Geological Survey of Queensland

Acquisition report for the CF23 magnetotelluric survey

GSQ Technical Notes — TN2021/05

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Summary

From April to June 2021 the Geological Survey of Queensland (GSQ) mobilised a four-person geophysics field crew to the townships of Winton, Boulia and Bedourie, QLD. The crew collected a magnetotelluric survey as part of the New Economy Minerals Initiative of the Queensland Government. The work was undertaken with the support of Geoscience Australia. The survey was planned and undertaken under the management of Dr Janelle Simpson.

The GSQ borrowed six sets of Phoenix MTU-8A receiver systems, together with induction coils and Pb-Cl electrodes from Geoscience Australia. Geoscience Australia staff also provided training to the field crew on instrument deployment and data processing.

Acquisition of 102 sites of broadband and audio MT data occurred during a continuous block of work between 19 April and 12 June. Site spacing was approximately 10 km. Sites were located along the major road, approximately 500 m from the road to minimise the impact of traffic noise. Time series data (five channel) were recorded at each site consisting of two orthogonal electric and three orthogonal magnetic field measurements. Sites were generally deployed for two nights providing data in the range of 10^{-4} to 10^{3} seconds.

Data quality was monitored throughout the survey by the field crew. Where the acquired data were not of sufficient quality, sites were repeated where possible. Data were generally of high quality despite a high percentage of days having low signal strength due to solar minimum conditions. Some sites have poorer quality data through the “dead band”, around 1 to 20 s. This can generally be attributed to cultural noise near towns, thunderstorm activity or animal disturbance leading to a shorter usable recording period.

Sites for this survey were collected on the traditional lands of the Koa, Miaiwali, Pitta Pitta, Wangkamahdla, Mithaka, Bularnu Waluwarra & Wangkayujuru and Wangkangurru & Yarluyandi peoples. Traditional Owner engagement in the project was determined though negotiation with each group.

Metadata summary table

Project name	CCAMT
Survey name	CF23 MT
Survey PID	MT100164
Number of sites	102
Site spacing	Approx. 10 km
Average record time	44 hours
Typical bandwidth	10^{-4} to 10^{3} s
Survey start date	April 19 2021
Survey end date	June 12 2021
Instrumentation	Receiver: MTU-8A Horizontal coil: MTC-150L Vertical coil: MTC-180L Electrodes: Phoenix PbCl pots
Operator	Geological Survey of Queensland
Collaborator	Geoscience Australia
Time series data format	Phoenix binary format *td_24k; *td_150 Binary Time series data
Processed data format	.edi
Survey job number	GSQ202101
Deployment style	Cross-shaped array; x: magnetic north; y: magnetic east
Dipole length	100 m
Channels acquired	Hx, Hy, Ex, Ey, Hz
Average signal strength (Ap index)	7
Declination	+6.5

Table 1. Survey metadata

Project background

This MT acquisition project was collected under the New Economy Minerals Initiative of the Queensland Government by staff of the GSQ and GA. The project is phase one of a two-phase MT program that is aimed at characterising the Carpentaria Conductivity Anomaly (CCA).

Support for the project was provided by GA in the form of MT equipment and training.

The CCA is potentially analogous to the large lower crustal conductor imaged by MT under the Olympic Dam deposit. The CCA has been imaged in proximity to the Ernest Henry Mine to the north of the project area and modelling suggests the deep conductor is connected to a shallower one which is spatially associated with the mine. Consequently the CCA's location and extent is of interest for explorers interested in Iron Oxide Copper Gold style mineralisation.

The project (CF23 MT), including landholder and Traditional Owner engagement ran from October 2020 to August 2021, with acquisition occurring between April and June 2021. The newly collected data is complementary to deep crustal seismic reflection data collected between 2014 and 2015 by the GSQ in collaboration with GA.

The MT sites span an area between Winton, the Northern Territory border and Birdsville in western Queensland. The sites are located along the major roads in the area. This project area encompasses the southern part of the Proterozoic Mount Isa Province as well as the adjacent Thomson Orogen. Prospective crystalline basement for the whole project area is covered by sediments of the Eromanga and Georgina Basins.

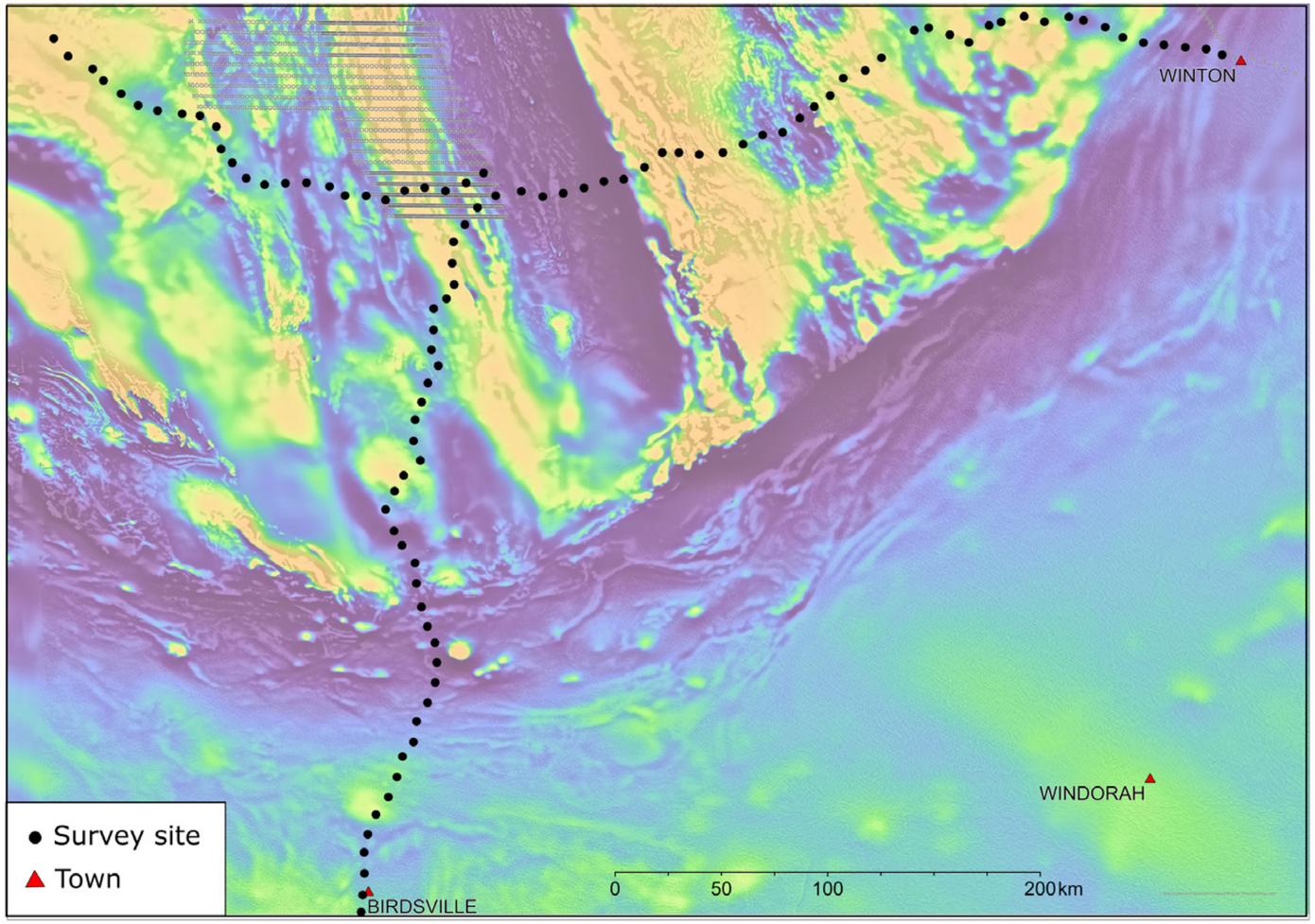

Figure 1. Survey location. Sites displayed relative to regional magnetic data.

Acquisition specifications – instrumentation

MTU-8A receivers are 8-channel systems for collecting MT data over a wide frequency band, designed and manufactured by Phoenix Geophysics in Canada. These receivers are stand-alone, GPS-synchronised modules designed to record up to 6 channels of magnetic data and two channels of electrical data. These receivers can simultaneously record data at 24k Hz and 150 Hz sampling rate, allowing collection of data with a bandwidth of 10^{-4} to 10^{3} s.

The Phoenix MTC-150L coils were used for the horizontal magnetic field acquisition and the shorter MTC-180L coils used for the vertical magnetic field data.

Phoenix nonpolarizing Pb-Cl electrodes were used for the electrical field data acquisition. Equipment was powered using 12V batteries that were recharged each night.

Figure 2. MTU-8 receivers

Acquisition specifications – field layout

At the start of the survey all receivers and coils to be used on the survey were set up in a parallel test to calibrate the equipment and ensure consistent measurements and functional operation of all senors and receivers. Results from the parallel testing are provided in the data package.

Each deployment site consisted of two E-field (Ex and Ey) dipoles and three H-field (Hx, Hy and Hz) components. Each site was set up using the configuration shown in Figure 3. Electric dipoles were measured to be 100 m. For each site deployment, Hx was oriented to magnetic north and Hy to magnetic east. Magnetic declination was imported into the receiver setup so that processed data is oriented relative to true north.

The inbuilt GPS provided location and timings of the recordings. Each receiver recorded constantly from deployment to collection using two different sampling rates to provide both low and high frequency data.

Time series data were copied off the SD card onto a dedicated hard drive upon pickup for processing. All magnetic and electric field sensors were buried for protection from movement and temperature variations. Receivers were remote referenced to a co-deployed site at least 20 km away.

At each site a handheld petrol auger was used to dig the hole for the vertical magnetic sensor (Hz). In some areas, the sensor could not be completely buried due to subsurface rock layers preventing the hole from reaching the required depth. In these instances the coil was buried as deep as possible and the exposed part of the coil was covered by an inverted plastic bin that was filled with soil to minimise wind noise.

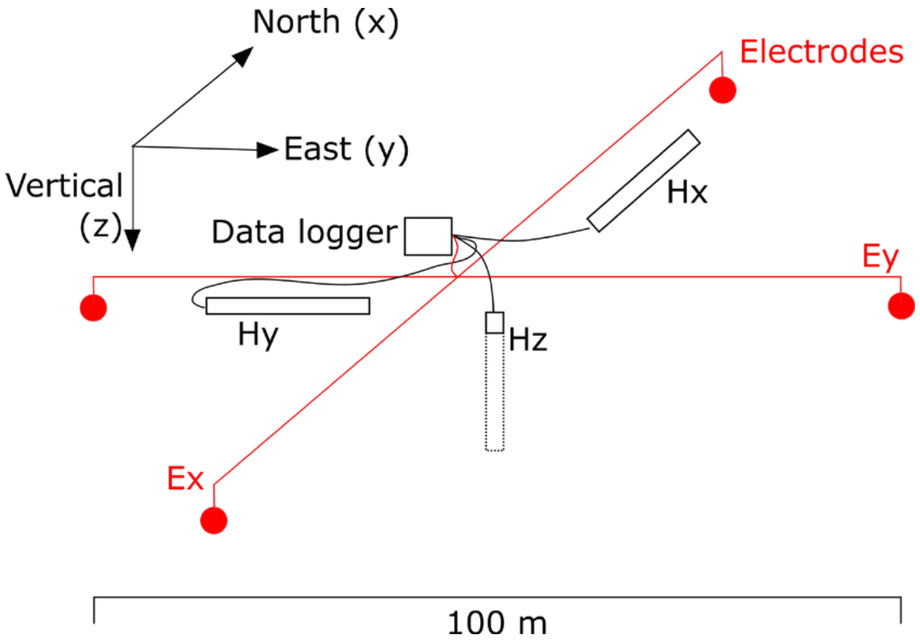

Figure 3. Site setup schematic and photo

Acquisition program

The acquisition was conducted from four base camps – Winton, Boulia, Tobermorey and Bedourie. Sites were deployed for 24 to 48 hours with a strong preference for two nights of recordings. Some sites have longer records due to survey logistics.

Parallel testing and calibrations were conducted at site BW620. Two of the six recording units failed to pass initial testing due to failure to record one of the electrical channels. Production was limited to two sites per day for the first part of the survey as only four systems were available. The recorder issues took a few weeks to resolve, after which production increased to 3-4 sites per day.

Because of the broad site spacing of the survey, a dedicated remote reference was not used. Instead the survey logistics were arranged such that two sites recording concurrently were not adjacent (i.e. minimum spacing between concurrently recording sites ~20 km).

Data processing

Raw time series data from the field were extracted from each receiver and processed using the Phoenix EMpower software. This software allows the operator to review data, edit time series, review calibrations and apply filters and perform basic editing operations. Remote reference station data were applied at this stage to assist with noise reduction. A magnetic field declination value of 6.5° was used in processing to allow EMpower to provide files rotated to true north.

The time series data were assessed in detail during processing to identify areas of noisy data and any disturbance of the site not detected during pickup. The start and end of all time series data were clipped during processing to remove noise associated with vehicle and crew movements on deployment and pick up.

Generally the remote reference for each site was the longest concurrent recording site. Where more than one concurrent site was available, the site with the cleanest data as assessed by the processer was used as the remote. Alternative remote sections were tested during processing as appropriate. The details of remote selection, data quality and any clipping applied to the time series applied during processing can be found in the provided processing notes.

A filtered version of the edi file is provided in addition to the unedited version of the processed data.

Final data

Site names are denoted either ‘BW’ or ‘BB’ to indicate sites collected on the east-west (border to Winton) or north-south (Birdsville to Boulia) lines respectively. Site numbering starts in the west for the ‘BW’ line and in the south for the ‘BB’ line.

The data package contains the preferred edis as a single folder. The best edi as judged by the processor was selected from either the unedited or robust processing streams for each site. These edi files have all long period data as processed by the EMpower software, no clipping of the long period or dead band data was completed. Modellers should take this into account and clean the data as suits their modelling aims. The complete sets of unedited and robust edis are also provided for comparison.

Acquisition and processing notes for all the sites are contained in the provided spreadsheet.

Data quality is generally higher for sites on the BW line, due to thunderstorm activity during acquisition of some of the BB sites.

Tipper data are generally fair quality, though typically more noisy than than the horizontal magnetic data.

Processed and time series data are both available for this survey.

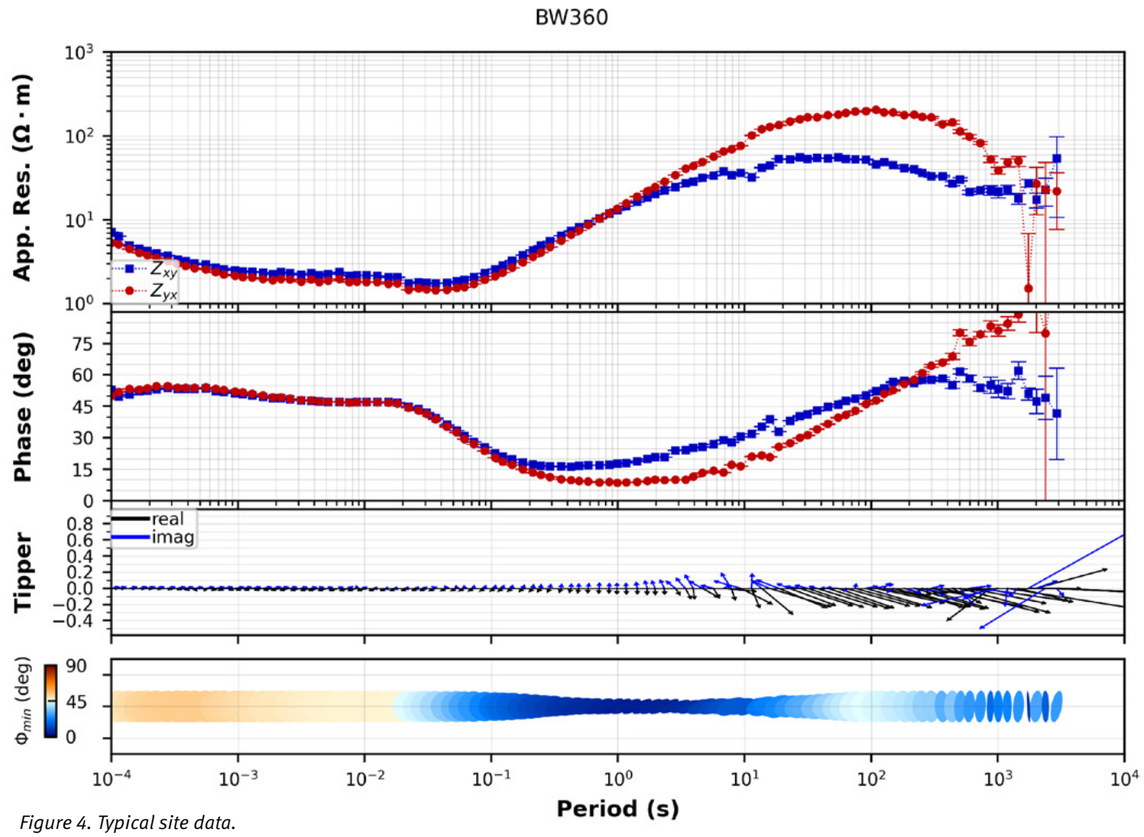

Figure 4. Typical site data.

Apparent resistivity and phase data

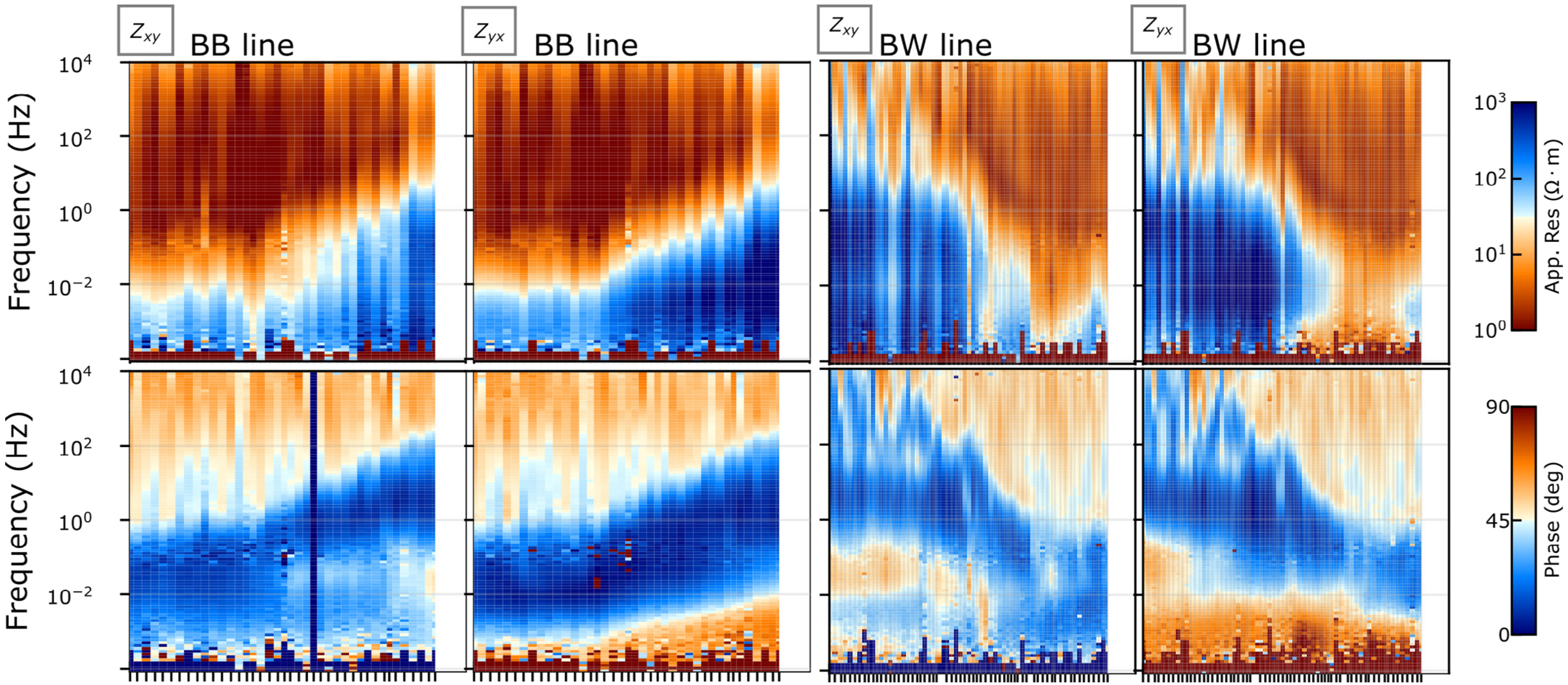

Figure 5. Apparent resistivity and phase plots for the BB north-south (left) and BW east-west (right) profiles. Note increased noise around 10 s for sites on the southern end (left) of BB line due to a combination of thunderstorm activity during recording and the MT dead band. Clean data to 1000 s is evident at most sites.

Phase tensor plot

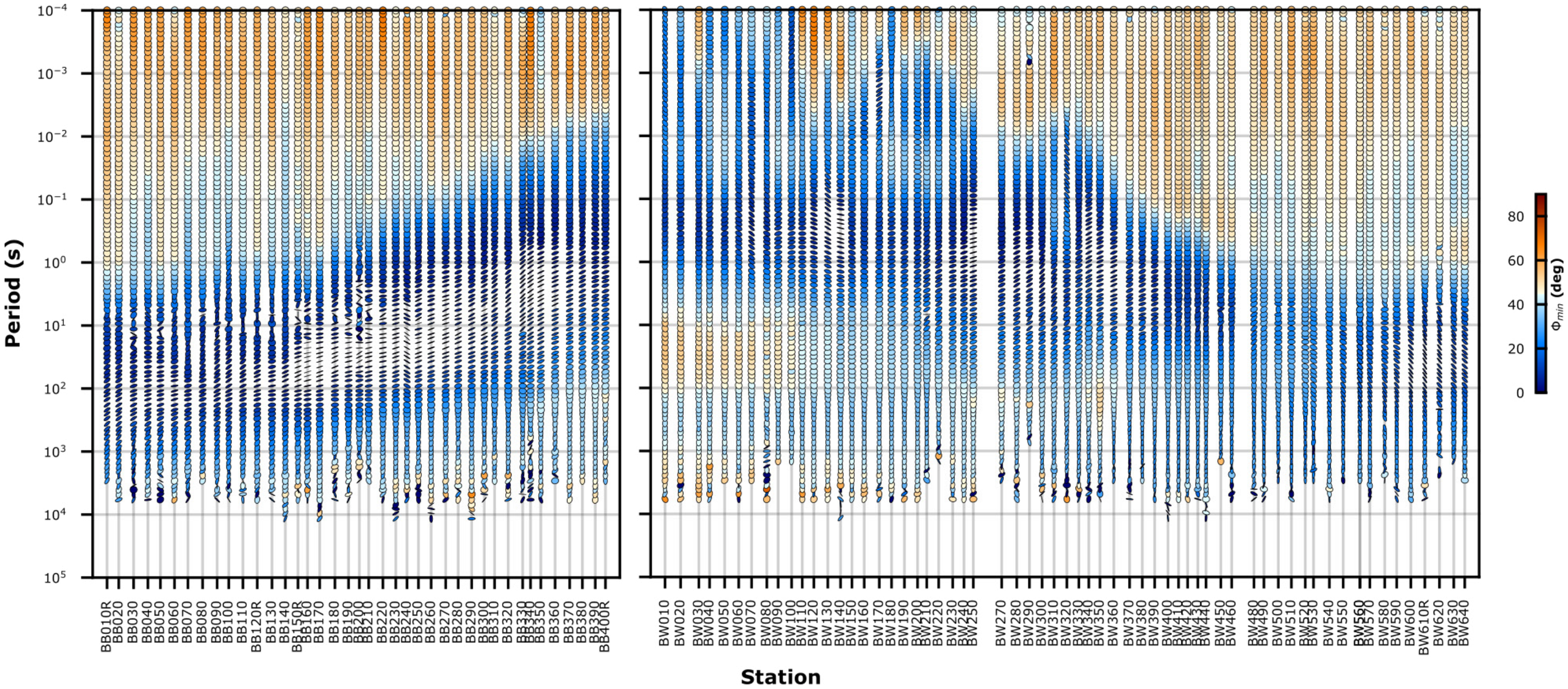

Figure 6. Phase tensor plots for the BB north-south (left) and BW east-west (right) profiles. Note increased noise around 10 s for sites on the southern end (left) of BB line due to thunderstorm activity during recording. Clean data to 1000 s is evident at most sites.

Induction arrow plots for tipper data

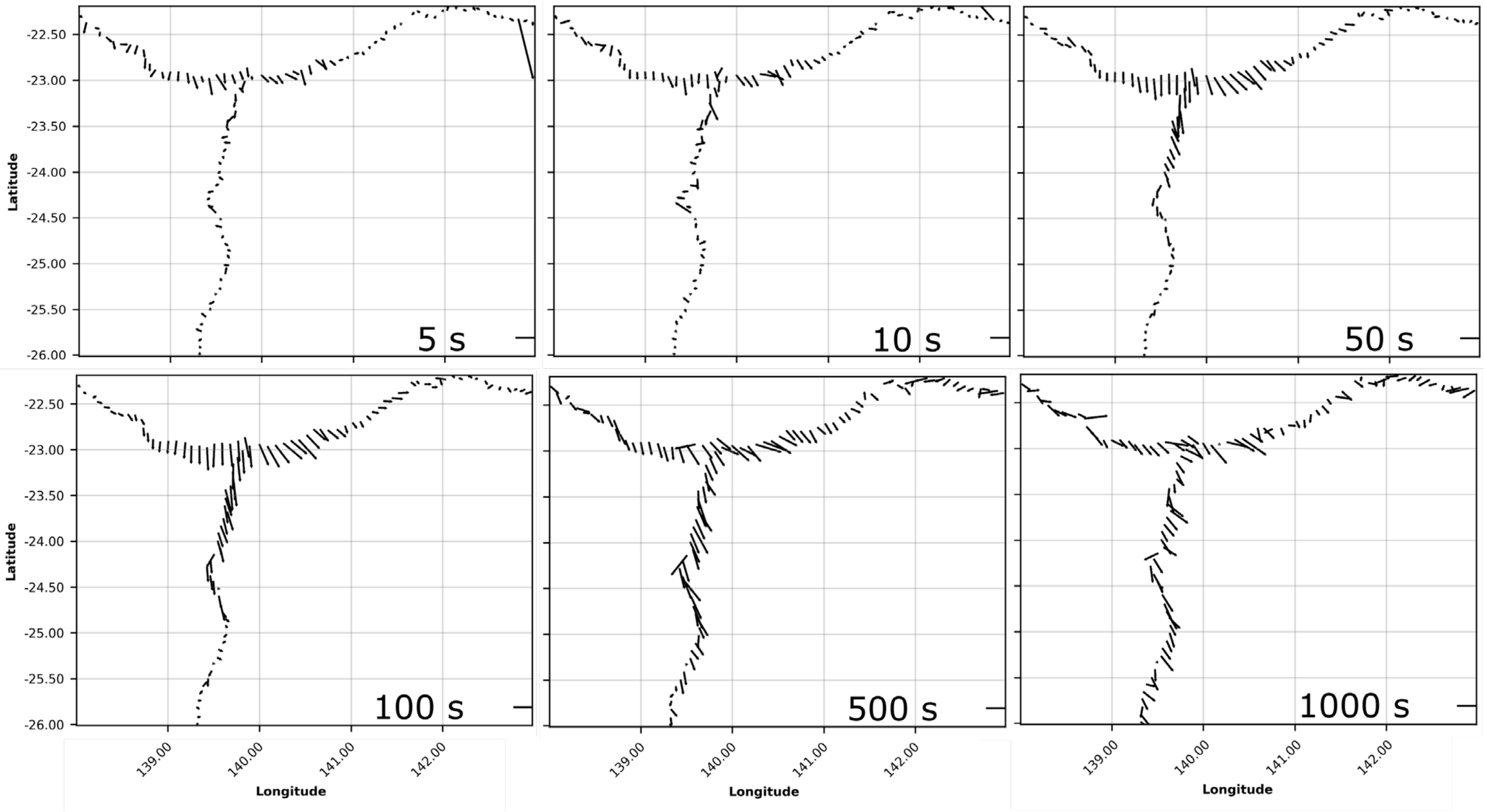

Figure 7. Induction arrow plots for the survey data. Note increased noise at 1000 s.

Preliminary inversions

Data along the north-south oriented BB line is not able to be modelled in 2D due to the data being collected at a high angle to the geoelectric strike of the geology. A handful of Occam2D inversions were run to test the quality of the results from the BW line. A typical inversion result for data is displayed below and the inversion parameters are provided in Table 2.

Cell size	2500 m
First layer thickness	20 m
Model depth	Mesh core 70 km + 350 km padding
Error floor	Res: 5% Pha: 2.5%
Bandwidth used	$10^{-2.3}$ to $10^{1.7}$ s
Layers	56
Starting resistivity	50 Ohm.m

Table 2. Inversion parameters

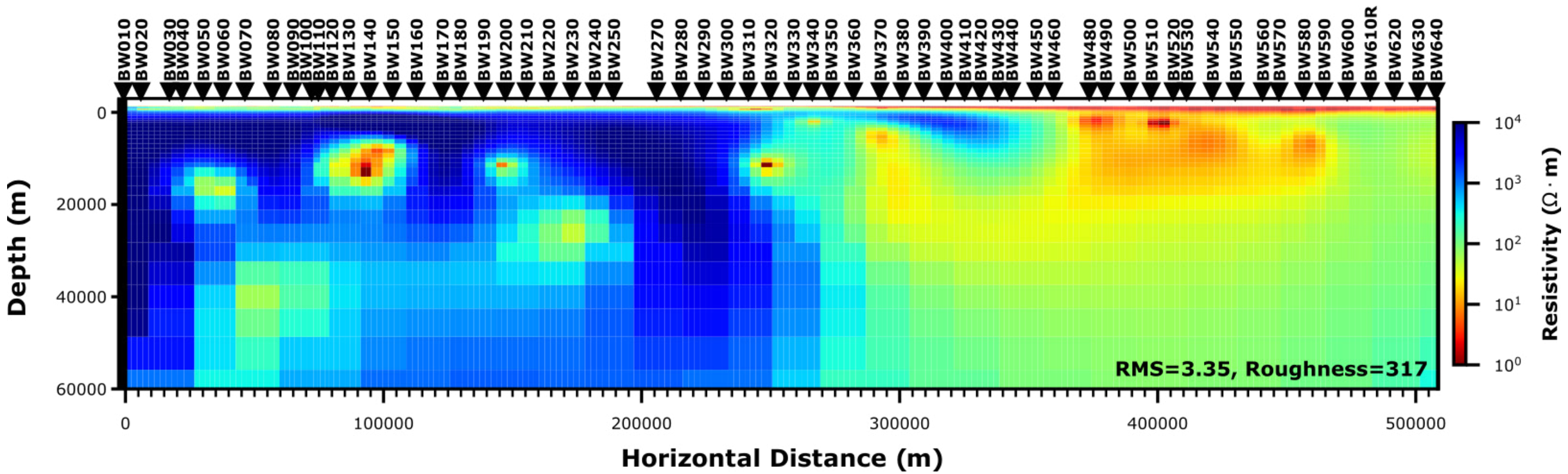

Figure 8. Occam 2D inversion result for BW data.