

**APPRAISAL OF  
COLEBROOK HILL  
GEOPHYSICS**

**AUG 1980**

**02\_4814**

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# MITRE GEOPHYSICS PTY LTD

MINERAL EXPLORATION AND ENGINEERING CONSULTANTS

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## APPRAISAL OF COLEBROOK HILL GEOPHYSICS

August, 1980

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### SUMMARY

The previous geophysical surveys are listed and the results assessed. The surveys are aero- and ground magnetics, aero- and ground- electromagnetics and induced polarisation surveys.

The aero-magnetics and airborne electromagnetics defined interesting anomalies in the vicinity of the old workings on Colebrook Hill.

The ground follow-up magnetic and electromagnetic (em) methods have so far failed to locate (and better define) the airborne anomalies.

The induced polarisation surveys (dipole-dipole and gradient arrays) did not work due to extremely conductive subsurface conditions.

It is recommended that the ground magnetics be re-checked over noisy lines.

It is recommended that the ground em methods VLF and PEM, be tested over the area - the former method to define near surface local mineralisation and the latter to search for a deeper, larger body.

It is suggested that consideration be given to conducting a self potential survey over the grid. The merits of a gravity survey are also considered.

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Appraisal of Colebrook Hill Geophysics - August 1980

Electrolytic Zinc Company of Australasia Limited\*; Mitr  
Bishop, J.R. EL1/1962

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APPRAISAL OF COLEBROOK HILL GEOPHYSICS

The area discussed below is contained within the co-ordinates (5,371,000N 5,372,600N) and (374,000E - 375,600E) A.M.G..

Detailed summaries of the area, its geology, etc are contained in E.Z. Report 134 (Progress Report 1979-80).

Geophysical Coverage

- A. Airborne
  - i) Scintrex Turair (em) and Magnetics (April, 1972).
  - ii) Geoterrex Input (em) and Magnetics (Sept. 1975).
  - iii) Georex Magnetics (April, 1978).
  
- B. Ground
  - i) Geoterrex Dipole-Dipole I.P. (May, 1980).
  - ii) Scintrex Gradient I.P. (May, 1980).
  - iii) Magnetics (June, 1980).
  - iv) V.H.E.M. (dip angle em) (July, 1980).

Geochemical Sampling

The area has been sampled and assayed for Cu, Pb, Zn, Sn, As, Fe, Mn, Ni, Co and Cr.

Summary of Results

Turair

There is one linear anomaly in the area. Interpreted by Scintrex as occurring over 3 flight lines, the conductor strikes SE-NW and goes from 375,180E on 5,371,700N to 375,000E at 5,371,850N.

The anomalies were interpreted by Scintrex as being caused by conductors at depths of between 25m to 50m below ground level.

The anomalies are all very weak and poorly defined, being for the most part within very noisy sections of the profiles which occurred on the ends of many of the lines. However, the conductor closely parallels the strike of two magnetic anomalies and appears closely associated with the more northerly one.

(The Turair survey had a nominal flight line spacing of 150m (550ft) and a terrain clearance of 45m (150ft)).

Input

There are three Input anomalies within the defined area with further anomalies to the north and south. These anomalies are exceptionally well defined, indicating very good conductors. The conductive zone of which these anomalies are part, extends for 6,000m - the limits of the survey; such a trend would usually be interpreted as lithological, and indeed for a large part of the 'conductive' area, the em anomalies overlie a strongly magnetic zone. However, at Colebrook Hill, the anomalies are to the east of strongly magnetic serpentinites.

The Input anomaly at 375,015E on line 5,371,700N occurs on all six channels and is associated with a well defined magnetic high which peaks some 100m to the west. The Input survey had a nominal flight line spacing of 400m and a terrain clearance of 150m, however, one adjacent flight line is 500m north of Colebrook Hill (anomaly at 374,940mE on line 5,372,200N) and to the south, two flight lines intersect 800m away.

The Input method does not permit an estimation of the depth of the conductor, although I understand that this may be possible with the latest version.

Aeromagnetics

There have been three aeromagnetic surveys:

- (a) one flown in conjunction with the Turair Survey (line spacing of 150m and clearance of 45m);
- (b) one flown in conjunction with the Input Survey (line spacing of 400m and clearance of 150m);
- (c) one flown specifically by Geoex (line spacing of 250m and clearance of less than 200m).

All three surveys show a strong magnetic response to the serpentinites on the west side of the grid and they also show a magnetic anomaly(s) near the crest of Colebrook Hill, north of the trig station.

On the Geoex map this anomaly is roughly circular in shape, has an amplitude of approximately 550 $\gamma$  and, from the contours, the body might be interpreted as a sphere. A reasonable fit was obtained for a sphere at a depth (to centre) of 200m below flight level, a radius of the order of 100m, and with a possible susceptibility contrast of between .001 and .01. Flight height over Colebrook Hill was approximately 60m, therefore the depth to the centre of the sphere is say, 100-140m below ground level. The centre of the sphere is located beneath 375,000E at 5,371,580N. (The interpretation ignored any remanent magnetisation but did take into account the variable altitude of the magnetometer).

The Scintrex aeromagnetic map shows two linear features in place of the one Geox anomaly. These two magnetic highs with amplitudes of 300 and 400 $\delta$  trend roughly SE-NW i.e. approximately parallel to the crest of Colebrook Hill. The Scintrex aeromagnetics have not been plotted at 1:10,000 scale and there is some difficulty in accurately locating these anomalies on the grid. However, the south westerly anomaly (300 $\delta$ ) appears to coincide with the 'Geox anomaly' and the other anomaly of 400 $\delta$  is some 300m to the north east. A profile drawn from a 'blow-up' of the contour plan from its original 1:15,840 scale to approximately 1:10,000, shows two close anomalies to the east of the serpentinites. The shape of neither anomaly suggests a simple causative body, however, the accuracy of picking the contours was low. Suffice it to say that two linear NW trending bodies are suggested, one approximately in the location of the interpreted sphere, the other some 300m to the north east. The Turair anomaly appears to be associated with the more northerly anomaly.

The aeromagnetic survey conducted with the Input Survey shows a broad magnetic high in a similar position to the 'Geox anomaly'. Since the survey was conducted at a greater height and coarser line spacing than the other two surveys, there is considerably less detail shown on the Input aeromagnetic map.

#### Induced Polarisation

#### Dipole-Dipole Array

Geotrex attempted a 40m dipole-dipole survey along 4 grid lines. On 5,371,600N (over the old workings) no readings could be obtained. On lines 5,371,800N, 5,371,900N and 5,372,000N, the lateral coverage was from 374,610E to 375,460E, 374,740E - 375,300E and 374,740E - 375,340E respectively. While attempts were made to reach depths

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of  $n=6$ , this was only achieved for three points on 371,800N. On 5,371,900N one reading was obtained at  $n=4$  and on 5,372,000N one reading at  $n=5$ . The lack of readings was ascribed to the very low resistivity of the area at depth. (The near surface readings recorded resistivities of the order of 1,000~m).

There are three locations on line 5,371,800N where the 'no-readings' came as high as  $n=2$  or 3 and one each on lines 5,371,900N and 5,372,000N; these might be interpreted as areas where the conductors are closer to the surface and thus potential drill targets. However, a survey by Scintrex on part of the same line, also with 40m dipoles, but with electrodes displaced by 20m, whilst showing the same general behaviour, has significant particular differences. These differences are interpreted as being due to the geometry of the electrode and to a very near surface conductor. That is, significantly different results will be obtained if an electrode is placed on an outcropping conductor than if it is placed to one side of the conductor.

Nevertheless, on line 5,381,800N the near surface anomalies are at 347,490E; 375,100E and 375,350E and a deeper conductor is at 374,720E. On line 5,371,900N the no-reading zone comes closest to the surface at 374,940E and on line 5,372,000N at 375,180E with a deeper zone at 374,800E.

The contouring of the pseudo-sections strongly suggests near horizontal layering with high near surface resistivities rapidly decreasing with depth.

#### Gradient Array

Following the confirmation of the Geotrex dipole-dipole I.P. results Scintrex undertook a gradient array survey over the area. It was hoped that a central zone of no-readings might be defined, thus better

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defining the causative body(s). The survey started on the western side of the grid and lines 5,371,200N, 5,371,400N, 5,371,600N, 5,371,700N, 5,371,800N, 5,371,900N, 5,372,000N, 5,372,200N, 5,372,400N and 5,372,600N were attempted. On nearly all lines readings were unobtainable east of a line drawn about 100m east of the eastern contact between the serpentinites and the Crimson Creek Sediments.

The exceptions were sections of lines 5,371,900N and 5,372,600N where very low resistivities were recorded and chargeability readings were unobtainable. On the electrode line, line 5,371,800N, no readings at all were possible.

#### Ground Magnetics

The ground magnetic data over the grid was collected in two parts: lines 5,371,800N, 5,371,900N, 5,372,000N, 5,372,200N, 5,372,400N and 5,372,600N were surveyed by Scintrex with a 20m station interval; lines 5,371,200N, 5,371,400N, 5,371,600N and 5,371,700N were surveyed by E.Z. with a 10m spacing.

On both surveys considerable variation was recorded at some stations, however, for the Scintrex survey this occurred at a total of only seven places and the readings usually varied by hundreds rather than thousands of gammas.

On the E.Z. survey, variations of up to several thousands of gammas were recorded and on some lines they accounted for the majority of the survey. In addition, the magnetometer used for the E.Z. survey had a 'weak signal' indicator and this 'weak signal' occurred more often than not.

It is unlikely that the difference between the two surveys is geological and because of the large number of readings showing no repeatability and large variations, the E.Z. survey must be discounted

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however, the fact that the Scintrex survey also recorded variations at some stations suggests (since the diurnal drift areas show no evidence of magnetic storms) the presence of localised high magnetic gradients.

The data from the Scintrex survey is also noisy ( rapid variations along the profile ) and the data is under sampled if the near-surface features are to be defined. An eleven point smoothing filter was run through the line 5,371,800N data and the resultant profile clearly shows a deep-seated source.

#### Ground Electromagnetics

A McPhar VHEM was used for the ground electromagnetic survey. This unit may be used either as a simple dip angle system or as a horizontal loop ('Slingram') system. It transmits at 600 and 2400hz. The horizontal loop system was first tried over lines 5,371,200N, 5,371,400N, 5,372,400N and 5,372,600N. This system requires a reference cable between the two (maximum coupled) coils and the in-phase and out-of-phase components of the received field are read as a percentage of the transmitted field.

It is apparent from the profiles that the out-of-phase component was not working and some very large anomalies (greater than 90%) were recorded on the in-phase component. This method is unsuitable in steep terrain, since it responds to topographical changes and variations in the distance between the loops (30m for this survey with a station interval of 20m).

The dip angle method was then evaluated on line 5,371,600N using high and low frequencies at coil separations of 20, 40 and 60m;

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following this test the whole grid was surveyed using the low frequency (600hz) at a coil separation of 40m. The results are very 'noisy' i.e. rapid variations of dip angles along the profile, also very large amplitudes were recorded. As with the magnetics, the data is under sampled - many anomalies are defined by one reading only. The width of the nulls were also recorded and these show that generally sharp nulls were obtained. 600 metres of line 5,372,000N were repeated (due to low batteries) and there is certainly some correlation (lack of correlation may of course be due to the state of the batteries). It is also fairly easy to draw trends across stacked profiles, however, little if any validity is attributed to this owing to the under-sampled nature of the anomalies. Thus it is not conclusive whether the ground em has 'worked', if it has, it has defined numerous shallow conductors (or magnetic bodies). Whilst they are well defined in terms of the anomaly amplitude, they are inadequately defined by station interval.

#### Geochemistry

There is some correlation between the results of the copper, tin, arsenic and to some extent lead assays and the geophysics, in so far as anomalous geochemical results are obtained in the general region of the old workings which are 'close' to the aeromagnetic and Input anomalies. There is also an interpreted electromagnetic trend close to a tin high on line 5,371,700N at 374,725E.

#### Conclusions

The geophysical programme has been approached in the classical manner; airborne geophysical techniques (magnetics and electromagnetics) have

produced well defined and interesting anomalies. Attempts have been made to locate these anomalies on the ground using ground versions of these methods as well as electrical techniques.

A detailed evaluation of all these ground methods suggests that so far this has not been achieved. The electrical methods showed that the ground is highly conductive, but gave no well-defined target. The electromagnetic method also gave a large number of (continuous?) strong anomalies, which if true, show only a series of shallow conductors. The ground magnetics also show a series of shallow anomalies and indeed there may be some correlation between these two methods (not obvious to this writer), since em anomalies may be due to areas of high magnetic susceptibility rather than high conductivity. After smoothing, the magnetics does show a deep seated body, but much of the magnetics is invalid since, in places, the average values of variations of up to thousands of gammas have been plotted.

The results of the geophysics and known geology pose the following problems and suggest the following hypothesis. The aeromagnetic surveys showed a magnetic anomaly within the Crimson Creek sediments. A well-defined Input anomaly coincided with this anomaly. The ground em and magnetic surveys, if and where valid, showed a series of thin near-surface mineralised zones. Both the em and magnetic methods may have responded to body(s) of high magnetic permeability. (For example a sill associated with the serpentinites). Only the I.P. results require a conductive body. The similar results of the two I.P. contractors and the same behaviour of different arrays suggest that the results must be accepted, i.e. the presence of a large conductor - either massive or in interconnected stockwork form.

The Crimson Creek sediments have a near-vertical dip and are relatively undeformed, except locally where it is often in association with

mineralisation. They strike approximately north south, i.e. perpendicular to the grid lines. The sediments make a contact of unknown dip with serpentinites on the western side of the grid. The aeromagnetics confirmed the north-south strike of the serpentinites and revealed a magnetic anomaly within the sediments.

The airborne electromagnetics (Input) revealed a long north south trending conductive zone of which the Colebrook Grid is part. To the north, this Input anomaly coincided with a strong magnetic trend, however, over Colebrook, the anomalies occurred within the Crimson Creek sediments. The dipole-dipole induced polarisation surveys showed, at least on the three lines surveyed, that the Input anomaly was not due to superficially conducting rocks, since quite high surface resistivities (of the order of  $1000 \Omega\text{-m}$ ) were recorded. This I.P. survey 'requires' a conductor of sufficient volume to be effectively a short circuit. Whilst a few percent of graphite mineralisation may be sufficient to make a rock quite conductive, mineralogical examination has found no evidence of graphite in surface samples. The pseudo-sections also suggested a horizontal layering. Possibly mineralisation parallel or sub-parallel to the grid lines might cause such behaviour; it would, however, presumably have to be continuous over the length of the grid line. There is no such evidence of cross mineralisation from the surface mapping.

The ground magnetics results and possibly the ground electromagnetic results show evidence for (thin?) zones of near surface mineralisation. The magnetics (after smoothing) also show evidence of a deep seated magnetic body. The I.P. results suggest the presence of a large sub-surface conductive body. It is desired to accurately define and locate this sub-surface magnetic and conductive body.

The variations in position and shape of the aeromagnetic anomalies from the various surveys show that this is not achieved by the airborne

magnetic surveys. Similarly the Input anomaly does not give sufficient information on which to base a drill hole; the flight lines are at least 500m apart and the positioning can only be verified by ground follow-up.

Recommendations

Since the electromagnetic method 'worked' in the air, it is reasonable to expect a ground-based response and similarly for the magnetics. A common problem is that 'geologic noise' may obscure the desired response. Local surficial mineralisation is included in the term 'geologic noise'; however, accurate mapping of any such mineralisation is also desirable.

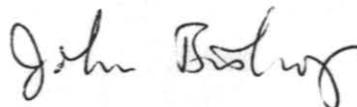
The ground electromagnetic method that has been tried has not located any deep seated anomaly and it is questionable as to whether the responses recorded are due to local mineralisation. To better define the local mineralisation, I suggest that the VLF (very low frequency) method be tested. This method uses a small hand held instrument that receives EM waves from the United States submarine communication network (e.g. North West Cape, Australia). Geophysically speaking the frequency is very high thus good resolution may be expected, but not penetration. The survey would be quick, cheap and require one person to operate it. To obtain a deeper-seated response I suggest a PEM survey (Crone's pulse EM equipment). This method uses a transmitted pulse or transient wave form rather than a single (or multi) frequency sinusoidal wave form. A pulse, depending on its shape, effectively contains many frequencies and thus, since penetration is dependent upon frequency, information may be obtained from a range of depths. The Crone PEM instrument unlike other transient systems was designed with a transmitter loop of only 10m. It has since been found that for very deep penetration (100m plus) a large loop is required, however, this should not be necessary at Colebrook Hill.

Again a test survey over one line is recommended using say, an 80m separation with a 20m station interval. At least two and preferably three people would be required. (This system will undoubtedly still respond to local mineralisation if the receiver is placed over same - a further advantage of the large loop systems (e.g. 100m x 100m) is their averaging capabilities).

The ground magnetics survey has shown that the aeromagnetic anomaly may be located and better defined. If the variations in the readings of the southern half of the area cannot be overcome, a taller pole (say 4-5m) could be tried. It is recommended that the magnetics programme be reassessed following the re-checking of lines 5,371,400N or 5,371,600N.

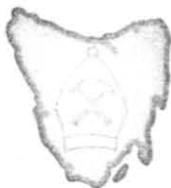
A method that works well in Tasmania but that is often neglected because of its failure on the mainland, is the Self Potential (SP) method. Like I.P. this method responds to black shales as well as sulphides and anomalies are often associated with topography. Nevertheless the method would be likely to show a significant response to a large conductive body beneath Colebrook. The results are usually readily contourable and often closely define the limits of the conductor.

Finally it may be worth noting that the gravity method apart from locating a massive sulphide body may also be used to calculate the excess mass, and if the densities are known, the total mass due to the anomaly. Thus gravity surveys may be used for ore reserve estimation as well as exploration.



Dr. J. Bishop  
22nd August, 1980

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## Addendum to: APPRAISAL OF COLEBROOK HILL GEOPHYSICS

A letter was received from Howland-Rose of Scintrex (21st August, 1980) suggesting that an MMR survey be conducted over Colebrook Hill. The letter also suggested that a VLF survey should not be carried out 'to assist in resolving information at depth'.

The VLF survey is not expected to resolve anything at depth, but rather to resolve conductors at and/or near the surface. For example the proposed VLF test survey would take in the isolated tin anomaly on the west side of Colebrook Hill.

I recommend (at the moment) that the MMR survey be not carried out prior to drilling, if for no other reason than the budgeting restraints. The recommendation is qualified since I believe that a well-defined geophysical target is very desirable (essential?) before drilling and if this is not forthcoming from the surveys I have already proposed, then a MMR would be included in any re-evaluation.

*J R Bishop*

19th September, 1980