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MINERAL EXPLORATION AND ENGINEERING CONSULTANTS
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A REINTERPRETATION OF THE DIGHEM SURVEYS OVER THE HUXLEY AND BIRD RIVER AREAS

for

THE MT. LYELL MINING AND RAILWAY CO. LTD.

by

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ML/MG82/09
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TABLES AND FIGURES

SUMMARY

A Dighem survey was carried out over two areas of Queenstown in February 1982. The 'Huxley' survey consisted of 51 flight lines totalling 297 line-kms., while the 'Bird River' survey consisted of five flight lines totalling 19 line-kms. Disappointing results were obtained over both areas: only one prospective anomaly (of very low amplitude) was recorded over Huxley and none over Bird River.

Because of the lack of anomalies, it was decided to reinterpret the data, looking for possible 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 a similar treatment of an earlier Dighem survey over Mt. Lyell's Selina area had shown that significant mineralisation could be found from a detailed examination of the data.

Thirty one anomalies (termed Mitre anomalies to distinguish them from the original Dighem anomalies) were picked from the reinterpretation of the Huxley area but only four of these defined any sort of a conductive zone; this was across the four southernmost lines about 1.8 km. WNW of Proprietary Peak. A further anomaly filled a gap in a zone defined by a reinterpretation of a 1980 Dighem survey over Lynch Creek. Although the 1982 Huxley survey did not repeat the 1980 responses (neither the Dighem nor the Mitre anomalies), the zone, on the northern end of Miner's Ridge, is considered worthy of follow up.

At Bird River, three Mitre anomalies were picked; no zone was defined, however one response may be along strike from an area of lower resistivity described in the Dighem report as possibly reflecting a bedrock source, and this area is also of potential interest.

The approximate AMG locations of the four areas mentioned above (as determined from the 1:100,000 state topography maps) are:

(1)	Dighem anomaly 16A	383,100mE	5,335,600mN
(2)	Proprietary Peak, West	380,900mE	5,331,100mN
(3)	Miner's Ridge, North	380,800mE	5,335,800mN
(4)	Bird River	385,100mE	5,312,000mN

It is recommended that these zones be followed up by ground EM surveys: the Max-Min method is particularly recommended. Since these reinterpretation anomalies, if genuine, represent weak and/or deep conductors, a wide coil separation of the order of 150m. would be required.

INTRODUCTION

A Dighem survey was conducted over two areas within Mt. Lyell's EL 9/66 during February, 1982. The survey, a helicopter-borne electromagnetic and magnetic system, recorded disappointing results over both the Huxley and Bird River areas. It was therefore decided to examine the data for responses not detected by the automatic anomaly picking program used by Dighem. Any such responses would be small, less than 3 ppm, but it was considered that the rigid criteria associated with a completely automated approach might miss some real anomalies. That this can be so was confirmed by a reinterpretation of a 1980 Dighem survey over the Selina area (also in EL 9/66) which showed that the Dighem interpretation had missed a significant belt of mineralisation: this was picked up by the reinterpretation and confirmed by a subsequent IP survey (Bishop, 1981a).

The Dighem EM system uses a towed 'bird' which contains two sets of transmitting and receiving coils: one pair of vertical coils with a common axis (co-axial) and a pair of horizontal, co-planar coils. The transmitted frequencies are sufficiently far apart to be recorded separately, but are close enough to assume both coils operate at 900 Hz. for mathematical treatment of the responses. The two coil orientations allow Dighem to differentiate between types of conductors, in particular conductive overburden from bedrock conductors.

The survey data is computer processed and, as well as giving the usual in- and out-of-phase data for both coil orientations, altimeter and magnetometer profiles, the profiles show apparent resistivity and depth (for a conductive earth); conductance (for a vertical dyke); as well as various anomaly enhancement channels. Also shown are ambient noise levels for both coil orientations. Further description

is given in the Dighem report (Peters and Dvorak, 1982) and in Fraser (1979).

The output from the Dighem survey consists of the original analogue records, computer processed profiles and four maps. One map shows the EM anomalies with a grade symbol and two series of dots. The grade is based on the conductance of a (assumed) vertical dyke as the cause of the anomaly. One series of dots shows the size of the response, the other the interpreted depth. A second map is a contour plan of resistivity (a conductive earth beneath a resistive layer is assumed). A third map is a contour plan of the magnetics, and the fourth map is a plan of enhanced magnetics. The processing for the last map removes broad anomalies and amplifies the response of narrow ones; thus it accentuates near surface magnetic bodies. The resistivity and both magnetics maps show the EM grade symbol but not the other information.

Dighem have defined six grades for a possible conductor. These are:

Dighem grade	Conductance (σt) range
6	$\geq$ 100
5	50 - 99
4	20 - 49
3	10 - 19
2	5 - 9
1	$\leq$ 4
X	Possible

The following quote is on all Dighem EM maps:

"Dighem anomalies are divided into six grades of conductivity - thickness product. This product in mhos (Siemens in S.I. units) 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 recognised, 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 Mogusi 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."

The Dighem system responds to a non-conductive magnetic body with a negative in-phase anomaly from 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."

Anomalies picked in the reinterpretation have been termed Mitre anomalies to distinguish them from the original Dighem anomalies: several have been picked in both areas. It is likely that most, if not all, are false anomalies (due to instrumental noise) which will not be locatable on the ground. Nevertheless the Selina experience where two and possibly three Mitre anomalies were subsequently shown to be coincident with mineralisation, and the very few Dighem anomalies recorded, justify a reinterpretation. No quantitative interpretation of the Mitre anomalies is possible and only those anomalies which form part of a conductive zone would warrant follow up in their own right; others would require independent back up such as favourable geology or geochemistry. There has been no attempt to integrate the anomalies with the geology; though when this is done it should immediately sort the anomalies, upgrading some and downgrading or dismissing others.

REINTERPRETATION

Huxley Area:

The survey of the Huxley area consisted of 297 line-kms. The line spacing and bird height were nominally 150m. and 35m. respectively. The four standard Dighem maps were produced on photo-mosaics at a scale of 1:10,000.

The EM results were disappointing, producing only two definite anomalies, one of which was over Queenstown's rubbish tip. The other anomaly was located over central sequence volcanics (Corbett, 1981) near the Huxley track, about 2 kms. north of Mt. Huxley. It is a very low amplitude response (all four channels less than 5 ppm) and the interpreted source of a 32 mho tabular conductor at 80m. depth is likely to be quite inaccurate: Peters and Dvorak (1982) stated that "it may well be due to aerodynamic noise". Two separate and isolated possible anomalies (amplitudes less than 3 ppm) were also defined; both were considered probably to have superficial sources. Resistivities were mostly high and several magnetic anomalies were outlined.

Thirty one Mitre anomalies were picked in the reinterpretation; they are shown in Figure 1 and listed in Table 1. Also shown are the Dighem and Mitre anomalies from a previous (1980) survey of the Lynch Creek area. The first survey of Lynch Creek, four flight lines at a nominal 200m. spacing, had defined three grade 1 anomalies around the King River mine, all probably due to superficial sources and one possible anomaly on the bank of the Queen River. In the reinterpretation, eleven Mitre anomalies were picked. In the 1982 survey, no Dighem anomalies were recorded, and only six Mitre anomalies were picked from five flight lines covering essentially the same area. The 1980 Dighem anomalies were essentially quadrature-only responses indicating conductive overburden, thus the lack of anomalies in the 1982 survey suggests an improvement in the anomaly recognition program, however the amplitudes of the 1982 results are considerably lower than those recorded in 1980 (e.g. the 'middle' of the three Dighem anomalies recorded 2:15 and 0:27 on the real and imaginary channels for the coaxial and coplanar coils respectively, whereas the maximum recorded values on the repeat survey (apparently flown directly over the 1980 anomaly) were 0:7 and 0:12). This suggests that the system is much less sensitive than before; certainly the noise levels on this survey were much lower, resulting in fewer Mitre anomalies than the 1980 surveys.

The bird height (above 'effective' ground level) for the survey has been contoured (by Exploration Computer Services) at 1:10,000 scale

and this map shows that the main areas of large ground clearance (say more than 75m.) are in the King and Queen River gorges: areas which one might expect to have reasonable outcrop and to be well prospected (?). Other significant areas with 75m.+ ground clearance are south of the King River and Queen River confluence in the south west corner of the survey. Similarly, the magnetic data has been re-compiled and contoured at a 5 gamma contour interval.

Only one series of anomalies from the reinterpretation constituted a conductive zone and this was on the four southernmost lines. If genuine, the lack of perfect alignment could be due to poor location. The area is resistive and therefore the responses are unlikely to be due to conductive overburden. The area of the zone is Proprietary Peak West, and the approximate coordinates are 380,900mE, 5,331.100mN (determined by locating the zone on a 1:100,000 scale map). The other area of consecutive (line by line) Mitre anomalies is within the area of the old Lynch Creek survey, on the northern end of Miner's Ridge (approximate coordinates 380,800mE, 5,335,800mN). This zone consists of three 1980 and one 1982 Mitre anomalies (this last was picked before the 1980 anomalies were plotted on the map). Assuming that the near alignment is not coincidental and the anomalies are genuine, the fact that the 1982 survey did not repeat the Mitre responses may be due to decreased sensitivity suggested above (possibly done to reduce the noise levels) or that slightly different bird attitudes and altitudes have resulted in no responses.

These two conductive zones contain the only Mitre anomalies which should be followed up without any other complementary information.

Bird River Area:

A small survey of five flight lines totalling 19 line-kms. was flown over the Bird River area. This area was chosen because of a report of outcropping sulphides by T.B. Moore, an early prospector (letter in Mt. Lyell archives). Although the survey specifications were the same as for the Huxley area, navigational control was poor and the plans show that much of the area is inadequately covered by flight lines with separations of more than 400m. There were no EM anomalies recorded, although Peters and Dvorak (1982) stated that one region of lower resistivity may be due to a (weak and/or deep) conductor.

The area was magnetically quiet.

Three Mitre anomalies were picked from the reinterpretation, one of which may be along strike from the more conductive area mentioned above. Thus this area could be considered for ground follow up surveys (approximate location on the 1:100,000 scale maps is 385,100mE, 5,312,000mN). The anomalies are shown in Figure 2 and listed in Table 1.

CONCLUSIONS AND RECOMMENDATIONS

The Huxley and Bird River areas consist of resistive rocks which are excellent hosts for EM conductors, however the Dighem surveys have produced disappointing results, with only one definite anomaly of potential interest. And the amplitudes of this anomaly are so small that the Dighem interpretors (Peters and Dvorak, 1982) suggest that the response may be due to noise.

A reinterpretation was carried out by picking small deflections, within the noise levels of the EM channels, which did not have other obvious causes or countering deflections on the other channels: this resulted in thirty one Mitre anomalies in the Huxley survey and three in the Bird River survey. Zones of anomalies (Dighem or Mitre), defined by a series of responses on consecutive flight lines, are of more interest than isolated anomalies (provided the zone is not too long) and one such zone was defined on the Huxley survey, with a second, partially defined by the 1980 Lynch Creek survey and improved with the reinterpretation of this survey. In the Bird River area, no zones were defined although one of the anomalies is (?) reasonably aligned (geologic strike not known) with a less resistive area, suggested by Peters and Dvorak (1982) as possibly reflecting a bedrock source.

Any possible association of EM responses with magnetic anomalies has not been considered here, since I do not believe that the magnetic method is a very diagnostic tool when exploring for massive sulphides in the Mt. Read Volcanics (the sulphides may or may not be magnetic: e.g. only some of the ore bodies on the Lyell mining field are magnetic, and only a (deep) part of the Rosebery ore body is pyrrhotite rich).

Peters and Dvorak (1982) note that "careful ground follow up" would be needed to verify that the Bird River low resistivity area was due to a bedrock conductor, and this advice applies to all the Mitre anomalies (and to the one potentially interesting Dighem anomaly, with its very low amplitude responses) since, if genuine, they reflect weak and/or deep conductors. There are various possible EM methods (see Bishop, 1981b), however a Max-Min or PEM survey is recommended with a wide (say 150m.) coil spacing. Although the Max-Min method is prone to in-phase topographic responses, experience suggests that it is more effective at detecting weaker targets than the recently developed Genie system which (supposedly) is free from terrain effects (Bishop, 1982, in prep.).

Before embarking on any follow up program it is strongly recommended that the particular area(s) be relocated on to good air photos direct from the flight strip; despite generally good recovery on previous Dighem surveys, location checking has always produced some changes.

J.R. Bishop
July, 1982

REFERENCES

Bishop, J.R., 1981a. A reinterpretation of the Dighem surveys over the Henty-Yolande, Selina and Lynch Creek Areas. Mitre Geophysics report no. ML/MG81/07.

Bishop, J.R., 1981b. Notes on some EM methods for ground follow up of Dighem anomalies. Mitre Geophysics report no. EZ-ML/MG81/06.

Bishop, J.R., 1982. Final report on the 1981-82 geophysical surveys over the Mine Lease. Mitre Geophysics report no. ML/MG82/10 for Mt. Lyell (in prep.).

Corbett, K.D., 1979. Stratigraphy, correlation and evolution of the Mt. Read volcanics in the Queenstown, Jukes-Darwin and Mt. Sedgwick areas. Tas. Mines Dept., Geol. Survey Bull. no. 58.

Fraser, D.C., 1979. The multicoil^{II} airborne electromagnetic system. Geophysics vol. 44, p. 1367-1394.

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TABLE 1

DIGHEM AND MITRE ANOMALIES

(1) Huxley Area:

a) Dighem Anomalies

Label	Response (ppm)				Quantitative Interpretation						Comment
	Coaxial		Coplanar		Vertical dyke		horiz'al sheet		conductive earth		
	R.	I.	R.	I.	mhos	depth (m)	mhos	depth (m)	ohm-m	depth (m)	
8A	0	32	2	14	1	0	1	51	1035	0	over Queenstown rubbish tip
16A	2	1	3	1	32	80	2	219	43	173	low response levels
22xA(s)											superficial possible anomaly
39xA(s)											superficial possible anomaly
203A(s)*	12	11	0	19	1	2	1	35	722	0	not repeated in the 1982 Huxley survey
204B(s)*	2	16	0	27	1	0	1	14	746	0	"
204C(s)*	2	3	0	5	2	27	1	116	405	48	"
204xA*											

b) Mitre Anomalies

1m

2m

9m

9n

10m

204m*

11m

12m

* recorded by the 1980 Lynch Creek survey

b) continued..

Label	Comment
203m*	
203n*	
203o* -	- Part of the north Miner's Ridge zone #
203p*	
13m	
203q*	
14m	
201m*	
201n*	
201o*	
202m* -	- Part of the north Miner's Ridge zone #
15m -	- Part of the north Miner's Ridge zone #
201p* -	- Part of the north Miner's Ridge zone #
20m	
21m	
21n	
24m	
24n	
26m	
26n	
26o	
27m	

* recorded by the 1980 Lynch Creek survey

\# approx. coordinates (from a 1:100,000 scale map): 380,800E, 5,335,800N)

b) continued..

Label	Comment
28m	
31m	
34m	
34n	
42m	
44m	
44n	
47m -	- Part of the West Proprietary Peak zone #
47n	
49m -	- Part of the West Proprietary Peak zone #
50m -	- Part of the West Proprietary Peak zone #
51m -	- Part of the West Proprietary Peak zone #

(2) Bird River Area:

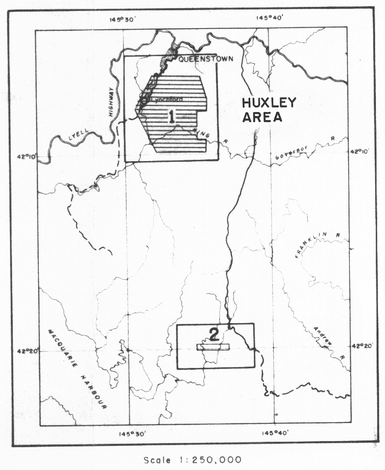
(No Dighem Anomalies)

Mitre Anomalies

2m	
3m -	- Possibly on strike with less resistive area to the south. (approx. coordinates 385,100E, 5,312,000N).
3n	

approx. coordinates (from a 1:100,000 scale map): 380,900E, 5,331,100N)

LOCATION MAP

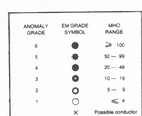


Scale 1:250,000

DIGHEM ANOMALY CODING

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 Maguel River camp (Quebec, Canada) yield grade 4 anomalies, while Mattabi and Whistle (Ontario, Canada) 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.



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.

S	Conductor axis
	Surface response (usually conductive overburden, but occasionally conductive response from broad expanse of weathered and unweathered rocks, and from culture which gathers current from conductive ground)
S?	Possible surface response
L	Culture (usually a line such as a fence, power or telephone line, but also includes buildings, etc.)
L?	Possible culture
?	Questionable anomaly
40	Apparent thickness in 10m
	Dip direction
100 ß	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.

SCALE 1:10,000

1/2 0 1/2 1 Kilometres

1/4 0 1/4 1/2 Miles

LEGEND

- A — Dighem anomaly (see Anomaly Coding).
- m — Mitre anomaly from reinterpretation.
- 4 — Dighem anomaly from earlier survey.
- Mitre anomaly from reinterpretation of earlier survey.
- Approximate area covered by 1980 Dighem survey of Lynch Creek.

(revised figure from Peters and Dvorak, 1982.)

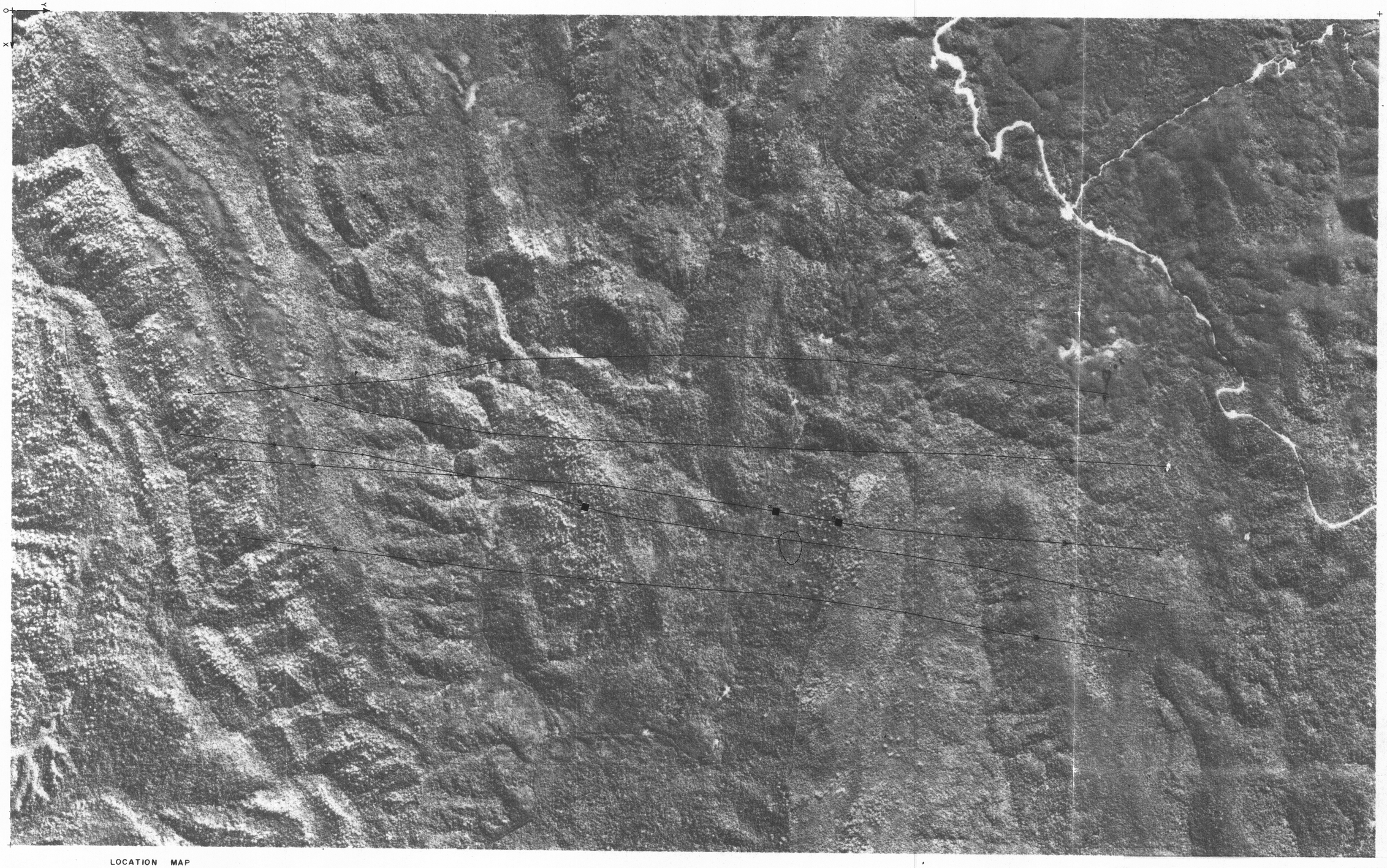
NOTE: The Dighem survey over the Huxley area detected few anomalies. Therefore the data was reinterpreted by Mitre Geophysics and further "anomalies" have been plotted. Although these are generally within the noise level and most if not all are false anomalies, previous experience (Bishop, 1981) has shown that they may be due to mineralisation.

301015

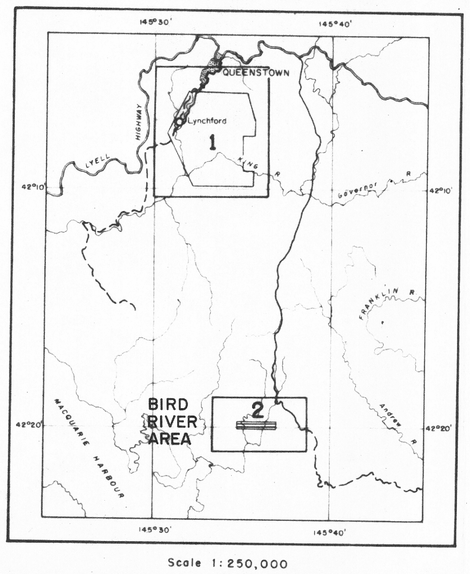
5 cm

MITRE GEOPHYSICS PTY. LTD.		
DIGHEM REINTERPRETATION HUXLEY AREA E.M. Anomalies		014
84-2259		
Drawn: J.B.	Scale: 1:10,000	FIG. 1
Traced: T.G.D.S.	Date: Aug. 1982	

Ref: ML/MGBZ/09



LOCATION MAP



Scale 1:250,000

SCALE 1:10,000

1/2 0 1/2 1 Kilometres

1/4 0 1/4 1/2 Miles

301016

5 cm

LEGEND

m — Mitre anomaly from reinterpretation.

Area of lower resistivity.

(revised figure from Peters and Dvorak, 1982)

NOTE : The Dighem survey over the Bird River area detected no anomalies. Therefore the data was reinterpreted by Mitre Geophysics and further 'anomalies' have been plotted. Although these are generally within the noise level and most if not all are false anomalies, previous experience (Bishop, 1981) has shown that they may be due to mineralisation.

Ref. ML/MG82/09

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DIGHEM REINTERPRETATION

BIRD RIVER AREA

E.M. Anomalies 015

84-2259

Drawn: J.B.	Scale: 1:10000	FIG. 2
Traced: T.G.D.S.	Date: Aug. 1982	