Interpretation of
Airborne Electromagnetic Data
from Moina, Tasmania
for Jervois Mining N.L.

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DISCLAIMERS

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1. Introduction

Planning for the EM survey began in January 2001. GeoInstruments (later to become part of Fugro Airborne Surveys Pty. Ltd.) were contracted by the Department of Mineral Resources, Tasmania, to acquire airborne electromagnetic data over selected areas of the state. The planned line spacing was 200 metres. Companies holding exploration tenements within these areas were invited to participate by flying infill lines to a spacing of 100 metres in their areas of interest. Jervois Mining N.L. negotiated to fly additional lines within Els 20/92 and 37/97.

Unfortunately, before the lines could be flown, the device containing the various coil pairs (known as the "bird") became detached from the helicopter and was irreparably damaged during its fall to the ground. Delays occurred while a new bird was configured and transported from Canada to Tasmania. After further complications and minor delays the survey recommenced and results delivered in November 2001. However, upon inspection, it soon became apparent that the survey had been flown with incorrect coordinates and was further north by up to 1200 metres. More than 50% of the area requested had not been covered. The contractor accepted liability for the error and a reflight was planned. It was not until late May 2002 that the survey was reflown and the results delivered to Jervois Mining N.L.

The survey was commissioned as part of the exploration programme for skarn style mineral deposits. Molybdenum, tungsten, tin and bismuth have been recovered from mines in the area. Other mines have been worked for gold, silver, lead and copper. The geology is presented on Map 9 - Geology of the Winterbrook-Moina area, 1: 25,000 (Geological Survey of Tasmania, Department of Mines, Hobart, 1989). The mineralisation is spatially related to the Dolcoath Granite and is intruded in to rocks forming the contact aureole. These are predominantly metasediments of the Denison Group and porphyrys with the Mount Read Volcanics. Approximately 50% of the survey area is covered by Tertiary basalts and younger sediments.

2. Survey logistics

The data from three separate surveys have been merged to form the final data set. These consist of:

- data from the original 200 metre lines for the MRD
- the first set of infill lines to the north, (November 2001)
- the second set of infill lines in the correct location (April 2002)

The first survey employed the original bird and coil pairs; the subsequent two surveys employed the replacement bird. The contractor ensured that the calibration processes correctly aligned all three data sets. A full logistics report was provided for the November 2001 infill survey and is a separate document to this report. A summary of the logistics for the second infill survey is included in

Appendix I with this report. There are 146 lines of airborne electromagnetic and magnetic data amounting to a total distance of 391.6 km. The flight line plan is shown in figure 2. As with all the plans, the coordinate datum applied is AGD66TMAMG55. The alternative data bases, GDA94MGA55 and WGS84SUTM55 are included in the digital file.

3. Interpretation

3.1. Magnetics and digital elevation model

The digital elevation model is derived from the GPS position of the helicopter and its distance above the ground; the contoured DEM is shown in figure 1.

The total magnetic intensity contours are shown in figure 3. There are three very high amplitude but localised anomalies that do not appear on the earlier magnetic maps. The current survey has a closer line spacing and a mean terrain clearance of 30 metres so it is likely that localised responses have been detected. They occur at:

419500E 5405450N	possibly metallic objects in or near Ti Tree Creek.
421500E 5405650N	possibly metallic objects in or near the Iris River.
421700E 5406500N	possibly metallic objects located on the small hill south of Lake Gairdner.

All have the appearance of being caused by man-made metallic objects and are not considered to be geologically related. There are two negative magnetic anomalies at 420350E 5406600N and 420700E 5406100N which are also likely to be due to metallic material. However, it is recommended that each of these locations is checked in the field to verify the assumptions made above. This is important because the magnetic anomaly with the highest amplitude other than those listed above is coincident with the skarn associated with the Shepherd and Murphy Mine (423350E 5406450N). Unfortunately not all of the skarns shown on the 1: 25,000 scale geological map have a magnetic signature. Other than Shepherd and Murphy, possible Moina and Stormont Bismuth Mine, the mapped skarns have very little magnetic signature.

The magnetic contour map has been used to define geological boundaries and identify potential faults. In almost all instances the magnetic anomalies have no recognizable geological cause at the surface and appear to be related to underlying extrusive rocks. The Dolcoath Granite is a non magnetic rock.
The interpretation of the magnetic data is shown in figure 9.

3.2. Resistivity from coplanar coil configuration, 34000 Hz

The general rule in electromagnetics is that the higher the frequency, the lower the effective penetration but increased definition; it follows that the lower the frequency, the greater the effective penetration but with less definition. This is the reason that multiple frequency surveys are preferred over a single frequency survey. Coplanar coils are better orientated to respond to steeply dipping variations in conductivity, while the coaxial coils are orientated to respond to horizontal variations. The Hummingbird EM system is designed to cover these various options. Finally, the in-phase and quadrature components of the secondary electromagnetic field are used to derive the conductivity and resistivity variations in the ground for each frequency and coil pair. Conductivity and resistivity are reciprocals of each other, therefore only the resistivity has been compiled and contoured in this report.

The resistivity derived from the coplanar 34000Hz coils is shown in figure 4. Values of less than 1000Ωm tend to outline the distribution of the Tertiary basalt flows. The outcrop of Moina Sandstone (Odm) has a resistivity range of 1000 - 3500Ωm and is also defined. The course of the River Lea and Iris River can also be seen in the data. The very low values of 1 - 10Ωm in the central east are suspected to caused by interference from the power station and electricity transmission lines. The skarns do not have a distinctive response in this data set.

The geological information derived from the coplanar 34000Hz results have been incorporated in the interpretation plan (figure 9).

3.3. Resistivity from coplanar coil configuration, 6000 Hz

The resistivity derived from the coplanar 6000Hz coils is shown in figure 5. There is a reduced influence from the purely surface geology with an increasing response from deeper geology. The skarn at the Shepherd and Murphy Mine is beginning to be identifiable as a resistivity high. The NW-SE faults can also be seen in this area. At Ti Tree Creek much of the skarn is related to higher resistivity values but part may be influenced by creek sediments or the valley itself. The skarns around Fletchers Adit are also related to elevated resistivity and, in this case NE-SW faulting. East of 424000E and south of 540700N where most of the old mines are located, the resistivities are generally higher than elsewhere. North of Narrawa Reward as far as Cethana Road there is another area of higher resistivities with no mineralisation recorded. This could be an area for further exploration.

3.4. Resistivity from coaxial coil configuration, 7000 Hz

The resistivity derived from the coaxial 7000 Hz coils is shown in figure 7. There is the least correlation with geology or mineralisation from this coil configuration and frequency. The most active part of the map is in a zone extending south-west from the power station which looks suspiciously like the effect from a high voltage electricity transmission line. In general the low resistivity areas correlate with the Tertiary basalt and the higher values correlate with the Moina Sandstone and the Dolcoath Granite. The skarn at Shephard and Murphy has a marginally higher resistivity response but it is not particularly distinctive. Nor do the other skarns or old mine sites have a distinctive response.

3.5. Resistivity from coplanar coil configuration, 880 Hz

The resistivity derived from the coplanar 880 Hz coils is shown in figure 6. The high resistivity anomalies along the line 424500E, 5405500N to 426250E, 5407250N are coincident with the high voltage power line and appear to be an artifact produced by electromagnetic interference with this transmission line.

The skarn at Moina (423250E, 5406500N) has a distinct resistivity high which is 500Ωm above background. At the Stormont Bismuth Mine and at Ti Tree Creek the skarns also show a resistivity high of between 400 - 500Ωm. Thes three features are labelled T_1, T_2 and T_3 on the interpretation plan (figure 9). Five similar features not correlated to mineralisation shown on the 1: 25,000 scale plan are located as follows:

Target	Coordinates	Strike	Length	Width
T_4:	420700E 5407400N	N135°E	500 metres	180 metres
T_5:	419950E 5407400N	N060°E	150 metres	100 metres
T_6:	422200E 5406750N	N000°E	250 metres	150 metres
T_7:	420400E 5405250N	N100°E	150 metres	100 metres
T_8:	420900E 5405300N	N030°E	300 metres	100 metres

The skarn at Ti Tree Creek has a complex resistivity response with a strong resistivity low on the southern side, falling to 50Ωm from a background of 300Ωm. There is also a low resistivity zone south of the Moina Skarn. There is no outcrop of skarn here but this may be a response from conductive rocks associated with the skarn beneath the basalt.

Higher conductivity responses are relatively uncommon within the survey area, but there is a broad zone extending from 422000E 540600N to 42400E 540800N, striking N45°E,which contains four distinct areas of increased conductivity. They are recommended for further exploration on the grounds that they could represent sulphide mineralisation with additional economic mineral associations. However it is also possible that the higher conductivity is the product of basalt alteration to clays.

In the south eastern part of the survey, east of 423500E and south of 5407000N, there are a number of resistivity anomalies with limited dimensions, frequently circular with a diameter of less than 100 metres. While they do not relate to the power line, neither do they have any spatial relationship to the numerous old mines in the area. The cause of these small features is not known, but at this stage they are not recommended for further work.

3.6. Resistivity from coaxial coil configuration, 980 Hz

The resistivity derived from the coaxial coils is shown in figure 8. The influence of the power line is quite apparent at this frequency and coil orientation. There is also a strong correlation between low resistivity and river channels and high resistivity with higher ground elevations. The high resistivity skarns outlined with the 880Hz response can be seen here, but with less clarity.
The zone of higher conductivity (422000E 540600N to 42400E 540800N) is clearly defined, suggesting that it is more likely to be the result of clay alteration derived from basalt.

4. Target selection

The targets selected for further exploration have been identified by correlation with the electromagnetic signature of known mineralisation, predominantly skarn related. In the following table, three areas of known mineralisation are included because the geophysical signature extends beyond the area of the mine shown on the geological map. However, further research may show that these areas have been evaluated either by surface drilling or underground development.

Target	Coordinates	Strike	Dimensions	Comments	Priority
T_1	423300E 5406500N	N140^{0}E	300 x 500 m	Moina Mine	Two
T_2	418800E 5405800N	N045^{o}E	300 x 75 m	Stormont Bismuth Mine	Two
T_3	420900E 5406350N	N000^{o}E	250 x 150 m	Ti Tree Creek Mine	Two
T_4	420700E 5407400N	N135^{o}E	500 x 180 m	High resistivity	One
T_5	419950E 5407400N	N060^{o}E	150 x 100 m	High resistivity	One
T_6	422200E 5406750N	N000^{o}E	250 x 150 m	High resistivity	One
T_7	420400E	N100^{o}E	150 x 100 m	High resistivity	One

	5405250N				
T_8	420900E 5405300N	N030ºE	300 x 100 m	High resistivity	One
Tc_9	422200E 5406400N	*****	500 x 500 m	Broad conductivity high	Three
Tc_{10}	422800E 5406700N	*****	400 x 400 m	Broad conductivity high	Three
Tc_{11}	423250E 5407400N	*****	450 x 600 m	Broad conductivity high	Three
Tc_{12}	424000E 5408000N	*****	500 x 700 m	Broad conductivity high	Three
Tc_{13}	423650E 5407150N	N140ºE	400 x 150 m	Lenticular conductivity high	Two
Tc_{14}	423250E 5406100N	N010ºE	200 x 200 m	High conductivity south of Moina Mine	One
Tc_{15}	420850E 5406200N	N135ºE	300 x 200 m	High conductivity south of Ti Tree Creek Mine	One

5. Conclusion

The EM survey has provided information which indicates changes to the outcrop geological map, particularly with respect to the distribution of the basalt. More importantly, a distinctive resistivity response can recognized at Moina (Shepherd and Murphy), Ti Tree Creek and Stormont Bismuth Mine, three major skarns. All are characterised by an increase in resistivity relative to the surrounding host rocks. Moina and Ti Tree Creek also show a conductivity high south of the outcrop which could indicate a sulphide rich component of the skarn. These three signatures have been used to identify other prospective targets, primarily those with a high resistivity response but also noting the local, defined conductive increases. T_4 to T_8 have been given a priority one rating as having the greatest similarity to areas of known mineralisation. Tc_{14} and Tc_{15} have also been given a priority one. Both are conductive zones with a close relationship with the mapped skarn. The broad zones of higher conductivity have been listed, but only with a priority three rating as they are considered to be more likely due to altered basalt.

Ground inspection is the next logical step in the exploration process but there may be very little outcrop at the target sites. The airborne EM survey is well located and it is possible that drill sites could be placed using this data. However it would be preferable to establish the geophysical signature on the ground using a ground based EM system prior to drilling.

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Appendix I.

A summary of the logistics for the final infill survey and data processing

Project:	Heli EM Survey
Client:	Jervois Mining NL and MRT
Client Rep:	Anthony Jannink
Survey By:	GEO Instruments
GEO Number	2113 infill Area A
Survey date:	November 2001, April 2002
Survey Base:	Sheffield
Survey Area:	A1 infill: Lake Barrington Area

1. DATA ACQUISITION

1.1. AIRBORNE SURVEY SPECIFICATIONS

Survey flown:	November 2001
Traverse line spacing:	200 metres / 100 meters infill
Traverse line direction:	000 / 180 degrees
Tie line spacing:	2000 metres / 1000 meters infill approx
Tie line direction:	090 / 270 degrees approx
Survey height:	EM towed Bird at 30m agl
Electromagnetic System	Hummingbird 5 frequency EM system.
Data acquisition:	Geo Instruments Model G2002 system Geotech Hummingbird system
Aircraft:	Squirrel helicopter

1.2. MAGNETOMETER

Type:	Geometrics G822A Caesium vapour
Resolution:	0.001 nT
Recording interval:	0.1 sec (approx. 3.5 metres sampling)
Installation:	Magnetometer sensor mounted in HEM bird.

1.3. NAVIGATION

Flight path navigation:	Real time satellite: Differential GPS system
Navigation equipment:	Fugro OMNISTAR GPS receivers
Flight path record:	WGS84 Easting/ Northing coordinates
Radar altimeter:	Collins Alt50
GPS base station locations:	Fugro OMNISTAR(Real Time DGPS)

1.4. HUMMINGBIRD COIL SPECIFICATIONS:

Bird 1 Before Julian day 67,2002, Flight 93

Channel	:	1	2	3	4	5
Freq (Hz)	: 7000	6600	980	880	34000	
Orientation	: CX	CP	CX	CP	CP	
Coil Separation (m) :		6.26	6.26	6.01	6.01	4.93

Bird 2 After Julian day 67, 2002 , Flight 94

Channel	:	1	2	3	4	5
Freq (Hz)	: 7000	6600	980	880	34000	
Orientation	: CX	CP	CX	CP	CP	
Coil Separation (m) :		6.25	6.25	6.03	6.03	4.79

NOTE: Processed data from Bird 2 has been adjusted to merge with Bird 1 data. Coil Separation from Bird 1 has been used for resistivity calculations.

2. DATA PROCESSING

2.1. MAGNETIC DATA

The magnetic data has been corrected for regional gradient by subtraction of IGRF model 2001.9 and secular variation model 1995-2000. Diurnal variations have been removed. System parallax has been removed. Tieline levelling has been applied. Microlevelling has been applied. The mean diurnal value and the IGRF base value have been added to the data.

2.2. ELECTROMAGNETIC DATA

The electromagnetic data has been filtered to remove the effects of sferics and other noise sources. Data has been corrected for system drift by subtraction of background zero levels determined from high altitude callibration data. System parallax has been removed.Apparent resistivities and depths have been calculated using both the Nomogram and Inversion techniques using the Geosoft HEM module. Inphase and quadrature channels have been levelled to remove residual flight line features in apparent resistivities. Microlevelling has been applied.

2.3. GRIDDING - Electromagnetics- Inphase & quad

Algorithm: Minimum Curvature
Grid mesh size: 20 x 20 metres

Grid filter: None

2.4. GRIDDING - Electromagnetics- Resistivities

Algorithm:	Minimum Curvature
Grid mesh size:	20 x 20 metres
Grid filter:	None

2.5. GRIDDING - Magnetics:

Algorithm:	Minimum Curvature
Grid mesh size:	20 x 20 metres
Grid filter:	None

2.6. GRIDDING - Digital Terrain:

Algorithm:	Minimum Curvature
Grid mesh size:	20 x 20 metres
Grid filter:	3x3 mean

2.7. LINE NUMBERING

Line numbers are in the form 'TLLLAA' where:

T =	Line type (1 = traverse, 7 = tie)
LLL =	Line sequence number
AA =	Line attempt number

eg: 100201 is traverse line 2 attempt 1
704802 is tie line 48 attempt 2

2.8. BIBLIOGRAPHIC REFERENCE

Surveyed by:	GeoInstruments Pty Ltd
Geo Instruments job number:	2113
Processed by:	GeoInstruments Pty Ltd
Grid production by:	GeoInstruments Pty Ltd

3. PROCESSED LOCATED DATA :

Format:	Geosoft GDB
Database Files:	Ax_IL_DB.GDB

3.1. LOCATED DATA FORMAT

Field	Field Name	Description
Column 1	LineNo_TLLLAA	line number (TLLLAA)

Column 2	FlightNo	flight
Column 3	Julian_Day	julian_day (YYYYDDD)
Column 4	Fid_geo	fiducial- Geoinstruments acqusition system
Column 5	Fid_humm	fiducial- HEM acqusition system
Column 6	Time_hh	time (decimal hours)
Column 7	AGD66TMAMG55_East	AGD66 easting (metres, TMAMG Zone 55)
Column 8	AGD66TMAMG55_North	AGD66 northing (metres, TMAMG Zone 55)
Column 9	GDA94MGA55_East	GDA94 easting (metres, MGA Zone 55)
Column 10	GDA94MGA55_North	GDA94 northing (metres, MGA Zone 55)
Column 11	AGD66GEODETIC_LAT	AGD66 longitude (decimal degrees, GEODETIC)
Column 12	AGD66GEODETIC_LONG	AGD66 latitude (decimal degrees, GEODETIC)
Column 13	GDA94GEODETIC_LAT	GDA94 longitude (decimal degrees, GEODETIC)
Column 14	GDA94GEODETIC_LONG	GDA94 latitude (decimal degrees, GEODETIC)
Column 15	Mag_Raw	Raw uncompensated magnetics (nanoTeslas)
Column 16	GPSalt_Raw	Raw GPS height (metres)
Column 17	Radalt_Raw	Raw radar altimeter (metres)
Column 18	Diurnal	Diurnal magnetics (nanoTeslas)
Column 19	IGRF	IGRF magnetics (nanoTeslas)
Column 20	TMI_Corrected	Diurnal & IGRF corrected magnetics(nanoTeslas)
Column 21	TMI_Levelled	Levelled magnetics (nanoTeslas)
Column 22	TMI_Final	Final magnetics microlevelled (nanoTeslas)
Column 23	GPSalt_Final	Final GPS height (metres, AHD)
Column 24	Radalt_Final	Final Radar altimeter (metres)
Column 25	DTM_Final	Final digital terrain model (metres, AHD)
Column 26	cx7Ki_PPM	Raw cx7Ki (ppm)
Column 27	cx7Kq_PPM	Raw cx7Kq (ppm)
Column 28	cp6Ki_PPM	Raw cp6Ki (ppm)
Column 29	cp6Kq_PPM	Raw cp6Kq (ppm)
Column 30	cx980i_PPM	Raw cx980i (ppm)
Column 31	cx980q_PPM	Raw cx980q (ppm)
Column 32	cp880i_PPM	Raw cp880i (ppm)
Column 33	cp880q_PPM	Raw cp880q (ppm)
Column 34	cp34ki_PPM	Raw cp34ki (ppm)
Column 35	cp34kq_PPM	Raw cp34kq (ppm)
Column 36	cx7Ki_F_L	Filtered & Levelled cx7Ki (ppm)
Column 37	cx7Kq_F_L	Filtered & Levelled cx7Kq (ppm)
Column 38	cp6Ki_F_L	Filtered & Levelled cp6Ki (ppm)
Column 39	cp6Kq_F_L	Filtered & Levelled cp6Kq (ppm)
Column 40	cx980i_F_L	Filtered & Levelled cx980i (ppm)
Column 41	cx980q_F_L	Filtered & Levelled cx980q (ppm)
Column 42	cp880i_F_L	Filtered & Levelled cp880i (ppm)
Column 43	cp880q_F_L	Filtered & Levelled cp880q (ppm)
Column 44	cp34ki_F_L	Filtered & Levelled cp34ki (ppm)
Column 45	cp34kq_F_L	Filtered & Levelled cp34kq (ppm)

Column 46	cx7Ki_F_LD	Final Levelled cx7Ki (ppm)
Column 47	cx7Kq_F_LD	Final Levelled cx7Kq (ppm)
Column 48	cp6Ki_F_LD	Final Levelled cp6Ki (ppm)
Column 49	cp6Kq_F_LD	Final Levelled cp6Kq (ppm)
Column 50	cx980i_F_LD	Final Levelled cx980i (ppm)
Column 51	cx980q_F_LD	Final Levelled cx980q (ppm)
Column 52	cp880i_F_LD	Final Levelled cp880i (ppm)
Column 53	cp880q_F_LD	Final Levelled cp880q (ppm)
Column 54	cp34ki_F_LD	Final Levelled cp34ki (ppm)
Column 55	cp34kq_F_LD	Final Levelled cp34kq (ppm)
Column 56	cp34k_AResistINV	Apparent cp34k Resistivity (ohms/m) INVERSION technique.
Column 57	cp6k_AResistINV	Apparent cp6k Resistivity (ohms/m) INVERSION technique.
Column 58	cp880_AResistINV	Apparent cp880 Resistivity (ohms/m) INVERSION technique.
Column 59	cx7K_AResistINV	Apparent cx7K Resistivity (ohms/m) INVERSION technique.
Column 60	cx980_AResistINV	Apparent cx980 Resistivity (ohms/m) INVERSION technique.
Column 61	cp34k_ACondINV	Apparent cp34k Conductivity (uS/m) INVERSION technique.
Column 62	cp6k_ACondINV	Apparent cp6k Conductivity (uS/m) INVERSION technique.
Column 63	cp880_ACondINV	Apparent cp880 Conductivity (uS/m) INVERSION technique.
Column 64	cx7k_ACondINV	Apparent cx7K Conductivity (uS/m) INVERSION technique.
Column 65	cx980_ACondINV	Apparent cx980 Conductivity (uS/m) INVERSION technique.

3.2. EM DATA:

Nomenclature for field name / processing relationship:

'_ppm'	Filtered Raw data:
'_F_L'	Filtered and levelled data. (FOR CDI Production)
'_F_LD'	Filtered, levelled and microlevelled data.
'_AResistINV'	Apparent Resistivity ohms/m calculated using the INVERSION technique.
'_ACondINV'	Apparent Conductivity uS/m calculated using the INVERSION technique.

3.3. GRIDDED DATA FILES:

Files: Extensions as for processed data above.
Format: ER Mapper

Cell size: 20 metres
Datum: AGD66
Projection: TMAMG
Zone: 55