SKYTEM SURVEY RENNER AND HELEN SPRINGS, NT

for

OM (Manganese) Ltd

Author: James Reid & Reece Foster

Geoforce Reference: SK812SG_3.0

Date: Tuesday, 4 March 2008

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1. Summary

Geoforce Job Number	SK812SG
Survey Company	Geoforce Pty Ltd
Dates Flown	29 - 30 October & 20 November - 14 December 2007
Client	OM (Manganese) Ltd
Terrain Clearance	30 metres (nominal)
EM System	SkyTEM (High moment)
Helicopter company	Professional Helicopter Services, Melbourne, VIC
	(29/10/07 – 30/10/07)
	Griffin Helicopters, Perth, WA
	(20/11/07 – 14/12/07)
Helicopter type	AS350BA (PHS)
	AS350B2 (Griffin)
Helicopter registration	VH-PHQ (AS350BA)
	VH-DHQ (AS350B2)
Traverse Line Spacing	200 metres (infill at 100 metres)
Traverse Line Direction	E – W
Navigation	GPS
Datum	MGA53 / GDA94

2. Personnel

2.2 Field Operations

Crew Chief (Geophysicist)	Aaron Mullineux
Geophysicist	Tristan Kemp
Field Assistant	Chris Ward-Allen
Pilots	Grant Collis (Griffin Helicopters)
	Marty Gambrill (Heli-Aust / Griffin Helicopters)
	Neville Wright (PHS)
	Justin Hooper (PHS)

2.2 Base Operations

Project Manager	James Reid
Data Processing	Reece Foster & James Reid

3. Flight plan

The flight plan is shown in Figure 1.

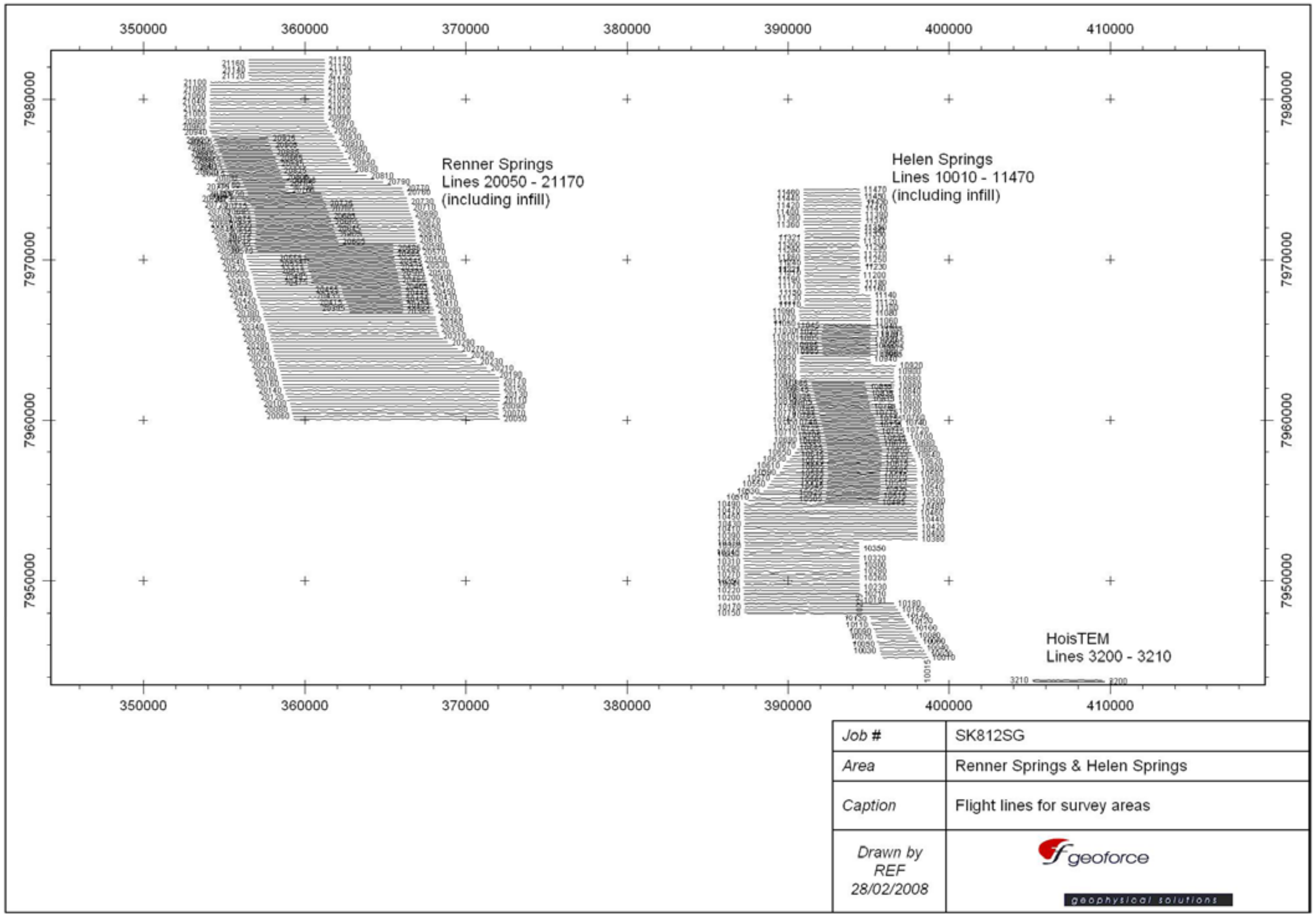


Figure 1 – Flight path map for Renner and Helen Springs (MGA53/GDA94)

4. Logistics

The survey was flown from local landing sites between Monday 29/10/2007 and Tuesday 30/10/2007 and between Tuesday 20/11/2007 and Friday 14/12/2007.

Logistics summary reports SK812SG_20071125.pdf, SK812SG_20071130.pdf, SK812SG_20071202.pdf, SK812SG_20071209.pdf and SK812SG_20071216.pdf are available on CD.

5. EM System specifications

EM Transmitter

Transmitter loop area	313.98m^2
Number of transmitter loop turns	4
Peak current	95A
Peak moment	119,320nAI
Tx loop height (nominal)	30m

Tx Waveform

Base frequency	25Hz
Tx duty cycle	50%
Tx waveform	Bipolar
Tx on-time	10ms
Tx off time	10ms
Tx ramp time	46μs

EM Receiver

EM Sensors	dB/dt coils
Rx coil effective area (Z and X)	31.4m^2
Low pass cut-off frequency for Rx coils	450kHz
Low pass cut-off frequency for X-component Rx electronics	106kHz
Low pass cut off frequency for Z component Rx electronics	225kHz

Z-component Rx coil position

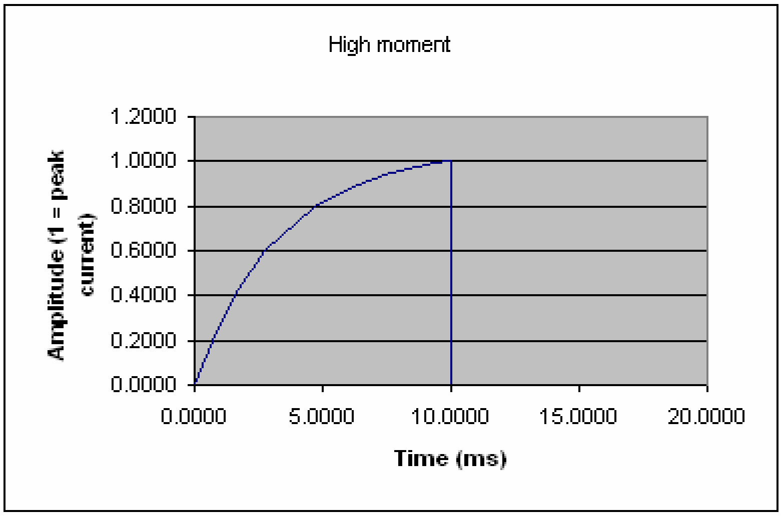
Behind Tx loop centre	12.43m
Above plane of Tx loop	2.22m

X-component Rx coil position

Behind Tx loop centre	13.81
Above plane of Tx loop	0m

6. Waveform

Time (ms)	Amplitude (0 – 1)
0.0000	0.0000
0.7100	0.2000
1.5900	0.4000
2.7400	0.6000
4.7200	0.8000
6.3800	0.9000
7.6700	0.9500
9.3800	0.9900
10.0000	1.0000
10.0436	0.0153
10.0446	0.0057
10.0456	0.0000
20.0000	0.0000



7. Channel times

Channel times are referenced to the start of the turn-off ramp.

LM = low moment

HM = high moment

Channel #	Centre (us)	Start (us)	Width (us)		
2	11.80	10.10	3.70	LM	
3	18.10	16.50	3.70		
4	24.60	22.90	3.70		
5	31.00	29.30	3.70		
6	37.40	35.70	3.70		
7	47.00	41.90	10.10		HM
8	59.80	54.70	10.10		
9	72.60	67.50	10.10		
10	88.60	80.30	16.50		
11	111.80	101.00	21.30		
12	145.40	130.00	30.60		
13	185.20	166.00	33.40		
14	234.40	210.00	47.00		
15	295.20	264.00	56.60		
16	370.60	331.00	79.00		
17	464.40	415.00	97.80		
18	581.40	519.00	122.00		
19	727.80	649.00	158.00		
20	911.20	812.00	194.00		
21	1117.00	1020.00	246.00	LM	
22	1429.20	1270.00	310.00		
23	1791.20	1590.00	393.00		
24	2246.00	2000.00	502.00		
25	2817.40	2500.00	629.00		
26	3535.60	3140.00	792.00		
27	4438.80	3940.00	997.00		
28	5575.00	4940.00	1260.00		
29	7000.00	6210.00	1590.00		
30	8800.00	7800.00	2000.00		HM

Only channels whose start times occur after the end of the Tx ramp contain valid data. The first useable channel for this survey is Channel 8 (ramp 46 microseconds).

8. Ancillary instrument specifications

RTK DGPS

SPS code	GP2
Model	Novatel DL-V3
RTK corrections	Omnistar HP
Cycle rate	1Hz
Height datum	AHD

DGPS (and base station)

SPS code	GP1
Model	UBlox RCB-LJ 16-channel Antaris
Antenna	Trimble Bullet III
Post processing	Base station
Cycle rate	1Hz

Laser altimeters

SPS codes	HE1, HE2
Model	LASER ACE models IM3R (type 150 or 300) or IM3HR (type 150 or 300)
Accuracy	0.2m
Recording rate	0.2s
Units	metres

Tiltmeters

SPS code	TL1
Type	Accelerometer
Manufacturer	Bjerre Technology, Denmark
Measured quantity	Tilt of Tx frame from horizontal in flight direction (X) and orthogonal to flight direction (Y) (not pitch and roll)
Sign convention	X: Nose up +ve Y: Starboard side up +ve
Units	Degrees
Fundamental accuracy	< 1 degree
Resolution	0.1 degrees
Recording rate	0.5s

9. Deliverables (available on CD)

A complete listing of available data is attached.

9.1 Raw data

Raw SkyTEM data (including every transient) are recorded in binary format *.SKB files and ancillary data in ASCII *.SPS files. These raw data are provided for client archive purposes in the event that any future reprocessing of the data is required.

9.2 Processed data

Binary data have been processed using the proprietary software package SkyPro to generate ASCII *.XYZ files of the SkyTEM data. All positions, altitudes etc in processed data are relative to the centre of the transmitter loop.

Electromagnetic data have been filtered as follows:

1. Data are stacked with a stack size of 6 to compress raw data.
2. A moving filter window of width 0.2 seconds is run over the stacked data from Step 1. EM data within the window are fit on a least-squares basis using third-order polynomial function. A separate polynomial function is fit to each EM channel.
3. A narrow (1 second, ~ 22m) moving average filter is run on the polynomial-filtered data from Step 2, in order to remove any minor discontinuities in the filtered response.

Final filtered data are output every 0.2 seconds (~4.4m on the ground at 80km/h groundspeed).

EM voltages have been normalised by receiver area (31.4m^2) and peak current (~100A) to yield units of nV/Am^2. As described above, only Channels 8 – 30 contain valid EM data, as Channels 1-7 are located within the transmitter switch-off ramp.

The *.XYZ file format is as follows:

Column 1	Line number (integer)
Column 2	Fiducial
Column 3	Date (YYYYMMDD) and flight number (e.g. 20080114.03 indicates flight 03 on 14th January 2008). *Note that all date and time stamps are GMT.*
Column 4	DateTime: Fractional days since midnight, 31st December 1899 (GMT).
Column 5	Angle X: Inclination of transmitter frame from horizontal in the in-line direction (nose up: +ve, units: degrees).
Column 6	Angle Y: Inclination of transmitter frame from horizontal in direction perpendicular to the flight direction (starboard side up: +ve, units: degrees).

Column 7	Terrain clearance from laser altimeters (m). Heights < 2m and > 250m are ignored during processing.
Column 8	Digital terrain model: Datum AHD. Calculated by subtracting laser altitude (column 7) from GPS elevation (column 13)
Column 9	Peak transmitter current (Amperes). Measured immediately prior to the start of the turn-off ramp.
Column 10	Total magnetic intensity (nT) – not used for this survey.
Column 11	Northing (MGA53/GDA94)
Column 12	Easting (MGA53/GDA94)
Column 13	GPS elevation of transmitter loop (metres, AHD).
Column 14	Ground speed in km/h
Column 15	Z component EM data at Channel 1. Units: nV/Am^2
⋮	
Column 44	Z-component EM data at Channel 30. Units: nV/Am^2
Column 45	X component EM data at Channel 1. Units: nV/Am^2
⋮	
Column 74	X component data at Channel 30. Units: nV/Am^2

9.3 Geosoft database

Processed data in the XYZ files has also been converted into a Geosoft database (*.gdb) format to enable easy viewing in common interpretation packages such as Maxwell.

To add SkyTEM channel times to the Maxwell drop down menus copy the contents of the Maxwell_SkyTEM.times file and paste at the end of the Maxwell.times file located in the same directory as the Maxwell.exe (usually in folder C:\Program files\Maxwell).

SkyTEM_314_HI_LEVEL.mcg is a Maxwell configuration file describing the geometry, waveform and channel times appropriate to this SkyTEM survey. After importing the Geosoft database file (SK812SG_HelenSprings.gdb & SK812SG_RennerSprings.gdb) select ‘Data / Preferences’ then ‘Edit and Process Lines’, select all the flight lines then load the configuration file by selecting ‘ Configuration’ then ‘Load’.

The SkyTEM_314_HI_LEVEL.mcg file approximates the actual hexagonal transmitter loop as a square loop of the same area, with the receiver coil located at the trailing edge of the loop. Maxwell only allows a single receiver to be specified so the position of the receiver above the loop is chosen as the mid-point of the actual Z and X coil positions (i.e. 1.11m above the plane of the Tx loop).

The configuration file sets the height of the transmitter and receiver equal to the LEVEL column in the Geosoft database (i.e. laser altitude).

The variables in the *.gdb file are as follows:

LINE	Line number
FID	Fiducial
ANGX	Angle X – see xyz file description above
ANGY	Angle Y – see xyz file description above
LEVEL	Laser altitude
ELEVATION	Digital Terrain Model, datum AHD
CURR	Peak current
EAST	Easting
NORTH	Northing
GPSALT	GPS elevation, datum AHD
EMZ	Z-component EM response, Channels 1 - 30 (array), null value 1e+33, Units: nV/Am^2
EMX	X-component EM response, Channels 1 - 30 (array), null value 1e+33, Units: nV/Am^2

9.4 EMAX_AIR processing

Z-component XYZ data have been converted to apparent conductivity vs depth using EMAX_AIR v2.24a (Fullagar and Reid, 2001).

Conductivity-depth data files have extension *.CDI. A complete description of the CDI file format can be found in the file header.

Images of CDI sections for each flight line are also provided.

9.5 Height-corrected data

EMAX_AIR has also been used to perform a basic height-correction of the measured data, in order to reduce the effect of flight-height variations on maps of the measured EM response at each channel. The height correction is done as follows:

1. For each sounding, compute apparent conductivity at each delay time.
2. At each delay time, assume that the earth model is a halfspace of conductivity equal to the apparent conductivity at that time
3. Compute the EM response of the half-space model at a constant altitude (30m) to yield height-corrected data for that delay time.

Units of the height-corrected data are uV (no normalization).

A complete description of the height-corrected data ASCII file format can be found in the file header.

10 References

Fullagar, P.K., and Reid, J.E., 2001, EMax conductivity-depth transformation of airborne TEM data: Expanded Abstracts, Australian Society of Exploration Geophysicists 15th Conference, Brisbane.

Appendix 1

Digital Datasets (Available on CD)

SK812SG_3.0 (Report on SkyTEM at Renner & Helen Springs)

Digital datasets

Folder	Sub folder	Files
Binary data	Raw data (Production flights)	20071029.02 20071030.01 20071120.02 20071121.01 20071123.01 20071120.03 20071121.02 20071123.02 20071124.01 20071125.01 20071126.01 20071127.01 20071206.01 20071124.02 20071125.02 20071124.03 20071125.03 20071207.01 20071208.01 20071209.01 20071210.01 20071211.01 20071207.02 20071208.02 20071209.02 20071210.02 20071211.02 20071207.03 20071208.04 20071209.03 20071208.05 20071213.01 20071214.01 20071213.02 20071213.03
		SK812SG_RS&HS_Production_flights.xls
EMAX AIR CDI	ASCII data	EMAX_AIR_CDI_output_readme.txt
		SK812SG_HelenSprings.cdi SK812SG_RennerSprings.cdi
	Images	SK812SG_HelenSprings_Line_numbers_MGA94z53.txt SK812SG_RennerSprings_Line_numbers_MGA94z53.txt
	Images \ SK812SG_RS&HS	SK812SG_HelenSprings_Line_3200.emf to SK812SG_HelenSprings_Line_3210.emf SK812SG_HelenSprings_Line_10010.emf to SK812SG_HelenSprings_Line_11470.emf SK812SG_RennerSprings_Line_20050.emf to SK812SG_RennerSprings_Line_21170.emf
Geosoft database		Maxwell_SkyTEM.times README.txt SkyTEM_314_HI_LEVEL.mcg
		SK812SG_HelenSprings.gdb SK812SG_RennerSprings.gdb

Height corrected data	ER Mapper grids	SK812SG_RS&HS_z10_HC.ers to SK812SG_RS&HS_z30_HC.ers
		SK812SG_RS&HS_DEM.ers
	Images	SK812SG_RS&HS_z10_HC.pdf to SK812SG_RS&HS_z30_HC.pdf SK812SG_RS&HS_z10_HC.jpg to SK812SG_RS&HS_z30_HC.jpg
		SK812SG_RS&HS_DEM.pdf SK812SG_RS&HS_DEM.jpg
		SK812SG_RS&HS_Survey_area.pdf SK812SG_RS&HS_Survey_area.jpg
	Processed data	SK812SG_HelenSprings_Height_corrected.dat SK812SG_RennerSprings_Height_corrected.dat
		SkyTEM_Height_corrected_readme.txt
Logistics		SK812SG_20071125.pdf SK812SG_20071130.pdf SK812SG_20071202.pdf SK812SG_20071209.pdf SK812SG_20071216.pdf
Photo		SkyTEM_Inflight_1.jpg to SkyTEM_Inflight_2.jpg
XYZ data		SK812SG_HelenSprings_Filtered.xyz SK812SG_RennerSprings_Filtered.xyz
		SkyPro31_314m2_20080219_poly3.ini

Appendix 2

SkyTEM technical overview (December 2007)

Geoforce-SkyTEM
Technical Description

20 December 2007

Max Halkjaer and James Reid

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Tel.: +45 30 28 99 88, Cvr: 27 70 43 79, www.skytem.com

Introduction

The Geoforce – SKYTEM system is designed to provide a helicopter platform which can produce similar quality electromagnetic sounding data from the air as is possible with high quality ground TEM sounding system (e.g. Geonics PROTEM or equivalent).

This document reviews the technical aspects of the SkyTEM system and illustrates its capability by means of field data examples. A full technical description of the SkyTEM is given by Sorensen and Auken (2004). Updates to the system parameters since 2004 are described in this document and in header files supplied with survey data.

Measurement setup and quality control

Technical approach

The Geoforce - SkyTEM system is designed for mapping geological structures for groundwater and environmental investigations, and was developed as a rapid alternative to ground-based TEM surveying. The entire system is carried as an external sling load suspended from the helicopter as shown in the figure below. No operator is required in the helicopter. During acquisition, essential data which confirms correct operation of the system is transmitted to the pilot via wireless link, and to the ground crew by radio modem. The pilot automatically receives notification to return to the ground base should any component of the instrument cease to operate correctly.

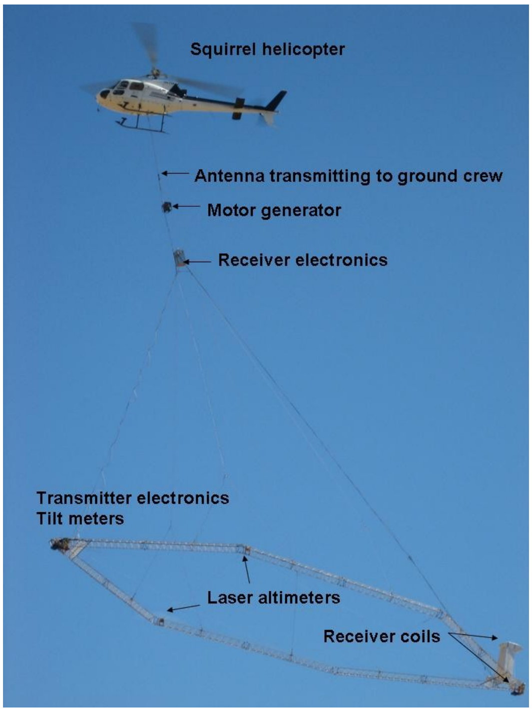

Figure 1 Photo of SkyTEM in operation at Toolibin Lake, Western Australia, October 2006. Transmitter area is 314 m^2.

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The measurement configuration is based on a 314 m^2 or 494 m^2 transmitter loop and vertical and horizontal in-line axis receiver coils. Transmitter and receiver geometry is illustrated in Figure 2.

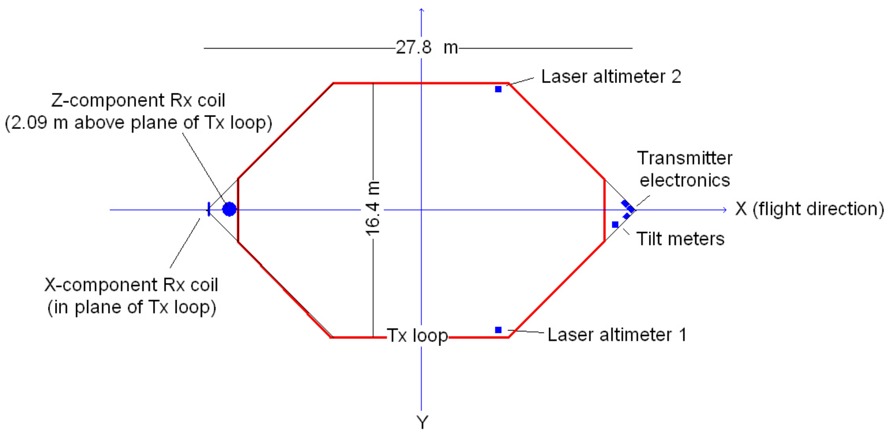

Figure 2 Sketch showing the Tx frame and instrument locations for a configuration with Tx loop area of 314 m^2.

Transmitter

The transmitter loop is roughly hexagonal with nominal diameter which can be configured to vary from about 15m – 30m. The 4 turn transmitter loop is mounted on a light weight wooden/PVC lattice frame, and is powered by a motor generator, which is suspended on the tow cable between the helicopter and the loop (Figure 1). Total weight of the system, including electronics and generator, is 300 – 400 kg, depending on the Tx loop size.

A unique feature of SkyTEM is that the system is capable of operating in a dual transmitter mode:

- **Low moment (LM)** mode where low current, high base frequency and fast Tx switch off provide early time data and high spatial sampling for shallow imaging;

- **High moment (HM)** mode, where a higher current and lower base frequency provides high quality late time data for deep imaging.

The system can operate in either the LM or HM mode, or in a combined (dual) mode. In dual mode, LM and HM data are acquired sequentially, (although the LM mode only uses one Tx turn). The exact sequencing of HM and LM measurements is completely programmable, and can be designed to trade off vertical versus horizontal resolution depending on the specific survey objective.

Transmitter waveform specifications in the LM and HM modes are as follows:

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Low moment

- 1 transmitter turn
- Current approx. 40 A
- Peak moment (314 m^2 Tx loop): 12,500 nAI
- Repetition frequency typically 222.22 Hz (programmable)
- Switch off typically 4 microseconds.

High moment

- 4 transmitter turns
- Current approx. 100A
- Peak moment (314 m^2 Tx loop): 125,600 nAI
- Repetition frequency 25 Hz
- Switch off typically 45 microseconds.

The nominal LM and HM Tx current waveforms are shown in Figures 3 and 4. The Tx waveform is measured on the ground once per month to verify correct Tx operation. Unlike some other airborne electromagnetic systems, it is not possible to record the SkyTEM system waveform during flight (e.g., at high altitude) as both receiver coils are null-coupled to the Tx in order to suppress the primary signal in the off-time due to any leaking current in the Tx loop. The waveform shape and timing are temperature-independent, whereas the amplitude (ie peak current) depends on the ambient temperature during survey operations. The peak Tx current is recorded just before the onset of the Tx current ramp for each transient recorded during a survey. During data processing and interpretation, the measured peak current is used to scale the amplitude of the complete waveform.

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a)
b)

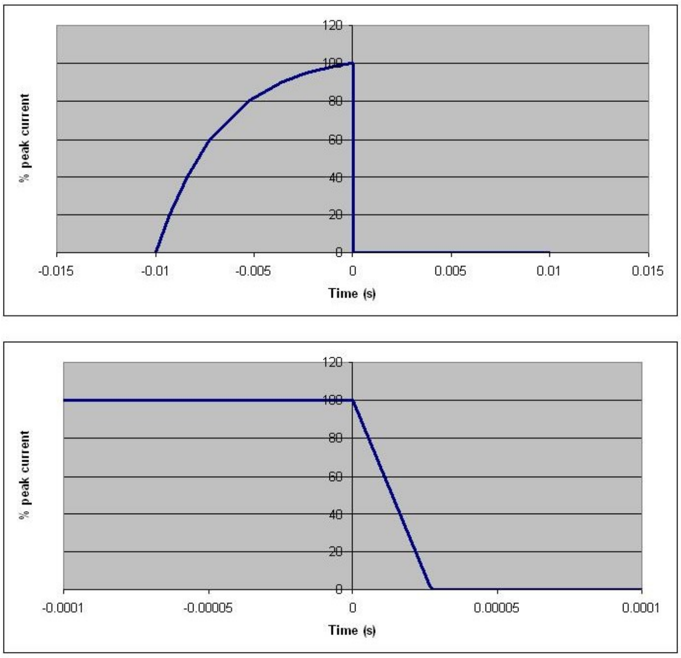

Figure 3 Waveform for the high moment transmitter, plotted as a percentage of peak current (typically 100A). Panel a) shows a complete half-cycle of the HM current waveform. b) shows detail of the current turn-off ramp. The current ramp is linear until 27 µs after the start of the turn off, during which time the current in the loop falls to approximately 1.5% of the peak current. The linear portion of the ramp is followed by a shorter exponential tail of approximately 3 µs duration, where the current falls from 1.5% of peak to zero. The total turn-off ramp is approximately 30- 45 µs, depending on peak transmitter current.

a)
b)

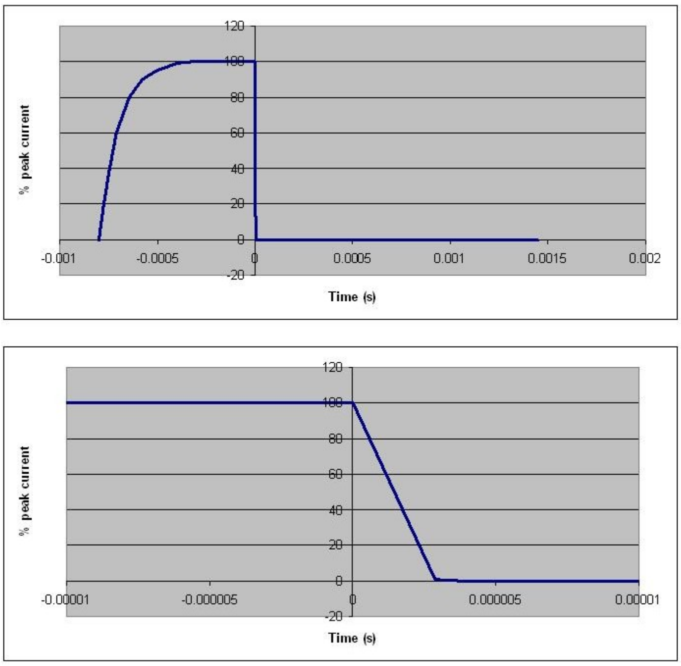

Figure 4 Waveform for the low moment transmitter, plotted as a percentage of peak current (typically 40A). Panel a) shows a complete half-cycle of the LM current waveform. b) shows detail of the current turn-off ramp. The current ramp is linear until 2.9 µs after the start of the turn off, during which time the current in the loop falls to approximately 0.6% of the peak current. The linear portion of the ramp is followed by a shorter exponential tail of approximately 1.2 µs duration, where the current falls from 0.6% of peak to zero. The total turn-off ramp is approximately 4 µs.

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Receiver

The receiver coils are shielded, overdamped, multi-turn loops, with a first-order cut-off frequency of 450 kHz. The effective area of the coils is 31.4 m^2.

The TEM receiver instrument is suspended on the tow cable between the helicopter and the Tx loop (Figure 1). The receiver samples the transient decay at 20 delay times in LM mode (designated channels 2 – 21), and 24 times in HM mode (designated channels 7 – 30). Receiver channel delay times are measured from the top of the current turn-off ramp (0 s in Figures 3 and 4).

In LM mode, the channel centre times range from 11.8 microseconds up to about 1.14 milliseconds, and in HM mode from 50 microseconds to 8.8 ms. Channel delay times and widths are listed in Table 1.

Gate No	Gate start sec	Gate center sec	Gate width sec	
1	3.66E-06	5.47E-06	3.63E-06	LM
2	1.01E-05	1.18E-05	3.63E-06	LM
3	1.65E-05	1.82E-05	3.63E-06	LM
4	2.29E-05	2.46E-05	3.63E-06	LM
5	2.93E-05	3.10E-05	3.63E-06	LM
6	3.57E-05	3.74E-05	3.63E-06	LM
7	4.19E-05	4.70E-05	1.01E-05	LM and HM
8	5.47E-05	5.98E-05	1.01E-05	LM and HM
9	6.75E-05	7.26E-05	1.01E-05	LM and HM
10	8.03E-05	8.86E-05	1.65E-05	LM and HM
11	1.01E-04	1.12E-04	2.12E-05	LM and HM
12	1.30E-04	1.46E-04	3.06E-05	LM and HM
13	1.66E-04	1.83E-04	3.34E-05	LM and HM
14	2.10E-04	2.33E-04	4.70E-05	LM and HM
15	2.64E-04	2.93E-04	5.66E-05	LM and HM
16	3.31E-04	3.71E-04	7.90E-05	LM and HM
17	4.15E-04	4.64E-04	9.78E-05	LM and HM
18	5.19E-04	5.80E-04	1.22E-04	LM and HM
19	6.49E-04	7.28E-04	1.58E-04	LM and HM
20	8.12E-04	9.09E-04	1.94E-04	LM and HM
21	1.02E-03	1.14E-03	2.46E-04	LM and HM
22	1.27E-03	1.43E-03	3.10E-04	HM
23	1.59E-03	1.79E-03	3.93E-04	HM
24	2.00E-03	2.25E-03	5.02E-04	HM
25	2.50E-03	2.82E-03	6.29E-04	HM
26	3.14E-03	3.53E-03	7.92E-04	HM
27	3.94E-03	4.44E-03	9.97E-04	HM
28	4.94E-03	5.57E-03	1.26E-03	HM
29	6.21E-03	7.00E-03	1.59E-03	HM
30	7.80E-03	8.80E-03	2.00E-03	HM

Table 1. Time Gates for high moment (HM) and low moment (LM) modes in seconds.

The receiver electronics have a first-order cut-off frequency of 106 kHz (X-component) and 225 kHz (Z-component).

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Quality control

The quality of SkyTEM data is comparable to that measured with similar ground-based TEM system (e.g., Geonics PROTEM). The measured data are not significantly distorted by drift or bias and are ready to be interpreted without further data processing, such as levelling.

High-altitude measurements are used to demonstrate that there is minimal bias in the system (Figure 5). Data are acquired with the system at >1000 m above the ground in normal survey mode and with the transmitter off as shown in Figure 5 below.

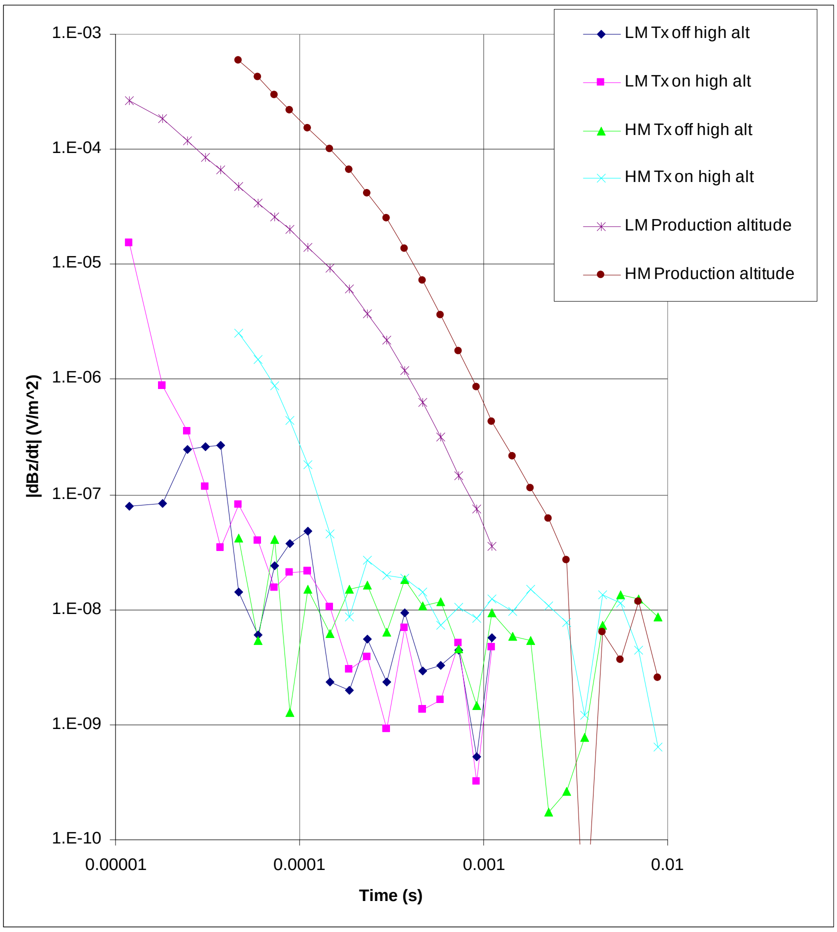

Figure 5. LM and HM noise response based on low (30 m) and high (1300 m) altitude measurements at Toolibin Lake, Western Australia in October 2006. High altitude measurements where there is no signal from the ground show that the response with the transmitter on lies largely within the natural noise envelope of the system measured with the transmitter off. A small bias signal is evident in the high altitude data measured with the transmitter on [channels 1 - 2 of LM data (pink curve) and channels 1 – 5 of HM data (light blue curve)]. However the bias signal is at least 1 – 2 orders of magnitude smaller than the amplitude of data measured at production altitude, and hence does not significantly distort the measured secondary response.

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During survey operations, hover tests (~ 1 min duration) are conducted over a fixed location at the completion of each survey flight. Data from these hover tests is used to confirm the absence of any system drift, and can be supplied along with survey data.

Calibration

The equipment has been calibrated at the Danish National Reference site. Figure 6 shows a comparison of SkyTEM data with the average response measured at the same site using ten different Geonics PROTEM ground TEM instruments. The ground TEM data have been upward continued to the same altitude as the SkyTEM measurement (15 m). The SkyTEM response reproduces the ground based soundings to within 2-3%.

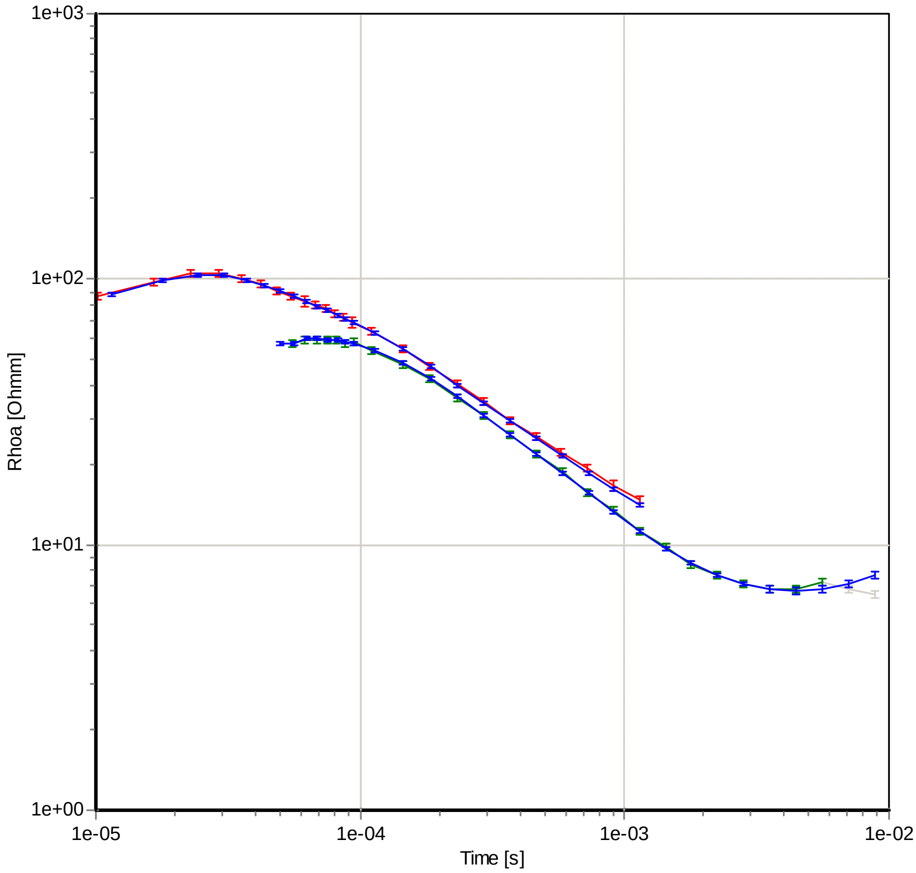

Figure 6. Calibration Data from 15 m altitude at the National Danish Reference site. The blue curves are the response related to the ground based systems and the green and the red curves are the measured data with the SkyTEM system. The error bars are 2%.

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Processing and Inversion

Geoforce offers several processing and inversion options, including

- EMax_Air conductivity-depth images (vertical-component data only)
- SELMA rapid layered-earth inversion (vertical-component data only)
- Layered-earth inversion (LEI - vertical-component data)
- Laterally-constrained inversion (LCI - vertical-component data)

EMax_Air conductivity-depth images (Fullagar and Reid, 2001) are useful for rapid, first-pass appraisal of SkyTEM data. LEI and LCI are more computer intensive, but provide a more reliable geoelectric model in areas of quasi-layered geology. For high quality imaging, we offer the Laterally Constrained Inversion (LCI) scheme developed by Auken et. al. (2005). The LCI simultaneously inverts both high and low moment data (if both are present). This approach has been demonstrated to provide high quality inversions of geometrically complex features with subtle resistivity variations. A relevant example is shown in Figure 7, where the LCI performance in imaging a fresh water bearing palaeochannel is demonstrated on three-dimensional model data and contrasted with a more conventional LEI approach (Jacobsen, 2004).

Toolibin Lake Study, Western Australia

We have undertaken an orientation survey over the saline environs of Lake Toolibin in Western Australia in late October 2006. The survey was flown over the same lines flown using a fixed-wing airborne electromagnetic system (TEMPEST) in 1998. Some survey results are shown in Figures 8 and 9. More comprehensive results and data from the Toolibin survey can be provided by Geoforce on request .The results demonstrated:

- That the SkyTEM data is highly repeatable.
- That the SkyTEM system could successfully map features conjectured to be associated with hydrogeological changes.
- That the SkyTEM system could map to a depth in excess of 100m under challenging conditions where ground resistivities of 1 – 10 ohm.m were typical.

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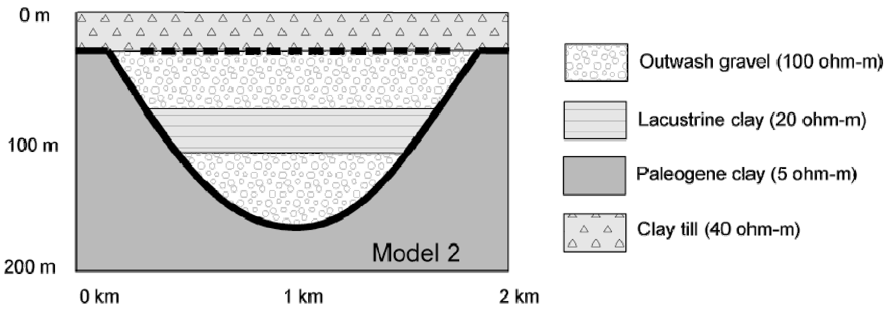
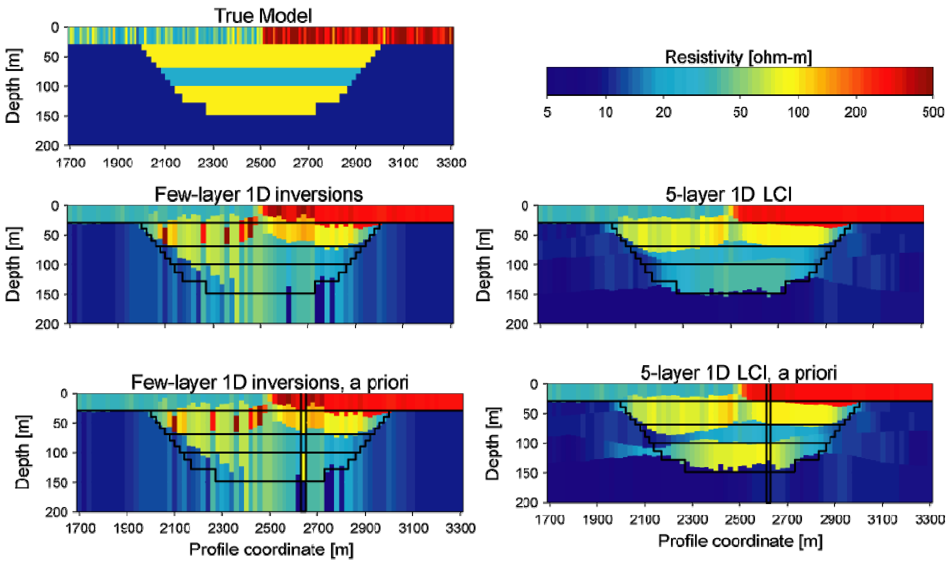


a)



b)

Figure 7 a) Conceptual geological and geoelectrical model, typical of a fresh water bearing palaeochannel in Denmark. b) Inversion results. A representative cross-section through the three-dimensional geoelectrical model of the palaeochannel is shown at upper right. The centre left panel shows the results of conventional LEI using a model with a few layers, and the bottom left panel shows the LEI inversion result when a priori information from a single borehole is included in the inversion. The right-hand panels show LCI results with and without inclusion of a priori information. The LCI improves the performance in mapping the geometry and internal resistivity structure of the paleo channel, particularly when a-priori information is added.This study indicates the advantage of LCI inversion when imaging geometrically complex features with relatively subtle resistivity variations.

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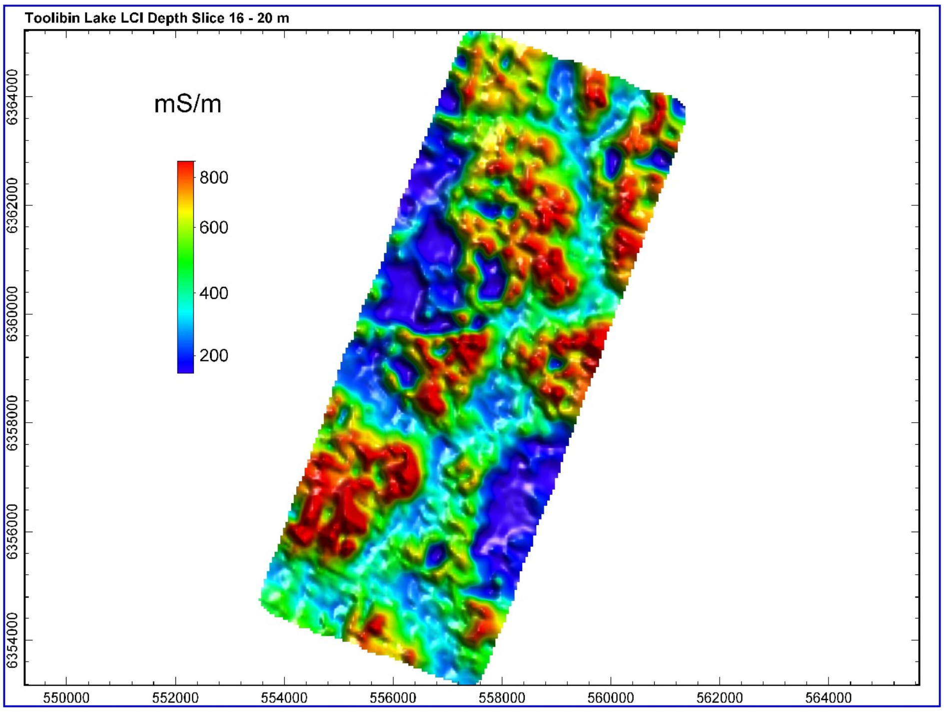

Figure 8. Orientation survey of about 340 line km flown over Lake Toolibin in Western Australia. The image shows an average conductivity slice for the depth interval 16-20 m produced via LCI inversion. The survey area was approximately 12 km × 4 km, and line spacing was 150m. Survey speed was typically 75 km/h and survey height was nominally 32m.

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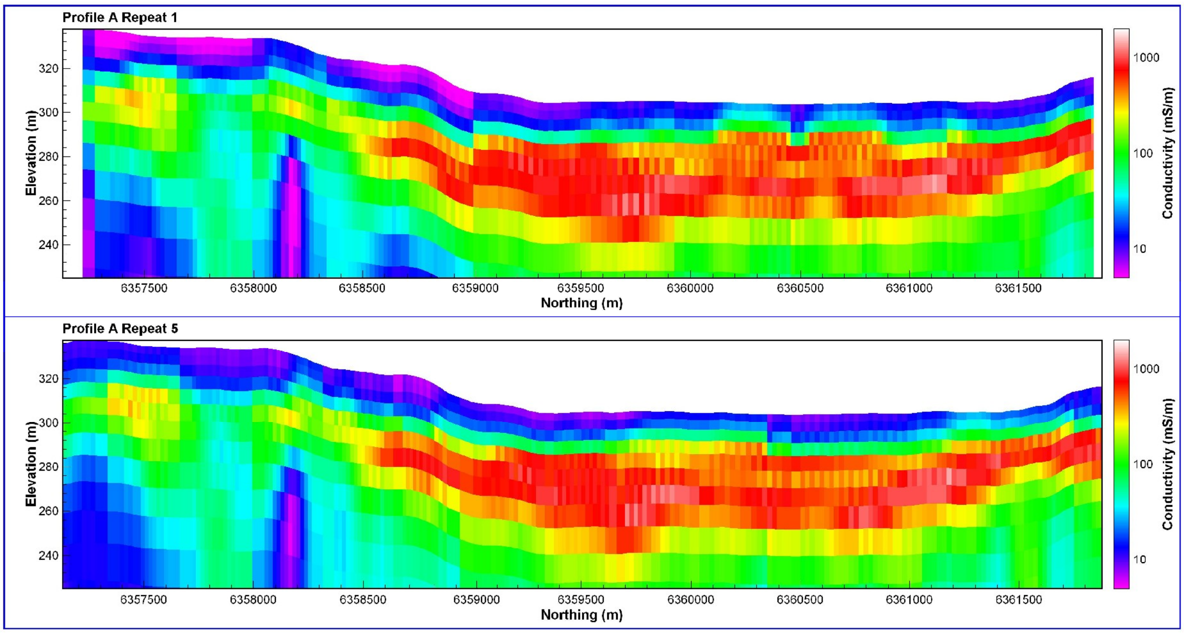

Figure 9. Two repeat calibration lines flown at Toolibin Lake. Lines are 5 km long. These cross sections are produced using 15-layer smooth model LCI inversions. The images are temperature coded with warm colours indicating high conductivity and cold colours indicating high resistivity. The line is dominated by a highly conductive layer at depths from about 20m – 60m. The key observation is that the inverted sections are repeatable.

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