

UNPUBLISHED REPORT 1988/02

**Review of
stratigraphic-structural implications
of geophysical data,
Lynchford area, western Tasmania**

by

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INTRODUCTION

The complex sequence of Cambrian extrusive and intrusive rocks and their associated sedimentary rocks south of Queenstown and east of Lynchford in western Tasmania has been described in detail by Corbett (1979). The stratigraphic placement of this sequence and its correlation with other parts of the Cambrian volcanic succession have not, however, been established. The exposures between Mt Owen and the Queen River reveal substantial intrusive masses, erosional breaks and complex structuring. Corbett (1979) suggests that the Lynchford Tuff may be equivalent to the Comstock Tuff - and thus part of the Tyndall Group - which would imply that only the upper parts of the Cambrian succession may be exposed. Leaman (1986 a, b) inferred that this suite of rocks lies on or close to Precambrian basement (within perhaps 2 to 3 km) using regional geophysical data available at the time.

In view of the uncertainties attached to the Cambrian rocks west of Mt Owen Everard (1987) has proposed a deep, vertical drill hole at Miner's Ridge (at 380 840E, 5336 620N or 380 863E, 5336 200N) near the axis of an anticline in order to constrain suppositions about the Lynchford sequence.

This report examines the geophysical data in the region in greater detail than was possible as part of the earlier regional studies. The review has been directed at evaluation of structural attitudes, depth limitations, and secondary definition of all relationships - data permitting. It was hoped that this process would assist or confirm site selection, allow some site rating, suggest required rig capacity, indicate issues which might lead to optimising site locations and provide an outline of predictions and assumptions which can be tested or revised by the drilling results. The prognosis method is the most honest and scientific approach in these conditions since it forces a solid pre drilling analysis and provides an objective test of concepts and solutions in a form which can be simply upgraded.

THE LYNCHFORD AREA

The region studied is outlined in Figure 1. The map has been reproduced from Corbett (1979). The unit relationships inferred by Corbett (1979) are shown in cross section in Figure 2 (also from Corbett, 1979). Review of both Figures will show how geologically complex the area is and why Corbett could give no assurance of stratigraphic order. The occurrence of significant intrusive features and several unconformable relationships compounds the problems.

Corbett (1984) placed the Lynchford Tuff and the tuff-agglomerates on Whip Spur within the Tyndall Group which unconformably overlies the Central Volcanic sequence at Whip Spur and the underlying volcano-sedimentary sequence at Lynchford. The Central sequence is at least partly intrusive.

The overall succession is predominantly volcanic; the proportion of normal sedimentary rocks - greywacke, shale, sandstone - is minor when compared with the volume of direct volcanic or volcanic - derived materials. The stratigraphic and structural difficulties are sufficient to question the magnitude of the anticline inferred near Miner's Ridge. Dip evidence is far from conclusive and stratigraphic evidence even more uncertain.

The present drilling proposal (Everard, 1987) is designed to clarify some of the stratigraphic issues by drilling the core of the Miner's Ridge anticline. It will already be evident from the summary and Figures presented that this need not necessarily be the best or only site for such drilling. In the following discussion and analysis I have attempted to confirm or deny as many aspects of the local structure as possible in order to sensibly evaluate such proposals.

ROCK PROPERTIES

Few specific rock property determinations are available for the Cambrian rocks south of Queenstown. An exception relates to black shale on Whip Spur which has dry densities in the range 2.78-2.80 t/cu m and susceptibilities of 15-40 x 10 exp -6.

Leaman (1986 a, b), however, deduced bulk property ranges for large segments of the succession in western Tasmania. While these must yet be confirmed by more detailed property inversions and sample determinations they nevertheless serve to constrain interpretations.

Precambrian basement rocks are virtually non magnetic and possess densities in the range 2.65-2.71 t/ cu m. There appear to be two density groups; 2.65-2.67 and 2.70-2.71 representing siliceous and Donah type rocks respectively. Rocks with a higher pelite content are also slightly more magnetic but the effective contrast remains less than 0.0002 cgs.

The Cambrian sequences are generally denser than 2.72 t/ cu m; Dundas Group and other sedimentary sequences are rarely less than 2.74 t/ cu m while igneous sequences range from 2.7-2.9 t/ cu m depending upon composition. Certain elements of the succession have been inferred to be less dense; including some members of the Western Volcanic Sequence (e.g., near Madam Howard Plains) and the Tyndall Group:- 2.62-2.65 and 2.68-2.70 t/ cu m respectively. Few members of the Cambrian succession possess significant magnetic contrasts but large parts of the succession generate a low but measurable background contrast. The mafic and ultramafic rocks are strongly but variably magnetised (0-0.02 cgs, 0.004 av) while the Tyndall Group rocks generate most of the anomalies of moderate scale observed in aeromagnetic surveys along the arc of Mount Read Volcanics (0.001-0.003 cgs). The volcanic piles or derived materials possess much lower contrasts but the contrast is sufficient to produce long wavelength effects in the magnetic field.

Ordovician and Silurian rocks are essentially non magnetic and only contribute to the magnetic field where alteration has occurred. These rocks exhibit a wide range of lithology dependent densities. Most units are siliceous and densities are typically 2.57-2.64 t/ cu m. Shale units tend to possess values at the upper end of this range while limestone members are not less than 2.74 t/ cu m.

All units contribute to the gravity field but only the Cambrian rocks create significant magnetic responses. High amplitude effects can be related directly to Tyndall Group or mafic rocks. Magnetic contrasts are reduced or eliminated by alteration or weathering.

GEOPHYSICAL DATA

The available gravity and magnetic data have been presented elsewhere (e.g., Corbett et al, 1982; Leaman, 1986 a, b). The gravity data base has, however, been updated since the original work of Leaman (1986b) and the number of stations west of Queenstown has been increased. Unfortunately, the coverage remains uneven and patchy west of the Queen River due to access and vegetation problems for helicopter surveys. The main Lynchford block has, however, been wholly covered at 1 km intervals. Such a coverage has limited value when dealing with thin localised units.

The gravity coverage is regional and irregular, as noted above, and may only be used for broad brush assessments at this stage. The limited coverage west of the Queen River and immediately off the west coast also limits the usefulness of the available data since many gradients may have at least part of their origin beyond the immediate area under study and contextual issues may only be crudely approximated. This may lead to depth range or density errors in local studies but should not greatly affect model concepts.

No such problems exist with the magnetic data base even though the east-west line spacing is 500 m. The coverage is uniform, at a nominal elevation of 130-150 m, and able to resolve issues related to primary boundary features. The nominal clearance was not maintained across parts of the Lynchford area and especially onto the western slopes of Mt Owen. As much of the variation west of 382 000 mE is less than 50-70 m I have not fully corrected the survey or the profiles used for analysis at this stage. The deviation is much greater onto Mt Owen and any conclusions concerning the section beneath Mt Owen must be tempered by this factor. Fortunately the greatest deviations lie east of the mountain. Any further treatment must use fully corrected data modelled to the actual terrain form.

INTERPRETATION

No previous, public domain, specific interpretation exists for the Lynchford area. Regional analysis (e.g., Leaman, 1986 a, b) has, however, considered data and conditions north and south of Lynchford. These interpretations have been reproduced as Figures 3, 4 and 5.

The character of the gravity profile as seen in Figures 3 and 4 is representative of the region. The western volcano-sedimentary sequence has probably been sampled between 375 and 385 000 mE in Figure 3 and 373 and 383 000 mE in Figure 4. Light units and a lower than normal Cambrian bulk density has been inferred for these blocks. Note also that the crystalline basement also appears to shallow northward along this axis. Considerable ambiguities could occur with respect to this point if the Cambrian rocks involved were much lighter in bulk than normal elsewhere (see discussion below). These interpretations would suggest that the Lynchford area is marginal to the main basin or structural axis. Consistent conclusions could be drawn from the available magnetic interpretation (Figure 5). Magnetic rocks are not infinitely thick and thin in the same sense. Note that the highest contrasts in the section are associated with the Tyndall Group. The main body of the section is much less magnetic and that the contrast is reduced by alteration.

In order to obtain a better and more specific regional perspective for the local analysis an additional gravity profile at 5337 000 mN was modelled. The profile made use of data acquired as part of the Mount Read Project (1986-7) and was extended off the coast in order to evaluate crustal components and allow analysis consistent with the regional study of west and north west Tasmania now in progress for the Mount Read Project (1987-8). Two solutions for the new profile have been offered (Figures 6 and 7). These Figures indicate where the potential ambiguities may lie - several kilometres west of the Queen River. Either model can be applied to provide the regional gradients observed near Lynchford.

Some comments are justified about these models since the use of any regional effect derived from them is ultimately critical to study of the Lynchford area. The reliability of the offshore data is not known but it has not been fully corrected. The data quality probably matches the inferences made from seismic data used to generate an estimate of the effect of the post Permian section. When the profile is compensated for water, Tertiary or long wave mantle effects three critical features emerge. There is a major basement boundary at this scale, a sizeable trough fill of denser sediments and, in order to create a consistent view of sections further north and south, a granite intrusive (Figure 7). The negative effect off the coast is due to the combined effects of granite, presumably Devonian, and Tertiary sediments. Although various solution paths were attempted only that presented in Figure 7 satisfies Occam's razor and other sections. The models effectively suggest the location of the western side of the Cambrian Trough.

DETAILED ANALYSIS:

The regional setting derived in Figure 7 was used to form the basis of all gravity models. Such a model provides the essential long wavelength elements of the field, the required shift match parameters for the data and general specification of those first order features which occur within the window of magnification. This is shown in each of Figures 6 and 7 and extends from 370 to 390 000 mE. The scale and context of structures and units is such that any more specific modelling would be unable to resolve the relationships sought. The extant data limits resolution in detail but not in concept.

Detailed profiles at 5336 000 and 5337 500 mN have been modelled magnetically in order to test the consistency of units and responses. The detailed gravity profile lies between these coordinates. Feasible solutions are presented in Figures 9, 10 and 11. Any acceptable solution must be based on use of both data sets.

Initial modelling utilised the induction of the regional gravity treatment. An end result (many paths were followed but only one led to a coherent solution) is shown in Figure 8. Use of the gravity data and the evolving density assumptions from previous work showed that the Lynchford succession cannot be very thick or it possesses bulk densities comparable with the underlying basement. While it would be possible to move the basement surface laterally or vertically in a regional sense it must still rise into the section fragment being modelled. There are limitations upon where this surface may be. Review of the local geology (Corbett, 1979) shows that up to half of the lithologies are massive and igneous. Several are mafic. While no determinations exist it is highly unlikely that these materials possess densities less than 2.6-2.63 t/cu m. Some must be much denser (ca. 2.8 t/cu m). Clearly if the rocks of the region possess an average density of 2.65 t/cu m then the interface between them and the basement cannot be resolved and their thickness would be indeterminate. Previous work (e.g., Leaman, 1986 b) has shown that no other segment of the Cambrian succession has such a density range in bulk. Indeed, the regional work illustrated in Figures 3, 4, 6 and 7 demonstrates that such densities cannot be persistent or pervasive in the vicinity of Lynchford. Critical controls on any magnetic-free solution are provided by the implications of the post Cambrian rocks and structures to east and west. While these are also not well controlled there are severe limits on any solution which attempts to explain the gravity field across them. And they present a density contrast with basement. However one seeks to account for the fold and fault structure west of the Queen River or the conditions east of Mt Owen there can be little doubt that the basement is very shallow - not more than 3.5 km - and that post Cambrian rocks may directly overlie it in places. This is, of course, wholly consistent with mapping east of the King River. More significantly, the Cambrian rocks must increase in bulk density west of the Queen River, irrespective of what assumptions are made in the Lynchford area. This is also

required regionally. Thus any uncontrolled gravity interpretation limits the available geological options. The local Lynchford section must have a density distribution which is not greatly different from the underlying basement, which cannot be very deep, even though some massive units exist within it. Further, and most significantly, the Lynchford section must be quite unlike that hidden beneath the Siluro-Devonian rocks west of the Queen River. The direct implication being that the Lynchford rocks overlie the section in the main trough and simply onlap each other and the basement east of Lynchford. The relatively thin section has then been intruded by various igneous rocks and capped with volcanics.

The two magnetic profiles (Figures 10 and 11) do much to refine these implications which may be taken as limiting conditions on the mass distributions.

Line 5336 000 mN (Figure 10) illustrates the essential features of the interpretation. As was the case in the Linda line (Figure 5), the largest anomalies are located beneath the Ordovician conglomerates or east of the range. At this northing the effect is introduced on Whip Spur but the character is not modified by materials on Mt Owen and can be unambiguously associated with exposures of the Tyndall Group on the eastern face of the mountain. It seems likely that Corbett's 1984 inference about the tuff on Whip Spur is correct and that a folded sequence of magnetic tuffs underlie the conglomerate. The contrast is relatively high at 0.001-0.002 cgs but consistent with other studies. The magnetic section is depth limited and the model provides an estimate of the depth and thickness of the Tyndall Group.

The major isolated anomaly near the Queen River is also associated with tuffs. The association of sundry igneous rocks near the King River Mine is only locally magnetic in comparison. The anomaly pattern offered by the contour map of the magnetic field confirms this relationship. These western tuffs have identical properties to those near Mt Owen. The Lynchford Tuff is irregular in shape and thickness reflecting the truncation by more recent rocks (see also Figure 2). It is not clear how far these rocks extend laterally but the contrast is relatively high and the rapid loss of field character indicates that the unit is either rapidly thinned or terminated to the west. It cannot extend to depths in excess of about 5 km. It is reasonable to assume that the Lynchford, Whip Spur and Comstock tuffs are equivalent. The distribution of this unit specifies the gross form of any anticline in the Miner's Ridge area.

Several other units between the King River Mine and Whip Spur contribute to the magnetic field. All are relatively thin and appear to be part of Corbett's basic to intermediate lavas category.

Detailed review of the profile confirmed that the entire section contributes to the responses observed. In the model provided in Figure 10 this base level response has been rated at 0.0005 cgs. It is unlikely that every unit is

slightly magnetic but most must be. Removal of this contrast is not feasible. Its requirement, coupled with the depth limitations implied by other more magnetic units, limits the overall thickness of the Cambrian section. Since all Cambrian sequences possess a background contrast this enables resolution of the basement surface which ranges in depth from 1.5 to 3.5 km in the Lynchford area.

The anomaly response near 370 000 mE indicates onset of the normal Cambrian character typical of the deep sections. The contrast estimate is not reliable and the depth cannot be predicted with certainty.

Line 5337 500 mN (Figure 11) supports all the points made above. The form of the profile is comparable with that at Mt Lyell (Figure 5). The more subdued nature of the response east of 382 000 mE may be due to increased flight clearance or alteration of the materials between 382 and 383 000 mE. While some effect seems likely from topographic adjustment (it has not been compensated in this study) examination of the patterns in the magnetic field, along strike and with respect to the geological basemap, indicates that the intrusive rocks between 5337 and 5338 000 mN are massively altered. The model shows that the association with the Tyndall Group is maintained.

The large anomaly near the Queen River reflects the greater surface exposure of the Lynchford Tuff. The implied contrast is comparable with the previous line. Minor anomalies along this line indicate a correlation with certain tuff members rather than lava members. More detailed review would be required to establish if this was indeed the case.

The bulk contrast conditions also apply but it appears that the basement may occur at a minimum depth of 1700 or 1800 m at this northing.

When the implications of the magnetic analysis are applied to the gravity field the solution developed in Figure 8 can be revised (Figure 9). This resolves most of the paradoxes. A solution consistent with the regional requirements and the magnetic data can be obtained which is also geologically believable. This suggests that the rocks of the Tyndall Group or its virtual time equivalents are present and that they onlap basement. The "normal" Cambrian section is developed further from the basin margin and contains some mafic units. The Lynchford rocks are relatively low density but the massive igneous members are denser. The solution also allows inclusion of realistic density contrasts for the Lynch Creek Basalts. The model presented in Figure 11 can be read in conjunction with Corbett's section (Figure 2).

The fault mapped across the region (Figure 1) has little significance magnetically since the disrupted section is relatively thin. It is not clearly recognised in the magnetic field and this observation may be contrasted with the near E-W linear which links the altered rocks north of Whip Spur with isolated prospects and the King River Mine (Figure 12).

SUMMARY

Detailed review has confirmed the original suggestion of a significant anticline east of Lynchford. The folded section, however, is relatively thin and would appear, as suspected by Corbett (1979, 1984) to comprise substantial parts of the Tyndall Group. The fold core will here include basement at depths of 1500 to 2000 m. The fault mapped across the region transects the axis of the fold. For all practical purposes Miner's Ridge lies near the axis of the fold. The present work has greatly simplified the structure which is clearly very complex but the sited position would be able to test the structure. Whether it would test or provide much useful stratigraphic information is questionable. Since a vertical hole has been proposed I very much doubt that it could be justified if all that would be encountered were the basement and that at nearly 2 km depth. Inclined holes would be more useful in stratigraphic terms but at the expense of greater drilling distance and cost.

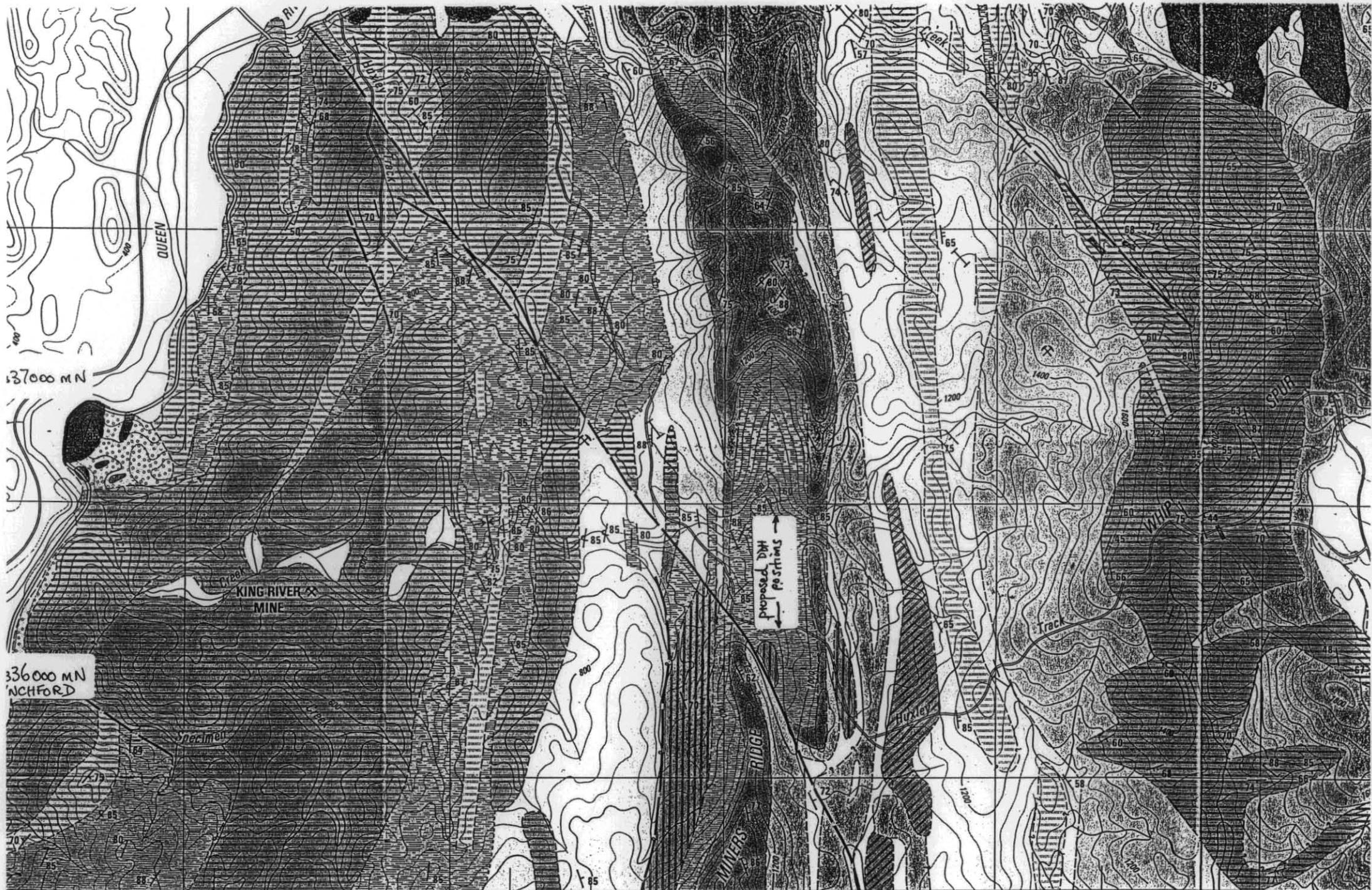
The broad brush treatment offered by this review when coupled with the mapped or inferred relationships tends to make a mockery of such terms as Mt Read Volcanics, and western or eastern sequence or volcano-sedimentary sequence since these all appear to interfinger - as the basement shallows. A compressed and intensely overlapped sequence may be implicit in the complexity of this area but a vertical hole will not resolve it. Nor will any other single hole less than 3 km. The mixture of intrusive and extrusive materials simply compounds the problems. The tuff relationships at Whip Spur and Lynchford stress the variability of pre Tyndall distributions. Moderately deep, high angle drilling across boundaries such as these may be more productive than at the proposed site.

It may be more constructive to combine drilling in this area with specific targets. The anomalous volcanics north of Whip Spur should be reviewed in more detail. A first stage in this process would be complete magnetic data correction followed by review of contrast variations. Drill hole Huxley 1 (Goldfields) was sited on the southern boundary of this anomalous area and was headed to the southeast. Some minor mineralisation was encountered. If these implications were confirmed then an extended hole could be sited north of Whip Spur to test the alteration proposition and the relationships between the massive porphyries and the intruded tuff section beneath. Other possibilities exist between Lynchford and the King River Mine where the Lynchford tuffs overlie the volcanic section and where a major lineament appears to have cross cut.

Drilling is certainly justified in this area but the appropriate site is not immediately obvious. Any useful structural hole will need to exceed 1500 m and it is unlikely that any hole of structural benefit will yield worthwhile stratigraphic data. I do not believe the present proposition can be supported on the basis of the arguments provided.

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337000 m N

336000 m N
WCHFORD

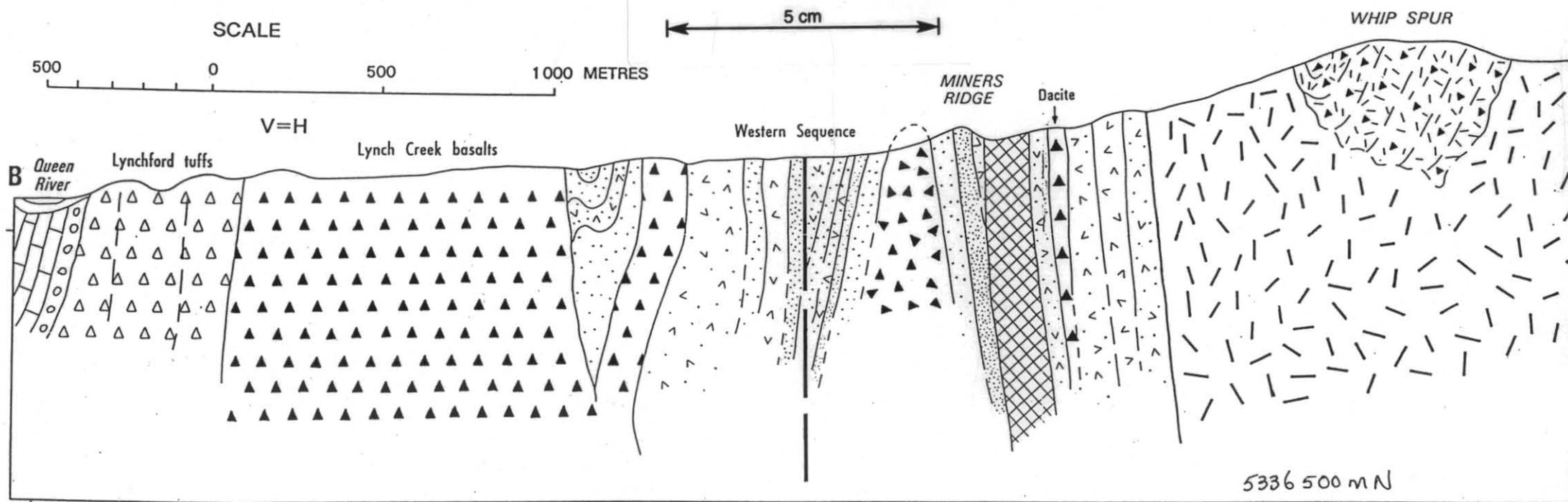
02-12 358 379000 m E 359 380000 m E 360 381000 m E 361 382000 m E 362

GEOLOGICAL BASEMAP (from Corbett, 1979)

FIGURE 1

5 cm

12/23



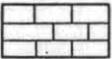
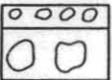
379 000
NE

380 000
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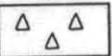
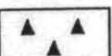
382 000
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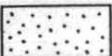
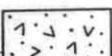
LATE CAMBRIAN - ORDOVICIAN

-  Gordon Limestone correlate
-  Owen Conglomerate, with Pioneer beds correlate in Queen River area

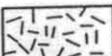
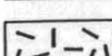
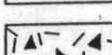
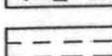
CAMBRIAN - MT READ VOLCANICS

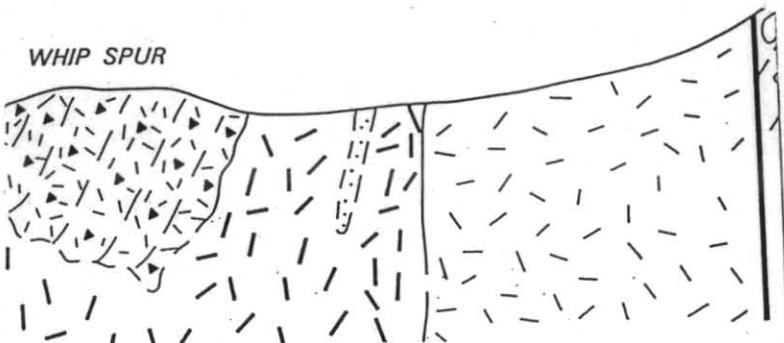
-  Lynchford tuff sequence
-  Lynch Creek basalts

WESTERN SEQUENCE

-  Quartz-feldspar porphyry
-  Dominantly greywacke & shale
-  Tuff or interbedded-tuff and sedimentary rocks
-  Miners Ridge Sandstone
-  Basalts at Miners Ridge

CENTRAL SEQUENCE

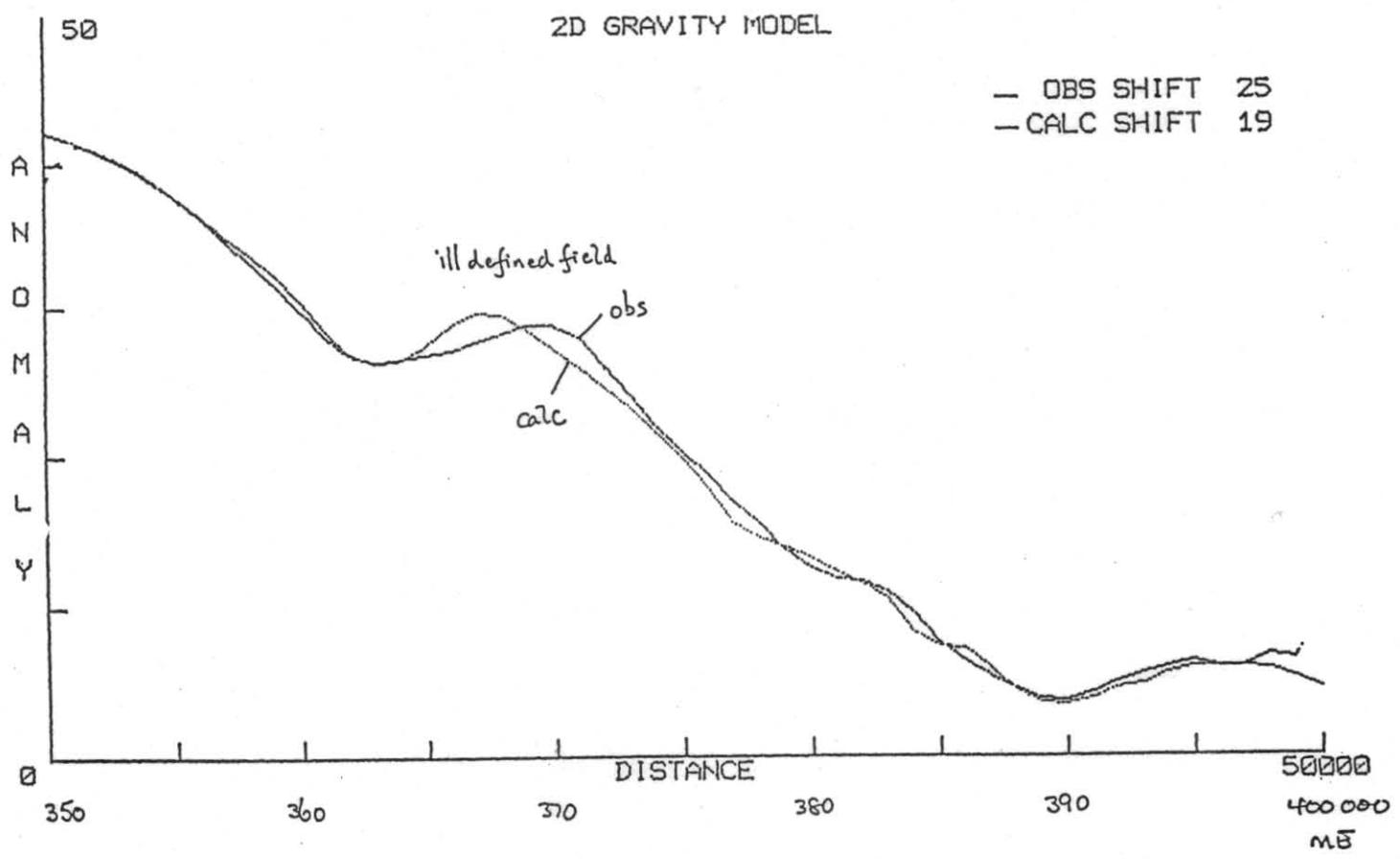
-  Mainly acid tuffs, agglomerates, lavas.
-  Basic-intermediate agglomerates
-  Andesite intrusives
-  Feldspar porphyry bodies
-  Whip Spur agglomerate sequence
-  Shale-tuff unit in upper Conglomerate Creek.



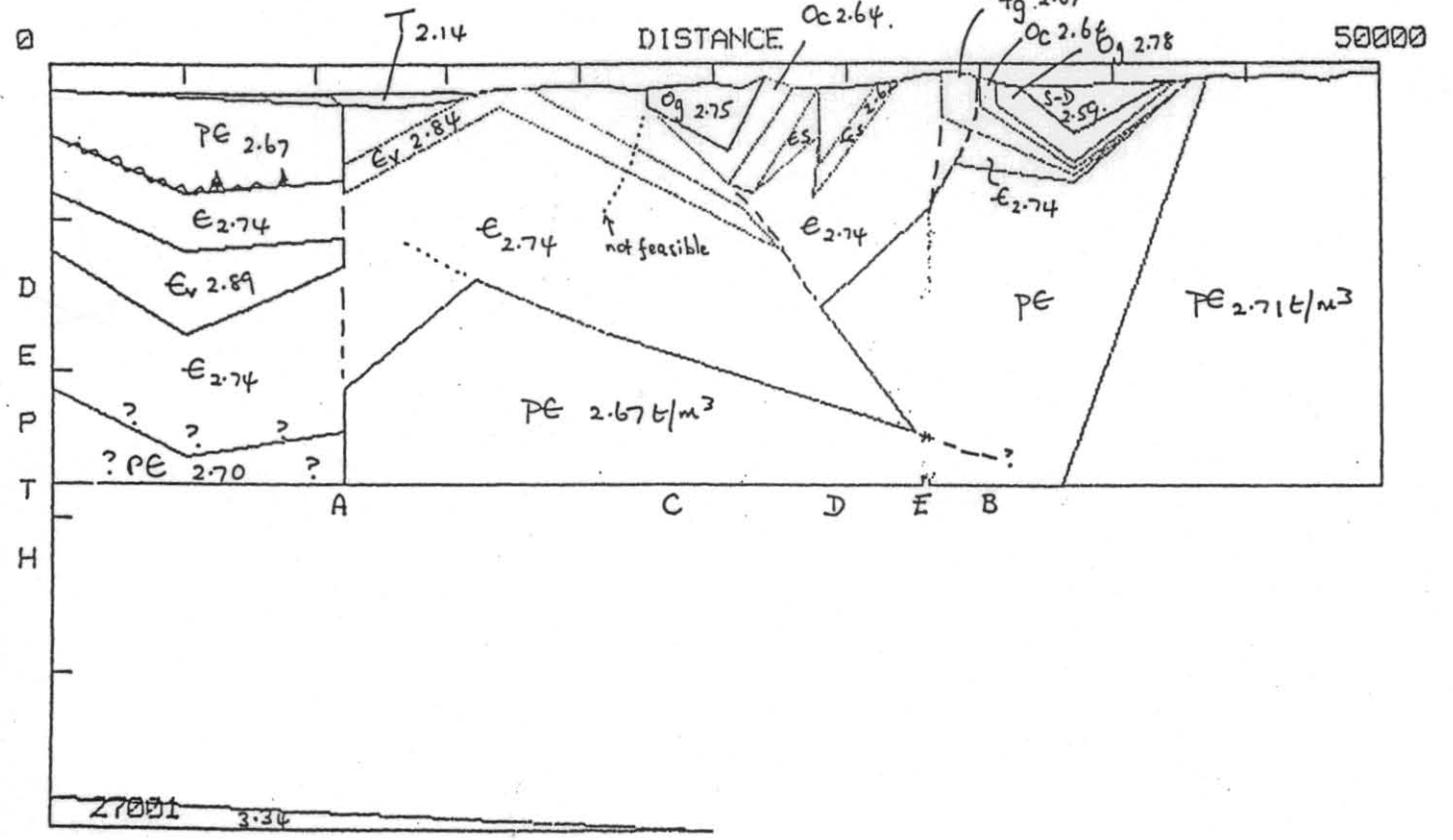
CROSS SECTIONAL RELATIONSHIPS LYNCHFORD
(from Corbett, 1979) FIGURE 2

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2D GRAVITY MODEL

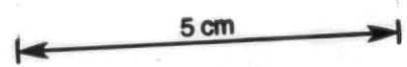


LINE 326500 MN 350-400 ME
 NX16 ADJ TERT BASIN 7



MODEL PROFILES: 5326 500 mN

FIGURE 3



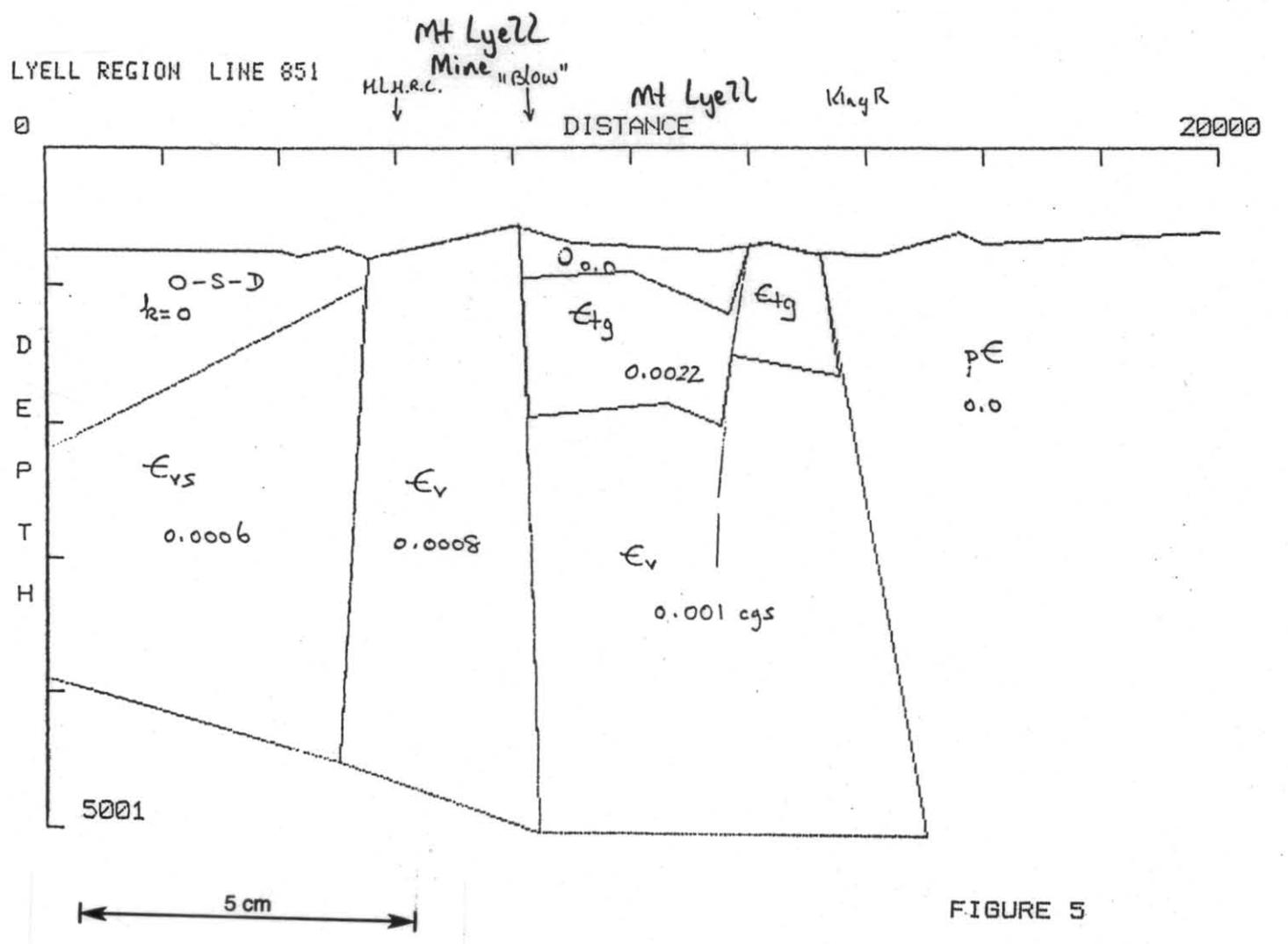
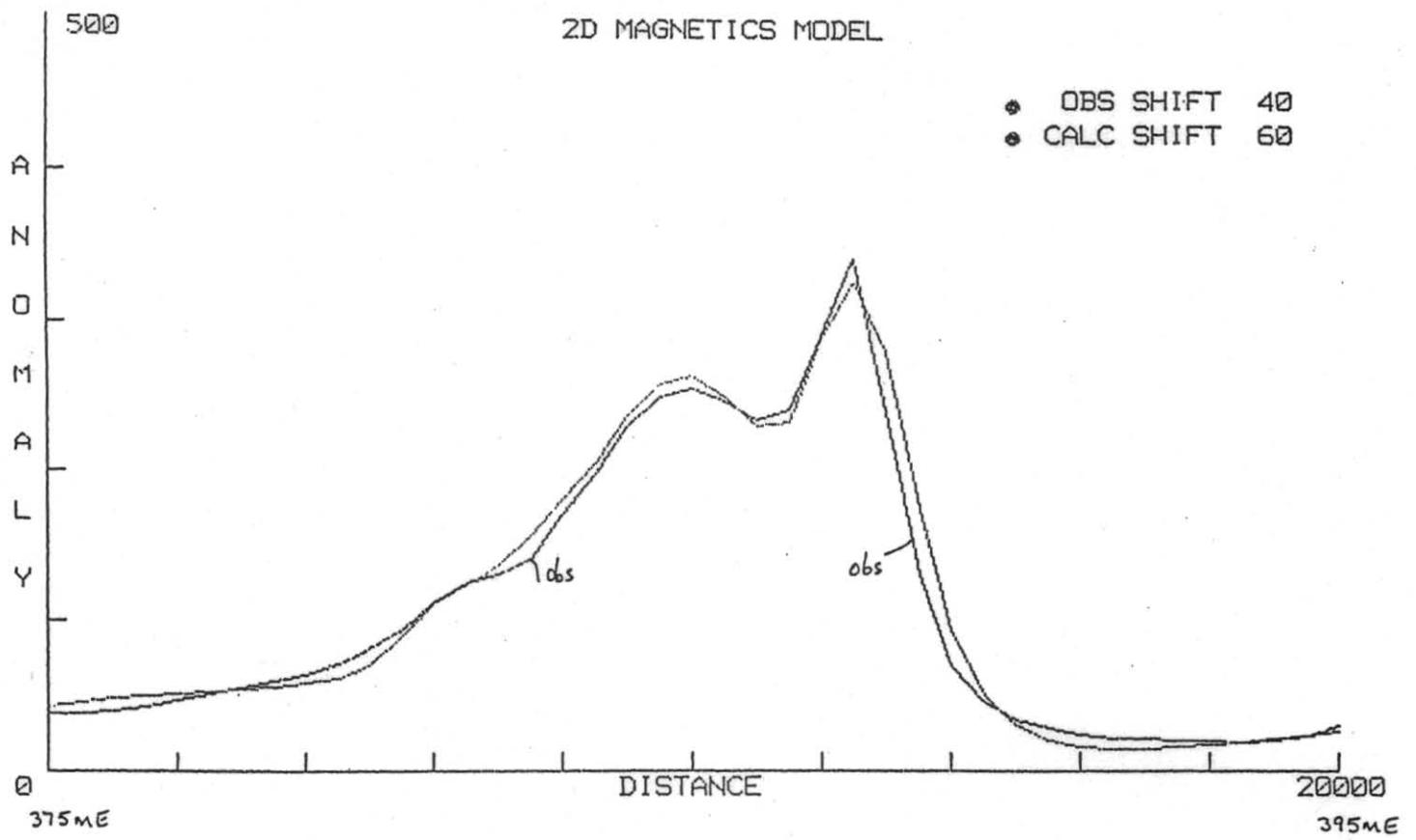
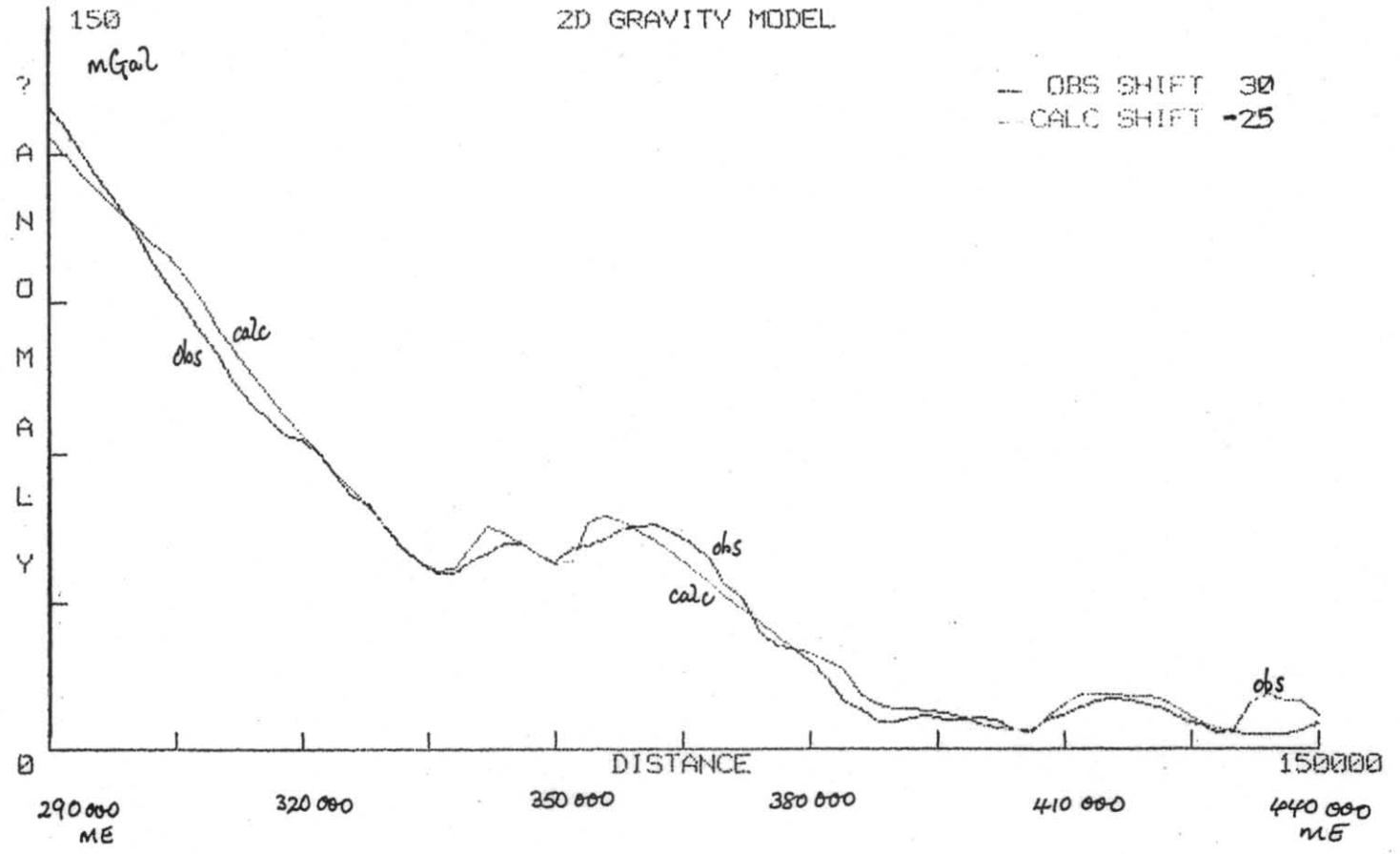


FIGURE 5

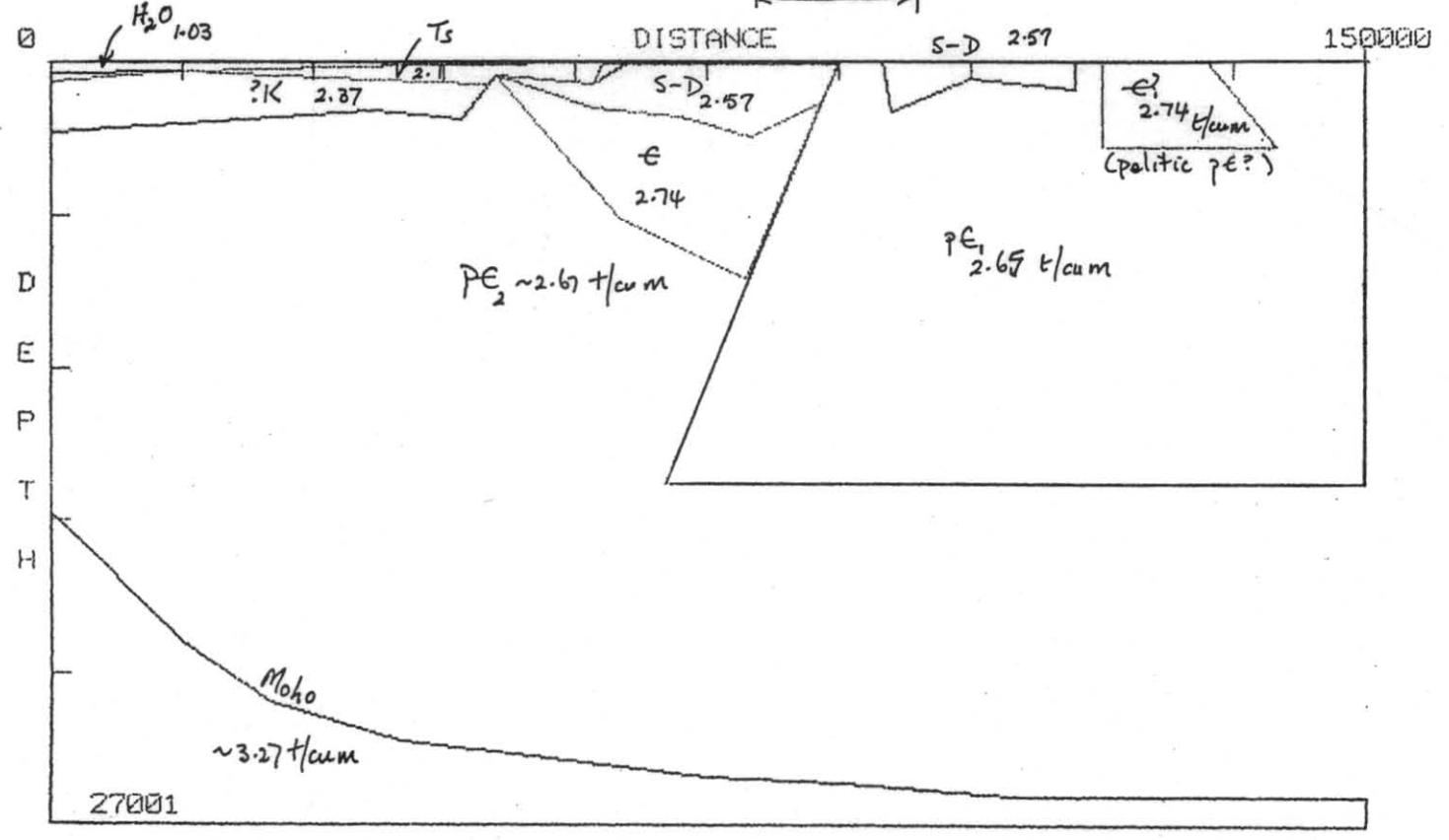
LINE 851 - through LINDA
(5342000 MN)

17/23

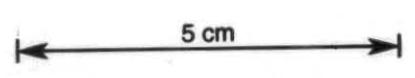
2D GRAVITY MODEL



LYNCHFORD DDH STUDY 5337000 N 290-440 E
ADJ 4 10 13

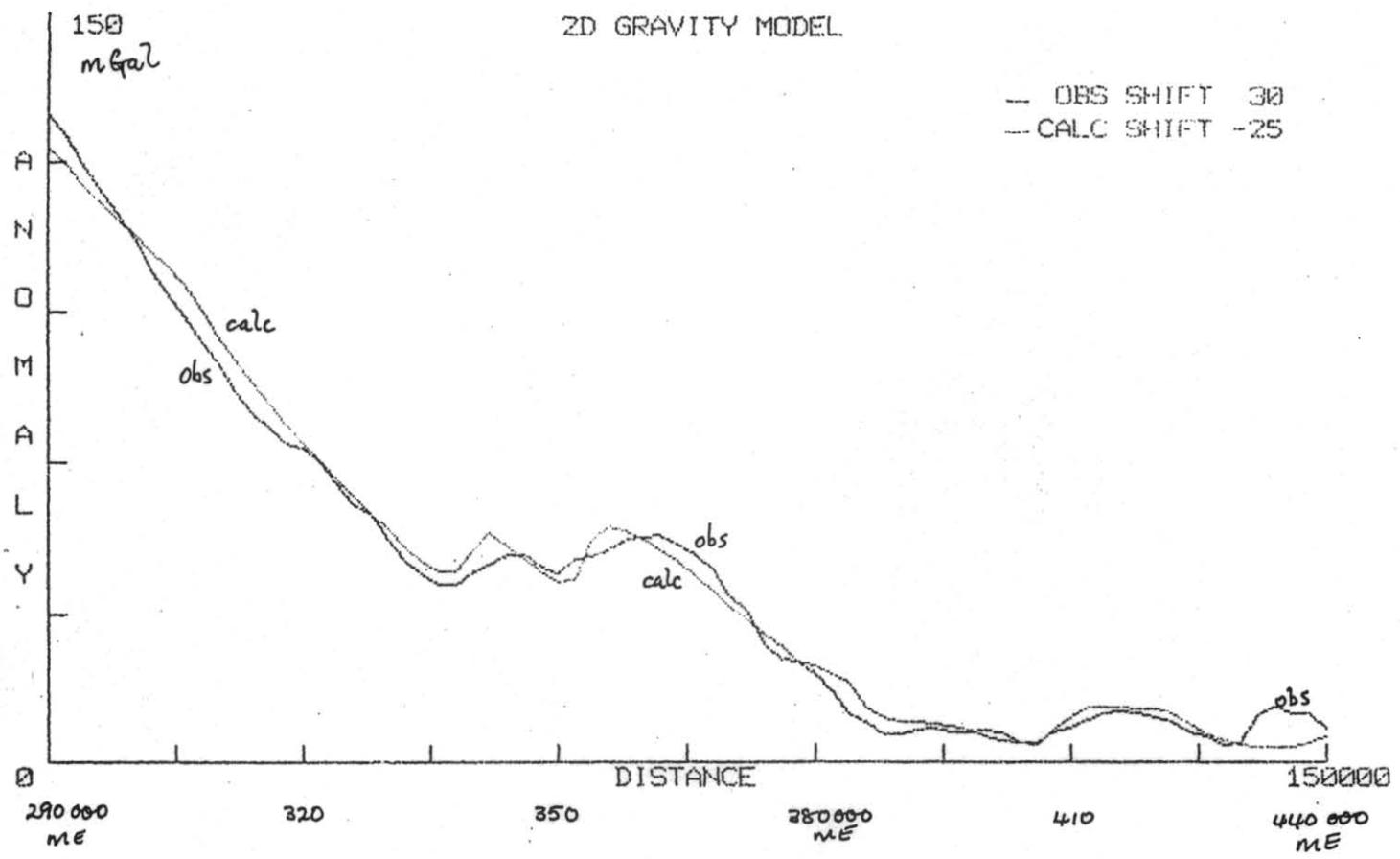


REGIONAL GRAVITY MODEL: 5337 000 MN - NO GRANITES - FIGURE 6



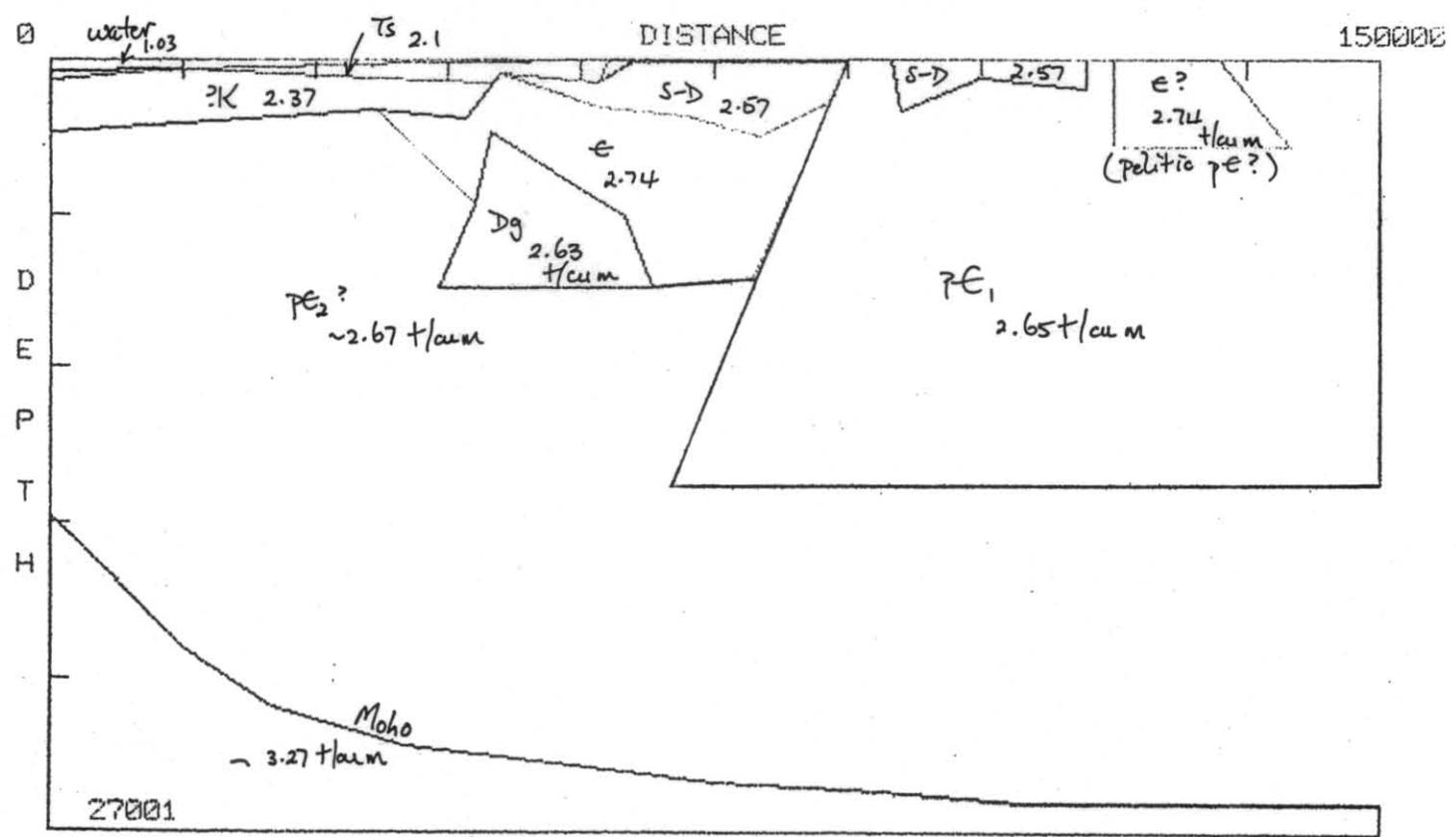
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2D GRAVITY MODEL

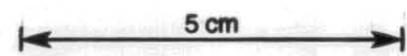


LYNCHFORD DDH STUDY 5337000 N 290-440 E
 ADJ 4 + 14 GRANITE PRESENT ALTERNATIVE PATH

LYNCHFORD STUDY AREA

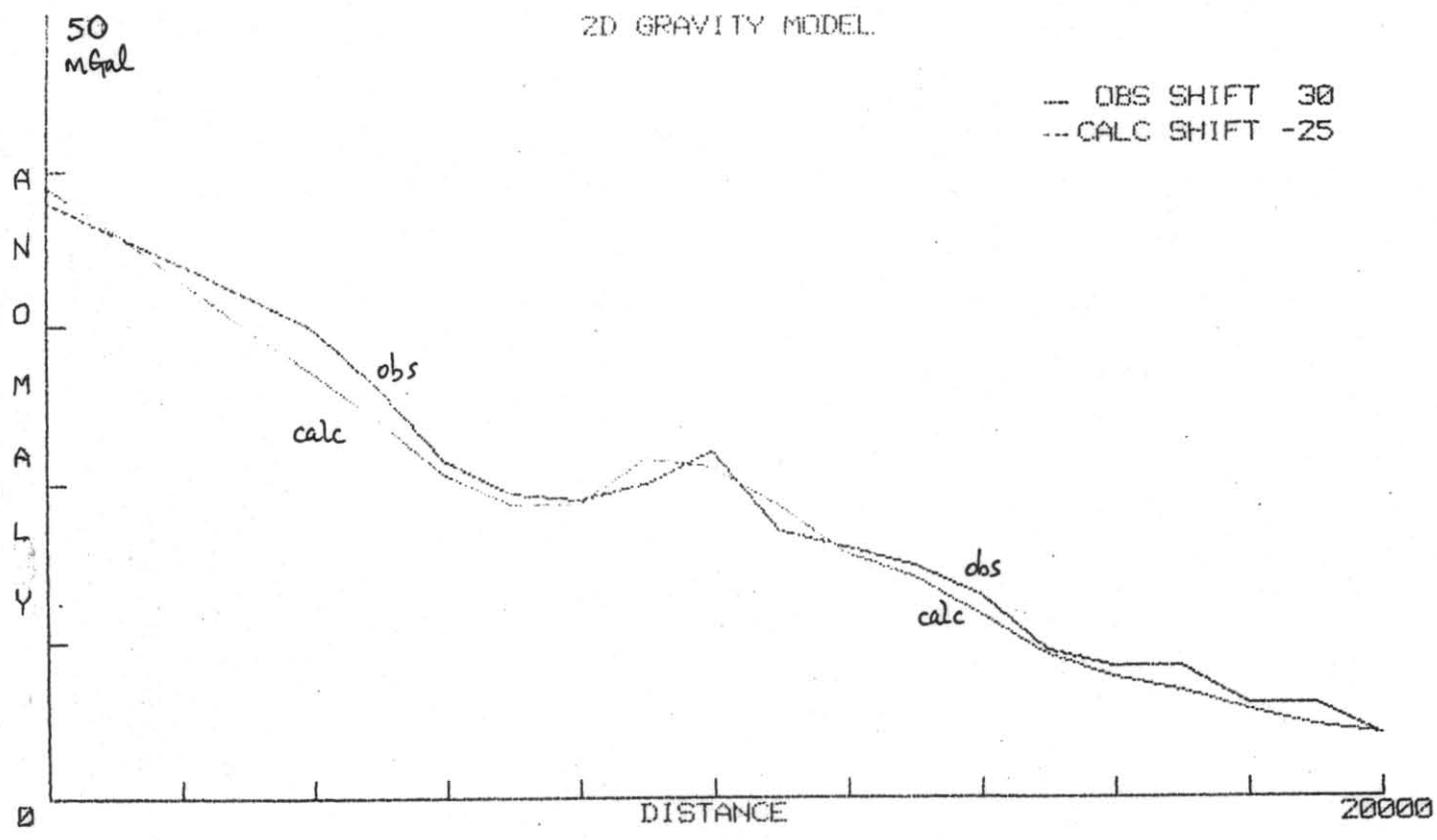


REGIONAL GRAVITY MODEL: 5337 000 MN - GRANITE PRESENT - FIGURE 7



19/23

2D GRAVITY MODEL

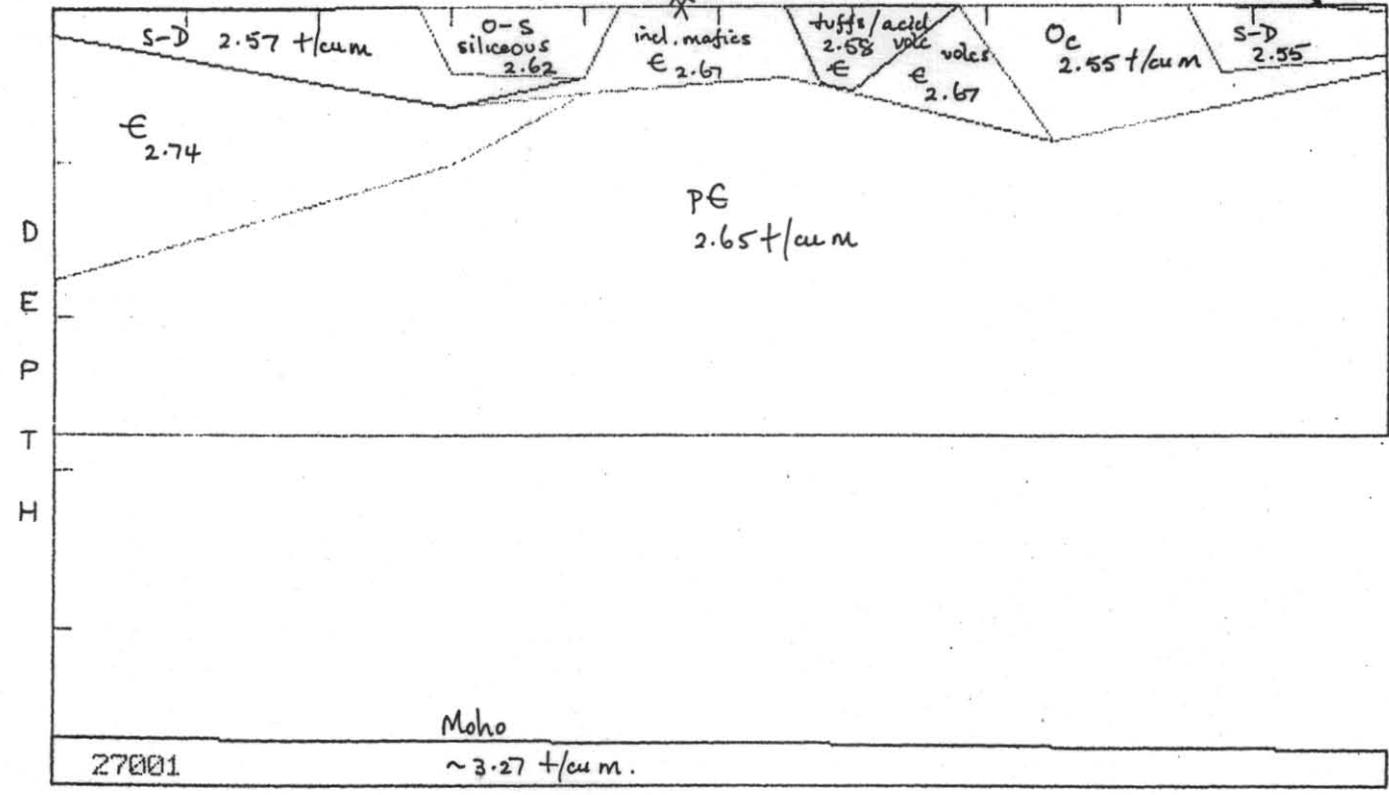


370 000 mE 380 000 mE 390 000 mE

LYNCHFORD DDH STUDY 5336500 N 370-390 E
 ADJ 6 16

Lynchford King R Mine Miners Ridge Whip Spur S. Mt. Owen. King R. 20000

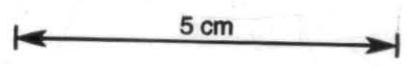
TS 2.17



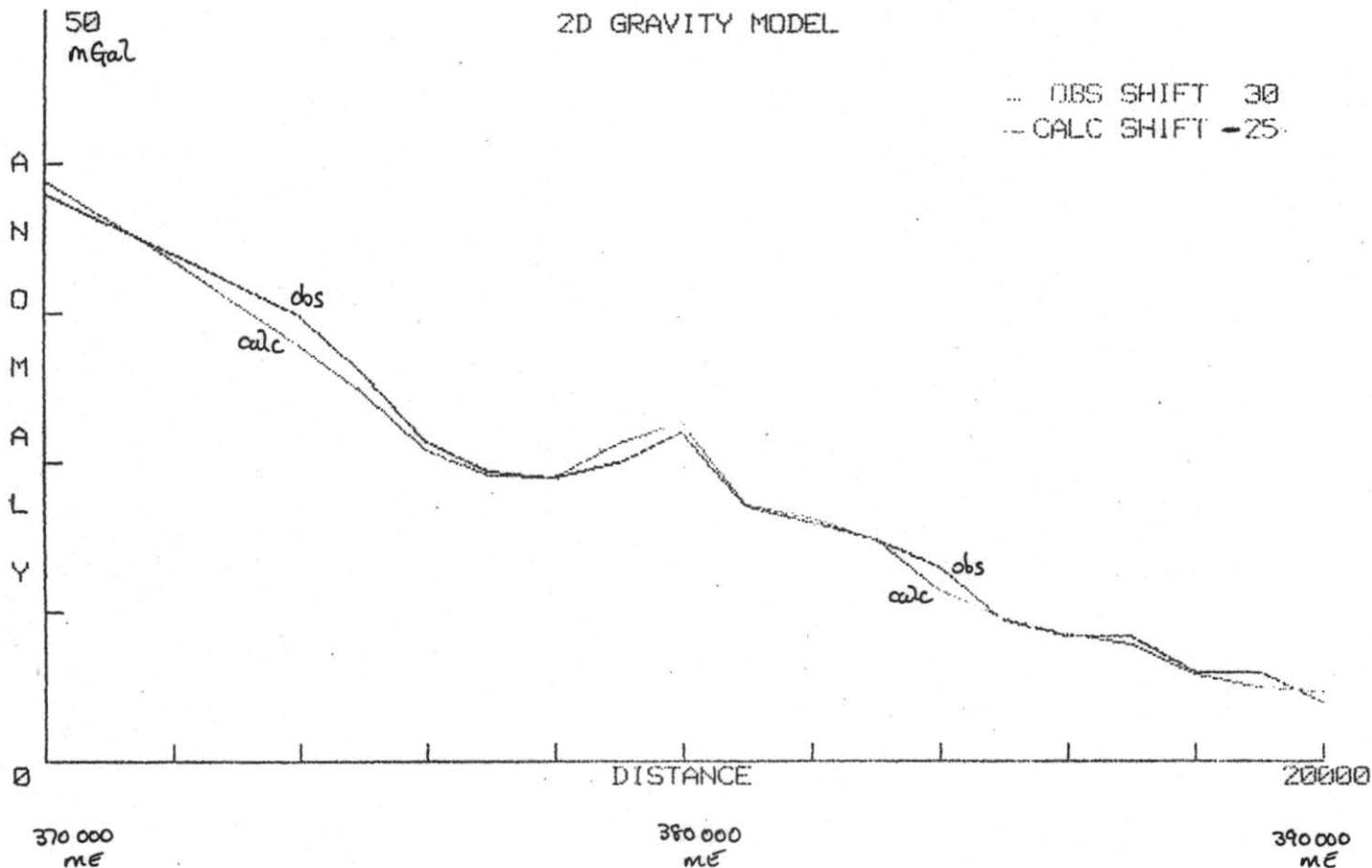
GRAVITY SOLUTION WITHOUT REFERENCE TO MAGNETIC INFERENCES
 5336 500 MN LYNCHFORD

FIGURE 8

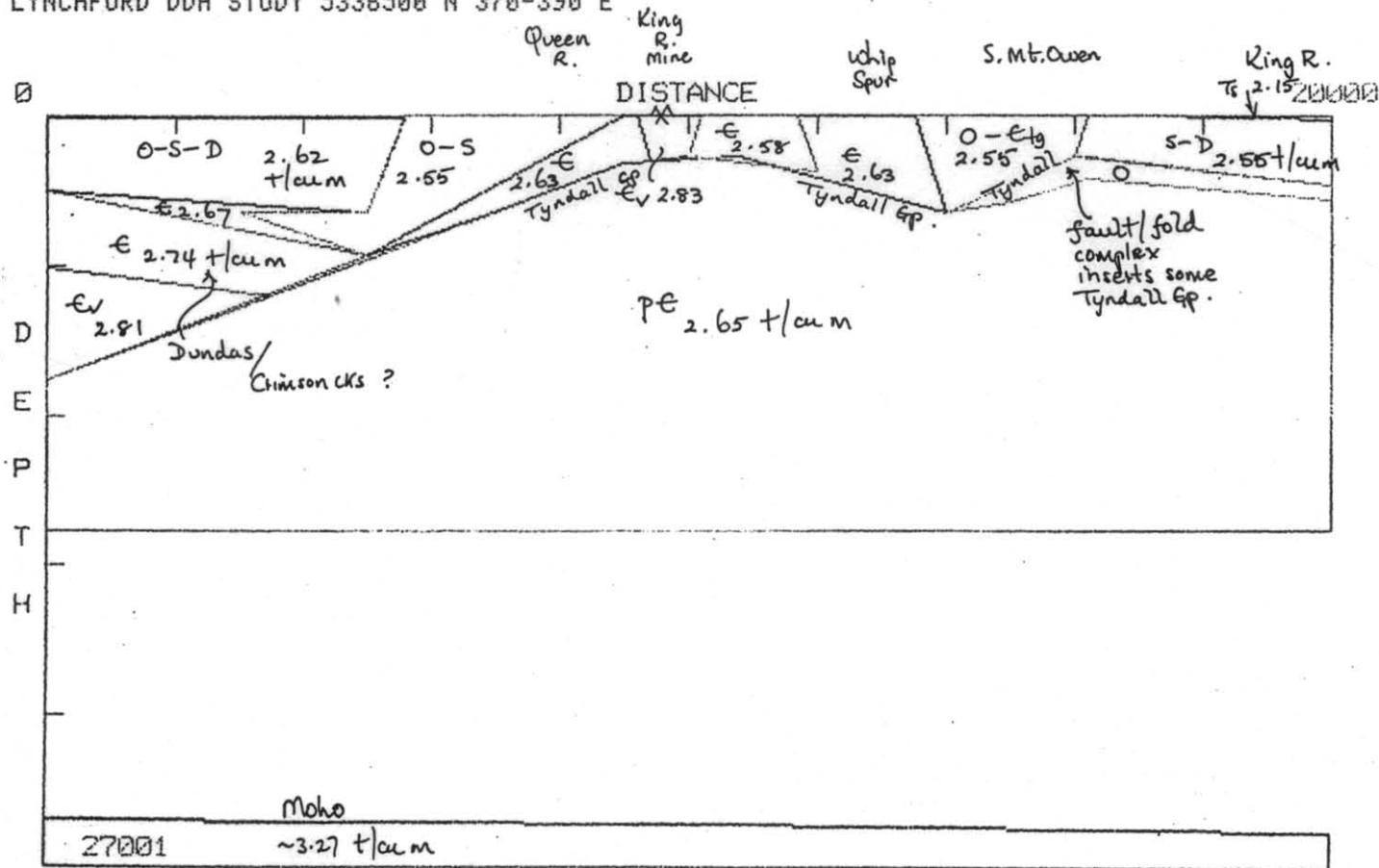
02-19



2D GRAVITY MODEL



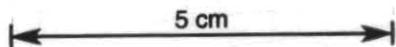
LYNCHFORD DDH STUDY 5336500 N 370-390 E



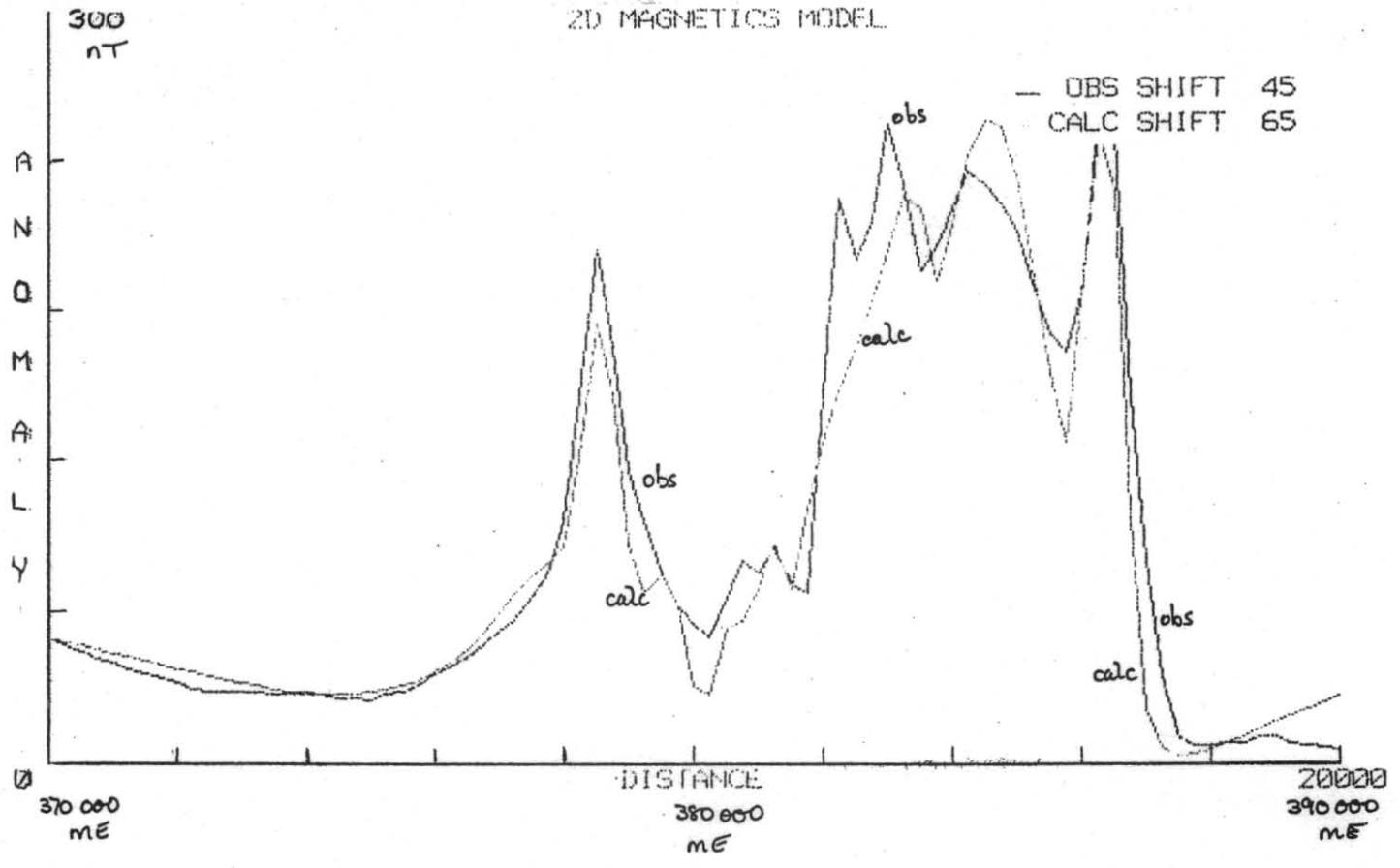
GRAVITY SOLUTION CONSTRAINED BY MAGNETIC MODELS
5336 500 MN LYNCHFORD

FIGURE 9

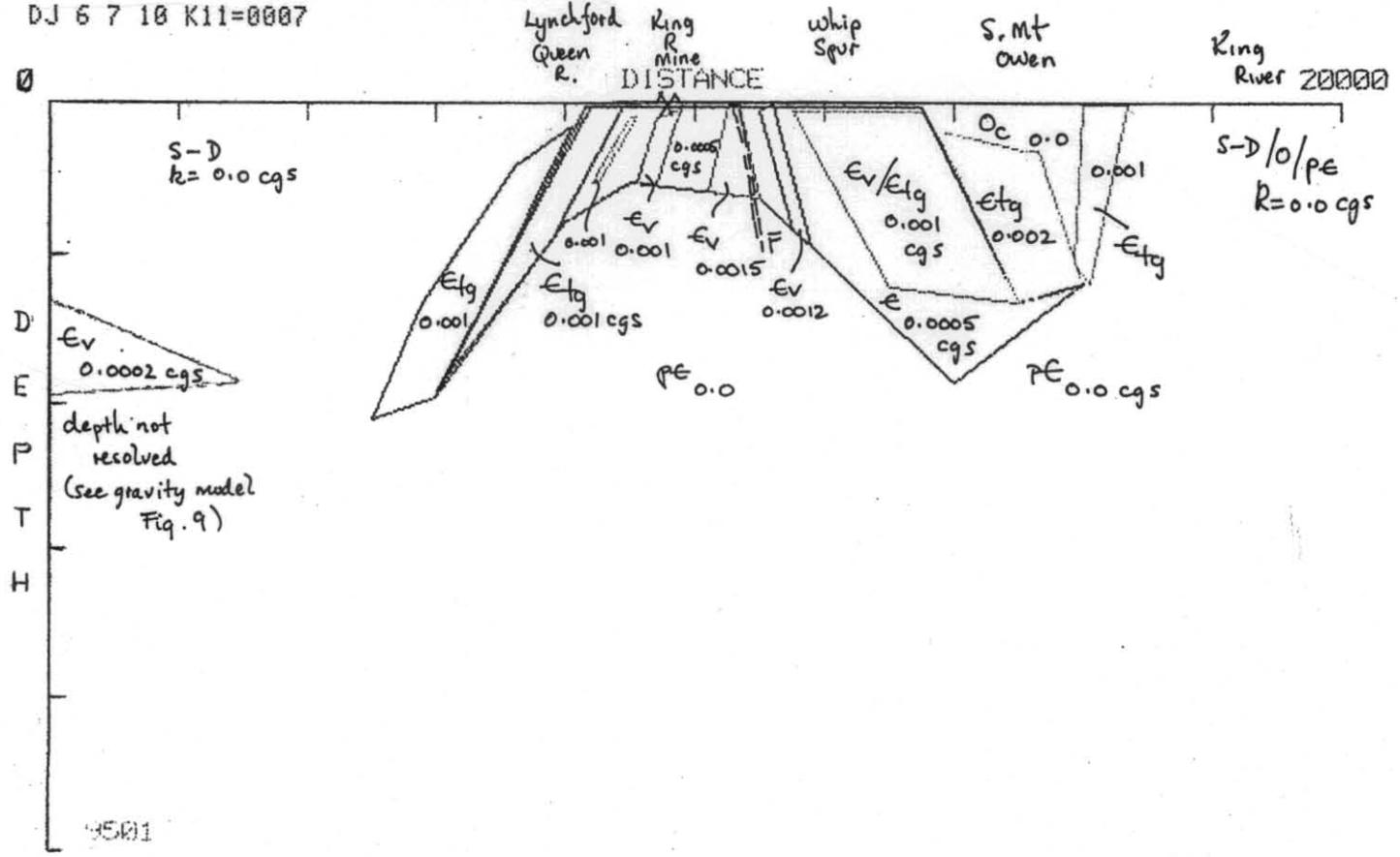
02-20



2D MAGNETICS MODEL



YNCHFORD DDH PROJECT 5336 000N 370-390 000E
 DJ 6 7 10 K11=0007

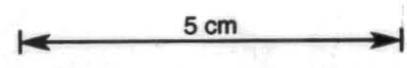


MAGNETIC MODEL

5336 000 MN LYNCHFORD

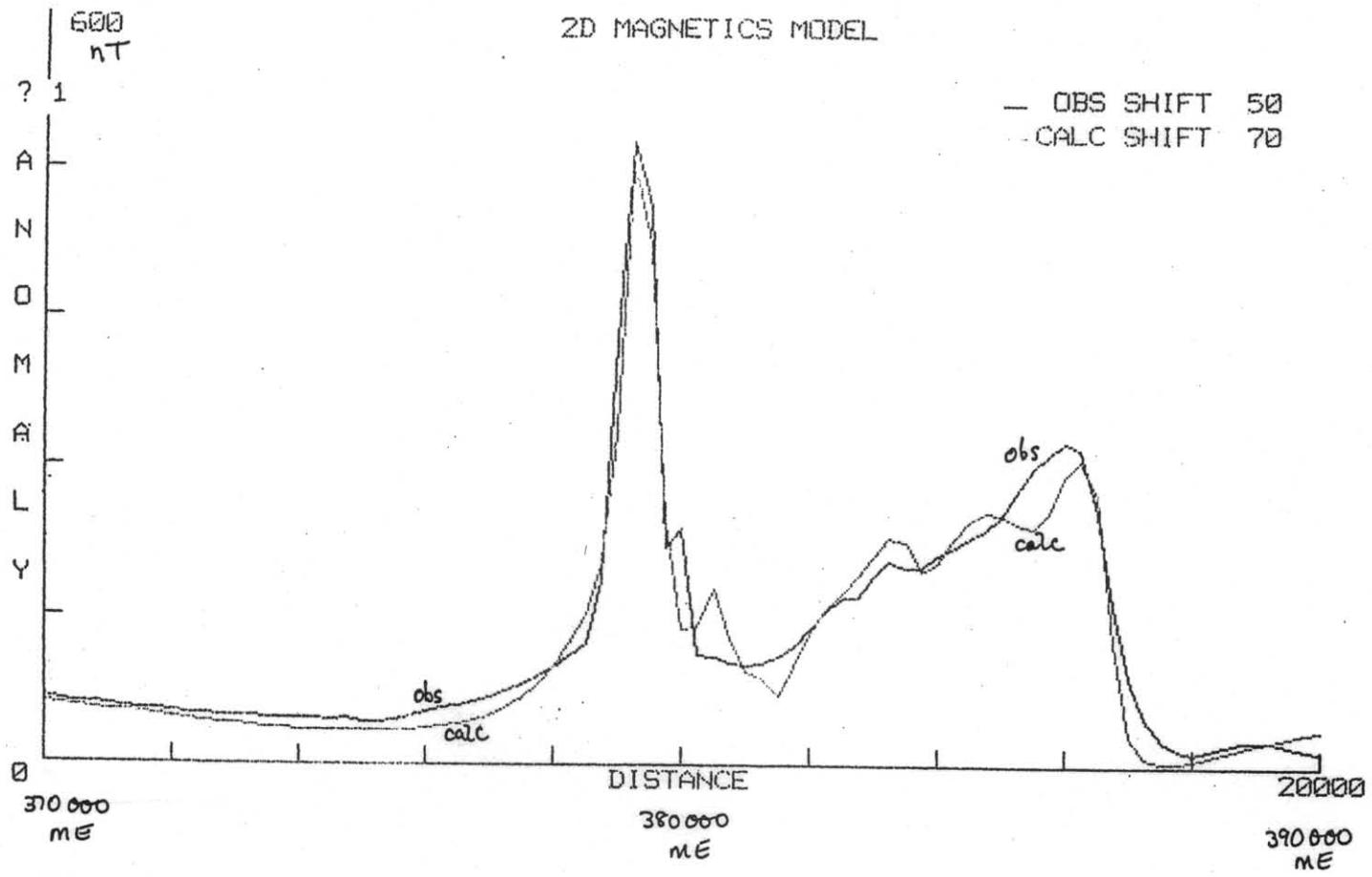
FIGURE 10

02-21

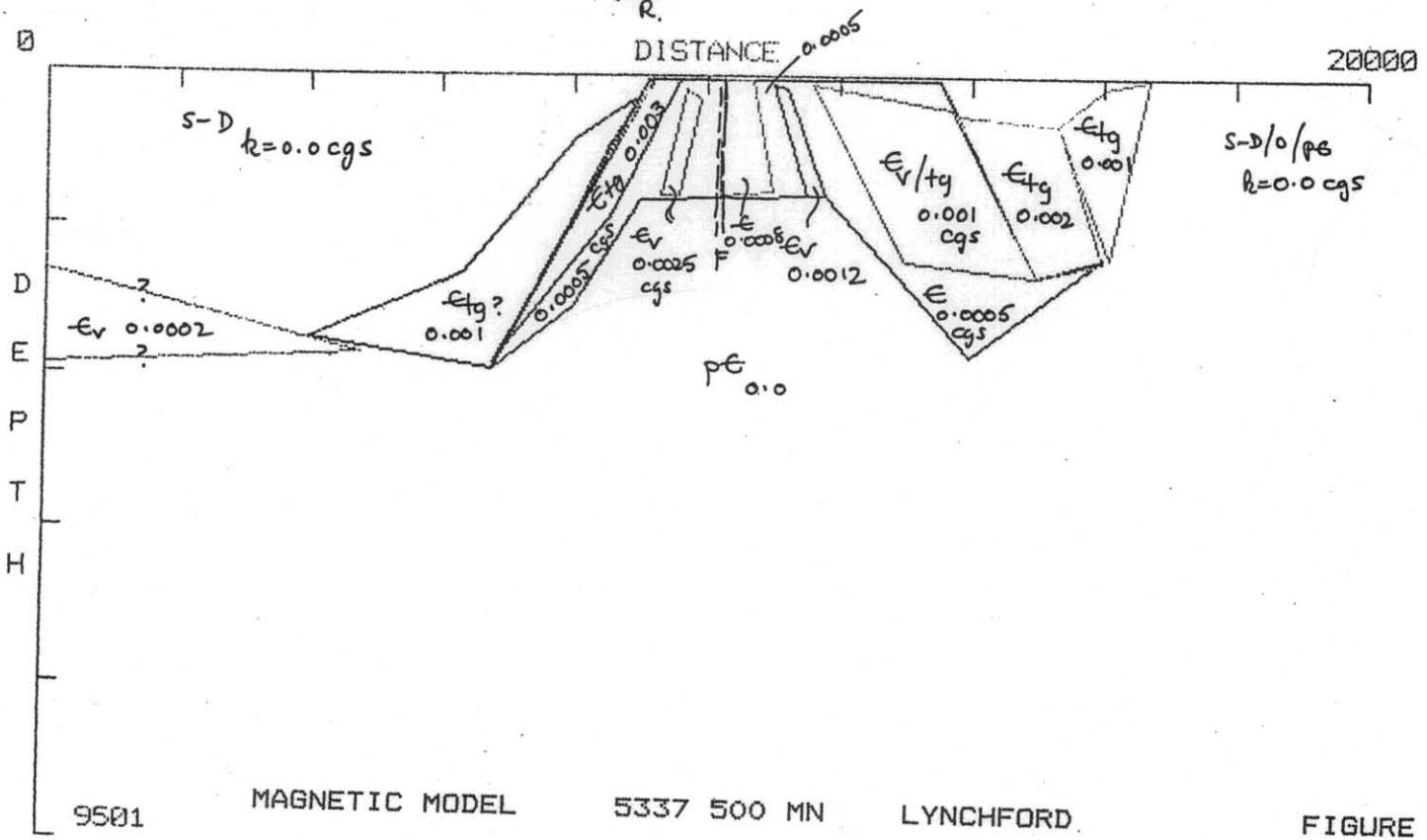


LINE PARAMETERS - ORIGIN, LIMIT, INCR : 0 20000 250

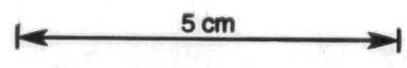
2D MAGNETICS MODEL



LYNCHFORD DDH PROJECT 5337 500N 370-390 000E
 ADJ 5 K6=0017 K10=0015



9501 MAGNETIC MODEL 5337 500 MN LYNCHFORD. FIGURE 11



02-23



LEAMAN GEOPHYSICS
G.P.O. Box 320 D,
Hobart, Tasmania 7001

5 cm

375000

380000

385000

MAGNETIC FIELD, LINEARS AND MINERALISATION - LYNCHFORD REGION
1981 Mines Dept Survey.

FIGURE 12

23/23