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MINERAL EXPLORATION AND ENGINEERING CONSULTANTS

BUGGS LANE ELLIOTT TASMANIA 7325 PHONE 004-363143

A REINTERPRETATION OF THE DIGHEM SURVEYS OVER THE HENTY-YOLANDE, SELINA AND LYNCH CREEK AREAS

FOR

THE MT. LYELL MINING AND RAILWAY CO. LTD.

BY

DR. J.R. BISHOP

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SUMMARY

A Dighem II survey was carried out over three areas of Mt. Lyell's exploration lease No. 9/66 during March, 1980. The survey, a helicopter-borne electromagnetic and magnetic system, totalled over 400 line kms, but recorded disappointing results over all three areas: Henty-Yolande, Selina and Lynch Creek. Because of the lack of anomalies, it was decided to reinterpret the results, looking for anomalies not picked by the Dighem interpretation. Since any such anomalies would be in the noise level, it was realised that most, if not all, anomalies would be caused by noise. However, the reinterpretation was shown to be justified by the picking of two anomalies on the Selina survey, which were subsequently shown to be coincident with strong IP anomalies over a narrow belt of sulphides. A third anomaly was coincident with another IP anomaly, the cause of which is not yet known.

The Selina reinterpretation picked 22 anomalies. It is most unlikely that the same success rate would be found for the 239 interpreted anomalies over Henty-Yolande or the 11 over Lynch Creek, however the Selina experience has shown that significant, conductive mineralisation can be missed by Dighem. It is expected that from the follow-up surveys recommended in this report, a better understanding will be gained of what Dighem will and will not detect.

The anomalies picked by the reinterpretation have been termed 'Mitre' anomalies. These have been graded into three categories, -3, -2, -1 in increasing order of merit below Dighem's 'possible' anomaly (the 'X' anomalies). However, there is really little to distinguish the Mitre anomalies, and none is considered to have sufficient merit by itself to warrant the effort and expense of cutting a grid to enable a ground EM survey to locate the anomaly. Rather it is considered that the anomalies should be regarded as complementary evidence to other techniques: for example the planned stream geochemistry survey over the Henty-Yolande area. Integration of the results from that survey with this report would make a sound basis for further work.

Similarly for the Lynch Creek anomalies, although the area there is sufficiently small that the expected locations of the anomalies could possibly be visually inspected for signs of mineralisation, alteration, etc.. The Lynch Creek survey crossed many of the rock types encountered on Mt. Lyell's E.L., and the results showed that these rock types are resisitive, confirming that EM methods should be an effective exploration technique.

Although EM methods should be used for location of EM anomalies, the IP survey over Selina may be considered to have tested those anomalies within the area of the grid. That is, it has verified that three Mitre anomalies are genuine anomalies, and that the rest, with the possible exception of one (anomaly 148m) may be discounted.

The Selina western and central bodies should be surveyed with EM methods to determine why the latter was not detected by Dighem and the former only just detected. These surveys should also show whether ground EM methods may still be a valid exploration method over areas already surveyed by Dighem. It is recommended that the Max-Min and VLF methods be used. VLF is recommended since, if it is applicable, this method is both quick and cheap. The Max-Min method however, will have better penetration and permits a more quantitative interpretation (for example it should be easier to isolate superficial anomalies with the Max-Min system). Surveys are also recommended over the black shale, partly to investigate the large anomaly on line 112, but also to add its type response to a proposed library of geophysical responses over black shales and mineralisation to assit in the discrimination of their responses before drilling.

Four case histories were examined. Mt. Lyell, Que River, Mt. Bulga and Woodlawn: all are volcanogenic deposits. Profiles from the first two, showed the mineralisation very clearly, however the second two showed that while the body may respond, it may be largely overshadowed by responses from adjacent conductors. The Dighem data processing has usually enhanced the body's response in some particular channel (e.g. resistivity for Woodlawn), but no consistent criterion could be used, even for the very few bodies studied here.

The Selina experience, of discovering a significant body of mineralisation, which was undetected by a Dighem survey emphasises the fact that an area which has not produced any Dighem (or Mitre) anomalies cannot be considered devoid of economic mineralisation. Nevertheless the Dighem method is considered to be a valid and useful 'first-pass' tool in inaccessable areas. The disappointing results obtained from this survey should not deter Mt. Lyell from using it in the future.

AIM AND INTRODUCTION

A Dighem II survey was conducted over three areas within Mt. Lyell's EL 9/66 during March, 1980 (Figure 1). The survey, a helicopter-borne electromagnetic and magnetic system, recorded disappointing responses over all three areas; Henty-Yolande, Selina and Lynch Creek. It was therefore decided to examine the data for anomalies not detected by the automatic picking program used by the Dighem system. Any such anomalies would be small (probably less than 2 ppm), however it was considered that the rigid criteria associated with a completely automated approach might miss some real anomalies. That this may be so, had been suggested by a survey for BHP in eastern Tasmania, where a very small anomaly over a (known) excellent conductor (with a conductivity-thickness product of 30 siemans) was not picked by the Dighem Interpretation (Bishop, 1980b). And this was confirmed at Selina where the Dighem interpretation missed a significant belt of mineralisation which was picked by the reinterpretation and a subsequent IP survey.

Three grades of 'anomaly' were used for the reinterpretation, these anomalies termed Mitre Anomalies to distinguish them from Dighem anomalies preceed the latter. Apart from the occasional anomaly rejected by the Dighem geophysicists, all anomalies have amplitudes of less than 2 ppm, (the Dighem noise cut-off level) and there is thus little real difference between the Mitre grades which have been designated -3, -2, and -1, in order of increasing interest.

This report has produced more anomalies in each of the three areas, and whilst it is expected that most of these will be due to instrumental noise (i.e. will not be locatable on the ground); the Selina experience, where two and possibly three Mitre anomalies were subsequently shown to be coincident with mineralisation, has justified the reinterpretation.

A resume of the Dighem method and the form of its output is given, and four profiles of Dighem surveys over known volcanogenic massive sulphide deposits are presented and briefly discussed. Apart from defining more possible targets, it is hoped that this report and the follow-up of its recommendations, will result in a better understanding of Dighem; its applications and its limitations.

THE DIGHEM SYSTEM

Much of the following has been condensed from Fraser's paper in 'Geophysics', The Multicoil^{II} Airborne Electromagnetic System (1979).

Dighem ^{II} (henceforth referred to without the superscript), is a helicopter-borne electromagnetic system which carries both transmitting and receiving coils in a 9m 'bird' towed about 30m below the helicopter. There are two pairs of transmitting and receiving coils: a co-axial pair, termed the standard pair, and a co-planar (horizontal) pair, termed the whale-tail pair (see Figure 2(a)). The co-axial and co-planar coils operate at 918 and 882 Hz respectively. The difference in frequencies is sufficiently large to allow the secondary EM responses to be recorded separately, but is close enough to assume both coils operate at 900 Hz, for mathematical treatment of the responses. Magnetics are recorded from a separate sensor located about 15m below the helicopter.

Most surveys are flown with a flight line spacing of 200m (100m for detail), with a nominal bird altitude of 30m. Lines may be as short as 2kms. The system is calibrated preflight and by high altitude checks at the end of each line. A recording base station is used for the magnetics. Navigation and flight path recovery is by conventional photographic means. The fiducial numbers on the flight film are changed either manually by the navigator or after a set time, i.e. each frame does not have its own number. When plotting fiducials , the position is extrapolated back to the first frame with that number.

For various conductor geometries, different responses will be recorded in the receivers of the two coil configurations. Thus the ratios of the responses may be used to determine the type of conductor. Fraser (1979), gives the results for various simple bodies:

(i) Homogeneous earth and two-layer earth

The ratio of coplanar/coaxial response is 2.05 $\pm$ .15 for both the in-phase and out-of-phase components, and is approximately independent of the flying height, frequency and conductivity.

(ii) Sphere

Spherical models may be used for bodies which approximately equi-dimensional. The ratio of coplanar/coaxial response is 4 for both the in-phase and out-of-phase componenets.

(iii) Steeply dipping dyke

The symmetrical response to a vertical thin dyke (e.g. less than 3m.), is shown in Figure 2(b). If the dyke is dipping, then the response from the coplanar coil configuration becomes asymmetric, with the larger response on the hanging wall side (Figure 2(c)).

From Figures 2(b) and 2(c) it can be seen that the coplanar/coaxial ratio for a thin dyke is zero over the top of the dyke. As the conductor thickness, the trough in the coplanar response weakens; the out-of-phase component weakening more quickly than the in-phase components (Figure 2(d)). Thus the ratio changes from 0 to 2 as the conductor changes from a thin dyke to an approximation of a half space.

The coaxial coils give the best response to a thin dyke, when flying perpendicular to strike: they give no response when flying parallel to strike. The coplanar coils are less sensitive to strike direction and so the coplaner/coaxial ratio may be very large (>4) for conductors surveyed at a low angle to strike.

The short separation between the transmitting and receiving coils and the relatively high frequency (about 900 Hz) gives the system good resolution (about 60m is claimed for the computer-processed profiles; about 40m for the analogue records). Fraser (1979) states this feature has enabled Dighem to respond to small ore bodies (strike lengths of 100m and 200m) that have been "surveyed previously by a large-scale, high-quality AEM system" with negative results.

A digital recording system is carried on board the helicopter. The data is computer processed and the output is given in profile form at the same scale as the base plans provided by the client. A brief description of the output in the form used for the Mt. Lyell surveys is given below (subsequent surveys have a slightly different form - see the Mt. Lyell case history). Table 1 (from the appendix of Dighem report No. 310) lists the channel functions.

The top two channels on the computer profiles, No's 28 and 29 "represent the ambient EM noise on the standard and whaletail receivers, recorded at a frequency of approximately 50 Hz off the transmitted frequency" (Fraser, 1979). Sferics (fluctuations in the naturally occurring EM field, usually caused by lightning normally only appear on the standard receiver (channel 28) which is responsive to horizontal fields. "The field of a powerline usually is recorded by both channels 28 and 29, although this depends on the harmonic content of the field, the sampled frequency, and the coupling" (Fraser, 1979).

The next channels, 35 and 36, are the anomaly recognition channels. The exact makeup of these channels has apparently been altered from time to time, but according to Fraser (1979) "Currently, channel 35 is the output from a band-pass filter where the input is the sum of channels 33 and 34 (i.e. the sum of the differences between the in-phase and out-of-phase responses). Channel 36 is the output of a band-pass filter where the input is x times the sum of channels 22 and 24 (i.e. the in-phase responses of the 2 coils). The input value of x is varied to suit the survey area, being 0 in highly conductive areas and 1 in highly resistive areas". Presumably it would be close to 1 for the Mt. Lyell surveys.

Channel 21 gives the altitude of the bird. The scale is 3m per mm.

Channel 20 is the magnetometer response. The scale is 10γ per mm.

TABLE 1.

DIGHEM PROFILE DATA

Channel Number	Parameter	Scale Units/mm	Noise
20	Magnetics	10 gamma	2 gamma
21	Altitude	3 m	2 m
22	Standard* coil-pair inphase	1 ppm	1-2 ppm
23	Standard coil-pair quadrature	1 ppm	1-2 ppm
24	Whaletail** coil-pair inphase	1 ppm	1-2 ppm
25	Whaletail coil-pair quadrature	1 ppm	1-2 ppm
28	Ambient noise monitor (standard receiver)	1 ppm	1-2 ppm
29	Ambient noise monitor (whale-tail receiver)	1 ppm	1-2 ppm
33	Difference function inphase	1 ppm	1-2 ppm
34	Difference function quadrature	1 ppm	1-2 ppm
35	First anomaly recognition function	1 ppm	1-2 ppm
36	Second anomaly recognition function	1 ppm	1-2 ppm
37	Conductance	1 mho	
40	Log resistivity	.03 decade	
41	Apparent depth to conductive half space	3 m	

* Vertical coaxial

** Horizontal coplanar

Channels 22 and 23 are the in-phase and quadrature responses of the standard coil pair respectively. The scale is 1 ppm per mm.

Channels 24 and 25 are the in-phase and quadrature responses of the Whaletail coil pair respectively. The scale is 1 ppm per mm.

Channel 37 is the conductance channel. "The conductance channel essentially is an automatic anomaly picker..... it is triggered by the anomaly recognition functions shown as channels 35 and 36" (Fraser 1980). The conductance is calculated from the relative amplitudes of the in-phase and quadrature responses.

Channels 33 and 34 are the in-phase and quadrature difference functions respectively. These channels "are almost free from the EM responses of conductive overburden and are fairly free of the negative in-phase response of magnetitude" (Fraser, 1979).

Channel 40 is the resistivity, which is derived from the in-phase and quadrature responses of the Whaletail coil pair. The model for the calculation is a resistive layer overlying a conductive half space.

Channel 41 gives the apparent depth below surface of the conductive material. "The apparent depth therefore is simply the apparent thickness of the overlying resistive layer. The apparent depth (or thickness) parameter will be positive when the upper layer is more resistive than the underlying material, in which case the apparent depth may be quite close to the true depth.

"The apparent depth will be negative when the upper layer is more conductive than the underlying material, and will be zero when a homogeneous half space exists. The apparent depth parameter must be interpreted cautiously because it will contain any errors which may exist in the measured altitude of the EM bird (e.g. as caused by a dense tree cover)". The absolute value of the negative depth is not a meaningful quantity and is not therefore a measure of the thickness of the conductive upper layer. However, it may be used qualitatively to show that the EM response is caused by conductive overburden.

The output from the Dighem survey consists of the original analogue records, the computer profiles with channel responses as discussed above, and four maps. One map shows the electromagnetic anomalies with the grade symbol and the conductance (conductivity-thickness product) value for a vertical sheet-like body. The interpreted depth and response of the in-phase and quadrature channels for the standard coil are indicated by a code of small dots beside the grade symbol. A second map is a contour map of resistivity. To calculate the resistivities for this map a conductive earth beneath a resistive layer is assumed (as discussed above). A third map is a contour plan of the magnetics, and the fourth map is a plan of the enhanced magnetics. The processing for the last map removes broad anomalies and amplifies the responses of narrow ones; thus it accentuates the near-surface magnetic bodies. The resistivity and both magnetics maps show the EM grade symbol but not the other information.

Dighem uses three models for the quantitative interpretation of the anomalies: a vertical sheet (the results of which are plotted on the EM anomaly plan); a horizontal sheet; and a conductive earth. The anomalies are listed at the back of the Dighem report with the parameters of the three models.

CASE HISTORIES

Four case histories are presented below. Mt. Lyell and Que River have been included as Tasmanian examples of ore-types sought in the areas surveyed. The N.S.W. examples are also of volcanogenic massive sulphide deposits and they illustrate difficulties that may be encountered in discriminating responses due to mineralisation from surface conductors, black shales, etc..

For both Mt. Lyell and Que River, where all the data was available, the profiles shown are the best anomalies. This is likely to be the case for the N.S.W. examples, Woodlawn and Mt. Bulga, but I have not seen any other data from these two deposits.

The Mt. Lyell survey is probably not an example in the sense that it is unlikely that a similar sized outcropping ore-body will be discovered within the E.L.. And while smaller Que River sized Cu-Pb-Zn ore bodies are more likely, undoubtedly it is the deeper, more subtle targets (the object of the reinterpretation) that must be followed up.

The N.S.W. examples show a much higher degree of geologic noise than the two Tasmanian examples, however similar environments certainly occur here, e.g. with conductive black shales and clay layers within moraine.

Mt. Lyell

The Dighem survey over Mt. Lyell was flown, early in 1981, for Geopeko and Aquitaine with Mt. Lyell's permission. The survey consisted of eight lines (Figure 3). Three lines were associated with the West Lyell open cut and five lines with the western Tharsis ore body. Two of the latter lines were placed off the ore body to see what effect if any, cultural objects, such as a 10cm steel water-pipe over the western Tharsis ore body, would have (it had none). Figure 3 shows that a grade 6 anomaly was obtained over the open cut and grade 2 and 3 anomalies over the western Tharsis mineralisation. These grades refer to the conductivity and size of the anomaly source (the conductivity-thickness product = the conductance upon which the grade is based); they do not refer to the size of the response. Figure 4 shows the response from the grade 3 anomaly 301A. This has amplitudes of about 30 ppm and 35 ppm for the standard in phase and quadrature channels respectively. In contrast, anomaly 303F (the grade 6 anomaly) has no discernable response in these channels (the conductivity is a function of the ratio of these channels). Thus whilst the grades are possibly a good indicator of conductor size and conductivity, the Dighem profiles should be closely studied when planning a list of follow-up targets. A broad magnetic response of 200 gammas was obtained from the West Lyell open cut, and a similar shaped anomaly was obtained beneath lines 204 to 207, just east of the East Queen River (between 5,343,200mN and 5,343,500mN). Western Tharsis (Figure 4) has no magnetic response.

At the time of writing this report, several months after the survey, Geopeko had only received a plan of the EM map (Figure 3) and no report. The original of this plan, plus full-scale copies of all the profiles are in the Mt. Lyell vault in a drawer marked 'Dighem'.

Que River

The Dighem survey over Que River was flown for BHP who have commissioned similar surveys over other mines and old workings in Tasmania. The Que River survey consisted of 26 lines, each over 5½kms long, with a nominal spacing of 250m. Figure 5, shows that, including the possible anomalies, the ore-body was detected over a strike length of about 500m. Including infill lines, the body was defined by six anomalies; two of grade 2, two of grade 1 and two possible anomalies. The anomalies immediately to the west are cultural responses. The responses over the powerline further to the west (which was not operating during the survey) are most inconsistent, varying from possible to excellent conductors. The anomalies straddling the Murchison Highway on the western edge of the survey are over graphitic shales. Figure 6, shows the profile of the best response over Que River. It is interesting to note that the Dighem processing has rejected the anomaly over the black shales; there is no response in either anomaly recognition function, nor in the difference functions 33 and 34. Note, however, that the ore-body and black shales are not separable from their resistivities. The complete set of data from this survey (analog and computer profiles, plus the EM, resistivity, magnetics and enhanced magnetics) are also stored with the other Dighem data in the Mt. Lyell vault.

Mt. Bulga

Mt. Bulga is a small (less than 1 million tonnes) Cu-Pb-Zn massive sulphide deposit. It is a steeply dipping, narrow sheet-like body about 30m below the surface and has been used for many years as a teaching and test area for geophysical methods. The body is not magnetic, but has a clear IP response and a strong SP anomaly. So far, time domain EM techniques have worked but not frequency domain methods. (A Max-Min survey using a 50m separation had failed to detect the body; surveys with larger spacings are planned.) Figure 7 shows the computer generated Dighem profile over the deposit. It can be seen that the poor, mainly out-of-phase response (207F) is largely swamped by strong responses from superficial conductors. However, the 1st anomaly recognition channel has reduced the ten anomalies in the conductance channel to six anomalies of which the sulphide deposit is one. The deposit is also one of the larger anomalies in the quadrature difference channel (Channel 34). Note that the body is not as conductive as geological noise responses to the west, which are apparently no shallower. Presumably in any follow-up survey, anomaly 207F would have eventually been checked, but the target response is very subtle. The survey was flown for Shell Minerals; no other data is available.

Woodlawn

The Woodlawn ore-body is a base metal volcanogenic deposit within the Lachlan fold belt of eastern N.S.W. (mid-late Silurian). The body consists of approximately 6.3 million tonnes of massive sulphides and 3.7 million tonnes of copper ore. The folded massive sulphide body has a strike length of about 300m; it is approximately 25m wide, and is within 20m of the surface at the southern end and 10m at the northern end.

The Dighem response to Woodlawn is shown in Figure 8. The profile is dominated by the response to a large conductive area to the west of the ore body. Since mining had already commenced, there is considerable interference from cultural effects. The ore body cannot be isolated from the EM response channel. However, unlike the Mt. Bulga and Que River deposits, it can be clearly identified in the resistivity channel. Being a very good conductor, it also stands out in the inphase difference channel. The anomaly recognition channels are not shown. "From the EM data, a westerly dip for the target may be inferred since the co-planar in-phase response peaks to the west of the co-axial in-phase response" (Fraser, 1981).

REINTERPRETATION METHOD

Dighem defines six grades of anomaly (6, the best grade) according to their conductivity-thickness product (calculated assuming a vertical, sheet-like body). The amplitude of the anomaly is not used for grading, but is shown as so many small dots beside the grade symbol. A seventh grade - a possible conductor - is shown as a cross. The letter 'S' is used to indicate a probable surface response and 'L' to indicate a probable line source (power line, pipe, fence etc.).

For the reinterpretation, three grades continuing on below Dighem's X grade were defined. These were based on amplitude and have been termed 'Mitre' anomalies. For the top grade, -1, a noticeable response on the in-phase and quadrature channels on both the standard and whaletail receivers was required. The second grade, -2, is less clear cut, but generally indicates that a response was recorded on the in-phase channel of the standard coil (a steeply dipping sheet-like conductor should affect this channel) and that probably a response is also shown on one of the anomaly recognition channels, 35 or 36, or on one of the difference channels 33 or 34. The bottom grade, -3, is more likely to be noise than the preceding two grades, and has usually been picked from some in-phase response of the standard coil (the noisiest channel) or a sharp excursion on one of the other channels.

No distinction can be made between surface or deep-seated causes of the Mitre anomalies. The question of culturally caused anomalies should be straight forward, by correlation with responses in the environmental channels. However Dighem's approach does not appear to have been consistent and there are some unusual 'line' responses on the Henty-Yolande survey. These are discussed in more detail in that section.

The Dighem system responds to a non-conductive magnetic body with a negative in-phase anomaly in both coil configurations. A conductive magnetic body will also give a quadrature response. Fraser (1979) states that the "difference technique (i.e. the difference in responses of the two coil orientations) which tends to eliminate the response of conductive ground, also has the same effect on broadly distributed magnetite".

The original Dighem anomalies plus the Mitre anomalies have been plotted as circles on base sheets of the areas surveyed. The anomaly grade has been marked in the centre, and an identification letter outside. Dighem anomalies start at 'A' on the profiles, but only those considered real were plotted onto their plans. Possible anomalies ('X's') have their own identification, also starting from 'A'. Mitre anomalies are identified by letters, starting from 'M' from the western end of the flight line. These anomalies have also been marked onto the computor-generated profiles. Anomalies shown with an 'L' on the original Dighem interpretation are similarly marked here. Mitre anomalies coincident with a response in the environmental monitor channels have been marked with a 'C' (for cultural response). Dighem anomalies which are similarly coincident, and not marked 'L', have also been marked with a 'C'.

RESULTS AND INTERPRETATIONS

Henty-Yolande

A total of 344 line kms were flown over this area at a nominal line spacing of 150m. Dighem picked a total of fifty five (55) anomalies, all weak, of which only four were classified as definite anomalies and a further eight were picked as possible anomalies. The rest were due to cultural effects (24) or were surface anomalies (19). The reinterpretation reclassified one definite and two possible Dighem anomalies as having a cultural cause. A further two hundred and thirty nine (239) anomalies were picked, of which thirty eight (38) were due to cultural effects. Of the two hundred and one anomalies picked as being of possible interest, thirty three were graded -2 and one hundred and sixty eight as -3 grade. The anomalies are shown on Figure 9.

This large number of 'extra' anomalies is an excellent example of the use of a defined signal level below which all responses - due to conductors as well as noise - are rejected. In this survey area (excluding cultural sources) the Dighem cut-off level isolated thirty seven anomalies from a total of two hundred and thirty eight (i.e. Dighem plus Mitre). Clearly the vast majority, possibly all, of the Mitre anomalies are just noise; however the absence of any worthwhile anomalies from the survey makes this reinterpretation worth trying and it is shown in the Selina section that genuine anomalies, missed by the Dighem interpretation can be detected.

This survey had a large number of cultural responses and since it is obviously important to be able to positively identify cultural sources, this aspect is discussed at some length in the interpretation. Included in this discussion is a line of responses that occurred strongly in the environmental channel and weakly in EM channels over several flight lines in an area of apparently untouched bushland.

Henty-Yolande Interpretation

A geological map by N.W. Sheppard (July, 1973 at 1:15,840) shows most of the surveyed area as Queenstown pyroclastics with some acid lavas and sills, and some basic intrusives. The south-west corner is shown as sediments, termed the Henty-Yolande grey-wacke sequence. An undated Mt. Lyell-Getty joint venture map showing just the broad geological divisions at 1 inch to a mile (1:63,360) shows the central part of the surveyed area as Queens-town pyroclastics, with the eastern part of the area (covered by the west Sedgewick grid) as the central lava belt, and the western third as Dundas group sediments. However, these differences are presumably differences in terminology rather than rock type, and the geology of the area may be summarised as: the western third as Cambrian sediments (possibly Dundas group); the remainder as pyroclastics with basic intrusives, acid lavas, plus some sediments. The southern most 200m to 300m of the survey was over Siluro-Devonian sediments (the Eldon Group). Known mineralised occurrences include barite, 300m NW of the Lyell -Zeehan high-ways intersection, and pyrite and chalcopyrite on the old Lake Margaret tramway near the power line (line 96S, West Sedgewick grid). There are also occurrences of alluvial gold on the Lake Margaret Road. Detailed geology is poorly known and further mapping, together with stream sediment sampling is planned for the next field season (R.Meares - pers. com.). Thus an integration of the Dighem interpretation with the geology is not yet possible.

The Dighem anomalies, being the larger anomalies, and having been quantitatively analysed, are discussed first; ground follow-up should also be first tried on Dighem anomalies (though probably not at Henty-Yolande).

Anomaly 1D, is described by Dighem (p18 of their report) as being caused by "either very thick conductive overburden or by a thick poorly conductive rock formation".

This anomaly is over the Eldon Group sediments which are not considered prospective.

Anomaly 7A, "This single-line grade 1 anomaly represents a narrow conductor coinciding with a stream. ..... a very weak bedrock conductor appears to be the most likely cause of 7A".
The "stream" is the Zeehan highway and the anomaly coincides with a strong cultural 'line' anomaly. Whilst the EM response may be (partly) due to currents induced in (poorly) conductive ground by the line source, the anomaly is one of many following a telephone cable beside the highway and it is not considered worth following up.

Anomaly 38A (written as 32A in the Dighem report, p18). "This anomaly occurs on a stream ..... it could have a cultural source".
Again the "stream" is the Zeehan highway and since a possible (and moveable) cultural source on the highway is quite likely, this one-line anomaly is not recommended for early follow-up.

Anomaly 53A "occurs on the same stream as 32A" (sic). Whereas anomaly 38A only responded on the whaletail coil pair, 53A also showed a slight response in the standard coil pair. Nevertheless, the comments made about 38A apply here, and 53A is not recommended for early follow-up.

The above are the only anomalies listed as being of likely interest in Dighem's report on the Henty-Yolande area. The appendix gives a list of 'all' anomalies plotted on the EM map (except 34A, which is missing), however all of the rest of the anomalies, not discussed above, are apparently caused by power lines or other cultural features.

There are several possible conductors (X's) shown on the reinterpretation plan, copied from the Dighem EM map; several are shown as probable surface response $(\frac{X}{S})$ or as possibly surface response $(\frac{X}{S?})$. With one notable exception, these possible anomalies are generally isolated occurrences. The exception is a line of three possible anomalies, all superficial, which occur near the western ends of consecutive lines (49, 50 and 51). The northernmost anomaly is over the Zeehan highway, about 300m east of the Henty River bridge. An alignment such as this would normally be considered encouraging, however the surficial classification and the quaternary cover (alluvium and/or moraine) in the region suggest that the cause is indeed a broad near-surface, conductive source within the overburden.

The surficial possible anomalies are not considered sufficiently important at this stage of exploration in the area to warrant ground follow-up without other, complementary evidence. The possible anomalies which are not thought to have a surficial (or cultural) source are listed below:-

7B, 11C, 25B, 25C, 53B.

Since ground follow-up of these anomalies would require a series of grid lines cut in what is probably fairly inaccessable country, it is recommended that any follow-up awaits the results of the planned stream sediment survey.

The same recommendation is made for the large number of Mitre anomalies picked (both -2 and -3 grades). As stated previously most, if not all of these, are 'false' anomalies, due to such things as sferics, yawing of the bird, instrumental noise etc.. Therefore independant data, e.g. geochemistry, which covers the same area, is an excellent complement to this type of survey.

It is worth mentioning here some of the apparent inconsistencies in the Dighem presentation, and the case of a 'hidden' cultural source. (Dighem's grade 1 anomaly 7A was over this source, and was not marked as 'Line'.)

On the eastern ends of Lines 1, 2 and 3, anomalies closely associated with the Lyell highway and coincident with large responses in the environmental monitor channels, have been plotted as Mitre 'C' (cultural) anomalies. On Line 4 Dighem has placed an X
S?

(anomaly 4D, plotted on Figure 9 as C X S?) beneath this cultural response. Similarly on Line 5, anomaly 5B (an 'X' type) is beneath a large cultural response, which has not been designated as such in the Dighem interpretation. On Line 6, a similar anomaly occurs (in the profiles), but the response was insufficient to trigger the automatic Dighem anomaly-picking routine. On Line 7 a grade 1 anomaly (7A) occurs which has been discussed above. The EM and channel 28 (environmental monitor) responses are very similar to responses marked elesewhere by Dighem as 'Line' anomalies (e.g. anomaly 16C, which has been pencilled "culture" by Dighem geophysicists in the profiles). It therefore appears that not only have Dighem failed to recognise the road (marked on the location map), but have also not recognised the cultural source of the EM responses.

Cultural anomalies on Lines 8, 9 and 10, that occur on the west side of the Zeehan highway have been picked as Mitre -3 grade anomalies to show the location of the cultural source. Dighem has picked 'X' type anomalies on lines 11 and 12 (11D and 12B, and shown a conductor axis - a heavy printed line - between them), however both of these anomalies are over the cultural source. (The channel 28 response is quite distinctive and is readily corelatable from line to line.)

On Line 13 the cultural source branches, the distinct channel 28 response leaving the road and trending NE to the Lake Margaret power lines. Dighem has plotted a further 'X' type anomaly, 15A, without indicating its apparent cultural source. Dighem anomalies on the NE branch (15B, 16C, 17A and 20B) have all been marked as Line sources.

Figure 9 shows the Mitre anomalies that have been picked on the intervening lines to show the trend of this cultural source. The cultural source was found to be a telephone cable which could be followed along the Zeehan highway and accounted for the anomalies near the road. The NE branch from Line 13 could not be seen from the road, nor from a helicopter, nor on the 1972 air photos, however 1976 air photos clearly showed a bulldozed track and the PMG confirmed the existence of the cable. The fact that it went under the power lines caused the strong channel 28 response.

The position of the telephone line between the Zeehan highway and the power lines has been accurately positioned on Figure 9, and it can be seen that there are location errors of over 100m (anomaly 20B).

Finally, the EM responses to the Lake Margaret power lines, were generally low (usually less than 5 ppm) but the grade of anomaly varied from possible to grade 4 (36 mhos). Although the bird should have been in the same attitude over the power lines, the profiles show that it was usually changing altitude.

Selina

"The Lake Selina survey comprised 40 line-km of the survey flown in a magnetically active but generally resistive area" (Fraser, 1980).

The flight lines over Selina were planned to correspond with the ground geophysical grid lines which were cut with a nominal spacing of 800ft (244m). However, the survey was flown at an angle of about 10^{o} to the grid (the Dighem lines are NW-SE of the grid lines). The grid lines have N after the number, the flight lines do not.

The anomalies picked by Mitre Geophysics were marked onto a 1:10,000 map together with the Dighem anomalies. Before transferring the anomalies onto the 1:5,000 base map, the flight lines were relocated by replotting the fiducial points. The large differences between the replotted and original flight lines plans illustrates the need for careful preparation of mosaics and/or subsequent checking against accurate base plans (i.e. the inaccuracies in the Selina flight plan may not have been revealed if the scale had not been changed).

The Dighem interpretation picked a total of 14 anomalies plus two 'possibles' (X's). Of these, one was a grade 3 anomaly, eight were grade 2 and five were grade 1. The reinterpretation picked twenty two more anomalies of which two were -1 grade, eight were -2 grade and twelve were -3 grade (Figure 10).

Selina Interpretation

Twelve of the Dighem anomalies line up to form a narrow arcuate zone on the eastern edge of the survey. This is typical of a conductive lithological horizon and apparently black shales occur within the Lower Cambrian sediments which are mapped on the eastern side of the area. However, the EM anomalous zone is at a very definite angle to the indicated geology which would suggest that the mapping, at least on the eastern side of the grid, is incorrect.

Stacked profiles of the in-phase and quadrature components of the standard coil response for these anomalies are shown in Figure 11. The figure shows that the best grade anomaly (184A) is barely noticeable (it is a little larger on the whaletail channels, but the standard coil profiles are shown since this configuration gives the more diagnostic response to a vertical sheet-like conductor). The -3 grade Mitre anomaly over this eastern conductive zone (148 0) is a definite response of about 1 ppm which was not picked by the Dighem process since it is within the noise level (the noise level was particularly low on this part of the profile) however, it is doubtful whether the reinterpretation would have picked it as a 'stand-alone' anomaly. Figure 11 shows the response on Line 112 to be significantly higher than elsewhere along the zone and although it may merely represent an increase in graphite or pyrite content in black shales, it may also be a consequence of mineralisation and it is recommended that this anomaly be followed up.

Of the two remaining Dighem anomalies (both grade 1), one (128A) was located over the western pyrite body on Line 128; the other (112A) occurs over moraine to the SE of Lake Selina and was interpreted as a superficial anomaly. One of the two possible anomalies (104A) lies on strike to the south of 112A; the other (160A) lies to the east of the 'black shale anomalies' over Lower Cambrian sediments (believed to be unprospective).

A description of the Mitre anomalies is given below in which they are related to the project geologist's (M. Hutton's) working map. This has not been drafted, although a copy (at 1:20,000) is shown in Bishop, 1980 (fig. 2). The geology is likely to be modified, but has been used here to help determine which anomalies may be worth following up and which may not.

Of the 22 Mitre anomalies, five may be classified as of no interest in the present interpretation of the area, since they are east of the conductive zone discussed above, and occur over Pre-Cambrian quartzite, or Lower Cambrian sediments. All five anomalies (128 O, 136M, 176N, 184M and 184N) are -3 grade. A -2 grade anomaly (128M) was picked over Owen Conglomerate about 180m east of Lake Selina and this also may be discounted.

Two -2 grade anomalies (104M and 120N) and one -3 grade anomaly (144M) were picked over Lower Cambrian sediments on the eastern side of the grid (but west of the conductive zone). However, these may still be of potential interest, since the outcrop is poor in this region and, has already been suggested, the geology here appears to be incorrectly mapped.

A grade -1 anomaly (120M) was picked over the western pyrite body south of the Dighem anomaly and one other was picked within acid volcanics, near to the (indicated) contact with the Lower Cambrian Sediments (128M). Four - 2 grade anomalies (112M, 112N, 136M and 148N) and three -3 grade anomalies (160N, 160 O and 176M) were also picked within the acid volcanics. Two -3 grade anomalies were interpreted over the Jukes Breccia (152M and 160M) and one -2 grade anomaly (148M) was picked over moraine to the NW of the pyrite body (with a magnetite response). (The 22nd anomaly is the previously mentioned 148O) over the conductive zone.) The anomalies are further discussed below, following the description of the Dighem anomaly over the western pyrite body.

At least three passes were made over the western pyrite body, but only one anomaly was recorded. Figure 12 shows that the in-phase conductive anomalies from both channels have been obscured by a magnetite response, but both standard and whaletail channels have clearly defined out-of-phase anomalies of about 10 ppm. From the ground EM survey, a in-phase response of similar magnitude would be expected.

Figure 13 shows the well defined response from the 'Max-Min' ground EM survey along Line 128N about 50m north of the Dighem anomaly. The larger out-of-phase response confirms the Dighem grading and the increase in amplitude with increase in frequency suggests a shallow source. An attempt at a quantitative interpretation gave a conductance one order of magnitude lower than the Dighem estimate of 3 siemans. However, there is some interference to the mineralisation anomaly by conductive surface conditions to the west; this led to a dip calculation of about 30°W, rather than the actual near-vertical dip. The Dighem interpretation gave a depth of 38m, assuming a vertical dyke (the body effectively outcrops and is about 100 million tonnes, wtih approximate dimensions 100m wide x 250m long). ??

A gradient array IP survey has been conducted over the Selina grid, and this has defined a narrow highly chargeable zone from Line 136N to 184N where it is still open. The zone is due to a thin body of pyrite mineralisation: although not fully explored, it is known to be massive in places. It has been termed the Selina ~~central~~ eastern pyrite ~~body~~ zone. The resistivity map from the gradient IP survey does not show this as a conductive zone, however dipole-dipole spreads over Lines 144N and 184N show well-defined conductive zones (Bishop, 1981b). A chargeable high was also defined on line 128N east of the western pyrite body at 1000W; again not shown as significantly conductive by the gradient arry. Little is known about this anomaly.

Two Mitre anomalies coincided with the ~~central~~ eastern pyrite ~~body~~ zone (148N, -2 grade and 160N, -3 grade); another (136M, -2 grade) coincided with the anomaly at 1000W on Line 128N (see Bishop, 1981b). The fact that no resistive zone was defined by the gradient array is considered a short-coming of that technique, rather than fortuitous for the reinterpretation, since the dipole-dipole surveys show at least the ~~central body~~ eastern pyrite zone to be significantly conductive. The coincidence of three Mitre anomalies with zones of mineralisation not detected in the original Dighem interpretation, is considered a strong justification for the decision to re-evaluate the surveys.

Eight flight lines crossed the ~~central Selina body~~ eastern pyrite zone, but the reinterpretation picked anomalies on only two lines. Locating the IP zone on the six other lines showed that any possible in-phase anomaly was usually obscured by a response (in both channels) to magnetite immediately to the west, but that on some lines, out-of-phase 'bumps' often too weak to pick as anomalies were coincident with the zone.

In view of the above, it is considered most unlikely that any of the Mitre anomalies within the area of the grid that are not associated with IP anomalies are worth following up. A possible exception is 148M (a ~~-2~~ -3 grade anomaly) which is located over swamp and/or moraine to the NE of Lake Selina and which is associated with a magnetite anomaly. It is possibly a response to a northern (and deeper) extension of the western pyrite body. The only anomalies outside the grid are those to the east of the conductive zone and these have been discounted on geologic grounds.

It is likely that Max-Min responses will be obtained from surveys along grid lines over the western pyrite ~~body~~ zone, i.e. areas of the ~~body~~ zone which did not give rise to Dighem anomalies (this work is planned for the next field season). This suggests that significant ground EM responses may be obtained from conductors that would not register on a Dighem survey. Also, from the Selina experience one may expect that Mitre anomalies which are true responses and not noise, will be readily locatable by follow-up ground EM surveys.

Lynch Creek

The Lynch Creek survey consisted of four lines with a nominal spacing of 200m. The total distance flown was 22km. The Dighem interpretation defined three superficial anomalies (all grade 1) and one possible anomaly. The three superficial anomalies are grouped together within a conductive area. (The area is mostly resistive.) The possible anomaly occurs on the northernmost line and is situated at the edge of the Queen River. The re-interpretation picked eleven more anomalies; four -2 grade and seven - 3 grade (Figure 14). The anomalies are scattered and with one possible exception, no conductive trends were defined. The possible exception is the two - 2 grade anomalies which occur close to each other on lines 202 and 203. The anomalies straddle the Huxley track and are sub-parallel to strike. There is, however, a prominent NW-SE striking fault between the two anomalies.

Lynch Creek Interpretation

Within the Lynch Creek area is the King River Gold Mine, perhaps the first mine in the Queenstown area. The gold, in quartz, was mined spasmodically into the early twentith century; however the gold was apparently very patchy (Cornelius Lynch had been lucky enough to strike a very rich pocket at the surface in 1883, Blainey, 1978). Robinson (1971) lists the various exploration companies that have recently held the area (no specific dates given). Of particular interest to this report would be the results of a ground EM survey conducted by Pickands Mather in the late 1960's, however this data was not available. Robinson's report was written for Cyprus Mines who felt that the area had good prospects for copper, lead and zinc mineralisation, and they carried out geochemical, magnetic and IP surveys over the area. Mt. Lyell had part of two lines resurveyed for IP in 1980. However, this report restricts itself to those aspects relevant to the Dighem survey; a complete evaluation of the area has not been attemptd.

The King River gold mine is situated within the more conductive area mentioned above. Thus it is quite close to the three (superficial) Dighem anomalies. (There is a discrepency of about 80m between the Cyprus Mines location of the mine and Corbett's 1:15,840 (1978) map of the Queenstown Whip Spur area.) A Cyprus Mines report (anonymous, 1971) states that 'kaolinisation is particularly strong throughout the volcanics, especially at King Gold Mine'. Another Cyprus Mines report (anonymous, 1972) states that clay up to 80ft (24m) thick occurs in places. Also Corbett (1978) wrote of deep weathering in the area. It is likely that the Dighem responses are due to this clay, certainly no gold mine has ever been rich enough to give a conductivity anomaly to an aerial or even ground EM system (disregarding the 'metal detector' which is an EM system capable of very high resolution but of little penetration or search-radius). IP has been used to explore for gold associated with sulphides and presumably if the sulphides were in sufficient concentrations, EM could then be used. It is also most unlikely that quartz veins, host to gold, would appear as resistive zones in either a Dighem-type EM survey or in an IP survey.

The less resistive area defined by the Dighem survey which surrounds the King Mine is in good agreement with the N=1 resistivity map prepared by Cyprus Mines from their IP survey (Figure 15) although the values are different. These results were from a dipole-dipole McPhar frequency domain survey using a 300ft (91m) dipole. The IP survey for Mt. Lyell covered only the immediate area around the mine, and the resistivities from this 25m (time domain) survey appear to be in general agreement with the N=1 resistivities from the McPhar survey (the profiles of which are not available).

Mt. Lyell's IP survey did not reveal any interesting anomalies.

The Lynch Creek Dighem survey traversed a large number of the rock types in the Mt. Lyell Exploration leases: these included the paleozoic sediments west of the Queen River; the tuffs, agglomerates, sediments and lavas etc. of Corbett's (1978) 'western' unit; and the feldspar porphyry and agglomerate, tuff with minor basic dykes of his 'central' unit.

All rock types except the Lynch Creek basalts are resistive (1000 ohm-m is the maximum resistivity value that can be contoured) although there is also a slight decrease over the limestones near the Queen River. The magnetic sequences were the Lynchford tuffs (western unit) and part of the Whip Spur agglomerate sequence (central unit) which contains some 'minor basic lavas and basic dykes' (Corbett, 1978).

The Dighem possible anomaly and the Mitre anomalies all lie outside of the area covered by the Mt. Lyell IP survey. The possible anomaly (204A) occurs on the edge of Queen River (approximately 378,500E 5,336,550N). The Dighem computer profiles show no in-phase response for this anomaly and the quadrature is active for most of the western half of the profile. Further, the rock types beneath and west of the Queen River in this area are barren Ordovician conglomerates and limestones (see Corbett, 1978). Thus this anomaly is not considered worth following up. Similarly with the Mitre -3 grade anomaly (201M) on the western side of the Queen River.

The remaining anomalies lie within Corbett's (1978) western sequence of the Mt. Read Volcanic. No major occurrence of copper, lead or zinc mineralisation has been found in this sequence, however there are many areas of sub-economic sulphides and many of the rocks, at least from their descriptions, are similar to those within the 'more prospective' central belt. For example, three of the Mitre anomalies occur within "Interbedded shale, tuffaceous greywacke, slate, vitric tuff, crystal tuff and agglomerate". One anomaly is -3 grade (anomaly 203M) and the other two are previously mentioned -2 grade anomalies which are located either side of a prominent fault (anomalies 202M and 203 O). This NW-trending fault has a dextral offset of about 300m (Corbett, 1978, p 10) and thus it is most improbable that the two Mitre anomalies relate to the one conductive zone. Nevertheless these anomalies are among the better possibilities in the area. The other -2 grade anomalies (201N and 204M) occur within the Lynchford tuffs - so far considered a barren sequence.

Three - 3 grade anomalies (201 O, 203N and 203Q) occur within the Lynch Creek basalts and another two (201P and 203P) occur on the contact between the Miner's Ridge samdstone and a quartz-feldspar porphyry.

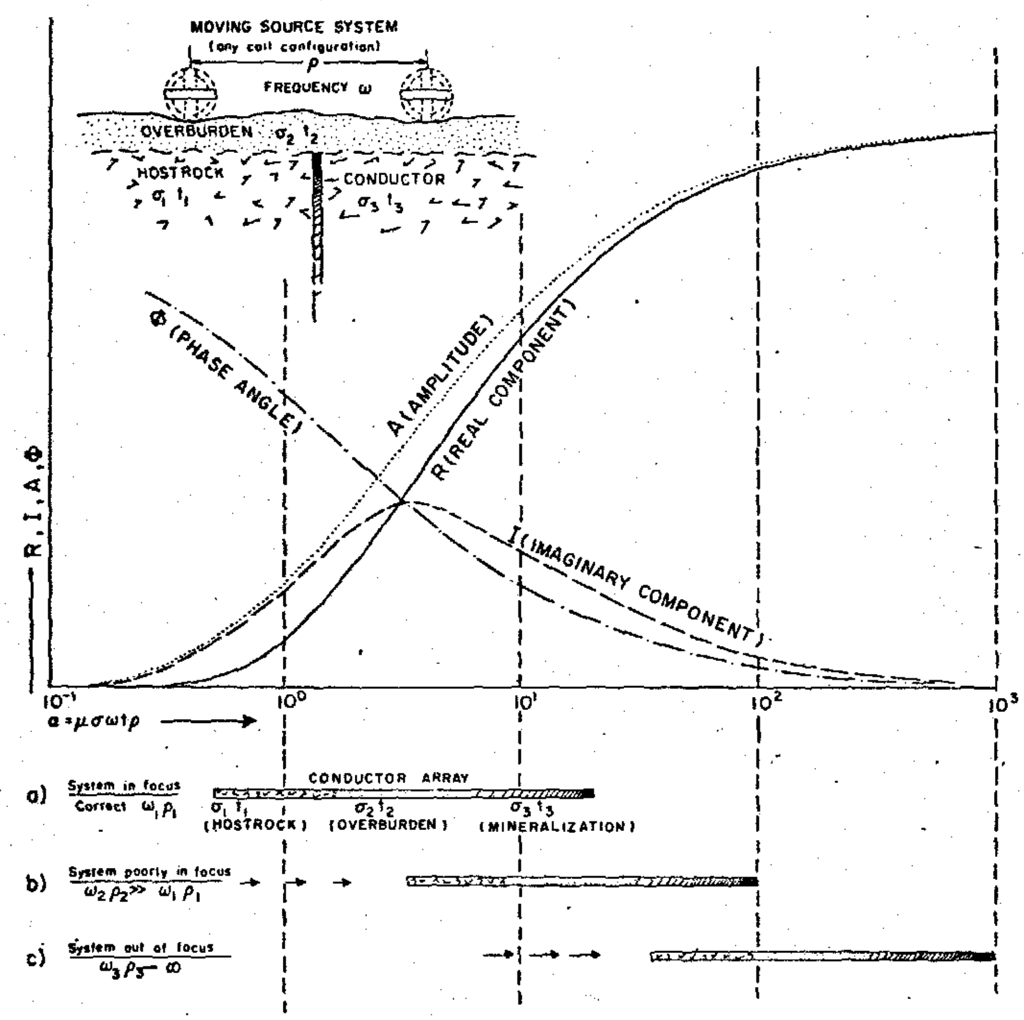
The difference in response between the two -2 grade anomalies (201N and 204M) in the Lynchford tuffs is remarkable. Both anomalies are coincident with strong and similar magnetic anomalies, and from the Dighem magnetic contour map these appear to be on strike. However, the more northerly anomaly shows a very strong response to the "magnetite" on the in-phase channels of both the standard and whaletail receivers, whilst the southern anomaly shows a very weak response, in the whaletail channel only. This magnetic response of the Lynch Creek area is approximately confined to the extent of the tuffs: the Lynch Creek basalts (described by Corbett, 1978 as 'basic to intermediate lava, breccia and tuff with possible intrusions') are not noticeably magnetic within the surveyed area.

A ground EM survey (Max-Min and possibly VLF) is recommended along Line 13,500N (see Figure 15) to determine what sort of ground response coincides with the surficial grade 1 Dighem anomaly 203A. No follow-up of the Mitre anomalies is recommended until targets have been obtained from other exploration techniques (e.g. mapping and stream geochemistry).

CONCLUSIONS

The reinterpretation has resulted in many more 'anomalies' in each of the areas. The coincidence of Mitre anomalies with mineralisation at Selina (these were picked before the results of the IP survey were available) has shown the worth of such a re-examination. However, it should be recognised that most Mitre anomalies will be noise anomalies, either geological or instrumental, and that therefore other techniques, such as geochemistry, should be tried to obtain other independant and hopefully complementary anomalies to the Mitre 'targets'. This is particularly true of the Henty-Yolande area where a very large number of anomalies, in largely unexplored country, were produced by the reinterpretation.

At Selina, the subsequent IP coverage has provided the complementary anomalies (more accurately, the other way around) and has eliminated many of the Mitre anomalies: that is anomalies picked in areas which do not show IP anomalies may, at least in this type of environment, be considered unprospective anomalies. Experience with ground follow-up at Selina has also suggested that ground EM responses may be obtained from conductors which Dighem has missed. Certainly this is expected on theoretical grounds; the 'response parameter' (i.e. the factors which determine the size and shape of the response) of a thin tabular body is $\mu \sigma w t \rho$, where μ = magnetic permeability; σ = conductivity; w = frequency; t = thickness; and ρ = coil spacing. Thus the larger (and variable) coil spacing of a ground system (and with variable frequency) should be able to be better 'focussed' on specific targets. This is illustrated in the diagram below from Bosschart (1967).



Also from the Selina experience one may expect that ground EM methods such as the Max-Min system will readily detect 'genuine' Mitre anomalies. This will be verified during the 1981-82 field season.

The reinterpretation of the Lynch Creek survey has defined several possible anomalies in largely unknown country, apparently not related to the mine area. The survey did, however confirm the zone of deep weathering (alteration?) surrounding the mine. The flight lines crossed many of the rock types which occur on Mt. Lyell's exploration leases, and they were shown to be quite resistive and thus excellent hosts of sulphide targets for EM methods such as Dighem. The only strongly magnetic sequences were the Lynchford tuffs (of the western unit) and part of the Whip Spur agglomerate sequence (of the central unit).

The study of a few case histories has shown that Dighem (not surprisingly) does respond to known ore-bodies, but that distinguishing the deposit from adjacent geologic (and to a lesser extent cultural) 'noise' anomalies may be rather difficult. Certainly no single Dighem channel has been consistantly anomalous even among the very limited number of examples presented here.

RECOMMENDATIONS

The type and range of response to Dighem and Mitre anomalies from various ground EM methods, should be established. Those anomalies not due to instrumental noise, may either be caused by geologic noise (e.g. swamps, faults, moraine, clays etc) or by mineralisation. The anomalies at Selina provide excellent targets for this purpose (and there is an existing grid). It is recommended that the western, central and 'black shale' anomalies be surveyed with Max-Min, VLF and any other method which maybe being considered as a follow-up technique (see Bishop, 1981a, 'Notes on some EM methods for ground follow-up of Dighem anomalies').

The rationale for the above two methods is that VLF is much cheaper and quicker than Max-Min, however it is more subject to geologic noise and may have insufficient penetration. The slower

Max-Min method has adequate penetration and permits a quantitative interpretation (i.e. an order of priority of anomalies should be possible).

During the follow-up at Selina, the Dighem anomaly on Line 112 over the black shales should be investigated. This and possibly other profiles over the black shales should be added to a library of geophysical responses over black shales and mineralisation; since these two causes of anomalies must be separated on geophysical grounds (as well as geochemical) before drilling. The Max-Min technique should be used over several lines on the western pyrite body, to determine whether Dighem will only respond to a conductor as weak as this, if it has the volume of this body and crosses it near the centre. (Fraser, 1979, claims that the Dighem system has detected small ore bodies not previously detected by other airborne EM systems but these presumably have been excellent conductors.)

Follow-up of the Henty-Yolande Mitre anomalies (or Dighem anomalies) is not recommended until other evidence such as that from the planned stream geochemistry survey is available. However, the two road anomalies could be used as accessible practice areas for the location and definition of Dighem anomalies. There is, however, the possibility that they were due to large cultural objects, since removed (but it is unlikely that these responses could be caused by a car).

The number of anomalies in the Lynch Creek area are sufficiently small that the expected approximate locations could be visited and examined for sources of mineralisation, alteration, etc. However like the Henty-Yolande survey, it is considered that the expense of surveying in grid lines to locate the possible anomaly if not warranted without other persuasive evidence. Max-Min and VLF surveys are recommended over Line 13,500N, since a grade 1 surficial Dighem anomaly (204A) overlies this line (which was also partly surveyed with IP for Mt. Lyell), and recognition of this type of response is needed for interpretation of any planned follow-up surveys.

The discovery at Selina of a significant body of mineralisation that was missed by the Dighem survey, emphases the fact that an area that has been surveyed by Dighem and shown to have no anomalies cannot be 'written off'. Que River is another example; EM techniques (ground or airborne) do not show an anomaly over the lead-zinc mineralisation, which accounts for nearly 90% of the ore-body. That is, Que River, without the copper-rich lens which responded to the airborne EM system, would most probably still be mineable. Therefore, Dighem should primarily be used as a first-pass system over areas which have not been 'gridded'.

The disappointing results obtained by Mt. Lyell should not deter it from using Dighem over this type of area elsewhere on its leases. Its widespread acceptance in Tasmania and elsewhere reinforces my belief that it is a cost-effective and worthwhile exploration method.

J R Bishop

J.R. BISHOP

JULY, 1981

JRB/amd

REFERENCES

Anonymous, 1971 — Results of initial reconnaissance programme for E.L. 47/70, West Tasmania Oct-Nov, 1971. Report for Cyprus Mines Corporation.

Anonymous, 1972 — Queenstown prospect. Results of Exploration programme Lynch Creek area, E.L. 47/70 Tasmania, Jan to March, 1972. Report for Cyprus Mines Corporation.

Bishop, J.R., 1980a — An appraisal of the geophysics carried out over the Selina, Rolleston and Dora areas. Mitre Geophysics report for Mt. Lyell.

Bishop, J.R., 1980b — A report on exchange of Dighem information. Mitre Geophysics report for Mt. Lyell.

Bishop, J.R., 1981a — Notes on some EM methods for ground follow-up of Dighem anomalies. Mitre Geophysics report for Mt. Lyell.

Bishop, J.R., 1981b — A gradient array IP survey over the Selina Grid. Mitre Geophysics report for Mt. Lyell (in prep.).

Blainey, G., 1978 — The Peaks of Lyell. Melbourne University Press (fourth edition).

Bosschart, R.A., 1967 — Ground Electromagnetic Methods, in: Mining and Groundwater Geophysics. ed. L.W. Morley (econ. geol. rep. No. 26, Geol. Survey of Canada.)

Corbett, K.D., 1978 — Stratigraphy, correlation and evaluation of the Mt. Read Volcanics in the Queenstown, Jukes-Darwin and Mt. Sedgewick areas. Geol. Survey (Tas. Mines Dept.) Bulletin 58.

Fraser, D.C., 1979 — The multicoil II airborne electromagnetic system. Geophysics Vol. 44 No. 8 p 1367-1394.

Fraser, D.C., 1980 — Dighem II Survey Henty-Yolande, Lake Selina and Lynch Creek areas, Tasmania. Dighem Limited, report no. 310 for Mt. Lyell.

Fraser, D.C., 1981 — Response of the Woodlawn orebody to the Dighem II system, in Geophysical Case Study of the Woodlawn orebody, N.S.W., Australia. Editor R.J. Whiteley, Perganom Press.

Robinson, A.M., 1971 — Preliminary investigations of E.L. 47/70 West Tasmanian. Report for Cyprus Mines Corporation.

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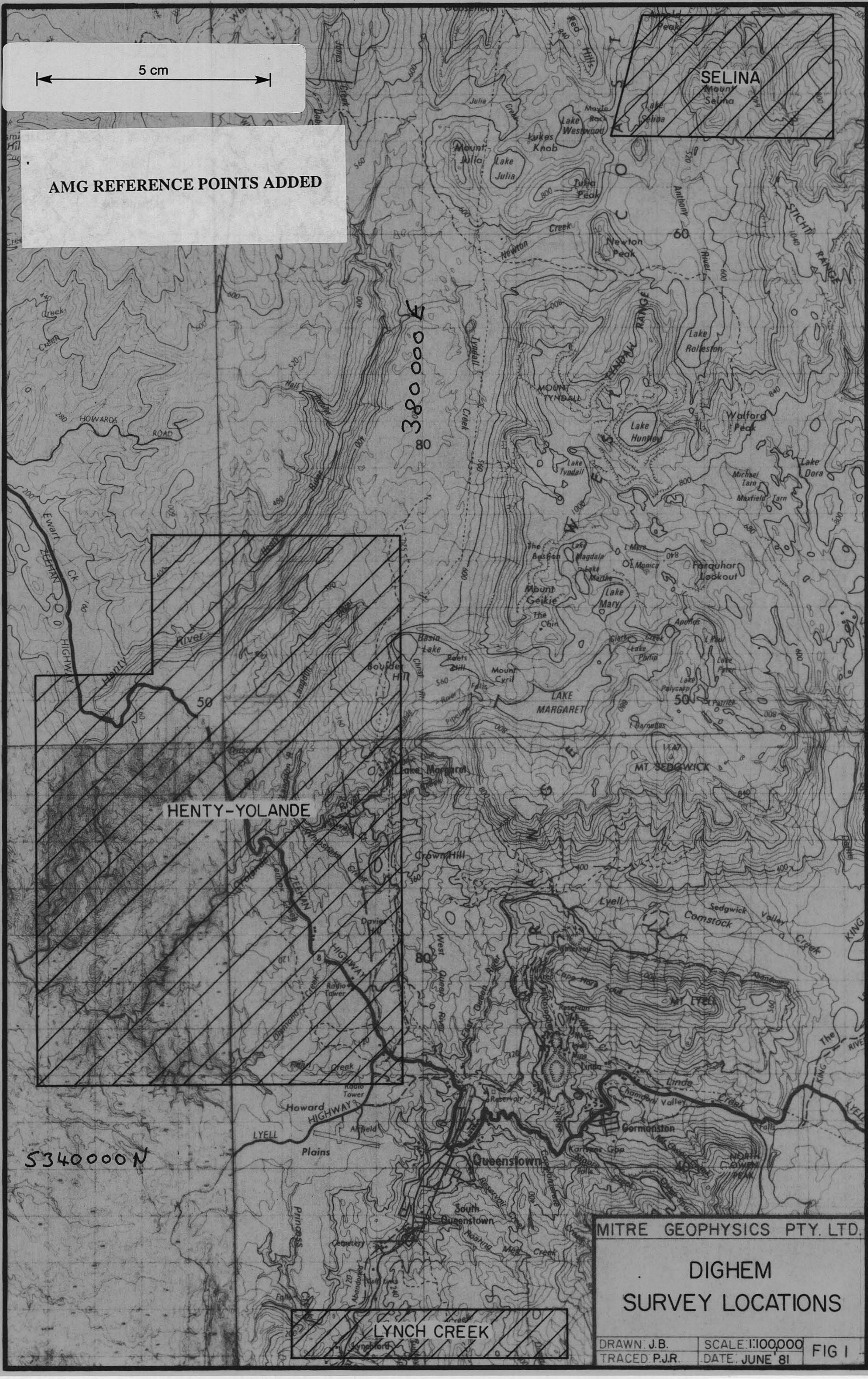

5 cm
AMG REFERENCE POINTS ADDED
SELINA
HENTY-YOLANDE
LYNCH CREEK
380000 E
5340000 N
Mount Selina
Lake Selina
Mount Julia
Lake Julia
Lukes Knob
Julia Peak
Lake Westwood
Newton Peak
Newton Creek
Anthony River
STICHT RANGE
TYNDALL RANGE
MOUNT TYNDALL
Lake Rolleston
Lake Huntley
Lake Tyndall
Walford Peak
Lake Dora
Michael Tarn
Maxfield Tarn
The Bastion
Lake Magdala
Lake Martha
Lake Mary
Mount Geikie
The Chin
Farquhar Lookout
Basin Lake
Boulder Hill
Mount Cyril
LAKE MARGARET
MT SEDGWICK
Crown Hill
Davies Hill
Lyell
Comstock
Sedgwick Valley Creek
MT LYELL
Gormanston
Queenstown
South Queenstown
Karlsons Gap
NORTH OWEN PEAK
Linda Creek
Lake Margaret
Howard
HIGHWAY
LYELL
Plains
Airfield
Radio Tower
ZEEHAN HIGHWAY
Henty River
HOWARDS ROAD
Ewart
ZEEHAN CK
Queen River
Princess
Roaring Meg Creek
80
60
50
MITRE GEOPHYSICS PTY. LTD.
DIGHEM
SURVEY LOCATIONS
DRAWN: J.B.
TRACED: P.J.R.
SCALE: 1:100,000
DATE: JUNE '81
FIG I

004

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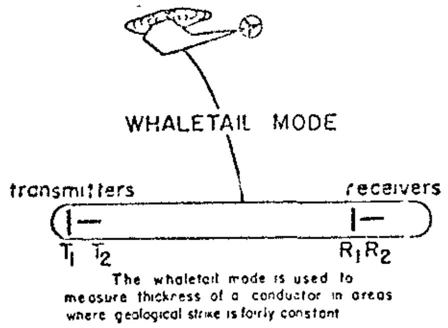
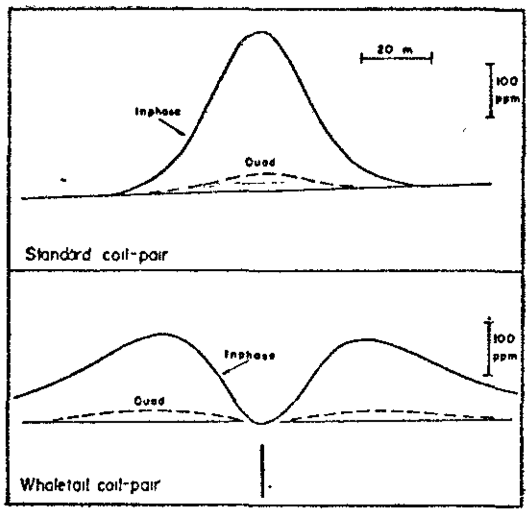
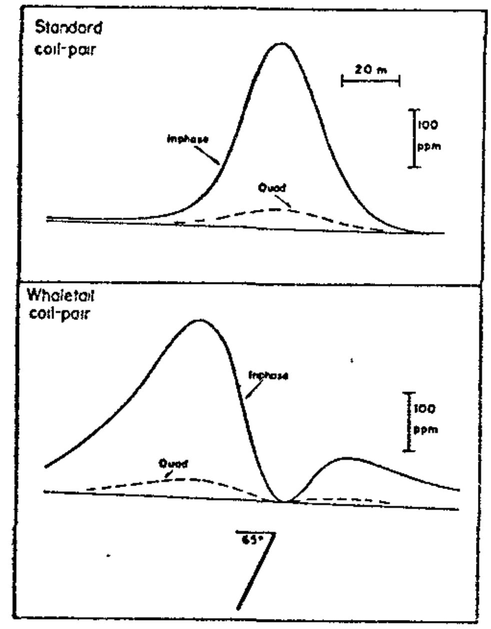


T_1R_1 Standard coil pair vertical co-axial
T_2R_2 Whaletail coil pair horizontal co-planar

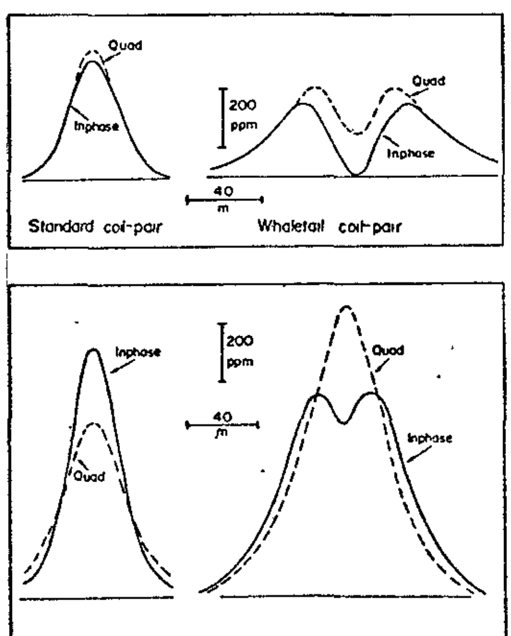
(a) Coil configurations



(b) Dighem response to a vertical, tabular conductor



(c) Dighem response to a dipping, tabular conductor



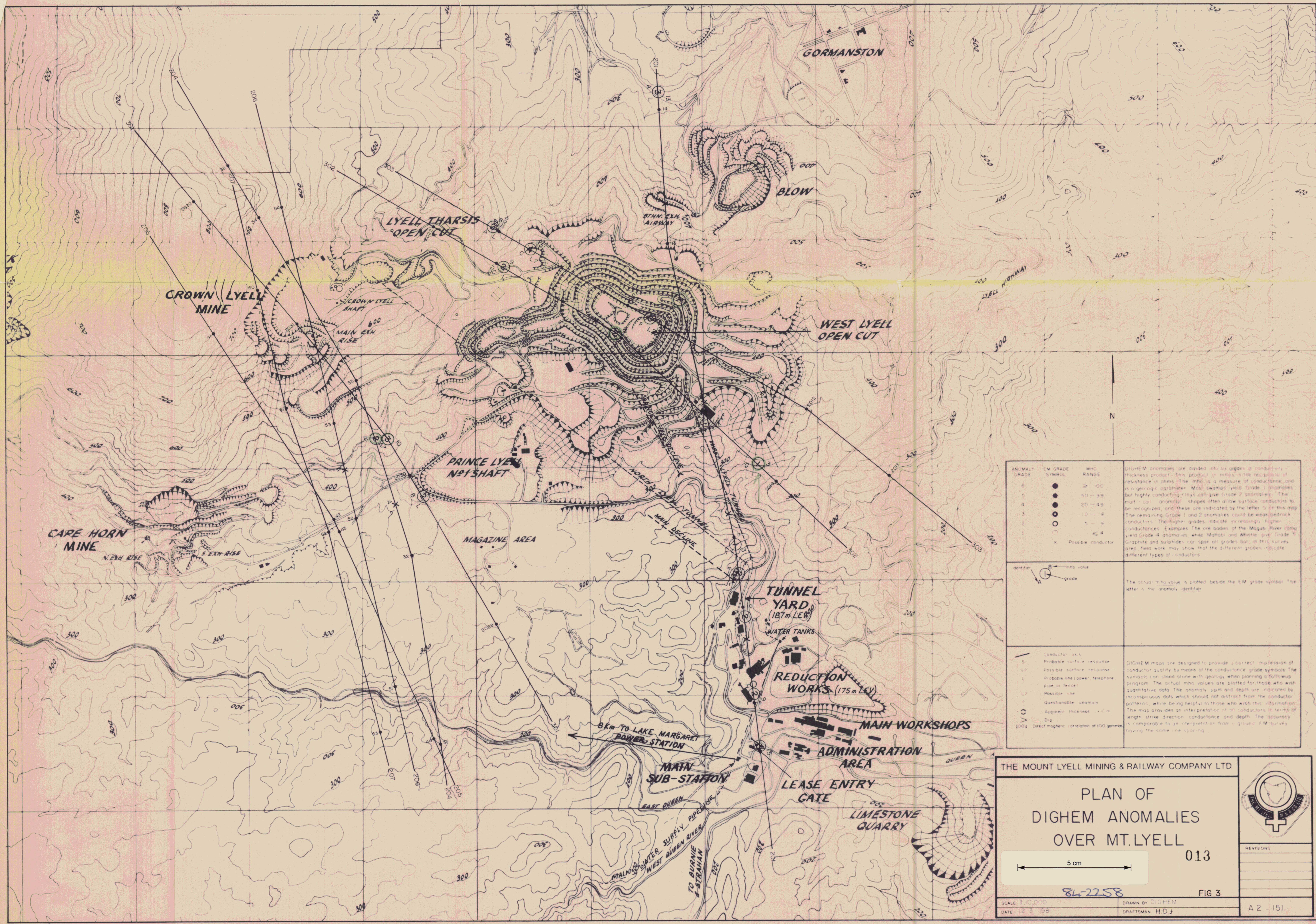
(d) Dighem response to a thick tabular conductor

5 cm

(Figures from Fraser, 1979)

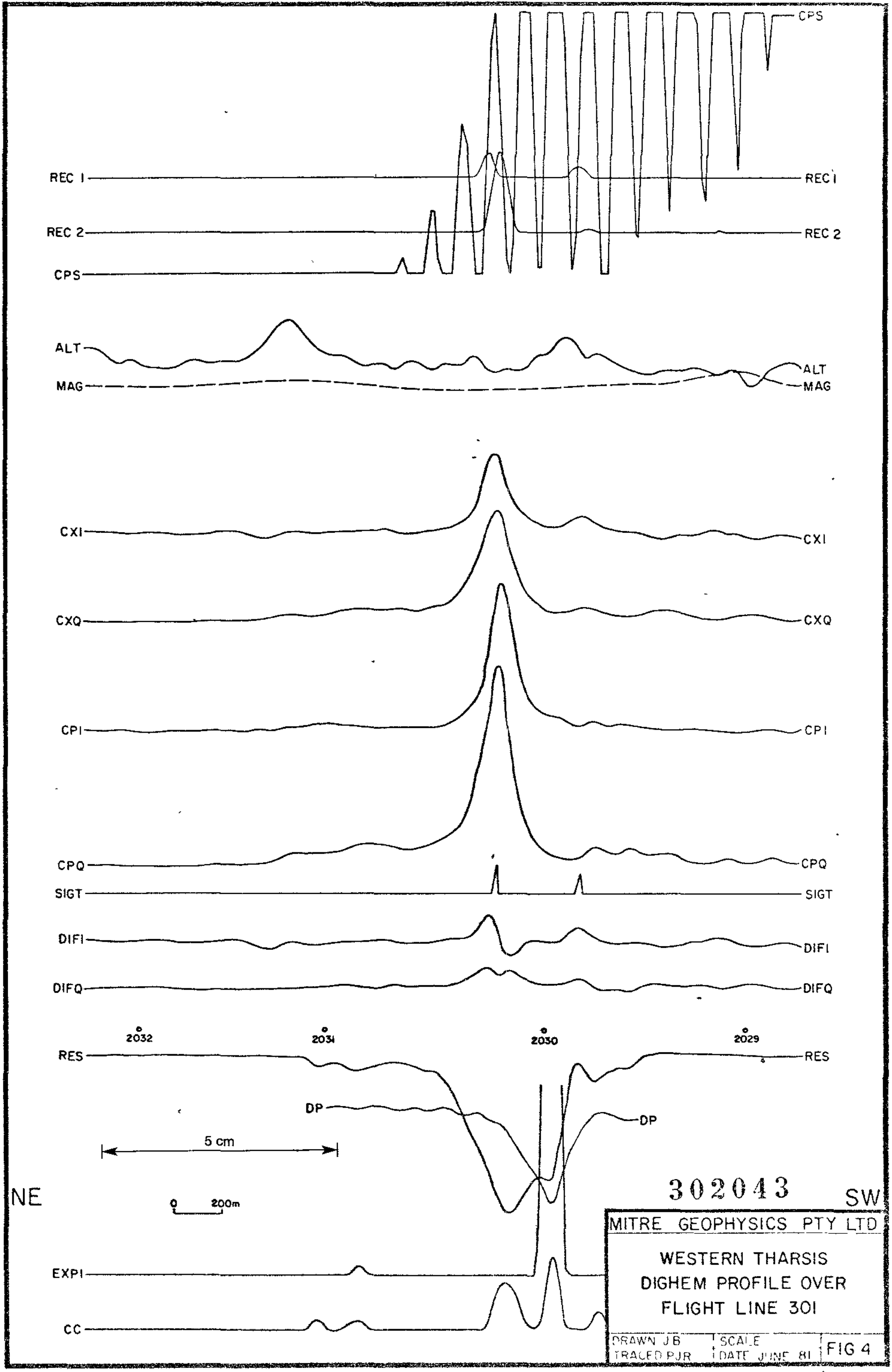
MITRE GEOPHYSICS PTY LTD		
COIL CONFIGURATIONS & RESPONSES		
DRAWN JB / TRACED PJR	SCALE / DATE JUNE '81	FIG 2

A4-134

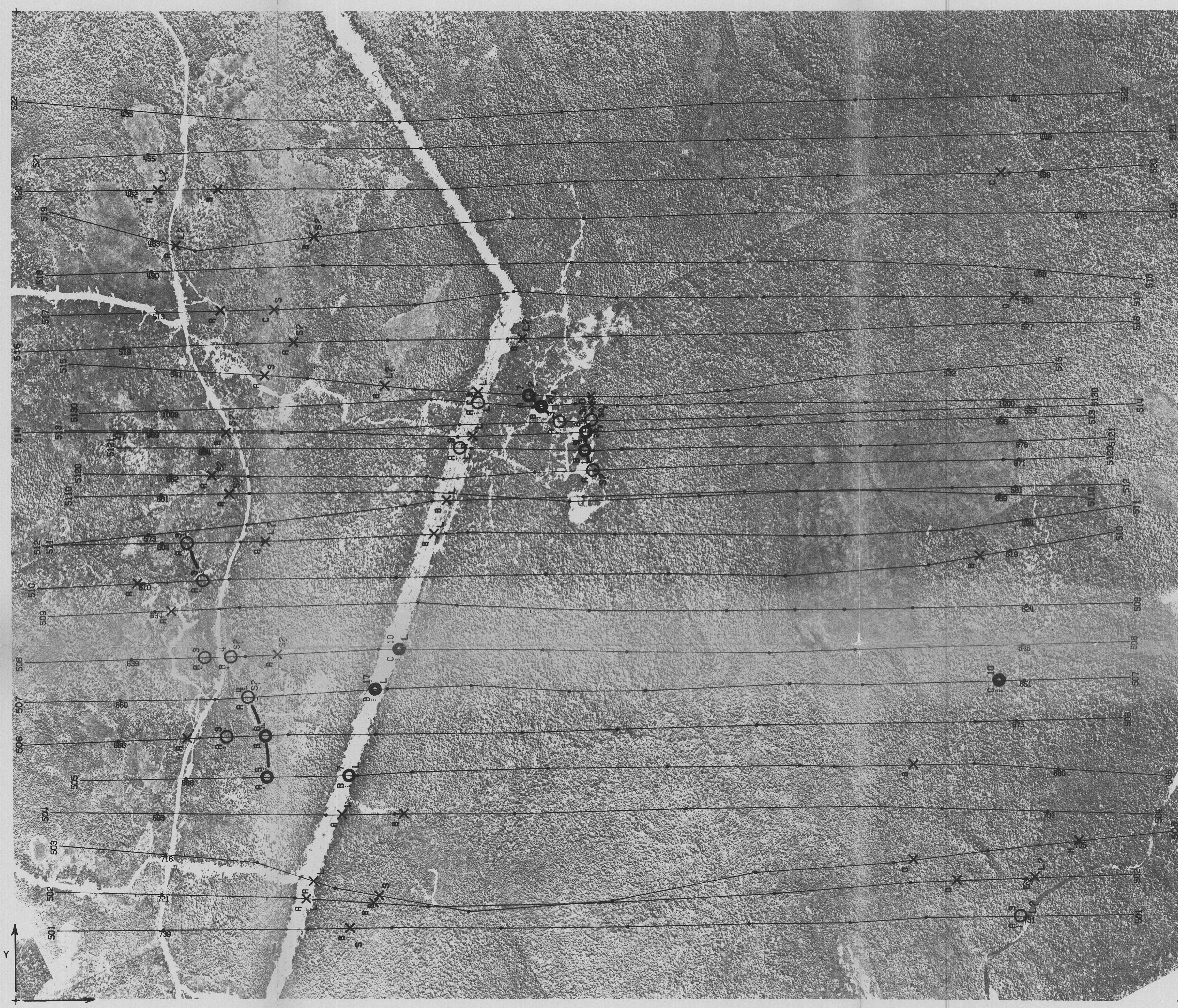

GORMANSTON
BLOW
LYELL THARSIS OPEN CUT
CROWN LYELL MINE
CROWN LYELL SHAFT
MAIN EXH RISE
WEST LYELL OPEN CUT
PRINCE LYELL No1 SHAFT
NORTH LYELL TUNNEL
MAIN DECLINE
CAPE HORN MINE
N EXH RISE
S EXH RISE
MAGAZINE AREA
TUNNEL YARD (187m LEV)
WATER TANKS
REDUCTION WORKS (175m LEV)
MAIN WORKSHOPS
ADMINISTRATION AREA
8Km TO LAKE MARGARET POWER STATION
MAIN SUB-STATION
LEASE ENTRY GATE
LIMESTONE QUARRY
EAST QUEEN
QUEEN
WEST QUEEN RIVER
MAIN WATER SUPPLY PIPELINE
TO BURNIE & STRAHAN
LYELL HIGHWAY
N
ANOMALY GRADE
EM GRADE SYMBOL
MHO RANGE
6 ≥ 100
5 50 — 99
4 20 — 49
3 10 — 19
2 5 — 9
1 ≤ 4
× Possible conductor
DIGHEM anomalies are divided into six grades of conductivity-thickness product. This product in mhos is the reciprocal of resistance in ohms. The mho is a measure of conductance and is a geologic parameter. Most swamps yield Grade 1 anomalies but highly conducting clays can give Grade 2 anomalies. The multi-coil anomaly shapes often allow surface conductors to be recognized, and these are indicated by the letter S on this map. The remaining Grade 1 and 2 anomalies could be weak bedrock conductors. The higher grades indicate increasingly higher conductances. Examples: The ore bodies of the Magusi River camp yield Grade 4 anomalies, while Mattabi and Whistle give Grade 5. Graphite and sulphides can span all grades but, in this survey area, field work may show that the different grades indicate different types of conductors.
identifier
mho value
grade
The actual mho value is plotted beside the EM grade symbol. The letter is the anomaly identifier.
Conductor axis
S Probable surface response
S? Possible surface response
L Probable line (power, telephone pipe or fence)
L? Possible line
? Questionable anomaly
Apparent thickness
Dip
100γ Direct magnetic correlation of 100 gammas
DIGHEM maps are designed to provide a correct impression of conductor quality by means of the conductance grade symbols. The symbols can stand alone with geology when planning a followup program. The actual mho values are plotted for those who wish quantitative data. The anomaly ppm and depth are indicated by inconspicuous dots which should not distract from the conductor patterns, while being helpful to those who wish this information. The map provides an interpretation of all conductors in terms of length, strike direction, conductance and depth. The accuracy is comparable to an interpretation from a ground EM survey having the same line spacing.
THE MOUNT LYELL MINING & RAILWAY COMPANY LTD
PLAN OF
DIGHEM ANOMALIES
OVER MT. LYELL
013
5 cm
84-2258
FIG 3
REVISIONS
SCALE 1:10,000
DATE 12 3 1981
DRAWN BY DIGHEM
DRAFTSMAN H.D.J.
A 2 - 151

302042

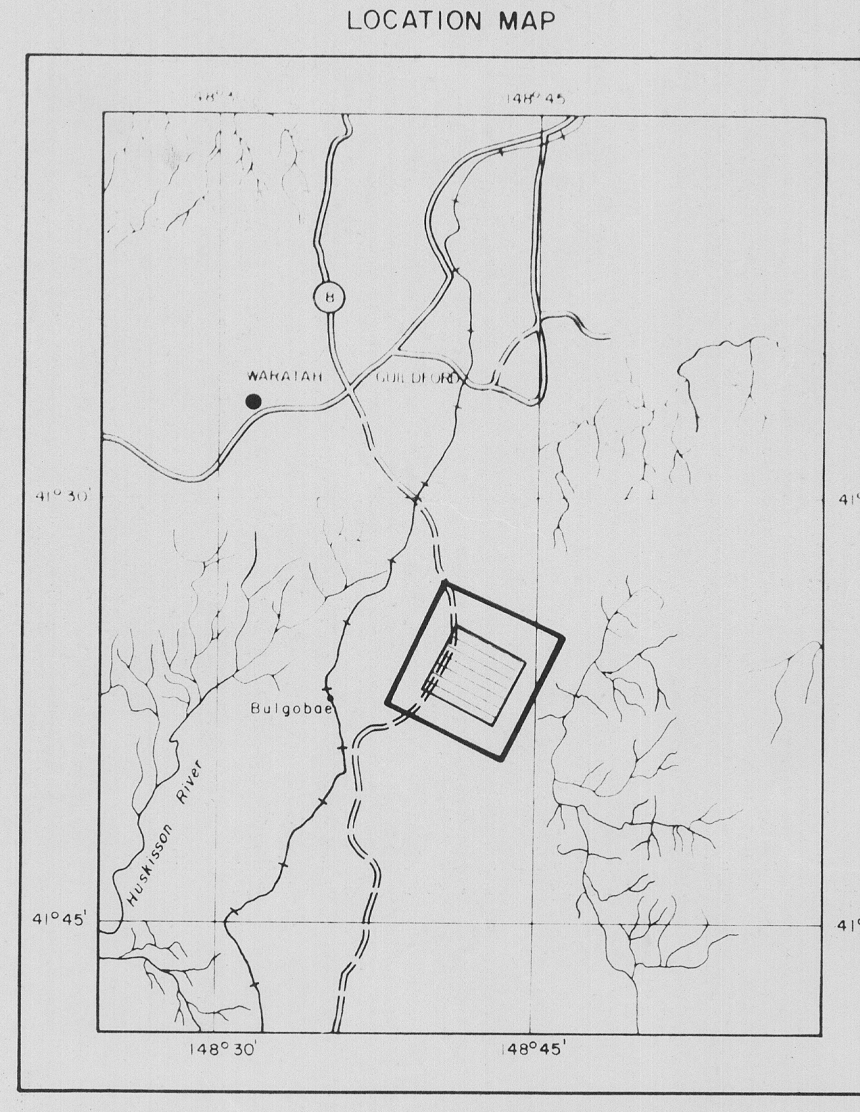
005


CPS
REC 1
REC 2
CPS
ALT
MAG
CXI
CXQ
CPI
CPQ
SIGT
DIFI
DIFQ
2032
2031
2030
2029
RES
DP
5 cm
NE
0 200m
302043
SW
EXPI
CC
MITRE GEOPHYSICS PTY LTD
WESTERN THARSIS
DIGHEM PROFILE OVER
FLIGHT LINE 301
DRAWN J.B.
TRACED P.J.R.
SCALE
DATE JUNE 81
FIG 4

A4-135



LOCATION MAP



Scale 1:500,000

DIGHEM II SURVEY

QUE RIVER, TASMANIA

ELECTROMAGNETICS

FOR

BROKEN HILL PROPRIETARY CO. LTD.

5 cm

SCALE 1:20,000

1 0 1 2 Kilometres

1/2 0 1/2 1 Miles

Flight line

Fiducials and numbers

302044

QUE RIVER

ANOMALY GRADE	EM GRADE SYMBOL	MHO RANGE
6	●	≥ 100
5	✱	50 — 99
4	●	20 — 49
3	⊙	10 — 19
2	O	5 — 9
1	○	≤ 4
	×	Possible conductor

DIGHEM anomalies are divided into six grades of conductivity – thickness product. This product in mhos is the reciprocal of resistance in ohms. The mho is a measure of conductance, and is a geologic parameter. Most swamps yield Grade 1 anomalies but highly conducting clays can give Grade 2 anomalies. The multi - coil anomaly shapes often allow surface conductors to be recognized, and these are indicated by the letter S on this map. The remaining Grade 1 and 2 anomalies could be weak bedrock conductors. The higher grades indicate increasingly higher conductances. Examples: The ore bodies of the Magusi River camp yield Grade 4 anomalies, while Mattabi and Whistle give Grade 5. Graphite and sulphides can span all grades but, in this survey area, field work may show that the different grades indicate different types of conductors.

identifier → c ● 38 ← mho value

Depth is greater than
. 50 feet
: 100 feet
⋮ 150 feet
⁞ 200 feet

Inphase and Quadrature of standard coil is greater than
. 5 ppm
.. 10 ppm
... 15 ppm
.... 20 ppm

Refer to list of anomalies in survey report for the actual ppm values for all coils, and for conductor depths.

The actual mho value is plotted beside the EM grade symbol. The letter is the anomaly identifier. The horizontal rows of dots indicate anomaly amplitude on the flight record, and the vertical column gives the estimated depth. This depth may be unreliable because the stronger part of the conductor may be deeper or to one side of the flight line, or because of a shallow dip or conductive overburden effects.

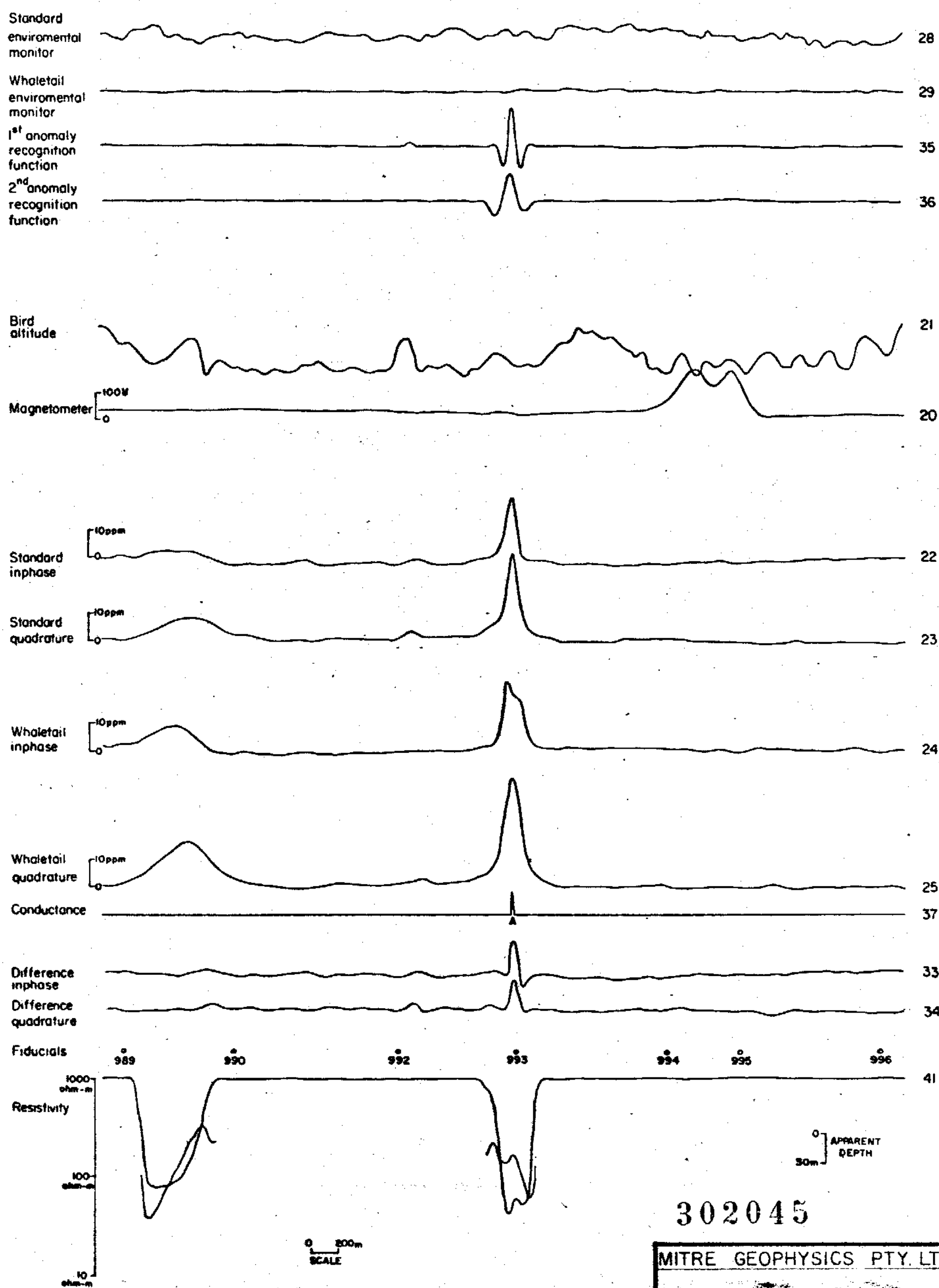
/	Conductor axis
S	Probable surface response
S?	Possible surface response
L	Probable line (power, telephone, pipe, or fence)
L?	Possible line
?	Questionable anomaly
⊂⊃	Apparent thickness > 10 m
>	Dip
100γ	Direct magnetic correlation of 100 gammas

DIGHEM maps are designed to provide a correct impression of conductor quality by means of the conductance grade symbols. The symbols can stand alone with geology when planning a followup program. The actual mho values are plotted for those who wish quantitative data. The anomaly ppm and depth are indicated by inconspicuous dots which should not distract from the conductor patterns, while being helpful to those who wish this information. The map provides an interpretation of all conductors in terms of length, strike direction, conductance and depth. The accuracy is comparable to an interpretation from a ground EM survey having the same line spacing.

FIGURE 5

014

84-2258



302045

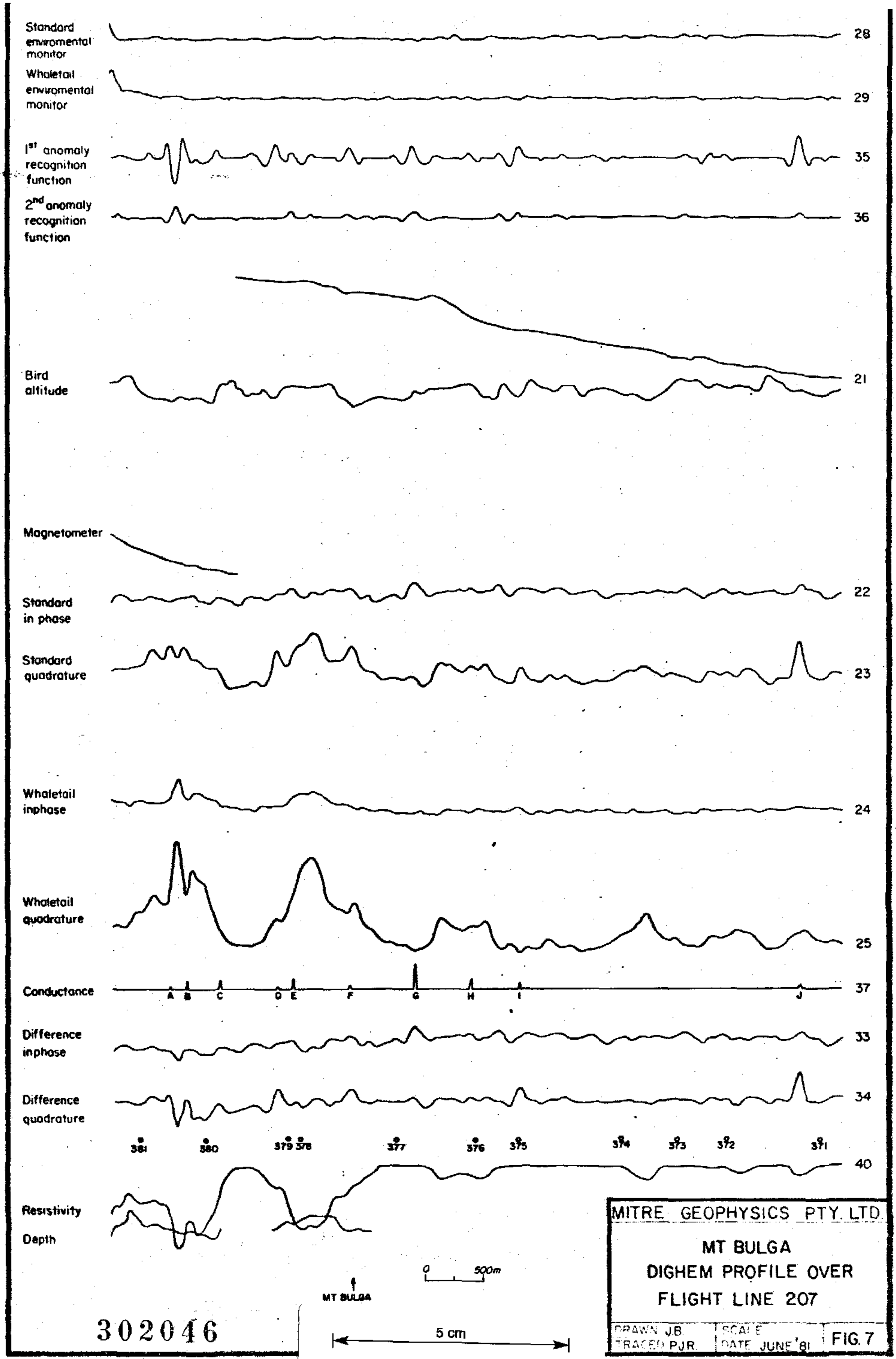
MITRE GEOPHYSICS PTY. LTD.

QUE RIVER
DIGHEM PROFILE OVER
FLIGHT LINE 513

DRAWN JB TRACED PJR	SCALE DATE JUNE '81	FIG. 6

A4-136

007



MITRE GEOPHYSICS PTY. LTD.

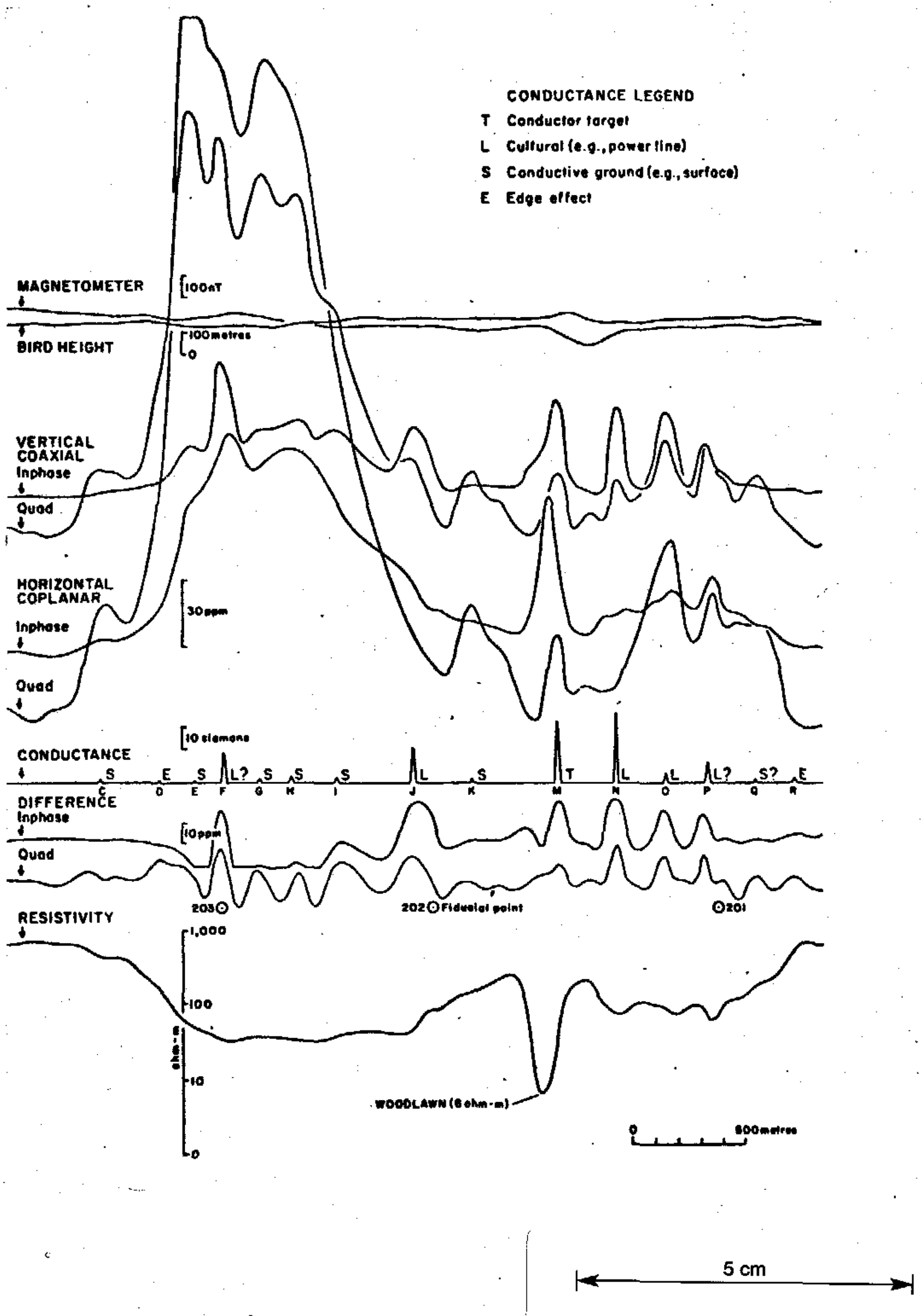
MT BULGA
DIGHEM PROFILE OVER
FLIGHT LINE 207

DRAWN J.B. TRACED PJR. | SCALE DATE JUNE '81 | FIG. 7

302046

A4-137

008



MITRE GEOPHYSICS PTY. LTD.

DIGHEM PROFILE OVER WOODLAWN N.S.W.

DRAWN	SCALE	FIG. 8
TRACED	DATE	

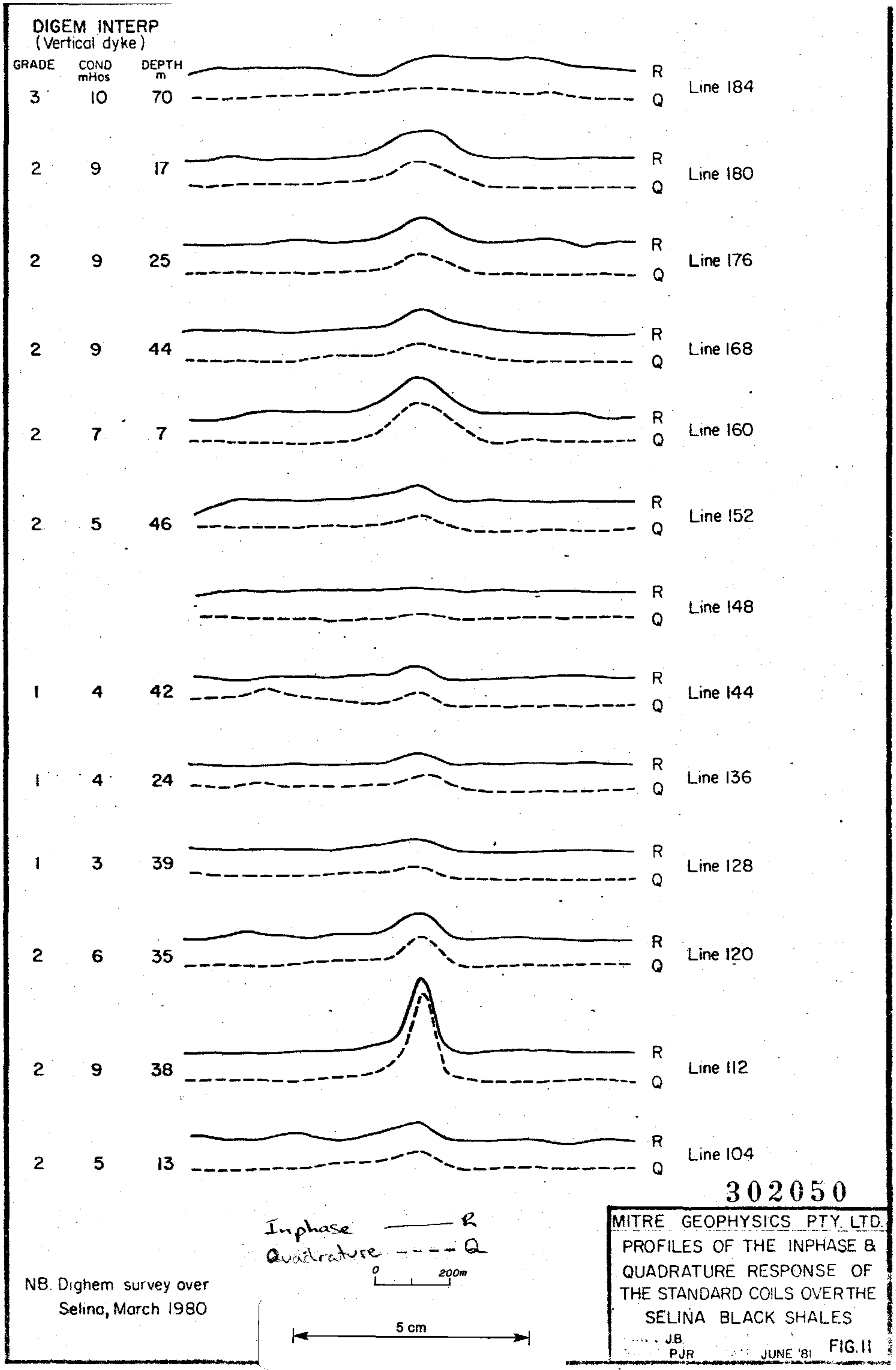
302047

A4-138


THE MOUNT LYELL MINING & RAILWAY COMPANY LTD.
DIGHEM REINTERPRETATION
HENTY - YOLANDE
015
DIGHEM AND MITRE ANOMALIES
84-2258
FIG. 9
SCALE 1:10000
DATE 4-8-1981
DRAWN BY MITRE GEO.
DRAFTSMAN H.D.J
REVISIONS
AO-149
5 cm
302048
Grade
C (Culture)
(Surface) S
m (Identifier)
or
(Line) L
ANOMALY GRADE
Dighem
Mitre
Increasing order of merit


ANOMALY GRADE
Dighem
Mitre
Increasing order of merit
Identifier
Grade
5 cm
MOUNT SELINA
176N
168N
160N
152N
144N
136N
128N
120N
112N
104N
96N
THE MOUNT LYELL MINING & RAILWAY COMPANY LTD.
302049
DIGHEM REINTERPRETATION
SELINA
DIGHEM AND MITRE ANOMALIES
016
84-2258
FIG. 10
SCALE 1. 5000
DATE August '81
DRAWN BY MITRE
DRAFTSMAN P.J.R
REVISIONS
AI - 152

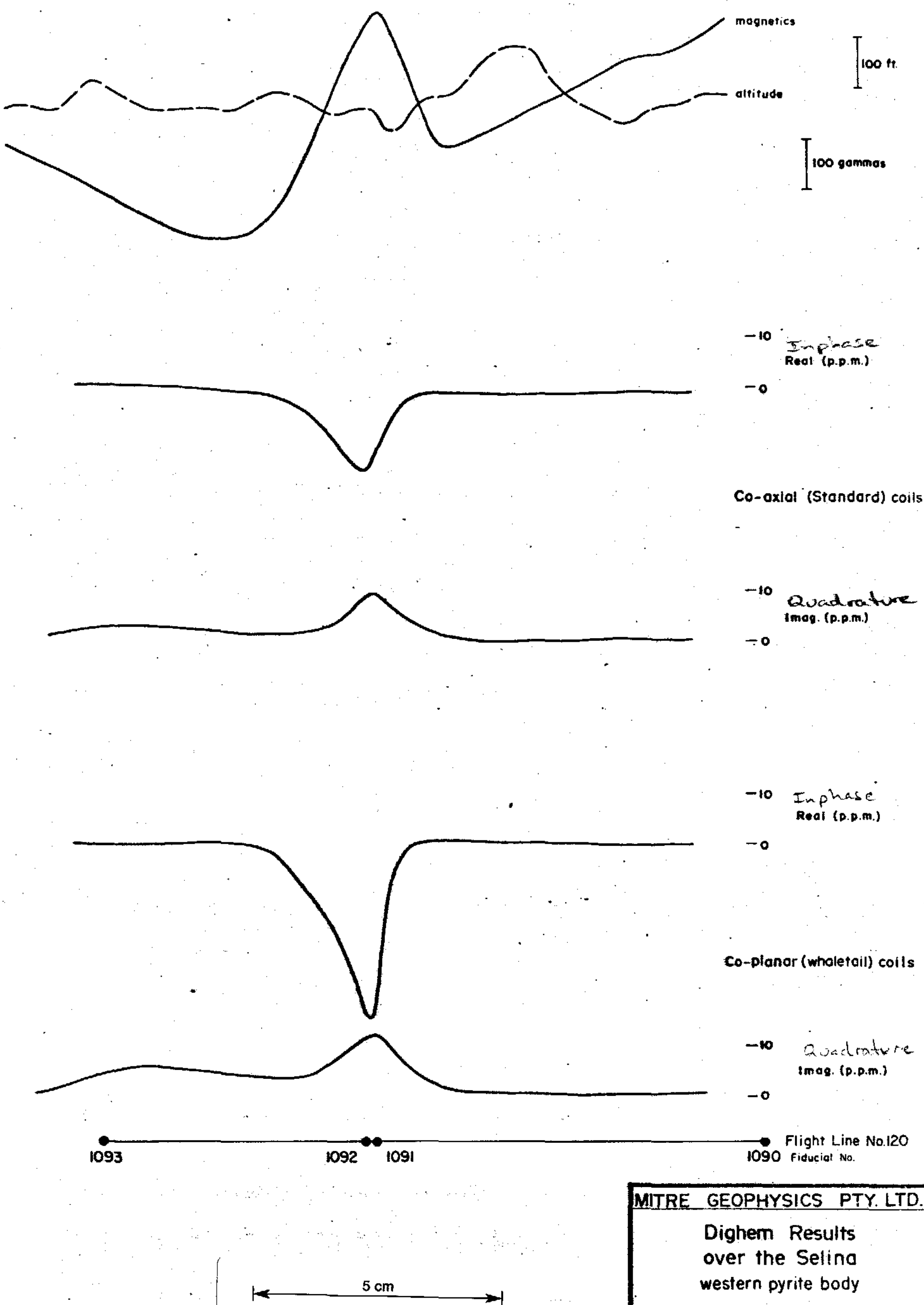
302050



MITRE GEOPHYSICS PTY. LTD.

PROFILES OF THE INPHASE & QUADRATURE RESPONSE OF THE STANDARD COILS OVER THE SELINA BLACK SHALES

J.B. PJR JUNE '81 FIG. 11

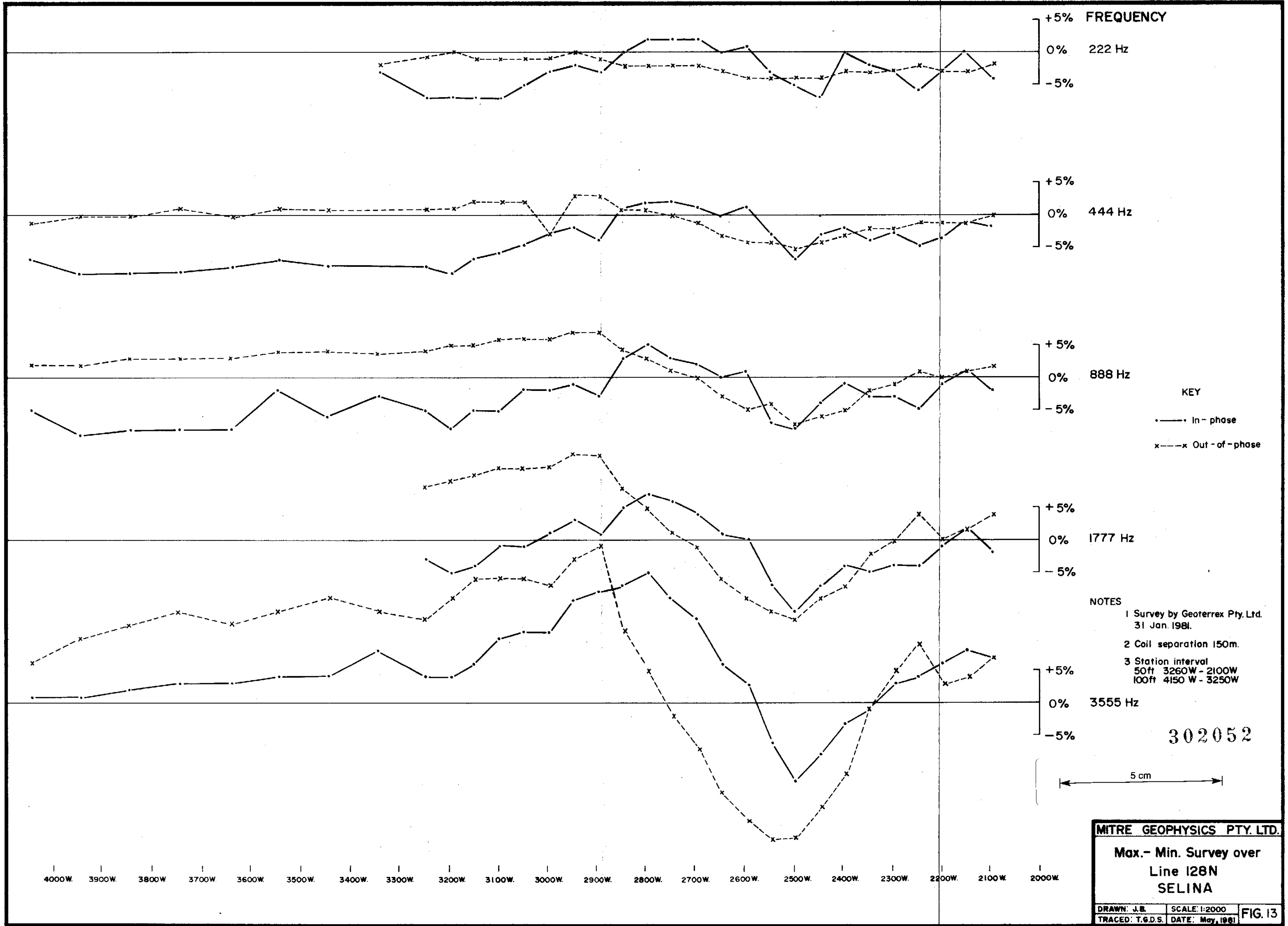


MITRE GEOPHYSICS PTY. LTD.

Dighem Results over the Selina western pyrite body

DRAWN: J.B.	SCALE: 1:10,000	FIG. 12
TRACED: T.G.D.S.	DATE: May 1981	

011

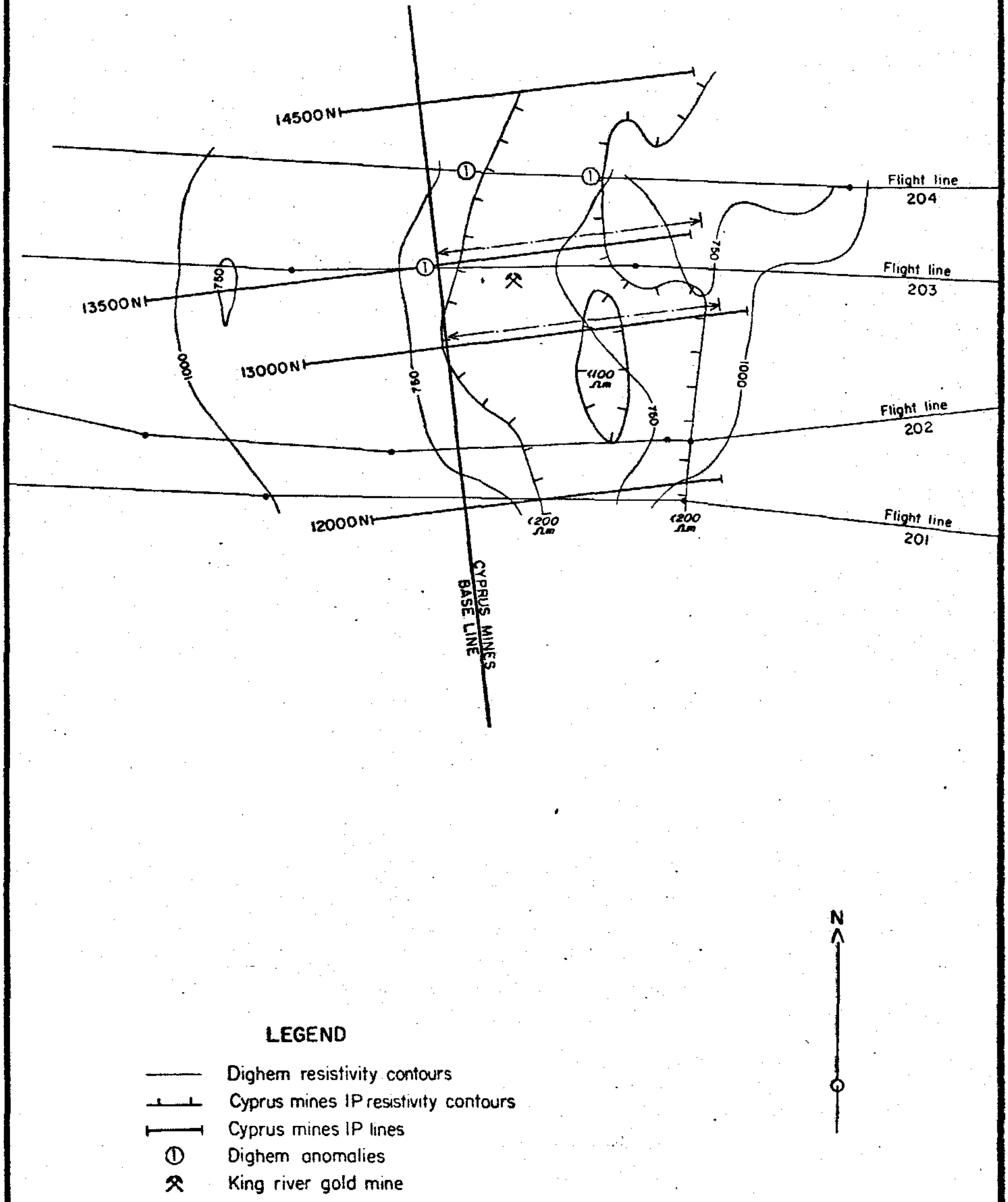


FREQUENCY
+5%
0%
-5%
222 Hz
444 Hz
888 Hz
1777 Hz
3555 Hz
KEY
In - phase
Out - of - phase
NOTES
1 Survey by Geoterrex Pty. Ltd. 31 Jan. 1981.
2 Coil separation 150m.
3 Station interval
50ft 3260W - 2100W
100ft 4150 W - 3250W
5 cm
4000W. 3900W. 3800W. 3700W. 3600W. 3500W. 3400W. 3300W. 3200W. 3100W. 3000W. 2900W. 2800W. 2700W. 2600W. 2500W. 2400W. 2300W. 2200W. 2100W. 2000W.
MITRE GEOPHYSICS PTY. LTD.
Max.- Min. Survey over
Line 128N
SELINA
DRAWN: J.B.
TRACED: T.G.D.S.
SCALE: 1:2000
DATE: May, 1981
FIG. 13

302052

78
79
80
81
82
83
204
1379
203
1387
202
1353
201
1316
1371
1366
1343
1326
KING RIVER
GOLD MINE
QUEEN
RIVER
ANOMALY GRADE
5 cm
Dighem
Mitre
Increasing
order of
merit
Grade
Identifier
A
S
Superficial
(Dighem anomalies
only)
MITRE GEOPHYSICS PTY. LTD.
LYNCH CREEK
DIGHEM RE-INTERPRETATION
DIGHEM & MITRE ANOMALIES
017
84-2258
FIG. 14
DRAWN: J. BISHOP
TRACED: P.J.R
DATE: 3-8-'81.
SCALE: 1:10000.
A2-148
302053

012



5 cm

MITRE GEOPHYSICS PTY. LTD.

DIGHEM & I P RESISTIVITY CONTOURS LYNCH CREEK

DRAWN J.B. TRACED P.J.R.	SCALE 1:10,000 DATE 25-6-81	FIG 15

302054

A4-147