Broadband MT and IP electrical property mapping with MIMDAS

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Summary

Induced polarisation (IP) and broadband magnetotelluric (MT) data were collected using Mount Isa Mine's distributed acquisition system (MIMDAS) to detect additional gold reserves around the MT Wright resource near Ravenswood in north-east Queensland, Australia. Additional targets were identified and VLF-MT telluric ratio profiling was assessed as a cost-effective method of collecting near-surface geoelectric information that can be used to identify shallow features that give rise to statics in MT data.

Introduction

Mt. Wright is located near the gold mining town of Ravenswood, 140 km south of Townsville in Queensland, Australia (Figure 1). Extensive drilling has revealed an estimated resource of one million ounces of Au within a granite-hosted rhyolite breccia pipe, coincident with the topographic high (Switzer, 1998). The mineralised zone stretches from 80 m below the hilltop to over 650 m, with the higher grade commencing at 160 m.

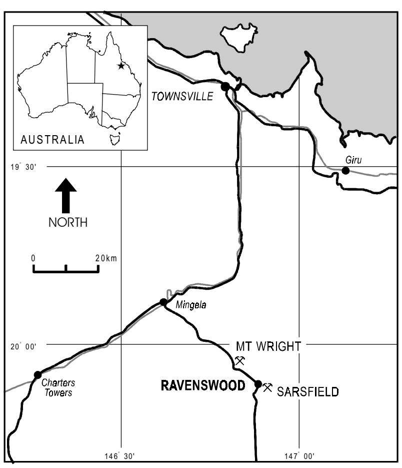

Figure 1: The location of Mt Wright, near Ravenswood in Queensland, Australia.

A MIMDAS IP and MT survey was undertaken on a grid consisting of seven parallel east-west lines (500 m spacing) varying in length from 2.8 km to 8.55 km, in order to test the response from the existing Mt. Wright resource and to delineate possible analogues. One line from the grid, 7784150N, is discussed in this abstract.

Instrumentation

MIMDAS is a broad-band, high-resolution, distributed (multi-channel) acquisition system. MIMDAS was designed to acquire networked multi-channel electrical and electromagnetic (EM) geophysical data, though it could be used to acquire seismic data. Each channel or data acquisition unit (DAU) is networked in series with a computer-interfaced central recording unit (CRU) and is capable of capturing 250 000 samples (stored in 32 bit words) or 1 Mb of data at many hardware specific but software selectable sample rates. MIMDAS has four gain settings (peak voltages 250mV to 32V) and is capable of 24 bit resolution at sample rates up to 4000 samples per second (sps) and 19 bit resolution from above 4 ksps to 48 ksps.

Method

MIMDAS MT is conducted in a manner similar to the continuous MT profiling method described by Morrison and Nichols (1997). The magnetic field is often measured at only one station on a network spread, as it is assumed relatively constant compared with the highly variable horizontal electric field. Figure 2 is a schematic of a 1.8 km segment of the first 3.3 km MIMDAS MT network spread (or layout). Here the vehicle-mounted CRU and computer are located between 482600E and 482700E. Most of the DAUs, which are identified by a unique serial number, are coincident with an electrode and measure the potential of a 100m in-line (E_x) dipole. DAUs also measure from an E_y dipole and magnetometers H_y and H_x, located at 481700E. Figure 2 depicts a segment of line 7784150N, a 4.8 km survey line that was read in two overlapping layouts each containing two sets of orthogonal, horizontal magnetometers and a coincident E_y dipole. A set of higher frequency magnetometers, located at 483000E for both layouts, was used with a view to analysing information in 48 ksps records. To investigate the electric field information at frequencies beyond the magnetometers upper band-limit, surface impedance (VLF-MT telluric ratio profile) transfer functions were calculated by using the signal from discrete spherics (Garner, 1998; Garner & Thiel, 2000). For this technique all inline (E_x) dipoles are measured and referenced (normalised) to an E_x dipole at the end of the line.

Pole-dipole IP data were collected on each of the network layouts. Accurately monitored current was injected at the midpoint of each of the inline dipoles, while measuring on all inline dipoles on both sides of the current injection site. This resulted in pole-dipole and dipole-pole resistivity and the chargeability (figure 3) pseudosections.

Results

The 2D inverted resistivity and IP models (McInnes, 1999) corresponding to the pseudosections of figure 3 are shown in figure 4. Figure 5 shows the resistivity model resulting from a 2D inversion (deGrood-Hedlin and Constable, 1990) of the MT data. A large conductive feature bounded by faults delineated at 481200E and 483000E appears below 750m in the MT inverted section. Vertical extensions from this flat lying structure (1300E – 1600E, 2300E - 2500E and 2800E - 3200E) correspond more closely to conductivity highs in the generally conductive flat lying structure in the inverted IP resistivity model. These appear coincident to zones of elevated chargeability. Both techniques clearly show the Mt. Wright resource that is marked by the outcropping rhyolitic pipe at the topographic high of 460m centered at 482450E. The remaining coincident zones of elevated chargeability and conductivity represent possible analogues that are currently untested by drilling.

Figure 6 shows VLF-MT telluric ratio amplitude and phase pseudosections for a single dipole reference (E_{ref2}) located at the western extreme (480000E -4800100) of layout 1. The green reference stripes at 50E in phase and amplitude, equating to 0^{o} and one respectively, correspond to the telluric ratio of the reference dipole with itself. Note that amplitude is a dimensionless parameter derived from the ratio of two electric field dipoles. Values greater than 1 simply indicate resistivities higher than the reference dipole, while values less than 1 indicate the dipole is on more conductive earth than the reference dipole. These phase and amplitude pseudosections both delineate Mt. Wright centered at around 2500E. This is manifested in the amplitude as a narrow conductive feature gradually broadening with increasing depth (decreasing frequency) to a maximum width at approximately 100Hz (the minimum frequency). There are shallower conductivity and phase anomalies between 500-700E, and centred on 1200E, 1600E and 2000E. These anomalies are also defined as very low resistivity zones in the IP resistivity model (figure 4) and MT resistivity model (figure 5).

Conclusions

The 2D inversions of the MT and IP data sets of line 7784150N have delineated known geological features including Mt. Wright 2300E-2500E and the fault at 3300E. Previously untested targets have been identified either side of Mt. Wright at 1300E – 1600E, 1900E – 2000E and 2800E - 3200E. There is a discrepancy in the MT and IP models with the estimated depth to the flat lying conductive feature. This may result from smearing of more discrete anomalies in the IP inversion. While the unconstrained MT inversion should benefit from some refining, including the addition of topography, it may be necessary to attempt 3D inversion of both data sets to resolve the issue.

Collecting high frequency natural signals for VLF-MT, during a regular MT survey, is cost effective and can be used to define the near surface electrical structure that can contain features can give rise to statics in MT.

References

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IP and MT with MIMDAS

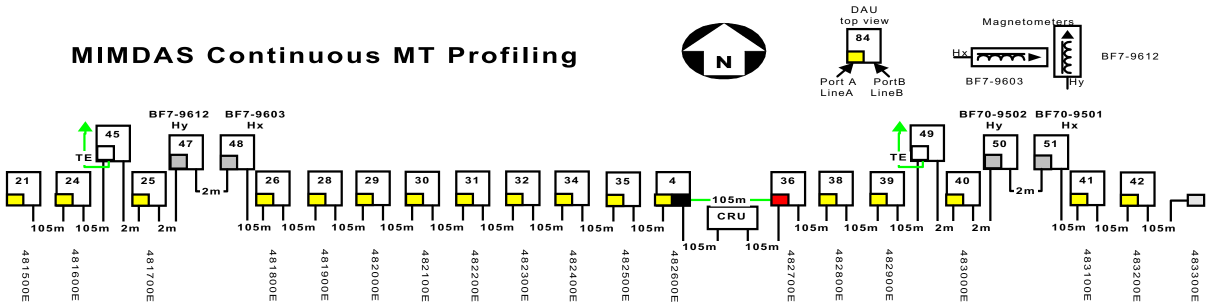

Figure 2: Schematic for 1800m of MT layout 1 for Line 7784150N (a=100m).

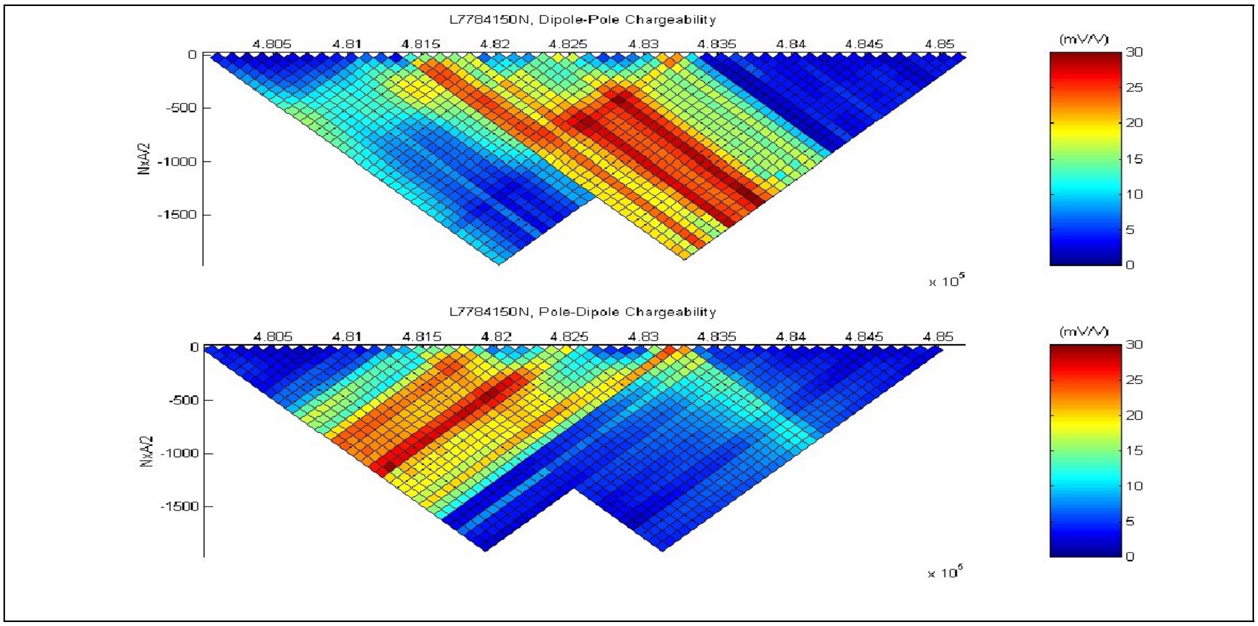

Figure 3: MIMDAS IP chargeability pseudosections f or Line 7784150N (a=100; fx=25/256Hz; t0=0.5s)

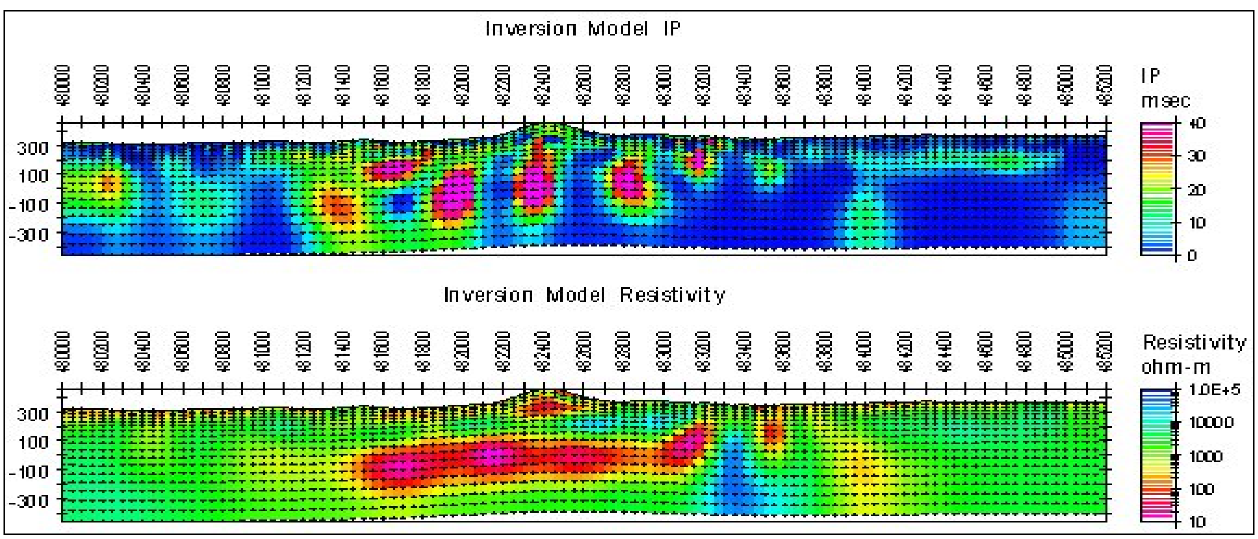

Figure 4: 2D inversion model of MIMDAS IP data for line 7784150N

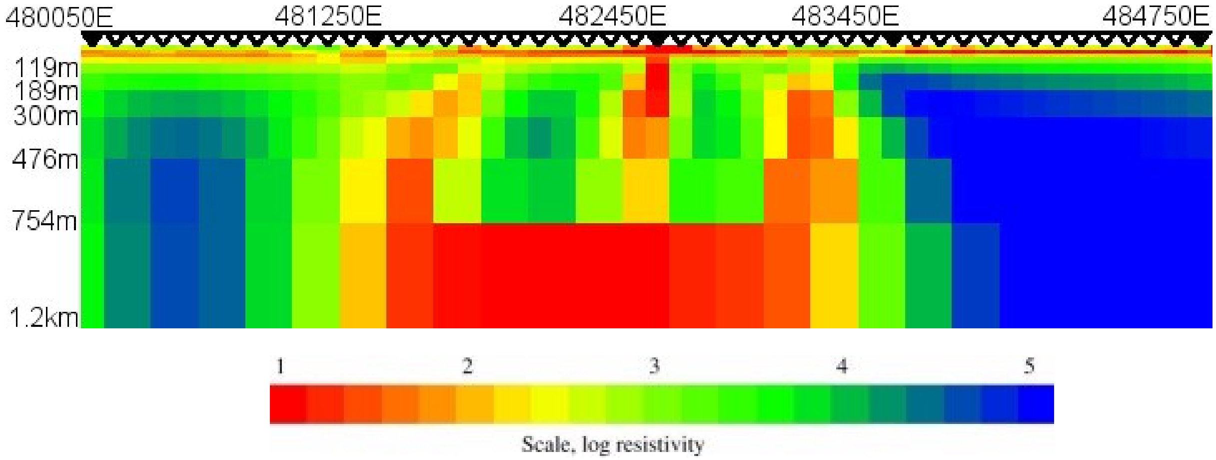

Figure 5: Inverted model section from MIMDAS MT on line 7784150N. The filled black triangles indicate the location of the site labels.

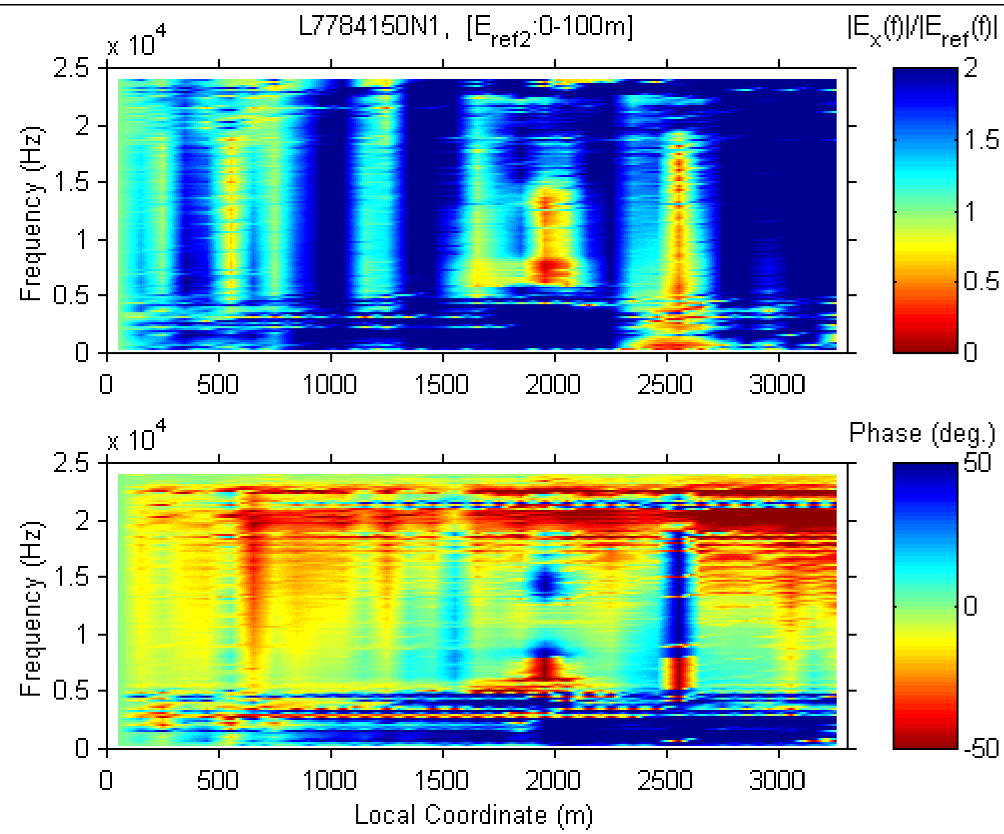

Figure 6: MIMDAS VLF-MT telluric ratio of line 7784150N layout 1. The green stripe (all frequencies) at 50E represents the reference dipole being referenced to itself, hence the amplitude is equal to .one and phase to zero for all frequencies.