MRV

PROJECT

1987

Mt Read Volcanics Project

Geophysical Report 5

Mineralisation Signature Study: Geophysics Gravity and Magnetics

by D. E. Leaman

Tasmania

MINERAL RESOURCES TASMANIA

029002

MOUNT READ VOLCANICS PROJECT:

MINERALISATION SIGNATURE STUDY:
GEOPHYSICS

GRAVITY AND MAGNETICS

by
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For
Mount Read Volcanics Project
Department of Mines, Tasmania

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029003

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FIGURES

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SUMMARY

Public domain gravity and magnetic data around the principal mineralised sites in western Tasmania have been reviewed and any direct responses described. In some cases the extant data base has been augmented. The effect of analytical line processing methods has also been reviewed. The primary objective has been, within the limitations set by available or acquired data, to evaluate the usefulness of various exploration methods with respect to differing styles of mineralisation, terrain and host geology. Those procedures which might contribute to resolution of incidental problems such as glacial or basalt cover have also been reviewed.

Regional AEROMAGNETIC data are available for the Cleveland, Renison, Mt. Bischoff, Hellyer, Que River, Rosebery, Hercules and Mt. Lyell areas. Tin mineralisation at Cleveland, Renison and Mt. Bischoff generates a strong magnetic response which is superimposed on a highly disturbed field reflecting gross thermal alteration by nearby granites. Lead-zinc mineralisation at Que River, Rosebery, Hellyer and Hercules produces relatively subtle but characteristic anomalies. Appreciation may depend on terrain and geological correction or derivative presentation. Much of the effect appears to reflect alteration about the ore rather than the ore itself. Lyell style copper-gold mineralisation also presents relatively subtle responses within grossly altered volcanics. The altered material is itself identifiable regionally but complete data correction and evaluation of a complex array of structural sources may be necessary first.

No detailed analysis of surface magnetic data has been undertaken but it is possible to infer that such surveys must be extensive in coverage with, preferably, a redundancy of observations if the effects of noise are to be defined and removed.

Evaluation indicates that available magnetic data has been underutilised for applications other than simple qualitative unit correlations or mapping support and that it can be employed with great benefit through all phases of exploration. The effort required to extract information on structure or property alteration may be substantial but less than that required to properly evaluate electrical surveys. The areal information provided can often be inferred in no other way and data acquisition costs are very low. Extended magnetic interpretation also retains the advantages of low cost while retaining and demanding a direct geological relationship between staff or programmes providing studies on properties, structural solutions, and input geological control. The technology is very much "feet on the ground" if applied to extract the optimum geological content in available data.

Regional GRAVITY data have been used to provide additional control on the structural setting of the deposits.

More detailed surveys at Que River and Hellyer have demonstrated that orebodies of this type generate a significant response. It is important that the regional field be defined or that the station coverage extend beyond the limits of the immediate prospect. Full terrain correction and meticulous field work is essential. The situation around Mt. Lyell is more complex and ore definition depends on extended analysis.

The gravity and magnetic surveys examined demonstrate that the potential methods offer viable, cost effective means of prospect assessment. While it is possible to employ high resolution, detailed magnetic methods on a grand scale and use the results to infer sites for follow up study, using magnetic or other methods, gravity methods should only be employed at follow up scale. The regional and tie framework of the gravity network in Tasmania is now approaching a coverage status where extended site survey will no longer be required with commensurate reduction in survey costs. While direct ore detection and evaluation by ANY method is depth and property limited this study demonstrates that deposits of economic size can be located by the potential methods at depths up to 300 or 400 m at least. Magnetic methods are more sensitive to lithological variations and can be used to define deep alteration which may conceal or contain an orebody. Both methods can be used to describe the structural setting but this may require advanced, three dimensional, whole geology analysis in some situations. The methods posses the ability to evaluate rock masses covered by till or conglomerate.

Regional gravity and magnetic data also indicate that economic mineralisation within the Mount Read Volcanics is related to major alteration zones within the crust. Several of these have been defined and possibly the most significant trend approximately east-west. These E-W corridors are rarely more than 1 or 2 km wide and mineralisation is associated with features (or suitable hosts) intersecting such corridors. It appears at this stage that NW-SE intersections are important. Non volcanogenic mineralisation also appears to reflect similar controls which supports their inferred fundamental character. Precise location of these possible controls on source plumbing may depend on complete correction and analysis of magnetic data and structural analysis, using either or both methods and surface mapping - especially where Devonian dislocations have occurred or are suspected. This style of treatment has been beyond the scope of this study and some of the data currently in the public domain.

INTRODUCTION

This report summarizes work undertaken as part of the Mount Read Volcanics Project. Several mineralised sites were reviewed using available data. Additional data was acquired at some sites (e.g., Boco, Mt. Lyell) or for particular purposes.

Provision of a reference collection of survey procedures and results was the principal object of the signature study. It is inevitably limited by the data available and the time allowed for analysis and represents only the basis for a more comprehensive collection at Tasmanian mineralised sites.

Each site is described individually. Available data, method resolution, specification, data acquisition needs and interpretation procedures have been assessed in order to guide future exploration. Two other special issues have been considered; the problems of surface cover (e.g., glacials) or basalt cover.

This preliminary report outlines assessment of gravity and magnetic data. Detailed treatments are described only for those sites where data was especially acquired for this sub-project. Inferences from regional data are included but the detailed analysis is reported elsewhere (Leaman, 1986a, c).

As the line spacing for regional magnetic data is about 500 m it must be appreciated that many sites may not have been optimally transected and the results presented might not be wholly representative. This is, however, realistic in the exploration context since surveys are typically found, in retrospect, to be far from ideal. Consequently any results indicated by less than ideal line locations are valuable since they provide description of minimum effects.

REGARDING THE METHODS

MAGNETICS:

The magnetics method has been used extensively in W and NW Tasmania for more than 30 years. Many surveys were listed by Leaman (1980). Applications have generally been limited to aeromagnetic overviews or very localised ground follow-up surveys. Interpretation of the former have, in my opinion, rarely done justice to the potential of the survey and have often been qualitative or simplistic and lacked appreciation of material properties. This view was expressed in Leaman (1973a). Other parts of the Mt Read Volcanics Project may fill the void relating to property appraisal (e.g., Hudspeth, 1987). Few second order interpretations exist and those are commonly flawed. Because the potential of magnetic surveys has rarely been realised my first report for the MRV Project (Leaman, 1986a) addressed the issues which might limit resolution or applications while providing samples of more extended interpretation. In that report I suggested that it was possible to evaluate structures in some detail, define zones with altered properties, and infer relationships with mineralisation. Critical issues were shown to be the adequate processing of the data and topographic problems induced by the various methods of data acquisition.

Localised follow-up surveys have generally sought to fully specify obvious magnetic sources identified in more regional or airborne coverages. In view of the results presented in published or open (and closed) file reports this has not been an especially fruitful approach. As suggested throughout this report it is possible that such surveys have been predicated on a false assumption and myopic application. It can be argued that any source producing clear responses in an airborne survey is unlikely to be altered or mineralised material - unless rich in magnetite (not a general condition) - but will be of geological or structural interest. Most known mineralisation is associated with subtle anomalies and relevant responses are set against depressed backgrounds and not strong anomalies (Leaman, 1986a ; this report). These features do not easily correlate between ground and air coverages and considerable areas must be included in follow-up work to define them properly. Consequently Webster and Skey (1979) in their description of exploration around Que River specifically excluded magnetics as a practicable method. An awareness of what actually constitutes a relevant response alters this view.

Several sections of this report demonstrate that local surveys need to be more comprehensive than has been standard practice. This is necessary in order to establish normal versus abnormal property or structural regimes. Better specification or coverage must also be coupled with more substantial and resolving interpretation since the indicator characters are subtle and easily overlooked. The great advantage of the magnetic method is its low cost throughout all phases of acquisition and analysis. Appropriately specified the method is workable even in developed areas(including mine sites and townships) - an overlooked application.

Various techniques have been used to assess the mineralised sites. Many of these processes are well established in the literature, most others are evolved refinements but two are unique. All are proven in exploration conditions.

The aim in each case was simply to assess the implications of profiles near each site and what would be needed to resolve useful character. The profiles bear, inevitably, a Murphy Law relationship to the sites. This is realistic and representative of a survey seeking an unknown. The range of less than ideal line-site correlations can be considered to provide an array of realistic indications.

Data has been adjusted, in most cases, for terrain and flight path irregularities and presented in corrected or derivative forms in order to enhance or expose features. Only in the Mt Lyell case have 3D procedures been applied. These were necessary to provide a demonstration of the ability of the method to resolve an alteration zone even though inspection of the data did not suggest such a feature. This is a vital point for future exploration. Application of these methods were limited in the various phases of the project allotted to me due to time and cost constraints but there is no doubt of resolving power and need for application.

A magnetic survey, in normal map form for example, should not be considered anomalous or a set of anomalies. Such a map merely describes, albeit imperfectly usually, the nature of the magnetic field and it mostly is what the materials - given their normal properties, distribution and geometry were we to know these - SHOULD produce. The deviation from the expected, in so far as we can infer it from geological mapping or property studies, is the true anomaly. Appraisal of such deviations is not simple and requires considerable understanding of properties and much geological input. Only then can unexpected, or disguised, elements of the structure or properties (e.g. alteration) be located. 2D methods can offer some scaling but only 3D methods can resolve the interlocking issues in the rough terrain and complex structuring of Western Tasmania.

GRAVITY:

There has been much less use of the gravity method in W Tasmania (refer Leaman, 1980) but with very few exceptions the applications have been fatally flawed. Problems can usually be traced to lack of rigour in fieldwork and corrections standards, failure to terrain correct and failure to define the regional field before generating residuals by limiting the survey to the immediate objective. Most of the problems derive from two assumptions; that gravity methods throughout all phases are simple, and that anyone can do them. The theory may be straightforward but the practice is not. Long experience of surveys, supervision of contractors and evaluation of standards, has convinced me that few clients obtain a valid data set! Buyer beware. Additionally, at prospect level, it is generally necessary to evaluate sources with 3D methods in W Tasmania due to strike limitations on all sources and problems of complex structural environments. In many areas the definition of the regional field is no longer a problem and extended site surveys may not be necessary (Leaman, 1986c).

Many surveys were undertaken prior to 1967 but the problems noted above led to unsatisfactory results and a judgment that the method was not viable or cost effective. I sought to show that this might not be so in a theoretical appraisal of various mineralised sites (Leaman, 1973b). This very simple review, criticised as a result, may be contrasted with the results summarised in this report and shown to be extremely conservative. While the method was demonstrated to be a valid means of evaluating granite margin structures (e.g. Leaman, 1975b) its use on more specific assignments is still questioned by many explorers.

The rejection of this method is not justified by its record when properly specified and undertaken. Mineralisation at Oliver Hill (Leaman, 1974) and Beulah (Leaman, 1975a) was shown to be uneconomic while that at Que River (Leaman and Richardson, 1981) and Hellyer (Richardson and Hudspeth, 1985; Hudpeth, 1986) is identified and appraised with some precision. Drilling confirmation would indicate that the method is very cost effective in site appraisal.

Reticence to use gravity methods would seem to reflect deflation of beliefs or non fulfillment of expectations over the years. Its theoretical simplicity is not matched by the care and precision required in observation and processing stages and the needs for a valid interpretation. It is not a method for amateurs, as Richardson and Leaman (198) found when reviewing, correcting and standardising an array of surveys for the TASGRAV data base.

REGIONAL INFERENCES

MAGNETICS:

The substance of the following comments has been drawn from the regional conclusions derived by Leaman (1986a).

Many lineaments are evident in the raw data presentations of the magnetic field. Some are clarified by analytical processing. E-W trends which generally lack strong supporting surface geological evidence appear to dominate NW-SE and NE-SW trends.

Available rock property data, measured or inferred from the anomalies, generally lead to structural interpretations which are consistent with inferences from surface mapping in the first 1 to 2 km below surface. However, large tracts of the province appear to have been overthrust (also Leaman, 1986c).

The magnetic field is disturbed and distinctive around the perimeter of most granites. Thermal metamorphic halo effects are implied. Processing can allow separation of source form and distribution from near surface effects.

Major mineralised sites appear to lie near the intersection of NW-SE lineaments and E-W corridors. This may appear to be a fortuitous effect given the possibility of late Cambrian or Devonian thrusting since block relationships should not, in general, have been maintained. It may be, however, that the corridors reflect deep crustal fractures or older fluid conduits whose location was barely modified by the history of complex high level deformations. In this case major Cambrian blocks and post Cambrian blocks might retain similar features while also carrying later overprint effects. There is some suggestion that some corridors are not continuous (refer Figure Lineament 6) but the options suggested in this summary cannot be evaluated until a complete analysis of the data has been completed. The separation of the potentially more fundamental E-W features can account for the longitudinal spacing of mineralised sites. Complex structural and sourcing issues are implicit in these suggestions and any exploration use of the concept requires careful structural analysis and review of the magnetic field.

Most tin deposits appear related to the alteration halo effect of local granites. Anomalies associated with other types of deposit appear to be subtle.

Prospect review requires a combination of structural control and signature analyis but most aspects of lineament and signature definition require correction and treatment of the data.

Consideration of the results from aeromagnetic data indicates that ground magnetics may prove confusing and noisy in many situations and that the only solutions are to use a close sample spacing, filter appropriately, and ensure that profiles or coverage is adequate. Long lines and a redundancy of data may be essential.

In some lithologies it will be necessary to analyse variations in properties in order to identify the most prospective sites. Most mineralisation is not strongly magnetic and host alteration may be a better indicator. Property variations can be inferred from the observed field when constrained by the geometric distribution of rock units. This style of interpretation is essential if deep targets are to be detected.

GRAVITY:

The following limited comments are based on the preliminary regional analysis of Leaman (1986c). Most mineralisation is concentrated within the acid-intermediate units of, or associated with, the Mount Read Volcanics or in the marginal or roof rocks associated with major Devonian plutons. The Mount Read Volcanics are a small portion of the Cambrian section volumetrically and are mainly located above and east of the margin of principal Cambrian rifting. In most situations the volcanics rest on continental basement. Mineralisation appears to be concentrated in haloes around the feeding systems for the volcanism, as reflected by granite plugs of limited volume presumed to have been subsidiary magma chambers. Devonian granites are concentrated around the intersection of Cambrian rifts at Waratah. Denser, more mafic, parts of the sequence account for a large fraction of the section within the Dundas Trough.

LINEAMENTS:

Several diagrams incorporating data from the prospect data base of Bamford and Green (1986) and lineaments inferred from the gravity and magnetic data are included (Figures Lineaments 1 to 5). Several comments are necessary.

1.
The prospect data base in incomplete around the periphery of the area plotted and may not be complete within it.

2.
The lineaments shown are essentially qualitative. Many were described by Leaman (1986a, b, c). These diagrams differ from earlier versions since most possible alignments of any continuity are shown - whether real or imaginary, however influenced by the data distribution. This was done in order to simulate some sense of frequency or extension as might be obtained by pixel integration methods.

3.
Three potential criticisms were expounded at the Burnie Symposium in November 1986 when these diagrams were first displayed.

a) Could the near E-W trends be an artifact of the survey flight paths. This topic was reviewed by Leaman (1986a) and there is both quantitative and qualitative evidence that the major features are not generated by line mismatches and that brackets of lines are involved. In any event many features are evident in gravity data which carry no line bias. Some trends are clearly reflected in the deposit plot independent of the lineament base. This trend should not be rejected outright and certainly not because it was unexpected.

b) Are there so many trends that the maps are useless? Perhaps, but only time will tell. It is better to plot any seen or suspected features rather than bias a plot with currently favoured concepts. A frequency analysis of these plots, and future refinements - as data density is increased or data analysed completely - may be critical to appraisal. For these reasons I have shown as much as possible and kept judgmental options open.

c) Are the maps of any exploration use? This question is also related to (b). It was considered that too many lineament possibilities may be a cause for concern. A further expressed worry was lack of resolution. What value is a plot that cannot specify a location for pegging? I believe these concerns demonstrate a misunderstanding of the origin of these Figures and usage of lineament diagrams.

The lineaments illustrated are rather subjective and derived from regional data. There is clearly scope for refinement. But, if there are intersections in or near potential hosts - whether exposed or concealed - then surely such sites are worthy of closer inspection or should, at very least, escape the relinquishment axe temporarily. It matters little whether the area can be specified to the nearest metre or nearest kilometre. A focus is obtained for effort which allows internal weighting within an exploration programme.

A target area of 2 or 3 square kilometres which, on regional inferences, appears to contain trend intersections, potential hosts or alteration is an area worthy of close study and further survey. I would recommend gravity surveys on such small areas as a viable follow-up.

In any event the scale of the present Figures suggests, within the definition possible with present data, that there are quite large areas of little interest and that the present work differentiates areas of interest.

In summary, this is primitive, original work. Refinements can be expected but features implied at this level should not be dismissed without good cause. Regional interpretation also suggests that large parts of W Tasmania have been overthrust and care must be exercised when relating particular styles and sites of mineralisation to hosts, sources or mechanisms. Although the gravity coverage is not yet sufficient to define many lineaments or trends it is certain that some features not immediately evident in surface mapping reflect controlling relationships. E-W trend systems seem to be fundamental and older than the conjugate NW-SE and NE-SW set.

029014

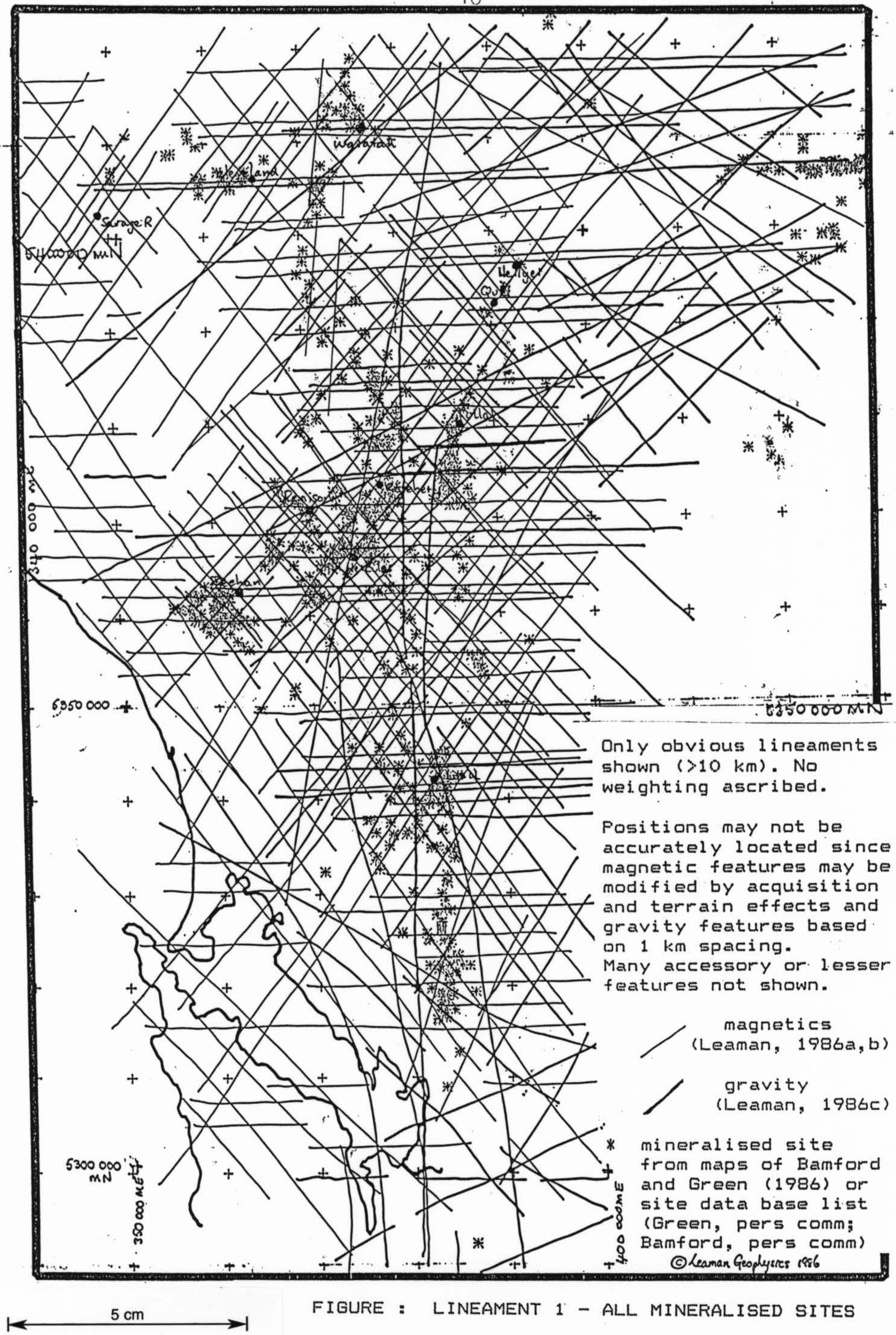

FIGURE : LINEAMENT 1 - ALL MINERALISED SITES

029015

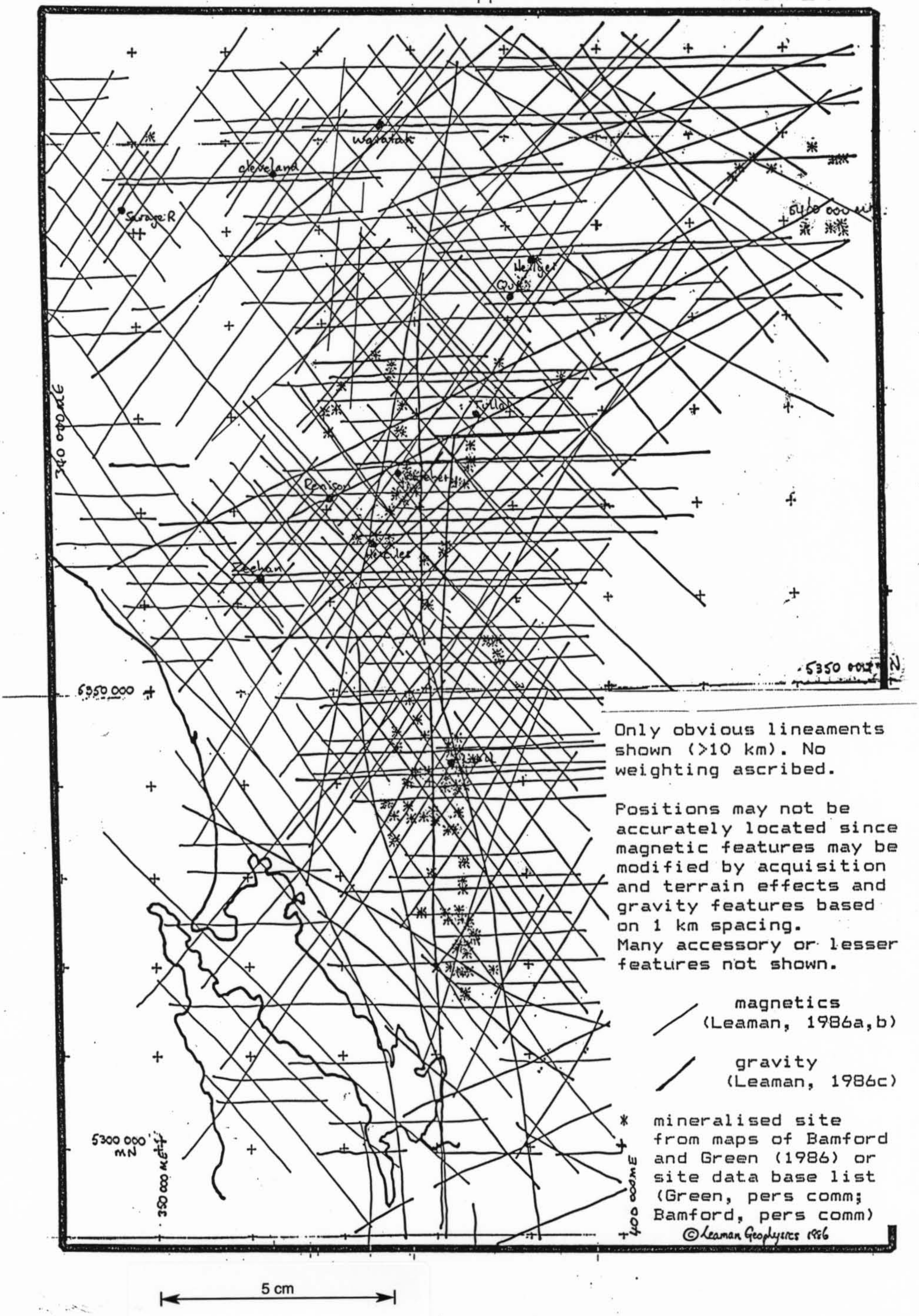

FIGURE : LINEAMENT 2 - GOLD

029016

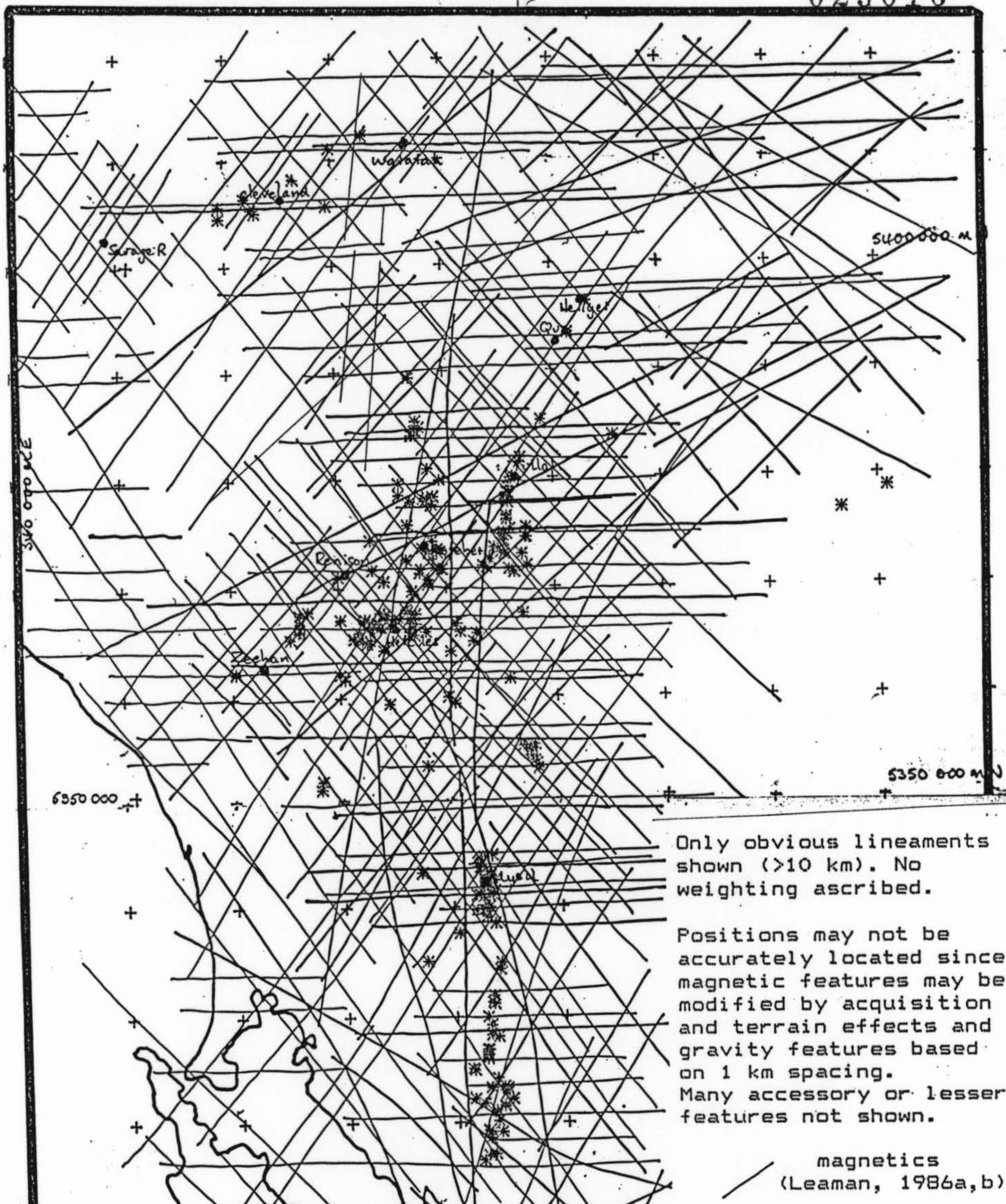

FIGURE : LINEAMENT 3 - COPPER

029017

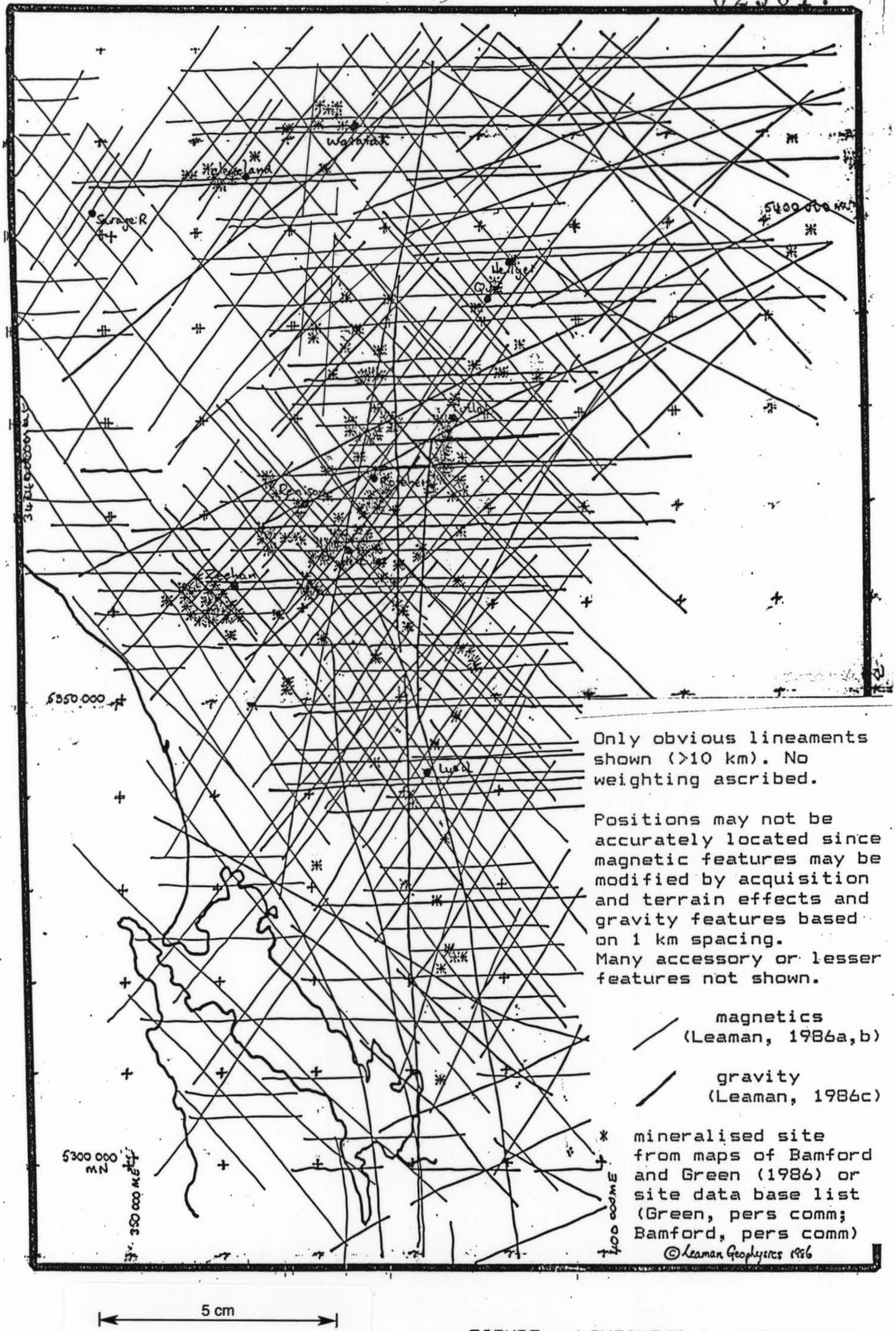

FIGURE : LINEAMENT 4 - LEAD-ZINC

029018

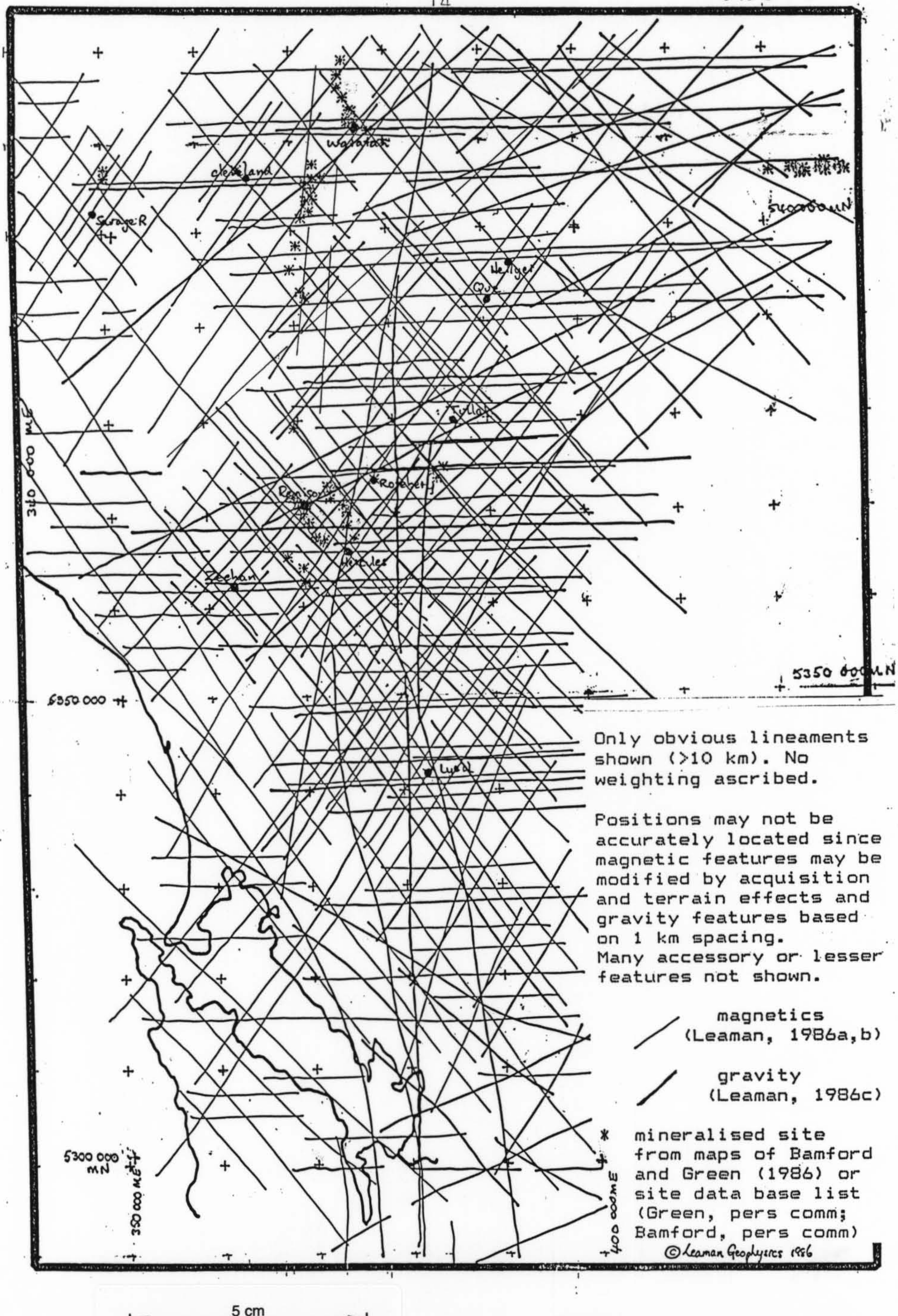

FIGURE : LINEAMENT 5 - TIN

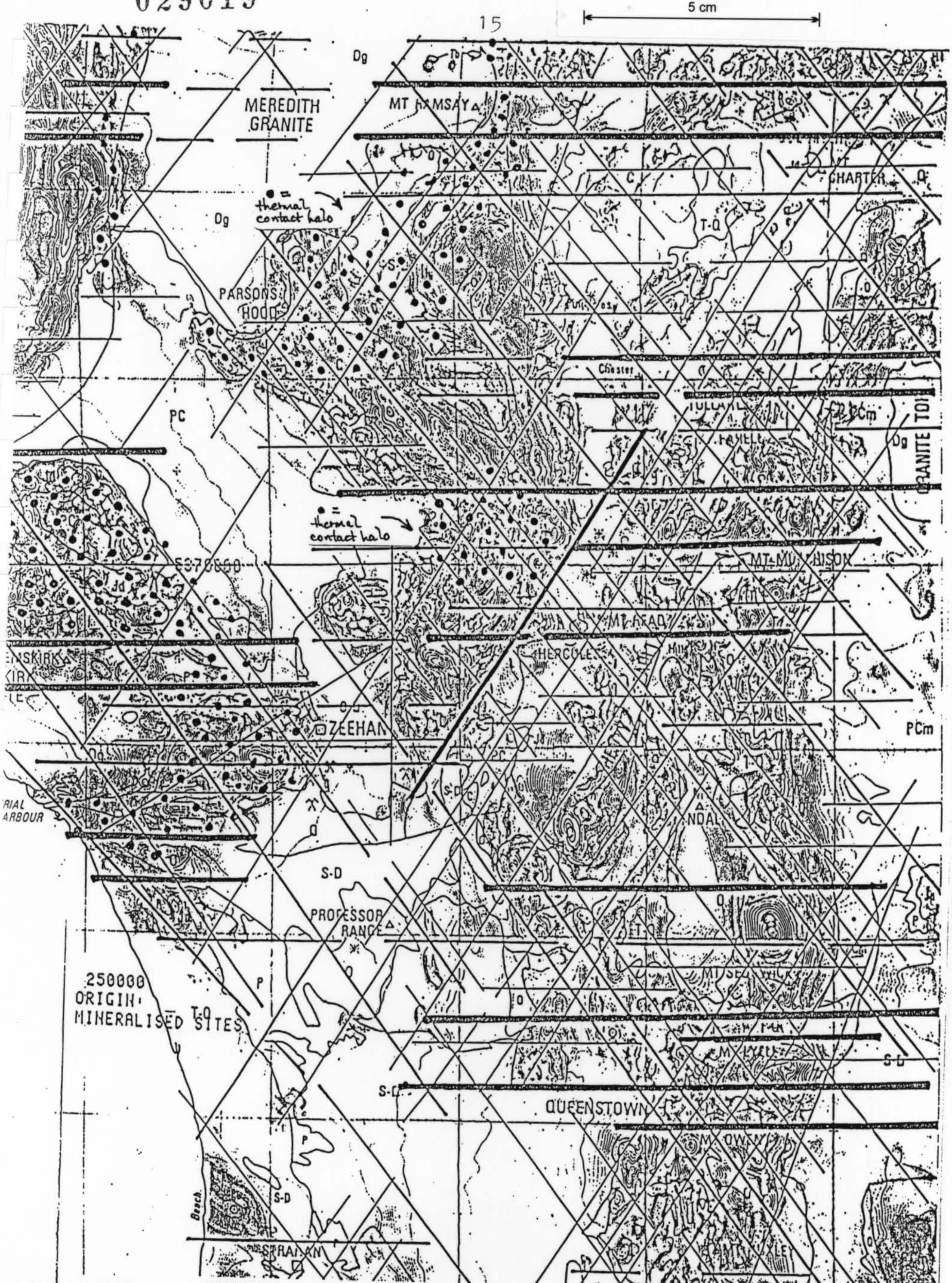

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FIGURE : LINEAMENT 6
OFFSET IN MAGNETIC LINEAMENTS WITHIN DUNDAS TROUGH
(From regional interpretation of magnetic data
Leaman, 1986a)

SITE EVALUATIONS

BOCO:

This site was examined as part of a comparative review of the geophysical methods available for assessment of both the thickness of glacial cover and the material beneath.

Details of recent surveys have been described by R.G. Richardson and his interpretation is included in this report as Appendix 2. Little can be added to the outline provided with the present data. As noted, the main weaknesses relate to line orientation, coverage and observation density and these will be removed by additional work.

Inspection of the magnetic profiles, however, does suggest that "basement" materials (Mt Read Volcanics) do display a range of properties across bands 100 to 150 m wide but the significance of this is not known. The lowest contrast materials lie near geophone 7 of spread 2 and geophone 1 of spread 1. The inferences can be made independently of spike or depth effects.

CLEVELAND:

No detailed data were acquired near this site for this study. Regional considerations have been described by Leaman (1986a, c). Gravity data are limited but regional magnetic data are adequate to show that the deposit is associated with a moderate anomaly. The contribution of the mineralisation to the effect is uncertain since it occurs within a region, marginal to the Meredith Granite, in which the field is disturbed and erratic with limited direct lithological relationships. These effects have been ascribed to thermal alteration (at least)(Leaman, 1986a, Sect 4-B, 4-G ; Webster, 1984).

Similar conditions prevail around the Heemskirk Granite (Zeehan field) and near Renison Bell (below). Leaman (1986a) has shown that for the latter example careful correction and processing of even regional magnetic data can separate various sources and reveal the extent of any underlying granite. Similar procedures may be used to confirm any qualitative, regional lineament implications suggested at Cleveland.

HELLYER:

Regional and site specific gravity data and regional aeromagnetic data are available.

Quantitative magnetic analysis has been restricted to a part of line 1940 (1981 Mines Department aeromagnetic survey - Leaman, 1986a). Results are presented in Figure Hellyer2. The observed field, after correction to a drape, exposes a classic contact anomaly on a regional scale with an abnormal segment near the mineralised zone (see discussion below). Qualitative lineament inferences by Leaman (1986a) indicate that the site lies near the intersection of E-W, NW-SE and NE-SW features. Regional gravity data are less refined but generally support this conclusion. Only the NE trend has any obvious geological control.

The detailed residual Bouguer anomaly (after Hudspeth and Richardson, 1985) is shown in Figure Hellyer1. The anomaly may be directly correlated with the mineralised area even though the centre of mass lies at least 200 m below surface and rarely less than 150 m deep. The observed anomaly is relatively small but, after careful survey and correction, is nearly an order of magnitude above probable noise levels. Given a contrast of 1.76 t/cu m for the ore as quoted by the above authors and Aberfoyle Exploration a minimum estimate of ore mass is about 12 million tonnes for the zone centred on the peak anomaly. Since the contrast has been applied to normal rock densities, localised alteration at the site would lead to the calculation being an underestimate. Its definition to this level depended upon a dense observational array and complete terrain corrections.

Unfortunately, available magnetic data are less specific to the site; line 1940 is at about 5396200 mN. The mineralised zone at this northing is wedged and narrow (see Figure Hellyer1). This line has been examined in some detail, however, since it contains several peculiarities which might well be enhanced over the mineralisation. Several small features are superimposed on the regional gradient. Only two, at 150 m flight clearance, are double noise levels. The first is a low at 329800 mE and the second a possible high at 393200 mE. The derivatives indicate that the principal change lies near 393100 to 150 mE which corresponds to the wedged zone between the ore limits. Structural information is clearly provided by this profile but the off centre response to the mineralisation is consistent with other deposits; a slightly magnetic ore zone is set in a locally lower susceptibility rock mass.

Further coverage is required before the implications of this line (and those at other sites) is confirmed at this deposit. Note, however, that surface traverses would need to be up to 2 km long with a sampling at no more than 10 to 15 m intervals (preferably less than 2 to 5 m) if noise and other problems are to be identified and controlled.

No attempt was made during the treatment of line 1940 to minimise observational or processing noise by filtering. Noise effects are most pronounced in the analytic signal as transferred by the horizontal gradient component.

While a magnetic signature is suggested but not established, even though the inference of subtle high in low responses is consistent with other sites, the gravity response is absolute and there can be no doubt of its correlation with mineralisation. Nor can there be any doubt that local loss of contrasts, due to alteration, has affected the observed field.

A NW-SE lineament can be inferred in the gravity data extending from the SE corner of the plot. This is consistent with regional magnetic inferences but not mapping. The Jack Fault is regarded as the fluid passage. While probably true locally, and at high crustal levels, I would argue that the site of the intersection of other trends - a little north of Hellyer mine - is the true locus of transfer from deeper levels.

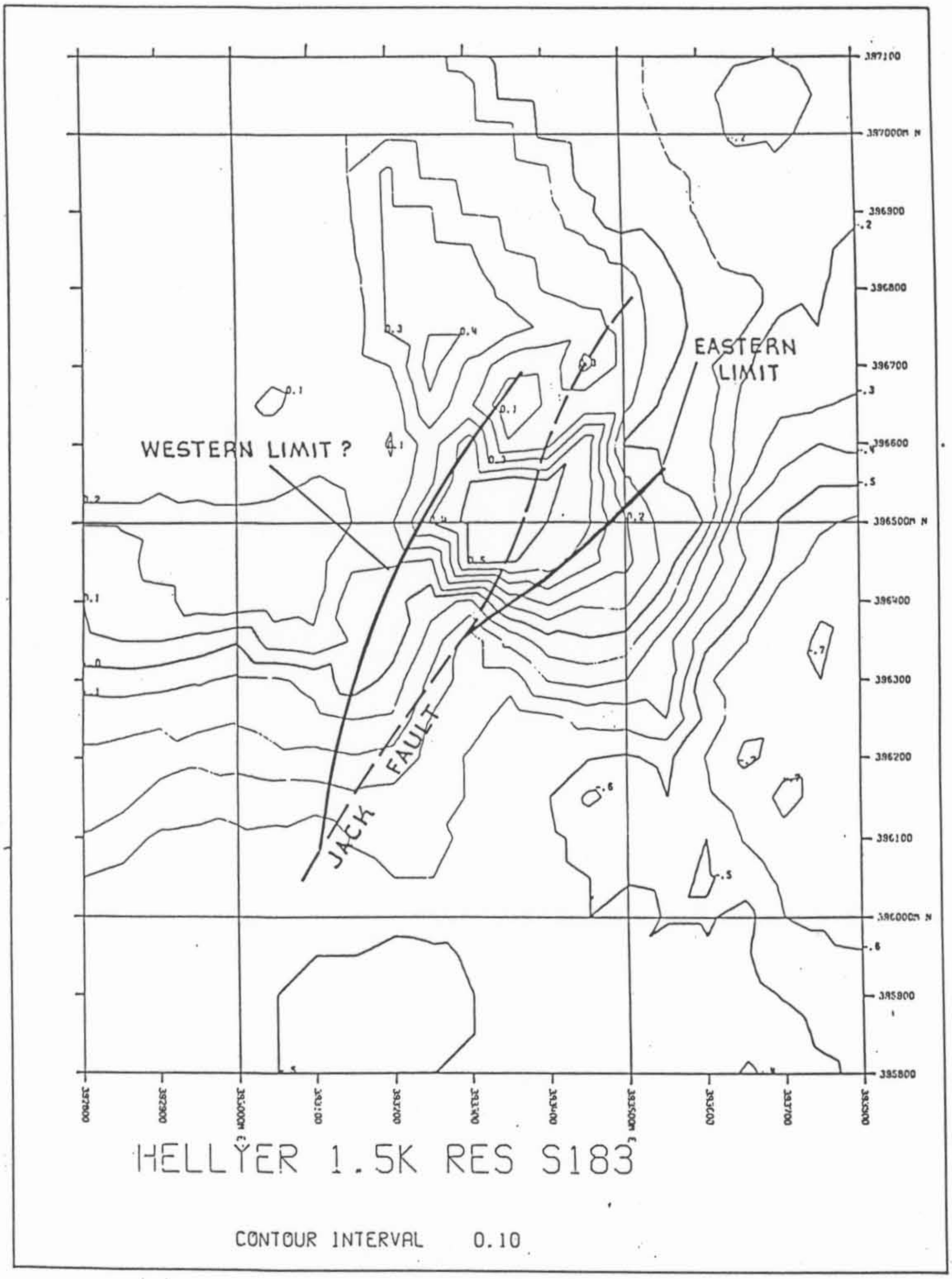

Figure 5. *1.5 km residual anomaly with approximate plan of Hellyer orebody (from Aberfoyle Ltd report, plan compiled by G. McArthur).*
(Figure from Hudspeth and Richardson, 1985)

5 cm

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```
 1            B:HLYERDET      36.5          52.06323
1981 W TAS MAGS 1940 DRAPE 150M FROM 392E   HELLYER
 2            B:D1HYRDET      42.44189      100.1617
VERTICAL DERIVATIVE 1  HELLYER DETAIL
 3            B:D2HYRDET      525.5359      816.5359
VERTICAL DERIVATIVE 2  HELLYER DETAIL
 4            B:ANHYRDET      74.86603      111.9232
ANALYTIC SIGNAL  HELLYER DETAIL
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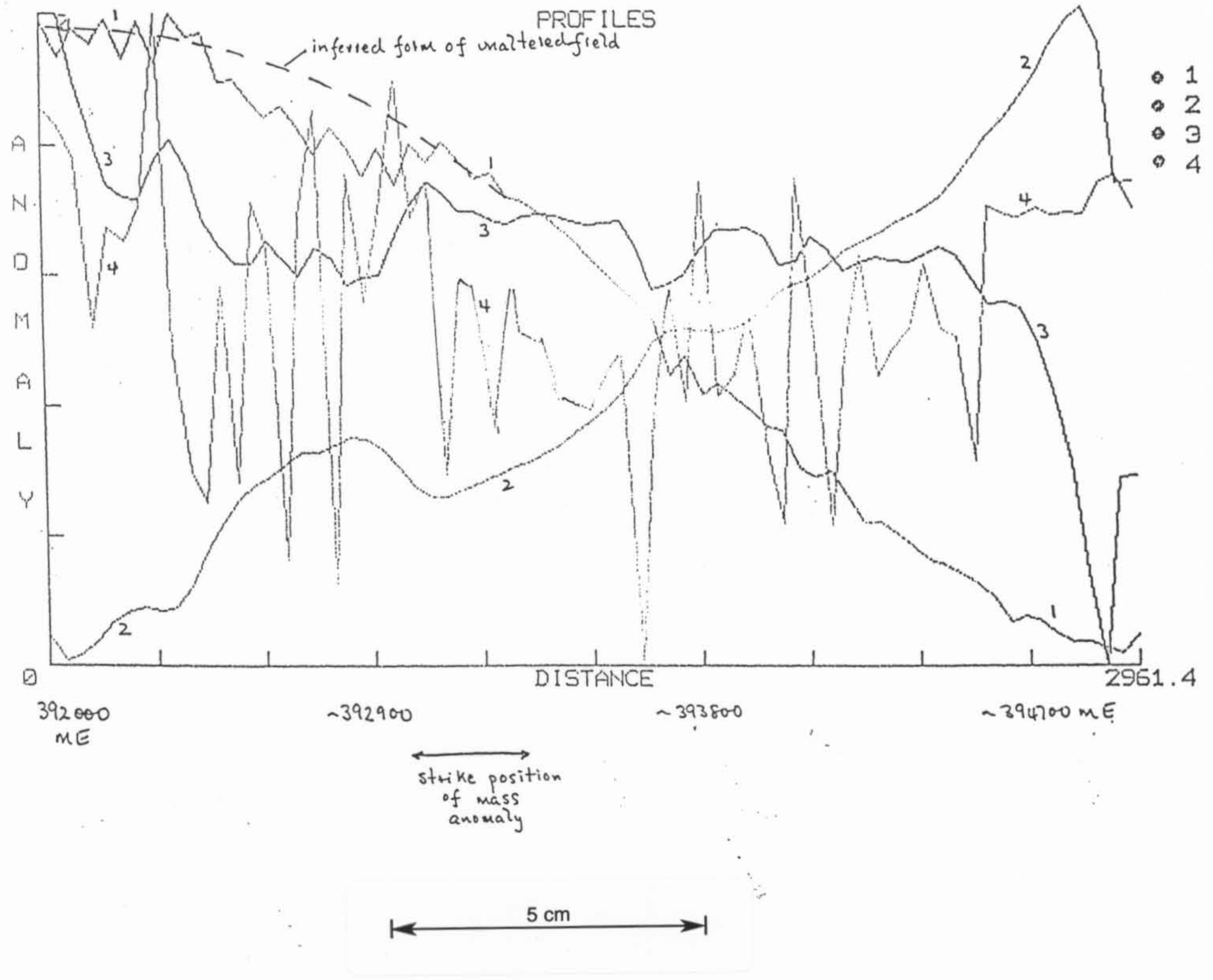

HELLYER DETAIL – MAGNETICS ca 5396 175 mN

FIGURE : HELLYER2

HERCULES:

No detailed magnetic or gravity data are available for this deposit. The regional magnetic data, however, do indicate that the deposit possesses a subtle magnetic signature. The available lines are widely spaced and the maximum response may not have been observed although line 1360 of the 1981 Mines Department aeromagnetic survey passes over part of the deposit. The response is subtle as shown in Figures Hercules1 and 2 but it is enhanced by processing (essential due to terrain and flight conditions) and separable from gross lithologic sources. Figure Hercules1 shows the regional character; the deposit lies on the western side of the "quiet" central portion. Several small anomalies are superimposed on the gross effect induced by the main body of volcanics. Such subtle variations are only recognisable due to the relatively quiet background offered by the body of volcanics. Some of the smoothing effect is probably due to whole rock alteration around the ore and, given the relatively low initial contrast of the volcanics, accounts for the subtle response. Conversely it might be expected to produce a more pronouanced effect in more magnetic materials. The effect might be more emphatic in more magnetic materials but there is little doubt that the magnetic field across the entire volcanic sequence is generally less than the regional and/or geometric relationships would imply. Compare Que River (below). Regional aspects of this site were discussed by Leaman (1986a, Sect 4-D). Another factor affecting responses at this site may be the virtual removal of ore materials. The larger anomalies to east and west reflect gross lithologic changes and the larger features within the central portion of the profile are probably related to tuffs within the sequence. Although the stronger features at 374 000 mE and east of 377 000 mE bias this review it is possible to infer a general regional low effect in this zone which is located near Mt. Read and not further east where structural bulking should place a lithologically sourced anomaly.

The regional data also indicate, especially after some processing clarification, that the site lies within a major E-W lineament corridor near the intersection with a NW-SE feature. Neither are represented obviously in surface mapping (Leaman, 1986a, Sect 4-D).

The critical zone, in which the magnetic field is thought to have been modified by alteration of properties within the sequence about the mineralisation, has been amplified using fully corrected data in Figure Hercules2. When this is done the high in low pattern noted at Hellyer, Rosebery and Que River is evident. It is very subtle at the flight level calculated since correction was to a higher than optimal level due to sampling and terrain difficulties. Even so, the noise pattern west of Hercules is consistent with the observations at Hellyer. The larger anomaly near 377800 mE seems to be a lithological variant.

The aeromagnetic data, while limited and probably not definitive in character, do show that a surface survey would be hard pressed to resolve these effects without high sampling, filtering and extended coverage since it essential that the entire subtle high-in-low pattern be defined.

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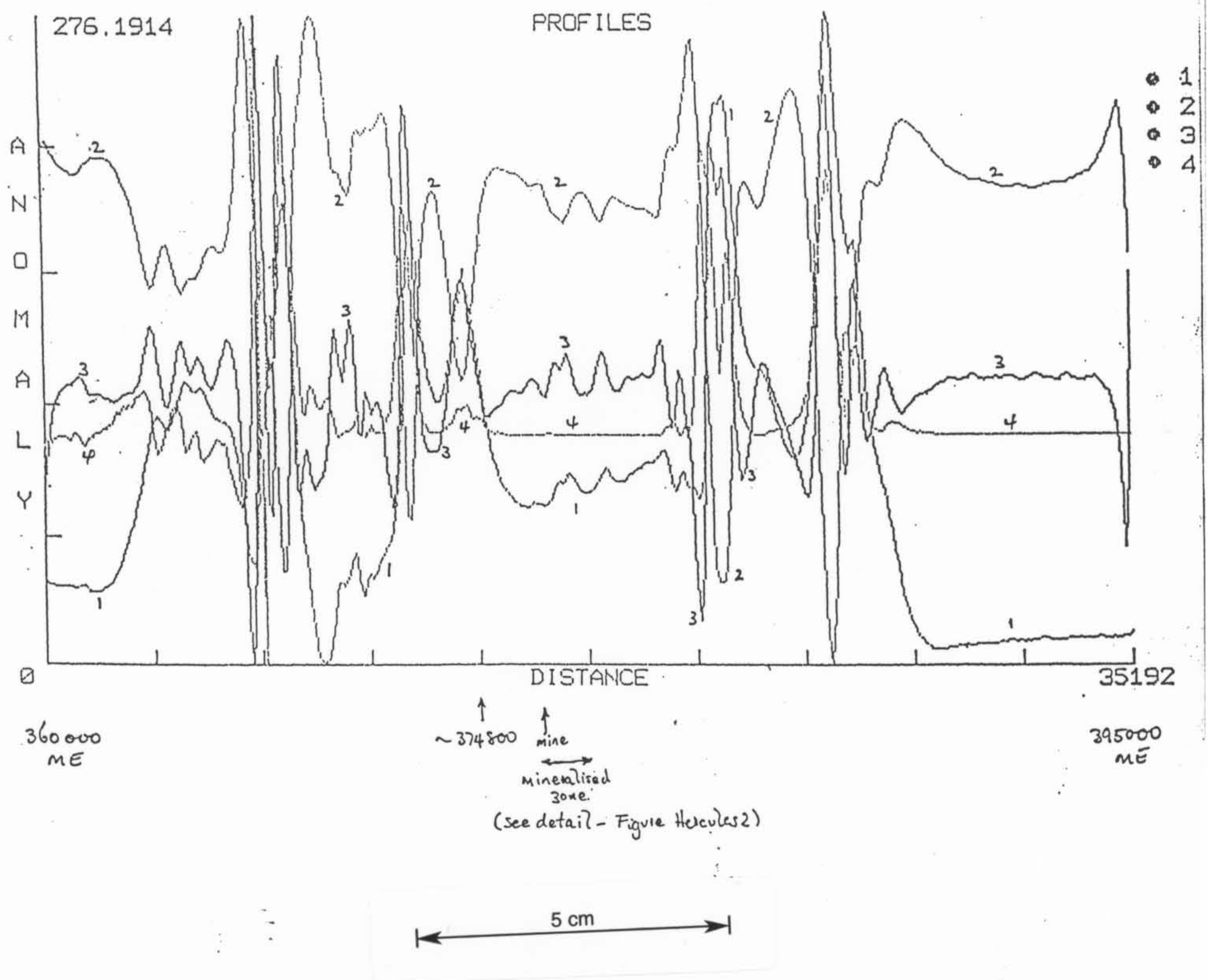
1	B:M1360	93	673
MAGNETICS DATA W TAS 1981 LINE 1360			
2	B:D1M1360	497.8875	731.5486
VERTICAL DERIVATIVE 1 W TAS MAGNETICS LINE 1360			
3	B:D2M1360	1336.827	3069.559
VERTICAL DERIVATIVE 2 OBS DATA LINE 1360			
4	B:ASM1360	874.3696	2499.987
ANALYTIC SIGNAL OBS DATA LINE 1360			



HERCULES REGIONAL MAGNETIC SETTING LINE 1360 - OBSERVED DATA
(ca 5367 000 mN)

FIGURE : HERCULES1

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```
 1              B:HERCUDET      56.01899       85.48101
W TAS MAGS 1360  DRAPE 300M FROM 375E  HERCULES
 2              B:D1HERDET      139.9022       203.2028
VERTICAL DERIVATIVE 1  HERCULES DETAIL
 3              B:D2HERDET      94.71964       200.9156
VERTICAL DERIVATIVE 2  HERCULES DETAIL
 4              B:ANHERDET      212.9672       276.1914
ANALYTIC SIGNAL  HERCULES DETAIL
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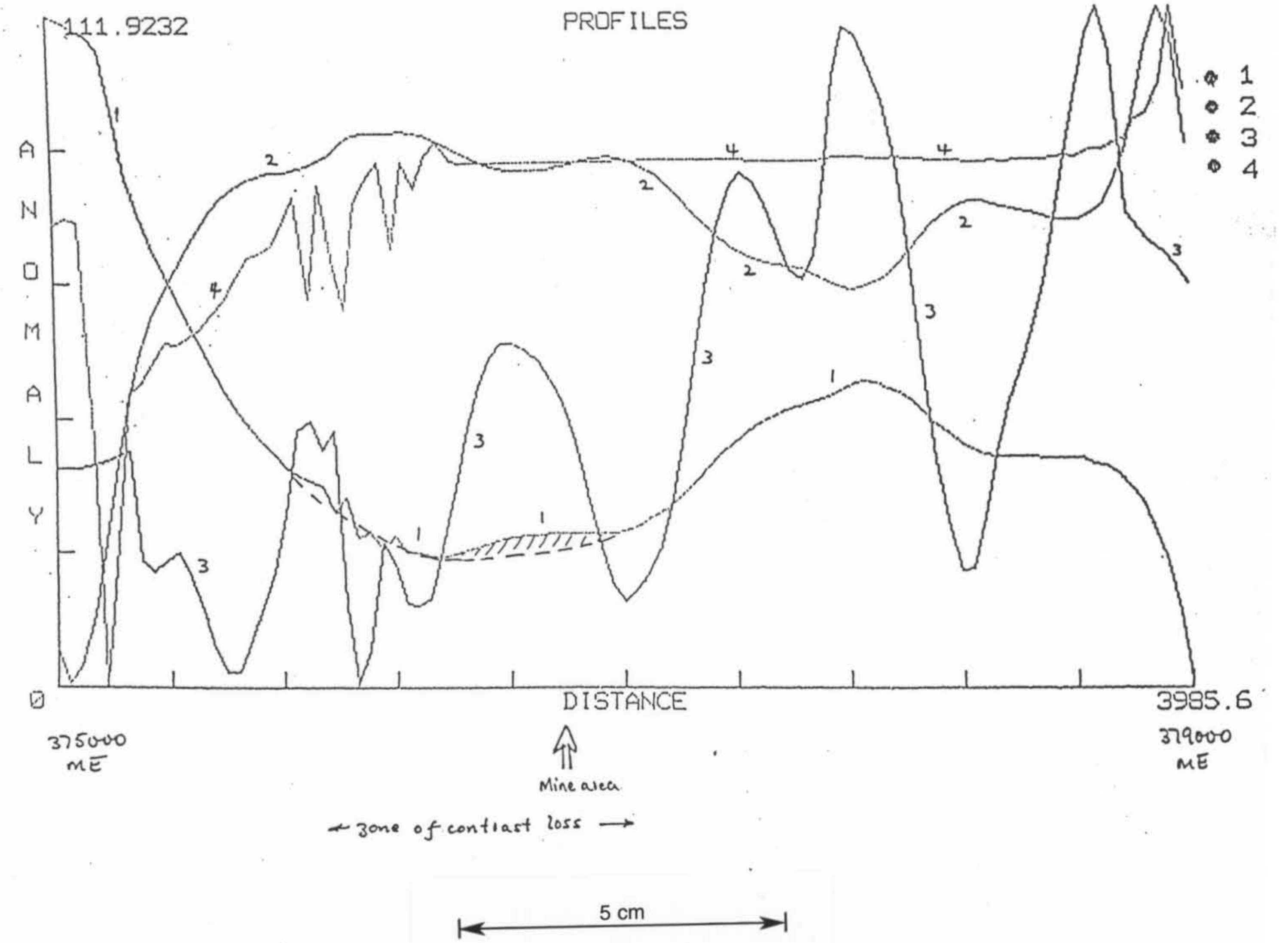

HERCULES DETAIL - DRAPED MAGNETICS (ca 5367 000 mN)

FIGURE : HERCULES2

MT BISCHOFF:

Only regional gravity and magnetic data are available for review. These were examined in some detail by Leaman (1986a, Sect 4-E). The mineralisation generates a strong magnetic anomaly which is comparable in most respects with those observed at Renison or Cleveland. The magnetic environment is less disturbed and a clear spike anomaly is superimposed on a broader but still substantial feature. The distinctive spike would not be observed were the deposit deeply buried or concealed by basalt although a residual suggestion of the broad basal anomaly would be recognised.

The regional data indicate that the site lies at the intersection of a wide array of lineaments. Without detailed analysis the most emphatic trends appear to be E-W and NW-SE.

Figures Bischoff1 and 2 demonstrate both the character of the response and the problems induced by depth of burial or basalt cover. A normalised view of the magnetic field presented in alternative forms is given in Figure Bischoff1. The observed data (1) may be compared with terrain corrected data (2) and continued data (3). The continued data allow evaluation of the effects of increased source depth (or increased source-sensor distances). The true proportions of these profiles is indicated in Figure Bischoff2. Correction, for this area, is not critical. There are severe implications for exploration however. Although the response is not severely modified by depth alone in the absence of any magnetic cover, and consequently might be inferred in other situations, it is virtually obscured where surface basalts are present. Magnetic materials, or rather variations within in them, may generate anomalies with comparable amplitude and frequency characteristics.

The spike anomaly reflects virtual exposure of massively mineralised material with a bulk contrast of 0.01 to 0.015 cgs which is easily attained with a few percent dispersed pyrrhotite. The base anomaly can be generated by a contrast of no more than 0.002 cgs overall although similar effects could be produced by thin, dispersed, deeper concentrations of magnetic material. The regional host sequence is generally non magnetic near the site which may indicate a more complex concealed structure containing pyrrhotite than is evident in existing mapping.

Leaman (1986c) showed the Precambrian host block to be overthrust across a thick Cambrian section. The effect of this structure (see also discussion on basalt cover and Figure Basalt2) and the impressed contact metamorphism due to apophyses from the Meredith Granite could well enhance any anomalous character.

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```
 1            B:M2260WAR      257            790
W TAS 1981 MAGNETICS LINE 2260  OBSERVED DATA
 2            B:FHT2260       256.5807       611.1751
CONTINUATION TO 800M W TAS 1981 MAGNETICS LINE 2260
 3            B:UC2260H       187.3552       359.9
UPWARD CONTINUATION 200M OF 800M LEVEL DATA W TAS MAGNETICS LINE 2260
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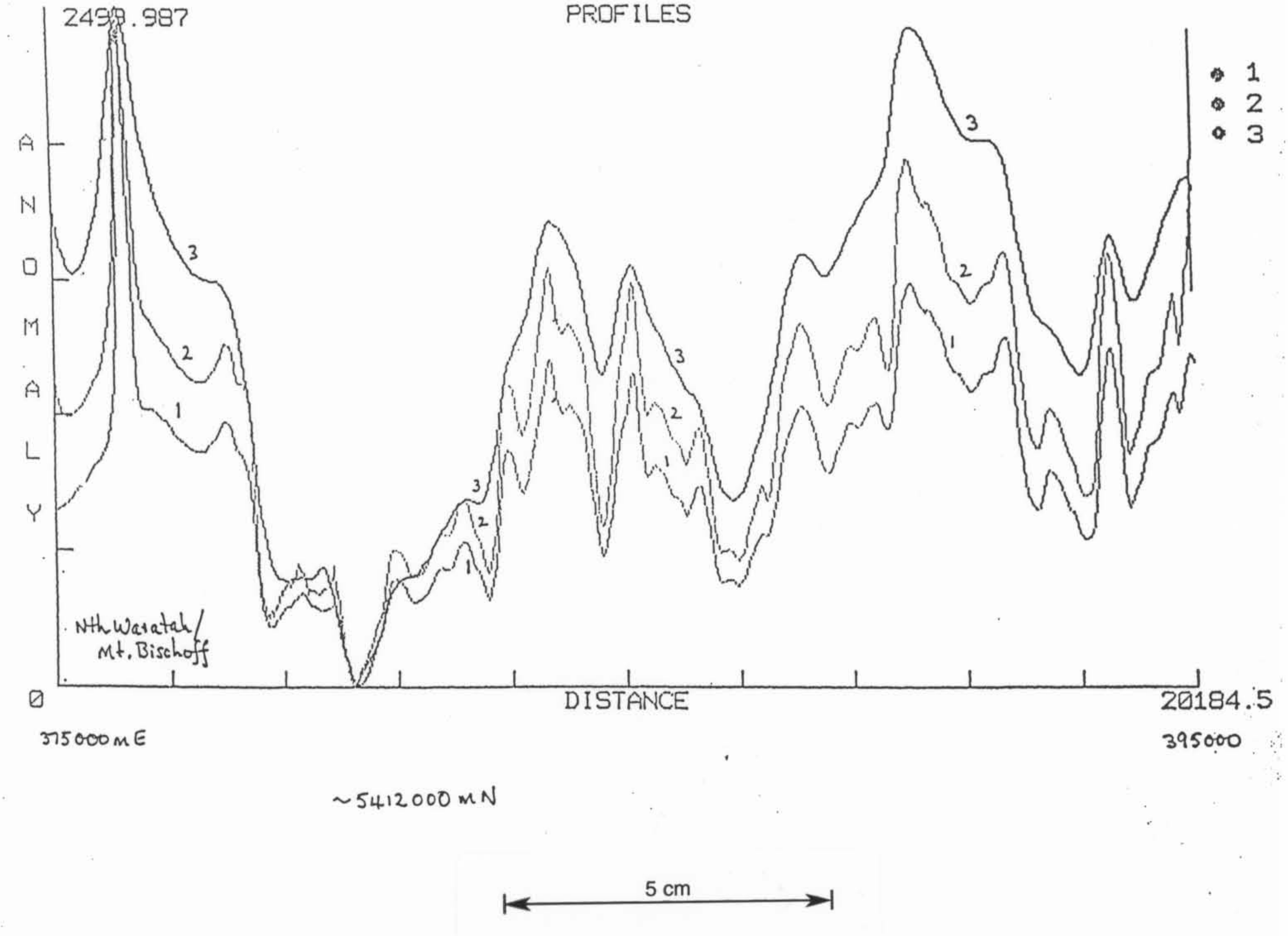

CHARACTER OF MAGNETIC FIELD - MT BISCHOFF REGION
Comparison of observed, draped and continued data

FIGURE : BISCHOFF1

029032

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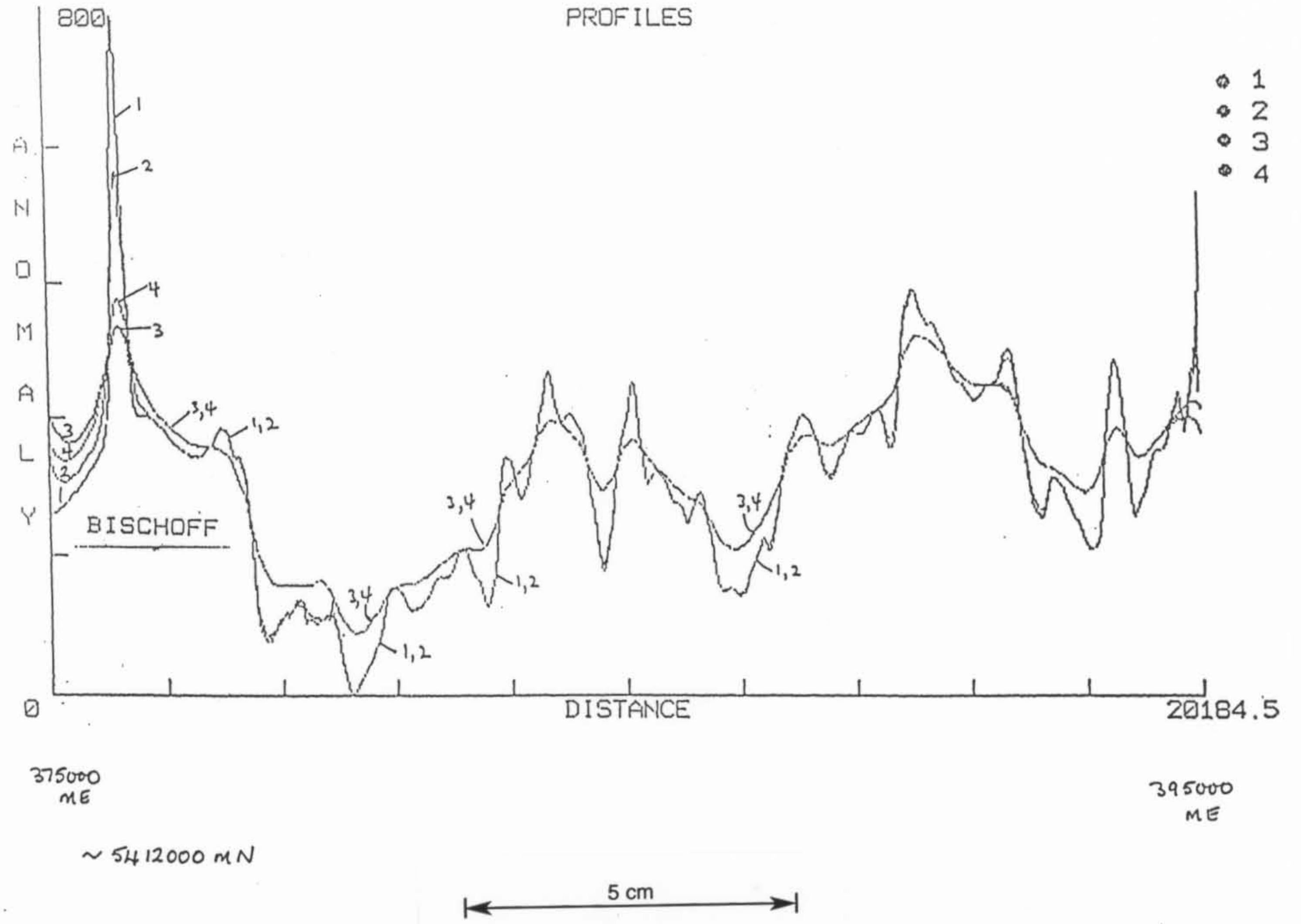
1 B:M2260WAR W TAS 1981 MAGNETICS LINE 2260 OBSERVED DATA
2 B:FHT2260 CONTINUATION TO 800M W TAS 1981 MAGNETICS LINE 2260
3 B:UC2260H
UPWARD CONTINUATION 200M OF 800M LEVEL DATA W TAS MAGNETICS LINE 2260
4 B:UC2260
UPWARD CONTINUATION BY 200M W TAS MAGNETICS LINE 2260 OBS
ZERO SHIFT : 257



REGIONAL MAGNETIC PROFILES - MT BISCHOFF REGION
Amplitude related

FIGURE : BISCHOFF2

MT LYELL:

Regional gravity and magnetic data have been inspected. The gravity data clearly reveal a gross E-W trend system through the site (Leaman et al, 1980; Leaman 1986c). This system was also recognised after analysis of the magnetic data (Leaman, 1986a). The wider than usual corridor is evident on the north face of Mt. Lyell but somewhat disrupted by the Linda disturbance to the south. NW-SE trending structures are not readily separable from Devonian structures locally. Appraisal of the site using either data set requires consideration of terrain interference problems. These can be resolved by source-structural analysis, as described by Leaman (1986a, Sect 4-C) to define the altered rock mass which has a considerable depth extent. Work done to date is insufficient to fully define the axis of maximum alteration within the north-south zone which extends from a little north of Comstock to the Lyell Highway near Gormanston at least. Regional data also indicate some anomalous zones within the broader altered axis and derivative processing allows correlation with established deposits in most cases. The treatment described above is coarse and incomplete but commensurate with the regional data available (refer Leaman, 1986a). A more detailed survey and analysis is justified but the objectives of the Mount Read Projects were limited to determinations of recognisability in minimum coverage data. It is, but not by inspection.

Each line of the 1981 Mines Department aeromagnetic survey in the Lyell region was reviewed for this signature analysis. Areal integration of the results was given by Leaman (1986a).

Several factors reccur across the mineralised axis. Strong anomalies are related to the Tyndall Group or associated materials, basic volcanics or gabbros. Subtler responses are induced by andesites but a high-in-low effect can be associated with the mineralised zone. The magnitude of the effect is controlled by depth and source composition and is only established upon analysis.

On line 851 (Figure Lyell1) the "Blow" area generates a simple strong response but on line 861 (Figure Lyell2) three features are recognisable; the two largest in terms of analytic signal and second derivative are lithological - Tyndall Group near the East Queen River and adjacent to the fault zone at Linda. The third feature, subtlest in the first derivative, can be correlated with the Lyell Mine near the open cut. The dominance of the lithological effects is apparent in the observed data (Figure Lyell2). Deeper sources are only defined, and sometimes only recognised, after terrain correction even though limited inferences can be made using observed data (also Figure Lyell3).

On line 871 (Figures Lyell4 and 5) the field is noisy across the altered, mineralised zone (see also Hercules, Hellyer) but is generally raised above levels generated by regional effects. Clarification comparable with line 861 depends on terrain correction. Various sources can be discounted - basic volcanics and andesites - but the spike evident in the analytic signal lies adjacent to the mine area. Correction and acquisition issues have been discussed by Leaman (1986a) but Figure Lyell4 demonstrates some of the problems in this data set. A normalised format was used here to contrast with the scaled formats standard in Leaman (1986a). Line 4 generally reflects topography while line 5 stresses the clearance deviations. Only lines 1 or 2 provide any real sense of anomaly proportion and relativity.

Line 886 (Figure Lyell6) across Philosophers Ridge shows major anomalies related to basic volcanics and porphyries, andesites, and Tyndall Group. The anomaly near the ridge is very small and best seen in the second derivative.

Line 890 (Figure Lyell7) is similar to line 871. The Cape Horn zone is present as a second order response but the analytic signal is insignificant indicating that the source is off section or deep. Figure Lyell8 presents an extract from a 3D model partial solution (see Leaman, 1986a for more detail) to illustrate the extent of terrain correction on quantitative appraisal of the data (profiles 1 and 4) and the need for allowance for gross structural geometries on definition of the volume of altered material.

Line 907 (Figure Lyell9) is similar to 890 but the Cape Horn mineralisation does produce more sizeable effects (virtually on line). Other sharper anomalies can be related to basic volcanics or Tyndall Group.

Some suggestion of the minimum volume of altered rock is given in Figure Lyell10 for line 925. The base of the volcanic pile is not unambiguously discriminated using simple interpretive procedures and the base of the model should not be taken literally. Other lines require complex correction before comparable estimates are possible for them (see also Leaman, 1986a).

The regional gravity data show that the site lies near a small shoulder on a steep gradient which extends over several kilometres. The gradient mirrors the juxtaposition of the volcanic pile and the Tyennan Precambrian Geanticline but review of the shoulder indicates local structural-topographic effects. See Leaman (1986c). These have been assessed by more detailed coverage (below). The regional analysis demonstrated that any gravity and magnetic appreciation of this region must be based on data that extends well beyond the confines of the obviously altered rock mass. This has never been done using ANY method in previous surveys but it is a critical requirement since no comparative evaluation with "normality" is possible and "anomalies" are difficult to explain otherwise. The more detailed coverage undertaken as part of this project has a nominal station spacing of 250 m and utilised extant grid lines wherever possible. It is much more extensive than most previous surveys around Mt Lyell - especially to the east. As noted below this minimum coverage is essential to gravimetric and structural appraisal.

The results of the more detailed regional coverage of the Lyell region are shown in Figure Lyell11. The compilation presented was drawn from the confirmed data base as at January 1987. Some gaps in coverage persist - especially in parts of the Comstock Valley and on the spine of Mt Lyell itself. Profiles (Figure Lyell12) show that these are not serious deficiencies at the level of the present study. Three effects are immediately noticeable; the strong gradient associated with the Great Lyell Fault passes through - not around - the mountain, the field is "lumpy" along the mineralised zone west of the fault and major offsets are restricted to the northern side of the Comstock Valley.

Gravity field patterns west of the mineralised zone are simple and the characteristics within the Linda and Comstock Valleys are similar but stepped in value. Several faults and structures recognised at the surface are reflected in the anomalies - including the offsets around Cape Horn. The block of conglomerate at Cape Horn is, however, clearly less significant than surface mapping would imply since the deeper structures are not much displaced. This suggests that the imposed Devonian structuring is either relatively minor when compared to the primary (Cambrian) features or that the block movements are shallowly based. Dislocations within the Mt Lyell region can be contrasted with those on the north side of the Comstock Valley. Near the northing at which magnetic data suggest onset of alteration in the Lyell schists (see Leaman, 1986a) the fault zone anomaly bends westward and locally bifurcates. The disruptive trends can be traced eastward and ESE down Comstock Valley.

The structures within the Comstock Vallely are clearly more important thatn those in the Cape Horn or Linda regions. This emphasis was also evident in the regional magnetic analysis (see Leaman, 1986a, Fig 4-C-11, 12) but not fully appreciated there. Similarly, the preliminary 3D magnetic model of Mt Lyell made to test whether the alteration of the schists was identifiable found that the published geometries for structures around Mt Lyell were probably not correct. The gravity data are more clear cut. Detailed structural analysis of either the gravity or magnetic data is beyond the time budget for this signature study and the implications could not be followed up.

The gravity map and preliminary magnetics work undertaken do suggest that the fault zone should be properly defined and interpreted. The information is likely to be of much value to further exploration. Prospectivity may not be diminished by apparent block overlaps or gross crenulations. These comments need not be limited to the Lyell segment of the structure but clearly definition in an area with established mineralisation should take priority.

The profiles (Figure Lyell12) display a surprising consistency for such a complex area and gross differences tend to be systematic. But are the minor irregularities real? This is the critical exploration issue - especially in an area of high relief, steep slopes and mining activity. It may be observed that the deviations are not related to gravity observation, position or elevation errors. The only possible source of significant error lies within the terrain correction. Typical terrain corrections in this survey segment range from 1 to 13 mGal and although some notes on conditions about the station were provided by the observers the best topographic maps leave something to be desired. Some effects might be underestimated due to the steep slopes, large pits and contour intervals provided. Any errors of this type will not affect any structural conclusions suggested above since there is general consistency of results and values from groups of stations intertwined from several loops. Minor problems may affect detailed appraisal of the mineralised belt, with its large pits and cliffs, along the ridge near the Great Lyell Fault.

In order to test this possibility by correlation with terrain problems and to assess any mineralisation signatures a residual separation was undertaken. It has already been remarked that the Bouguer anomalies are "lumpy" in the zone west of the fault between 341 and 345 000 mN - character which persists beneath the Cape Horn spur where terrain effects are substantial. These observations suggest that corrections are reasonably valid and independent of particular topographic issues, some possible small, occasional and local deviations notwithstanding. The survey would be meaningless without the extended terrain corrections applied irrespective of their ultimate precision which is generally better than 0.1 to 0.2 mGal.

The residual separation was based on smoothing of the profiles. The regional field used is shown in Figures Lyell13 and 14. These Figures illustrate the minor impact of the Cape Horn - Linda displacements and show that the North Comstock effect is more significant. The implied residuals are also shown in these Figures. The residuals must be assessed with some caution. While certainly representing relatively near surface effects (sources estimated within 500 m approx) the precise source content is unclear and the removal of large ore tonnages must have modified any signatures. Any serious quantitative appraisal of the gravity field should, in these conditions, be based on the Bouguer anomalies (Figure Lyell11) and not solely on residuals of doubtful content. The separation was undertaken here in order to appraise terrain correlations and identify any obvious pattern to anomalies and mineralisation.

Some qualitative observations can be made. The residuals demonstrate that a NW-SE grain is general but that it is superimposed on a single N-S trend. The N-S trend is made up of adjacent positive and negative components which extend from south of the Prince Lyell ore bodies toward the Cape Horn spur west of the North and Crown Lyell ore bodies. Although this trend is apparently curved to the northwest and terminated near the Cape Horn ore body its natural extension terminates at Lyell Comstock. The disrupting influence of the North Lyell Fault is partly evident in both residual and regional components of the gravity field. I suspect these relationships may imply much about the sequence of mineralisation and structuring in the region. The positive trend reflects the sulphide rich zone west of the Lyell Fault.

Although the residual anomalies are only coarsely contoured in the Figures there are distinct ore body relationships. In every case ore bodies lie near the zero value (probably not important) and at the maximum gradient between local anomaly pairs. The location and definition of this correlation is imperfect since the nominal station spacing of 250 m with some larger gaps is not sufficient to resolve the detailed form of largely mined ore bodies and their associated, more intense alteration zones. The localised anomaly relief - in all cases except Prince Lyell and Blow - exceeds 3 mGal. The stronger effects south of Prince Lyell (and southwest of the Blow) and also southeast of Lyell Comstock are in areas unaffected by large scale mining and exploration (see Figures Lyell 13 and 14). These areas should be examined closely since the first might indicate an extension of mineralisation much closer to the Lyell Highway and the second might mean that the relatively small shows and bodies in the Comstock region are the tip of a deeper ore zone.

There is no doubt, however, that the correlation of gravity anomaly and mineralisation in this region is not as clear cut as at Que River or Hellyer. This may be partly due to ore type and density, background host density or station density, local complexity, character of alteration and depth range. The mineralised belt is certainly picked out and it is possible that refinement and accretion of the data base would result in improved definition. One aspect is certain, there is considerable footwall alteration at least. My experience of other sulphide orebodies has shown that alteration normally dominates the gravity effect and, much as shown to be the case for the magnetic signature of the smaller ore bodies elsewhere in the region, the positive response of the ore is virtually swamped. Any abrupt, negative effects in rocks which should not normally generate them should be taken as signals worthy of attention.

Both magnetic and gravity data sets, although essentially regional or sub-regional in coverage, are able to locate the mineralised zone and would do so without any knowledge of what was present provided some regional mapping information was available. In the magnetics case identification of BOTH alteration patterns and mineralised zones requires compensation for terrain effects and some form of extended processing coupled with basic surface geological distribution of materials. The gravity data, while more visually indicative of the mineralised belt, may be less definitive with extant coverage. The present, rather limited, analysis does suggest that both methods can make a contribution to further exploration of this mineral field. Any such contribution will not be based on simple techniques and must be coupled with a structural-model geological relationship treatment. 3D methods must be used. Structures within and around Mt Lyell are not simple. Both methods are well suited to resolution of such issues. I would recommend that further structural-alteration studies use the magnetic data base extensively with any conclusions tested against the gravity data base. These procedures could be used along the entire length of the Great Lyell Fault and the application would not be significantly affected by cover of till or post Cambrian materials.

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```
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W TAS 1981 MAGNETICS LINE 851
 2             B:D1M851        811.1645       1067.207
VERTICAL DERIVATIVE 1 W TAS MAGNETICS LINE 851
 3             B:D2M851        1128.063       4314.2
VERTICAL DERIVATIVE 2  W TAS MAGNETICS LINE 851
 4             B:ASM851        5.210152       5321.71
ANALYTIC SIGNAL W TAS MAGNETICS LINE 851
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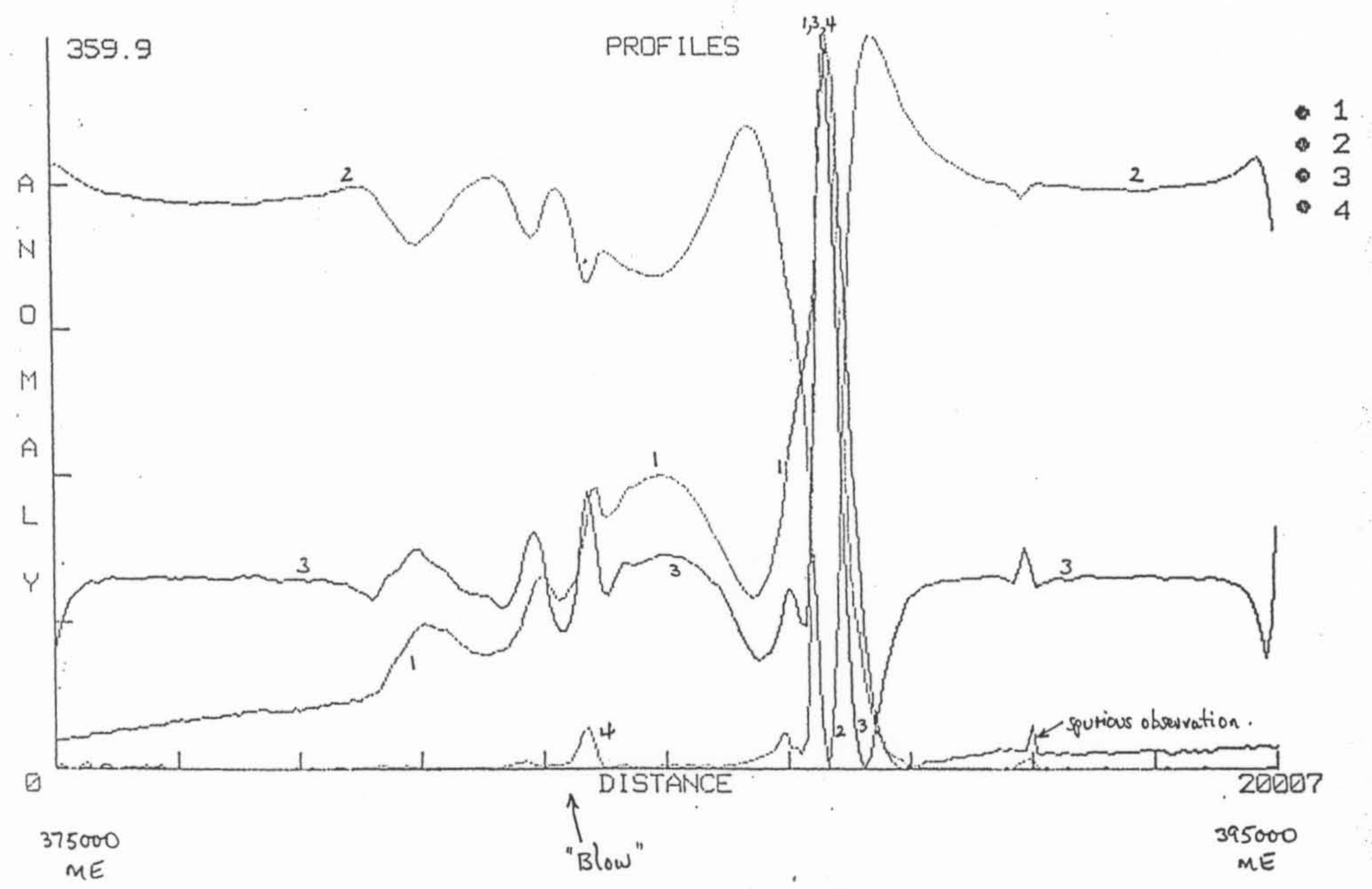

5 cm

MT LYELL MAGNETICS - LINE 851
ca 5341 500 mN, "Blow"

FIGURE : LYELL1

029039

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1	B:M861	29	623	W TAS MAGNETICS LINE 861
2	B:D1M861	448.3709	659.0514	

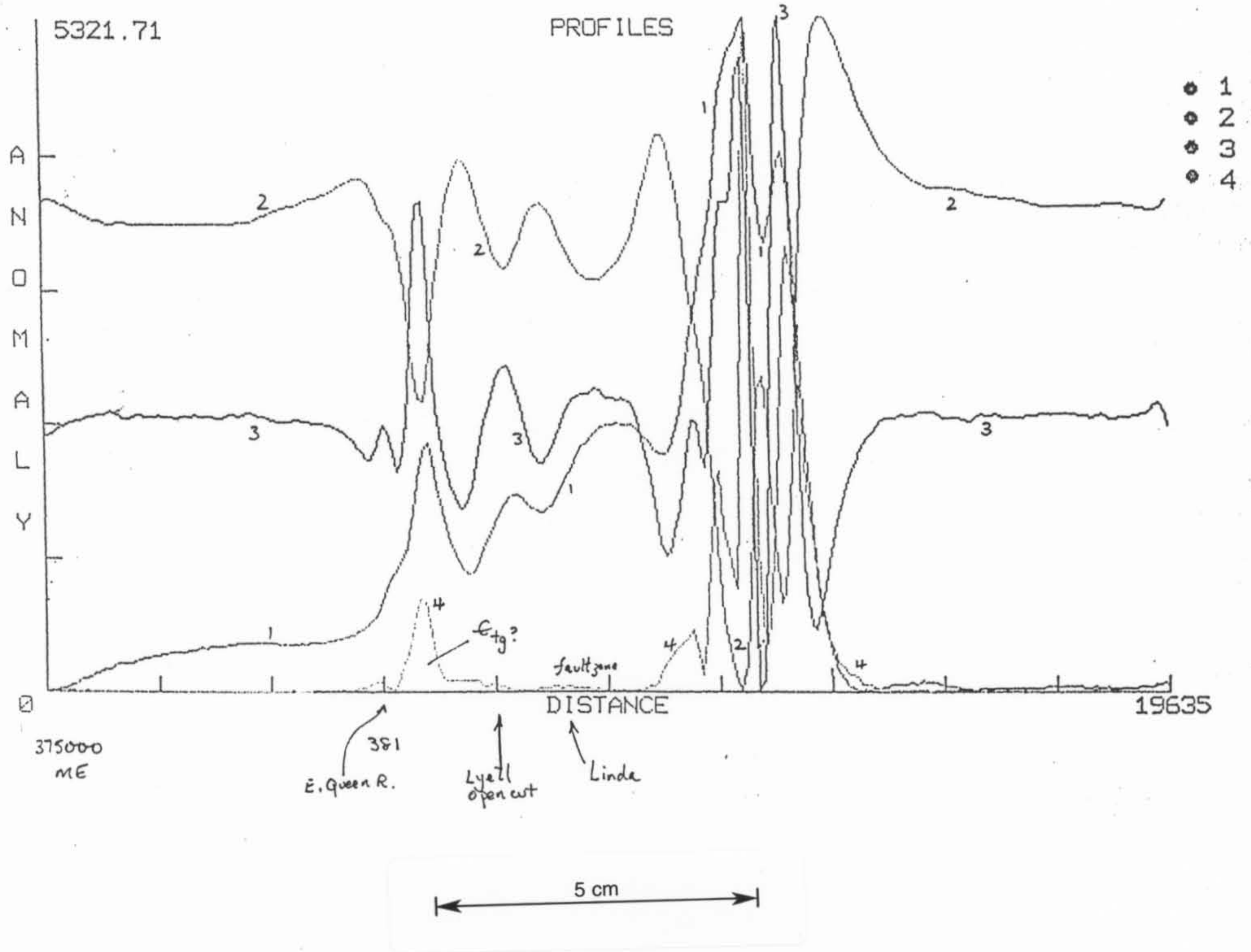
VERTICAL DERIVATIVE 1 W TAS MAGNETICS LINE 861

3	B:D2M861	954.0296	2331.147

VERTICAL DERIVATIVE 2 W TAS MAGNETICS LINE 861

4	B:ASM861	2.282941E-02	1678.372

ANALYTIC SIGNAL W TAS MAGNETICS LINE 861



MT LYELL MAGNETICS - LINE 861
DERIVATIVE TRANSFORMATIONS - OBSERVED DATA
ca 5342 000 mN, "Lyell mine"

FIGURE : LYELL2

029040

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```
 1            B:FHT861        14.4562       412.0882
CONTINUATION TO 1000 M W TAS MAGNETICS LINE 861
 2            B:D1FH861       221.7362      310.38
VERTICAL DERIVATIVE 1  1000M CONTINUATION  LINE 861
 3            B:D2FH861       190.8174      511.2345
VERTICAL DERIVATIVE 2  1000M CONTINUATION LINE 861
 4            B:ASFH861       .1463768      90.64439
ANALYTIC SIGNAL  1000M CONTINUATION LINE 861
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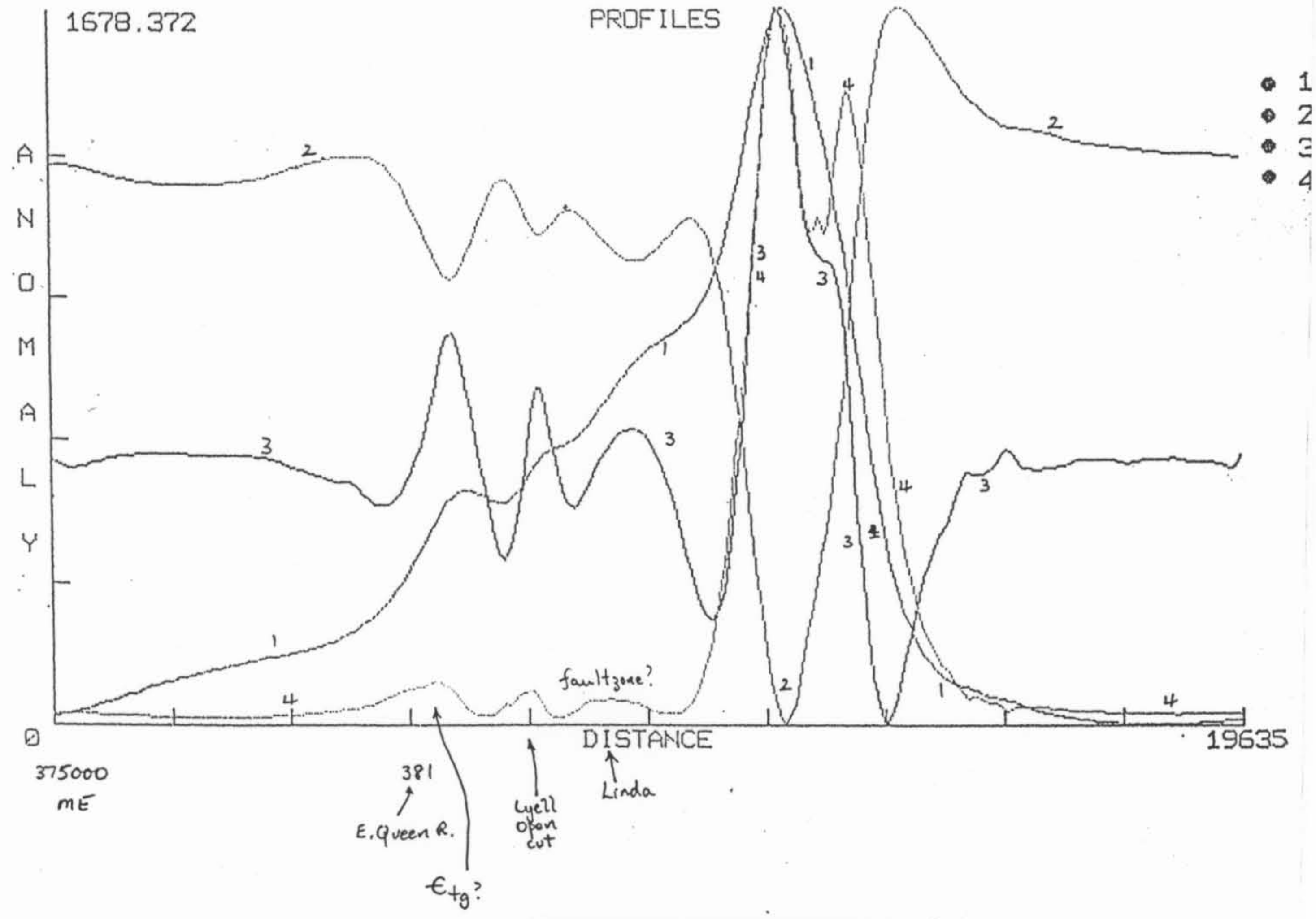

MT LYELL MAGNETICS - LINE 861
DERIVATIVE TRANSFORMATIONS - CONTINUED DATA 1000 m
ca 5342 000 mN, "Lyell mine"

FIGURE : LYELL3

029041

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1	B:M871	34	773	W TAS MAGNETICS LINE 871
2	B:D250871	61.05965	677.6105	

DRAPE 250M W TAS MAGNETICS LINE 871

3	B:FHT871	9.449909	493.9904

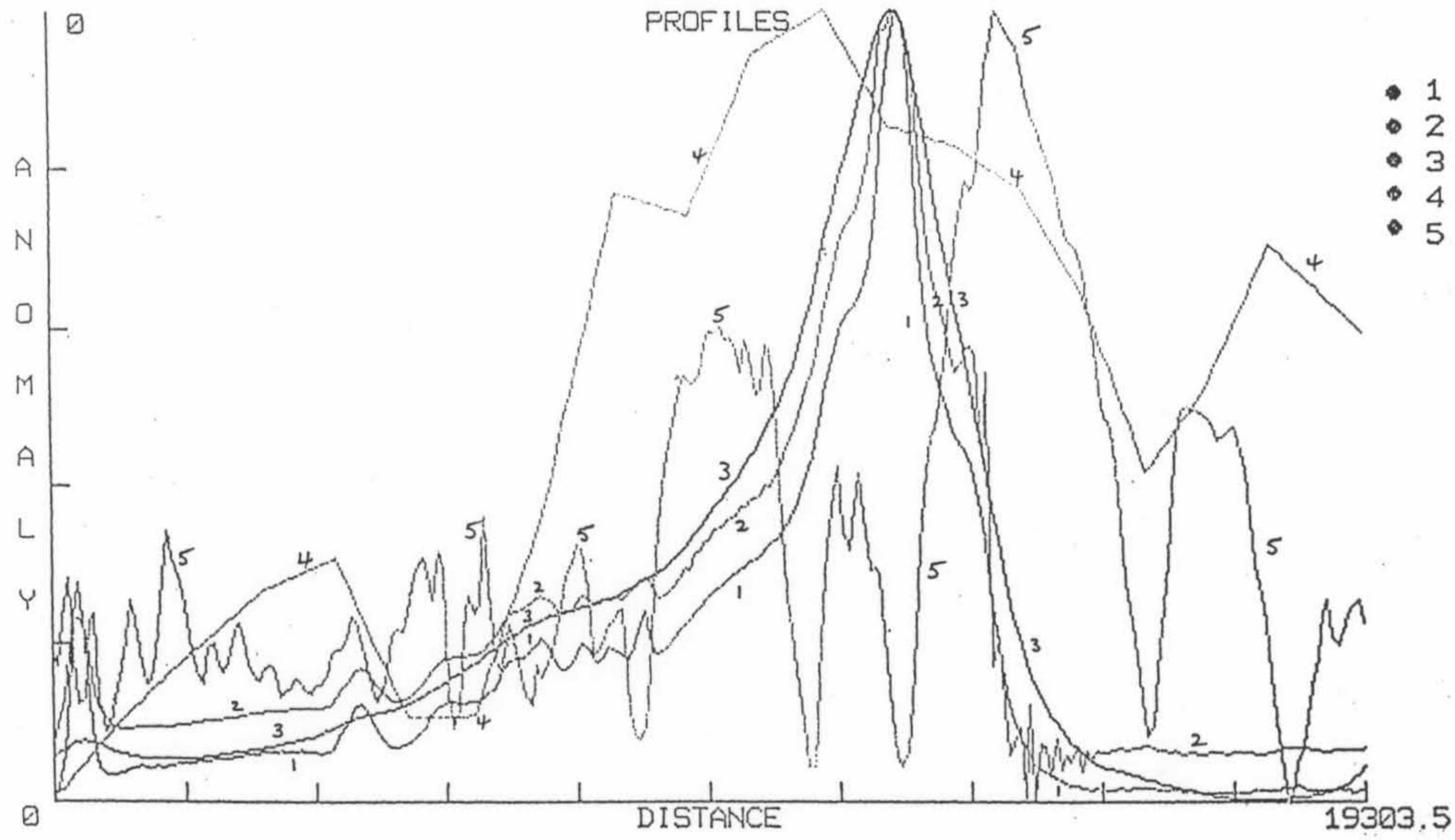
CONTINUATION TO 1000 M W TAS MAGNETICS LINE 871

4	B:ELEV871	342	363

FLIGHT ELEVATION PATH W TAS MAGNETICS LINE 871

5	B:DIFF871	350	1009

CLEARANCE (FT) W TAS MAGNETICS LINE 871



375000 mE

385

5 cm

MT LYELL MAGNETICS - LINE 871
ACQUISITION AND PROCESSING INFORMATION (NORMALISED PLOT)

FIGURE : LYELL4

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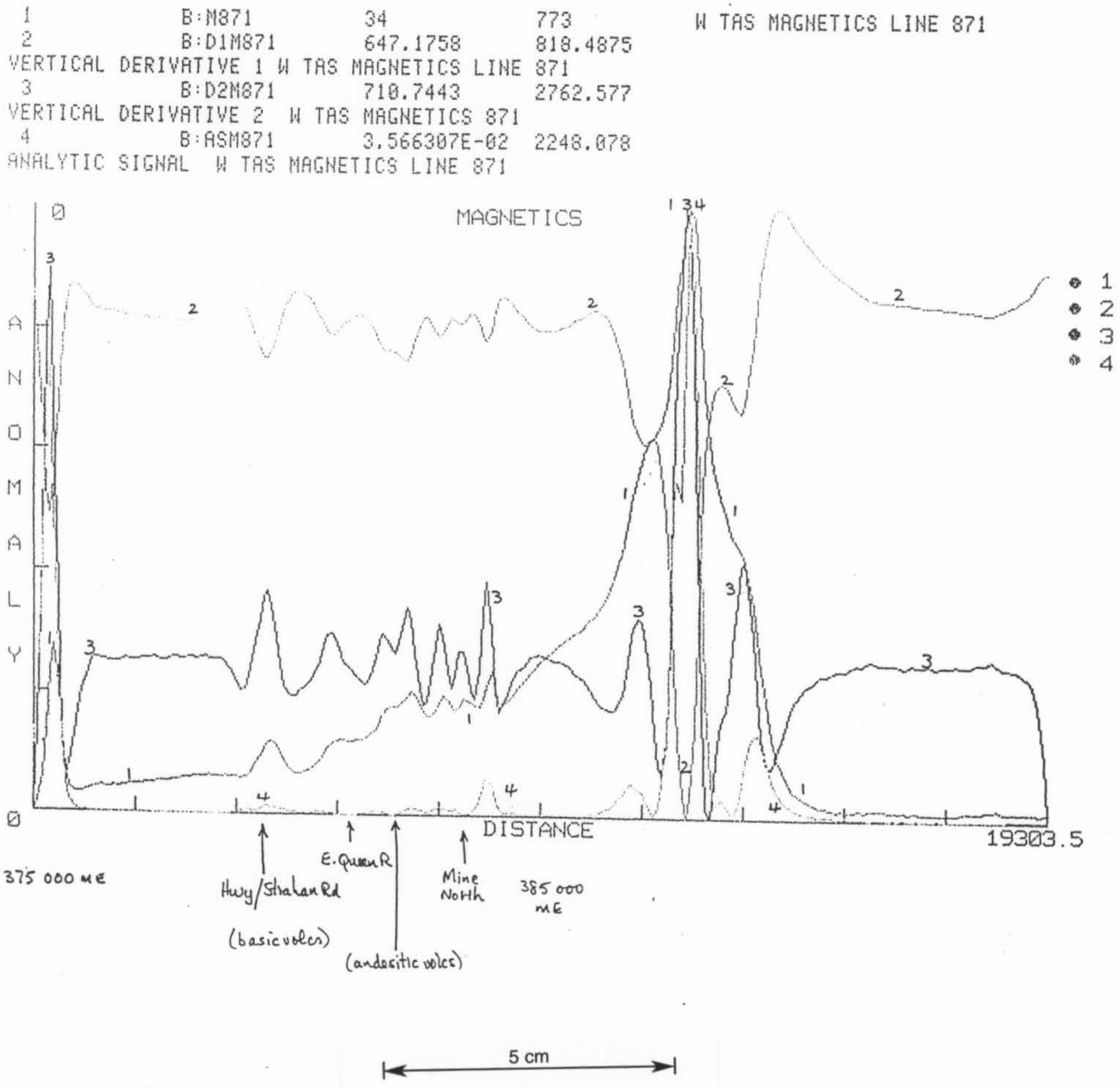
029042



MT LYELL MAGNETICS - LINE 871
DERIVATIVE TRANSFORMATIONS - OBSERVED DATA
ca 5342 500 mN

FIGURE : LYELL5

029043

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```
 1             B:M886          .5            678.5
W TAS 1981 MAGNETICS LINE 886  ORIGIN FID 6487  375E
 2             B:D1M886        495.8448      685.7038
VERTICAL DERIVATIVE 1  W TAS MAGNETICS LINE 886
 3             B:D2M886        1024.251      3942.049
VERTICAL DERIVATIVE 2  W TAS MAGNETICS LINE 886
 4             B:ASM886        1893.019      3845.372
ANALYTIC SIGNAL  W TAS MAGNETICS LINE 886
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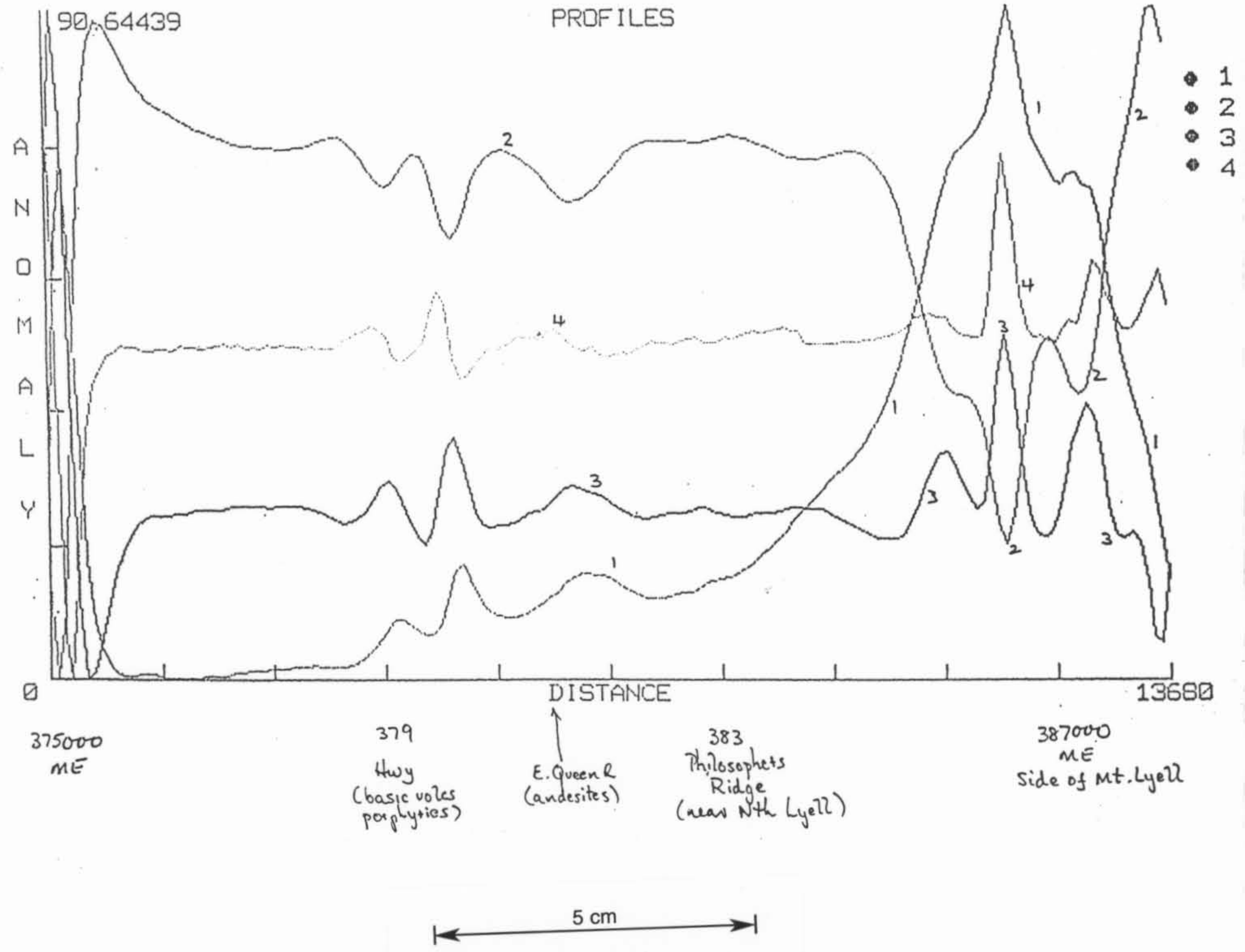

MT LYELL MAGNETICS - LINE 886
DERIVATIVE TRANSFORMATIONS - OBSERVED DATA
ca 5343 000 mN, "North Lyell"

FIGURE : LYELL6

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```
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W TAS 1981 MAGNETICS LINE 890  ORIGIN FID 4405
 2            B:D1M890       472.5222        630.3084
VERTICAL DERIVATIVE 1  W TAS MAGNETICS LINE 890
 3            B:D2M890       1478.691        4097.423
VERTICAL DERIVATIVE 2  W TAS MAGNETICS LINE 890
 4            B:ASM890       2.660626E-02    2154.365
ANALYTIC SIGNAL  W TAS MAGNETICS LINE 890
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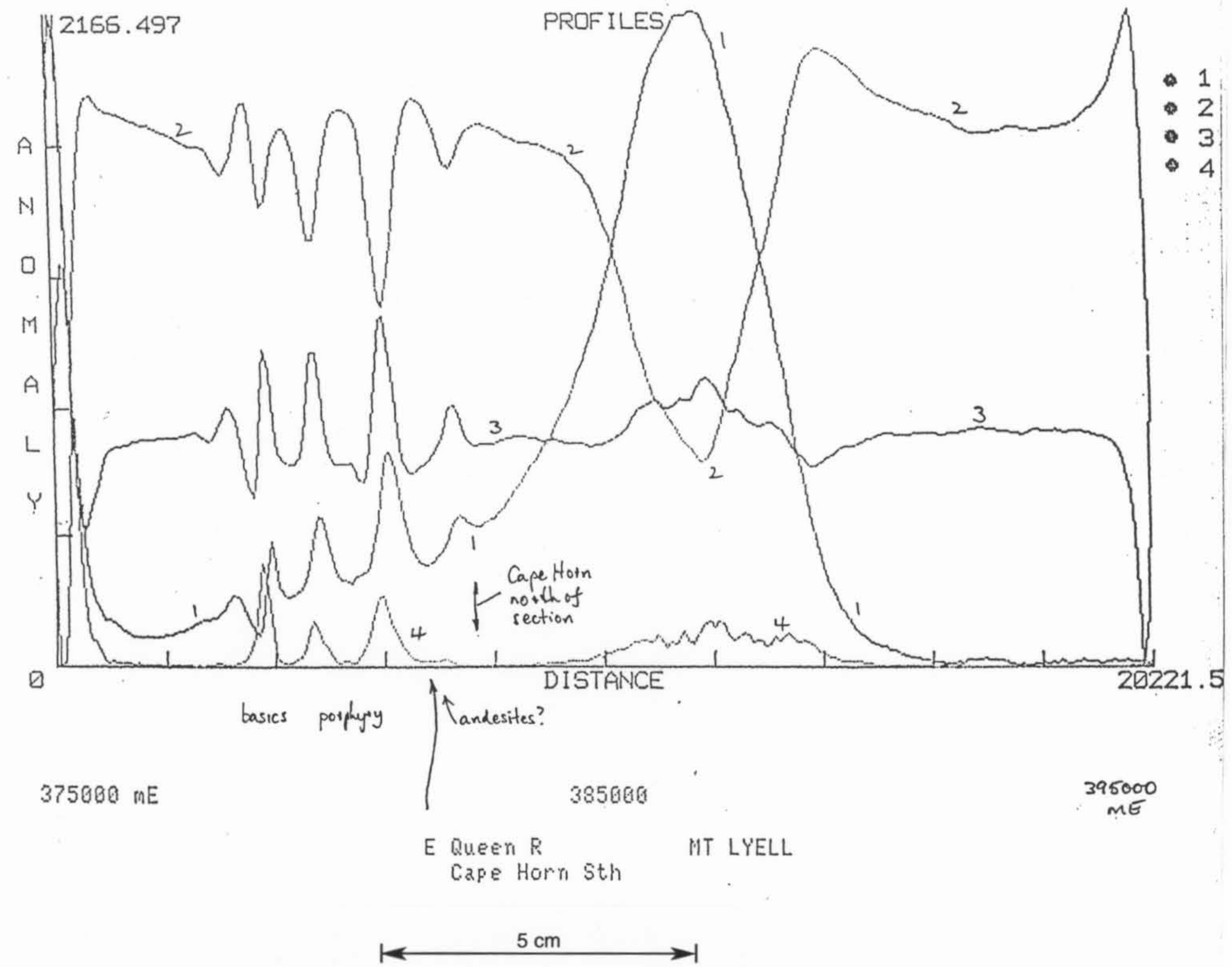

MT LYELL MAGNETICS - LINE 890
DERIVATIVE TRANSFORMATIONS - OBSERVED DATA
ca 5343 500 mN, "South Cape Horn"

FIGURE : LYELL7

029045

41

5 cm

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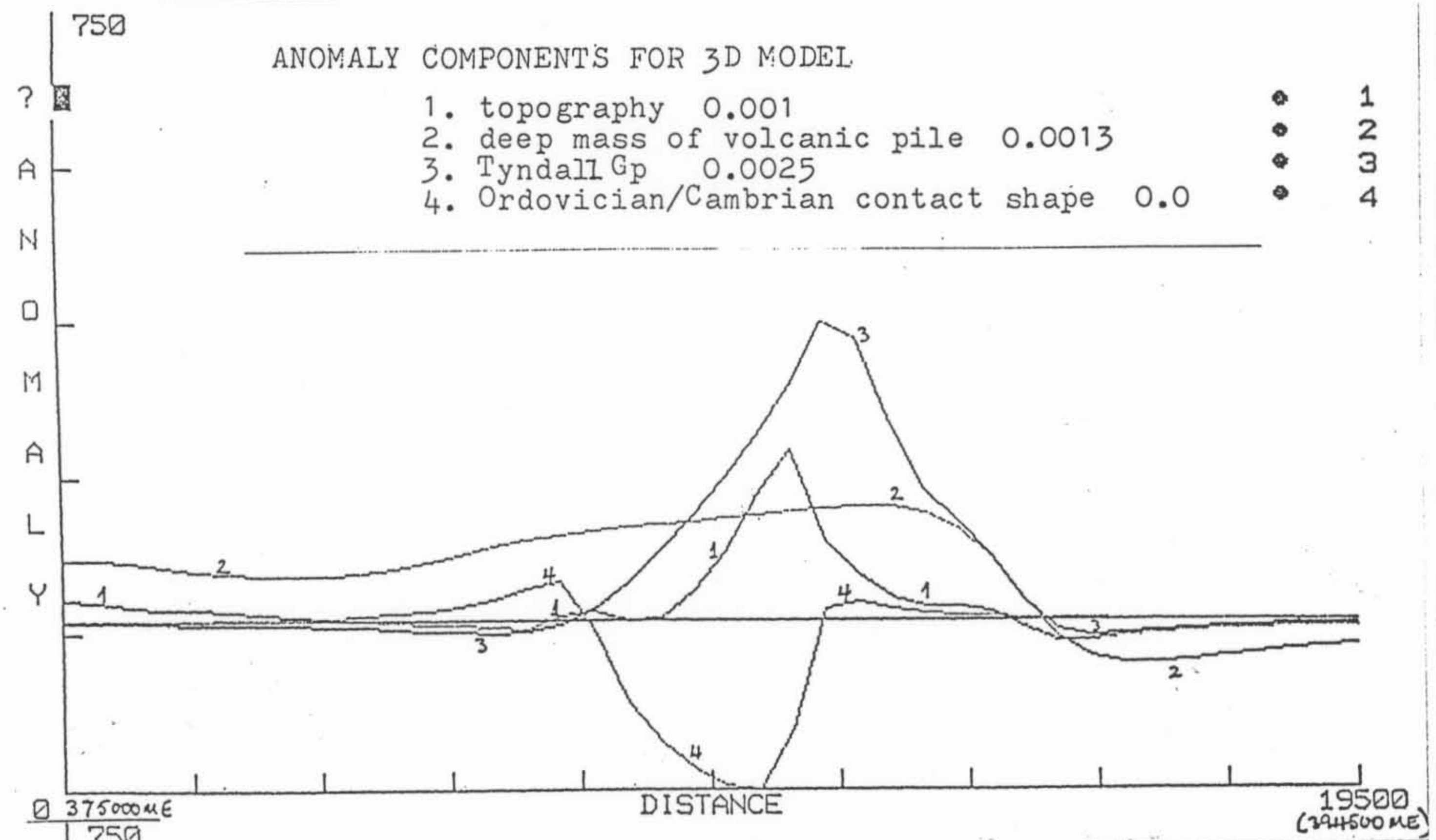

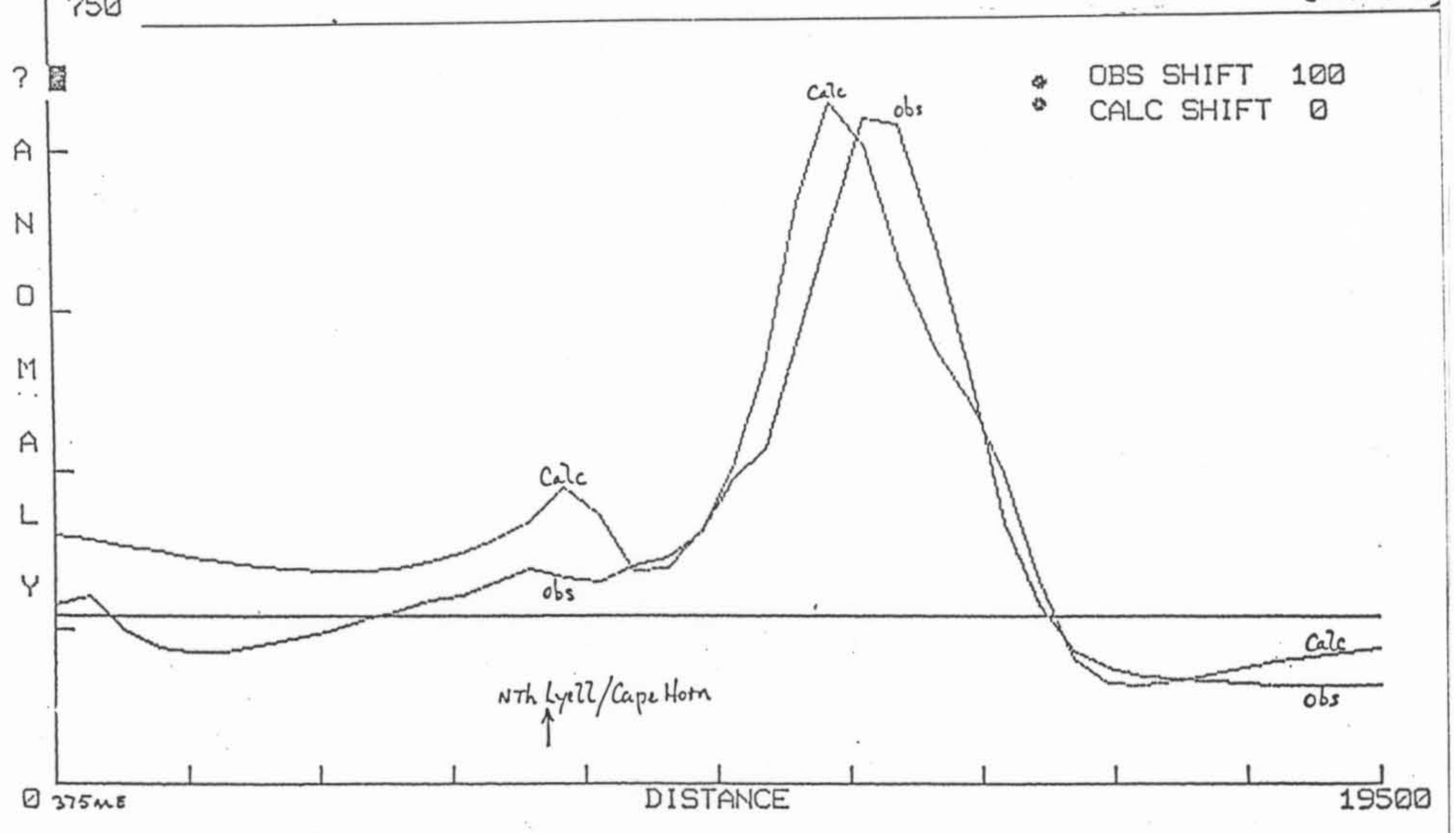

MODEL RESULTANT VS OBSERVED PROFILE

INDICATION OF TERRAIN AN ALTERATION EFFECTS - MT LYELL

FIGURE : LYELL8

029046

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```
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W TAS 1981 MAGNETICS LINE 907  ORIGIN FID 1925
 2            B:D1M907        587.066         740.1616
VERTICAL DERIVATIVE 1  W TAS MAGNETICS LINE 907
 3            B:D2M907        1972.13         6051.099
VERTICAL DERIVATIVE 2  W TAS MAGNETICS LINE 907
 4            B:ASM907        2.014009E-02  2166.497
ANALYTIC SIGNAL  W TAS MAGNETICS LINE 907
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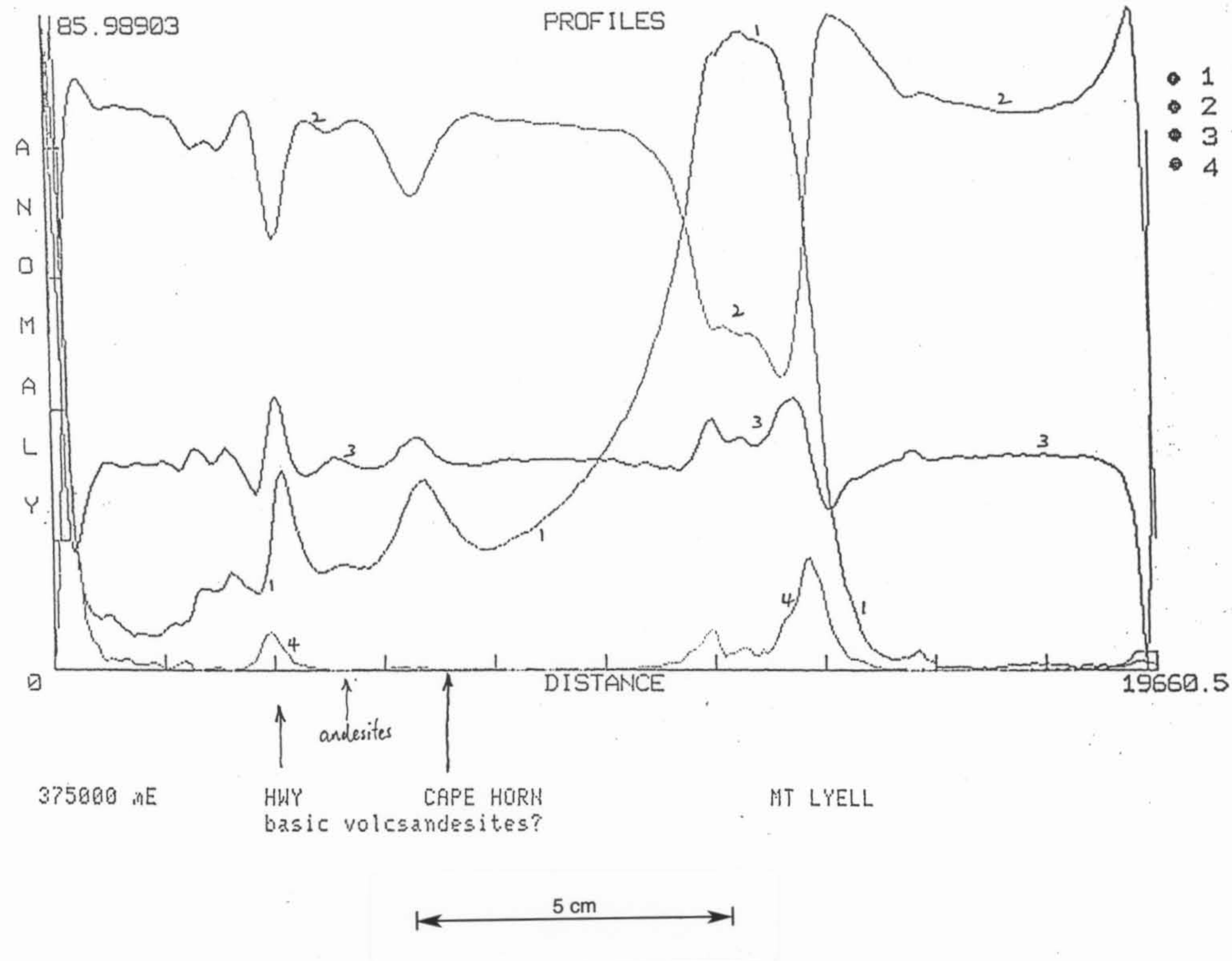
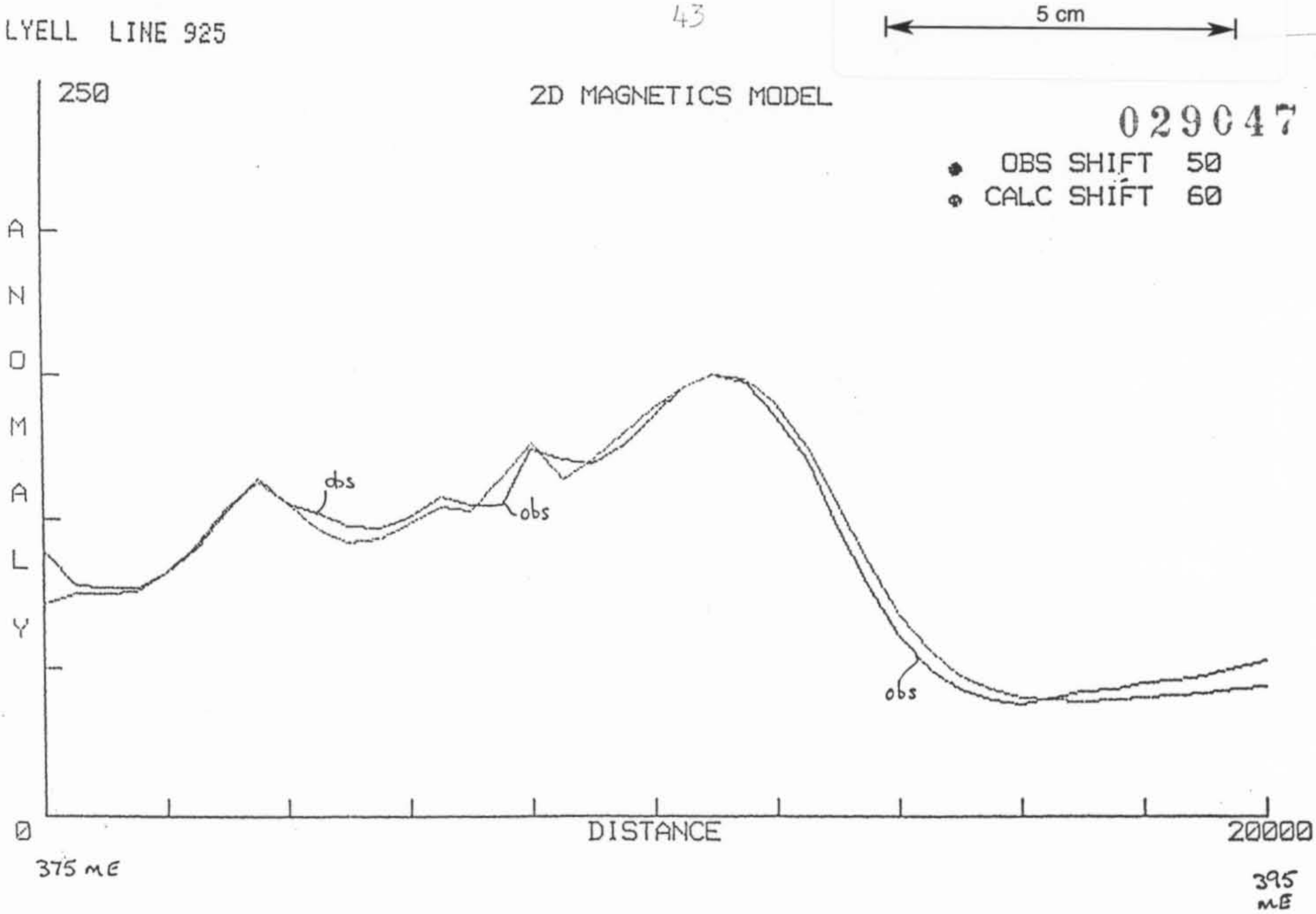
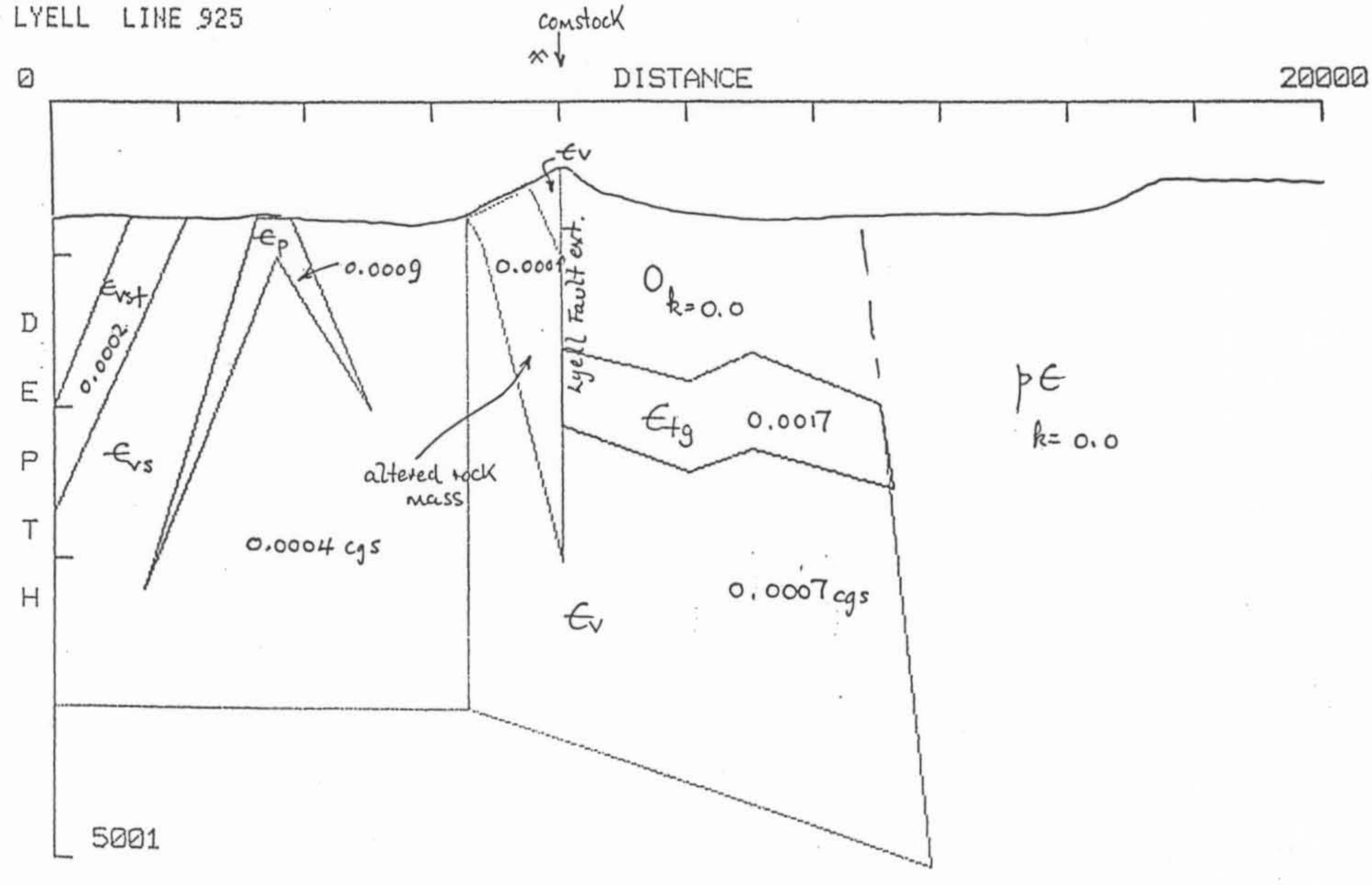


MT LYELL MAGNETICS - LINE 907
DERIVATIVE TRANSFORMATIONS - OBSERVED DATA
ca 5344 000 mN, "Cape Horn"

FIGURE : LYELL9

029047





2D MAGNETICS MODEL ALONG COMSTOCK VALLEY - LINE 925

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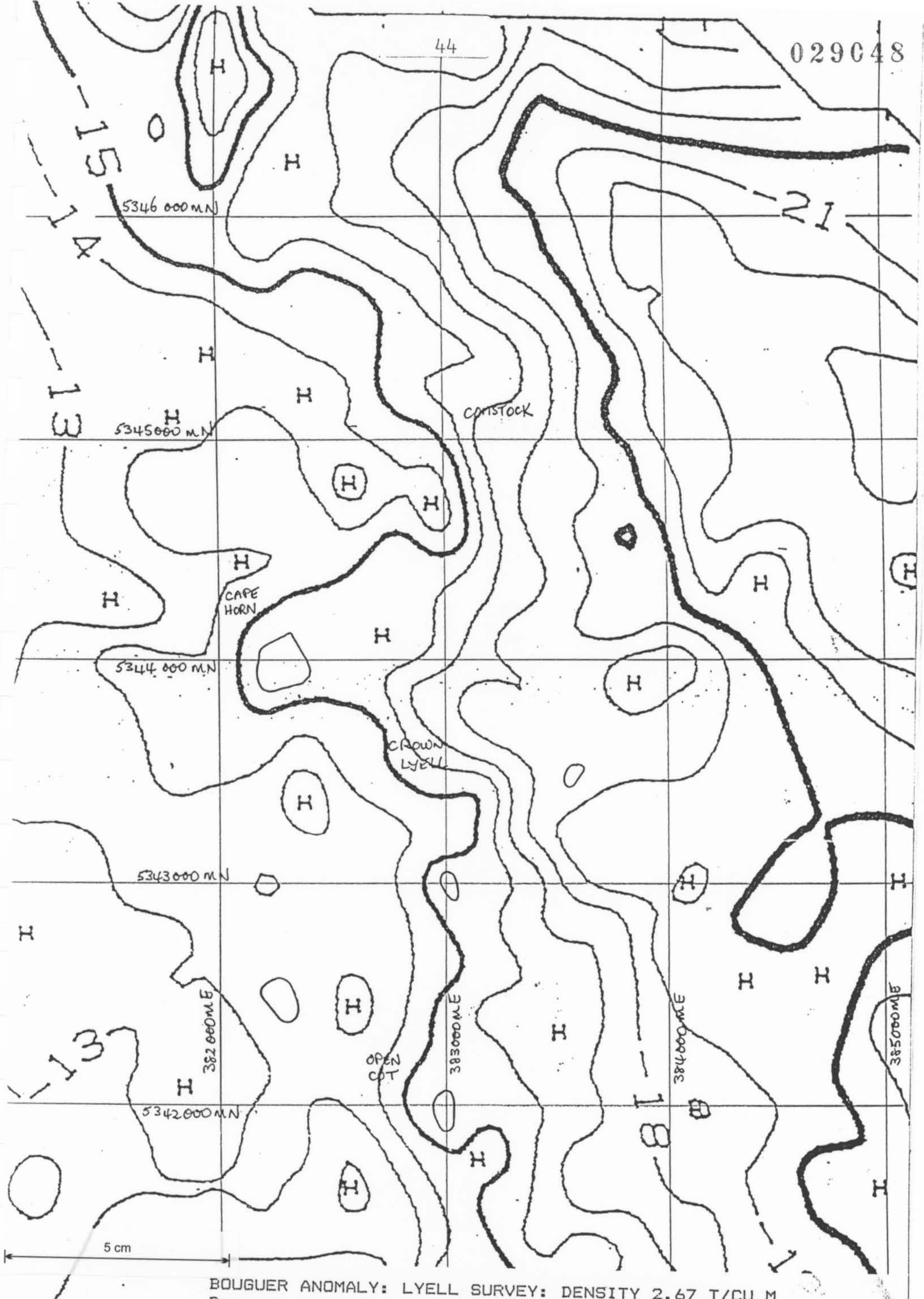
FIGURE : LYELL10



BOUGUER ANOMALY: LYELL SURVEY: DENSITY 2.67 T/CU M
Basemap: see Figure Lyell13, 14

FIGURE: LYELL11

GRAVITY PROFILES

LYELL SURVEY

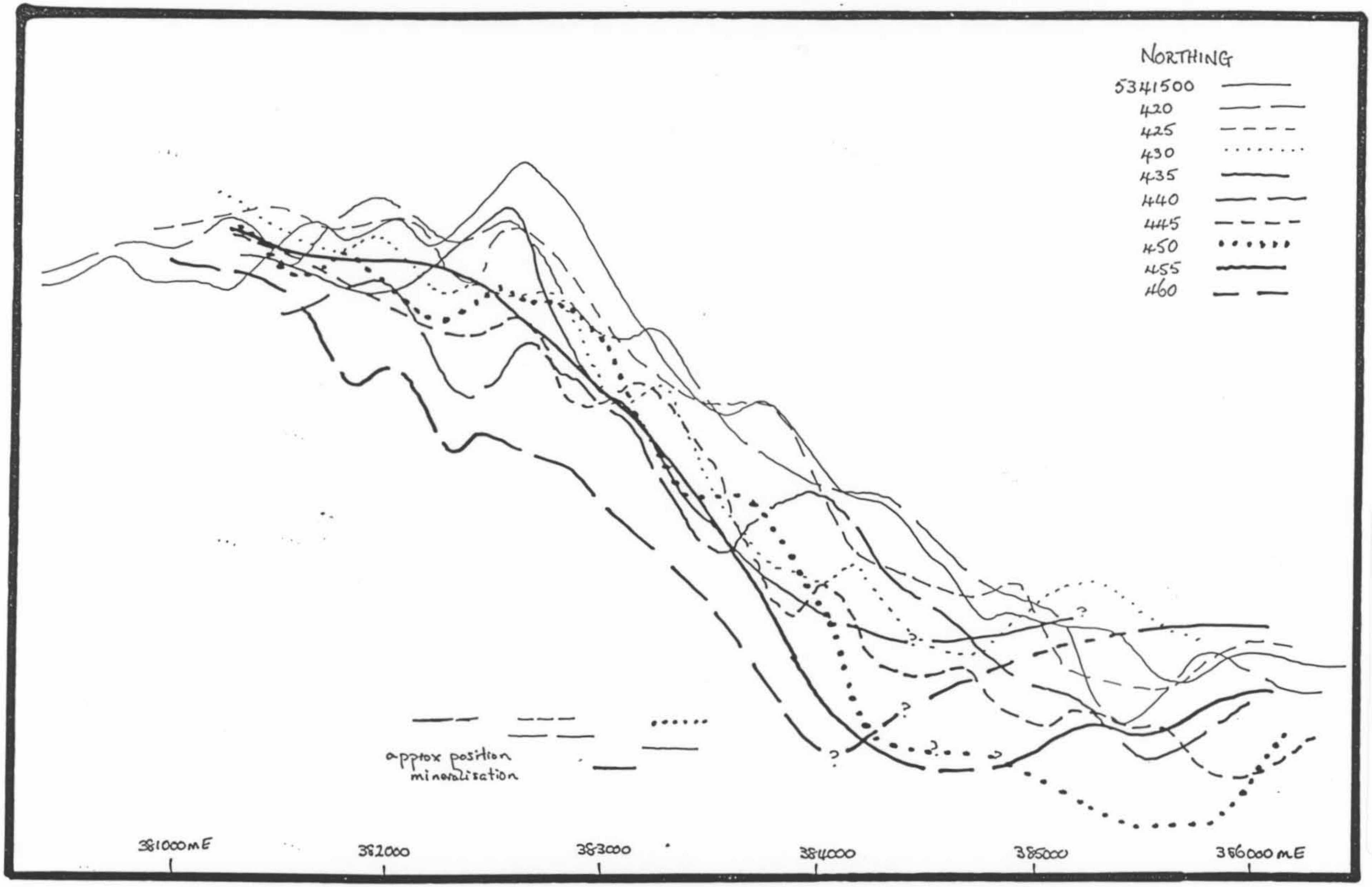
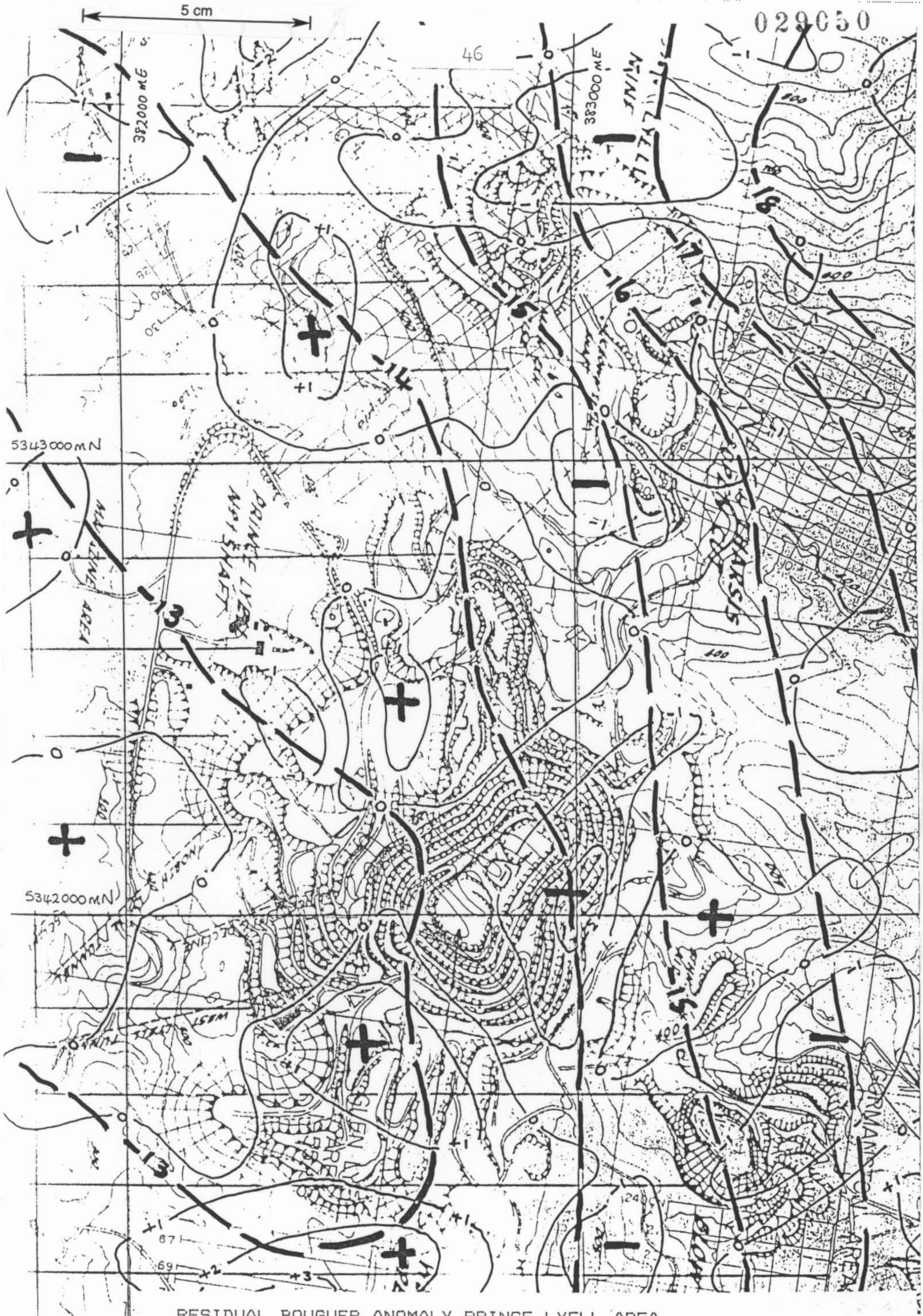


FIGURE: LYELL12

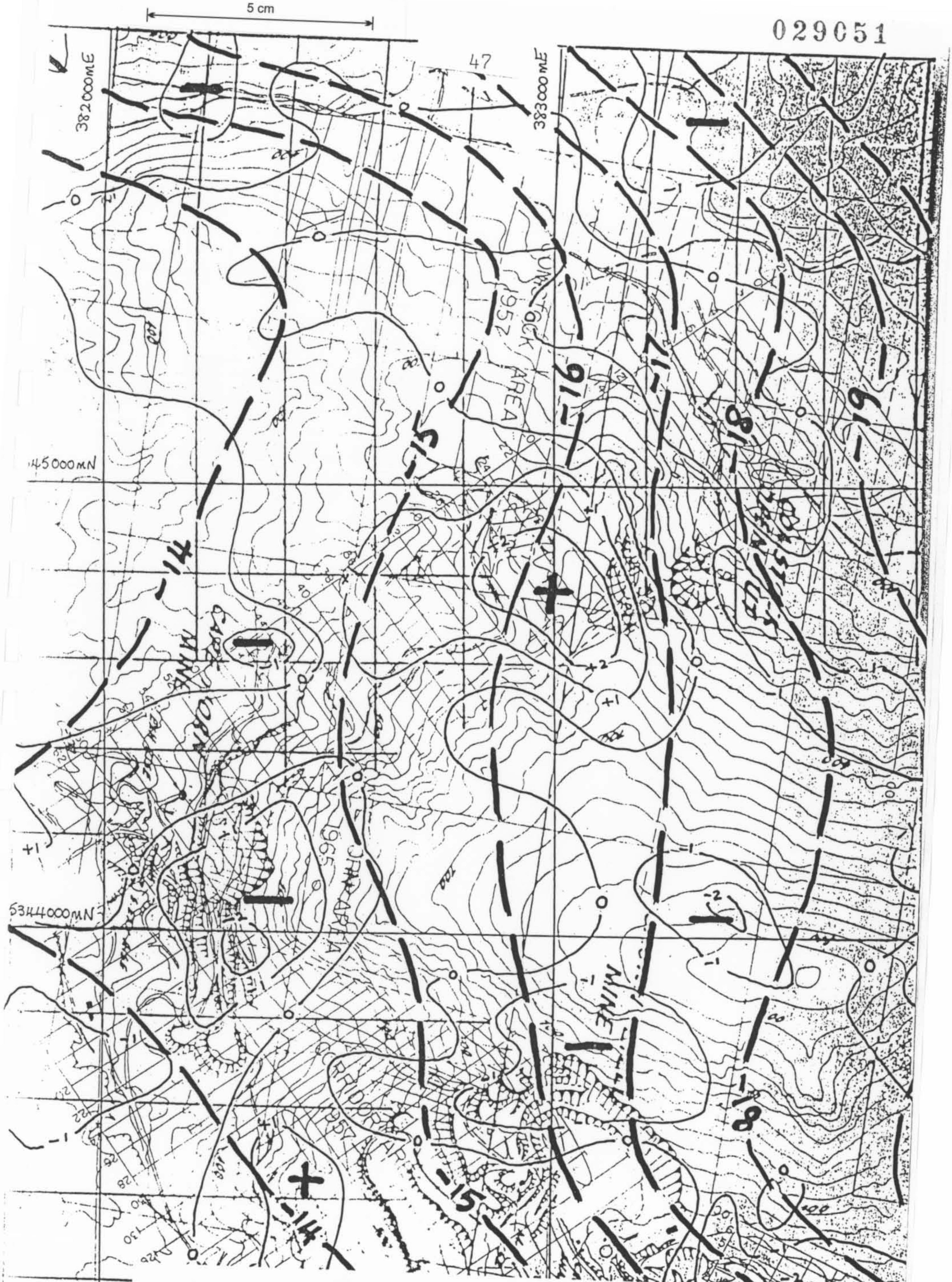
029C49



RESIDUAL BOUGUER ANOMALY PRINCE LYELL AREA
Removed regional effect also shown (heavy line)

LYELL13

029051



RESIDUAL BOUGUER ANOMALY COMSTOCK AREA
Removed regional effect also shown (heavy line)

LYELL14

QUE RIVER:

Regional gravity and magnetic data and a site specific gravity survey have been reviewed. The regional magnetic data were described by Leaman (1986a). The anomaly due to the mineralised area is very subtle and probably largely due to local alteration. It is enhanced by processing. Figure Que3 presents a detailed treatment of part of line 1890 (1981 Mines Department aeromagnetic survey). The mineralised area is characterised by a field intensity minimum. Unfortunately at the northing of this line only the southern extremities of the ore lenses have been transected. Figure Que3 suggests the position of the mineralisation (extrapolated where necessary). Strong field and derivative responses are evident. The true perspective of the effect is not provided by Figure Que3 (see Leaman, 1986a). The full scale for Figure Que3 is 15 nT and the anomalies are therefore very small. The character is clarified by correction (see also Leaman, 1986a for regional relationships).

More importantly, perhaps, is the recognition of gross lineaments near the site. The most difficult to explain are the E-W and NW-SE features although some small E-W faults have been mapped (Komyshan, 1986).

Detailed gravity survey reveals an anomaly due to mineralisation (Leaman and Richardson, 1981). The anomaly is more spiky and irregular than that at the Hellyer deposit but this reflects a smaller deposit which is virtually exposed (profiles, Figure Que1). The smoothed gravity field is shown in Figure Que2. Correlation with the magnetic line suggests that the latter has sampled only the southern nose of the mineralisation. Leaman and Richardson (1981) estimated the ore mass at 5 million tonnes and reviewed various styles of data extraction and enhancement. Relatively simple treatments are adequate to resolve the feature provided the survey was of high resolution, fully corrected and of adequate coverage with high sampling.

029053

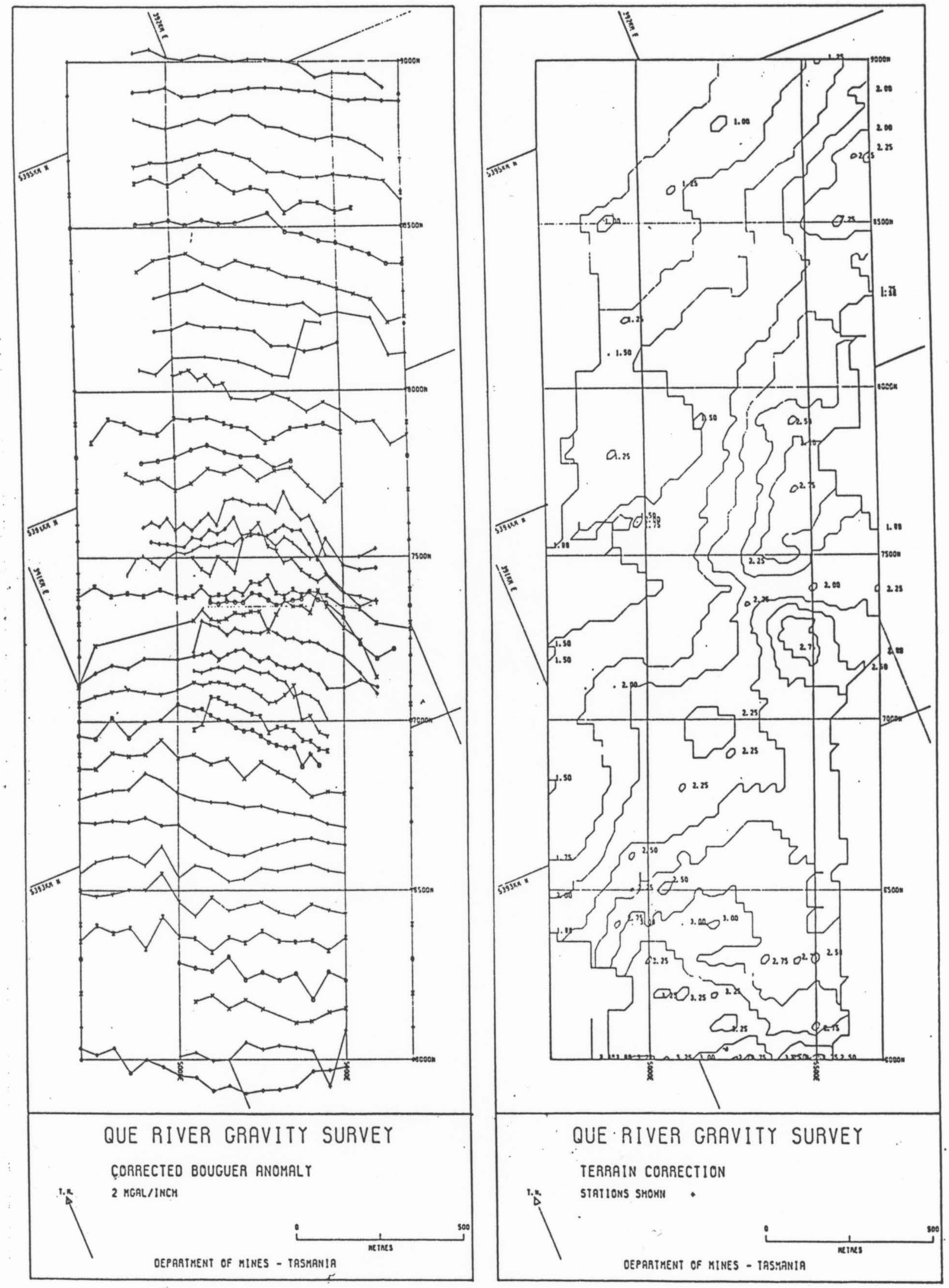


Figure 4. (of Leaman and Richardson, 1981)

5 cm

QUE RIVER GRAVITY SURVEY - PROFILES AND TERRAIN CORRECTION

FIGURE : QUE1

029054

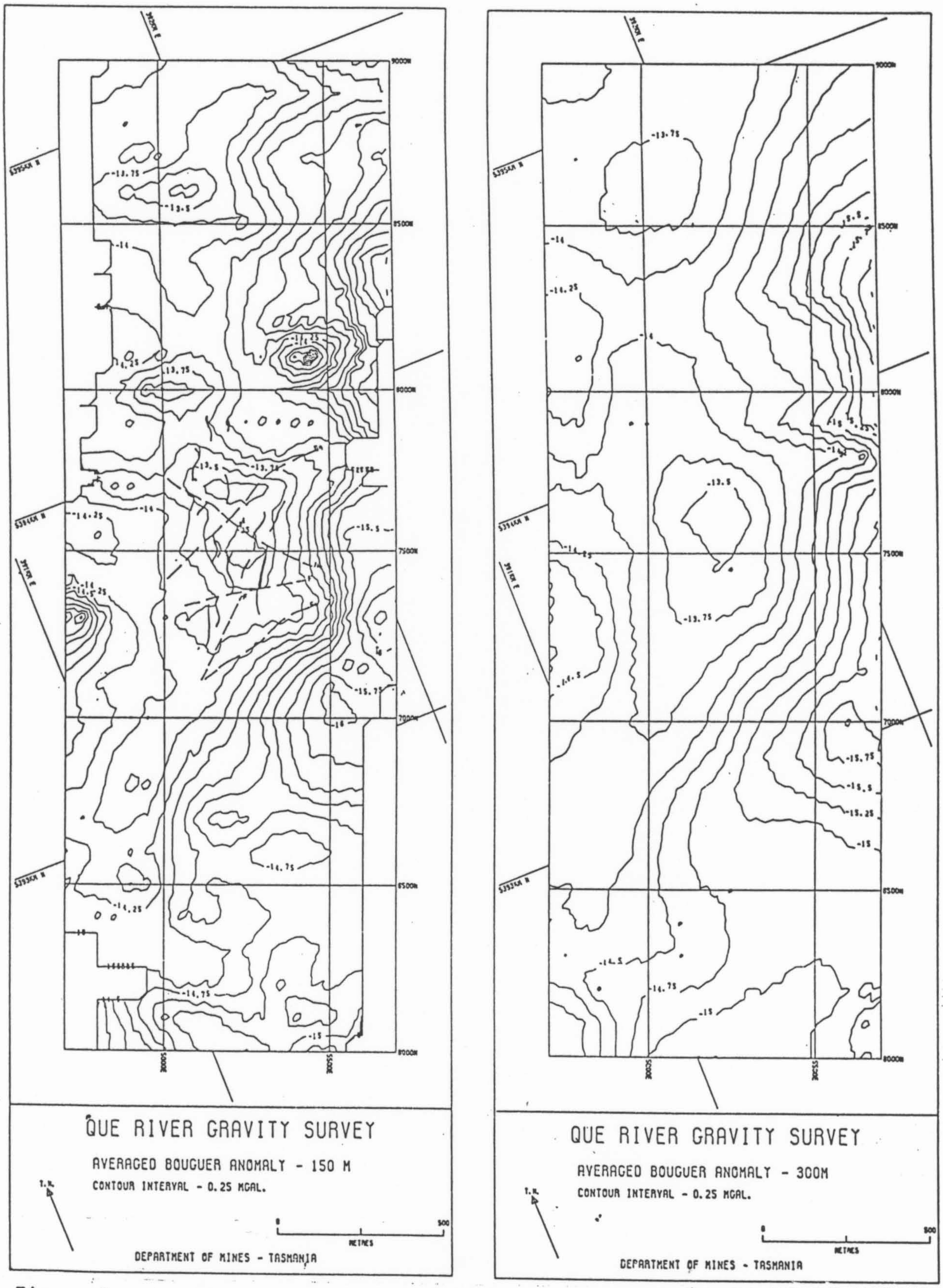


Figure 5. (of Leaman and Richardson, 1981)

5 cm

QUE RIVER GRAVITY SURVEY - BOUGUER ANOMALY

FIGURE : QUE2

029055

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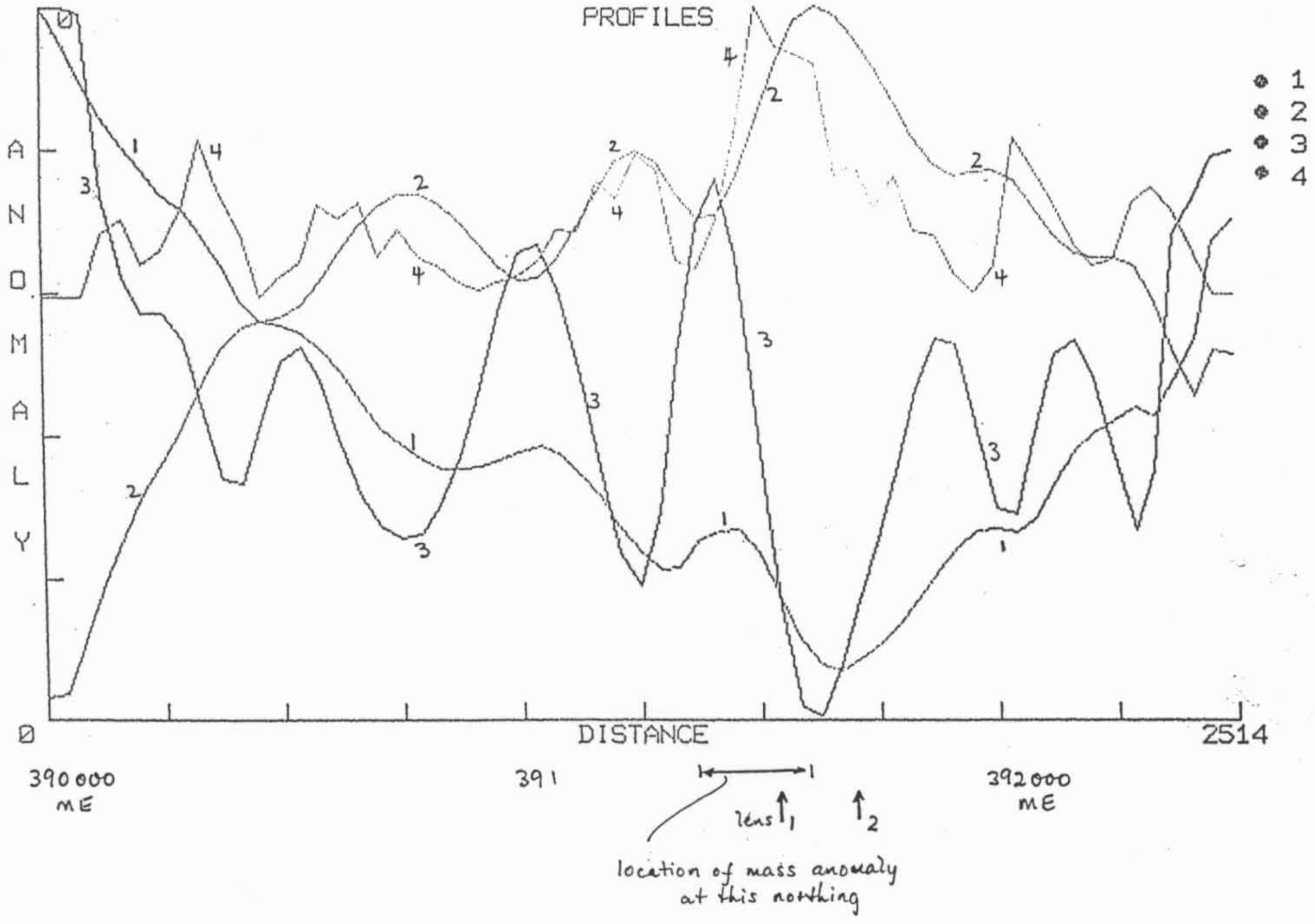
```
 1              B:QUEDETAI      119.483        14.83299
1981 W TAS MAGS 1890  DRAPE 200M FROM 390E  QUE RIVER
 2              B:D1QUEDET      19.04677       31.48701
VERTICAL DERIVATIVE 1  QUE RIVER DETAIL
 3              B:D2QUEDET      65.05974       146.0597
VERTICAL DERIVATIVE 2  QUE RIVER DETAIL
 4              B:ANQUEDET      0              1.685856
ANALYTIC SIGNAL   QUE RIVER DETAIL
```



QUE RIVER DETAIL - MAGNETICS (ca 5393 500 mN)
(South of main lenses, interpolations shown)

FIGURE : QUE3

5 cm

RENISON:

Although older BMR detailed data are available for this site only the regional context has been examined in this review. Both gravity and magnetic data reveal the extent of the underlying granite mass (Leaman, 1986a, c). The gravity data more directly indicate the presence and gross extent of the local granite but processed magnetic data define the extent of the shallowest granite and appraise the thermally altered zone. The anomaly due to the mineralisation at Renison itself is also recognisable (see Leaman, 1986a, Sect 4-D).

Analysis of the regional magnetic data shows that the mineralisation lies on the northern side of a granite cap which has an E-W axis and which lies south of the major E-W Rosebery magnetic corridor. Mineralisation appears to have local NW-SE control superimposed on this fundamental system.

The Renison anomaly is easily recognised and this mineralisation possesses the strongest magnetic response west of the Colebrook Hill ultramafics. The location of the sources and their relative scale is best indicated by the second derivative. This derivative also offers an indication of base level conditions. A second anomaly about 1.5 km to the east may be as significant but is apparently downgraded by the negative component of the ultramafic anomaly.

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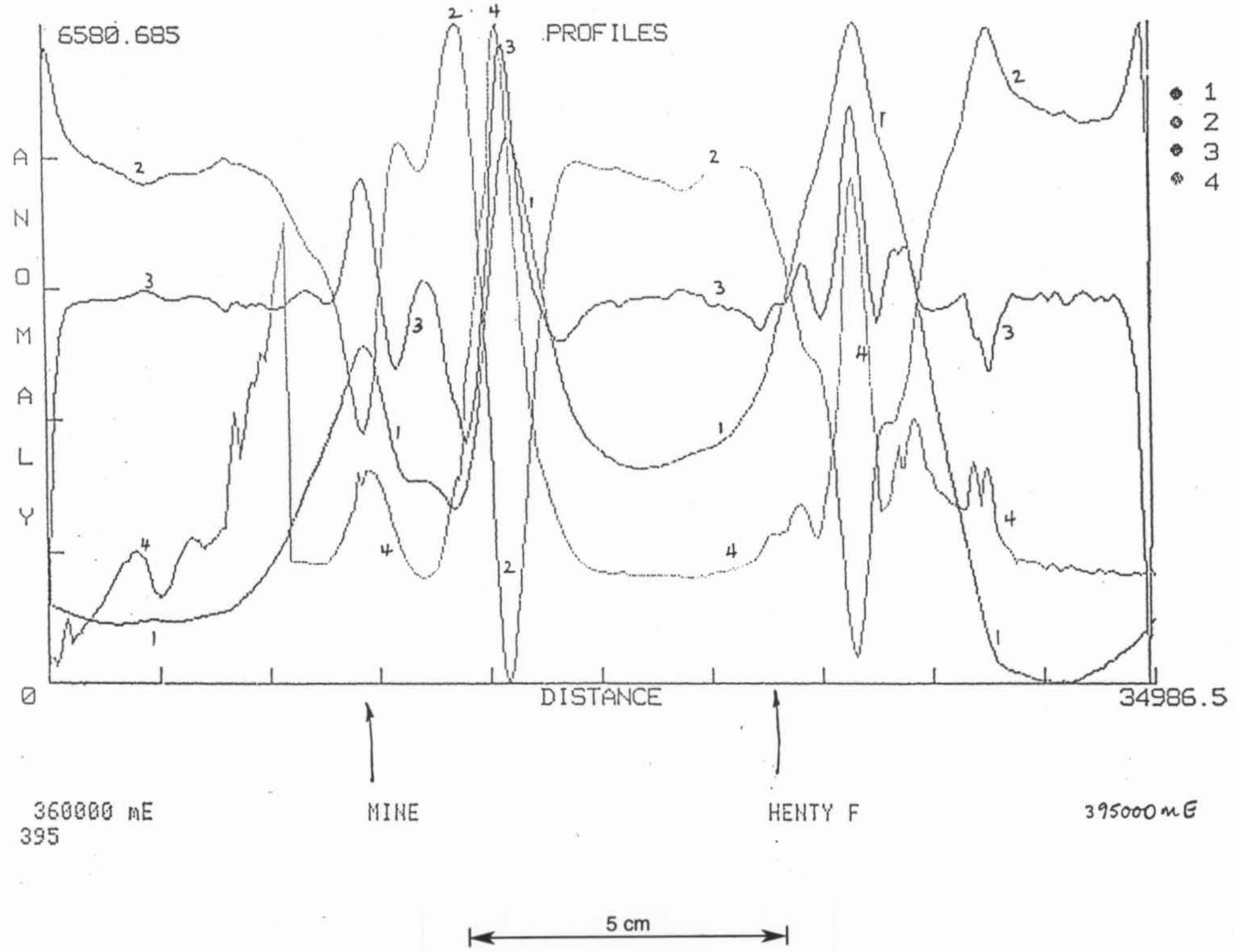
```
 1          B:FHT1441       61.30663      429.5036
CONTINUATION TO 1275M W TAS MAGNETICS LINE 1441
 2          B:D1FH1441      170.18        249.7045
VERTICAL DERIVATIVE 1  1275M  LINE 1441
 3          B:D2FH1441      468.9838      794.3553
VERTICAL DERIVATIVE 2  1275M  LINE 1441
 4          B:ASFH1441      12.56559      85.98903
ANALYTIC SIGNAL  1275M  LINE 1441
```



RENISON REGIONAL MAGNETIC SETTING - LINE 1441
ca 5371 000 mN - data continued to 1275 m level

FIGURE : RENISON1

ROSEBERY:

The Rosebery site has been examined regionally using both gravity and magnetic data. Both data sets reveal gross E-W structuring near the site (Leaman, 1986a, c; Leaman et al, 1980). Subsidiary NW-SE features are also present while NE-SW trends may reflect more obvious stratigraphic control.

Regional magnetic data also show that the deposit presents a measurable anomaly (Figure Rosebery1). This is larger than those noted at Hercules and Que River and is enhanced by processing. Figure Rosebery2 needs little explanation. The dominant character, in detail, is that of a strong positive anomaly set in a field minimum of greater wavelength. Relative levels are defined by the second derivative. The strength of the Rosebery effect, when compared with other Pb-Zn deposits, may be related to the obvious, dispersed magnetite component in the mineralisation or, more likely, to the superimposition of Devonian thermal effects related to a spine of granite extending from Granite Tor to Zeehan (see Leaman, 1986c).

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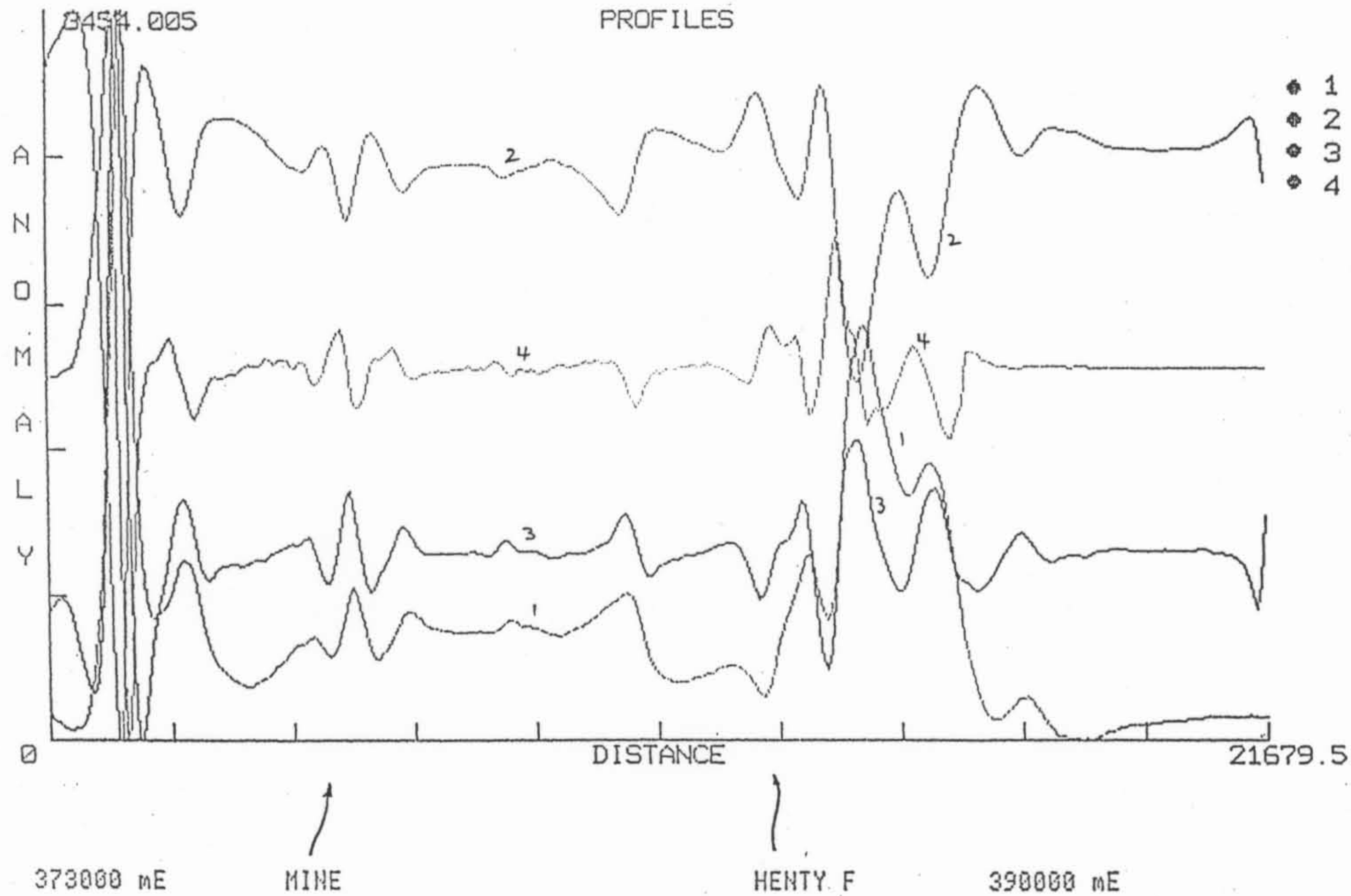
```
 1              B:M1500         105             1020
MAGNETIC DATA W TAS MAGNETICS LINE 1500
 2              B:D1M1500       1289.43         1649.212
VERTICAL DERIVATIVE 1  W TAS MAGNETICS LINE 1500
 3              B:D2M1500       2452.328        9408.928
VERTICAL DERIVATIVE  OBS DATA  LINE 1500
 4              B:ASM1500       3349.124        6580.685
ANALYTIC SIGNAL  OBS DATA  LINE 1500
```



5 cm

ROSEBERY REGIONAL MAGNETIC SETTING - LINE 1500
ca 5374 000 mN

FIGURE : ROSEBERY1

029060

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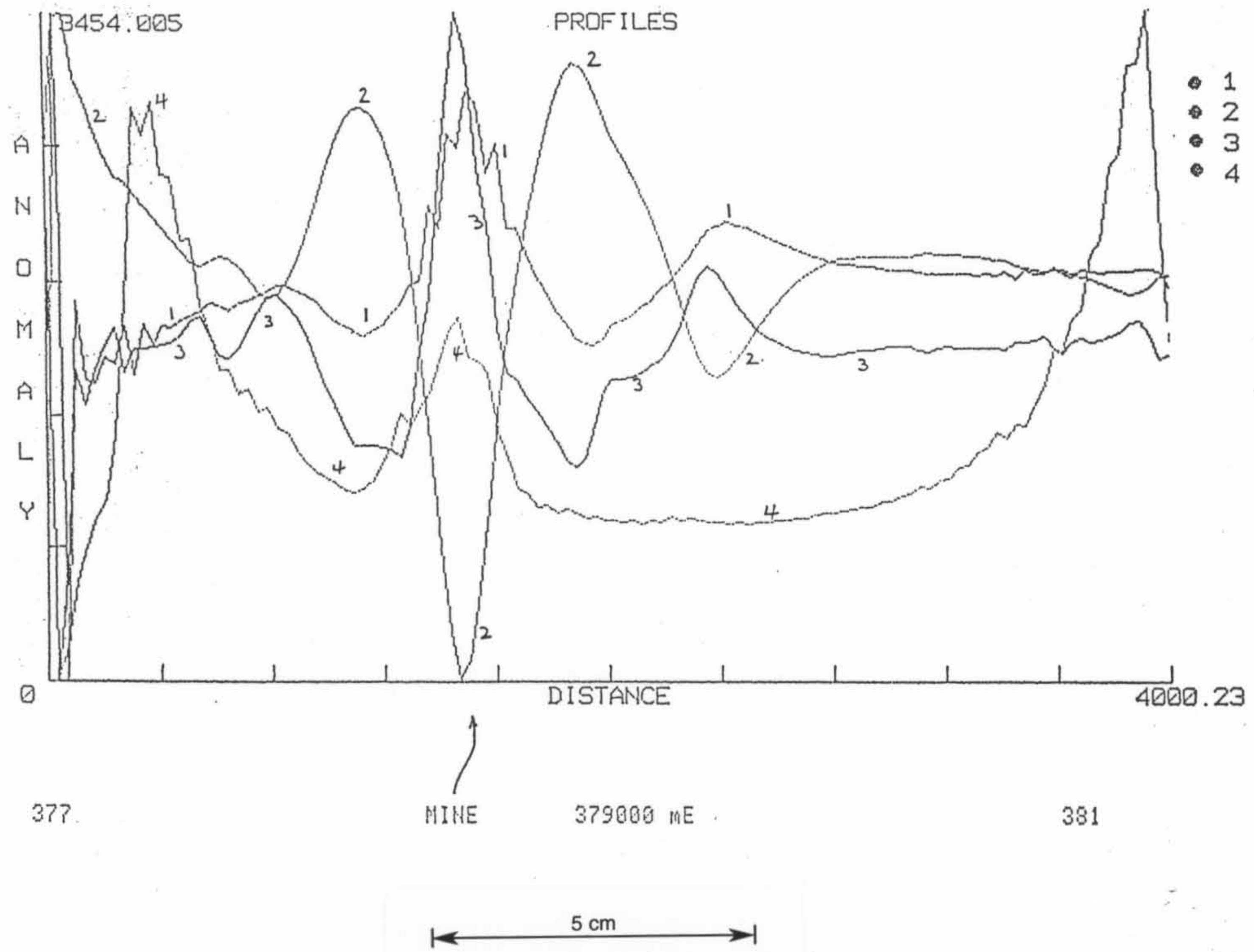
```
 1            B:ROSEDET       191.6708        391.6402
W TAS MAGS 1500 DRAPE 150M FROM 377E  ROSEBERY
 2            B:D1ROSDET      361.215         572.1457
VERTICAL DERIVATIVE 1  ROSEBERY DETAIL
 3            B:D2ROSDET      3636.668        7247.154
VERTICAL DERIVATIVE 2  ROSEBERY DETAIL
 4            B:FI300ROS      1215            3454.005
ANALYTIC SIGNAL  ROSEBERY DETAIL  300M FILTER
```



ROSEBERY DETAIL - MAGNETICS (ca 5374 000 mN)

FIGURE : ROSEBERY2

SPECIAL ISSUES

GLACIAL COVER:

Glacial cover was examined at only one site, Boco. An array of methods was used to evaluate the material and its thickness. There is a useful seismic contrast between till and underlying Palaeozoic rocks and refraction or high resolution reflection methods could be used to define the interface. Till velocities are in the range 1600 to 2000 m/s and provide a strong contrast with older rocks which have velocities in excess of 3700 m/s. Velocity profiles indicate quite abrupt changes across the interface and there is little evidence for thick weathering or other gradational profiles. These velocity ranges could be expected to occur widely in Western Tasmania. Seismic data suggest only that the underlying rocks are not deeply weathered but probably variably fractured. Richardson (Appendix 2) notes discrepancies between drill hole and seismic (and gravity) results which imply up to 20 m of surface alteration or weathering on the basement profile. The differences may also be explained by spread orientation with respect to the edge of the deposits. Gravity and seismic methods are about equivalent in effectiveness.

Magnetic data are not as effective in estimating the till profile and also appear to present a complex view of the entire section. This is to be expected. This method is more dependent upon the critical chemical variations within the rock mass beneath the till and therefore, if adequate data has been collected, more useful to an exploration programme. The role of the seismic results cannot, however, be underestimated since these would provide, in the absence of drilling or detailed gravity observations, independent control on source depths thus permitting more realistic property estimates.

The problems posed by glacial cover are not dissimilar in many ways to those presented by Ordovician conglomerate. Both cover prospective materials. As shown in this report and in Leaman (1986a) gravity and magnetic methods can do much to overcome the problems. The methods separately, or in tandem, can be used to provide structural outlines or thickness estimates and magnetics can be used to evaluate whether the hidden materials are altered. If depths are not too great and alteration volumes and extent (as measured by property loss) are significant then further exploration may be justified. In the Ordovician cover situation it is unlikely that seismic methods can play a useful or cost effective role due to loss of acoustic contrast.

BASALT COVER:

Difficult problems are presented exploration in basalt-covered areas. Many geophysical methods have been tried. None are uniformly or universally successful. This reflects the variability of the material, flow discontinuities, intercalations and irregular base conditions including valley fill sediments. All properties are affected; density, susceptibility, velocity, resistivity .... Various attempts were referenced by Leaman (1986a). Surface basalts present expensive field problems and uncertain results seismically. Developments using EM methods have been proposed. While seismic and electrical methods are expensive and not areally cost effective they may provide information on the basalt section, its thickness and the material beneath. In exceptional circumstances gravity methods may achieve similar results although these are best used as a second string approach. Magnetic methods seem ideally placed to treat the basalt part of the section but are somewhat limited with respect to the sub-section. However, horizontal and vertical variability renders simple modelling procedures impotent. Spectral techniques, or variants of them, have been proposed and these may be useful within certain limitations. Sufficient data of adequate quality are essential. An example of a complex variant of this approach was given by Leaman (1986a, Sect. 4-E) in providing an areal interpretation of basalt thickness around Guildford. Coupled with regional data this approach permitted inferences concerning sub-basalt materials. The advantages of this style of analysis are threefold.

- it is inexpensive at data acquisition and process/ interpretation stages,
- it provides areal coverage, not point indicators, and
- it provides a redundancy of interpretation by providing a thickness pattern which can be used as a consistency test.

The results, of course, can be no more guaranteed than for any other method at this stage but anomalous areas can be identified and drilling or other methods can then be concentrated on such sites. An example of my magnetics approach to rapid treatment of basalt anomalies is given in Figure Basalt1.

Figure Basalt2 interpolates the results of the interpretation given by Leaman (1986a) to the road section used for AMT trials. The available gravity data are shown in profile and these enable the contact between Precambrian and Cambrian units to be located. There is no obvious correlation between the gravity profile and basalt section although the relief on the lower surface increases with the change to Cambrian basement type. Modelling of this profile (2D only) showed that the gradients can be fitted with a contrast of 0.08 t/ cu m at the depths implied provided the overthrust Precambrian block is about 2.5 km thick (also Leaman, 1986c). The anomaly is not two dimensional and this contrast is therefore a minimum - suggesting a section with much mafic content and probably not Mt Read Volcanics.

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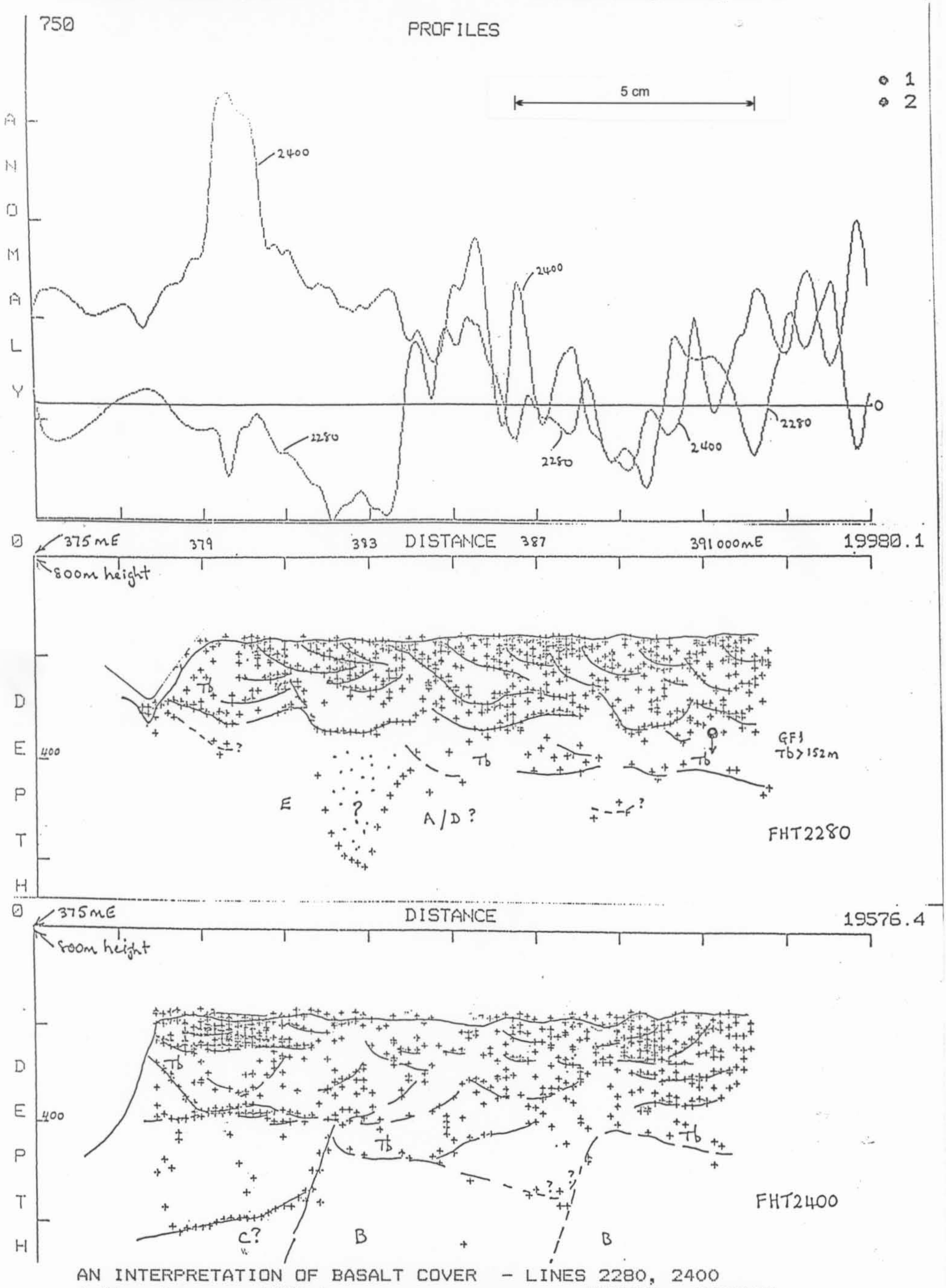

AN INTERPRETATION OF BASALT COVER – LINES 2280, 2400
(after Leaman, 1986a)
FIGURE : BASALT1

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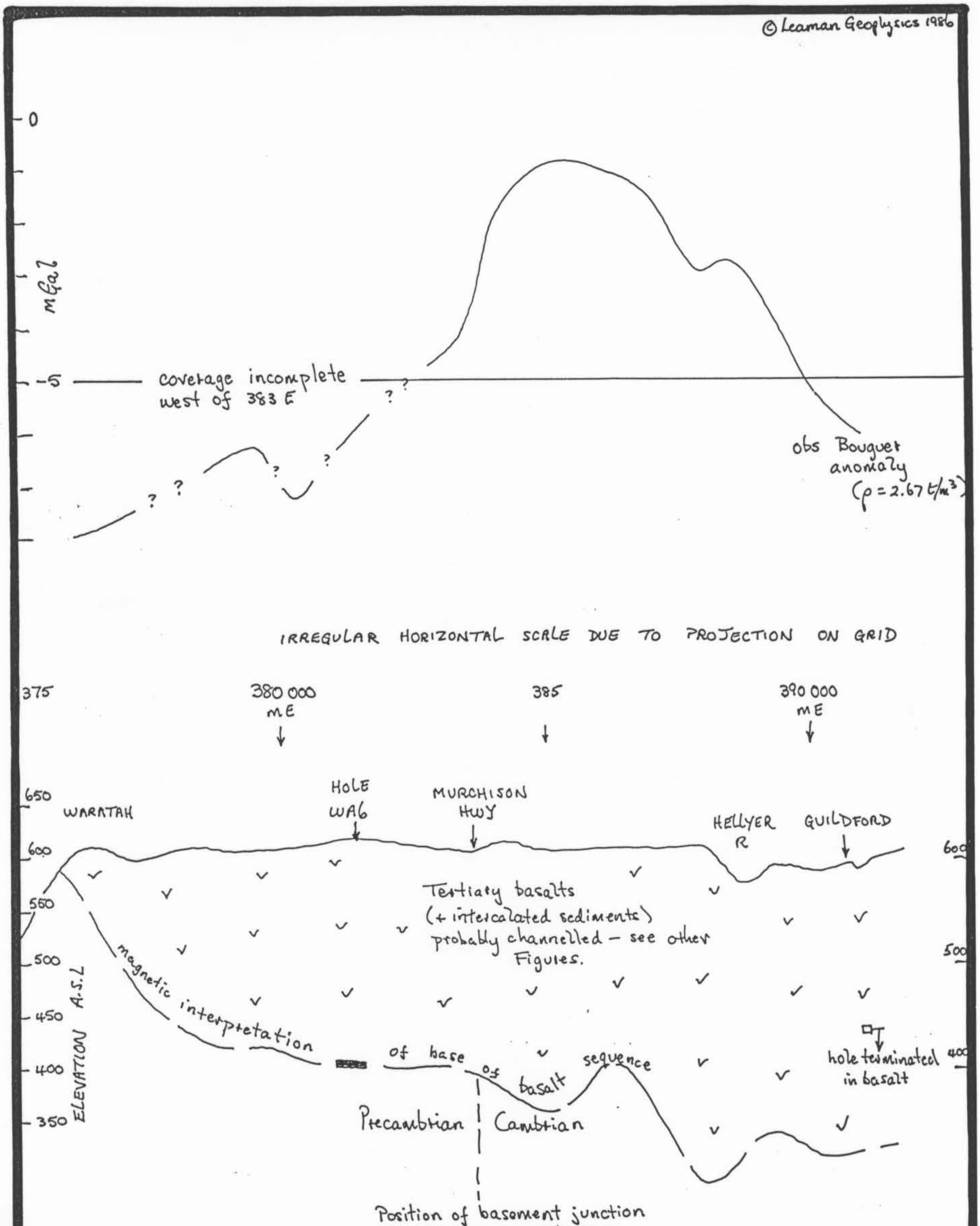

GRAVITY-MAGNETIC INTERPRETATION :
WARATAH TO GUILDFORD ROAD

FIGURE : BASALT2

029066

MINERALISATION SIGNATURES AND IMPLICATIONS FOR EXPLORATION

The characteristics of the principal mineralised areas have been tabulated below. Any comments are based on available geological information in the public domain.

It must be recognised that while a few deposits have a defined signature as a result of the mineral association present, others may possess an obscure or generalised character due to the properties of the host rock(s). In most cases only the host lithology (or variants of it) and gross structural considerations are likely to produce circumstantial correlations at the level of analysis permitted for some deposits using extant data.

Aeromagnetic data will, in addition, integrate many important subtleties and present to the viewer a filtered summation of magnetic properties. While this may be less confusing than surface data, high resolution observation and close sampling is advisable for many targets. Proper and complete correction of the observed data and unbiassed or smoothed presentations of it are often essential. Some ambiguity and complication due to flight and terrain issues is universal in high relief areas. This problem was discussed at length by Leaman (1986a).

Inferences are regional since the data is widely spaced (approx 500 x 40 m) at 120 to 600 m terrain clearance and many sites may not have been flown closely enough to offer definitive responses.

This study (and the more regional treatment by Leaman, 1986a) indicate that certain types of mineralisation may have usable magnetic signatures. These are

i) tin of the Bischoff type. Strong positive anomalies somewhat isolated from a direct granite alteration halo.

ii) tin of the Renison - Cleveland type. Strongly anomalous and coupled with an area of disturbed field which implies thermal alteration and haloes about granite contacts.

iii) copper-gold of the Lyell type. A more subtle effect requiring appropriate correction of data for recognition. Alteration effects.

iv) iron of the Savage River type. No comment necessary.

v) lead-zinc of the Que-Hercules-Rosebery-Hellyer type. Subtle anomaly couplets best seen in derivative treatments. Strongest at Rosebery. Relatively strong alteration effects.

There are several instances involving lesser deposits where the correlation between magnetics and mineralisation is more uncertain and in which the host rock may be the material identified. Alteration, and recognition of it, may be as important to exploration as any direct signature since it is likely to identify massively anomalous areas which may contain larger or deeper targets. Other associations may be established with further work.

Examples include sections of the Zeehan field.

All sites of worth lie on, or very close to, extensive and nearly east - west lineaments or corridors (also gravity data, Leaman (1986c). These features trend a little north of east (ca 85 deg true) and are not always obvious in the original map presentation but are always enhanced by correction of the data. Structures with comparable orientation are rarely marked in surface exposures or regional mapping but are universally observed upon close examination. This suggests that primary crustal structures initiating bulk property alteration are involved. That alteration may be due to passage, perhaps repeated, of mineralising fluids. Consider some of the relationships between the E-W system and other trends, not always apparent in regional mapping, at several important sites.

BISCHOFF: some surface evidence E-W + minor N-S, NE-SW, NW-SE
CHESTER-PINNACLES: weak E-W Pinnacles, both + lesser NW-SE
CLEVELAND: + NW-SE, NE-SW
FARRELL: + possible NW-SE
HELLYER: + possible major NW-SE
HERCULES: some surface evidence E-W nearby + minor NW-SE trends.
LYELL: some surface evidence E-W + poss NW-SE, N-S minor trend
QUE RIVER: some surface evidence E-W nearby + possibly major NW-SE
RENISON: some surface E-W + lesser NW-SE trend, granite in E-W axis
ROSEBERY: +lesser NW-SE trends (NE-SW host control)
ZEEHAN FIELD: other lineaments require detailed review but NW-SE and NE-SW features are present. Two E-W corridors may have fundamental control.

This list indicates either a fiction or a pattern that is too consistent to be accident and suggests that an intersection near, or in, reasonable host rocks is associated with a worthwhile accumulation. Other prospects may represent secondary mobilisation and deposition along structures transecting such hosts or zones, migration within a host unit or general sweating of sulphides at susceptible sites. Without a primary feeding system such sites could never have accumulated sufficient sulphides to be economic. Encouragingly this thesis has exploration potential since there are several other E-W features intersecting the Mt Read Volcanics which are either apparently unmineralised or inadequately explored. Additionally, detailed work could be concentrated on the corridors with established mineralisation. A global approach using magnetic methods might assist but follow up work of any sort should use methods whose coverage is adequate to define abnormalities. This has been a common weakness with detailed surveys - especially when the primary and more regional analysis of the type reported by Leaman (1986a,b,c) has not been done.

There are some complex structural and fluid control options within the framework of the interpretations derived from the first pass analyses applied to the potential field data for the Mount Read Volcanics Project. There remains much to be considered. Some questions which might be raised include:

Why are the E-W lineaments associated with Devonian and Cambrian mineralisation if they are fundamental and much of the sequence has been shifted and possibly overthrust? Are lineaments any guide at all?

This is clearly a complex environment but if the lower crust does contain some E-W system then it could easily feed into any dislocations at times of activity (e.g., Hellyer - Cambrian; Renison offset - Devonian). Indeed the primary interpretation (Leaman, 1986a) did suggest that some of these features are not continuous across the L. Palaeozoic West Coast fold belt (also Figure Lineament6). Finer analysis may define the thrusted section. Similarly overprinting with Devonian effects may utilise the lower crustal system and any relevant Devonian stress field. There are many combinations, any of which could yield the pattern inferred above were it to prove real. The hypothesis is currently too new, too undeveloped and inadequately tested to make a judgment. I suspect the near E-W system to be fundamental and originally Precambrian; the other NW-SE and NE-SW systems are superimposed and probably Devonian.

This limited study indicates that all major mineralised sites possess a magnetic signature, albeit a very subtle one in some cases, or some reflection of host alteration. There are situations where this might be appreciated only by a highly detailed survey and other methods may prove more effective (e.g. EM). But the signature does exist and magnetic data acquired in the past or at an early stage of exploration should not be neglected.

The regional studies also suggest that detailed exploration be restricted to certain E-W corridors barely wider than 2 km and often narrower. These can be recognised in aeromagnetic data although some clarifying processing is advised. I have suggested that these features are the fundamental elements controlling mineralisation while recognising that the existence and retention of suitable hosts and intersecting structures near the present land surface set the scene for any economic deposit. This concept is applicable even when Ordovician cover is dominant.

Given the generally difficult surface conditions I believe that magnetic data should be used to define alteration along the inferred corridors and subtly anomalous features within it and that where these cannot be explained by exposed materials other methods then be considered. I also believe that the key to successful use of any method (incl electrical) is an assurance that coverage and penetration is adequate. This has been a common fault (see below) and is often crucial for gravity and magnetic surveys. It follows that a more balanced proportion of E-W and N-S flight paths may be beneficial in detailed aeromagnetic surveys.

This work also suggests that the common practice of drilling obvious positive anomalies is unlikely to assess subtle, mineralised or altered formations. Straightforward lithological explanations are to be expected in most cases. Experience supports such a conclusion. The approach suggested in this report is more complex and difficult, and untried.

Two other issues may be raised at this point.

1. How relevant and useful is the magnetic signature for Pb-Zn-Ag deposits generally?
2. What about problems in detailed or surface surveys?

These issues are related and may impose restrictions on magnetic analysis. The subtle Hercules and Que River signatures, for example, are visible only because there is a locally quiet background. Assessment might be impossible if the background were noisier. A contrast is seen in line 1360 through Hercules where unit effects are evident at the western end of the line and while they are so identifiable from all characters, any superimposed mineralisation effect might not be. I suspect, however, that were a site mineralised any "normally" strong responses would be locally muted by alteration effects as occurs at Rosebery or Hellyer. Alteration muting is likely to be of second order magnitude while any direct ore response will be much less on the basis of the examples reviewed. Where the field is complex, generally subdued or affected by geological blocking then methods of the type used around Lyell (3D unit assessments etc) may be required for proper evaluation.

Surface surveys with adequate coverage or station density are likely to prove noisy and confusing in some areas. Similar problems and reduction techniques apply but difficulties may be exacerbated by inadequate sampling or line extension. In most of the examples quoted in this report the definition of anomalies and their source relationships depends on the availability of extended coverage. Oversampling in surface surveys is recommended since filtering, subset selections and character identifications then become feasible. Note that ground magnetic surveys are feasible within mine areas or towns given appropriate specification, instrumentation and observational procedures. Processing requirements have been found to be a function of actual responses, nature of interfering infrastructure, data coverage, and data redundancy. Gravity surveys are not restrained by similar problems.

Consequently, I suggest that exploration funding for follow up or site work would be better divided between potential (gravity and magnetic) and electrical methods than simply spent on only one method class (usually electrical since 1970). This would yield a sounder geological appraisal of the region covered and targets within it and would be more cost effective. It is a strongly quantitative approach and one untried in Tasmania.

Some appraisals may depend on structural evaluations economically possible only with gravity and magnetic methods. These applications are necessary wherever displacements are suspected from/within the corridors.

Overall this is a more conceptual, reasoned approach based on regional indications of crustal control and sourcing of mineralisation followed by more restrictive areal review. The second order concentration of effort can take the usual forms (mapping, geochemistry, electrical surveys etc) but refined usage of the regional methods is likely to prove more cost effective at all stages. Such methods demand geological input commensurate with the concepts and prospects under test. In this respect the approach is both more difficult and productive since it suffers from less risk of black box detachment from the geology under review.

Further, the methods offer practicable means of assessing rock volumes concealed beneath non magnetic cover such as till, alluvium or Ordovician units. Hidden extensions of lineaments can be evaluated magnetically.

CONCLUSIONS

The signature analysis and detailed review of, in most cases semi-regional data, suggests that both magnetic and gravity methods have considerable potential as exploration tools in western Tasmania. Applied appropriately they are likely to be the most cost effective means of prospect identification and evaluation. This does not mean that other methods are to be excluded, rather the use of magnetic and subsequently gravity methods may offer considerable focus to the coverage and application of the more expensive, some might say more useful, methods. This is argued on the basis of the examples described in this report and the supporting information provided by, or referenced in, Leaman (1986a, c).

The MAGNETIC method is one of the most suitable for regional evaluation given its low cost and airborne capability. This study has shown that airborne data of high resolution can be adequately corrected and compensated for terrain influences and other problems to reveal quite subtle features which can be directly correlated with mineralisation. In virtually every case removed from the margin of a Devonian granite the effects are small and it could be argued, as did Webster and Skey (1979), that other methods are more viable. Yet the responses are present, reproducible and should be sought in future if only as confirmation for responses observed by other means. In some cases no method offers clear signals in regional coverage - e.g. Mt Lyell. Yet processed, geometrically compensated magnetic interpretation can expose the extent and focus of alteration, or define controlling structures, in a complex field pattern. Such sites are worthy of further examination by any appropriate method. The important thing in the early stages of exploration is to locate altered or mineralised rock volumes or, where mineralisation has long been known, to identify those restricted volumes in which the effect is maximised. This is far from obvious in any distribution of prospects or surface map. I suspect that best results from magnetics will always come from suitably corrected airborne data since there is no coverage problem and much noise has been limited. This presumes an appropriate original specification. Any feature recognisable at 100 or 150 m is certainly of economic significance if mineralisation can be proven. Future interpreters must look beyond the obvious to the delicate or subdued.

Surface surveys, on the other hand, must be carefully specified, of sufficient coverage to confirm the airborne indication, and corrected for terrain effects. While many subtle indications may be directly observed in corrected profiles it should be anticipated that the evaluation of such features and the recognition of other anomalous rock volumes will require extended quantitative examination. 3D methods will be essential in many cases since geometrical geologic-structural effects must be appraised and compensated to define the actual anomalies.

The scale of the components considered to form the signatures is quite small and nearly critical with respect to the specifications of the data used available. The 1981 survey, and its extensions, carries the minimum specification necessary in this environment. Future, or more detailed, surveys should use higher sampling rates (closer spacings), full range radar altimetry and possibly more precise magnetometry although the latter is not essential.

GRAVITY methods are at once more all encompassing and more specific. The extant regional survey permits evaluation of gross structures generally and second order structures affecting the Mt Read Volcanics. Such evaluations may prove crucial to basic appraisal and selection of prospect areas. Detailed gravity methods, however, should not be employed within a prospect area unless there is some other independent indication of prospectivity. This may result from use of other geophysical or geochemical methods. The gravity method may then be used, given likelihood of reasonable contrasts, to evaluate the site - presuming that a small area is involved. No response will invevitably suggest that the site is uneconomic up to a certain minimum depth. Since the method has proven able to focus on the Hellyer ore mass at depths of 150 to 250 m this provides a measure of the tonnage - depth function applicable in the volcanics. The method should not be employed to blanket cover a lease unless it is intended (by management edict) to pattern drill or extensively use other methods (not geochemical or magnetics). Relative costs should then be assessed since it is possible that a whole lease gravity coverage will prove more definitive than extensive IP or EM surveys within the lease for the same cost. These bad practices are mentioned here because examples exist.

I have suggested (Leaman, 1986a) that the best exploration sequence within this province is to use magnetic data to identify anomalous rock volumes, correlate these inferences with known geology, prospects or geochemistry and follow up with selected surface methods (which may again include magnetics). As soon as a focus for further detailed work is located the gravity method should be employed in order to evaluate the status of anomalous masses. Is there evidence for massive mineralisation or is the prospect trivial and a candidate for relinquishment? No other method can answer these questions for targets within practicable mining depths. At various stages along this path the regional gravity and magnetic data can be analysed in an evolutionary fashion as control and knowledge improves. I believe this use of the data base, either available from various sources or acquired specifically, will prove the most cost effective method of exploration in terrain which does not welcome close surface scrutiny.

Neither method has ever been used near its potential in western Tasmania. Gravity methods have certainly been affected by the lack of a regional data base but this problem has now been largely overcome. This does not account for the problems of many specific surveys which have often been specified and undertaken by explorers unfamiliar with the gravity method. I will simply say that the average textbook leads one to think of the gravity method as simple. Its theory is, its execution is not. The examples raised in this report show what the method can do (including the null results of Oliver Hill and Beulah; Leaman, 1974, 1975a) if the application is undertaken with the care and concern required. Similar comments could be made regarding magnetic surveys but the needs of magnetic data are only manifest if used beyond the scan-of-contour map stage since the actual acquisition of the data is usually beyond reproach (unlike the gravity data). In rough terrain, however, it is important that the data be adequately corrected and processed and then the benefits optimised by detailed analysis. No review of uncorrected airborne data could have described the response at Que River, Hercules or Mt Lyell. The Rosebery anomaly is thought to be a special case in which granite at shallow depth has enhanced the local alteration pattern.

Specification is a separate issue which can not be generalised. There are inevitable trade offs to be made between the proposition and acquisition of a survey. These must be carefully reviewed since there are several open file examples where the potential value of the survey was completely negated by retention of line density at the expense of line length or cross lines. Wherever possible gravity data should be acquired on a grid or scatter basis rather than a line basis and where lines are the only means of data acquisition several orientations should be used to optimise definition of the field and its relationship to any topographic influence.

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APPENDIX ONE

AN EXPLORATION PHILOSOPHY BASED ON GRAVITY AND MAGNETIC METHODS

This sequence of exploration techniques is not intended to be a hard, fixed recommendation since the existence of certain data types will reduce some of the options or variations. It is intended, however, to suggest that the potential methods can contribute much, and at a much lower cost, to the exploration effort in W Tasmania. I have argued that this should be so for many years but have not previously had the opportunity to generally demonstrate the potential and effectiveness of these methods. The interpretation and evaluation studies (Leaman, 1986a, b, c) provide some measure of the underutilisation of the ubiquitously acquired magnetic data (especially). While those reports cannot offer the last word, due to project and data limitations, they certainly indicate some directions which might usefully be followed. It is a new path. One with a better balance of geological concept, and appraisal, with less dominance by any single class of geophysical method. I have always believed that electrical methods have been over used in Tasmania, and often with poor specification or regard to the prevailing geological conditions. Potential methods, when in fashion, have suffered similar problems. Specification and survey quality issues are pertinent to all methods and gravity applications have been most affected by the latter. I would add that gravity and magnetic methods are often presented as simple techniques. Careless or ignorant applications and interpretation based on this presumption may rapidly lead to unsound and ridiculous results which more often than not lead to ridicule of the method and not the technician.

My suggestions based on the implications of the surveys and signatures are:-

1. Review available open file airborne data, especially magnetics. This may be in usable digital form. If not, or non existent, acquire new data.

2. Where necessary acquire or infill aeromagnetic data for the area of interest. The area may have been specified on the basis of

previous exploration, other indicators (geochem etc) or regional location of lineament corridors. Where surveys infill care is necessary to avoid herringbone and false correction effects. Acquisition in virtual drape format, at heights less than 150 m, and sampling at less than 25 m is preferred.

3. Inspect data for lineaments with no immediate geological expression, unit continuity, mapping extension information.

4. Process to fixed level formats and evaluate derivatives. Review qualitative lineament indications. Compare results with available gravity or airborne EM data.

5. Review individual line data for abnormalities. Contouring may obscure the necessary detail.

6. If major intersecting lineaments (esp. E-W, NW-SE) are evident after (4) then proceed to (7). If not, stress (5) but not over-optimistically since the main indicators of large deposit plumbing would appear to be absent. Vet other indicators if extant (geochem, existing shows). On my hypothesis I would predict these to reflect secondary sweating points if present at all.

7. The style of second order treatment depends on the mineralisation sought or expected.
a) if tin: review terrain corrected processed maps for indications of cupola positions and pluton margin shape. Both magnetic and gravity data can be used. Separate anomaly sources and pin point trend intersections and unaccounted anomalies. This may require extended interpretation.
b) if lead-zinc: review E-W corridor positions and assess results per (5) to aid definition of altered areas or subtle unexplained features. Other data may assist here (e.g., geochem and EM as at Que River and Hellyer). Definition of alteration may require extended whole geology structural and property appraisal.
c) if copper-gold: it is possible that viable prospects will only be resolved by extended structural-property analysis of magnetic data. This will identify true anomalies and may indicate targets.

Irrespective of target the siting of more detailed reviews will be focussed by the structural implications of the first order treatments (1 to 6). Where attractive structural conditions appear to be buried by glacials, basalt or Ordovician materials full structural analysis is possible and essential. Only in this way can targets be identified in unexposed hosts.
Gravity surveys are a viable follow up tool for deposits of classes 7a, b ;esp. b since these yield a strong response where the magnetic response is subtle and indirect. Magnetics is probably the best approach throughout for class 7c.

8. Consider alternative follow up methods in anomalous areas. Includes electrical family, geochemistry, additional mapping, review of host materials... Where there is evidence of Devonian structural displacement, and the mineralisation sought is older, then these

methods will yield misleading results. A better path is then to extract any possible structural information from extended magnetic and gravity surveys and drill any unexplained zones. Seismic methods are unlikely to be cost effective and their viability is unproven.

General comment:

The potential (gravity and magnetic) and seismic methods are essentially tools for structural analysis. That potential methods often may have direct application for ore location and estimation is a bonus usually provided by more specific rather than general coverage. The methodology I have recommended above is therefore a sound analytical structural geology approach to exploration in the first instance which may be expanded to refinement of geological understanding of a prospect or identification of a target within it. Other methods, at best, can only be applied to the latter object and I would argue that any procedures which provide, or contribute to, geological appreciation and knowledge are worth applying - especially since the results are permanent and the methods are the cheapest overall.

APPENDIX TWO

1986/77. Geophysical surveys at Boco Siding - Stage 1

R. G. Richardson

Abstract

Two reversed seismic refraction spreads, combined with gravity and magnetic traverses along the same lines, showed that the depth of the glacial materials at Boco Siding varies from approximately 40 m to 100 m along the line of the traverse. The density contrast of the glacial materials compared with the underlying materials is approximately -0.7 t/m^3 and supports the use of the gravity method, with suitable control, for determining the basement depth.

INTRODUCTION

As part of the Mt Read Volcanics Project a number of known problem areas for geophysics are being surveyed using a variety of techniques. Boco Siding is one such area, where a highly variable thickness of glacial materials overlies Cambrian volcanic rocks. Thicknesses in excess of one hundred metres are known. Augustinus and Colhoun (1986) reported that the glacial deposits contain boulders of Owen Conglomerate, High Tor Granite, and Cambrian volcanic rocks. Their measurements of the density of the Cambrian volcanic clasts show a range from 2.22 to 2.66 t/m^3. No bulk density measurements for the glacial deposits are available.

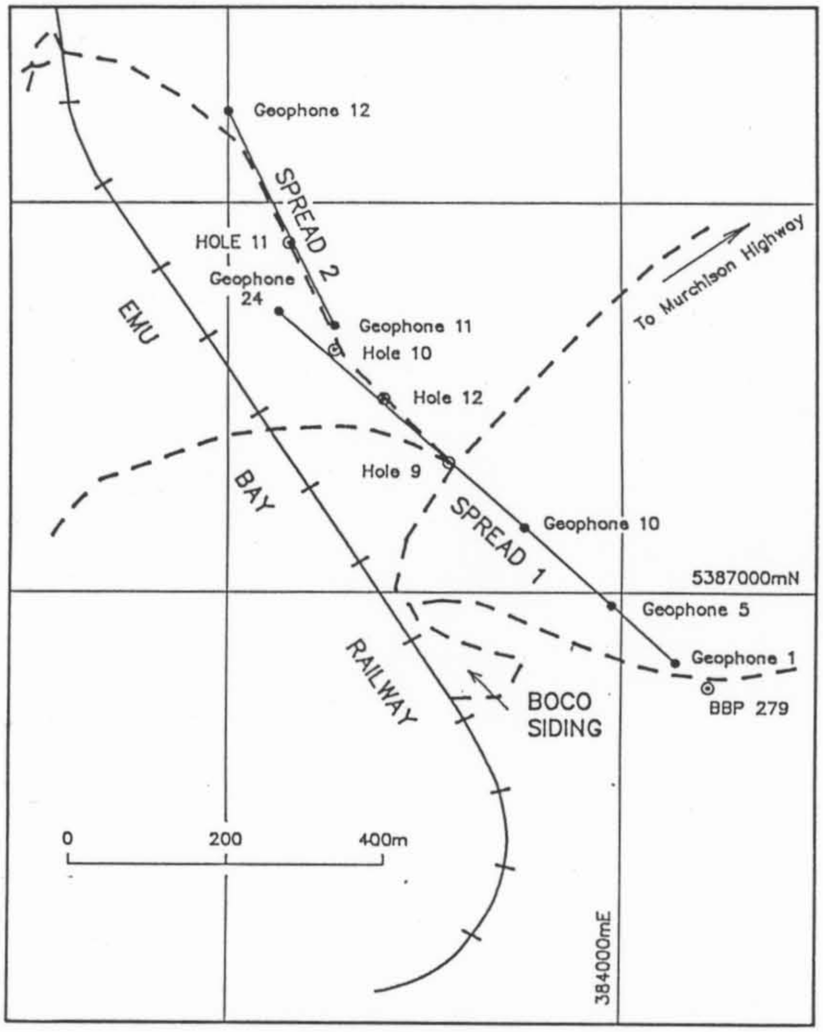


Figure 1. *Locality plan, Boco Siding*

5 cm

The traverse position (fig. 1) was recommended by Dr J. R. Bishop as providing maximum drill-hole control. The vegetation was low buttongrass and access to the southern and northern ends of the traverse was by foot. Levelling and positioning was carried out by using a combination of electronic distance measurement and optical levelling.

The gravity data was acquired using Sodin gravity meter number 183 and fully corrected to yield a Bouguer anomaly. A Bouguer density of 2.67 t/m^3 was used. The magnetic data was acquired using a McPhar proton magnetometer and corrected for diurnal variation by repeat reading of a base station. The reversed refraction spreads were recorded with a 30 m geophone interval and used the reciprocal method (Hawkins, 1961). Spread 1 used 24 channels and Spread 2 used 12 channels.

The field data was acquired over two days. Heavy rain on the first day and periodic showers on the second day slowed operations and associated leakage on the reciprocal phone lines produced 50 Hz interference that obliterated the signal on the last shots of Spread 2. In fine conditions the duration of the field survey would be reduced by approximately 30 percent.

RESULTS

Spread 1

30 m geophone spacing
24 channels
End shots 30 m north of geophone 24 and 30 m south of geophone 1.
Long shots 200 m north of geophone 24 and 200 m south of geophone 1.

V_1 = 1270 m/sec
V_2 = 1900 m/sec
V_3 = 4900 m/sec

Depth from south end shot 84 m
Depth from north end shot 112 m

The depth profile obtained after applying the reciprocal method to the data from the long and end shots (fig. 2) agrees in shape with the drill hole profile but the depths measured are up to 20 % deeper. This may be attributed to weathering of the basement surface, the inhomogenous nature of the glacial deposits, and the known irregular basement profile.

Spread 2

30 m geophone spacing
12 channels
End shots 30 m north of geophone 12 and 30 m south of geophone 1
Long shots 200 m north of geophone 12 and 200 m south of geophone 1

V_1 = 1750 m/sec
V_2 (northern end) = 5200 m/sec
V_2 (southern end) = 4100 m/sec

Depth from south end shot 67 m
Depth from south long shot 103 m
Depth from north end shot 41 m

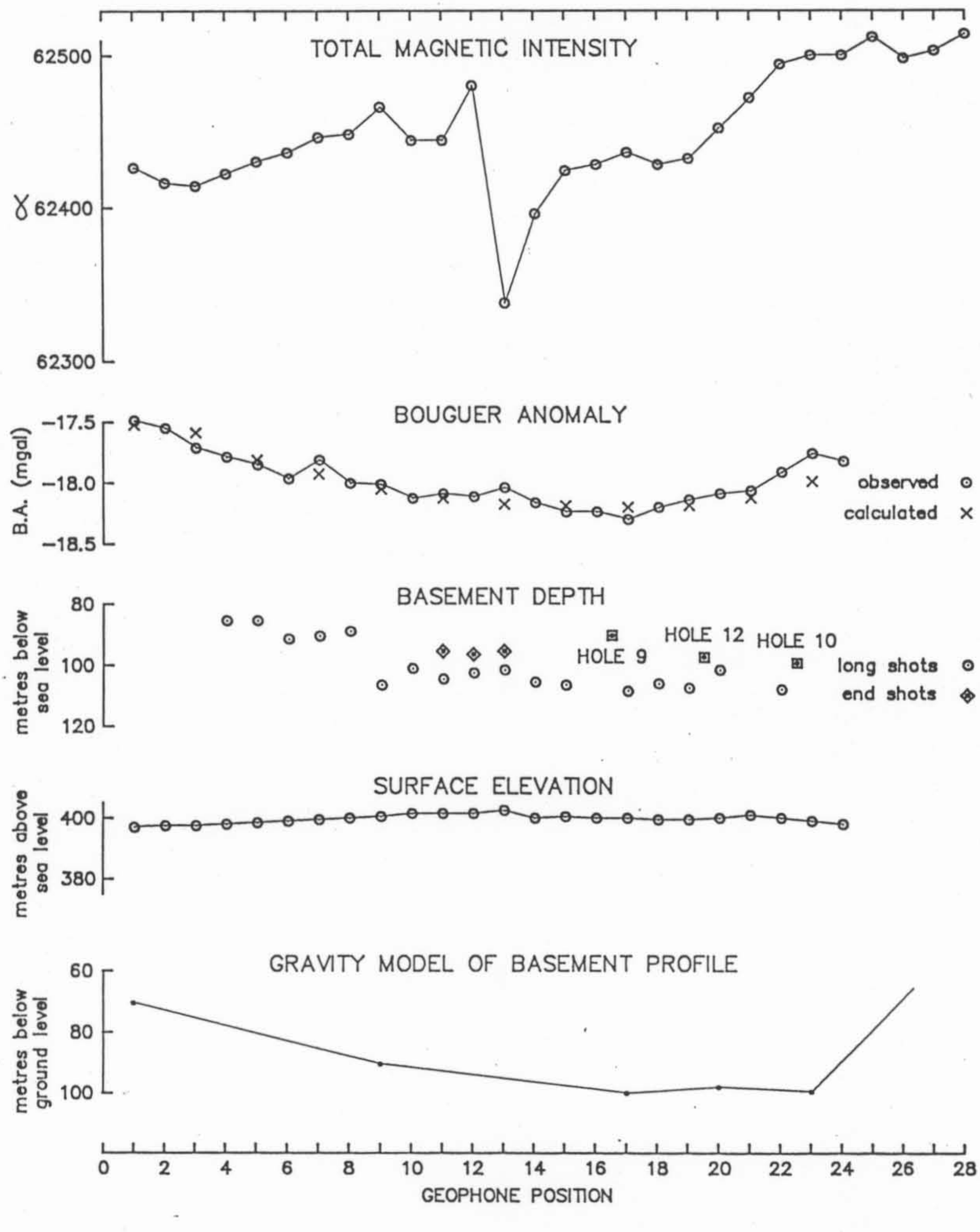
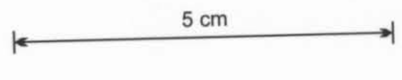


Figure 2. *Data from Spread 1*



The reciprocal time was only recorded for the north end shot because of 50 Hz interference and the depths calculated at geophones 6 and 7 using the reciprocal method (49 m and 47 m respectively) were used to obtain a theoretical reciprocal time of 282 m/sec for the long shots. The depth profile thus obtained (fig. 3) corresponds to the basement depth measured at Hole 11.

Magnetics

The magnetic data were acquired at the geophone positions, and in the case of Spread 1 for an additional 120 m to the north, after removal of the cables and geophones. The data are plotted on Figures 2 and 3. Surface boulders in the area are up to six metres across and buried boulders of such dimensions could easily account for the single point anomalies. The magnetic data from both Spreads 1 and 2 show a marked increase in value north of Hole 10, corresponding to the decrease in basement depth between Holes 10 and 11.

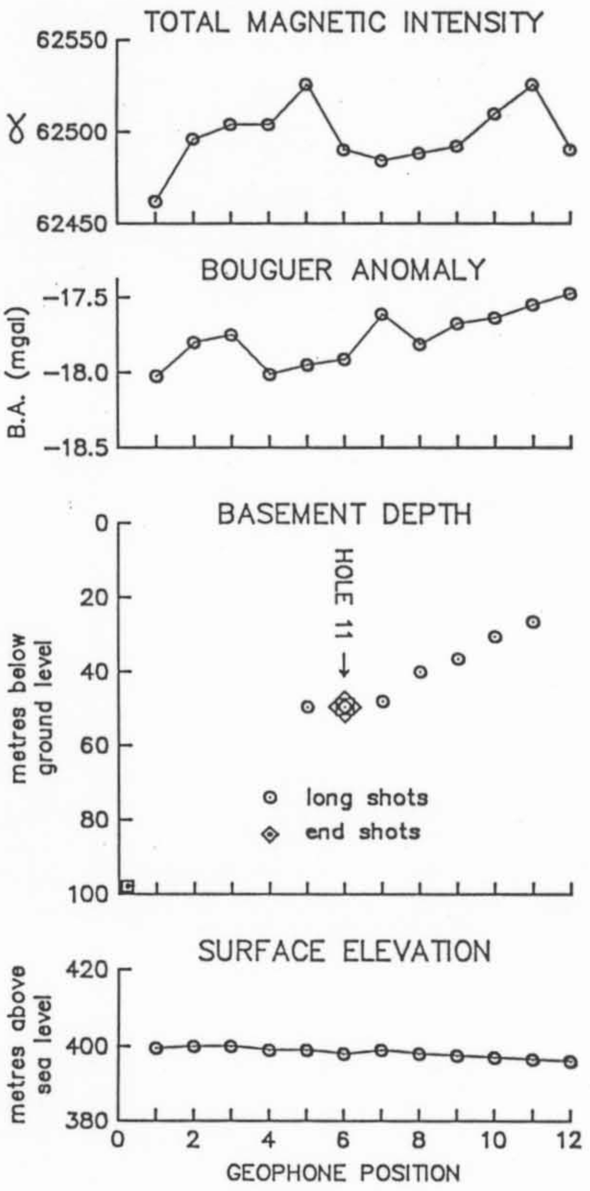


Figure 3. *Data from Spread 2*

Gravity

The gravity data were acquired at the geophone positions and are shown on Figures 2 and 3. A simple model based on the drill-hole data (fig. 2) and using an average bulk density contrast of -0.7 t/m³ show acceptable agreement between the observed and calculated Bouguer anomalies. The exception is at Hole 9 where the gravity model indicates a depth of 100 m rather than the 90 m reported from the drill-hole. This greater depth is in agreement with the depth profile from the seismic refraction data.

CONCLUSION

The methods applied have delineated the basement profile and show an average bulk density contrast of -0.7 t/m³ between the glacial deposits and the underlying basement. A further set of surveys running approximately east-west across the glacial deposits between basement outcrops is planned. A smaller sampling interval will be used for the magnetic measurements to provide possible information on near-surface boulders within the glacial deposits.

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