Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP): New South Wales

Data Release Report (Phase One)

GEOSCIENCE AUSTRALIA
RECORD 2020/11

Darren Kyi[1], Jingming Duan[1], Alison Kirkby[1], Ned Stolz[2]

1. Geoscience Australia
2. Geological Survey of New South Wales

Department of Industry, Science, Energy and Resources
Minister for Resources, Water and Northern Australia: The Hon Keith Pitt
Secretary: David Fredericks PSM

Geoscience Australia
Chief Executive Officer: Dr James Johnson
This paper is published with the permission of the CEO, Geoscience Australia

Geoscience Australia acknowledges the traditional custodians of the country where this work was undertaken. We also acknowledge the support provided by individuals and communities to access the country, especially in remote and rural Australia.

ISSN 2201-702X (PDF)
ISBN 978-1-925848-79-3 (PDF)
eCat 132148

Bibliographic reference: Kyi, D., Duan, J., Kirkby, A., Stolz, N. 2020. *Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP): New South Wales*: data release report. Record 2020/11. Geoscience Australia, Canberra. http://dx.doi.org/10.11636/Record.2020.011

Version: 1901

Contents

Executive Summary

The Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP): New South Wales (NSW) magnetotelluric survey is an ongoing collaborative project between the Geological Survey of New South Wales (GSNSW) and Geoscience Australia.

There are approximately 320 sites planned on half degree grid spacing within the state of NSW in south-eastern Australia. Phase one of long period magnetotelluric data acquisition began in 2016 and, as of June 2020, 224 sites have been completed.

This record outlines the field data acquisition, data QA/QC, and data processing methodologies relating to the 224 sites released in phase one. The data are released in EDI format containing impedance estimates and transfer functions for each processed site. This record assists users of the AusLAMP NSW data in understanding the lineage of the data and derived products such as conductivity models. A separate publication will provide information on data analysis, data modelling/inversion and data interpretation.

The remaining data will be released upon completion of phase two acquisition, processing, data QA/QC, and interpretation. The ongoing acquisition in 2020 has been delayed from March due to temporary suspension of field activities in response to the COVID-19 non-essential travel guidance.

1 Introduction

The Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP) is a collaborative, multi-year project between the Australian Federal and State Governments, and research organisations. This project will acquire long period magnetotelluric (MT) data at approximately 3000 sites across the Australian continent at a nominal 0.5° x 0.5° (~55 km) station spacing (Figure 1). This national scale MT survey aims to map the electrical resistivity of the continent in three dimensions. The project will provide significant additional information about Australia's geodynamic framework as well as valuable pre-competitive data for resource exploration. The project aims to improve understanding of the lithospheric structure, how geological processes work and the geological makeup of the region; and how large-scale crustal and lithospheric structures control mineral deposition and hydrocarbon basin formation in the region. AusLAMP New South Wales is a collaborative project between the Geological Survey of New South Wales (GSNSW) and Geoscience Australia. GSNSW has provided the funding, managed land access and assisted with field data acquisition. Geoscience Australia has provided in-kind contributions; project management, data acquisition, data processing and data QA/QC.

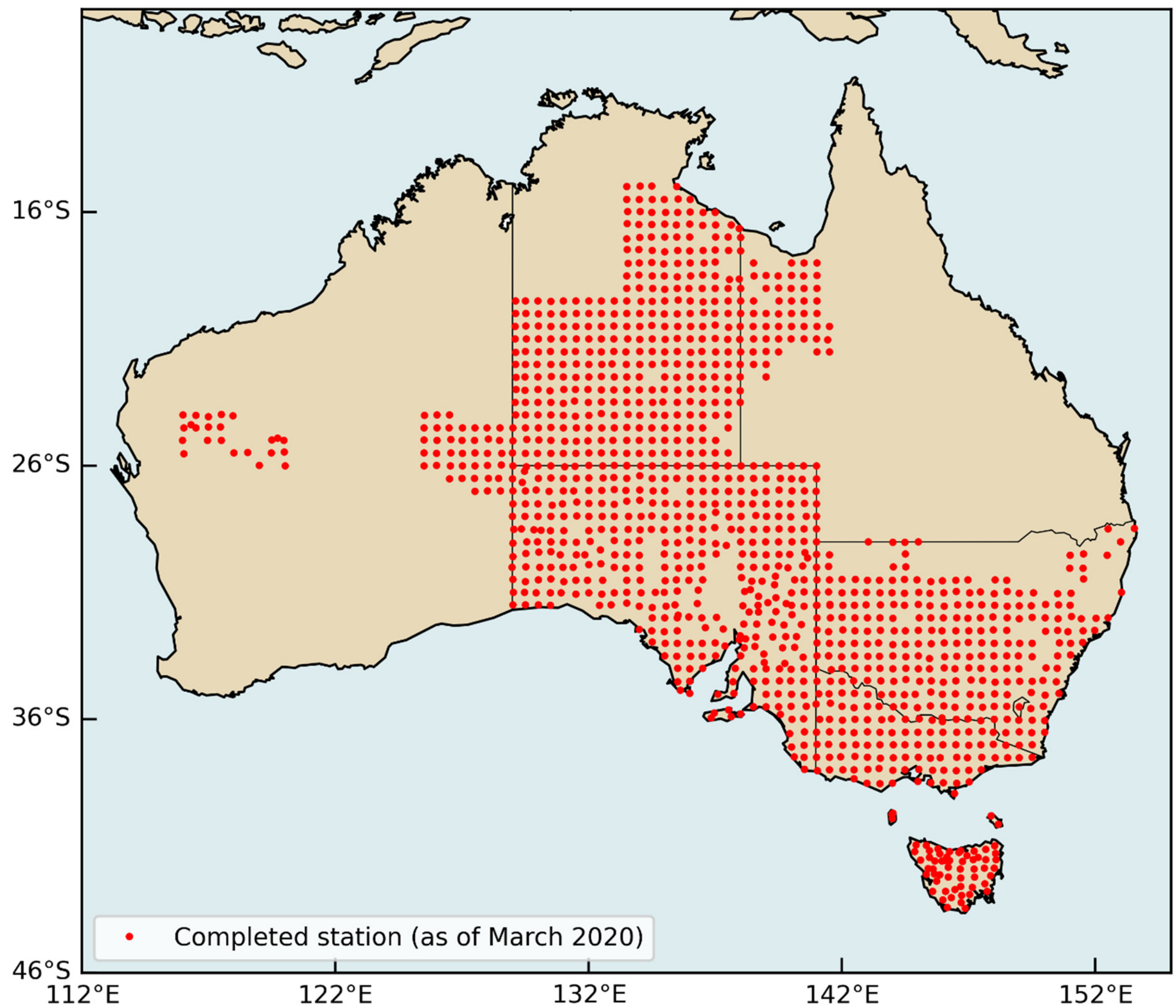

Figure 1: AusLAMP status at March 2020 showing the location of completed stations. The partners involved in this collaborative project are: AuScope, Geological Survey of NSW, Geological Survey of QLD, Geological Survey of South Australia, Geological Survey of Tasmania, Geological Survey of Victoria, Geological Survey of Western Australia, Northern Territory Geological Survey, The University of Adelaide, The University of Tasmania, and The University of Western Australia.

2 Description of the MT method

The MT method is a passive electromagnetic geophysical technique that utilises natural variations of the Earth's magnetic and electric fields to investigate the electrical resistivity distribution of the subsurface from depths of tens of metres to hundreds of kilometres. The MT source fields are generated by world-wide thunderstorm activity (mainly lightning discharges at frequencies above 1 Hz) and the interactions between the solar wind and the Earth's magnetic field in the magnetosphere and ionosphere (at frequencies less than 1 Hz). These sources provide a rich spectrum of electromagnetic fields suitable for crust and upper mantle studies. A detailed description of the MT method, including mathematical derivation, can be found in Chave and Jones (2012), Simpson and Bahr (2005), Vozoff (1972; 1991) and other references in the literature.

Under the plane wave source assumption, the horizontal electric field (E_x, E_y) in mV/km and magnetic field (B_x, B_y) in nT have a frequency-dependent linear relationship via a tensors (M) following the notation of Weaver et al (2000):

$$E_x = M_{xx}B_x + M_{xy}B_y \tag{1}$$

$$E_y = M_{yx}B_x + M_{yy}B_y \tag{2}$$

The M tensors are in units of mV/km.nT. The relation to impedance tensors in ohms is

$$Z = \mu_0 M = \mu_0 \frac{E}{B} \tag{3}$$

where μ_0 is the permeability of free space.

The apparent resistivity $\rho_a(\omega)$ provides a ball-park estimate of the Earth's electric properties. It has the units of ohm-metres (Ωm), which is related to the amplitude of the impedance tensor

$$\rho_a(\omega) = \frac{1}{\omega\mu_0}|Z(\omega)|^2 = \frac{1}{\omega\mu_0}\left|\frac{E}{B}\right|^2 \tag{4}$$

Where ω =2π f is the angular frequency of the fields.

This formulation is based on the quasi-static approximation for the impedance and assumes the magnetic permeability of the Earth is approximately the same as the permeability of free space, μ0. It is possible to estimate the electrical resistivity of a medium, if perpendicular components of the electric and magnetic fields are known within a medium. For a half-space model, the Earth's true resistivity is equal to the apparent resistivity.

Phase is the difference between the electric and magnetic fields, which can be obtained from impedance. Expressed as phase angle, ∅ in degrees is

$$\emptyset = tan^{-1}\frac{Im\, Z(\omega)}{Re\, z(\omega)} \tag{5}$$

The electric field always leads the magnetic field. If electrical property variations are 1D there is a phase difference of 45°. In many situations, phases exceeding 45° correspond to geoelectric structures in which resistivity decreases with depth and phases of less than 45° correspond to resistivity increasing with depth.

The vertical magnetic field transfer functions (VTFs) give the linear relationship between induced vertical magnetic component B_z and horizontal components B_x and B_y of the source field in the frequency domain (Simpson and Bahr, 2005). The induction vectors in Parkinson convention point towards conductive bodies or away from resistive bodies. The length of the arrow is determined both by the magnitude of the anomaly and its distance from the sounding site, with range increasing for longer periods.

$$B_z = T_x B_x + T_y B_y \tag{6}$$

VTFs are often represented as complex induction vectors (or induction arrows)

$$T_z = T_x \hat{\boldsymbol{x}} + T_y \hat{\boldsymbol{y}} \tag{7}$$

Where $\hat{\boldsymbol{x}}$ and $\hat{\boldsymbol{y}}$ are the unit vectors in the geographic north and east direction respectively.

The MT method has been well established and widely used for mineral, petroleum and geothermal exploration, and crust and mantle lithospheric studies. One advantage of the method is that it allows depths of investigation up to and greater than 100 km and hence is useful for understanding crustal-scale structures and tectonic evolution. The penetration of an electromagnetic field into a medium depends on the medium's electrical conductivity and the frequency of the variations in the electromagnetic field. Lower frequencies penetrate more deeply than high frequencies. Higher sub-surface conductivity reduces penetration at a given frequency. Very deep signal penetration requires measuring very low frequencies. These are captured by recording signals for long periods of time, in this case, several weeks. The electrical properties at different depths can be estimated approximately by measured electric and magnetic fields at a given frequency.

3 Data Acquisition

3.1 Survey planning and land access

Initial site location planning was a nominal 0.5° x 0.5° latitude-longitude grid spacing across NSW. Site location could then be adjusted to work around Cultural Heritage areas or restricted areas at the access permission stage. An area of 100 x 100 m with clear, flat ground is preferred to set up the electrode array but consideration was also given to fire and flood risks in the area. Sites were chosen to be as far as practicable from noise sources such as power lines, pipelines, pumps, and human or animal activity. Final location decisions were made in conjunction with field crews at site and landholder preferences. Sites could be moved up to 5 km from the nominal 0.5° grid without compromising the spatial resolution of the survey.

The MT survey is a low impact activity with minimal ground disturbance, however, there was still significant work involved in gaining land access permissions. Overarching access permission was granted under section 250 of the *Mining Act 1992*, but further permission was sought from the relevant parties for each individual site. Sites that were within NSW National Parks were acquired under a scientific research permit and sites in State Forests were acquired under permit from Forestry Corporation of NSW. Sites within Crown Lands were conducted through permission of the Crown Leaseholders while sites on private land were acquired with the specific permission of each of the private landholders.

GSNSW arranged initial land access permissions for the majority of the sites and then field crews made further contact to arrange specific access requirements with individual parties. Before selecting a prospective site, the Aboriginal Heritage Information Management System was interrogated and the site was moved if any presence of Aboriginal cultural heritage was indicated. On arriving at the field location, the crew completed a site-specific safety check to identify terrain, vegetation, animal or other potential hazards. If a field crew observed signs of cultural heritage on site they would not proceed with the deployment and the site location would be adjusted.

All of the landholders: traditional, private, and government, are thanked for their support in acquiring these data.

3.2 Instrumentation

Data acquisition was carried out using LEMI-424 instruments owned by Geoscience Australia. This system (Figure 2) consists of a data logger, electrode junction unit with lightning protection, and a LEMI-039 three component fluxgate magnetometer (Figure 3). The instrument was housed in a weatherproof case and powered with a deep cycle 12 V battery charged by a 40 W solar panel. Four electrodes (Cu-CuSO4 solution suspended in clay compound) were connected back to the recorder by cables and a brass ground stake was installed near the data logger.

The 32 bit resolution data logger with in-built GPS module recorded three magnetic field components and up to four electric field components simultaneously at 1 sample per second, as well as diagnostic information such as temperature and input voltage. Data are stored on SD cards in ASCII format with time and location information recorded for each sample.

The three-component fluxgate magnetometer (LEMI-039) is hermetically sealed by silicon compound for protection against dust and moisture and was deployed in an acrylic housing for added protection.

The magnetometer has a measurement range of ± 65000 nT within the frequency band of DC-0.5 Hz, with low noise and minor temperature drift. A thermometer is built into the magnetometer housing to monitor temperature and allow data to be corrected for magnetometer thermal drift.

The LEMI-701 non-polarising electrode is low noise, has minor temperature drift and has low environmental impact. The electrodes have porous ceramic contacts and contain Cu-CuSO4 solution suspended in a clay compound which is able to provide electrical stability over several weeks. Matched pairs of electrodes have achieved low drift of 50-60 µV over four months during experimental tests.

Figure 2: Geoscience Australia's typical LEMI acquisition system. The weatherproof plastic case contains an acquisition unit, an electric line junction box, a GPS antenna and a battery. A solar panel is attached to the case to charge the battery.

Figure 3: A LEMI-039 magnetometer housed in a clear acrylic protection housing. Note that the cap has been temporarily removed from the housing for clear display of the bubble level and magnetometer.

3.3 Data acquisition

Long-period MT data acquisition for AusLAMP NSW commenced in July 2016. The 224 sites released in phase one (Figure 4) were collected up to June 2020. The targeted recording length for each acquisition was 6 weeks with some recording for up to 9 weeks.

Detailed notes Appendix A) on equipment, layout, location, personnel, and contact information were taken for each acquisition site. This allowed equipment to be tracked throughout the project and assisted in data QA/QC and processing by providing important environmental context for the field measurements.

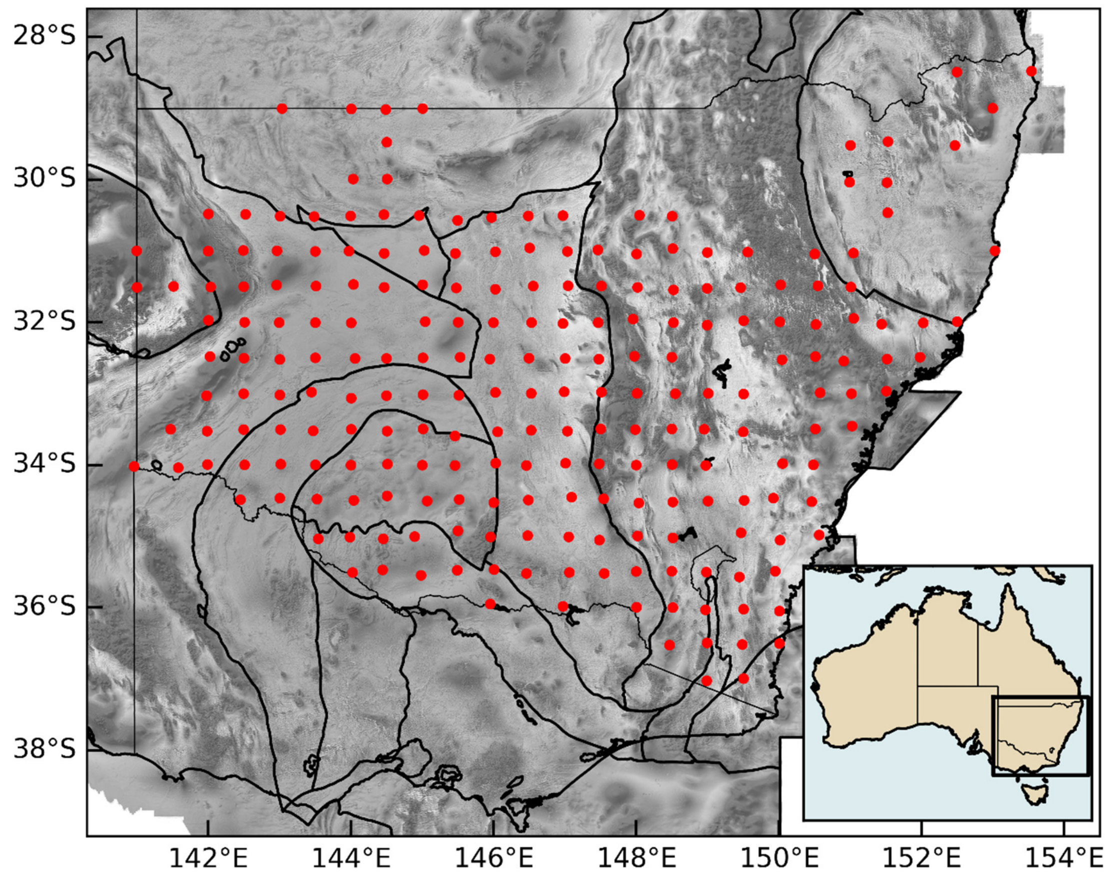

Figure 4: Location of the AusLAMP NSW project sites acquired within phase one of the data release from July 2016 to March 2020 over magnetic map of region (Geoscience Australia, 2015). Sites on, and 50 km east of, the NSW/SA border, were collected as part of the AusLAMP SA program (Robertson et al., 2016) and were only collected in this program if it was necessary to repeat the site. Geological province boundaries after Raymond (2018) shown in black.

Magnetic field channels are recorded at each site using the three-component fluxgate magnetometer (Figure 3), this records two orthogonal horizontal (Bx, By) and one vertical component (Bz). The magnetometer is oriented to magnetic north and buried in a hole about 60 cm deep to mitigate the effects of temperature, vibration and environmental and cultural noise.

Horizontal electric field components were measured through two orthogonal (E1, E2) 100 m dipoles with non-polarising copper/copper sulphate electrodes (Figure 5). An orthogonal cross layout was used with positive directions North and East (Figure 6). Dipole or segment lengths could be adjusted slightly (less than 30 m per segment) to allow for terrain or other constraints.

Figure 5: LEMI-701 Cu/CuSO4 electrode installed in a hole (before burying, shown at shallower depth for visibility).

Careful attention was given to electrode installation to ensure stable performance over long periods of time. Electrodes were buried in a hole about 50 cm deep and locations were selected to provide similar ground conditions (soil, moisture) across electrode pairs. Electrodes were installed in a mud slurry and angled to allow for escape of any accumulated gases that could impede good electrical contact with the ground. Burial of electrodes also prevents loss of moisture and protects against large temperature variations and disturbance by animals or people.

Dipole resistance and AC and DC voltages were measured when sites were deployed to check for installation or equipment problems and assess environmental noise at the site. These measurements were repeated when the site was retrieved to assess any significant variations during the deployment caused by changes in ground conditions or equipment damage.

At most sites the dipole and magnetometer cables were buried in shallow furrows to minimise wind noise and prevent damage from wildlife. At some sites this was not possible due to surface conditions or minimising ground disturbance in sensitive areas.

QA/QC of magnetotelluric time series data was carried out during the deployment and retrieval of each site to ensure that the equipment was operating correctly and that adequate signal and time series length had been recorded.

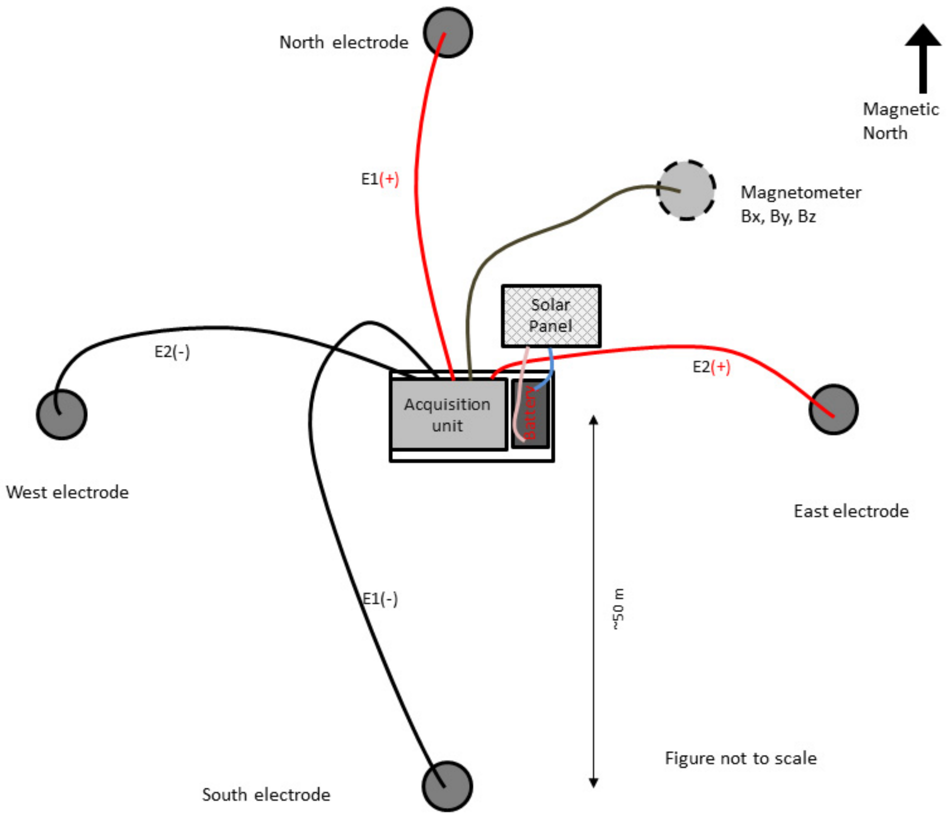

Figure 6: Top-down view of typical site layout for MT data acquisition. E – electric field sensor, B – magnetic field sensor. Ex (E1) and Bx are aligned with a North-South direction and Ey (E2), By with an East-West direction, Bz being vertical.

4 Data Processing

4.1 Data processing

Full time series data harvested from recording units was plotted and visualised (Figure 7), so that noise, outliers, and instrument or deployment issues could be quickly identified and assessed. Time series were then windowed to capture the longest time periods with minimal noise. Pre-processing also included removal of outlier spikes and corrections to recorded fields where instrument setup parameters may have been incorrect or needed to be adjusted to the as-installed setup.

Data quality was good for most sites with noise increasing near the more highly populated areas of the east coast and regional centres.

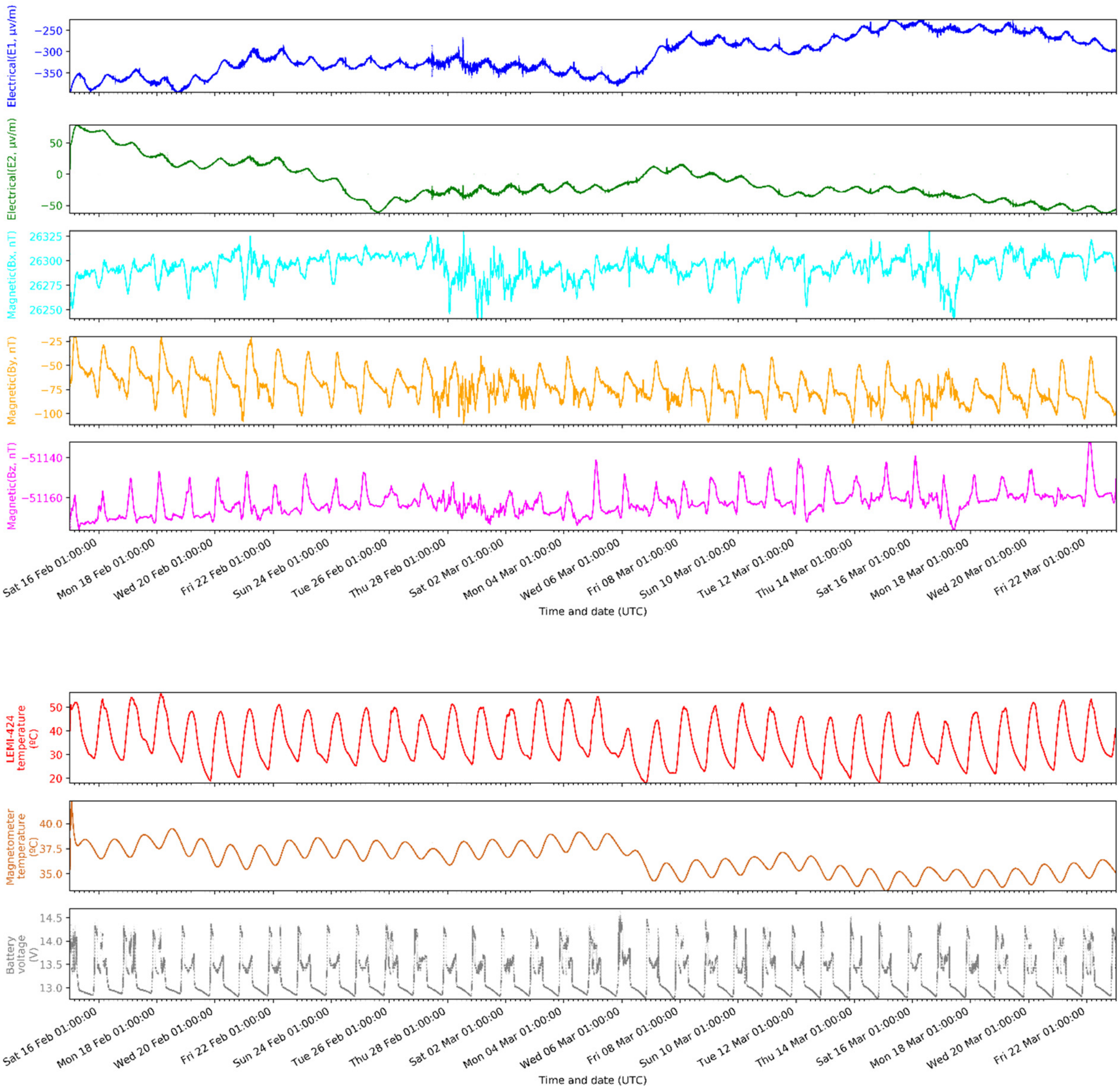

Figure 7: Plot of the simultaneous time series of the magnetic and electric field components at a site (H10) for 36 days. The temperature of the recorder and magnetometer and battery voltage for the recording period are also shown.

MT data processing is fundamentally a Fourier transformation of the electric and magnetic field time series data into the frequency domain to derive the complex impedance tensor of the subsurface. The impedance tensor links the horizontal components of electric and magnetic fields in the frequency domain and reflects the Earth's resistivity structure beneath the measurement point. The apparent resistivity and phase as a function of frequency are then derived from the impedance tensor. A summary of the processing workflow used for the phase one sites is provided in Table 1.

Table 1: Summary of processing workflow

Processing Stage	Details
Time series QA/QC	Plotting of time series (Figure 7)
Pre-processing time series corrections	Removal of artificial spikes, corrections to acquisition parameters and geometry as required, windowing of time series
Computation of four component impedance tensors and VTFs	Lemigraph software (Korepanov et al., 2014) using robust remote reference with coherence pre-sorting (Chave et al., 1987; 2004; Gamble et al., 1979). Apparent resistivity and phase are calculated from these impedance tensors.
Testing of other processing parameters or reprocessing	Pre-whitening to increase spectral stability, alternate reference stations, substitution of magnetics channels.
Rotation of processed data	Data are rotated to true north using declination for the site location from the Australian Geomagnetic Reference Field and stored in EDI format
QA/QC of processed data	As detailed in Table 3

The reference sites were chosen from the other sites acquired during a given acquisition period. Timing between sites was established via the GPS timestamps recorded for each sample. Different reference sites were often used on the same primary site for comparison and to improve the confidence in the final results. Optimum reference sites were selected based on the following criteria:

- Low noise (particularly on magnetic channels);
- Acquisition period encompasses or is similar in length to the primary site to ensure maximum intersecting time series is used;
- Greater than 100 km from the primary site to reduce the chances of coherent noise being present in both datasets.

Where possible, instrument layout errors or deviations from the standard deployment procedure were corrected for during or before data processing. These errors may include adjusted dipole lengths, orientation of orthogonal fields to an azimuth other than magnetic North, failed magnetic channels and incorrect date stamps due to GPS issues.

Sites were repeated (denoted with suffix 'R' after site names) if there were failures in the recording that prevented sufficiently long period signals being captured. This was usually caused by damage to the electrical dipoles within approximately the first two weeks of acquisition resulting in insufficient contiguous time series.

As the magnetic field does not vary significantly between adjacent sites, failures in the magnetic field channels at a site could be fixed by substituting from a nearby site. Where possible, the available local data were processed and compared with the results of the substituted site to evaluate whether any significant distortion was present at the common time windows. Usually all adjacent sites were tested and compared for consistency to provide further confidence in the final result. A summary of the affected sites and channels and the substituted sites is provided in Table 2:

Table 2. A summary of sites where some or all magnetic channels failed or were affected and the substituted sites. No tipper data was produced where the vertical field was affected.

Site	Issue	Action
J5	Magnetometer shifted after 5 days due to cable being pulled.	Used Bx/By fields from J6, Bz from J5 as vertical field did not appear significantly affected
K2	Magnetometer pulled out after 2 days	Used magnetic channels from K3
K18	Magnetometer moved/pulled out	Used magnetic channels from L18
G15	Magnetometer shifted after 6 days	Used magnetic channels from H15
H16	Magnetometer knocked off alignment after 5 days	Used magnetic channels from H15

4.2 Data quality control

The processed impedances and vertical magnetic transfer functions at period range of 15 s – 10,000 s are good quality for most sites. Some of the data display poorer quality within certain period ranges. Edited files are provided in addition to the unmasked files to address this issue. The edited files have had masking applied to particularly noisy periods on horizontal or transfer function components, or both, mainly targeting periods with very high errors or spurious points. Unless already masked, vertical components were also masked to exclude periods greater than 10,000 s because data quality and reliability declined at longer periods. If it is decided to repeat some phase one sites because of data quality problems then updated processed files will be released at a later stage.

Data quality is variable for the 224 sites but overall is good. The histograms below (Figure 8) summarise the minimum and maximum impedance periods of which were reasonably resolved by the data and retained after masking:

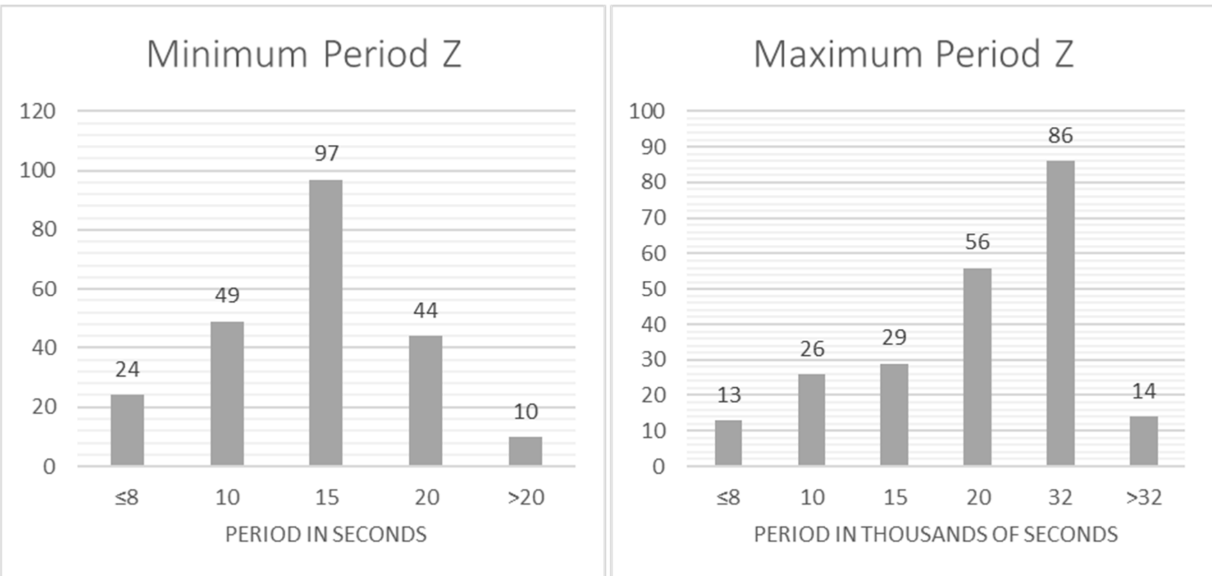

Figure 8: Histogram plots displaying minimum and maximum impedance periods retained in masked data

Several approaches were used in the process in order to evaluate data quality and determine any requirement to repeat the acquisition. These are summarised in Table 3.

Table 3: Summary of data QA/QC stages

Data QA/QC stage	Details
Evaluation of time series	Plotting of time series (Figure 7) and inspection of field notes to identify major issues with recording. Coherence plots between corresponding electric and magnetic channels and power spectral density plots in the frequency domain assisted in highlighting problems
Processing stages	As detailed in Table 1
Evaluation of apparent resistivity and phase	Result plotted (Figure 9) as a function of period to visually inspect processed data quality, data error, instrument issues, and layout errors. Sites are also viewed in comparison with proximal sites to assess consistency within the region
Evaluation of vertical magnetic transfer function (VTF) and other parameters	VTFs or tipper magnitude and tipper phase and induction arrows are plotted and evaluated. These refer to the vertical and horizontal components of the magnetic field
Reprocessing or repeat of unreliable data	If attempts at reprocessing still result in poor quality data sites are marked to be repeated, this may occur when logistically convenient.
Masking of unreliable periods in EDI	Masking is applied to poor quality and outlying data periods for all components.

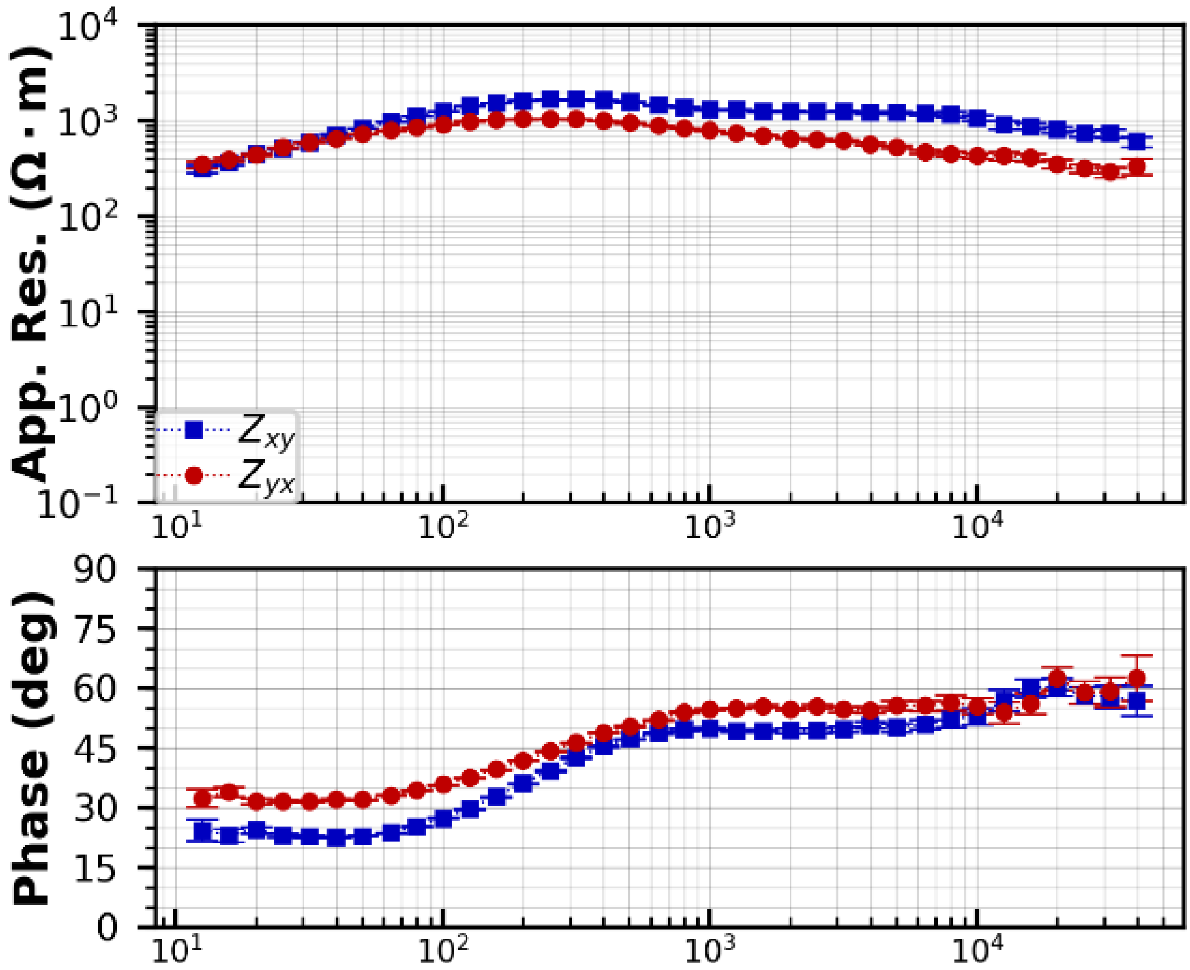

Figure 9: Example plots from site E3 showing apparent resistivity (ohm-m) and phase plotted between 0-90 degrees using the MTPy software (Kirkby et al., 2019).

5 Conclusions

Long-period MT data were acquired at 224 sites for AusLAMP NSW by GSNSW and Geoscience Australia from July 2016 to June 2020. LEMI-424 long-period instruments owned by Geoscience Australia were used for data acquisition. Three component magnetic field and two component electric field time series data were recorded for approximately 6 weeks at each station.

Reliable transfer function and impedance tensor data were derived from the time series data by applying the Lemigraph robust processing algorithms. Several techniques of data quality control were used to recognise errors and to ensure data integrity.

Data quality for this phase is generally good with nearly all sites providing data with a maximum period of 10,000 s or greater.

Acknowledgements

This record forms part of a collaborative project between the Geological Survey of NSW and Geoscience Australia.

The authors acknowledge all landholders, without whose cooperation these data could not have been collected.

Richard Chopping led the acquisition in the early stages of data collection in southern NSW and provided scripts for extracting and plotting the time series data as in Figure 7.

Many thanks to Peter Maher, Matthew Carey, Craig Wintle, Levi Hempenstall, John Glowacki and support staff from Geoscience Australia, who worked on the data acquisition and instrument support for this project.

Grant Taylor from Geological Survey of NSW is thanked for his assistance and support with this project.

Dr Wenping Jiang and Dr Josef Holzschuh from Geoscience Australia are thanked for reviewing this record.

This record is published with the permission of the Chief Executive Officer, Geoscience Australia.

References

Chave, A.D., Jones, A.G. (Eds.), 2012. The magnetotelluric method: theory and practice. Cambridge University Press, New York.

Chave, A.D. and Thomson, D.J., 2004. Bounded influence magnetotelluric response function estimation. Geophysical Journal International, 157(3), 988–1006.

Chave, A.D., Thompson, D.J. and Ander, M.E., 1987. On the robust estimation of power spectra, coherences and transfer functions. Journal of Geophysical Research-Solid Earth, 92, 633-648.

Gamble, T.D., Goubau, W. M., and J. Clarke, 1979. Magnetotellurics with a remote magnetic reference, Geophysics, 44, 53-68.

Gamble, T. D., Goubau, W. M., and Clarke, J., 1979, Error analysis for remote reference magnetotellurics: Geophysics, 44, 959–968

Geoscience Australia, 2015. Magnetic Map of Australia grid sixth edition 80m cell size. Digital dataset, Geoscience Australia, Canberra, Australia. http://dx.doi.org/10.4225/25/5625EAFE3F2A8

Kirkby, A., Zhang, F., Peacock, J., Hassan, R., Duan, J., 2019. The MTPy software package for magnetotelluric data analysis and visualisation. Journal of Open Source Software 4, 1358. https://doi.org/10.21105/joss.01358

Korepanov, V., Ladanivskyy, B., and Leonov, S., 2014. New user-friendly program for field data processing. Extended Abstract, Proceedings of the 22nd EM Induction Workshop, Weimar, Germany. 4 p.

Raymond, O., 2018. Australian Geological Provinces 2018.01 edition. Canberra: Geoscience Australia. Available at: https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/116823.

Raymond, O.L., Liu, S., Gallagher, R., Zhang, W. Highet, L.M., 2012. Surface Geology of Australia 1:1 million scale dataset 2012 edition. Digital dataset, Geoscience Australia, Canberra, Australia. http://www.ga.gov.au/metadata-gateway/metadata/record/74619/

Robertson, K., Heinson, G., Thiel, S., 2016. Lithospheric reworking at the Proterozoic–Phanerozoic transition of Australia imaged using AusLAMP Magnetotelluric data. Earth and Planetary Science Letters. https://doi.org/10.1016/j.epsl.2016.07.036

Simpson, F., Bahr, K., 2005, Practical Magnetotelluric. Cambridge University Press

Vozoff, K., 1972, The magnetotelluric method in the exploration of sedimentary basins: Geophysics, 37, 98–141

Vozoff, K., 1991, The magnetotelluric method, in M. N. Nabighian, ed., Electromagnetic methods in applied geophysics – Vol. 2 Applications: Investigations in geophysics No. 3, 641–712.

Appendix A

A.1 Example of field deployment and retrieval notes

MT Survey Site Report

DEPLOYMENT

SITE NAME		Landholder Name Traditional Owner			
Operator		Landholder Number Traditional Owner Contact			
UTC time & day		Landholder Address Traditional Owner Council			
Local time & date		Landholder property name			
Lat (LEMI)		Long (LEMI)		Elevation (LEMI)	
Lat (HH GPS)		Long (HH GPS)		Elevation (HH GPS)	

SITE LAYOUT NOTES (directions, site layout, location information)

Electrode	Lat	Long
N		
S		
E		
W		

INSTRUMENTATION NUMBERS (****ensure ALL recorded in case of damage or error!!)**

Record system	Recorder #	SD Card	Interface box #	Case #	Power (Battery V)
LEMI					No Load: w/ Solar panel: LEMI:

MAGNETIC (level and aligned to magnetic north)

Channel	Mag field	LEMI readings	Fluxgate Mag Sensor Number	Sampling rate (Hz)	Azimuth (°)
Ch0	Bx (north)			*1*	*0*
Ch1	By (east)			*1*	*90*
Ch2	Bz (vertical)			*1*	*0*

ELECTRIC

Channel	Dipole	Length (m)	Length input to box (m)	R; +ve to -ve (KΩ)	AC (mv)	DC (mv)	Azimuth (°)	Electrode Numbers
Ch1	Ex/**NS**	+ -	L1 =					+ -
Ch2	Ey/**EW**	+ -	L2 =					+ -
Ch3		+ -	L3 =					+ -
Ch4		+ -	L4 =					+ -

CULTURE/NOISE (eg nearby electric fence, powerline, pipeline, metallic objects, rivers, houses, animals)

Noise Type					
Distance and direction from Equipment					

MT Survey Site Report

RETRIEVAL

SITE NAME		UTC time & day	
Operator		Local time & date	

MULTIMETER MEASUREMENTS

Dipole	Power (V)	Resistance + to - (KΩ)	AC (mv)	DC (mv)
Ex	N/A			
Ey	N/A			
BATTERY		N/A	N/A	N/A

CABLE STATUS (inspect cable prior to packing up site)

Good: No changes
Minor: few nibbles, minor damage shouldn't affect data
Major: casing is damaged, internal wire is damaged
Extreme: cord chewed through or connector missing

Please tick	Good	Minor	Major	Extreme	Notes
Solar Panel					
Mag					
Ex					
Ey					
Central					

NOTES:

Appendix Figure A. 1 Example of deployment and retrieval notes collected at each site