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Helicopter Geophysical Survey - Final Grids of
Magnetic, DTM and EM Data - Final Located EM,
Geoinstruments Proprietary Limited; Oceania Tasmani
Anon ML123M/47; ML19M/9

OCEANIA TASMANIA PTY LTD

MICROFILMED
FICHE No. 015300-

Helicopter Geophysical Survey

123M/47
PT4
See folio 26A
19M/95 PT1
See folio 60A
43M/85 PT2
See folio 62A

Final grids of Magnetic, DTM and EM data

Final Located EM, Mag, DTM data

March 1999

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**Helicopter Geophysical Survey
 Oceania
 GEO# 9904 Mar 1999
 Final Grids of Magnetic, DTM and EM data
 Final Located EM, Mag, DTM data.**

CD # 1 of 1

DRAFT

FOR CLIENT
REVIEW.
APPENDICES
TO FOLLOW.

510003

Operations and Processing Report

**ON THE 1999 HELICOPTER ELECTROMAGNETIC SURVEY,
COMSTOCK BLOCK, ZEEHAN, TASMANIA**

March 1999

**OCEANIA TASMANIA PTY LTD
Level 3, MLC Building
65 Murray Street
HOBART
TASMANIA 7000**

123M/47

See File 123M/47
folio 60

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1. INTRODUCTION

This report describes the field operations and data processing for the Comstock helicopter geophysical survey conducted five kilometres from Zeehan on the west coast of Tasmania, by Geo Instruments Pty Ltd under contract to Oceania Tasmania Pty Ltd. The survey program was completed between 19th and 23rd March 1999. The survey areas contain volcanic and sedimentary units of the Mt Read Volcanics which are the host to significant Pb-Zn-Ag massive sulphide deposits, as well as intrusive rocks which may be associated with other styles of mineralisation.

The survey collected a total of 196 line kilometres of electromagnetic, magnetic and elevation data in two days of survey operations. Important features of the design of the survey were the close line spacing of 50 metres and the acquisition of data both parallel to regional strike and perpendicular to regional strike. The results of the geophysical survey were presented as colour images of resistivity for three frequencies, magnetics and digital terrain model, plus multi-parameter profiles of each line direction.

2. SURVEY SPECIFICATIONS

The survey comprises airborne geophysical mapping over the Comstock Block at Zeehan, Tasmania. Data acquisition totalled 196 line kilometres of airborne electromagnetic, magnetic and elevation data.

2.1 LINE SPECIFICATIONS

NNE-SSW Lines

Traverse Line Direction	025°-205°
Traverse Line Spacing	50 metres

ESE-WNW Lines

Traverse Line Direction	115°- 295°
Traverse Line Spacing	50 metres

2.2 INSTRUMENTAL SPECIFICATIONS

Electromagnetic

Sampling Interval	0.1 second
Sensitivity	1 ppm
Coaxial Coil Frequencies	980 and 7001 Hz
Coplanar Coil Frequencies	385, 6606 and 34133 Hz

Magnetics

Sampling Interval	0.1 second
Total Noise	< 0.05nT

Base Station Magnetometer

Sampling Interval	1 second
Noise Level	< 0.2nT
Resolution	Better than or equal to 0.1nT

Radar Altimeter	Output 4mV/ft
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2.3 FLYING SPECIFICATIONS

Electromagnetic and Magnetometer Sensor Nominal Terrain Clearance	30 metres (30 metre bird cable)
Flying Speed	40m / second

3. SURVEY OPERATIONS

3.1 SURVEY BASES

The survey entailed one block referred to Comstock. The base for the program was the Heemskirk Motel in Zeehan.

The helicopter, the survey equipment and the party chief were on site in Zeehan on 13th March 1999. The base magnetometer and base GPS stations were set up and installation and testing were completed that day. Rain and low cloud precluded flying in the survey area for three days. Surveying of the Comstock Block commenced on 19th March. Heavy rain and strong winds resulted in no production for several more days. The Comstock survey concluded on 23rd March.

The quality control (QC) and field data processing were carried out at the Heemskirk Motel. The helicopter was always parked at the same location at the base to ensure consistency in ground calibrations.

3.2 FLIGHT PLANNING

Coordinates of all flight blocks (see maps in Appendix 1), were planned out in separate blocks for each line direction. Maps of the proposed flight lines were reviewed with the client prior to commencement of flying. Both areas are located in UTM Zone 55.

3.3 FLIGHT PATH CONTROL

A NovAtel 951R receiver was used for navigation and for flight path verification. The position solution from the receiver was obtained using signals from the U.S. Global Positioning System (GPS). Real time corrections were provided by the Fugro Omnistar satellite system. Altitude control is derived from the radar altimeter.

Navigation solutions from the 951R are sent at 38kbps to the logging computer once every second. The logging computer then calculates the cross track error, the distance between the intended flight path and the helicopter position, and displays this deviation from the required path on an analogue position display directly in front of the pilot. An analogue display of the radar altitude is also mounted in front of the pilot.

The GPS base station was a NovAtel 3151R unit.

3.4 SURVEY PLATFORM

Helicopter: Aerospatiale AS350BA "Squirrel" Helicopter
Registration: VH-JWD
Contracted From: Heli-Aust Pty Ltd of Bankstown
Endurance: 3.5 hours fully loaded
Survey Speed: 30 m/sec

3.5 WEATHER DETAILS

The weather was often unfavourable for flying in March as cold fronts with strong wind and heavy rain or low cloud and light rain were encountered on several days. The Comstock work was completed during two half days of favourable weather.

3.6 SAFETY MANAGEMENT

There were no aviation incidents during the implementation of the airborne survey for the aircraft utilised on the project. Safety procedures included strict rotation of pilots, and adherence to daily and scheduled maintenance of the helicopter. The presence of major and minor powerline cables and towers in the survey areas presented a recognised safety hazard. Daily flight plans and radio communication with base camp on completion of each flight line served to predict the position of the helicopter at all times.

4. PERSONNEL

Survey management and geophysical personnel were provided by Geo Instruments Pty Ltd, Sydney. The helicopter pilot was provided by Heli-Aust Pty Ltd. In field quality control was undertaken at the Heemskirk Motel in Zeehan and data processing, map production were undertaken by Geo Instruments Pty Ltd in Sydney.

Field Operations

Field Project Manager:	Zoltan Beldi
Pilot:	Tony Feller
Operator:	Marc Thomson
Field Processor	Neil Fiset

Data Processing

Data Supervisor:	Neil Fiset
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Client Representative

Field Operations and Data Processing:	Malcolm Bendall
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5. GEOPHYSICAL EQUIPMENT

5.1 ELECTROMAGNETIC SYSTEM

The electromagnetic system is the Geotech Hummingbird 5-frequency system. It consists of two vertical coaxial coil pairs operating at 980 Hz and 7001 Hz and three horizontal coplanar coil pairs operating at 385 Hz, 6606 Hz, and 34133 Hz housed in a 6.5m long bird together with the magnetometer sensor. The transmitter-receiver separation for each coil pair is 6.2 metres. The receiver coil responses are processed into their in-phase and out-of-phase (quadrature) components by processors installed in the bird, and are then transmitted by serial cable to the Geo Instruments data acquisition system in the aircraft.

The EM system is mounted in a lightweight Kevlar bird which is towed 30 metres below the helicopter. Measurements of the in-phase and out-of-phase signals for each frequency are recorded at the rate of 10 times per second, with a sensitivity of one millionth of the primary field (1 part per million).

5.2 MAGNETOMETER

The Geometrics G822A Magnetometer is a highly sensitive unit incorporating an optically pumped sensor. The constant harmonic frequency from the sensor is proportional to the surrounding scalar magnetic field. This frequency is resolved by the Counter/ Processor which provides the magnetic field to a nominal accuracy of 0.01nT at 10 times per second both in analogue and digital forms. The sensor and pre-amp was mounted in the EM boom which was attached by approximately 30 metres of cable to the helicopter.

5.3 ALTIMETER

A Sperry AA210 radar altimeter system was installed in the helicopter. This controls the pilot's analogue indicator, which provides a terrain clearance display from 0 to 750 metres (0 to 2,500 ft.) above ground level. This is the primary tool used to maintain a consistent terrain clearance. The output of the altimeter is 4 mV/ft and it can be read to a resolution of 1 mV for 0.305 metres.

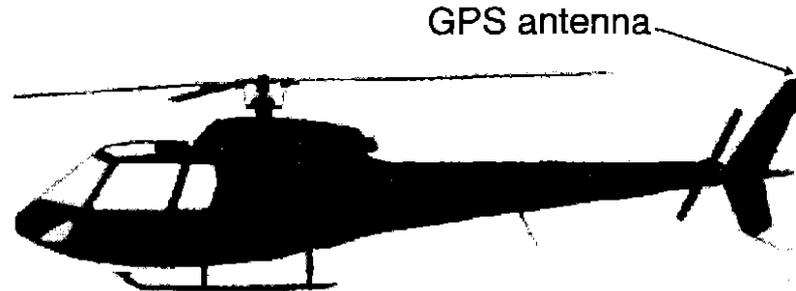
The reference height above the geoid used for data purposes, was derived from the differentially corrected height value provided by the GPS receiver.

Both GPS altitude and the radar terrain clearance were recorded every second by the digital acquisition.

5.4 GPS NAVIGATION SYSTEM

The guidance system for the helicopter was based on the U.S. Global Positioning System. GPS co-ordinates were referenced to the AGD84 spheroid.

A NovAtel 951R receiver was used for navigation. The corrected position is accurate to 1 metre for X and Y and 5 metres for Z (see Section 3.3). The GPS antenna was mounted on the upper rear fuselage of the helicopter.



The GPS base station was a NovAtel 3151R unit, with the antenna mounted on an external wall of the Heemskirk motel.

5.5 DATA ACQUISITION SYSTEM

The Geo Instruments G2002 digital acquisition system is based on the IBM PC AT architecture. The system is fitted with several modules tailored to condition the input data from the various sensing instruments. A custom written software package facilitates the following:

- (a) Correct synchronisation of the data streams,
- (b) Formatting of all data received,
- (c) Extended error checking of all parameters,
- (d) Visual data presentation for monitoring purposes,
- (e) Generation and distribution of synchronising fiducial numbers,
- (f) Recording of data to magnetic media,
- (g) Calculation of position and provision of steering display for pilot.

5.6 BASE STATION MAGNETOMETER

A Geometrics Recording Base Station Model G-856 with analog and digital recording was used as a diurnal monitor and run continuously during the survey periods. The sensor of the magnetometer was placed in a low gradient area beyond the region of expected influence of any man-made interference. This base station was located at Zeehan airstrip approximately 1km northeast of Zeehan. This was used to record the diurnal variations in the earth's magnetic field, and was running continuously throughout periods of survey flying.

Digital recordings from this instrument were made every 5 seconds with a resolution of 0.1nT and an accuracy of 0.1nT. The base station was synchronised with the airborne magnetometer.

All diurnal base station magnetometer data form part of the delivered digital information and individual records are not included in this report.

Diurnal activity was classed as quiet throughout the survey and there were no significant diurnal variations.

6. CALIBRATIONS

6.1 ELECTROMAGNETIC SYSTEM

The electromagnetic response is calibrated using an external Q coil at the commencement of the survey program. Calibration checks are conducted at the beginning and end of each sortie using internal coils, and at the beginning of each day using a ferrite phasing bar. Any drift is monitored by flying out of ground effect (above 350 metres) twice per hour to record electromagnetic zero levels. Prior to the commencement of surveying the EM system is run for at least an hour to stabilise temperatures and the system drift is observed and verified to be less than 5 ppm in 5 minutes.

6.2 MAGNETOMETER

The Geometrics G-822A Caesium vapour magnetometer operates on a split-beam principle with a constant relationship between the earth's magnetic field and the Larmor frequency (the frequency with which gyromagnetic moments precess in a magnetic field). They are therefore not subject to instrumental drift and do not require calibration.

6.3 ALTIMETER

The radar altimeter was calibrated against GPS height by multi-level flights prior to the commencement of the survey.

7. DATA PROCESSING

7.1 IN-FIELD DATA VERIFICATION

In-field quality control (QC) of the survey data entailed two stages of assessment. Firstly the field party leader at the survey base conducted an analysis of the most recently acquired data using both proprietary company software and commercial software (e.g. Geosoft).

At the survey base the post-processed GPS position information was merged with the geophysical data and then subjected to the following checks:

- a) Speed correlation,
- b) Identification of spikes, dropouts and noise bursts in all data streams,
- c) Verification that adequate flight path coverage was achieved,
- d) Checking flight line spacing and terrain clearance tolerances,
- e) Conformity to Contract specifications.

7.2 FINAL PROCESSING

The final data processing was undertaken by Neil Fiset for Geo Instruments Pty Ltd using both Geosoft and Intrepid software. All data had previously been checked for abnormalities by the in-field data verification system described in 7.1 above.

7.2.1 Flight Path Recovery

Processing of the differential GPS location data entailed the following steps:

- a) Post-flight differential GPS corrections using Geotracer differential position processing software,
- b) No fiducial synchronisation is required as both range data and fiducials are synchronised to GPS time,
- c) Merging of positional data with geophysical data.

7.2.2 Electromagnetic Data Processing

Processing of the in phase and quadrature EM channels entailed:

- a) Filtering to remove major spheric events and reduce system noise;
- b) Base level correction using high altitude EM zero levels;
- c) Calculation of apparent resistivity for the coplanar coils;
- d) Gridding at 25m cell size and micro-levelling

The resistivity formulae are taken from "Geo-Electromagnetism" by James R. Wait, Academic Press, 1982, pp. 108-112. They are standard integrals involving Bessel functions and reflection coefficients for a layered halfspace. For the nomogram look-up, a large number of models over a range of resistivities and depths are calculated, giving in-phase and quadrature results, to produce the nomogram grids (with in-phase and quadrature values on the axes, and the grid variables being resistivity, and depth.) The resistivity for a given value of in-phase and quadrature is then found by interpolating the grid.

7.2.3 Magnetic Processing

Having verified all data in the field, the final processing sequence is reduced to the following steps:

- a) Five point low pass filter,
- b) Diurnal variation removal,
- c) System parallax removal,
- d) IGRF removal,
- e) Micro levelling,
- f) Addition of the mean diurnal value and the IGRF base value,
- g) Gridding at 25m cell size

The helicopter magnetic data have been corrected for regional gradient by subtraction of the IGRF Model for 1998.9 derived from the 1995 secular variation model. The IGRF was calculated at each sample point at the GPS height of the aircraft, adjusted for the geoid-spheroid separation. Diurnal variations and system parallax have been removed. The mean diurnal value and IGRF base value have been added to the data. No filters were applied to the data prior to gridding. The Akima algorithm was used for gridding of the data.

7.2.4 Digital Terrain Model (DTM) Processing

The digital terrain model is computed from the difference in GPS height and radar altitude. The raw GPS range data are recorded internally every one second and corrected using real time factors provided by the Fugro Omnistar satellite system. This yields the position of the aircraft GPS antenna, including longitude, latitude and height relative to the AGD84 reference ellipsoid for each set of range data (every one second).

The radar altimeter provided the aircraft's ground clearance, the altimeter data being sampled every tenth of a second. The radar altimeter results were lightly smoothed to remove any spikes, spurious reflections or instrument noise.

The raw ground elevation data were then calculated as the difference between the height of the aircraft above the ellipsoid and the height of the aircraft above the ground. These raw elevation data calculated every one second are relative to the AGD84 reference geoid.

The GPS antenna was mounted on the tail fin of the aircraft. The radar altimeter sensor was located under the belly at the front of the aircraft.

The digital terrain model information was gridded at 25m cell size using the Akima gridding algorithm. Decorrugation and microlevelling tools in Intrepid were then applied.

DISCLAIMER NOT TO BE USED FOR NAVIGATION

This digital terrain model (DTM) has been computed from data generated during the course of an airborne geophysical survey flown at a nominal line spacings and data have been interpolated/gridded between such lines. Every effort has been made to make the model a useful general reference. No guarantee can be made that this model is a true representation of height above sea level and it does contain radar altimeter responses from buildings and dense timber. Users of this product should be aware of the topographic limitations mapped here within. **Do not use this DTM for navigation purposes.**

8. DELIVERED ITEMS

Following implementation of all corrections and levelling of the EM, magnetic and DTM fields, ERMapper grid files were generated and subject to further micro-levelling. Preliminary maps and preliminary grid files were delivered for review and approval, then final digital data files were delivered.

Map Products

Flight path map, draft contoured TMI map, draft contoured apparent resistivity maps for 385Hz, 6.6K Hz and 34K Hz.

Multi-parameter plots of EM data plus TMI and DTM.

In-phase and quadrature stacked profiles of EM data.

Digital Data

CD-ROM containing Final Located Data, Gridded Resistivity for each coplanar coil set, Gridded Total Magnetic Intensity and Gridded Digital Terrain Model.

Operations Report

Data delivery included this Operations and Processing Report on the helicopter electromagnetic survey program and data processing.