Zonge Engineering and Research Organization (Australia) Pty Ltd

Isa Region MT Survey

Survey Summary

March 2020- April 2020

for

Hammer Metals

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1. SUMMARY

During March 2020 – April 2020, Zonge Engineering and Research Organization (Zonge) mobilized a two-person geophysics field crew to Hammer Metal's Kalman camp, QLD to conduct an Audio Magnetotelluric (AMT) survey for Hammer Metals.

Tensor (five channel) MT data were recorded at 92 sites throughout the survey area. Two lines of data were collected with station spacing around 200 metres within each line. Data were acquired using five channel receivers recording two orthogonal electric field and three orthogonal magnetic field measurements per site. AMT data were recorded over four hours providing data over the range 10kHz to approximately 500 seconds.

Data quality were monitored throughout the course of the survey from Zonge's Adelaide office. This allowed identification of station for repeat readings. Data were generally interpretable over the whole frequency range, with the exception of the AMT "dead band" around 2kHz. The data had very little impact from cultural noise however appears to suffer higher than usual noise levels on some stations due to the difficult deployment conditions in some areas.

2. INSTRUMENTATION

Figure 1 MTU-5C receiver

MTU-5C (Fig.1) are 5-channel receivers for collecting MT data over wide frequency band designed and manufactured by Phoenix Geophysics, Canada. These receivers are stand-alone, GPS-synchronized modules designed to simultaneously record up to 5 channels in 2E3H configuration, meaning 2 electric orthogonal components and 3 magnetic orthogonal components of MT field can be read simultaneously with 24 bit resolution.

These receivers can work in the range of 10kHz-0.00002Hz however another limiting factor would be the used sensors' sensitivity. Manufacturer specification sheets for receivers and sensors are presented in Appendix III.

Five Phoenix MTU-5C receivers were used throughout the survey for BBMT data acquisition. Each receiver sensed BBMT magnetic field data using three Phoenix MTC-150L coils, electric field data were sensed using single conductor wires and non-polarisable electrodes.

Equipment was powered using 12V batteries that were recharged every night.

At the commencement of the survey 5 receivers were setup in a parallel test to ensure consistent and correct operation of all receivers, sensors and calibrations. The test site was set at convenient location to be later used as the remote location. Results from these tests confirmed all 5 receivers and 15 magnetic field sensors were working correctly and provided consistent results. Results of this parallel test are presented on the accompanying disc under "Parallel-Rx-Testing", plots of principal component apparent resistivity and impedance phase are presented in Appendix IV.

3. DEPLOYMENT METHOD

Each receiver site consisted of two E-field (Ex and Ey) dipoles and three H-field (Hx, Hy and Hz) components. Each receiver site was setup at pre-planned locations using the configuration shown below in Figure 2. The total length of electric field dipoles was pre-measured to 100m. The orientation of each site was X toward magnetic north and Y toward magnetic east. Magnetic declination was imported into receiver setup files so that processed data was re-oriented relative to true north. Receivers were GPS synchronised which provides accurate locations and timing of recorded time series data.
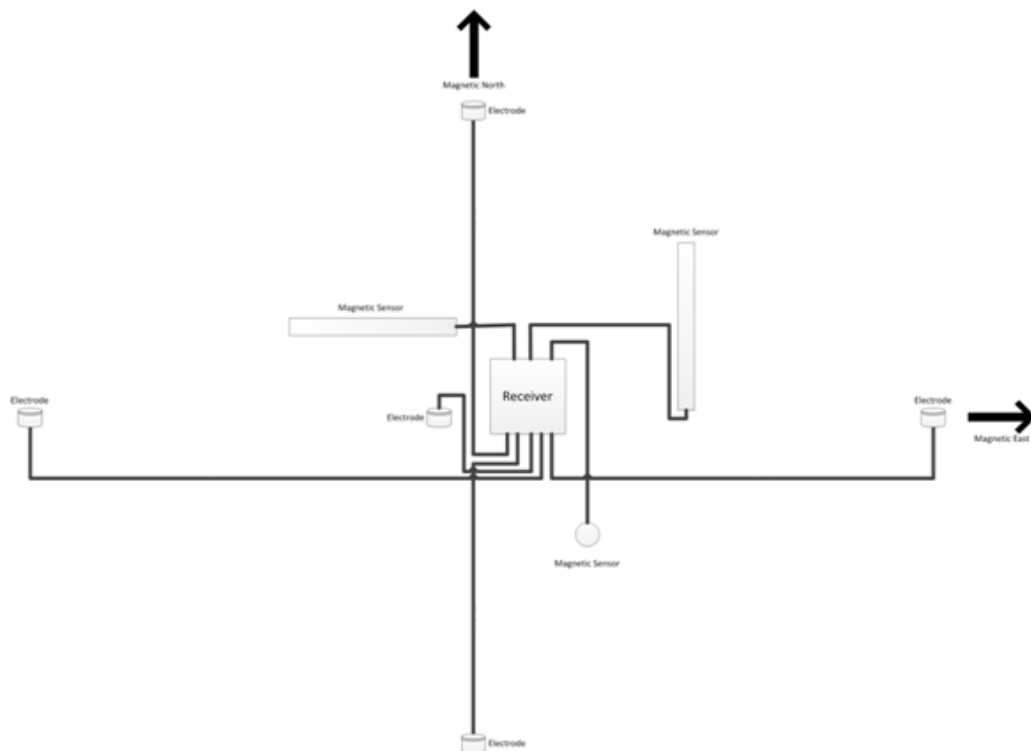
Figure 2 AMT Site Layout

Each receiver recorded constantly from deployment to collection over three separate frequency bands determined by different sample rates. Low frequency data were recorded continuously at a sample rate of 150 Hz. Mid and high frequency data were recorded using 24000 Hz.

The raw time series data from each day was downloaded from the receiver's removable flash memory to a field laptop computer before being sent to Zonge's Adelaide office. Final processing was completed in Zonge Engineering's Adelaide office.

4. SURVEY PARAMETERS

The survey was conducted as closely as possible to the plan provided by Hammer Metals which was for sites to be deployed near the planned tracks at approximately 200 meter intervals. MT sites were deployed at the locations shown in Appendix II.

Information relating this survey as provided to Zonge by Hammer Metals can be found in the "Survey_Info" directory on the accompanying disc.

Summary of collected data can be found in Appendix I.

5. PRODUCTION AND SAFETY SUMMARY

No incidents were reported during this survey. Difficult deployment conditions were encountered by the crew with sites often being chosen based on where vehicle access could be found. The terrain was hilly with rocky exposed slopes so the burial of magnetic sensors, particularly the vertical component was difficult. Electric field sensor contact resistances were often good however thick vegetation in some areas made avoiding wind movement of wires difficult.

Throughout the survey the crew suffered repeat failures of the receivers and many sites were re-occupied to ensure suitable deployment times were recorded, this was done at Zonge's cost.

All safety documentation including JSA, toolbox meeting notes and all documents produced for and during this survey may be found on the accompanying disc under *"Safety_Documentation".*

Appendix I provides a summary of the Production of Job 200104. More detailed information on daily production may be found on the accompanying disc under *"Production Reports".*

6. DATA PROCESSING

Data is processed, reviewed and edited using the software and stages shown in the flow diagram shown below and is described here. These processing stages apply to data recorded on Phoenix hardware only and does not apply to data acquired on Zonge International MT systems.

Raw time series data from the field is extracted from each receiver and processed using Phoenix's EMpower software. This software allows the operator to review data, calibrate and perform basic editing operations. Remote reference station data is applied at this stage to assist with noise reduction. A magnetic field declination value of 5° was used in processing to allow Empower to provide subsequent (to time series files) files rotated to true north. An operator may correct for polarity errors in acquisition and remove outlying impedance estimates on all recorded components before producing edi and other format impedance data files for further review.

Processed MT data in edi file format is then imported in CGG's Geotools software for interpretation, further review and modelling. Within this software the data is reviewed and unreliable portions of each site's data are removed before analysis is performed.

Generally the data reflects a strongly 2D and 3D geologic environment with prominent 3D behaviour adjacent the Kalman deposit, Kalman West and Pilgrim fault on the southern profile and near the Ballara and Pilgrim faults on the northern profile. As a consequence of the complex behaviour on many sites, the apparent strike of the data varied from station to station as well as over frequency. For inversion modelling a rotation consistent with observed geologic strike, perpendicular to 2D inversion on each profile (013 and 030 degrees for southern and northern profiles respectively) was used. TE mode was assigned to XY mode data. No static correction of the observed data was performed however the modelling was allowed freedom to account for static effects.

Models were run with the model section following the survey sites location (along tracks) however for the southern section in particular this required a significant deviation from 2D inversion model assumptions and should be considered with this in mind. Models were also created across interpreted strike with sites projected onto these profiles. These models are technically valid however for the southern profile particularly this projection distance was quite large and this should also be considered during interpretation.

Some additional sites were collected east of the Kalman deposit (90 and 91) to allow additional data across strike, colinear with stations 57-66. This was done to allow these stations to be assigned to a profile (Kalman-section-*.png) more appropriate for 2D modelling.

In consultation with Mark Whittle of Hammer Metals models were also run with a bias toward vertical structures. Mapped fault surfaces were also gridded and incorporated in the modelling as tear surfaces to compare model results. The models with fault surfaces did affect model smoothness in the faulted areas however any errors in fault location on the model profile may have resulted in unjustified complexity in results. The introduction of fault surfaces has also inadvertently generated unrealistic horizontal surfaces in some models. Model results are presented along with this report as well as a map of how each profile was constructed with respect to MT sites (Profile-map-northern.png and Profile-map-southern.png).
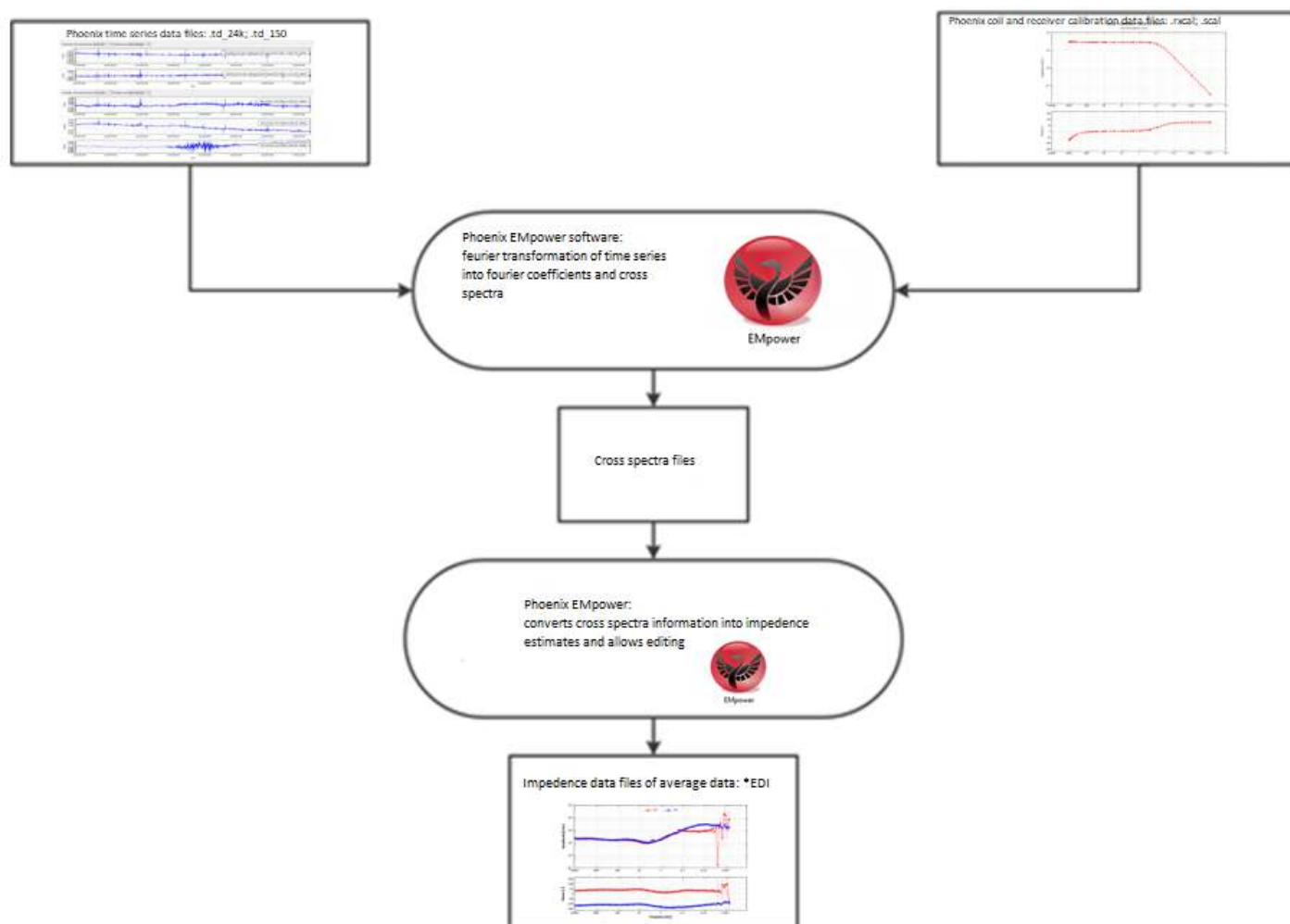
Figure 3 MT Processing Graph

7. EXPLANATION OF FILES

Digital data is provided on hard drive. Data from each surveyed line are placed in the following directory structure on the accompanying drive: *Processed_Data\line#*. File formats are explained below:

Data	Extension	Type	Applies to	Comments
Raw	*.tbl; *.json	Binary		Header file with station info
Raw	*.ts2; *.ts3; *.ts4; *.td_24k; *.td_150	Binary		Time series data
Processed	*.emt; *.mmt; *.xmt	Binary	Station	EDI-like binary files with cross-spectra
Processed	*.edi	Text		EDI file
Processed	*.res; *.tip	Text		Splines
Processed	*.mtcproj	Binary		Project files for Nord-West's MT-Corrector

APPENDIX I

Isa Region Data Summary

Site name	Date	RX number	Method	Coils			Ex			Ey			CRES to Ground	Battery	GPS lock	Comments from crew	Crew	Processing notes (K1)
				Hx	Hy	Hz	Length	CRES, kOhm	Az	Length	CRES, kOhm	Az	N-G, kOhm					
Parallel	17/03/2020	63	AMT	53688	53702	53755	50	2.75	0	50	2.05	90	2.25	13.02	17:15	E/W road 200m north, windy, rocky ground.	K1,LT	Ey bad.
Parallel	17/03/2020	64	AMT	54089	54122	54817	50	0.8	0	50	1.6	90	0.8	12.89	17:15	E/W road 200m north, windy, rocky ground.	K1,LT	Bad data.
Parallel	17/03/2020	59	AMT	53890	53781	53813	50	1.5	0	50	1.4	90	3.2	12.61	17:15	E/W road 200m north, windy, rocky ground.	K1,LT	
Parallel	17/03/2020	78	AMT	53685	54112	53697	50	1.5	0	50	2.2	90	1.3	12.65	17:15	E/W road 200m north, windy, rocky ground.	K1,LT	
Parallel	17/03/2020	90	AMT	53784	54128		50	2.75	0	50	2.05	90	2.25	12.89	17:15	E/W road 200m north, windy, rocky ground.	K1,LT	Hx failed.
30 (Remote)	18/03/2020	90	AMT	53545	542128		50	0.25	0	50	0.24	90	0.5	12.77	12:28	N/S track 150m west, windy, swapped Hx after failing during parallel test.	K1,LT	
89	18/03/2020	78	AMT	53685	54112	53697	50	0.9	0	50	0.775	90	0.8	12.79	14:00	Windy, N/S track 100m east, E/W road 20m south.	K1,LT	
87	18/03/2020	59	AMT	53890	53781	53813	50	0.7	0	50	0.5	90	0.7	12.79	15:00	Windy.	K1,LT	
85	18/03/2020	64	AMT	54089	54122	54817	50	0.9	0	50	1.7	90	1.8	12.67	16:10	Very rocky ground, windy, E/W road 75m north.	K1,LT	
83	18/03/2020	63	AMT	53688	53702	53755	50	1.3	0	50	0.9	90	1.2	12.65	17.:20	E/W road 70m north, windy, rocky ground.	K1,LT	
30 (Remote)	19/03/2020	90	AMT	53545	542128		50	1.4	0	50	3.2	90	1.5	13.02	7:09	N/S track 150m west, windy, Lemi pots.	K1,LT	
82	19/03/2020	63	AMT	53688	53702	53755	50	1.5	0	50	1.4	90	1.4	12.45	8:45	E/W road 50m north, resistive quartz rich ground, clay pots.	K1,LT	
86	19/03/2020	59	AMT	53890	53781	53813	50	0.75	0	50	1.4	90	0.7	12.82	10:00	Windy, E/W road 50m north ,clay pots.	K1,LT	
88	19/03/2020	78	AMT	53685	54112	53697	50	2	0	50	1.7	90	1.4	12.95	10:55	Windy, N/S track 100m east, E/W road 20m south, clay pots.	K1,LT	
84	19/03/2020	63	AMT	53688	53702	53755	50	1.15	0	50	0.8	90	0.65	12.55	14:00	Windy, E/W road 60m south, clay pots.	K1,LT	
89_R	19/03/2020	59	AMT	53890	53781	53813	50	0.8	0	50	0.65	90	0.65	12.64	14:48	Windy, N/S road 50m east, E/W road 50m south, clay pots, repeated due to data file from RX 78 being corrupt.	K1,LT	Used magnetic data from station 85 for processing (Hy saturated).
85_R	19/03/2020	78	AMT	54089	54112	54817	50	0.6	0	50	0.8	90	0.9	12.85	15:25	Windy, N/S track 100m east, E/W road 20m south, clay pots.	K1,LT	
30 (Remote)	20/03/2020	90	AMT	53545	542128		50	1.4	0	50	1.2	90	0.6	12.92	7:00	N/S track 150m west, Lemi pots,e ast double potted.	K1,LT	No error, though no data.
76	20/03/2020	63	AMT	53688	53702	53755	50	2.4	0	50	3.2	90	3	12.81	8:43	Very rocky and resistive ground, E/W road 100m north.	K1,LT	No remote data.
78	20/03/2020	78	AMT	54089	54122	53817	50	2.2	0	50	1	90	1	12.95	10:55	Windy, very rock and resistive ground, E/W road 60m north, N?S fence 100m wesat.	K1,LT	No remote data.
76	20/03/2020	59	AMT	53890	53781	53813	50	1.8	0	50	3.2	90	1.4	13.05	11:49	Very rocky, E/W road 60m north, windy.	K1,LT	Stopped acquisition after 1 hour.
80	20/03/2020																	
74	20/03/2020	64	AMT	53685	54112	53697	50	1.3	0	50	1.3	90	2	13.01	17:06	E/W road 50m north, resistive ground.	K1,LT	No remote data.
30 (Remote)	21/03/2020	90	AMT	53545	542128		50	1.2	0	50	0.7	90	0.6	12.95	6:55	N/S track 150m west, Lemi pots,e ast double potted.	K1,LT	
75	21/03/2020	64	AMT	53685	54112	53697	50	3	0	50	2	90	1.6	12.77	8:23	E?W road 130m north, N/S road 100m west, very rocky sub-surface.	K1,LT	
77	21/03/2020	63	AMT	53688	53702	53755	50	1.5	0	50	1.1	90	1.3	13.08	13:40	E/W road 70m north, E/W fence 75m north, N/S fence 40m east, E/W fence 100m south.	K1,LT	
79	21/03/2020	78	AMT	54089	54122	53817	50	1.7	0	50	3.4	90	1.5	12.77	10:29	Windy, rocky ground, E/w road 100m north.	K1,LT	
80_R	21/03/2020	59	AMT	53890	53781	53813	50	1.3	0	50	1.7	90	0.8	12.35	10:52	E?W road 60m north, REPEAT, Receiver failed twice.	K1,LT	
68	21/03/2020	64	AMT	53685	54112	53697	50	0.5	0	50	0.42	90	0.4	12.76	13:25	Windy, very rockyy ground, N/S road 60m west.	K1,LT	
70	21/03/2020	63	AMT	53688	53702	53755	50	1.1	0	50	0.7	90	0.78	12.97	14:35	N/S road 80m west, rocky sub-surface.	K1,LT	
72	21/03/2020	78	AMT	54089	54122	53817	50	1.6	0	50	0.4	90	0.45	12.55	16:17	Windy, N/S road 60m west.	K1,LT	
30 (Remote)	22/03/2020	90	AMT	53545	542128		50	1.4	0	50	0.9	90	0.9	12.99	6:48	N/S track 150m west, Lemi pots,e ast double potted.	K1,LT	
81	22/03/2020	59	AMT	53890	53781	53813	50	2.1	0	50	1.75	90	2.3	13.05		E/W road 60m north, very rocky ground, repeated several times stil failed.	K1,LT	
69	22/03/2020	64	AMT	53685	54112	53697	50	1.65	0	50	0.95	90	1.9	12.86	9:37	Very rocky ground, N/S road 60m east.	K1,LT	

Station	Date		Type													Comments		Notes
71	22/03/2020	63	AMT	53688	53702	53755	50	0.7	0	50	0.6	90	0.85	12.76	10:40	N/S road 60m west, windy, rocky sub-surface.	K1,LT	Time series look OK, but there is red exclamation mark against it saying "not present", reprocessed without Hz, data looks better, possible repeat?
73	22/03/2020	78	AMT	54089	54122	53817	50	0.8	0	50	2.4	90	1.6	12.76	12:00	Windy, NE/SW road 50m NW, power generator (not running) 40m southwest, failed twice, repeated.	K1,LT	
60	22/03/2020	64	AMT	53685	54112	53697	50	0.85	0	50	0.9	90	1.15	12.88	14:45	Windy, very rocky ground, E/W road 65m south.	K1,LT	Will be repeated.
62	22/03/2020	63	AMT	53688	53702	53755	50	0.815	0	50	0.6	90	0.5	12.83	16:00	Windy, E/W road 60m south.	K1,LT	Exclamation mark next to Hy, processed with coils from 69.
30 (Remote)	23/03/2020	90	AMT	53545	542128		50	2.9	0	50	0.8	90	0.9	13.08	6:47	N/S track 150m west, Lemi pots,e ast double potted.	K1,LT	
81_RRRRR	23/03/2020	78	AMT	54089	54122	53817	50	1.2	0	50	0.8	90	0.9		16:30	AfterRX59 failing twice the day before and once today, used RX 78 with old coils. FAILED AGAIN, resetted with coils dedicated to RX 78., used air compressor to get dust out of SD card slot.	K1,LT	
65	23/03/2020	78	AMT	54089	54122	53817	50	1	0	50	0.65	90	1	13.03	8:45	N/S road o50m west, N/S road 50m east.	K1,LT	
60_R	23/03/2020	64	AMT	53685	54112	53697	50	1.3	0	50	0.8	90	1.2	12.88	9:41	REPEATED after Rx failing 50m through data acquisition.	K1,LT	Repeat?
63	23/03/2020	63	AMT	53688	53702	53755	50	1	0	50	0.79	90	0.95	12.61	10:37	Windy, E/W road 60m north.	K1,LT	
66	23/03/2020	64	AMT	53685	54112	53697	50	0.5	0	50	1.4	90	0.49	12.68	14:39	Windy, N/S road 20m west.	K1,LT	
64	23/03/2020	63	AMT	53688	53702	53755	50	1.2	0	50	0.75	90	0.8	12.59	15:38	E/W road 40m north.	K1,LT	
30 (Remote)	24/03/2020	90	AMT	53545	542128		50	0.6	0	50	1.2	90	0.75	13	7:05	N/S track 150m west, Lemi pots,e ast double potted.	K1,LT	
67	24/03/2020	59	AMT	53890	53781	53813	50	1	0	50	0.5	90	1	12.77	8:10	Windy, N/S road 40m west.	K1,LT	
81	24/03/2020	78	AMT	54089	54122	53817	50	1	0	50	0.8	90	0.8	12.66	8:47	Repeat (failed again for 7th time, using 2 different receivers, multiple Fcards, different pots, coils, station abandoned for the time being).	K1,LT	
59	24/03/2020	64	AMT	53685	54112	53697	50	1.85	0	50	1.8	90	1.5	13	10:05	Very rocky ground, N/S road 60m west.	K1,LT	
61	24/03/2020	63	AMT	53688	53702	53755	50	0.7	0	50	1	90	0.7	13.02	11:18	Windy, E/W road 50m soiuth.	K1,LT	
57	24/03/2020	78	AMT	54089	54122	53817	50	1.15	0	50	1.2	90	1.55	12.76	5:16	Very rocky ground, used rocks to cover coils, (Failed, resetted at 16:48).	K1,LT	
52	24/03/2020	59	AMT	53890	53781	53813	50	0.78	0	50	1.5	90	0.82	12.67	15:15	Rocky ground, N/S road 67m east.	K1,LT	
54	24/03/2020	64	AMT	53685	54112	53697	50	0.5	0	50	0.65	90	0.48	12.77	16:38	E/W road 60m south.	K1,LT	
58	24/03/2020	63	AMT	53688	53702	53755	50	1	0	50	0.9	90	1.3		17:58	E/W road 10m north.	K1,LT	
30 (Remote)	25/03/2020	90	AMT	53545	542128		50	0.6	0	50	2.8	90	2.6	12.67	6:55	N/S track 150m west, Lemi pots,e ast double potted.	K1,LT	
47	25/03/2020	59	AMT	53890	53781	53813	50	0.5	0	50	1.5	90	1.3	12.85	8:39	E/W road 10m south, firmware upgraded.	K1,LT	noisy bellow 1hz.
49	25/03/2020	64	AMT	53685	54112	53697	50	1	0	50	1.28	90	0.88	12.61	9:54	E/W road 35m north, rocky ground, upgraded firmware.	K1,LT	noisy bellow 1hz.
57_R	25/03/2020	78	AMT	54089	54122	53817	50	1.2	0	50	1.4	90	1.7	13.1	10:50	Repeat, RX failed, no data recorded, upgraded firmware.	K1,LT	noisy bellow 1hz.
51	25/03/2020	63	AMT	53688	53702	53755	50	0.95	0	50	0.7	90	0.7	13.13	11:59	Windy, very rocky ground, used rocks to burry coils, upgraded firmware.	K1,LT	noisy bellow 1hz.
53	25/03/2020	59	AMT	53890	53781	53813	50	0.5	0.8	50	0.98	90	0.9	12.82	13:30	Very rocky ground, E/W road 40m south, windy.	K1,LT	noisy bellow 1hz.
48	25/03/2020	64	AMT	53685	54112	53697	50	1.75	0	50	0.95	90	1.4	12.55	14:46	E/W road 70m north, windy.	K1,LT	Strange E field time series.
	25/03/2020																	noisy bellow 1hz.
57_RR	25/03/2020	63	AMT	53688	53702	53755	50	1	0	50	1.4	90	1.15	12.8	16:09	Repeat, swapped receivers, used coils dedicated to RX 78.	K1,LT	
50	25/03/2020	59	AMT	53890	53781	53813	50	0.85	0.8	0.56	0.56	90	0.78	12.66	17:26	Windy, rocky ground, E/W road 70m north.	K1,LT	noisy bellow 1hz.
30	26/03/2020	90	AMT	53545	542128	53629	50	0.65	0	50	0.9	90	1.2	13.04	7:16	Complete setup., N/S road 150m west (not used).	K1,LT	
62_R	26/03/2020	63	AMT	53688	53702	53755	50	0.7	0	50	0.68	90	0.55	12.76	8:55	Very windy, rocky ground, E/W road 60m south.	K1,LT	South pot dissconnected after 10 hours (processed twice).
71_R	26/03/2020	78	AMT	54089	54122	53817	50	0.9	0	50	1.25	90	0.9	12.78	8:47	Windy, NE/SW road 60m NW.	K1,LT	
1	26/03/2020	59	AMT	53890	53781	53813	50	2	0	50	1.9	90	1.6	12.88	12:31	Very rocky ground (quatrtzite), resistive gorund N/S road 40m east.	K1,LT	

3	26/03/2020	64	AMT	53685	54112	53697	50	0.98	0	50	0.43	90	0.54	12.53	13:20	Windy, N/S road 40m east, old fenced off grave 55m east. :(	K1,LT	
75_R	26/03/2020	90	AMT	53545	542128	53629	50	1.35	0	50	3	90	1.4	12.77	14:59	New remote, repeat, used TP for Hz.	K1,LT	
61_R	26/03/2020	78	AMT	54089	54122	53817	50	0.55	0	50	0.7	90	0.6	12.7	16:44	Windy, E/W road 50m south.	K1,LT	Not great.
74_R	27/03/2020	63	AMT	53688	53702	53755	50	1.05	0	50	1.9	90	2.8	12.73	8:07	Windy, repeat, N/S road 80m west, stopped recording after 26 minutes due to alligator clip issues, resetted at 14:30.	K1,LT	Receiver shut down again after 2 hours and 19 minutes, data looks decent (?).
81_R	27/03/2020	78	AMT	54089	54122	53817	50	1	0	50	0.9	90	0.8	12.9	8:45	Repeat for 8th time (first 7 times failed due to receive failures).	K1,LT	
75 (Remote)	27/03/2020	90	AMT	53545	542128	53629	50	1.45	0	50	1.5	90	1.4	12.88	9:03	Lemie pots, used TP for Hz, N/S road 100m west.	K1,LT	
9	27/03/2020	64	AMT	53685	54112	53697	50	2	0	50	1.5	90	1.4	12.55	10:47	E/W road 70m north, E/W fence 110m south, rocky ground.	K1,LT	
5	27/03/2020	59	AMT	53890	53781	53813	50	3.8	0	50	1.5	90	3.5	12.73	12:18	Very rocky ground, N/S road 60m west.	K1,LT	
2	27/03/2020	78	AMT	54089	54122	53817	50	1.8	0	50	1.4	90	0.5	12.79	15:30	N/S road 10m east.	K1,LT	
4	27/03/2020	64	AMT	53685	54112	53697	50	1.05	0	50	0.65	90	0.4	12.47	16:45	SE/NW road 75m NE, rocky ground.	K1,LT	
75 (Remote)	28/03/2020	90	AMT	53545	542128	53629	50	2.1	0	50	1.5	90	2.4	13.14		Lemie pots, used TP for Hz, N/S road 100m west.	K1,LT	
19	28/03/2020	63	AMT	53688	53702	53755	50	0.75	0	50	0.56	90	0.54	12.47	8:05	E/W aroad 45m north, windy.	K1,LT	Not processede, raw data available, Hy & Hz shit.
5_R	28/03/2020	59	AMT	53890	53781	53813	50	3.2	0	50	1.6	90	3.1	12.43	8:40	Repeat, N/S road 60m west.	K1,LT	
17	28/03/2020	64	AMT	53685	54112	53697	50	0.56	0	50	0.45	90	0.37	12.68	9:45	Windy, E/W road 100m south.	K1,LT	not processed (hy failed), raw data available.
15	28/03/2020	78	AMT	54089	54122	53817	50	0.74	0	50	0.95	90	1	12.88	10:57	E/W road 75m south, fence 300m north, windy, rocky ground.	K1,LT	
8	28/03/2020	63	AMT	53688	53702	53755	50	2.4	0	50	2.4	90	3.8	12.44	14:22	Very rocky, N/S road 20m west, used rocks to cover Hy.	K1,LT	
6	28/03/2020	59	AMT	53890	53781	53813	50	3.6	0	50	2.8	90	3.7	12.84	14:47	N/S road 20m west, N/S old railroad 30m west.	K1,LT	
10	28/03/2020	64	AMT	53685	54112	53697	50	1.5	0	50	2.38	90	1	12.65	15:20	North electrode in creek bed (double potted) windy, salt bush.	K1,LT	
14	28/03/2020	78	AMT	54089	54122	53817	50	0.49	0	50	0.48	90	0.8	12.8	16:32	E/W fence 80m north, E/W road 50m north, rocky sub-surface.	K1,LT	
75 (Remote)	29/03/2020	90	AMT	53545	542128	53629	50	3.1	0	50	2.2	90	3.2	12.65	6:50	Lemie pots, used TP for Hz, N/S road 100m west.	K1,LT	Relatively lovely data.
25	29/03/2020	59	AMT	53890	53781	53813	50	1	0	50	0.6	90	0.55	12.78	8:20	E/W road 75m north, windy, spinife, rocky ground, Hy covered with rocks.	K1,LT	Terrible bellow 1hz.
23	29/03/2020	78	AMT	54089	54122	53817	50	1.15	0	50	0.9	90	1.25	12.76	9:43	Windy, very rocky, Hx & Hy covered with stones.	K1,LT	
16	29/03/2020	63	AMT	53688	53702	53755	50	0.65	0	50	0.95	90	0.75	12.85	12:53	Issue with alligator clips, E/w road 60m south.	K1,LT	
12	29/03/2020	64	AMT	53685	54112	53697	50	0.57	0	50	0.7	90	0.43	12.6	14:21	E/W road 40m north, N/S road 150m east, windy, thick bush.	K1,LT	
18	29/03/2020	78	AMT	54089	54122	53817	50	0.67	0	50	0.72	90	0.71	12.68	15:31	Windy, rocky, E/W road 60m south, spinifex.	K1,LT	
20	29/03/2020	59	AMT	53890	53781	53813	50	0.4	0	50	1	90	0.5	12.73	16:37	Very rocky, HX covered with rocks, spinifex, windy.	K1,LT	
75 (Remote)	30/03/2020	90	AMT	53545	542128	53629	50	3.4	0	50	2.1	90	3.6	12.39	6:51	Lemie pots, used TP for Hz, N/S road 100m west.	K1,LT	
21	30/03/2020	59	AMT	53890	53813	53781	50	0.75	0	50	0.85	90	0.5	12.23	8:10	Swapped Hy with Hz, rocky ground, E/W road 60m soiuth.	K1,LT	
17_R	30/03/2020	78	AMT	54089	54122	53817	50	0.58	0	50	0.59	90	0.37	12.87	9:08	Widny, repeat, E/W road 60m south, rocky, spinifex.	K1,LT	
13	30/03/2020	63	AMT	53688	53702	53755	50	1.5	0	50	0.9	90	2	12.56	10:12	E/W fence 70m north, E/W road 60m north, N/S road 40m west.	K1,LT	
11	30/03/2020	64	AMT	53685	54112	53697	50	2	0	50	2.15	90	3	12.4	11:20	North electrode in creeck bed (double potted), thick bus, E/W road 65m north, old E/W railroad 60m north.	K1,LT	
26	30/03/2020	59	AMT	53890	53813	53781	50	1	0	50	0.58	90	0.575	12.57	13:20	Swapped Hy with Hz, NE/SW road 60m north, spinifex, rocky ground.	K1,LT	
24	30/03/2020	78	AMT	54089	54122	53817	50	0.5	0	50	0.6	90	0.7	12.75	16:29	E/W road 2m south,very rocky (migmatite), used rocks to cover Hx & Hy.	K1,LT	
22	30/03/2020	63	AMT	53688	53702	53755	50	0.59	0	50	0.88	90	0.7	12.21	16:25	E/W road 10m north.	K1,LT	
75 (Remote)	31/03/2020	90	AMT	53545	542128	53629	50	3.2	0	50	4.1	90	3.7	13.11	6:57	Lemie pots, used TP for Hz, N/S road 100m west.	K1,LT	
33	31/03/2020	64	AMT	53685	54112	53697	50	2.2	0	50	0.5	90	3.1	12.49	8:44	N/S road 60m west.	K1,LT	

29	31/03/2020	78	AMT	54089	54122	53817	50	1.05	0	50	1.7	90	1.4	12.71	9:44	E/W road 50m south, N/S road 60m east, N/S railroad 65m east, N/S road 60m west, grassland.	K1,LT	
27	31/03/2020	63	AMT	53688	53702	53755	50	0.7	0	50	0.6	90	1.075	12.8	10:52	E/W road 60m north, rocky, windy, spinifex.	K1,LT	Bad phase data.
34	31/03/2020	59	AMT	53890	53813	53781	50	0.81	0	50	0.6	90	0.65	12.9	15:35	Windy, rocky sub-surface, flat terrain.	K1,LT	Bad phase data.
32	31/03/2020	64	AMT	53685	54112	53697	50	0.9	0	50	0.68	90	0.57	12.4	16:35	Flat terrain, thick scrubs, windy, N/S road 30m west.	K1,LT	
28	31/03/2020	78	AMT	54089	54122	53817	50	0.45	0	50	0.49	90	0.38	12.63	17:49	Flat terrain, E/W road 10m north, N/S road 20m west, cattle in the vicinity.	K1,LT	
75 (Remote)	1/04/2020	90	AMT	53545	542128	53629	50	4.1	0	50	4.3	90	4.4	12.l90	6:55	Lemie pots, used TP for Hz, N/S road 100m west.	K1,LT	
37	1/04/2020	78	AMT	54089	54122	53817	50	0.71	0	50	1.6	90	1	12.77	8:09	Black clay, east electrode in rocky ground, N/S road 40m west, cattle in the vicinity.	K1,LT	
35	1/04/2020	59	AMT	53890	53813	53781	50	0.75	0	50	0.7	90	0.9	13.03	9:07	N/S road 60m west, flat terrain, bush.	K1,LT	
33	1/04/2020	64	AMT	53685	54112	53697	50	1.15	0	50	0.82	90	0.85	12.78	10:30	Windy, flat terrain, bush, N?S road 50m west, N/S railroad 55m west.	K1,LT	
42	1/04/2020	63	AMT	53688	53702	53755	50	9	0	50	6.5	90	8.5	12.58	12:03	Very resistive ground, E/W road 60m south, hilly, spinifex.	K1,LT	
40	1/04/2020	78	AMT	54089	54122	53817	50	1.3	0	50	1	90	1.8	12.7	14:10	Very rocky ground, N/S road 1m east, windy.	K1,LT	
38	1/04/2020	59	AMT	53890	53813	53781	50	1.9	0	50	0.75	90	1.6	12.83	15:17	N/S55m west, windy, flat terrain, spinifex.	K1,LT	
33	1/04/2020	64	AMT	53685	54112	53697	50	1.5	0	50	1.4	90	1.6	12.6	16:15	Reset, receiver error message.	K1,LT	
50_R	2/04/2020	90	AMT	53545	542128	53629	50	1.5	0	50	1.5	90	1.7	12.56	8:10	Lemie pots, E/W road 60m north, rocky ground, REPEAT.	K1,LT	
39	2/04/2020	59	AMT	53890	53813	53781	50	1.7	0	50	1.5	90	1.9	12.76	9:45	Very rocky and hilly terrain, spinifex, N/S road 55m west.	K1,LT	
41	2/04/2020	78	AMT	54089	54122	53817	50	0.78	0	50	0.9	90	1.6	12.45	10:40	N/S road 50m south, rocky sub-surface, bush.	K1,LT	
43	2/04/2020	63	AMT	53688	53702	53755	50	1.425	0	50	2.25	90	2	12.52	11:49	Creek bed, thick grass, windy, E/W road 70m north.	K1,LT	
34_R	2/04/2020	64	AMT	53685	54112	53697	50	0.5	0	50	0.56	90	0.4	12.81	13:44	Repeat, open flat terrain, abundance of pebbles in the sub surface, N/S road 75m west.	K1,LT	
36	2/04/2020	59	AMT	53890	53813	53781	50	1.1	0	50	0.5	90	0.9	12.7	16:19	N/S road 20m west, flat plains, bush, windy.	K1,LT	
46	2/04/2020	78	AMT	54089	54122	53817	50	4.1	0	50	2	90	5.5	12.46	15:49	N/S road 5m west, rocky sub-surface, bush.	K1,LT	
18_R	2/04/2020	63	AMT	53688	53702	53755	50	0.74	0	50	1.4	90	1.5	12.45	17:00	East and west electrodes in rocky ground, E/W road 50m south.	K1,LT	
64.5	3/04/2020	90	AMT	53545	542128	53629	50	1.35	0	50	2.2	90	1.1	12.98	9:10	Lemie pots, E/W road 5m north.	K1,LT	
45	3/04/2020	78	AMT	54089	54122	53817	50	3.4	0	50	4.5	90	2.4	12.96	10:37	N/S road 1m west, flat terrain, rocky, windy, moved to half way between 43 and 46 (skipped 44).	K1,LT	
19_R	3/04/2020	63	AMT	53688	53702	53755	50	0.55	0	50	0.6	90	1.1	12.59	12:02	Windy, moved 50m south, E/W road 5m south, REPEAT.	K1,LT	
34_RR	3/04/2020	78	AMT	54089	54122	53817	50	0.5	0	50	0.4	90	0.35	12.72	16:03	Repeat, open flat terrain, abundance of pebbles in the sub surface, N/S road 75m west.	K1,LT	
33.5	17/04/2020	64	AMT	53089	54122	53817	50	3	0	50	1.7	90	2.2	12.9	9:45	Flat terrain, bush,sediments, N/S road 60m west.	K1,LT	
32.5	17/04/2020	90	AMT	53784	542128	53629	50	1.05	0	50	2.8	90	1	12.61	10:27	N/S road 20m west, multiple creek beds, bush, windy.	K1,LT	Hx failed, processed with magnetic data from station 33.5
63.5	17/04/2020	78	AMT	53685	54112	53697	50	1.7	0	50	1.5	90	2.05	12.87	12:05	Hilly terrain, rocky, spinifex, E/W road 50m south.	K1,LT	
90	17/04/2020	63	AMT	53688	53702	53755	50	1.6	0	50	3.8	90	1	12.72	14:12	Very rocky ground, E/W 20 degrees slope, windy, HZ: no windshield.	K1,LT	Noisy bellow 1Hz.
91	17/04/2020	59	AMT	53890	53813	53781	50	3.8	0	50	2.4	90	3.8	12.86	15:01	Flat terrain, near creek and cliff edge, resistive ground.	K1,LT	

APPENDIX II

Isa Region MT Site Map
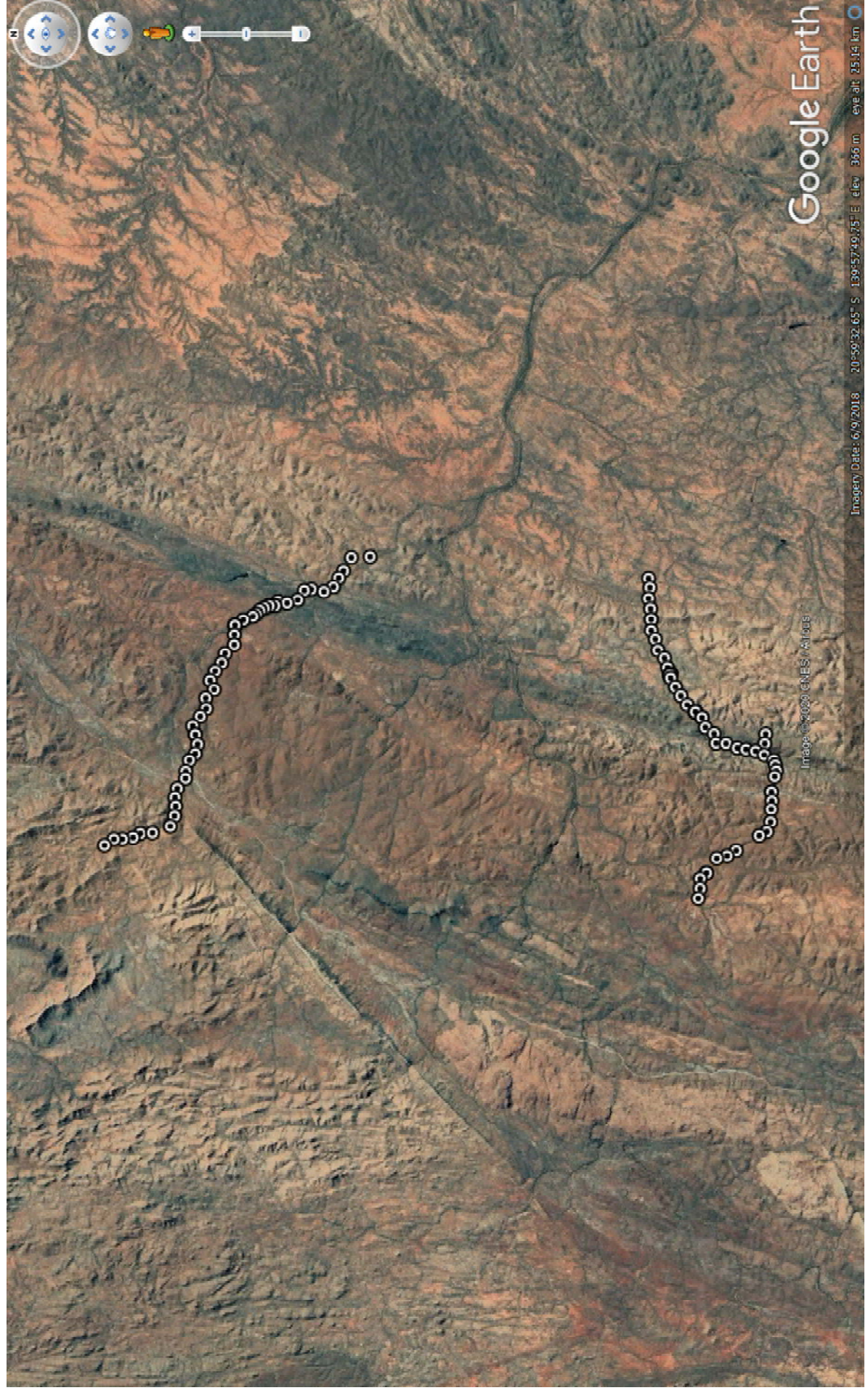
APPENDIX III

Equipment Specification Information

ULTRA-WIDEBAND MT (UMT) SYSTEM

MTU-5C GEOPHYSICAL RECEIVER

MAIN ADVANTAGES

One system does it all:

- MT-AMT-BMT-LP (long period)
- Simultaneous recording of high and low bands
- Better resolution in MT and AMT deadbands
- One set of sensors
- One recording
- One processing
- 10,000 Hz to >50,000 seconds

EMPOWER Advanced system suite

- Powerful database manager: keep track of your survey progress
- Diagnose, QC operations and data
- Multi Core MT parameter calculation, deliver results immediately
- Advanced editing and processing features
- Open ended development path supported by professional software team of 10 persons.
- Continuous improvements in processing techniques, released often

Introducing our new UMT (Ultra-Wideband MT) system

One system does it all!

The new Phoenix UMT system supersedes older separate AMT, MT, BMT and Long Period MT systems. Differentiation of AMT, MT, BMT and LP-MT is no longer required. There is no longer any need for expensive, separate deployments of different systems to capture the necessary spectrum. This simplifies and saves money on procurement, training, operation and maintenance thus providing lowest total cost of ownership (TCO).

Thanks to EMPOWER, our new advanced database management and processing software, operations are extremely simplified. EMpower is multiplatform and intuitive, any user can easily deploy the MTU-5C to acquire the entire spectrum to cover automatically more than 8 decades; this can be done with a single set of UMT magnetic sensors model MTC-150. Sensors are automatically detected by the system for easy acquisition and processing. The system is inter-operable with previous generation of Phoenix MT systems such as the MTU-5A.

Through-the-night acquisition captures AMT data at the optimal time thus greatly mitigates the AMT and MT dead band problem. Shorter day-time recordings capture the high frequency part of the spectrum and some parts of the low frequency bands, thanks to the simultaneous full spectrum acquisition.

For long periods, high-frequency data is an essential complement for long period (LMT) data; The hi-freq data provides superior inversions of the shallower section, as well as reliably identifying MT static shift. Static shift cannot be identified in widely separated, LP-MT only stations. Without mitigation of static shift, LP-MT inversions always are somewhat uncertain.
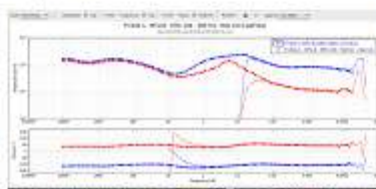
Phoenix Geophysics Ltd is the world leader in MT with thousands of systems sold worldwide since 1980.

SPECIFICATIONS

Acquisition mode:
One mode: Ultra Wide MT (UMT: both HF and LF simultaneous)

Sample rate:
24 KHz continuous acquisition, or decimation with sparse 24 KHz and continuous 150 Hz acquisition. Additional sampling schemes to be soon delivered. A/D conversion: Ultra low noise, true 24 bits

Number of channels:
5 UMT

Sensor connectors:
3 Magnetic sensor connectors, military grade, 10-pin, compatible with broadband MTC-150, MTC-180, MTC-50H, AMTC-30, MTC-80H and most common fluxgate sensors. 20 kOhm input resistance. 2 pairs of rugged electric channelbinding posts. 10Mohm input resistance.

Connectivity:
Ethernet for networking, external WiFi adapter.

Synchronization between instruments:
GPS disciplined, better than 500 nanoseconds

Environmental:
Operating temperature range:-25 to -60 CelsiusIP-68 compliant, water and dust proof

Case:
Ruggedized, monobloc, aluminium case for maximum strength and reduced weight. Impact resistant, shock mounted architecture, one meter drop test. Tested waterproof immersion. Ballistic nylon carrying bag for easy transport

Weight and dimensions:
5.1 Kg, 120 x 22 x 14 cm

Updates:
Easy firmware updates direct from SD card

Ultra Low Power consumption:
6.7 Watts (for 5 UMT channels)

Dynamic range:
Better than 130dB.

Storage:
Environmentally rugged SD card, up to 512 GB (hundreds of measurements)

Display:
Colour, graphical, low power, 160x128 pixels.

Integrated realtime quality control:
Self diagnostics at power up, at recording start and real-time recording statistics. Displayed through the colour screen, live display of levels, instrument status and recording status (GPS, operating mode, diagnostics, sensors detected, etc.). Parallel noise test :automatic acquisition and processing (EMpower)

Calibration:
Simple automatic in-field calibration of instrument and sensors for higher accuracy of processed data and advanced system quality control. Comes with default calibration.
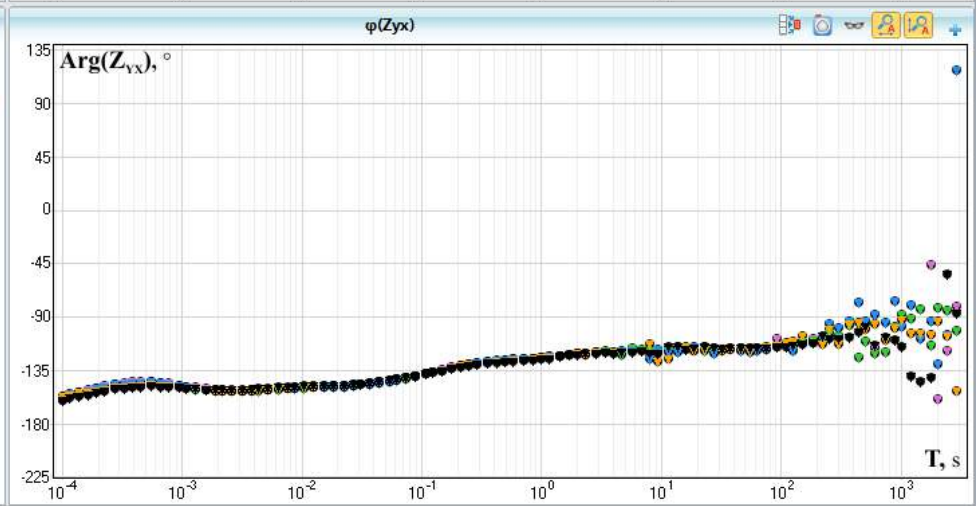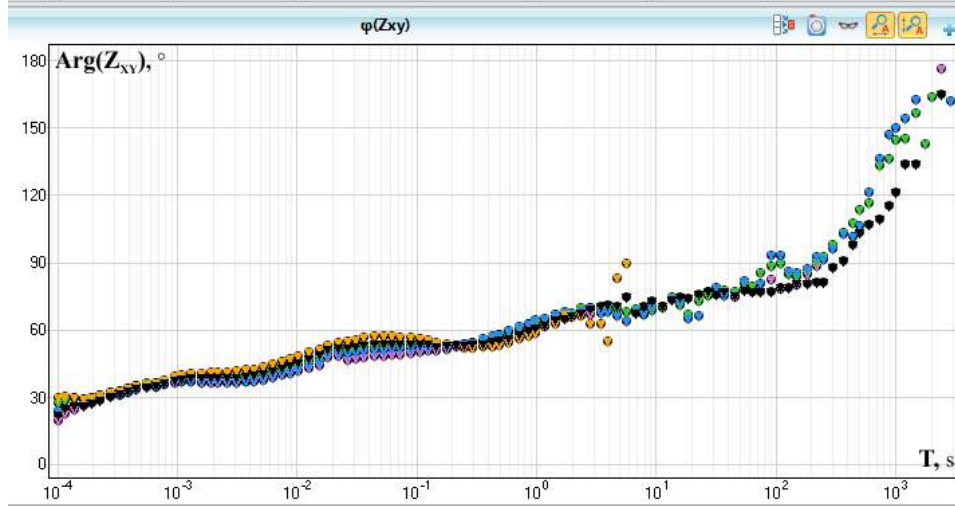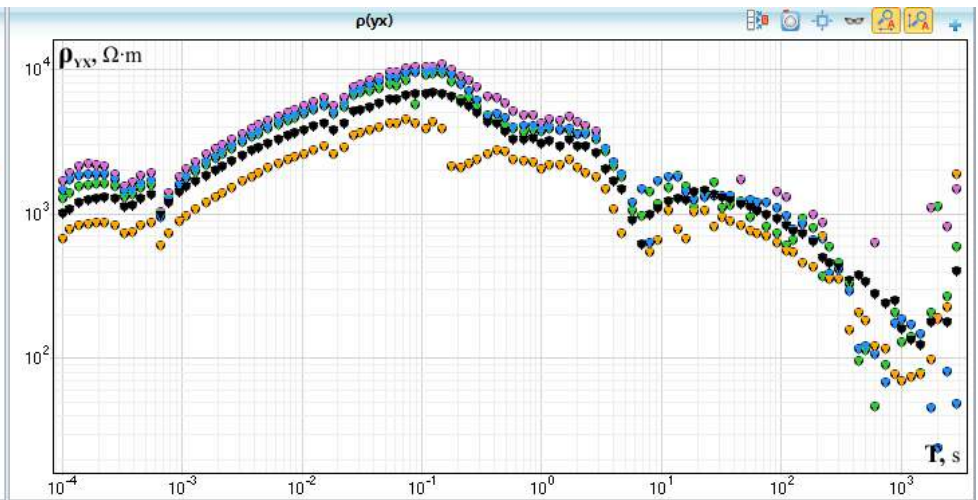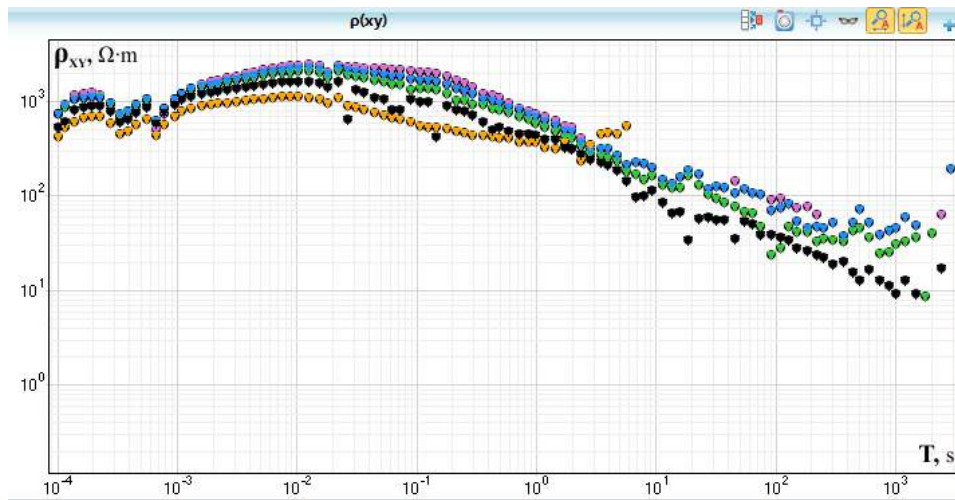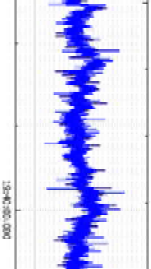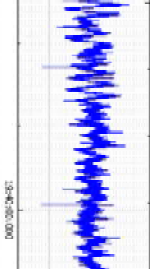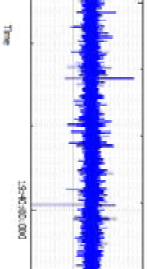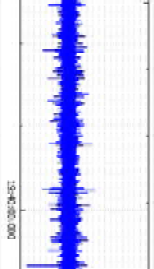

APPENDIX IV

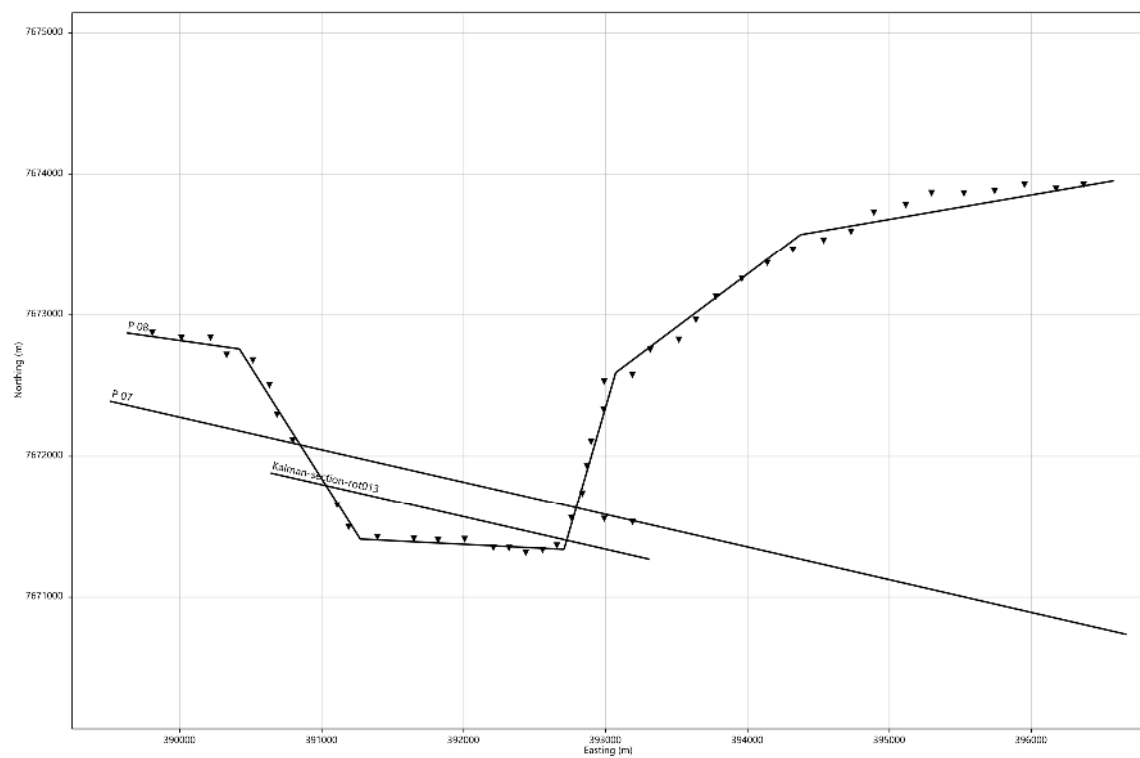Plots of Receiving Equipment Parallel Test: Principal Component Responses
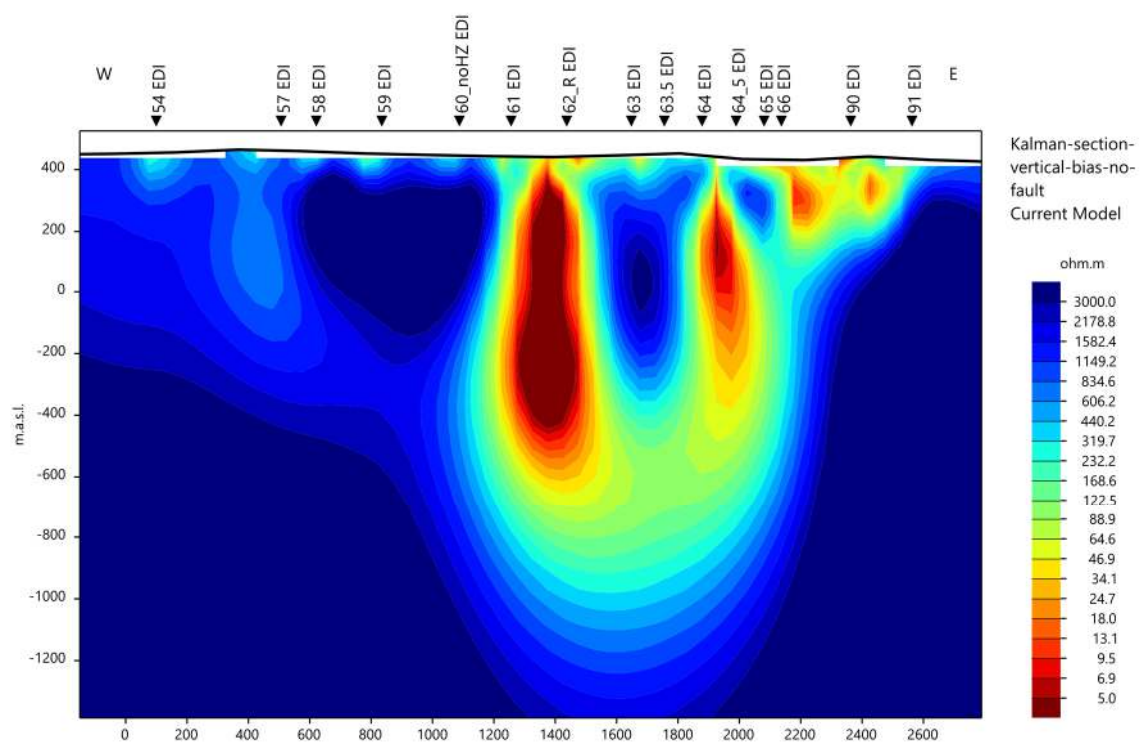
APPENDIX V

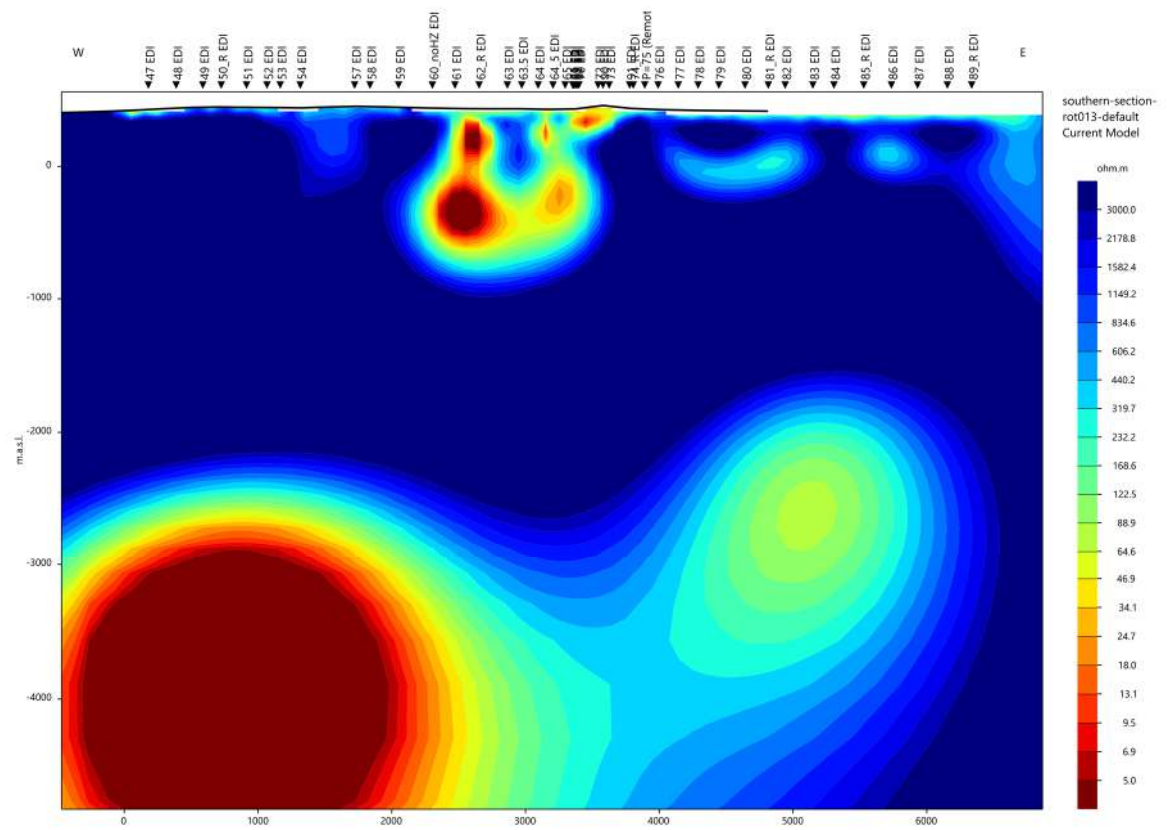Example of Time Series Data
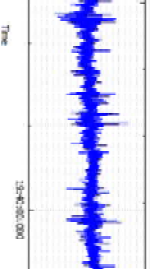
APPENDIX VI
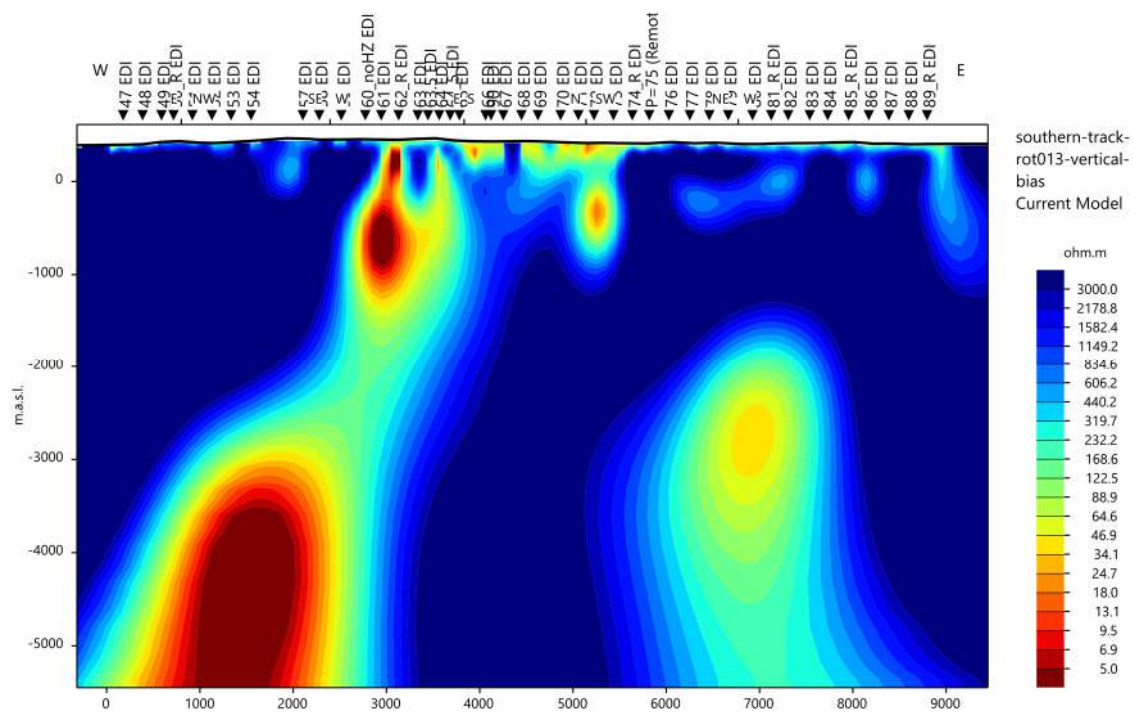
2D Inversion Model Sections
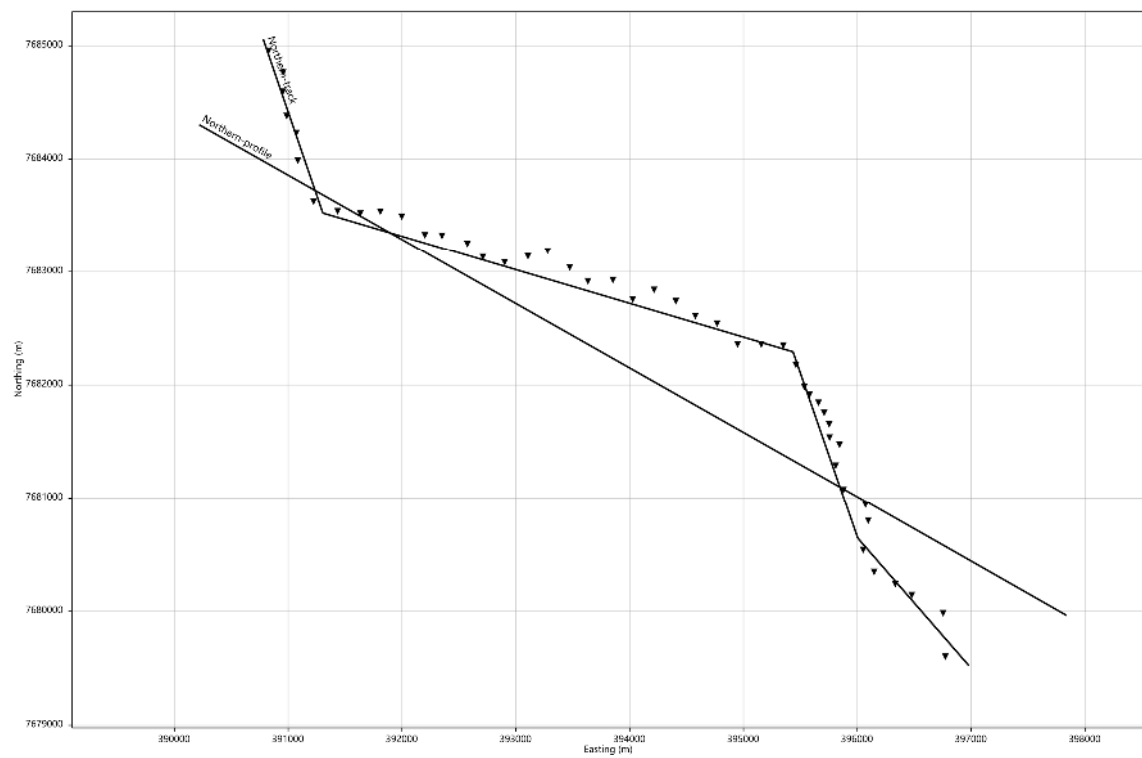
Southern profile model sections
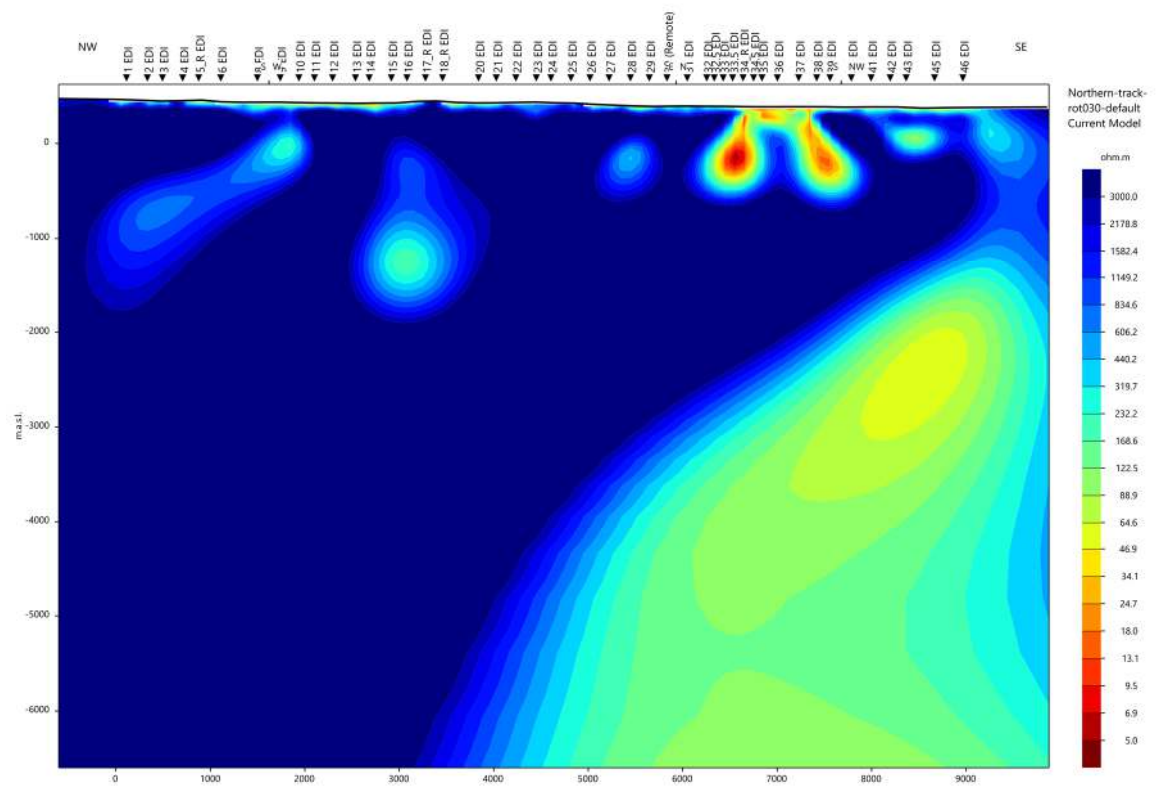
Kalman section with vertical bias
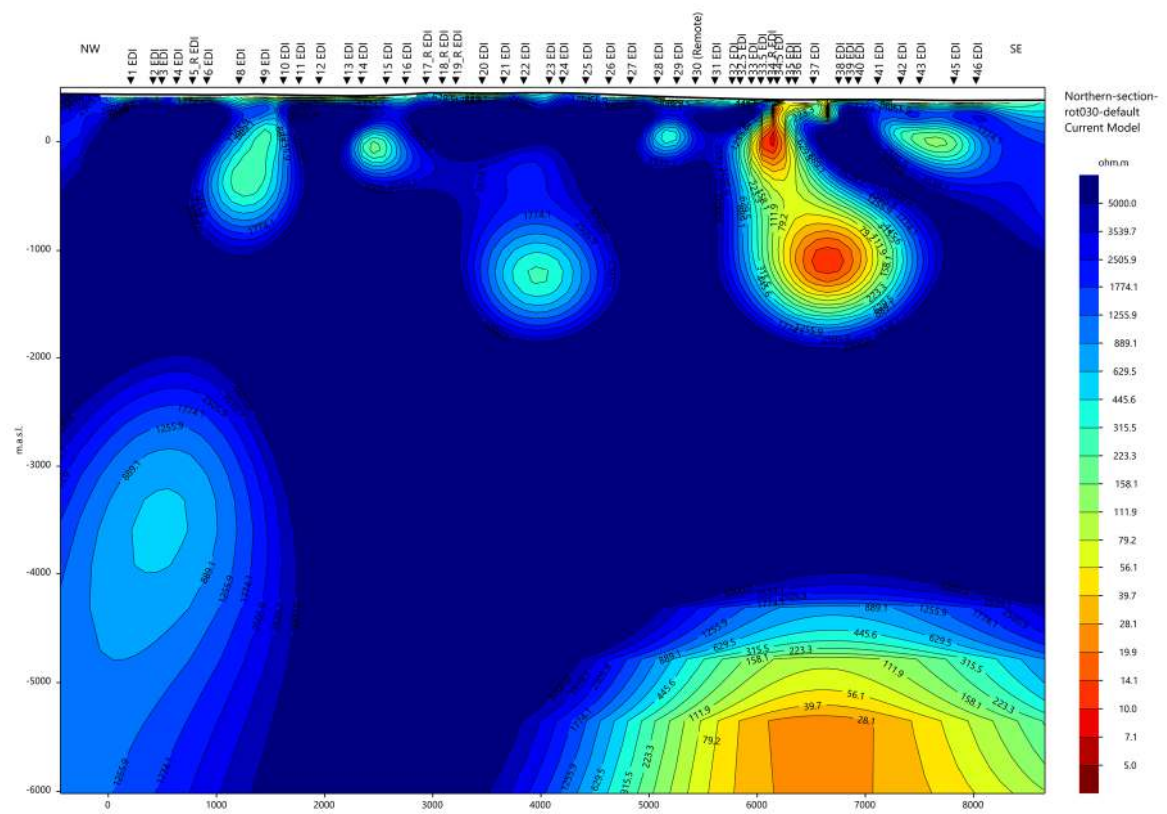
Southern track model (P08)

Southern track model with vertical bias (P08)

Northern profile model sections

Northern track model

Northern profile model