THE APPLICATION OF GEOPHYSICS IN WESTERN TASMANIA'S VOLCANIC TERRANES

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INTRODUCTION

This memorandum gives a summary of the various geophysical techniques applicable for exploration programmes in the volcanic rocks of western Tasmania. Historically, the most attractive target is a volcanogenic massive sulphide (VMS) deposit such as Rosebery or Hellyer lying within the Mt Read Volcanics (MRV). However a number of companies have placed some effort, as yet unrewarded, into exploring the more mafic volcanic sequences which lie to the west of the MRV. More recently, attention has turned to volcanic-hosted gold and at least one deposit of this type is expected to be developed in the near future.

Before recommending specific geophysical techniques for each type of target, their physical properties are briefly discussed, and the capabilities, costs and recent developments for the relevant geophysical methods are also given.

PHYSICAL PROPERTIES

The 'typical' VMS deposit is conductive, chargeable and dense, but not magnetic. The most important of these properties for location of a deeply buried body is probably conductivity. Although there has in the past been some debate about whether or not these deposits were sufficiently conductive to give rise to EM responses, test surveys and petrophysical measurements have shown that all of the economic deposits (and a number of sub-economic ones) are 'good' conductors. However there appears to be a class of zinc-rich occurrences, eg Elliott Bay and possibly Chester-Pinnacles, which are much less conductive (and less chargeable). Exploration in the vicinity of these deposits has included EM techniques in the expectation(?) that an economic-sized deposit would include a conductive mineral assemblage.

Volcanic-hosted gold deposits may be structurally controlled and may be expected to occur with disseminated sulphides which will give rise to an IP response: a resistivity anomaly may not occur. (Large areas of the MRV were covered by IP in the 1970s, looking for VMS deposits. Much of this data could be usefully re-examined for anomalies over auriferous pyrite deposits.) Other styles of gold deposits may include magnetic 'ironstones' and intrusive related mineralisation which may also have a magnetic signature.

AIRBORNE TECHNIQUES

All of western Tasmania has been covered by aeromagnetic surveys. The three or four separate surveys have similar specifications with a line spacing of 500m and a nominal terrain clearance of

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130m. Effective use of this, and the regional gravity data, can be made prior to on-the-ground investigations. Image processing often greatly assists structural interpretation and in some areas, lithological mapping. As a direct aid to ore search, haloes of alteration may be recognised as magnetically 'flat' regions in VMS exploration, and magnetic highs may be identified as targets in a gold exploration program. Radiometric data was obtained with some of the above surveys but little use has been made of the data. (This is generally true of radiometrics in Tasmania, but it is possible that modern equipment with large volume detectors could effectively penetrate the vegetation cover and aid mapping and alteration recognition. Most airborne survey systems are permanently fitted with radiometric equipment and the data can be gained at little extra cost. Some systems are also capable of recording VLF signals which may be useful for structure.)

None of the regional surveys described above are of exceptional accuracy or sensitivity and more detailed surveys may be required. All up costs (data aquisition and processing, but not mobilisation) are $15 to $20 per line-km for a fixed wing survey and about double that for a helicopter survey.

Airborne EM has been used in several areas as a first-pass method for relatively shallow (less than 50m) mineralisation. Instrumentation and interpretation have been substantially improved since the early 1970s when the (outcropping) Que River deposit was discovered using this method, but penetration is not comparable to some of the ground methods; perhaps a maximum of 100m in very resistive ground for a large target with suitable geometry (eg, not the elongated cone shape of Hellyer). The rugged topography of most of western Tasmania requires a helicopter for effective coverage. At present there is no such system resident in Australia, but companies such as Dighem (now represented in Australia by Geoterrex) will bring their equipment here. Dighem also routinely provides magnetic data (with a much improved quality ~~of~~ their earlier surveys) and can record VLF. ~~Dighem mk 3 also uses~~ a high frequency signal which is used to produce an improved resistivity contour plan; possibly useful for mapping alteration. Costs are of the order of $125 per line-km plus mobilisation at $10,000+ (if sole client). (The latest fixed wing system, Geotem, costs around $75 per line-km plus mobilisation. This is a time domain system which can be expected to have better penetration than the frequency domain (FEM) Dighem system.)

GROUND TECHNIQUES

Magnetics and Gravity

Magnetics is commonly used for structural definition and mapping within the volcanics. Noise envelopes of the latest instruments are still likely to be in excess of 5nt, despite the improved sensitivity and diurnal reduction procedures. Hire of two memory magnetometers* plus a computer is around $200 per day (without operator).

Gravity surveys have been used to locate suspected less conductive sulphides as well as to aid mapping and structure on a more regional scale. Because of levelling costs and the usually large terrain corrections required, this technique has not been widely used in western Tasmania. Also, its application for deeply buried mineralisation is minimal. For example, Aberfoyle geophysicists have commented that the expected response of 0.3 to 0.4mgal over Hellyer would be within the noise envelope. (However a very carefully executed survey by the Mines Dept has outlined this deposit.) Hire costs are between $100 and $200 per day. A new development by Scintrex, the CG-3 gravity meter, reads and records measurements automatically and has digital output with the same (claimed) sensitivity as established instruments. However the same corrections and associated costs (eg, levelling) will still apply.

Induced Polarization

IP was a popular method in western Tasmania in the 1970's for several styles of mineralisation including VMS deposits, however its use is now largely restricted to disseminated sulphide deposits and occasionally where non-conductive (zinc-rich) massive sulphides are suspected#. Recent work by Bishop and Lewis for the Mines Dept has investigated whether spectral IP techniques can be used to differentiate between black shales, barren pyrite and economic sulphides with some success. This method has also been applied to gold deposits with considerable encouragement. Scintrex now also routinely produce spectral parameters and use them for quality control and to help discriminate gold-bearing sulphides. A three man crew for IP will cost around $900 per day plus accomodation and mobilisation.

The MIP method has recently been released from copyright. This method was originally promoted as being designed to detect chargeable bodies beneath conductive cover; eg, the salt lakes of W.A.. Thus it has had limited application in Tasmania where surface conditions are usually resistive. One other possible merit of the method is the fact that it energises the ground along strike. This may be appropriate for detecting weak conductors of long strike length such as occur at Mt Lyell. However a

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* In easily accessible areas requiring high accuracy data, the Uni. of New England's TM-3 should be considered. This caesium vapour magnetometer provides near continuous read-out with high sensitivity and is linked to an odometer for automatic positioning (walking or vehicle). Data processing and plotting is done on location.

Sphalerite is also non-chargeable, however an IP response may be obtained from any associated sulphides.

trial profile at Mt Lyell showed no advantage over conventional IP. Because of the copyright on the method there has been no objective assessment of MIP. It is hoped that an AMIRA reseach project or similar, will soon investigate the technique.

AMIRA have developed, and contract out, a sophisticated down hole IP logging truck, which is capable of running several different array types and spacings. Results are plotted on location and the system has proved useful for gold exploration.

Electromagnetics

FEM / TEM desirable?

Fixed loop TEM techniques have become the most commonly used technique for exploring for VMS deposits following the success with UTEM at locating Hellyer. TEM undoubtedly has better resolution and penetration than IP and is superior, in nearly all cases, to FEM*. However it is not the universal panacea for exploration; a number of barren holes have resulted from TEM surveys. The targeted anomalies have often been caused by current channeling in weakly conductive faults or contacts and illustrate why IP was 'invented' some 30 years ago. Experience has shown that follow-up surveys using a moving 'horizontal loop' geometry are required over 'suspect' anomalies.

An exciting development of TEM is its down-hole application (DHEM). The placing of a receiver down-hole into (usually) resistive rock closer to the source usually produces much better data than is available from the surface. Detection distances of up to 200m from the hole can be recognised if the hole is long enough. There are a number of developments in DHEM which will further improve this method. These include three component receivers and down hole magnetometric resistivity (DHMMR); both developments giving better directional information. The potential of this method is such that all holes drilled for massive sulphides should be routinely cased with plastic piping.

Costs for fixed-loop TEM surveys are between $1000 and $1200 per day with DHEM surveys somewhat cheaper.

Controlled Source Audio Magnetotellurics

This is a new method still undergoing rapid development. It has been claimed that the method is capable of greater penetration than fixed loop TEM, but this has not yet been proved to my satisfaction. However, on the two occasions I have used it in Tasmania, the CSAMT results were far superior to the TEM. In one

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* One case where a deep-seeking FEM method such as Turam would be expected to be superior to a TEM system is in the vicinity of large amounts of electrical noise. However a recent trial Turam survey over Hellyer was unsuccessful: the noise level from the overhead power line swamped any signal.

case the mineralisation was fairly resistive and in the other, highly conductive. The depths involved were no more than 200m. So far only 'scalar' data has been gathered (one electric dipole, parallel to the transmitter and one magnetic coil, measuring the vertical component). Much more information can be obtained from vector measurements (using two orthogonal dipoles and three component magnetometers and preferably two different transmitting positions), but at a (usually) prohibitive cost. Apart from expected improvements in interpretation, it is possible that improved instrumentation will negate the need for a controlled source (ie, the earth's natural fields will be used), which will permit much better interpretation (more valid assumptions) and more flexibility in the field.

CSAMT has a slow production rate; generally no more than 20 stations per day in areas of easy access and perhaps half that in difficult areas. Costs are $850 per day for a two man crew (at least one more person would be required to achieve the above quoted production rates) plus a charge of $20 per station for processing.

EXPLORATION STRATEGIES

(a) VMS in Mt Read Volcanics.

* For new ground, use existing magnetic and gravity coverage with published geology maps to help identify areas of interest.

* Increasingly, these areas are likely to lie beneath Tertiary basalt, Ordovician or younger sediments or glacial cover. Regions with a thin enough cover for exploration can be identified with TEM soundings, CSAMT or magnetics if the cover or target is magnetic (eg, basalt).

* If the area has received little previous attention and is 'difficult' (eg, poor access or rugged topography) and/or is environmentally sensitive, an airborne EM survey should be considered for a 'first-pass' program. Ground verification of any anomalies would be done using a rapid reconnaissance FEM system such as Genie or Maxmin.

* In areas of poor outcrop, relatively large areas can be 'mapped' with gradient array IP. This does not give any great penetration, but more chargeable host horizons may be identified.

* If the area has been previously (well) explored and mapping and sampling have defined certain regions as potential host horizons, then fixed-loop TEM surveys will provide the most effective coverage for 100m+ penetration. Poor anomalies which should be checked

before drilling can be verified with gravity if shallow, or moving loop TEM if shallow or deep.

* In well defined areas with good potential (ie, the 'right' rocks, perhaps some zones of anomalous geochem, and drill hole intercepts of minor mineralisation), but no TEM or other anomalies to target on; a series of widely spaced, deep stratigraphic holes is recommended, with DHEM follow-up. Each surveyed hole could be considered as having explored a (bent) cylinder of diameter ~400m, extending for some distance below the hole. Given an economic deposit is expected to have a strike length of at least 500m, holes could be drilled at 1km centres.

* CSAMT may also be used to cover a well-defined area where deeply buried mineralisation is suspected.

(b) Cu/Zn in mafic volcanics.

* Economic grades of copper should be sufficiently conductive to allow a similar strategy to that outlined above.

* In this more magnetic environment, detailed aeromagnetic coverage would be useful in poorly mapped areas.

(c) Volcanic-hosted gold.

* Mapping with a detailed aeromagnetic/radiometric survey will help to identify structure, lithologies and areas of probable alteration.

* It cannot be assumed that sampling of streams and rock chipping is necessarily a sufficient program of exploration. Given a prospective lithology, dipole-dipole IP should be carried out to locate disseminated sulphides (if the model predicts such an association).

* Prior to the IP, magnetic and VLF surveys should be carried out to locate structure (and possible areas of magnetic 'ironstones').

* If auriferous sulphides are located, spectral IP analysis may help to discriminate these from barren sulphides. Thus data from all IP surveys should be collected using (in the time domain) full waveform recording equipment such as the Huntec mk 4.

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