

The hatched bands shown in Figure 9 have been derived from the aspect map and indicate the most striking elements of this presentation. Two belts of changed aspect extend almost E-W across the region covered by the licence areas. These cannot be traced continuously with a single trend but each carries the same component directions. The curl mapped appears similar to the curl in magnetic trends observed at Alberton (Fig 3), and to the same directions. Since these two orientations (ENE, ESE) are commonly recognised in the region in geophysical data sets it must be presumed that these are fundamental and present at all scales. The PASS technique also defines these trends in geologically anomalous character and the locations are coincident within the precision of the various types of data set.

The gravity aspect map also defines a large sinuous curl which extends through the positions where the curl is neutral or actually E-W. This position may represent the axis of the batholith but it extends from near Gladstone, to south Mt Cameron, to Warrentina-Branhholm and south east toward Pyengana. Major changes in direction of this feature may be important and the major change occurs in the Branhholm-Warrentina area.

SITE NOTES

Lyndhurst

The most detailed information, free of the interference of magnetic cover rocks, is available for the Lyndhurst area. The nature of the magnetic field can be seen in Figure 4 (and Maps 1, 2).

Gross trends in the region have been shown in Figure 8. This compilation does not suggest any consistent correlation between mineralised sites and mapped features although it is possible that

ENE and N-S elements may be important. Only the two Southern Cross mines actually lie along any feature which can be identified in several presentations. All other sites are slightly scattered. A number of PASS points are also indicated and several of these can be correlated with some of the magnetically-determined trends (Fig 10).

This more detailed view suggests that ENE and ESE trends are important and perhaps dominant but that several NW and NE features are present and these actually truncate portions of the aureole and granite contacts.

The trend patterns contain two facing triangular zones (shaded in Figure 10) across the central N-S structure which is clearly an anomalous feature. No deposit is known outside these features and their sinistral restoration (observed dextral movement implied) would make a small rectangular area about 2 km by 2 km. The restored position would coincide with a regional gravity feature trending ENE.

Assuming that this N-S displacement is relevant then at least three other interesting nodes are present; one at each end of the structure and at least one within it. These have been labelled A-D.

Other sites may be related to lesser N-S features, which also trend slightly east of north (Map 2), but many groups express a curl which is consistent with experience in other areas such as Alberton or Lefroy and which suggests that the fracture dilation options filled by the veins are asymptotic to other elements and deeper strains. At Lyndhurst these sense might be to the ENE.

It may also be noted, sand cover effects notwithstanding, that all sites are associated with elevated total counts and disruptions of ESE or ENE patterns. It is unclear how much note should be taken of these correlations; for example are the wind blows, erosion and exposure patterns related to other structures?

The aspect map (Map 5) provides the clearest view of patterns in the area.

Forester

The small group of mineralised sites near Forester lie at the southern end of what may be termed the Lyndhurst belt. The geophysical character of the region between the marked change in character just south of the old mines, and Waterhouse is very similar; simply free of any marked N-S structures. Other trends are variably recorded but the area is far simpler, structurally, than the Lyndhurst end, or the region to the south (but inverted in sense).

Figure 8 shows, however, that the southern part of the Lyndhurst-Forester zone contains some N-S elements and is slightly more structured than the central zone. The known mineralisation can be associated with N-S and NNW-trending structures within a triangular segment west of the granite exposures. Seen in this way these sites are very similar in location and structural style to the northern

sites at Lyndhurst.

Fine grain in the AGC and aspect presentations define the trend changes and pattern groupings and also suggest that trend offsets and the mineralisation may be associated with ESE trend intersections. At Lyndhurst the correlation appears to be with ENE intersections (magnetic data) consistent with an inverted variation (Maps 2,4, 5).

The aureole and granite boundaries are clearly defined by several presentations between 5455 and 5464 000 mN. These are the only features with a predominantly NNW sense (e.g. Map 2).

There is no NNW-trending link, or structure, or any suggestion of one, between any of the Forester or Lyndhurst mineralised zones (see Maps 2, 5).

All sites are associated with elevated total counts and a major E-W disruption of a N-S trend. This association must be real; it is free of the Lyndhurst or Gladstone problems. The sites of the group may also be linked by a NE regional trend (gravity - Fig 8) and the entire set appear to lie at an ESE/NE/ENE node.

Warrentina and Connors Hill

Generally isolated sites near Warrentina, Connors Hill and Pearly Brook can not be positively correlated with any particular features. Magnetic character in this area is best exposed by aspect, residual and AGC presentation (Maps 2, 4, 5).

The Connors Hill site and some others to the east are associated with a near N-S structure and its intersection with an ESE element while those at Warrentina are offset from a sub N-S structure but lie at the intersection of ESE and NE-trending structures. Other definitive associations are not evident (Figure 8). Some more regional ENE features are indicated.

The entire region south of Forester, and around Mt Horror, is shown to be structurally complex; the eastern Mt Horror portion is dominated by NE-trending features. The area has a magnetic character quite unlike that revealed north of Forester and the irregular magnetic anomaly which trends crudely NE south of Forester marks the change in structural patterns. This is best seen in AGC form (Map 4). No consistent patterns or trends can be traced across the region south of Forester. Very few elements are clearly displayed in several presentations.

The isolated Pearly Brook sites lies at the edge of the survey area on one ENE projection of the zonal boundary feature which crosses the belt. Figure 8 shows that there is also a gravity conjunction (555 500 mE, 5453 000 mN) and radiometric values are elevated. No other isolated sites possess this gravity correlation.

Branxholm

The north Branxholm region is distinctive (Figure 8). Although there is a gross ENE orientation to any array of components few have any continuity. South of this belt of features many features trend SE or

SSE and there are few ESE and fewer ENE trends. North of this axis there are no ENE elements but several ESE structures. This view is supported by all processing options.

There is no obvious control for the group of mineralised sites north of Branxholm but all lie within the broad ENE axis and adjacent to many complex terminations from the south. The mineralisation is associated with the most complex part of this entire zone. The known prospects have a general alignment a little east of north. Although there is no single structure or magnetic element with this orientation there is a general trend of broken features, defined by several formats, which extends from about 5440 to 5453 000 mN and best seen in Maps 4 and 5. It could be argued that this general trend is actually N-S but composed of a series of offset segments which provide the slight easterly aspect overall. Such a structure, assuming that it exists, extends from a kink in the boundary effect east of Forester south through the most disturbed part of the Branxholm area into the valley west of Mt Paris.

The northern and southern limits of this local belt are defined by regional gravity elements which mostly tend ENE but one ESE structure is also present (see also Fig 9) and these suggest possible regional controls. The magnetic field features across the southern Whiskey Creek zone tend ENE while in the northern New Find area these tend ESE.

If this is a valid view of the structural patterns in the area then it may be possible to unify the Warrentina site with the Branxholm sites.

Mt Cameron area

No magnetic coverage exists in the Mt Cameron area and any appraisal of this area depends on the use of the available gravity data. It is discussed below after the better defined sites have been reviewed in light of the implications of the gravity data.

EXPLORATION RANKING

The magnetic data summarised in terms of source distributions and subtleties (as in Figures 8 or 10) indicate that the known mineralisation is associated with either complex structuring and/or gross N-S elements. Interplays of these structures with ESE or ENE features appear to be important.

The gravity data lack the resolving power of the magnetic data base but a number of gross features can be recognised or traced across this region. These are also indicated in Figures 8 and 9. If it is presumed that any features defined in the gravity data represent gross crustal elements, and therefore represent distinct source types at least an order of magnitude larger and deeper, then these offer a means to both explain and discriminate shallower source patterns.

It should also be noted that the gravity trends may only be defined within a general envelope which may range from +/- 500 to 1000 m of the nominated position depending upon the local station density.

Most of the gravity features which are distinct from granite boundary effects trend ENE, NE or ESE. These are regionally continuous.

Consider the location of each of these structures or their intersections.

1. The largest of these structures occurs north of Lyndhurst at Waterhouse. It is unclear how relevant this might be since the magnetic data in the region have a coarse character and the area is sand-covered.

2. The next pair of these structures intersect in the general region of the N-S structure at Lyndhurst about midway between the established workings; that is, the centre of the offset core zone (Figure 10)(about 5367 000 mN). The near surface orientations mirror these gross features.

3. Another intersection occurs near the N-S structure at about 5363 000 mN. This point is of interest since it marks a focal point and a fan of structures. Several ENE trends occur at this site as well.

4. A similar conjunction occurs at about 5360 000 mN.

All these sites are associated with the N-S offset and all mark terminations or changes in trend emphasis of other features. It is also possible that changes in features noted near 556 000 mE, 5460 000 mN may be related to trend group 4.

5. The next critical intersection occurs near the Forester sites. This is a major alignment and marked in aspect presentations (see Figure 9). Many changes in character are associated with this zone, including the NE bias to the major zone change. There is a gravity trend with this orientation. The disturbed trend patterns defined magnetically are associated with these major lineaments.

The deformed zone extending SE of Forester and culminating in the terminations at 562 000 mE, 5452 000 mN is associated with one of these lineaments (ESE).

6. Two intersections may be noted with the north Branhholm ENE axis and aspect change. One is near Whiskey Creek, the other about 3 km to the ENE. The gradient, AGC and aspect presentations can sustain this

view irrespective of the apparent complexity of the raw magnetic field data which are dominated by the effects of Tertiary basalts. The effect of these complex and patchy sources can be distinguished and largely, if not completely, ignored.

Lesser sites (apparently) such as Pearly Brook mark the only other gravity conjunctions recognised and this example is actually a second intersection against a single ESE element (Fig 8). Changes in orientation of geophysical and geological features also occur nearby and along the inferred trend axes. These would plot as PASS points and essentially confirm the existence of a significant underlying source of structural distortion in this area.

There are no other gravity-based lineament intersections along the Branxholm-Lyndhurst axis.

The only other feature of note may be the sinuous gravity aspect change which extends from Pyengana, through Branxholm and on to South Mt Cameron (Figure 9, Maps 7, 8). If this is superimposed on the magnetic trends of Figure 8 the many changes in character which arc around the Branxholm and Warrentina area may be linked. All mineralised sites are then linked also.

The coupling of crustal indicators (gravity) and surface local controls (magnetic) suggests that the known mineralisation is far from randomly located. Major changes in structural grain or trends are, similarly, not random. All mineralisation lies within about 1 to 1.5 km of the defined sites. This agreement and focus represents the effective resolving power of the present gravity data set.

Applying these principles to the few other defined sites we may predict that there may be only five or six other nodes of equivalent status and stress factors - as reflected in the terminations and deformation. These might be mineralised, or altered, although most of the areas must have been subject to prospecting search and prospectors have not been known to miss much - unless the resource is bound in a low grade alteration volume and any recoveries could not be traced to a vein system. No records exist which might suggest how many observations of this type were made last century since the "mother lode" was always the goal. Could a different style of lode reside near some of these crustal nodes?

What weighting should be placed on these elements?

The general location of the mineralised sites can be defined and explained. Several equivalent and apparently unmineralised sites can also be recognised.

Any conjunction of structures which is based only on magnetic or radiometric data is not considered significant unless a regional gravity feature can be associated with them. This is the discriminant factor.

The aspect version of the gravity map suggests a more limited version in which only the Waterhouse, Forester and Warrentina-Branxholm conjunctions are significant. The only difficulty with this thesis, as an additional discriminant, is that it excludes the Lyndhurst

province. Why should this be? Is the thesis inadequate, or is this province economically insignificant?

An additional problem is suggested by Figure 9. The Ansons Bay to South Mt Cameron segment of the central aspect lineament which trends ESE could be projected on to Lyndhurst. Was it continuous prior to intrusion of the batholith? Even so its ranking and weight is less than other comparable trend elements.

I conclude on the basis of this review and ranking that the most important and critical sites lie close to Branxholm.

The next ranking would apply to the Forester site.

Lyndhurst is a lesser region.

All other sites must be given a lower rating.

The PASS technique of anomalous sites supports this view. All available suggestions occur on the lineaments through Waterhouse, Forester and Branxholm.

It is now possible to project some rankings into the Mt Cameron area. Although there are no records of gold production and no magnetic coverage the gravity data would indicate that two major conjunctions occur in this region. These are indicated in Figure 9. These lie on the only PASS lineament in the area. No detailed location can be offered for these sites given the limited resolution of the current gravity data in that area.

The analysis further suggests that there is no NNW control on the mineralisation or structure. The "Great or Main Slide" would appear to be a fiction in this area, as I have argued it must be further south. No late stage dominant shear, kink or thrust zone of this orientation is reflected in any data set, or in the PASS points. There is no evidence for any significant displacement within the belt of Mathinna Beds.

The gravity aspect map covering the entire island (Map 8) suggests the real economic relativities of some of these features. The wrinkles in aspect can be seen to curl ENE/ESE across the state.

Consider the edges of the main W Tasmania defect; Rosebery-Renison and Zeehan lie on one edge and Queenstown-Mt Lyell on the other. This association is not obvious in the raw residuals and cannot be chance. The narrow kink to the north lies at the northing of Que/Hellyer!

If this approach and pattern recognition is carried into E Tasmania then marked features are associated with Mangana, Alberton and north Branxholm with a lesser feature at Mathinna. The Branxholm feature can be projected west across the Tamar at Beaconsfield (!) to Moina. This feature has two faces, one near Whiskey Creek, the other near Forester. A third feature, relevant to these ELs, extends from Waterhouse to Gladstone and might mean that the most interesting sites in the north of the area are under sand north of Lyndhurst, and in the Mt Cameron area. The proportions seen island-wide are consistent with ranking judgments based on the local data given above.

RECOMMENDATIONS

Some recommendations for further work may be suggested on the basis of this treatment of the data and the inferences drawn from it. The conclusions are necessarily subjective and built upon evolving concepts as to what might be relevant.

Each of the nodal areas central to the three principal mineralised areas should be evaluated geochemically and structurally. Geophysically they could be ranked; Branxholm fading to Warrentina, Forester, Lyndhurst north. In each case there should be a focus about a N-S kernel structure.

Other foci south of Lyndhurst, north of Forester, SE of Forester or ENE of Branxholm may be considered of lower priority but should be reviewed. The two site options in the Mt Cameron licence area should be reviewed with the same procedures and given the same status.

Ground evaluation of these relatively small areas should take three forms;

- geological and structural mapping to identify kink and alteration zones with the orientations implied in the magnetic data.
- geochemical sampling based primarily on gold, rather than tracers like arsenic alone.
- ground magnetics with lines no more than 50 m apart and sample spacing no more than 1 m. Depending upon staff and equipment available it may well be that the techniques used by the Geophysical Research Unit of the University of New England may prove most cost effective and supply some data redundancy.

The first of these must be undertaken, preferably first.

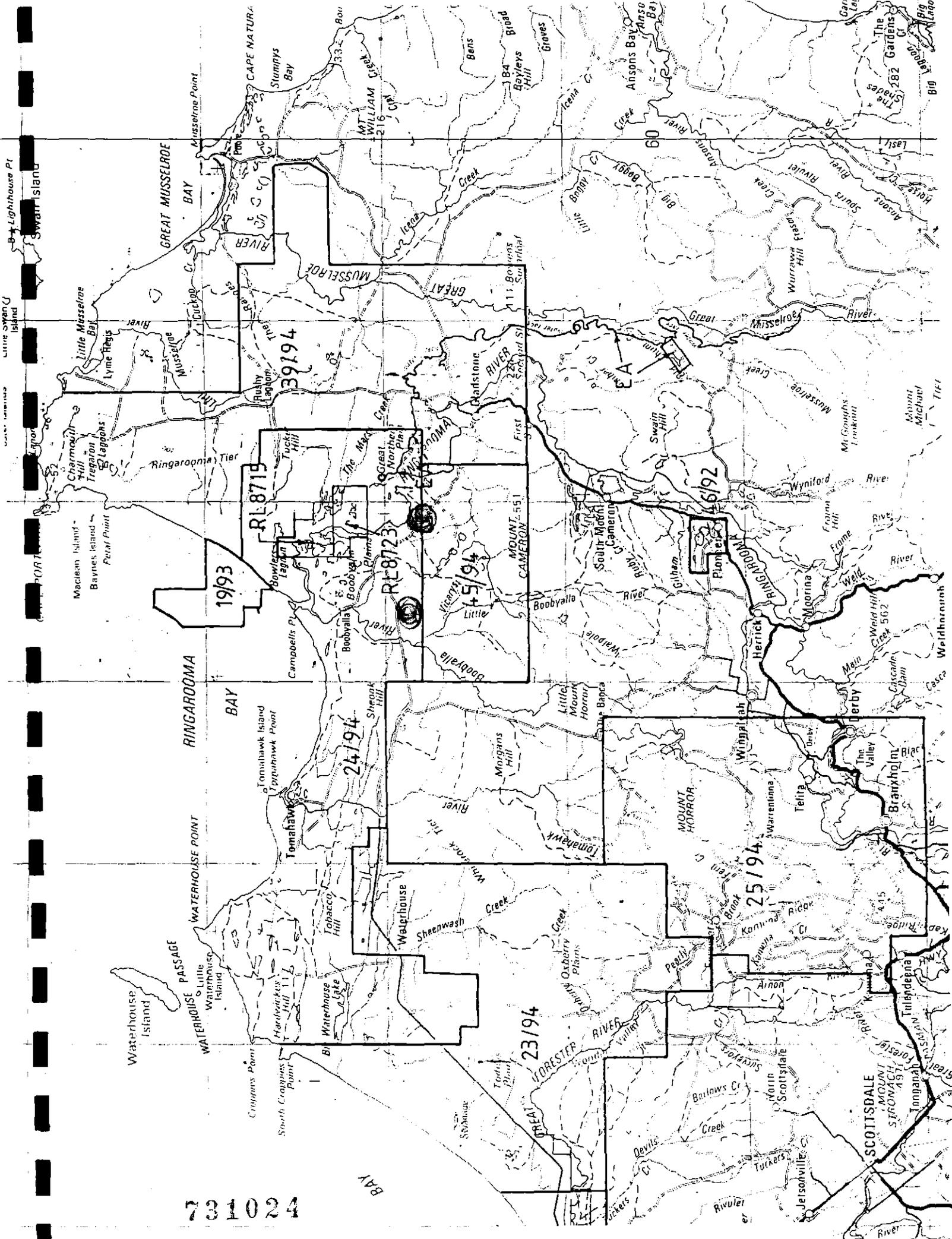
Areas sampled or surveyed may need to be rated in light of both the regional aspects or the implications from exposure.

Should the magnetic option be used as a filter and guide then areas of about 2 km by 2 km should be covered about the nominal node positions in order to cover the target areas and allow for the resolution limits in some data sets. This option could define altered, anomalous and mineralised ground if the Alberton experience represents general response conditions.

A much less practical path might be to use radiometric ground methods since there does appear to be some correlation between known sites and total count response. Given the uncertainties and potential cover problems the magnetic method is much to be preferred.

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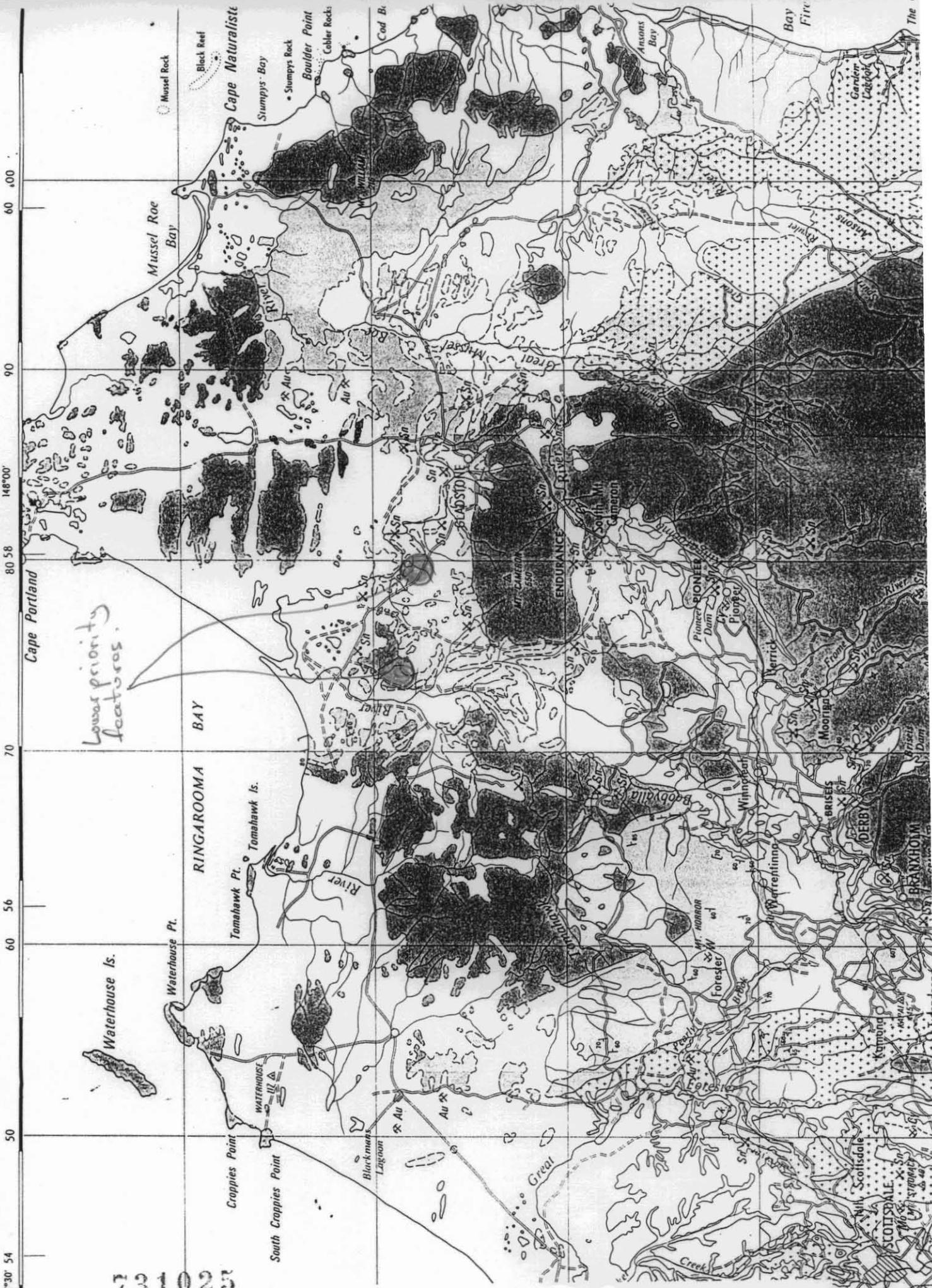
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LOCATION OF LICENCE AREAS NORTH EAST TASMANIA
HERALD RESOURCES

FIGURE 1



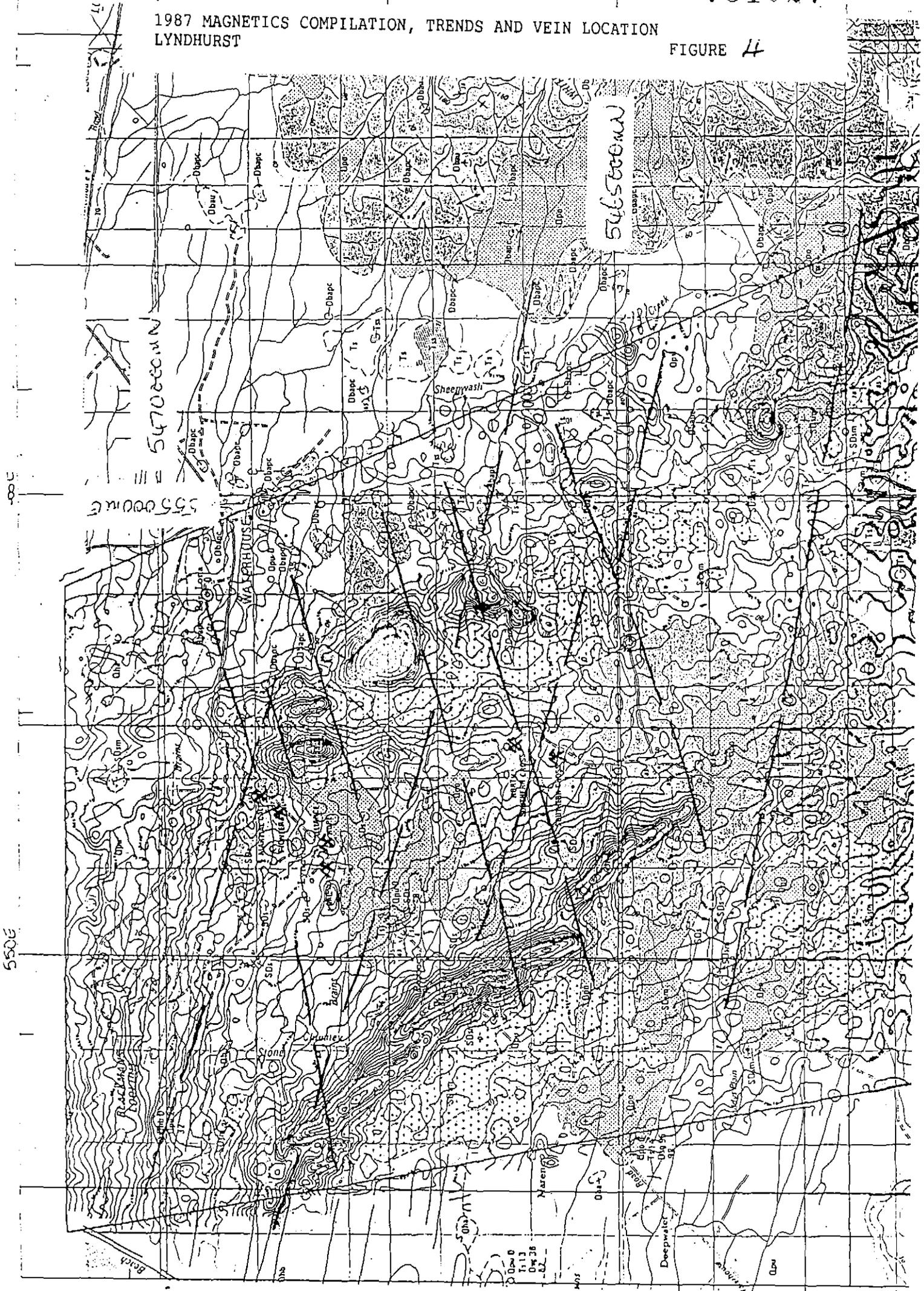
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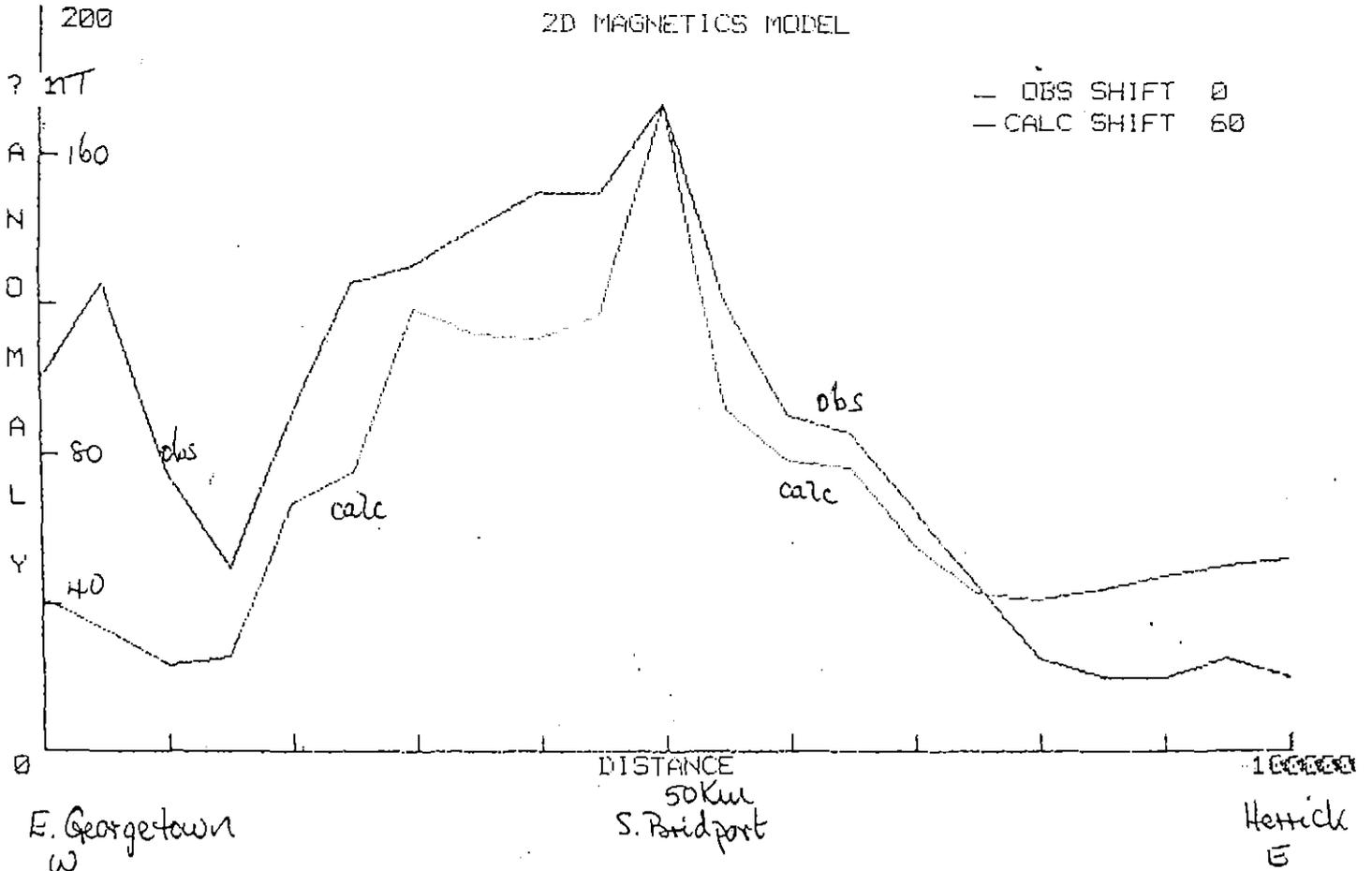
GEOLOGY OF NORTH EAST TASMANIA
 MINERAL RESOURCE TASMANIA MAPPING
 (dark areas, granite; crosses, granodiorite)

FIGURE 2

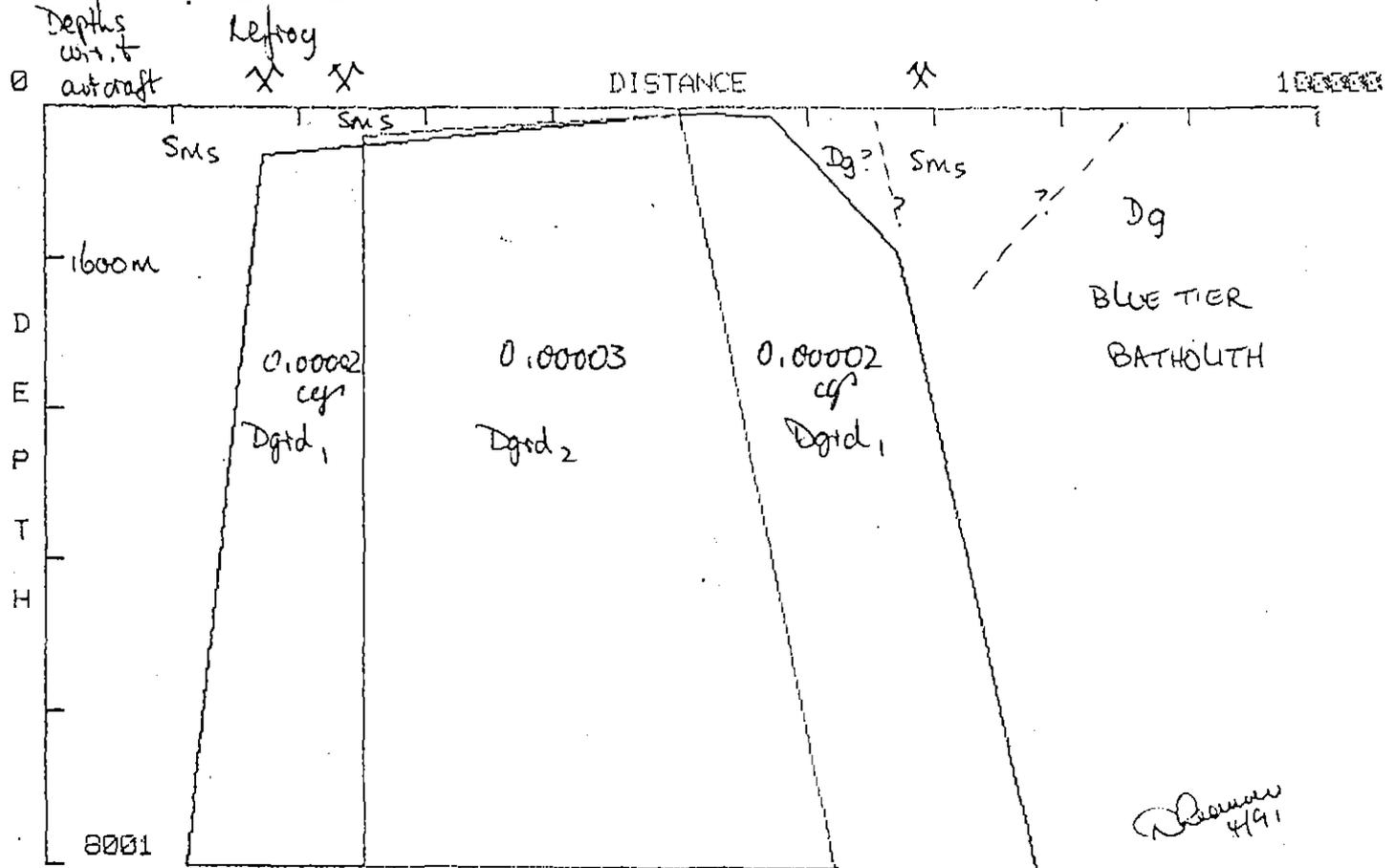
1987 MAGNETICS COMPILATION, TRENDS AND VEIN LOCATION
LYNDHURST

FIGURE 4





LYNDHURST M7 REGIONAL SOURCES



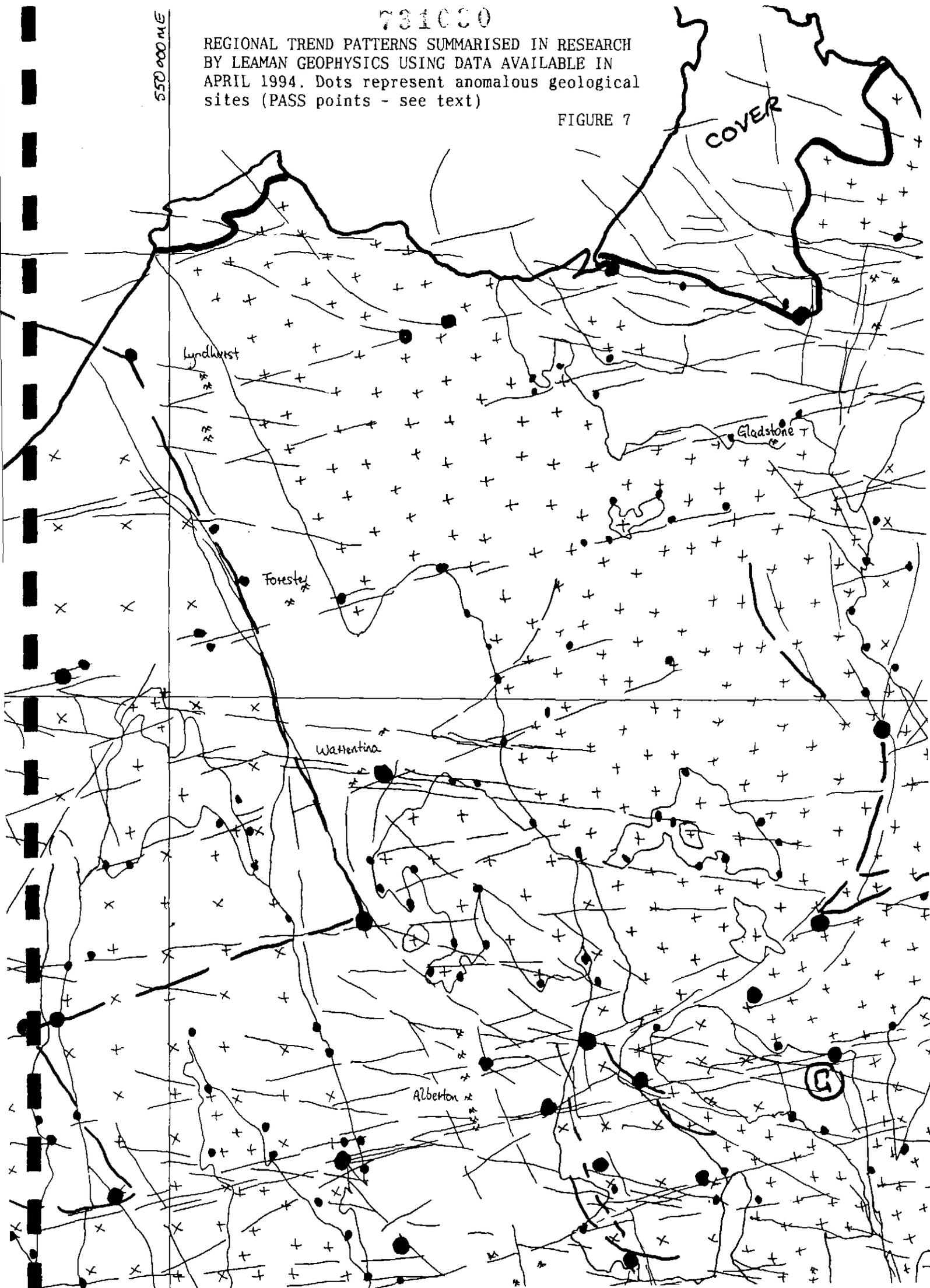
MAGNETIC INTERPRETATION LYNDHURST AREA - LINE M7
REGIONAL PROFILE: GEORGETOWN TO HERRICK

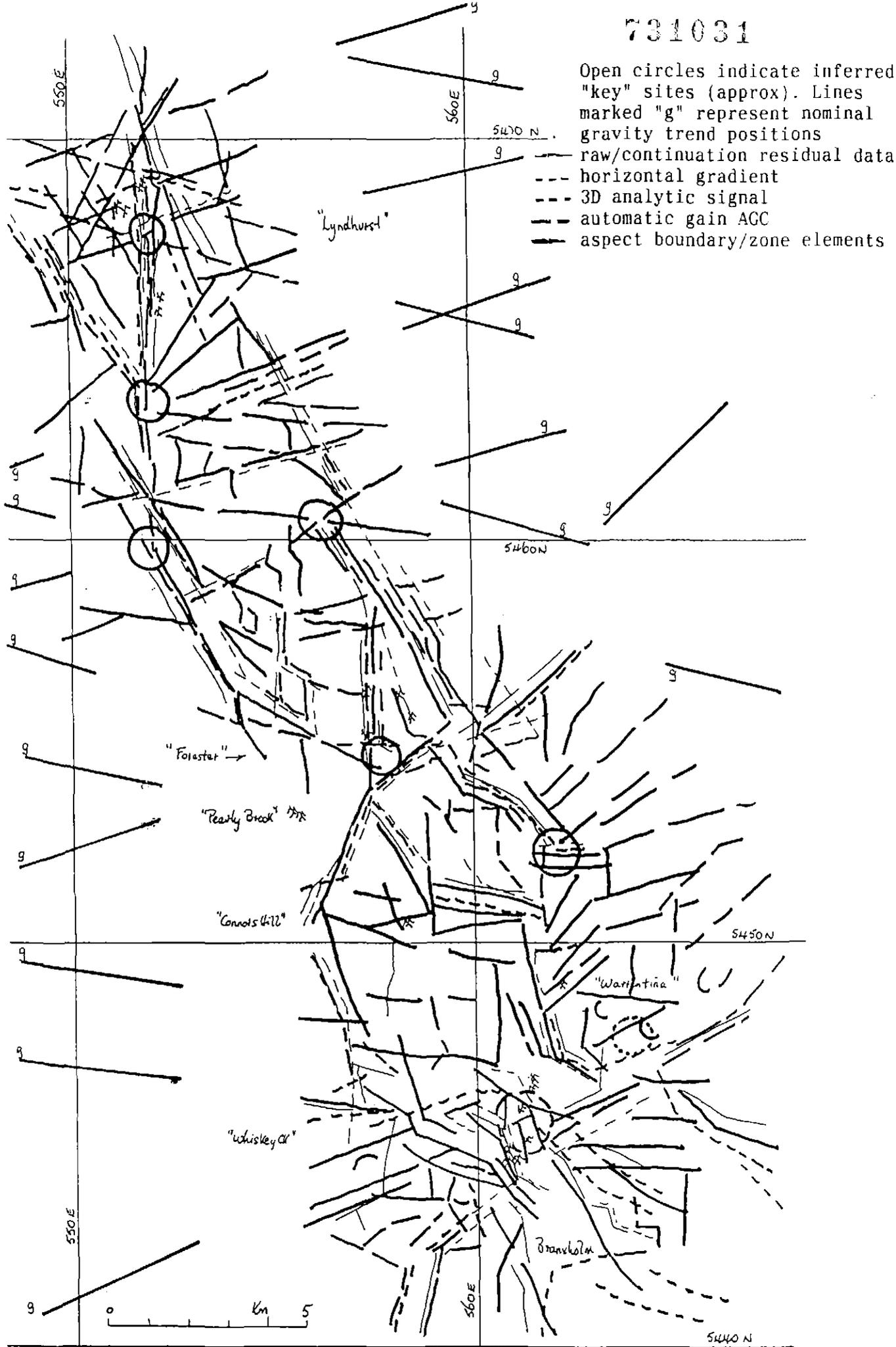
FIGURE 6

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REGIONAL TREND PATTERNS SUMMARISED IN RESEARCH
BY LEAMAN GEOPHYSICS USING DATA AVAILABLE IN
APRIL 1994. Dots represent anomalous geological
sites (PASS points - see text)

FIGURE 7





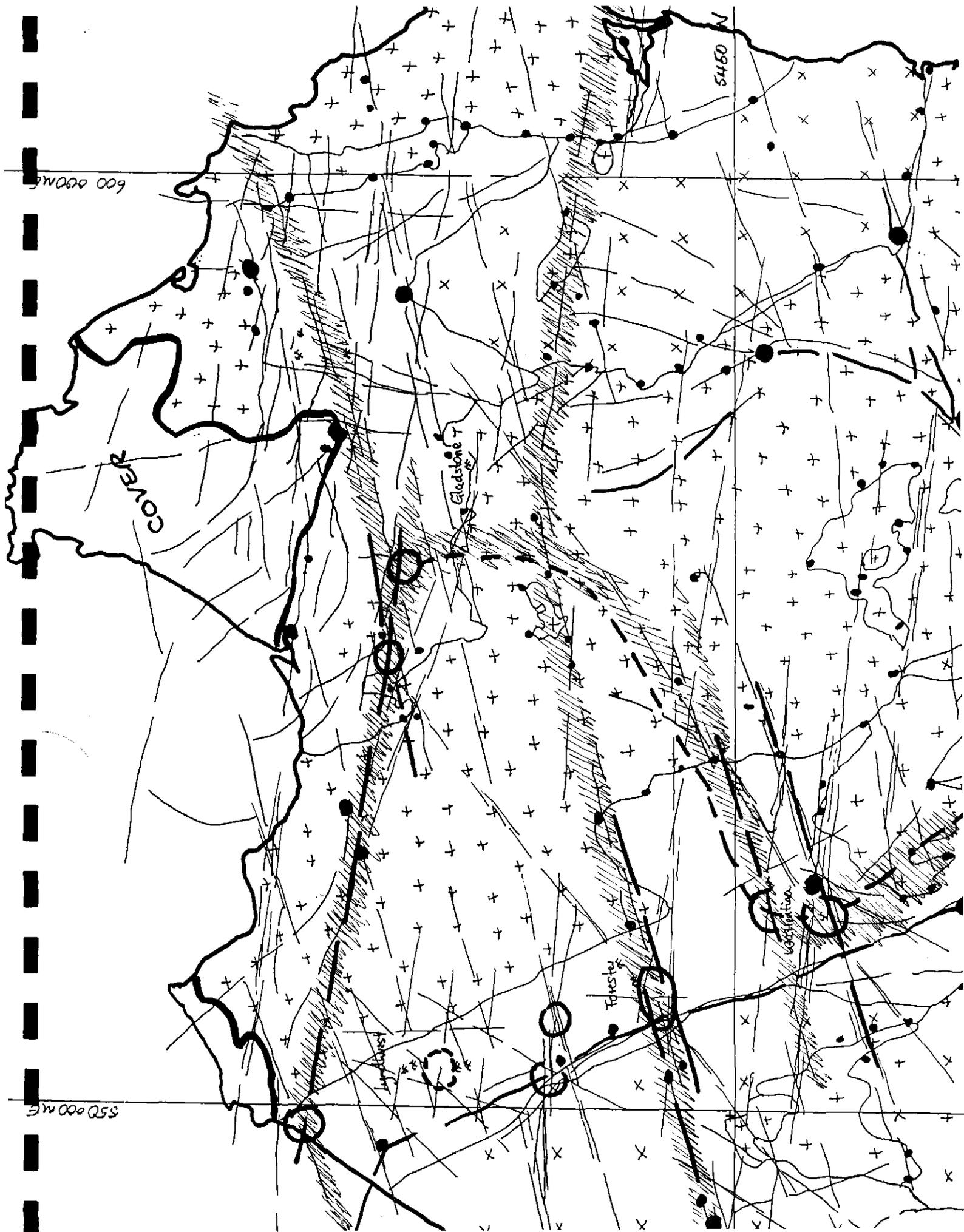
TREND AND STRUCTURE INTERPRETATION OF THE LYNDHURST-BRANHOLM REGION
NORTH EAST TASMANIA
Based on magnetic data and processing variations

REVISED REGIONAL TREND PATTERNS BASED ON PREVIOUS WORK AND THE NEW GRAVITY DATA PRESENTATIONS USED IN THIS REVIEW

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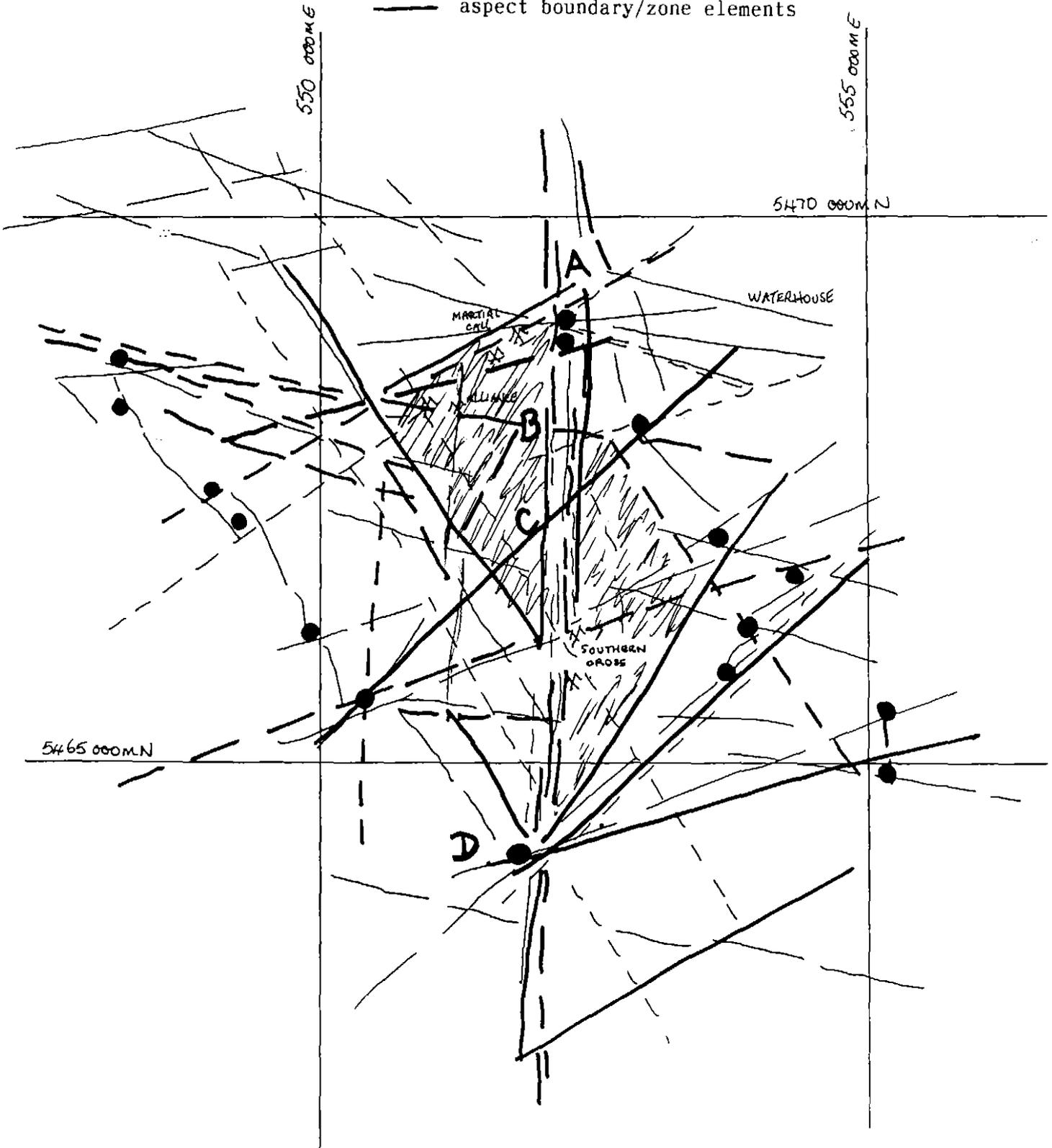
Hatched zones represent warps in 'aspect'. Open circles indicate important junction zones.

FIGURE 9



Open circles indicate inferred "key" sites (approx). Lines marked "g" represent nominal gravity trend positions

- raw/continuation residual data
- - - horizontal gradient
- - - 3D analytic signal
- - - automatic gain AGC
- aspect boundary/zone elements



SUMMARY OF DETAILED ANALYSIS IN LYNDHURST REGION
 Most inferences based on magnetic data.
 Inferred critical sites are labelled;
 closed circles indicate anomalous geological
 locations (PASS points - see text).

FIGURE 10

APPENDIX ONE

GOLD EXPLORATION AND THE USE OF MAGNETIC METHODS IN NORTHEAST
TASMANIA
(from Bull. geol. Surv. Tasm., 70, 149-160; 1992)

Gold exploration and the use of magnetic methods in northeast Tasmania

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ABSTRACT

A review of the physical characteristics of and available data about major gold deposits in northeastern Tasmania suggests that these deposits can be linked to particular granitoid compositions and regional and local trend patterns. Rather subdued ENE elements appear to be crucial, and large deposits occur where regional and local trends of this type are superimposed. The actual details of a mineralised site are governed by local conditions including lithology changes or fold conditions but these are not diagnostic.

Magnetic surveys, in the form of regional and specific area surveys, seem the simplest way of locating target sites in terms of these concepts and conditions, and the use of magnetic data has been critical to definition of the common characters listed. Ground surveys can limit exploration to specific prospects once the target zones are established. These methods, with support from semi-regional gravity surveys, can provide comprehensive structural, genetic and target evaluation, and achieve site discrimination in terms of potentially economic deposits.

The review study indicates that "Golden Gate"-style mineralisation may be recognisable but subtle, and that only some of the plethora of small workings possess similar characteristics. If this is indeed indicative of worthwhile prospectivity then the same techniques could be applied to blind target possibilities.

INTRODUCTION

Much gold has been recovered from many small to large workings in northeast Tasmania. Most occurrences were irregular and often thin vein systems variable in size, continuity, orientation and grade. Many occurred in a single NNW-trending zone about 500 m wide extending from near Mangana to the coast at Lyndhurst. The presence of so many sites along a single axis does not mean, however, that vein systems within or along the axis are controlled by the regional orientation; they appear to be virtually randomly oriented within it. Previous workers have assumed the regional orientation, or structure, to be ascendant but consideration of the spread of occurrences, including the significant Lisle, Lefroy and Beaconsfield workings, suggests that more than one element has controlled mineralisation. The NNW trend may be recognised widely, but never appears specific to mineralised sites.

No consistent geological or geophysical patterns have ever been recorded for Tasmania's gold deposits. Most exploration over the past century has been based on the pan or the trench, or inspection, where possible, of previous workings. The lack of obvious criteria or controls and a monotonous, repetitive host geology of Mathinna Beds has deterred science-based exploration. The rocks, and their complex deformed structures, are not easily understood. The presence of important mineralisation in this environment is simply frustrating.

Geochemical and geophysical methods are recent innovations in exploration programs. The apparent association of gold with sulphides or arsenic has encouraged many trials, but no characteristic responses have yet been proven. Anomalies also tend to be diffuse. There is also no

necessary basis to the assumption that arsenic is a gold indicator. Reid (1925) observed that while there is a correlation between gold content and arsenic there is a cut off, and high arsenic/arsenopyrite levels are usually lacking in gold.

Geophysics has been applied even more sparingly. This reflects the assumption that no useful physical contrasts exist in the relevant materials. Quartz is notoriously difficult to identify and the Mathinna Beds host rocks have also been considered homogeneous. These assumptions have long been known to be invalid but the province has never attracted the innovation required to apply workable exploration technologies. Leaman (1974), in the pioneering geophysical research on these rocks at Lefroy, showed that self potential, thermal and piezoelectric methods can define the quartz systems (but not say whether they are mineralised) and that magnetic methods yielded some curious results only recently explained. Most of these methods are not in the "in general use" category and have not been taken up.

Genetic relationships have also been a long-standing puzzle. Workers such as Klominsky and Groves (1970) have recognised the affinity of the gold with biotite hornblende granodiorite and implied a direct genetic relationship. While this association seems reasonable in some localities it has always been generally rejected, as the important Mathinna, Mangana, Lefroy and Beaconsfield sites appear far removed from granitoids of any type. This is another fallacy. Workers since 1973 have ignored the findings of Leaman *et al.* (1973) who suggested that granodiorite is less than 1.5 km beneath the mineralisation at Lefroy.

Regional mappers in northeast Tasmania have attempted detailed subdivision of the granite and adamellite families of the two major batholiths (Scottsdale and Blue Tier) but have

placed all granodiorites into a single class. Textural and magnetic property differences suggest that this should not be done (Leaman, 1992a). It should not, therefore, be accepted either that granodiorites are not associated with gold because they are nowhere to be seen or because there seems no reliable relationship with them. The latter condition ignores the possibility of a single family member forming the key source and control upon mineralisation.

Vein orientations and local structures in the Mathinna Beds hosts have also be found to be variable where recorded. Local controls appear dominant, even where major regional control would be expected — as along the Mathinna to Albrton zone. Vein patterns do not appear to be systematic or significant. These problems are compounded by poor outcrop generally, deep weathering in some units, and a complex, several-generation vein suite.

Grades and vein extent also remain a crucial problem for any evaluation. A very few mines have provided significant production; most workings have been marginal or limited in development. This usually reflects variation in grade with depth, but may indicate under capitalisation, which was endemic when the region was in full production. Major reductions in grade, often of an order of magnitude, have been noted near the level of regional weathering or water tables. Only some sites maintain grade levels to significant depths (>50 m) and it is these rare sites, such as the Golden Gate at Mathinna or the Tasmania at Beaconsfield, which have produced large quantities of gold. It is clear therefore that some form of discriminator must be found which can separate the golden eggs from the chaff, as all may look the same near the surface. Presuming they outcrop of course...

EXPLORATION NEEDS

A principal aim of any exploration is to assess and define the identifying characteristics of such important sites and determine their presence elsewhere. This approach then allows ranking or discrimination of the many known small workings or new target prospects. In this respect the Mathinna area, and the Golden Gate Mine with its production of 7895 kg, must be used as the prototypical yardstick until a greater understanding is achieved for the entire province. It represents a large vein system in typical host materials. Alluvial deposits, such as Lisle, are excluded from this discussion.

Some indication of the current understanding and knowledge about this important, and once highly productive, gold province can be obtained by considering the magnitude of published descriptions. The topic has rated a half page or less than two pages respectively in the 1962 and 1989 editions of the 'Geology of Tasmania'.

Let us consider what an explorer may need to know or what may be essential to site definition.

Systematic exploration is usually based on some conception of general or genetic setting. In this case an ability to define host structures or units (basic detailed mapping not possible from outcrops) as well as vein location and orientations, coupled with the facility to discriminate mineralised from unmineralised terrain, is required.

Any method able to achieve target focus or discrimination in the apparently bland, poorly exposed, vein-rich terrain of the Mathinna Beds would be rightly considered a sound right

arm. If it was applicable at all scales and low cost as well; perhaps a saviour...

Such a method exists.

Magnetic methods are able to provide information in respect of all regional-to-focus requirements. Leaman (1992a) has recorded a twenty year research and specification history, initially considering common as well as exotic geophysical methods with structural bias, to support this claim. This paper considers only examples and conclusions based on that research.

A more fundamental issue relates to the worthiness of the region in the first place. The region has been a producer of some note but does it have the potential to be a great producer? Leaman (1992b) shows that the basic setting of northeast Tasmania is comparable with other very rich provinces, and that the gold was possibly derived from large Cambrian ultramafic bodies during the Devonian uplift-intrusion cycle. This under-rated region is worth some effort.

DISCUSSION

Mineralised sites at Mathinna, Mangana, Dans Rivulet, Golden Ridge, Albrton, Mt Horror, Warrentinna, Lyndhurst, Gladstone, Burns Creek, Lisle, Golconda, Lefroy, Back Creek, The Glen, Beaconsfield and Little Den (fig. 1) have been assessed for regional context and common denominators.

Few of these sites are well served by any type of data set. Only a few have been covered by any aerial magnetic data and fewer by adequate ground survey. Most are covered by a regional gravity survey but the station density is uneven and generally coarse.

The figures provide an indication of the best data available and of some of the conclusions which may be drawn.

Figures 2 and 8 illustrate how high quality aeromagnetic surveys can define formation scale, continuity and lithological variations, as well as structural offsets, within the almost non-magnetic Mathinna Beds. This is prized information given the difficulties of mapping these rocks. See Leaman (1987b, 1990, 1992a) and Richardson (1992) for some indication of the specification required.

Figure 3 provides an example of an older survey using poorer specifications. It is still most informative and draws attention to the primary variations in the units of the Lisle region. Structure can be mapped across at least part of the area and it is not wholly consistent with published regional mapping. Many other elements are exposed by such surveys. Several of the surveys cover blocks of granodiorite, and demonstrate that these intrusive rocks present a range of properties and relationships. Some are strongly magnetic. See also Leaman (1992a).

These examples prove that the magnetic method can define most of the structural and stratigraphic elements of northeast Tasmania.

Figures 6 and 7 illustrate the nature of magnetic responses due to the presence of granodiorite and the type of inferences which may be drawn. Figure 6 shows that granodiorite lies both east and west of Mathinna — as well as beneath it. This crude model does not discriminate compositions or true

thicknesses. Figure 7 suggests that several granodiorite members are present in the Lisle-Golconda area but that only one is associated with the known gold deposits. The properties of this intrusive are almost identical with those inferred in the vicinity of Golden Ridge, Mathinna, Lyndhurst and Gladstone. This correlation, wherever data is available, seems more than coincidence.

Gravity data, or nearby exposure, at other sites indicates that granodiorites are a genetic element in these gold deposits, including Beaconsfield. These intrusives are now remnants of the original plutons because of diapiric intrusion and dilation by later granite-adamellites. The critical composition, marked by its physical properties, appears to be the first intruded on the basis of rock relationships. Any genetic relationship may be in terms of fluid generation, transfer and fracture control, rather than any compositional control.

Thus magnetic methods may have assisted (with gravity methods) creation of a genetic model. Regional exploration may need to consider the location of particular members of the granodiorite family.

Figures 4 and 5 provide examples of the use of medium resolution ground surveys to trace vein system orientation (Gladstone) or define anomalous, possible altered or mineralised, zones (Tower Hill). Veins produce spikes due to oxidation and alteration in the wall rock. Each vein produces a double spike which is usually integrated as a single feature. Background variations with spike responses appear to mark mineralised areas. Very high resolution ground surveys have shown that such areas are very limited and, where previously worked, very productive. Vein alteration trends in such zones always curl asymptotically to sub E-W trends, even though more obvious structures may trend NNE or NNW. This curl of trends would explain the common observation of E-W trends at many sites while veins in the surrounding hosts display scattered orientations. Primary stress controls at the time of emplacement seem to be reflected by these observations but many more sites need to be examined using very detailed surveys.

Figure 8 stresses the need for very high quality data if all the required information is to be recovered. The contour interval is 0.5 nT. The left plot provides a basic compilation of the data while the right plot draws attention to some very subtle ENE trends. Initial analysis (Leaman, 1990) overlooked these, including failure to view appropriately shaded sun images, and they were only recognised after consideration of common factors seen in other data and other sites.

Other factors reviewed included suggestions from gravity data, vein information and drainage patterns. The trend is apparently general at prime sites and must be sought. Its poor representation in this data set is due to a 3:1 line bias in favour of E-W lines even though the line spacing is about 100–150 metres. This line bias must be changed for future surveys.

The examples shown in Figures 2 and 8 demonstrate that magnetic data can also define structures of some subtlety but regional persistence. Mineralised sites (or zones) are positively discriminated.

SUMMATION

The observations noted in the above discussion may be condensed into five factors.

1. A granodiorite association is definite at many sites and can be inferred (within 1.5 km) at others (including perhaps Little Den and Beaconsfield). A genetic link is implied — if only in terms of heat engine, circulation and fracture association with primary plutons.
2. The key granodiorite lithology forms part of a primary intrusion, and possesses low density and susceptibility properties.
3. The quartz veins occupy fracture fills in the roof of this body, and the essential deformations predated or were contemporaneous with the intrusion. Subsequent venation and disruption reflect the disturbance associated with intrusion of the batholith series.
4. Mineralised sites are complex but mappable units and clear disruptions of the units are not necessary elements in the process controlling venation or mineralisation. While vein systems may be locally controlled by shallow features, the fundamental controls are exercised regionally or from depth. Thus a range of vein orientations is to be expected at mineralised sites. Particular sites may occur in fold limbs, axes or ductility differences in the host sequence. These are random elements.
5. Sites appear to occur at nodes along ENE or E-W trending features and intersections. Large deposits occur where local features of this trend are superimposed on regional elements. These are the non random elements.

Thus magnetic methods, although dismissed because "nothing is magnetic" and no adequate data were acquired until 1987, are able to provide critical targetting or discriminating focus in terms of all exploration needs at all scales.

All companies generating the data used here have never had, or taken, the opportunity to utilise it in the manner suggested because of financial collapse or withdrawal from tenements. It is time that the approach suggested here was properly tested on new targets.

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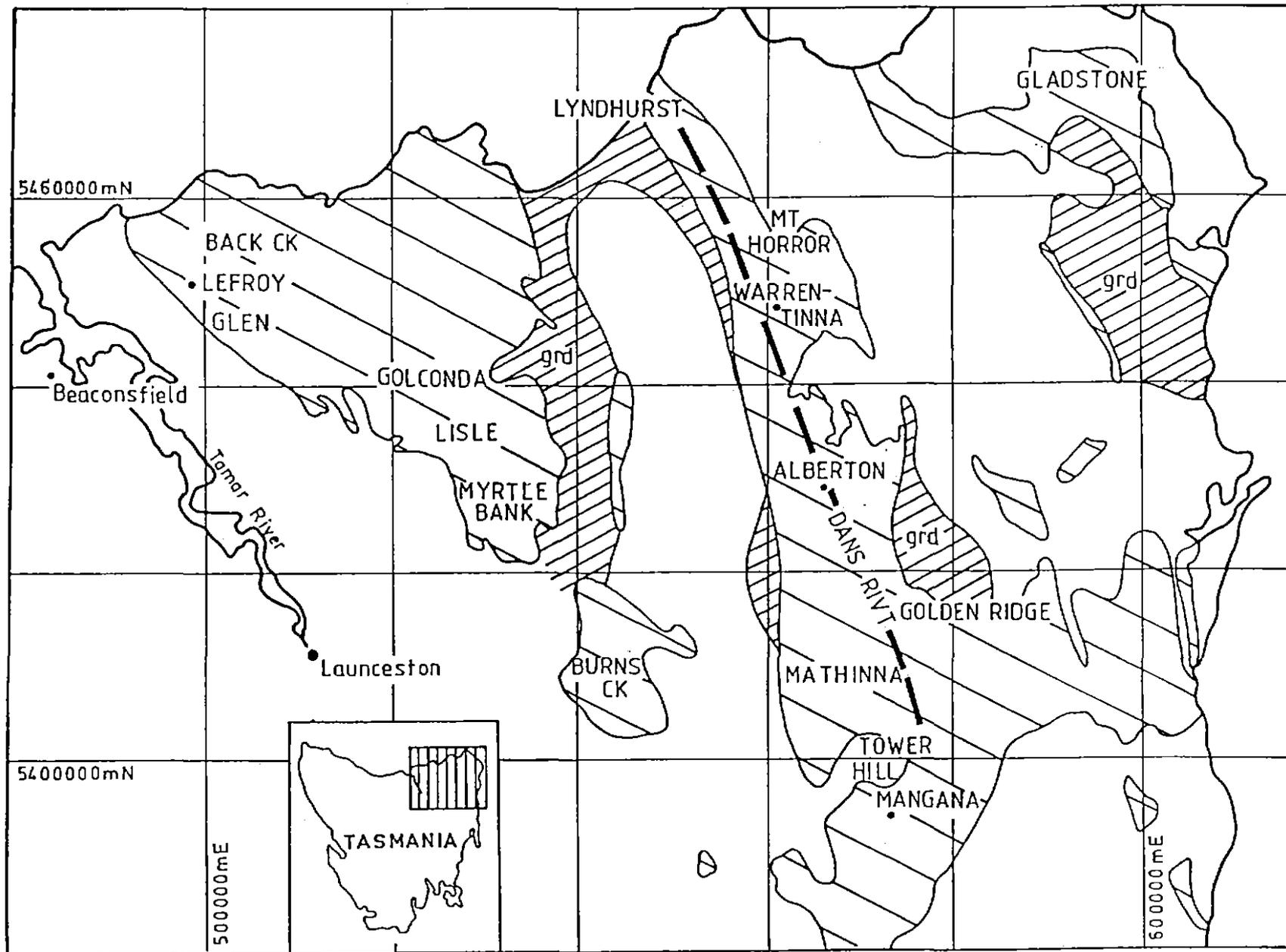


Figure 1. Locality map showing principal goldfields. Mathinna Beds are shown by open diagonal pattern and generic granodiorite in dense pattern.

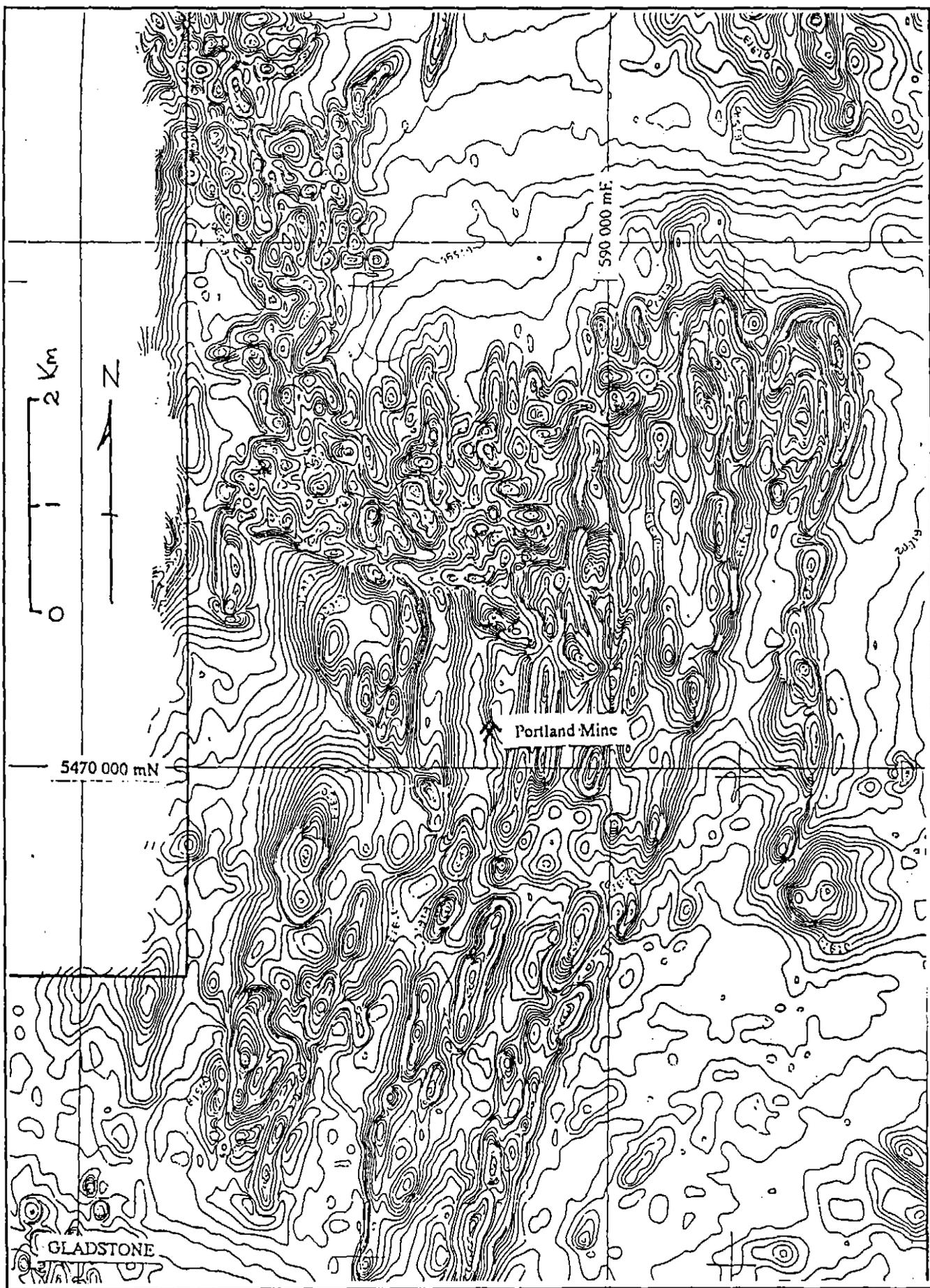


Figure 2

Part of the aeromagnetic intensity map of the Gladstone area (Leaman, 1987b). Note the texture within the block of Mathinna Beds about the mine. Very subtle and poorly defined sub E-W trends can be recognised in the data.

TASMANIA — AN ISLAND OF POTENTIAL

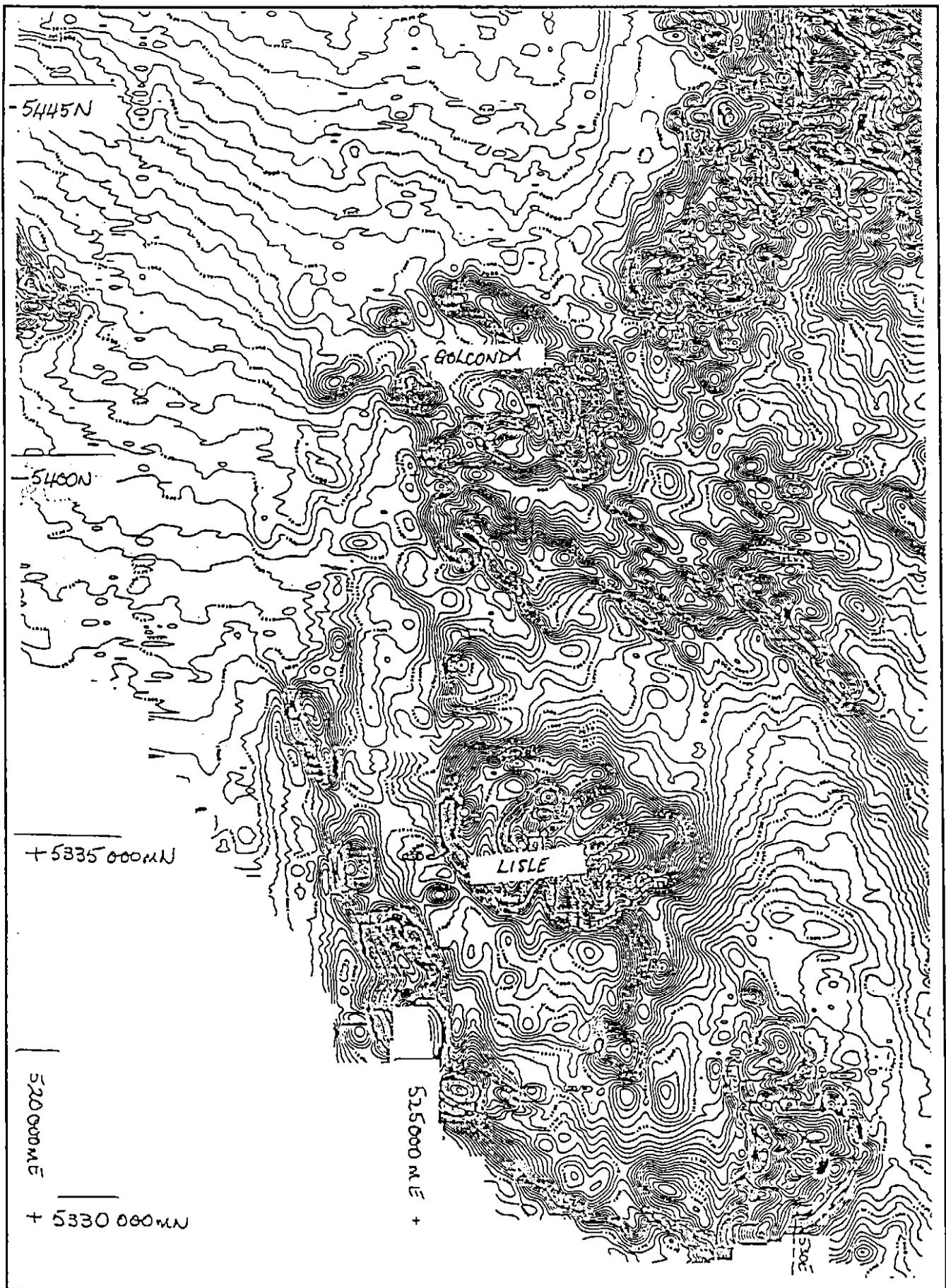


Figure 3

Most of an older aeromagnetic survey in the Lisle-Golconda area. Mathinna Beds responses and the effect of granodiorite and thermal haloes produces an array of patterns. An interpretation of this data is shown in Figure 7.

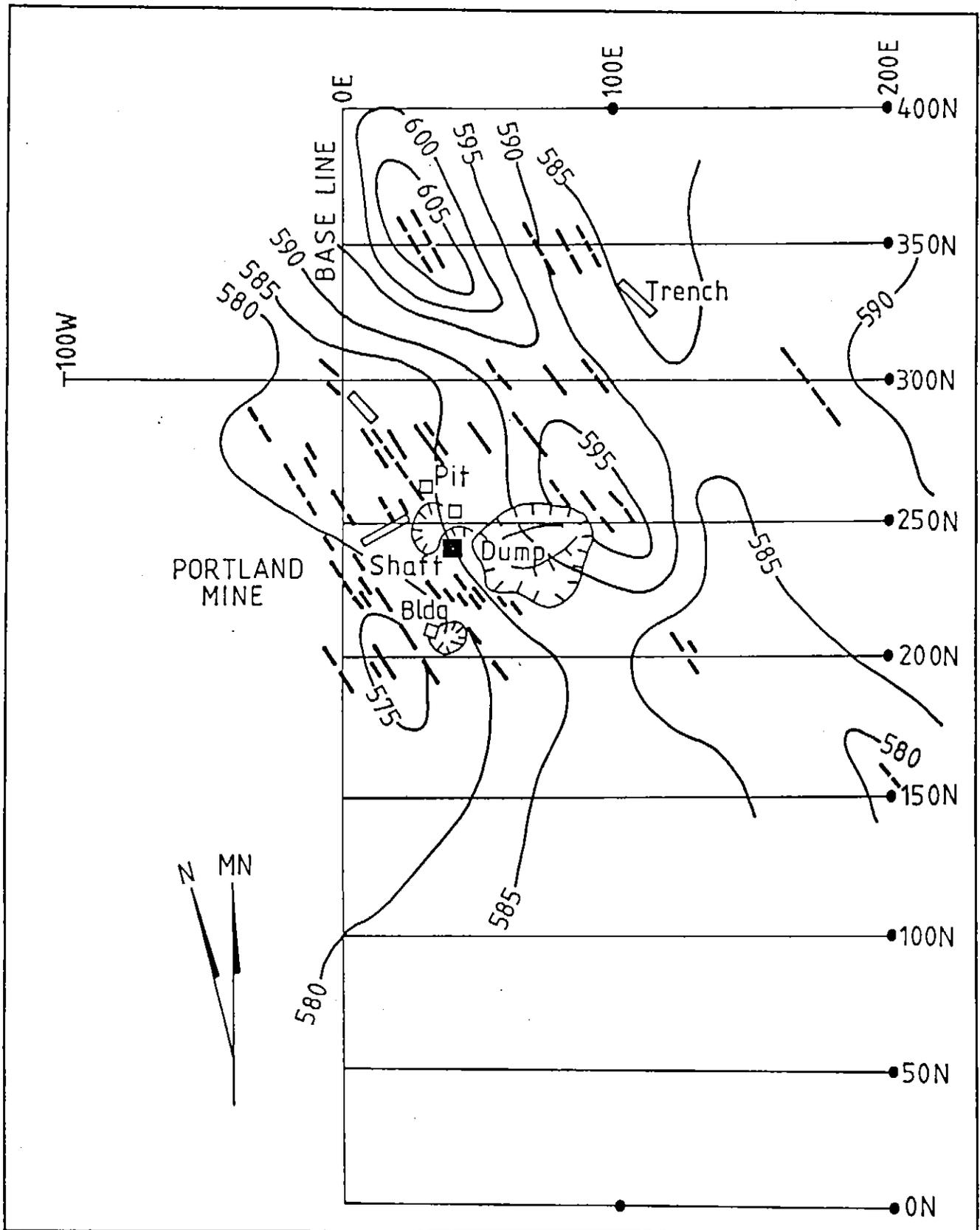


Figure 4

Plan showing veins mapped near the Portland Mine by ground magnetics (Leaman, 1987a). Although the veins are oriented NW, as described in reports during mining, all occur in or near a 200 m corridor oriented ENE as defined by the magnetic field more regionally. Gross lithological effects are also oriented NW-NNW.

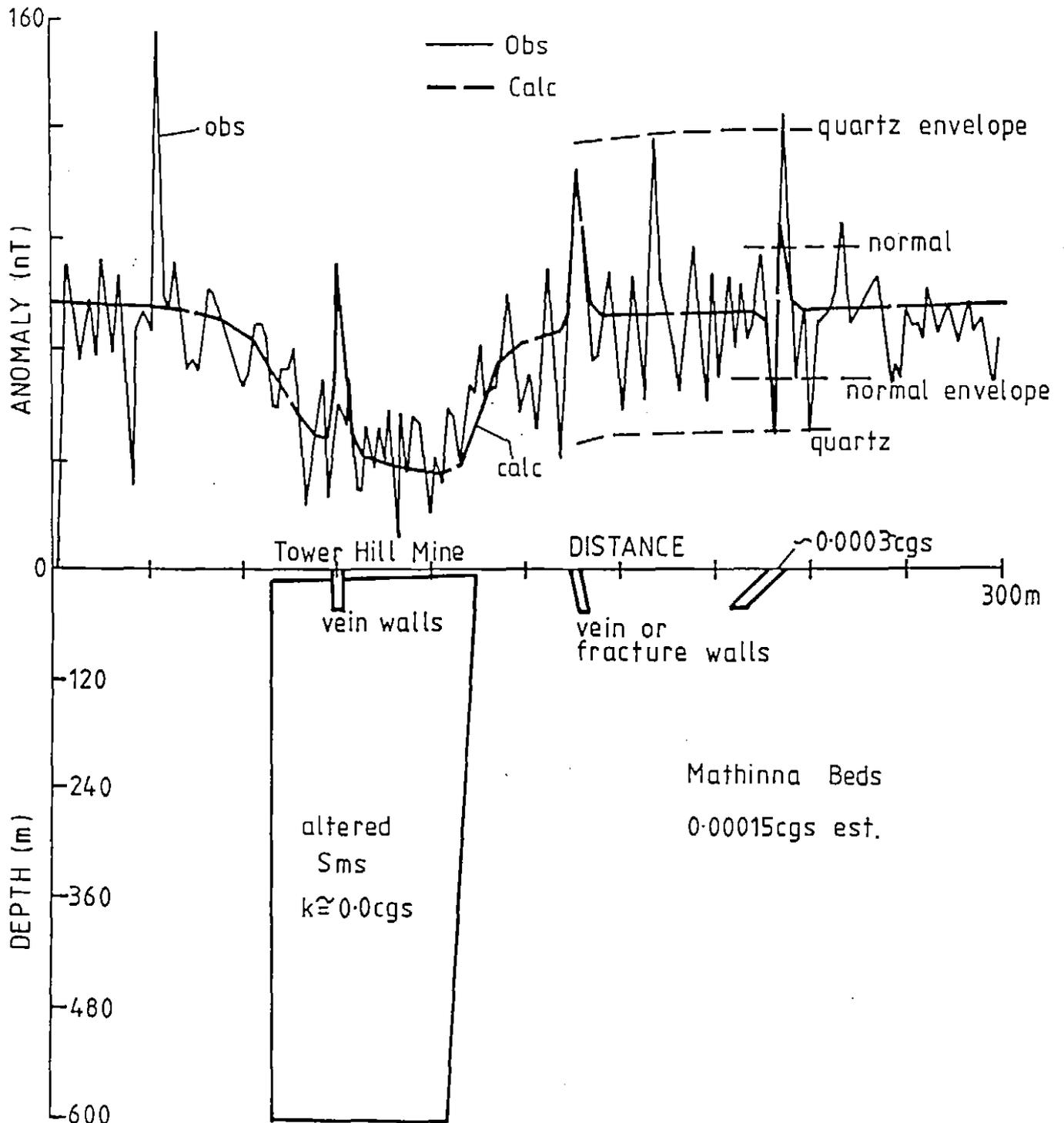


Figure 5

Example of results of ground survey near the Tower Hill Mine (Leaman, 1989). Spikes reflect shallow veins while the broad dip in field intensity reflects local host changes about the mine. Spikes are due to property changes of up to three orders of magnitude in the vein walls. Spikes can be mapped by detailed survey.

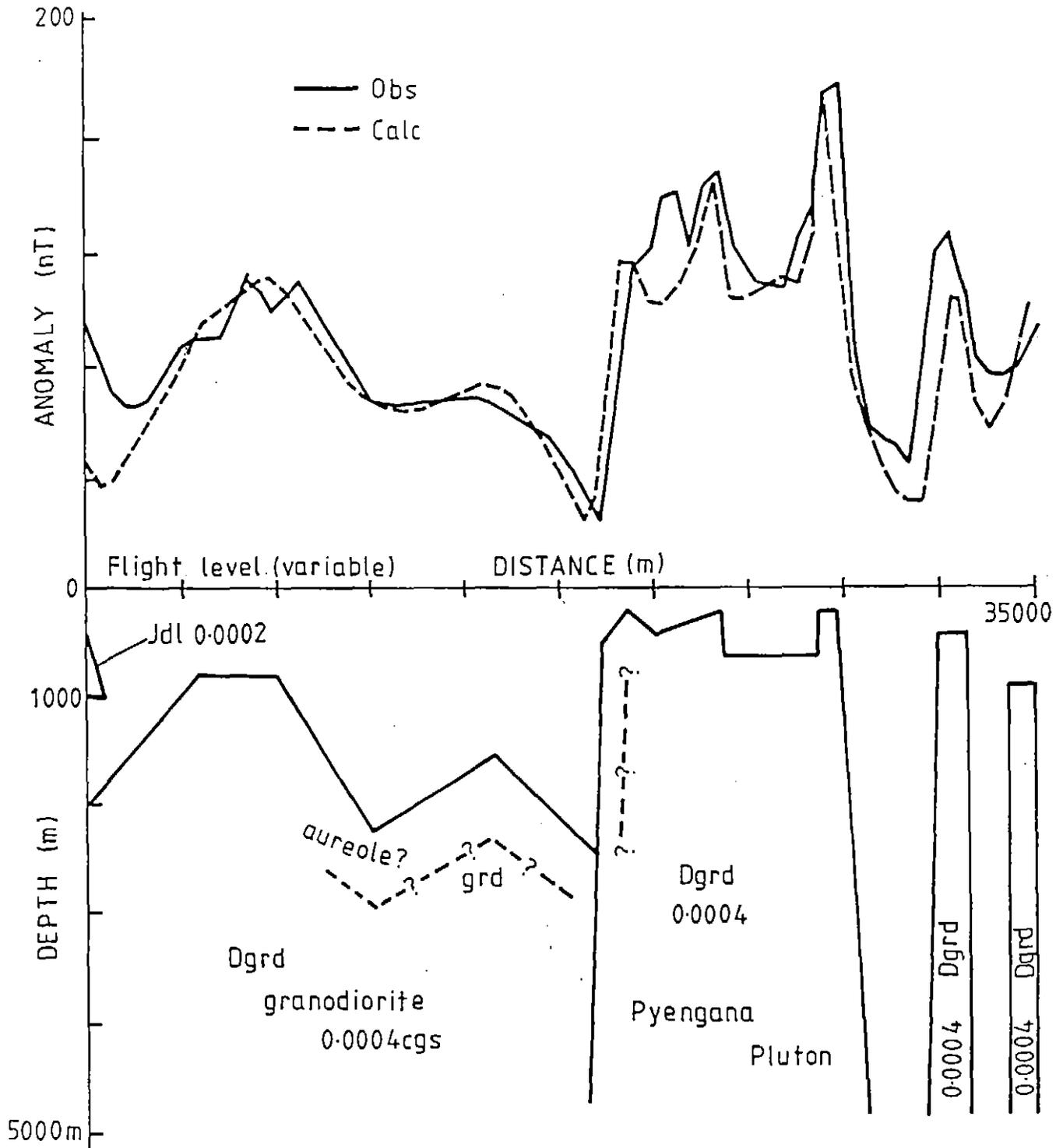


Figure 6

Section across the South Esk Valley near Mathinna showing continuity of granodiorite between exposures to the west and east (Richardson, 1989). This early interpretation makes no allowance for possible variations in granodiorite properties or limited volumes of material after subsequent granite intrusion deep in the section. The implication is general, however, much as inferred by Leaman *et al.* (1973).

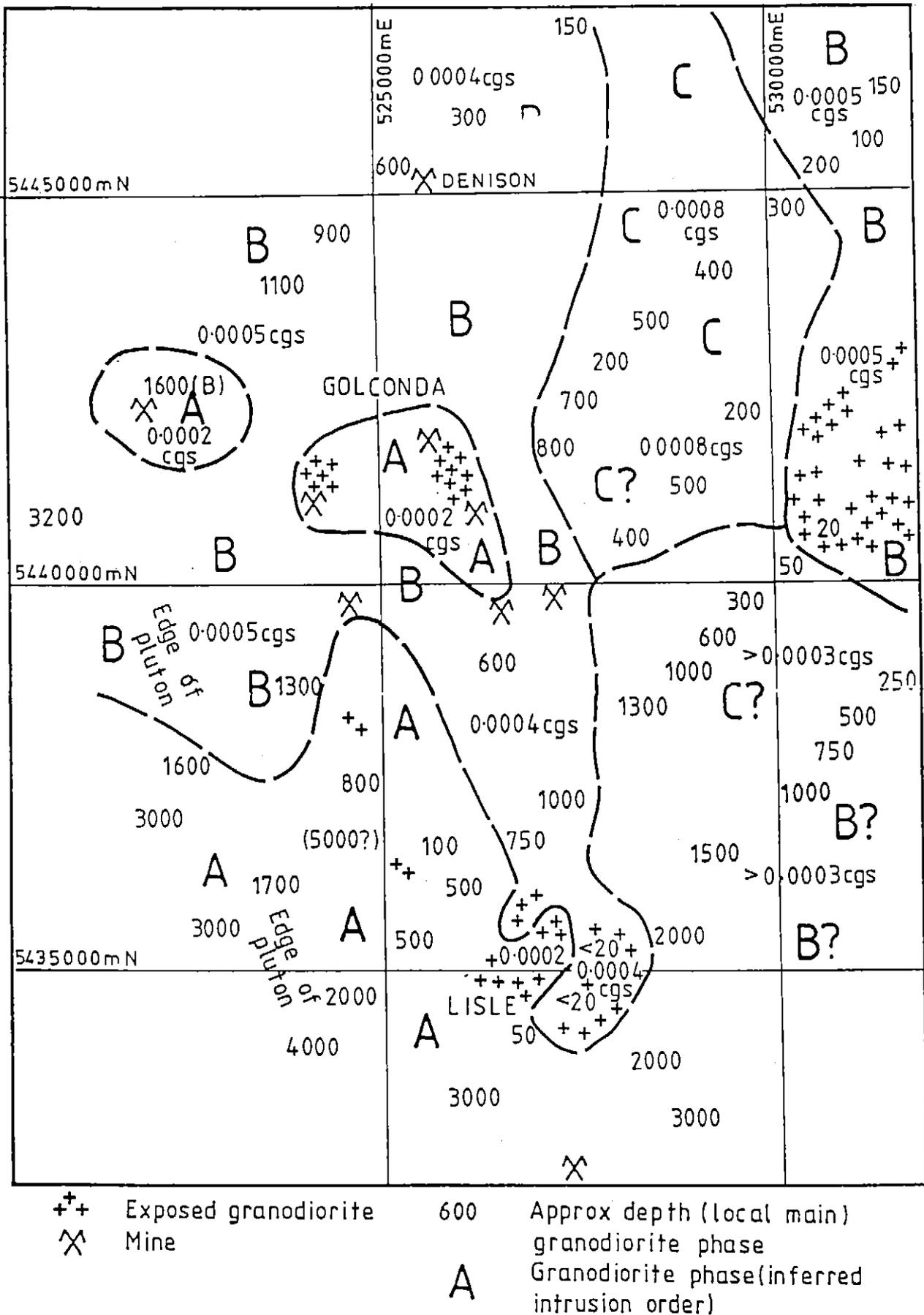


Figure 7

An interpretation of the possible distribution of granodiorite types in the Lisle-Golconda area. These plutons intrude each other in the inferred order and have largely escaped subsequent dilation and intrusion by later granitoids of the Scottsdale Batholith. The alluvial gold at Lisle is concentrated in a valley trap where erosion has worked the roof of body A and its metamorphic halo in the country rocks.

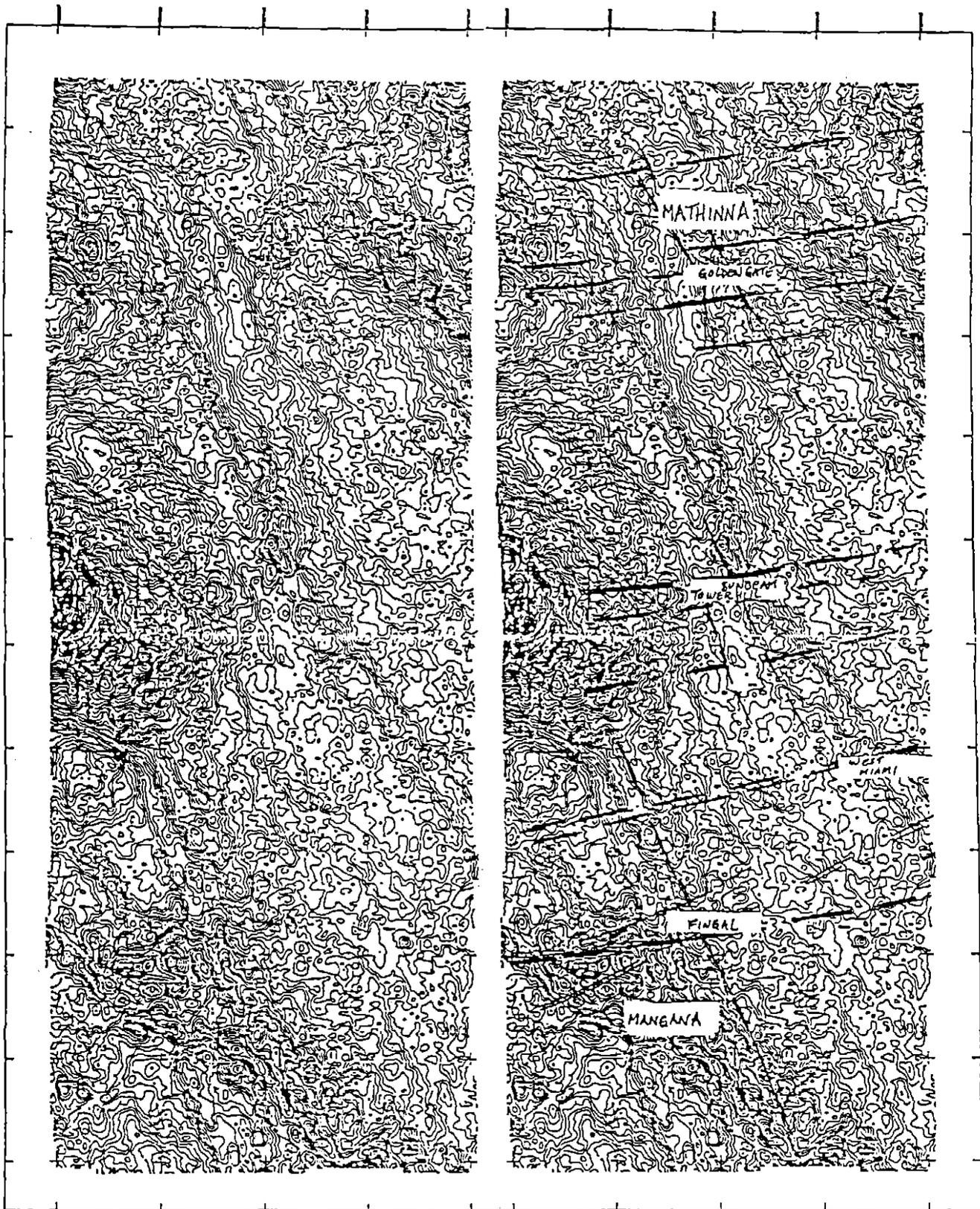


Figure 8

The Mathinna–Mangana detailed aeromagnetic survey with contour interval of 0.5 nT (Leaman, 1990; Richardson, 1992). Two major sites are shown and attention is drawn to some of the more subtle trends in this data. These trends have been rendered poorly because of an unfortunate E-W line bias. More obvious trends are related to lithological changes in the Mathinna Beds.

APPENDIX TWO

MAINLY MAGNETICS, MATHINNA BEDS AND GOLD MINERALISATION IN NE
TASMANIA
(from Exploration Geophysics, 23, 185-190; 1992)

Mainly Magnetics: Mathinna Beds and Gold Mineralisation in NE Tasmania

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Abstract

Gold-bearing quartz reef systems within the Lower Palaeozoic Mathinna Beds metasediments of NE Tasmania have been mapped magnetically even though magnetic contrasts are small. High-resolution airborne surveys have resolved differences between the granitoids which intrude the host sequence, and an array of structures within the host rocks. All known mineralized areas studied appear to be associated with one member of the granodiorite family, and with particular structural orientations. Detailed ground surveys can define the volume of altered or potentially mineralized host rocks, and relate local vein orientations to the more regional controls. Vein systems are themselves mappable magnetically owing to oxidation along the vein walls, which produce spike responses.

Key words: Magnetics, gold, quartz veins, granodiorites, Mathinna Beds, North east Tasmania.

Introduction

The northeast portion of Tasmania contains a sequence of variably metamorphosed shale, sandstone, slate and quartzite of Ordovician — Devonian age known locally as the Mathinna Beds (Fig. 1). This sequence is rarely fossiliferous, often turbiditic, multiply folded, faulted with detachments, and generally poorly exposed. Its thickness is unknown and its original depositional character is uncertain owing to intrusion of large Devonian batholiths. There are at least two families of granitoids, granite-adamellites and granodiorites. Only limited research has been done on the latter and no subdivisions are offered on regional geological maps. The province has produced much gold, mainly pre-1900, and is very similar to the gold-bearing regions of Victoria and New South Wales. Most production was derived from vein quartz systems.

Tin mineralization in this environment has been genetically and structurally linked to the more siliceous granites but the source of the gold continues to be debated. It is possible that it has been derived from Cambrian mafic sequences of west Tasmanian type, which may underlie the Mathinna Beds (Bendall *et al.*, 1991; Wellman, 1988).

Exploration until recently has depended on panning or indicator geochemistry and has lacked sophistication. The transformation in understanding of the setting and possible controls of mineralization offered by appropriate geophysics, and the ramifications for future exploration, are described in this paper using data now in the public domain.

History of geophysics

Most geophysical surveys in NE Tasmania have been directed toward definition of granite cupolas or leads associated with tin mineralization, or groundwater basin studies. Early workers did not recognise any cost-effective means for evaluation of structure or mineralized sites within the Mathinna Beds. The problem was two fold; what contrasts or features are relevant, and are responses measurable? Most property studies have suggested negligible contrasts of all types and, of course, few methods can directly define quartz veins. A lack of clear or workable genetic concepts has also restrained exploration. Poor exposure and deep weathering also pose problems.

Previous research in the productive Lefroy area was summarised by Leaman (1974), where it was concluded that self-potential and piezo-electric methods were able to locate

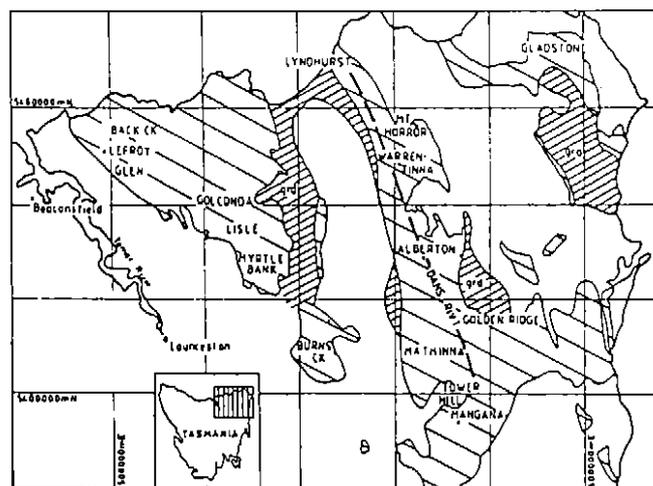


FIGURE 1
Distribution of Mathinna Beds (light hatch) and exposed granodiorites (dark hatch). The Mathinna-Lyndhurst shear or detachment is marked by the heavy line. All locations (except Launceston) are sites of past gold production.

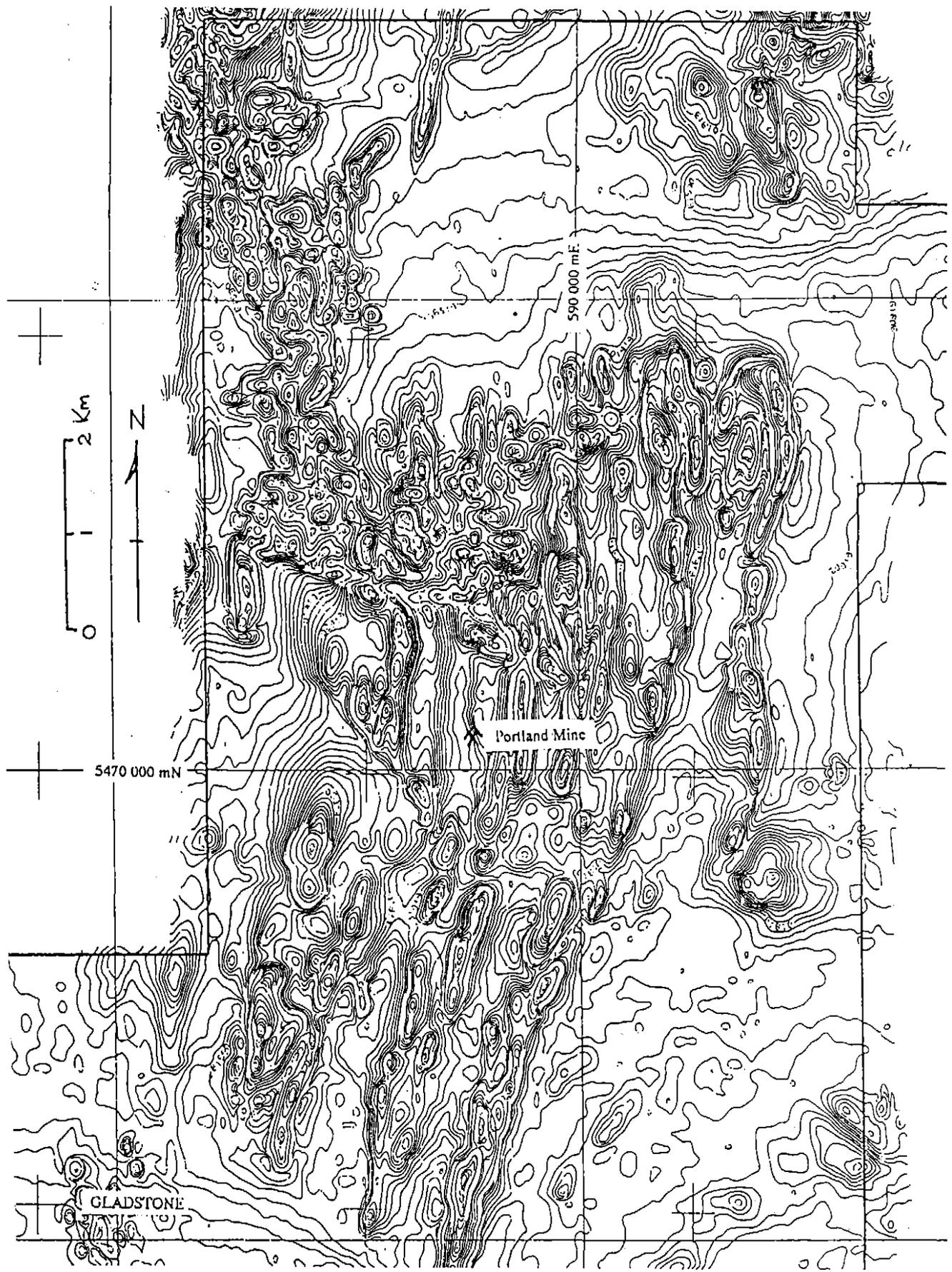


FIGURE 2
 High-resolution aeromagnetic compilation of magnetic field in Gladstone area. All high-amplitude texture has been generated within Mathinna Beds. Fold noses, faults and units are identified. Little of this information could be inferred from limited exposures. Pimple anomalies near Gladstone township correlate with metal roofs. The E-W line bias of this first survey does not adequately define ENE trends, but nick points reveal their presence at Portland Mine.

veins but could not screen mineralized from normal Mathinna Beds or separate barren from productive veins. Neither method was taken up by explorers since they were exotic and some form of regional targetting was also required. Some unusual magnetic results were reported but the method was dismissed because it was assumed that the contrasts were too subtle. Desperation produced a breakthrough in 1986 after it was argued that mineralization might be related to granodiorites in some way. As it was thought that these rocks were more magnetic than Mathinna Beds, a very high resolution survey was flown in the Gladstone area (Leaman, 1987b) in the hope that some structural information about the intrusive might be obtained. This survey demonstrated that the Mathinna Beds are not magnetically uniform (Fig. 2) and that surface property measurements were misleading. Structures, disruptions and units could be defined. Granodiorites, while important elements of the geology, were variably rather than strongly magnetised, as had been assumed from preliminary property studies.

Several other surveys have now been completed. High sampling rates, very low clearances (60 m preferred), flight-line spacing of 125 m, high-sensitivity magnetometers and often, helicopters are required.

The granodiorites

Property collation and evaluation remains incomplete but at least three members of the granodiorite family can be distinguished using magnetic and density character. These have typical susceptibilities and densities of 0.0002, 2.70; 0.0004, 2.70; and 0.0008 cgs, 2.75 t/m^3 respectively. Gold mineralization appears to lie uniquely in the halo of the first type (A in Fig. 3), where it is exposed or can be inferred as at Golden Ridge, Lisle, Gladstone and Lyndhurst. It appears to have been the first emplaced pluton and is now very diluted and fragmented by subsequent intrusion (e.g., Fig. 3). Magnetic surveys can discriminate intrusives, but care is required to identify lithology if only one or two members are present in an area. It has also been argued, using both gravity and magnetic data, that sites such as Lefroy, Beaconsfield and Mathinna, which appear far removed from granodiorite, are spatially very close to concealed bodies (Leaman *et al.*, 1973; Richardson, 1989; Fig. 4). Regional data indicate a primary association with granodiorites which may be genetic or structural.

Structure

Figure 2 shows that much character can be defined, and that structural assemblies and improved maps are possible. Model calculations based on anomaly relief, implied unit thickness and contrasts yield susceptibility values close to those observed in fresh samples from core or deep workings. All

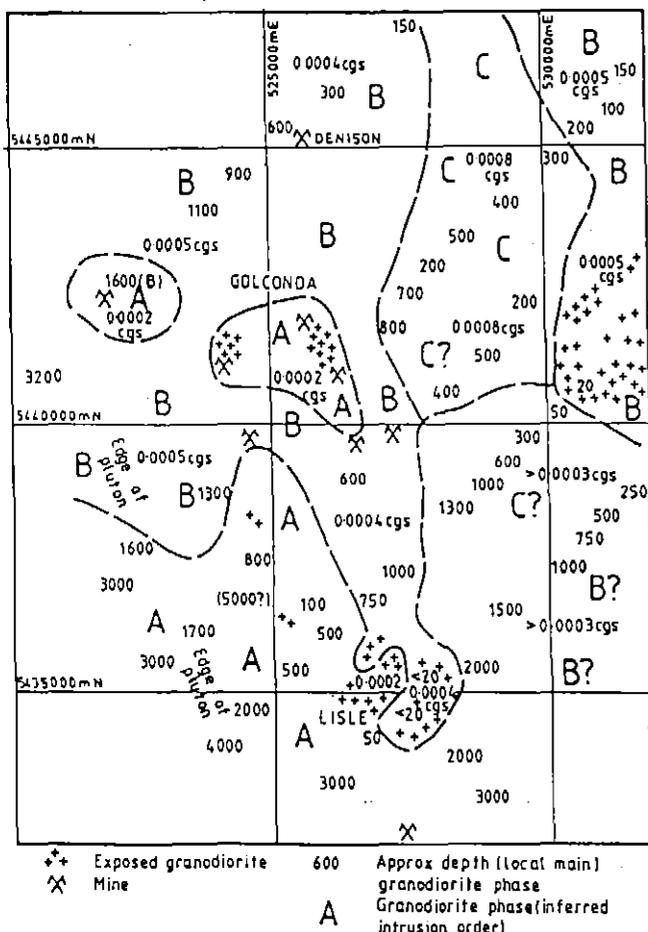


FIGURE 3
Interpretation of granodiorite types in the Lisle-Golconda area. Exposures are of different rock types not separable in thin section but which possess different physical properties. This area contains all three known variants. Some ambiguity persists where pluton forms are restricted or complex; these could be resolved with more detailed survey and analysis.

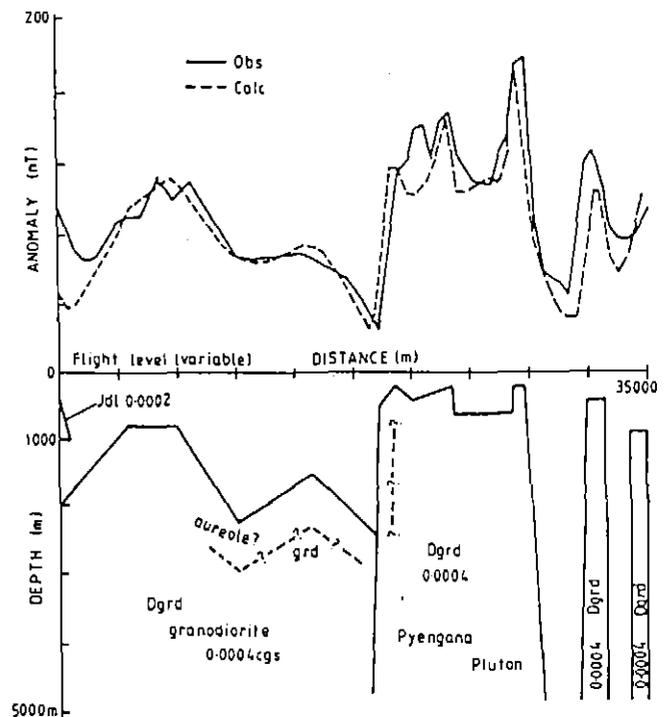


FIGURE 4
Example of magnetic responses due to granodiorite in the Mathinna area. Exposed pluton from 18 to 28 km produces strong, well defined response but character to the west suggests the maximum contrast possible. The lowest contrast granodiorite may be present at greater depth with similar form. The mineralised zone lies above the secondary crest at 15 km. Low contrast granodiorite is exposed between the higher contrast slices from 28 to 35 km. Gold is present in the haloes of these zones only.

values are less than 0.0003 cgs, but mudstones are more magnetic than sandstones. Surface measurements are rarely reliable owing to deep weathering (up to 50 m) within the Mathinna Beds. Some granodiorite members cannot be discriminated from some units of the Mathinna Beds.

Vein location

Leaman (1974) had noted that the magnetic field in the Lefroy area seemed spiky but the fluxgate magnetometer used was not able to resolve such spikes. No other magnetometer was available at the time and, in retrospect, this circumstance was most unfortunate. Groundwork near the old Portland Mine at Gladstone (Fig. 5) (Leaman, 1987a) showed that mudstones produced the principal anomalies. Detailed infill revealed spikes with amplitudes of up to 50 nT. Each feature could be traced for distances up to 100 m and orientations could be established. The predominant orientation of 325° was subsequently found to be that of the worked vein system (Fig. 5).

Several spike anomalies were excavated and found to be associated with the alteration along vein-rock contacts. The thickness of the vein was not important, but a change in magnetisation of at least an order of magnitude was observed in Mathinna Beds near the vein.

This procedure was further refined at Tower Hill (Fig. 6) where it was found that the mineralized zone was magnetically distinctive. Spikes locate veins but not all veins are mineralized. Many prospectors have believed that NNW

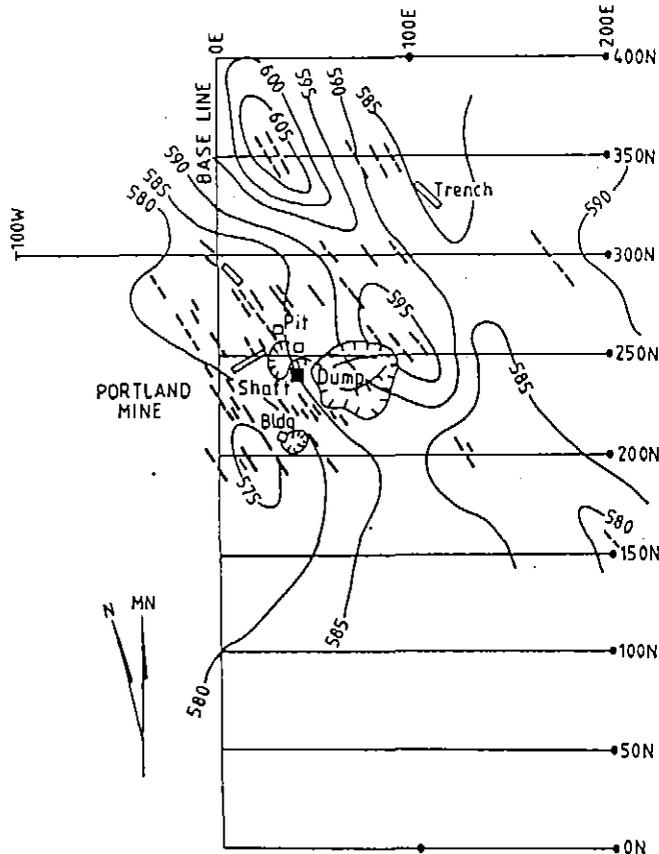


FIGURE 5
Detail of the ground magnetic survey near Portland Mine, Gladstone. The general anomaly trend is mirrored in the airborne data, where it is quite anomalous (Fig. 2). Many veins are associated (line segments).

trends are associated with mineralized sites. Indeed, the best known axis of mineralized sites extends NNW from Mangana to Lyndhurst, but only half of all mineralized sites lies near this axis (Fig. 1). The Tower Hill survey (Leaman, 1989) was followed by a very high resolution helicopter survey of the area between Mangana and Mathinna. This revealed a much subtler cross trend (ENE), at first overlooked, which has now been recognised at every known mineralized site which has been surveyed. The major sites, such as Mangana, Mathinna and Alberton, occur on corridors with this orientation at their intersection with regional NNW fractures. The local veins tend to curl asymptotically to these regional trends and are consequently ambiguous guides from patchy exposures. More detailed ground survey at Alberton has further confirmed that the mineralized areas are distinctive and very localised, while also showing an asymptotic curl of the bounding structure to ENE. All Alberton mineralization occurs in a NNW-trending belt about 500 m wide.

Conclusions

Exploration of highly prospective and underexplored rocks such as the Mathinna Beds has been retarded by lack of clearly useful procedures which can relate either source concepts and possible controls to workable target volumes, or discriminate between known or possibly mineralized sites.

Present research suggests that the gold is related to an early intruded low-contrast granodiorite which is distinguishable magnetically. Such bodies are now thought to lie within 2 km of all occurrences, but the exact nature of any genetic or structural role is not yet known.

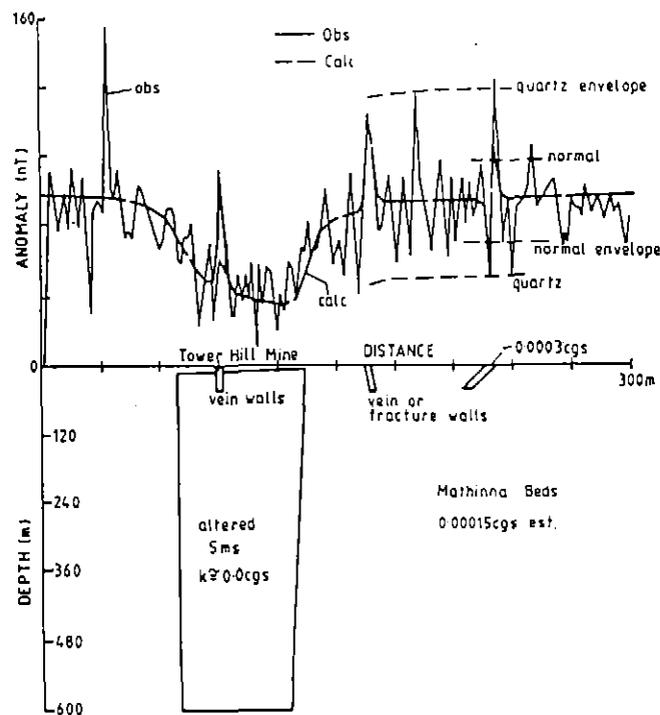


FIGURE 6
Surface magnetic profile at Tower Hill Mine. Spike responses are related to vein contacts, while longer wavelength low-frequency response reflects loss of magnetic properties due to alteration. Veins outside this zone were barren.

High-resolution aeromagnetic surveys can define local structures and units within the Mathinna Beds and discriminate granitoid types. Confirmation of the presence of the proposed source-rock type and inferred structural controls (ENE, NNW) within its halo delimit a primary target area. It appears that only the ENE trend acts as ultimate control, but this is usually only subtly displayed unless presentations enhance it.

Detailed ground surveys in target areas or about old mines reveal similar trend controls but also provide definition of the possible mineralized area, the orientation of the vein network and any local alteration changes.

A sequence of magnetic surveys, used first for regional evaluation of granodiorites and structures, and then local specification within target areas, can provide cost-effective targeting for drilling or appraisal of large regions and rock suites never before rationally assessed for concealed mineralization. Geochemical indicators, such as use of arsenic, are much more diffuse, are costly, and cannot provide any regional perspective.

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Report submitted on behalf of
Leaman Geophysics
by

D. Leaman

Dr. D.E. Leaman, B.Sc., Ph.D
F. Aus. I.M.M., M.M.I.C.A

21/11/94

Map 1

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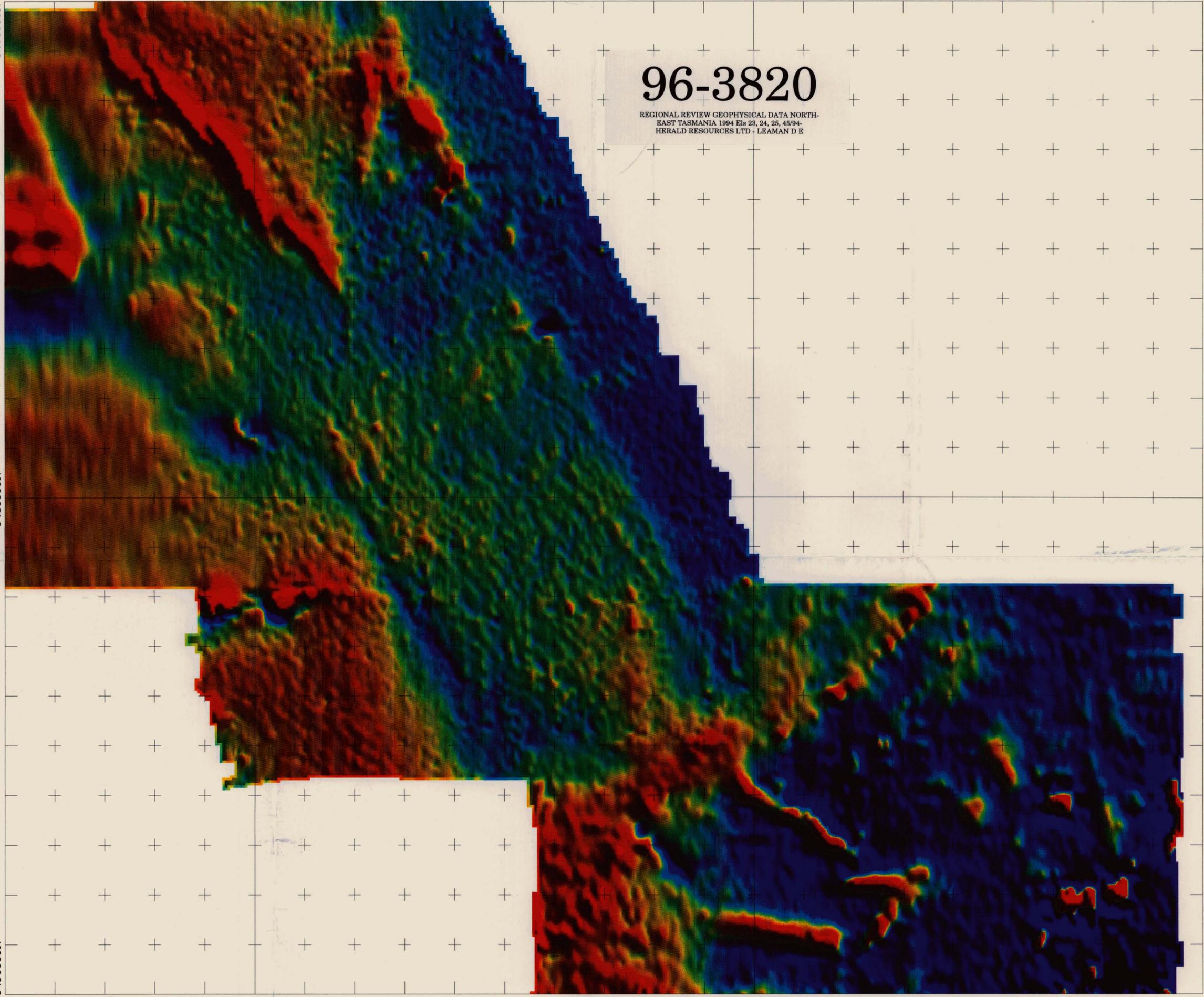
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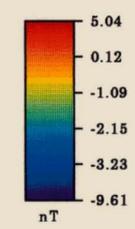
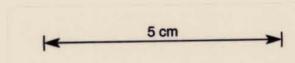
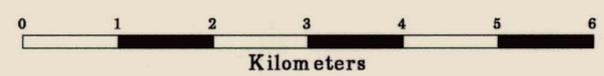
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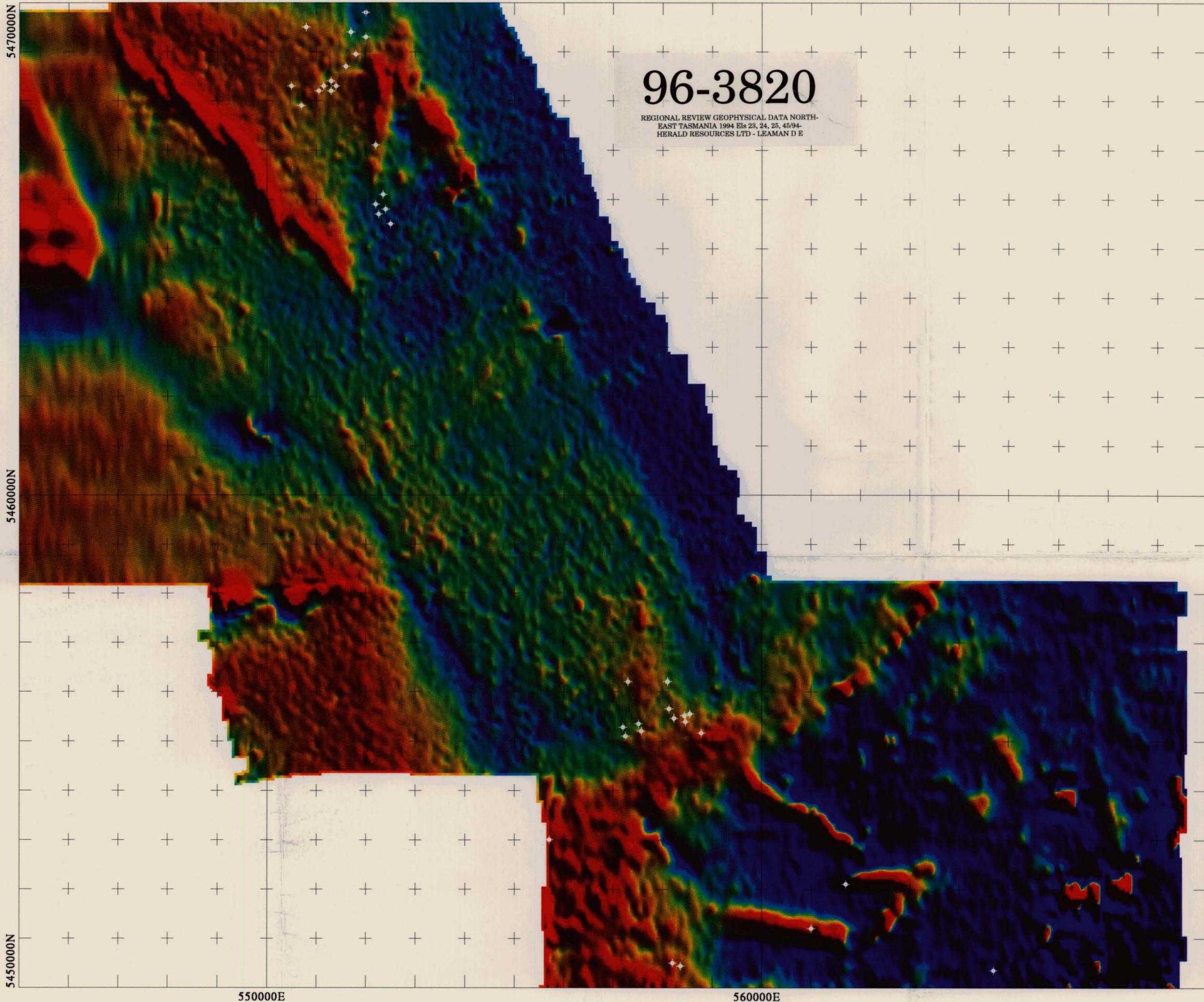


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Map 1

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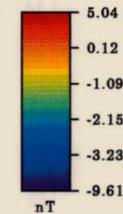
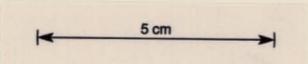
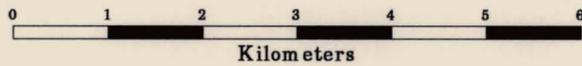
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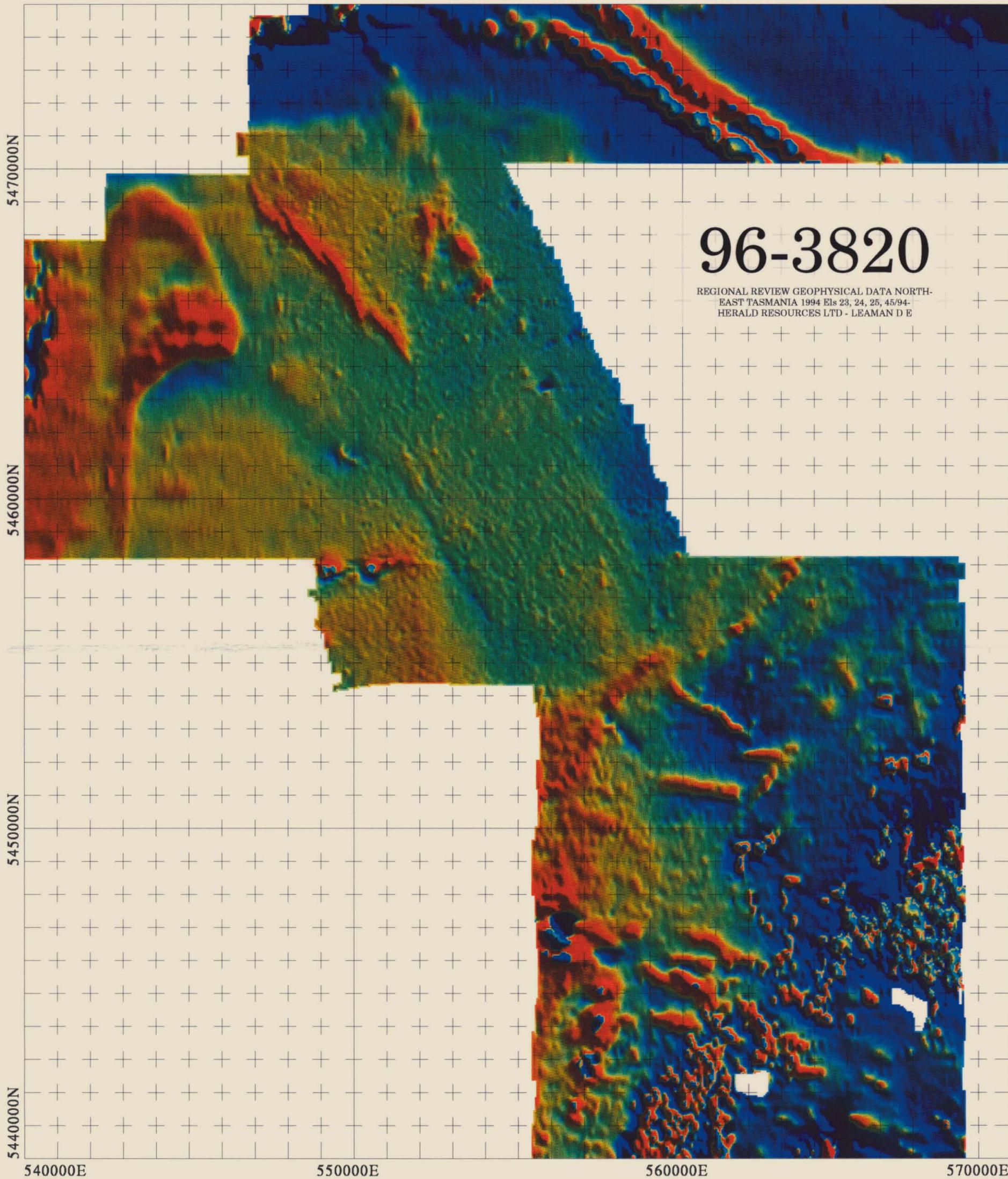
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Gold mineralisation shown in white



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AEROMAGNETIC DATA - RESIDUAL USING 1500m CONTINUATION

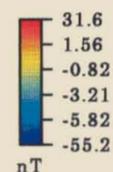
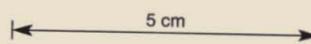
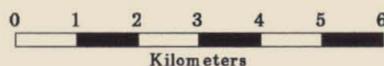


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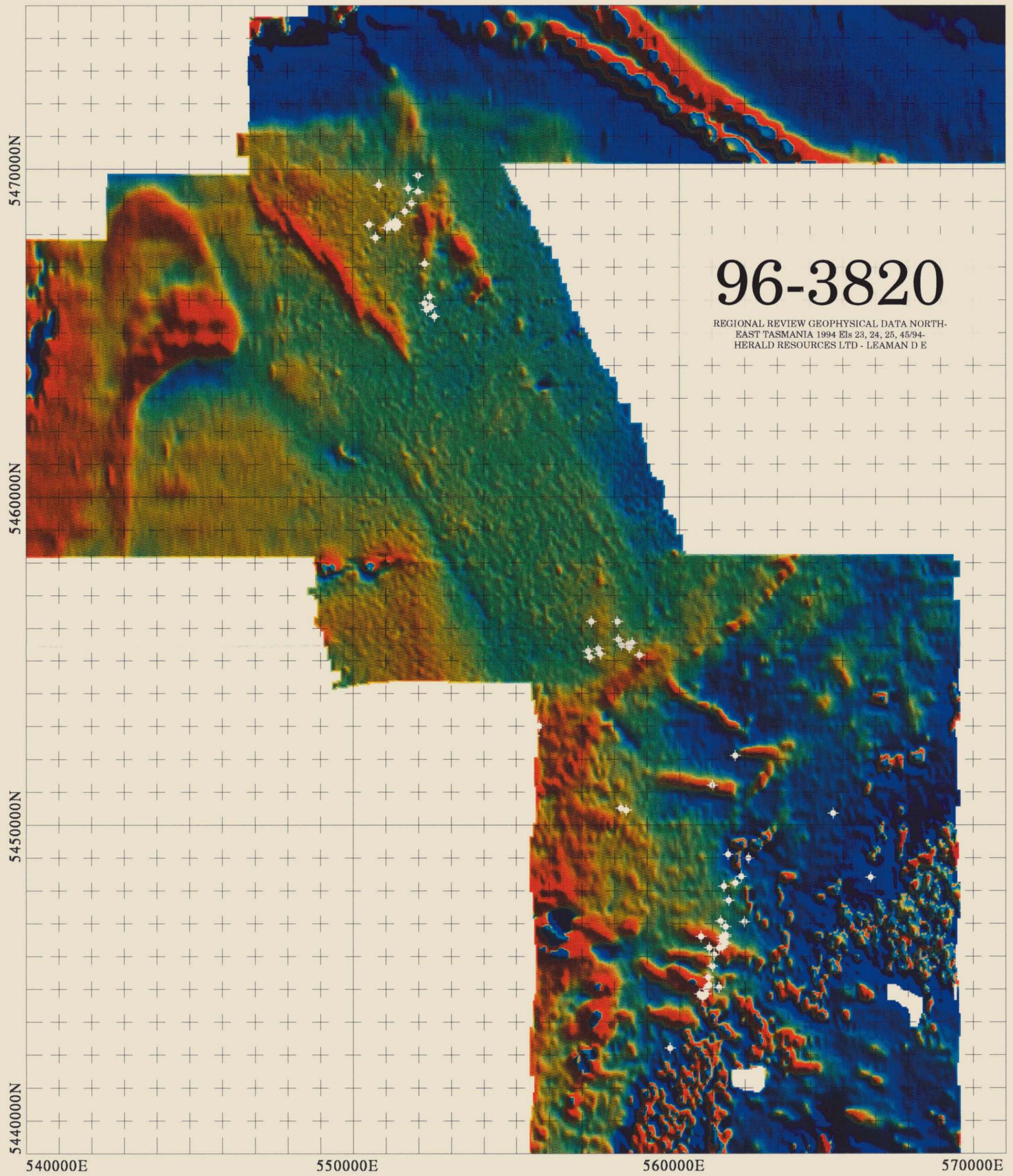
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AEROMAGNETIC DATA - RESIDUAL USING 1500m CONTINUATION



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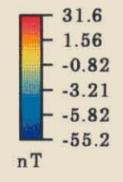
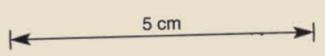
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Gold mineralisation shown in white

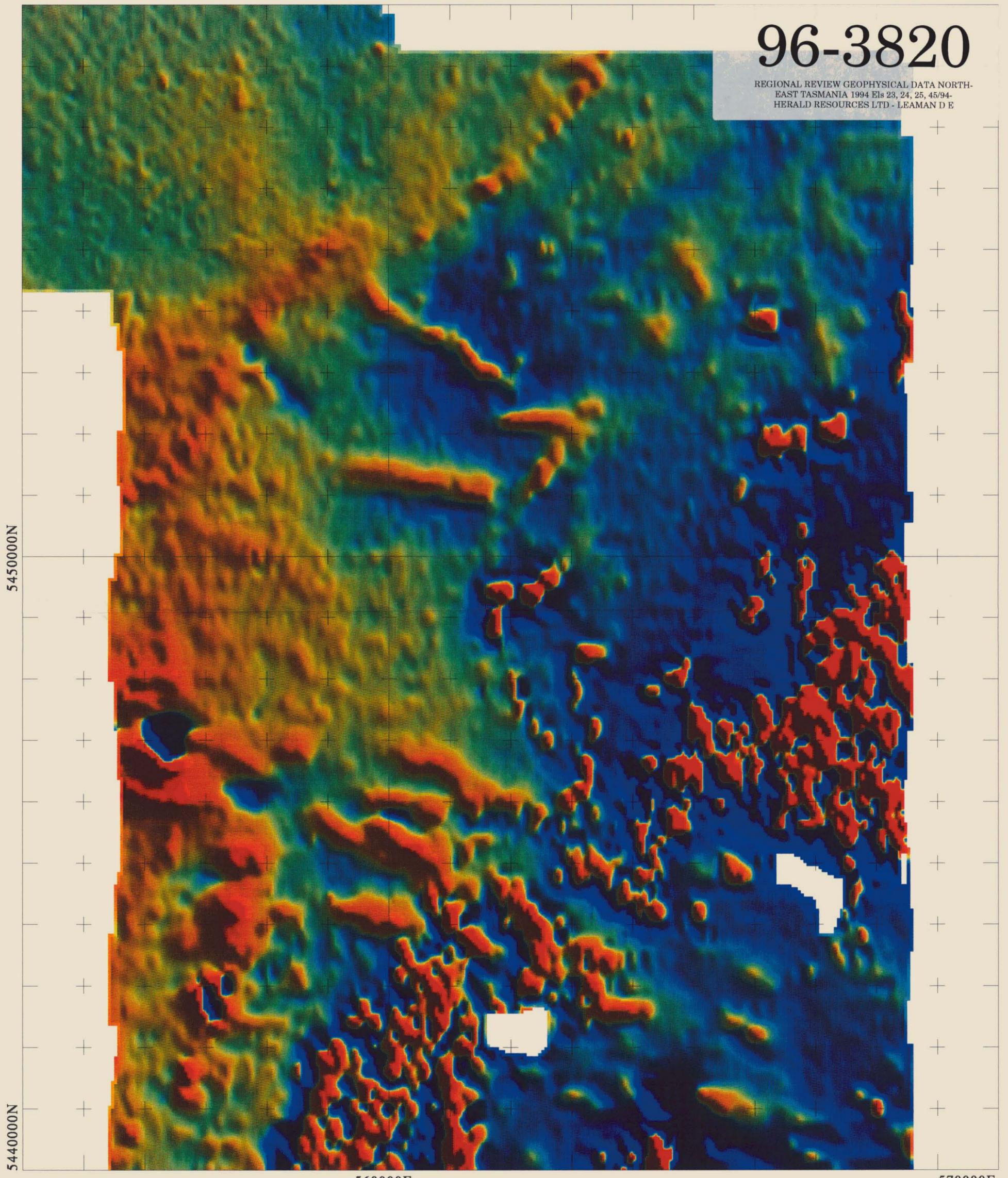


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AEROMAGNETIC DATA - RESIDUAL USING 1500m CONTINUATION

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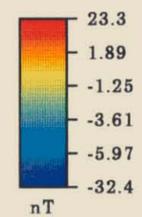
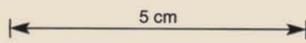
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50m grid mesh

Mineral Resources Tasmania 1994

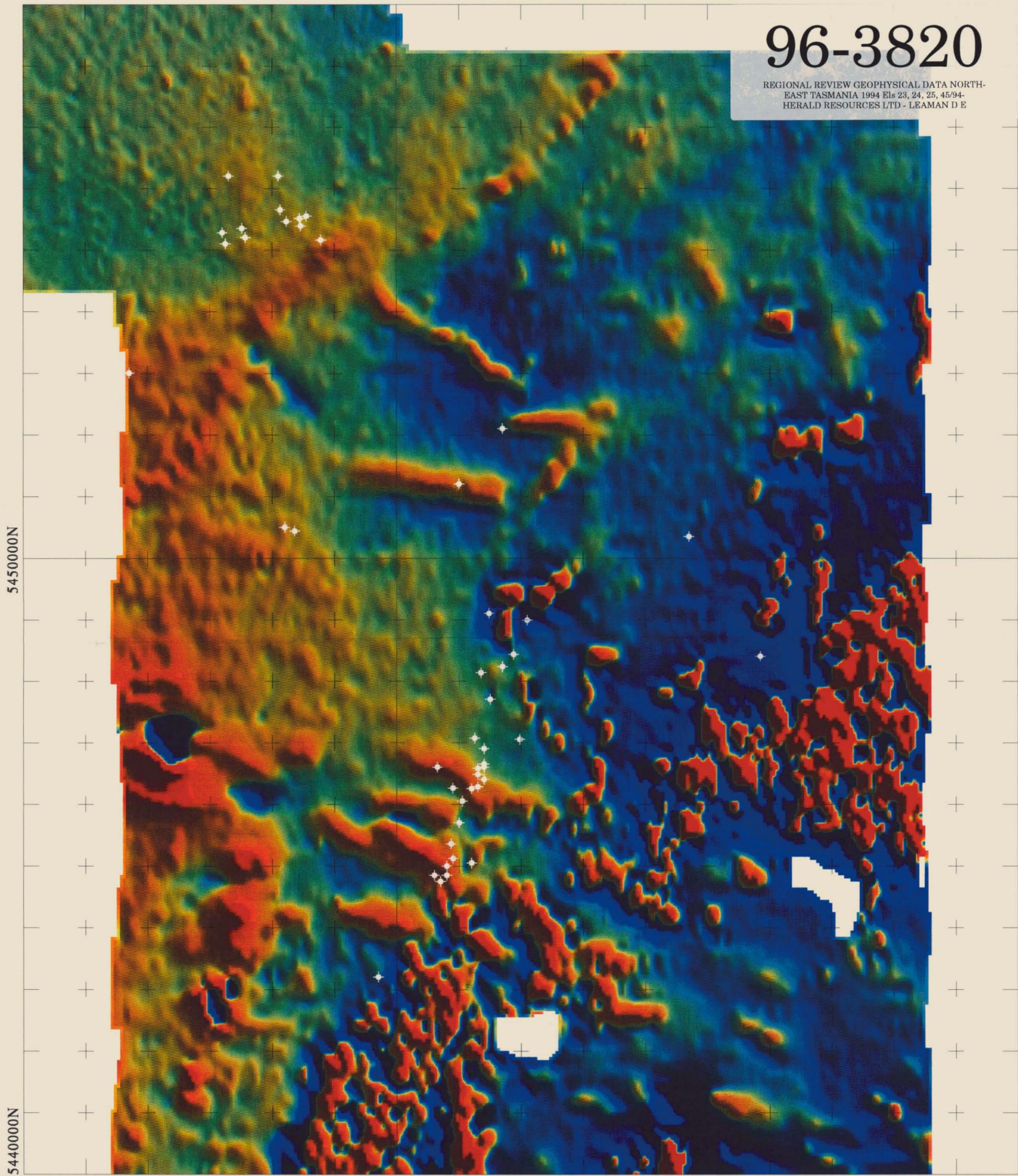


herdiffsth_alg

AEROMAGNETIC DATA - RESIDUAL USING 1500m CONTINUATION

96-3820

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-HERALD RESOURCES LTD - LEAMAN D E



5450000N

5440000N

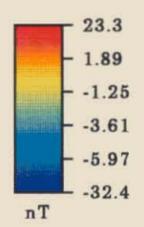
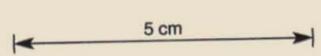
560000E

570000E

50m grid mesh

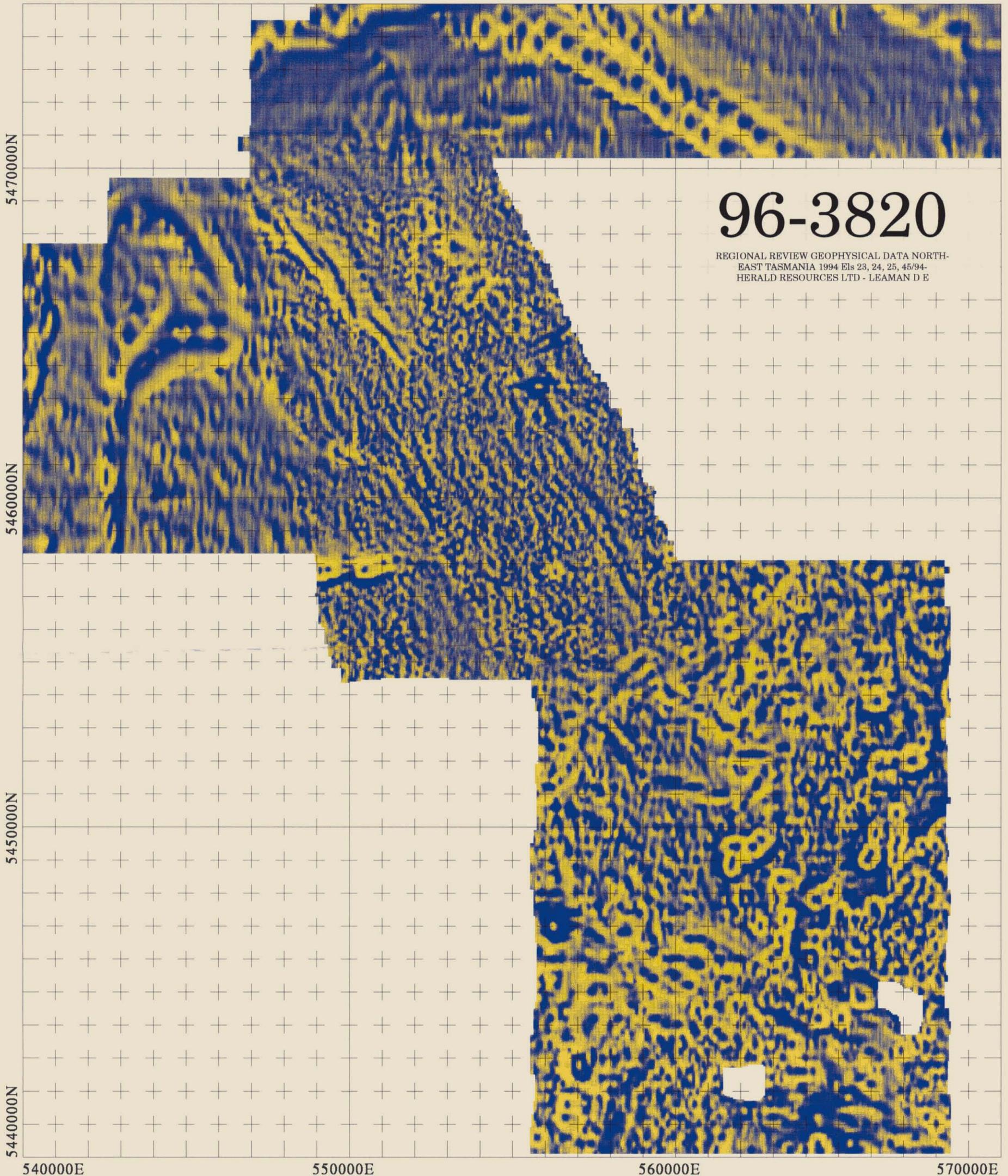
Mineral Resources Tasmania 1994

Gold mineralisation shown in white



herdiffsth_alg

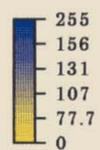
AEROMAGNETIC DATA - AUTOMATIC GAIN CONTROL



96-3820

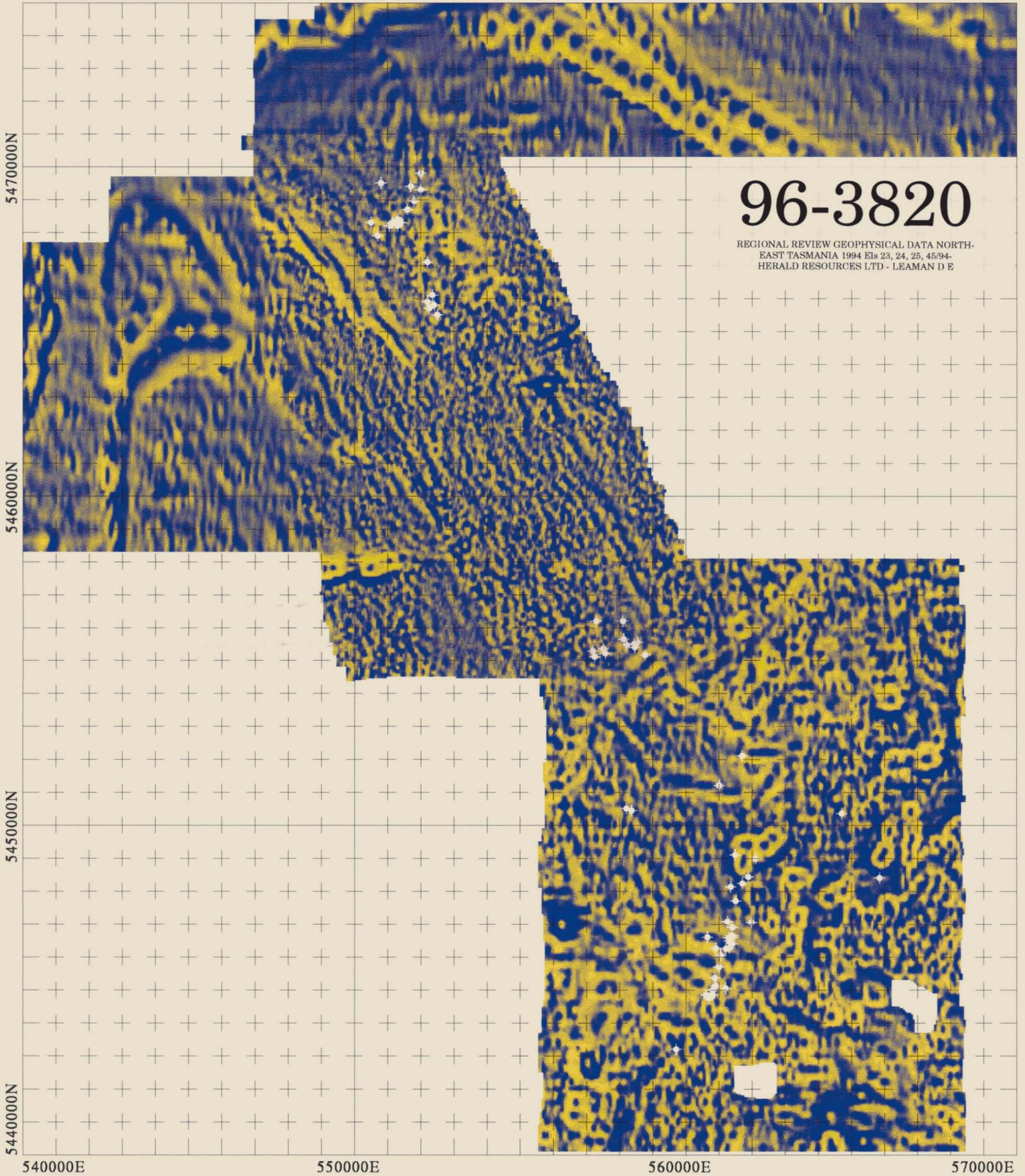
REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E

50m grid mesh 7x7 AGC filter
Mineral Resources Tasmania 1994



hervirtagc_alg

AEROMAGNETIC DATA - AUTOMATIC GAIN CONTROL



96-3820

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E

5470000N

5460000N

5450000N

5440000N

540000E

550000E

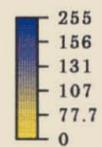
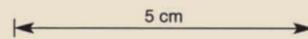
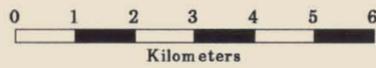
560000E

570000E

50m grid mesh 7x7 AGC filter

Mineral Resources Tasmania 1994

Gold mineralisation shown in white

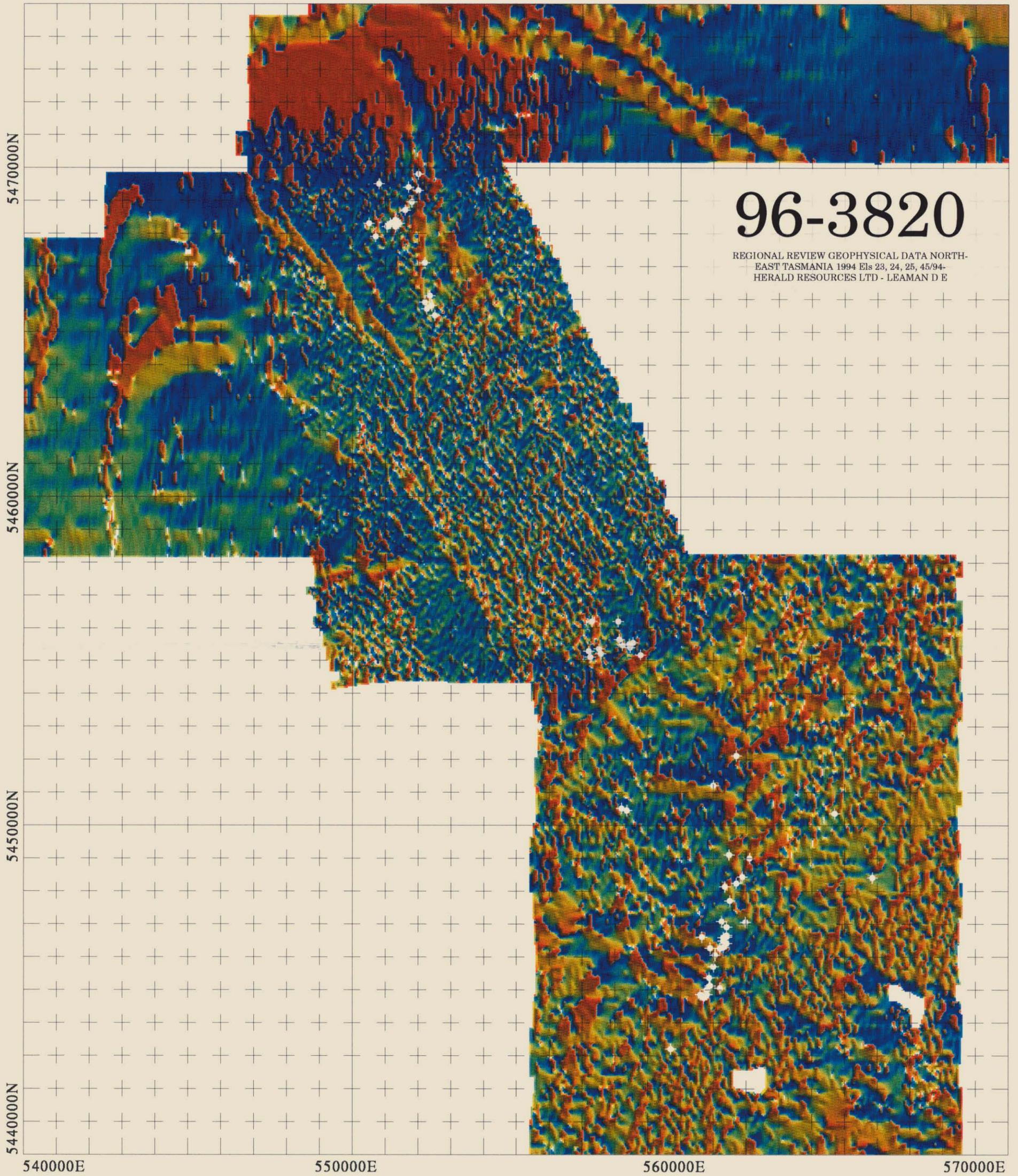


hervirtac_alg

Map 5

731003

AEROMAGNETIC DATA - ASPECT



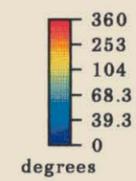
96-3820

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 Els 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E

50m grid mesh

Mineral Resources Tasmania 1994

Gold mineralisation shown in white



hervirtagc_alg

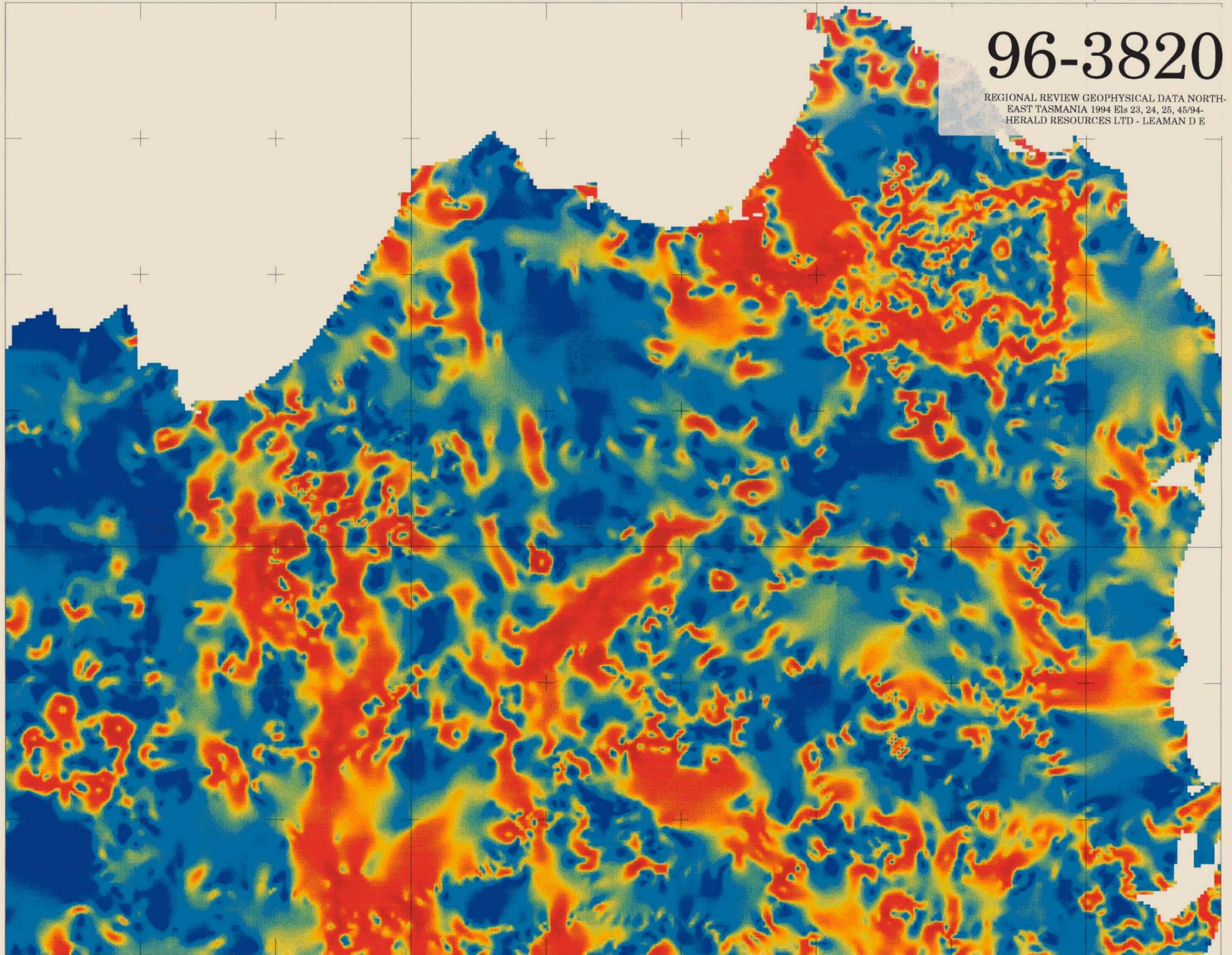
RESIDUAL GRAVITY ANOMALY - SLOPE

Map 6

96-3820

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E

450000N

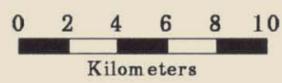


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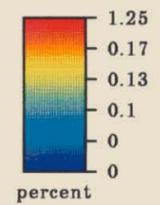
600000E

250m Grid Mesh

Mineral Resources Tasmania 1994



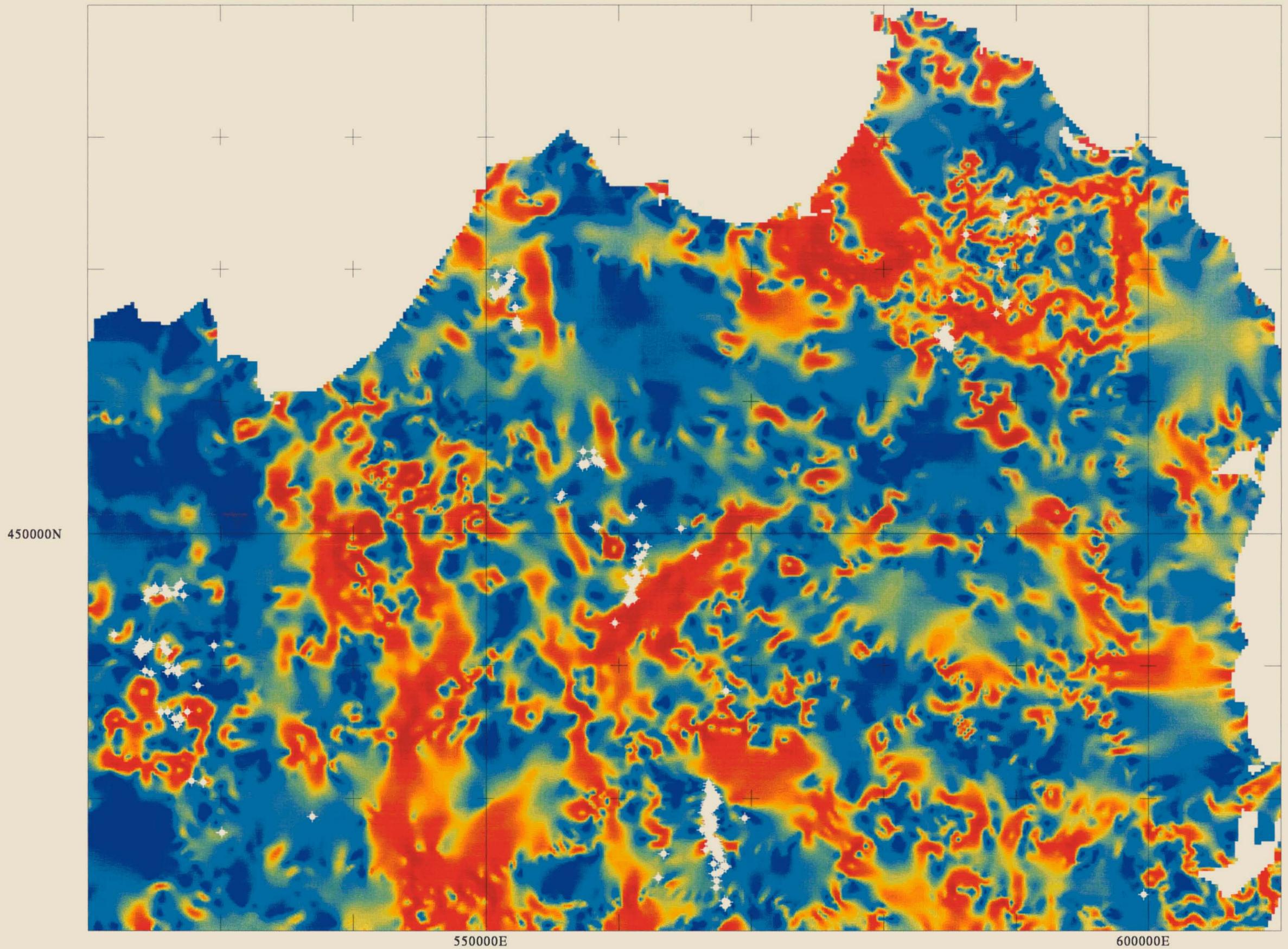
5 cm



resslope_alg

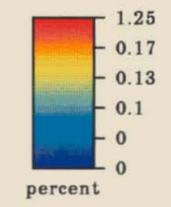
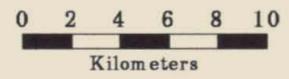
RESIDUAL GRAVITY ANOMALY - SLOPE

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E



250m Grid Mesh

Mineral Resources Tasmania 1994



Gold mineralisation shown in white

resslope_aig

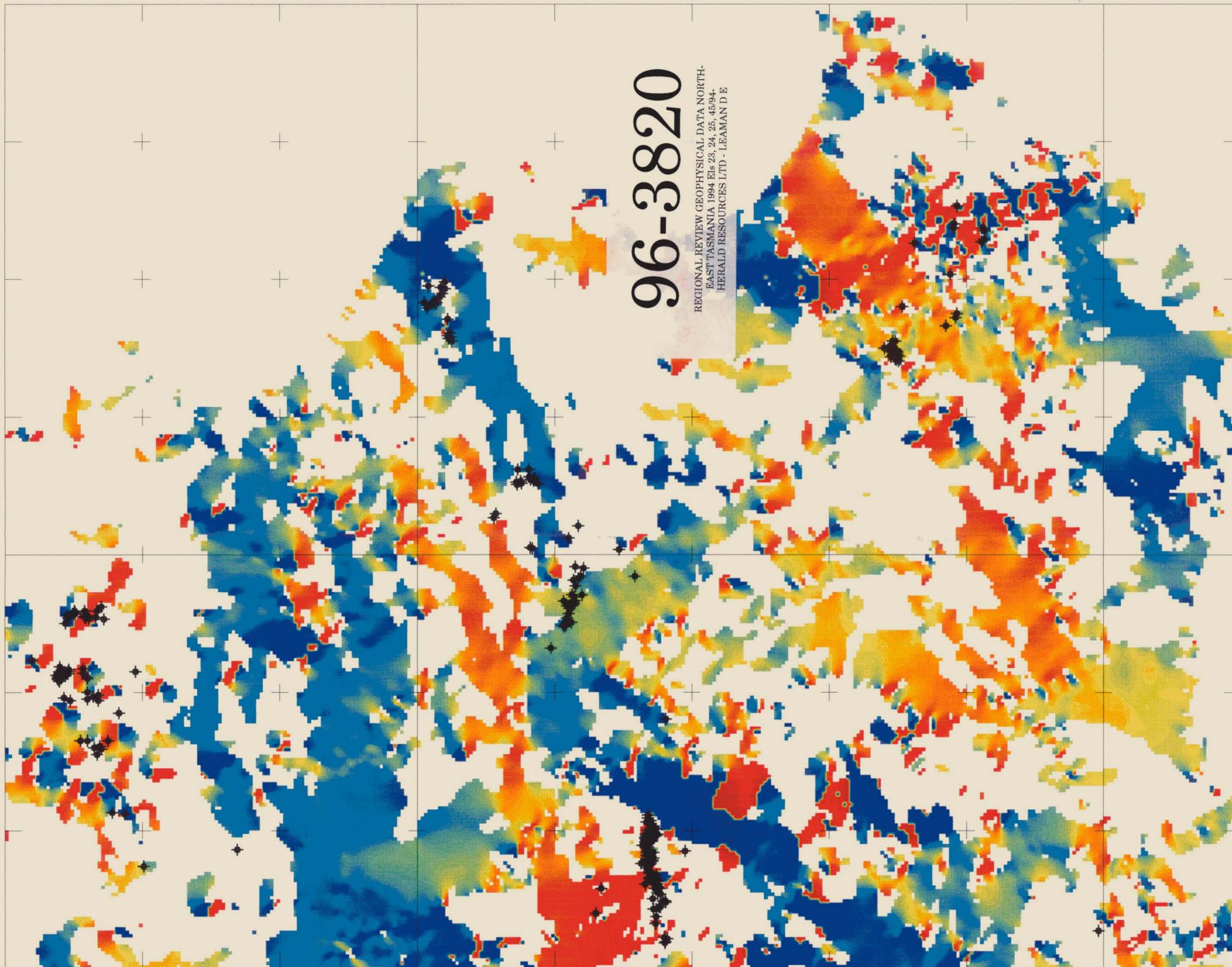
RESIDUAL GRAVITY ANOMALY - ASPECT

Map 7

96-3820

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIS 23, 24, 25, 45/94.
HERALD RESOURCES LTD - LEAMAN DE

450000N

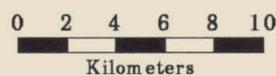


550000E

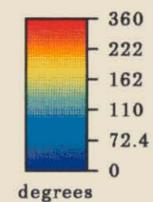
600000E

250m Grid Mesh

Mineral Resources Tasmania 1994



5 cm



Gold mineralisation shown in black

resaspect_alg

RESIDUAL GRAVITY ANOMALY - ASPECT

Map 7

96-3820

REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E



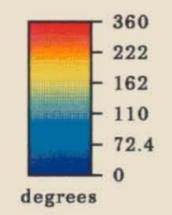
450000N

550000E

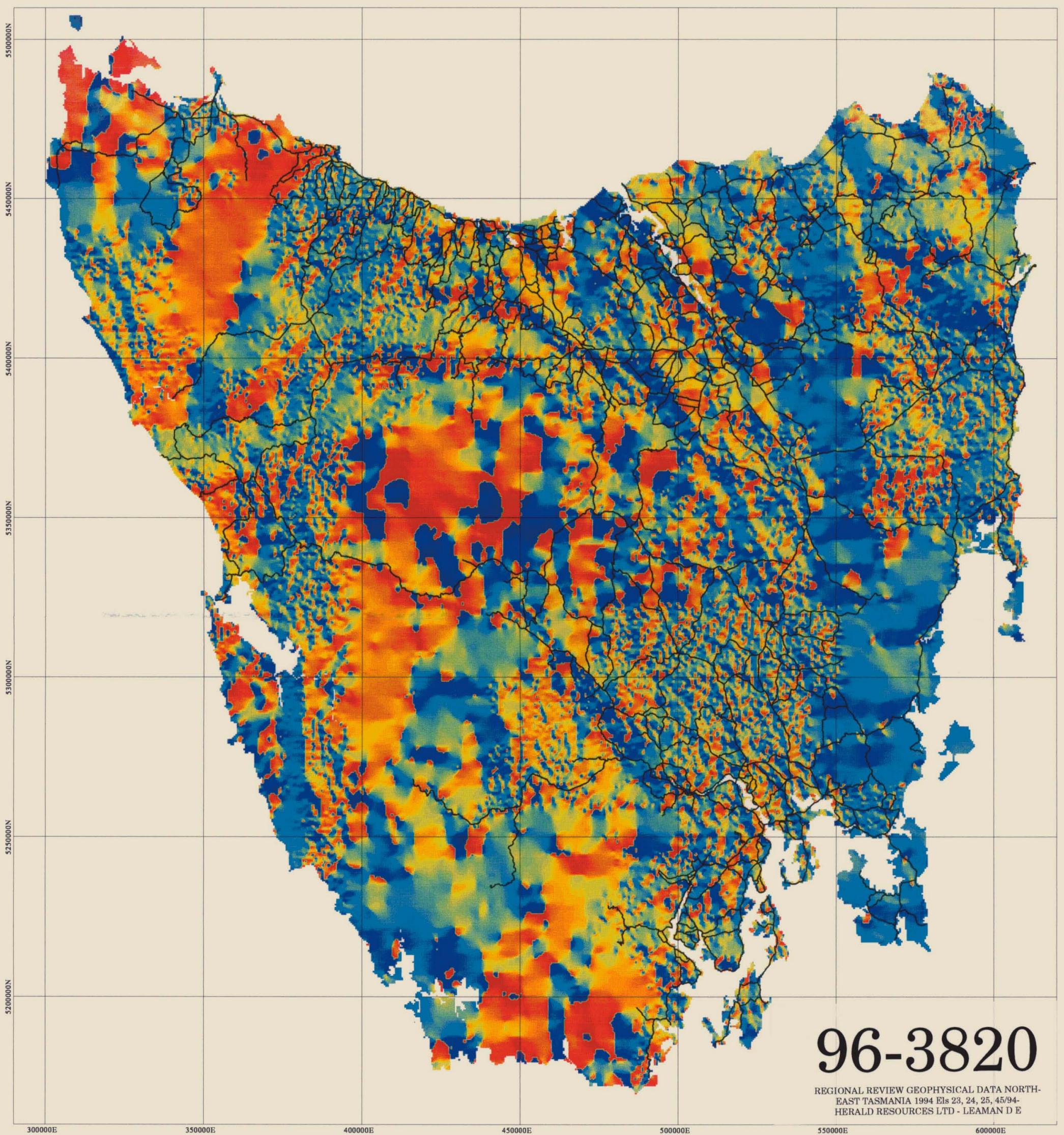
600000E

250m Grid Mesh

Mineral Resources Tasmania 1994



resaspect_alg

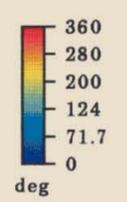


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REGIONAL REVIEW GEOPHYSICAL DATA NORTH-
EAST TASMANIA 1994 EIs 23, 24, 25, 45/94-
HERALD RESOURCES LTD - LEAMAN D E

Residual Gravity - Aspect

Map 8



731068