

Geophysics at Geoscience Australia: new data and innovation

Geoscience Australia (GA) exists to meet the geoscience information needs of the Australian Government. GA's strategic priorities are focussed on six key areas:

- (i) building Australia's resource wealth;
- (ii) ensuring Australia's community safety;
- (iii) securing Australia's water resources;
- (iv) managing Australia's marine jurisdictions;
- (v) providing fundamental geographic information; and
- (vi) maintaining geoscience knowledge and capability.

For more than six decades GA has been collecting geophysical datasets over the Australian region with the provision to the public of pre-competitive geophysical data a fundamental activity of the agency. Geophysical surveys have collected magnetic, radiometric, gravity, airborne electromagnetic, seismic (passive and active), nuclear magnetic resonance, induction, gamma and magneto-telluric datasets at various resolutions depending on the aims of the respective surveys. Through collaboration with governments at all levels, GA is the custodian of the largest publicly available geophysical databases in Australia. These geophysical databases can then be combined with other geoscientific datasets (e.g. geology, geochemistry, geochronology and hydrogeology) to enable GA to build and map the national geological and hydrogeological framework of the continent in order to inform resource exploration and development. This knowledge is publicly available to enable the development of new methods and tools, and new data interpretations to accurately assess the resource prospectivity of the Australian continent. This information enables industry to explore and invest in Australia with confidence.

In addition to the resources-aligned geophysics activities, GA continues to use geophysical methods to support the Australian Government in many diverse areas. These include the search for MH370 and other bathymetric mapping, maintaining the navigation and the geodetic reference frame, global positioning, hazard monitoring (such as bushfires, earthquakes, tsunamis, floods), secular earth observation through remote sensing and monitoring for the Comprehensive Test Ban Treaty.

Onshore geophysical activity

Exploring for the Future is a \$100.5 million program (2016–2020) to provide new pre-competitive data and knowledge in order to attract exploration investment into Northern Australia and parts of South Australia. The program is a collaboration between GA and the governments of Queensland, Northern Territory, Western Australia and South Australia. A large proportion of the budget is being spent on acquiring new geophysical datasets, including: large regional and transcontinental surveys of passive and active seismic, airborne electromagnetic, gravity, and magnetotelluric methods. These data will be complemented by more focussed geophysical studies such as ground magnetic resonance. These geophysical datasets will be released once they are processed and will be integrated with complementary geological, hydrogeological, geochemical, remote sensing and geochronological studies into a thorough understanding of the region's

geology and prospectivity for minerals, energy and groundwater resources.

Exploring for the Future is a \$100.5 million initiative by the Australian Government dedicated to:

Petroleum exploration

One of the major achievements by the Exploring for the Future Program was the completion, in early August 2017, of the acquisition of deep crustal seismic reflection data in the region between the southern McArthur Basin to the Mt Isa western succession (Figure 1), crossing the South Nicholson Basin and Murphy Province. Five seismic lines were acquired totalling 1100 line km with two of the seismic lines to the east linking with existing deep crustal seismic data in the Mount Isa western succession.

Other new data of the South Nicholson Basin has been released; this was collected by a gravity survey GA conducted in July 2017 across a 43 330 km² area over the basin. These gravity

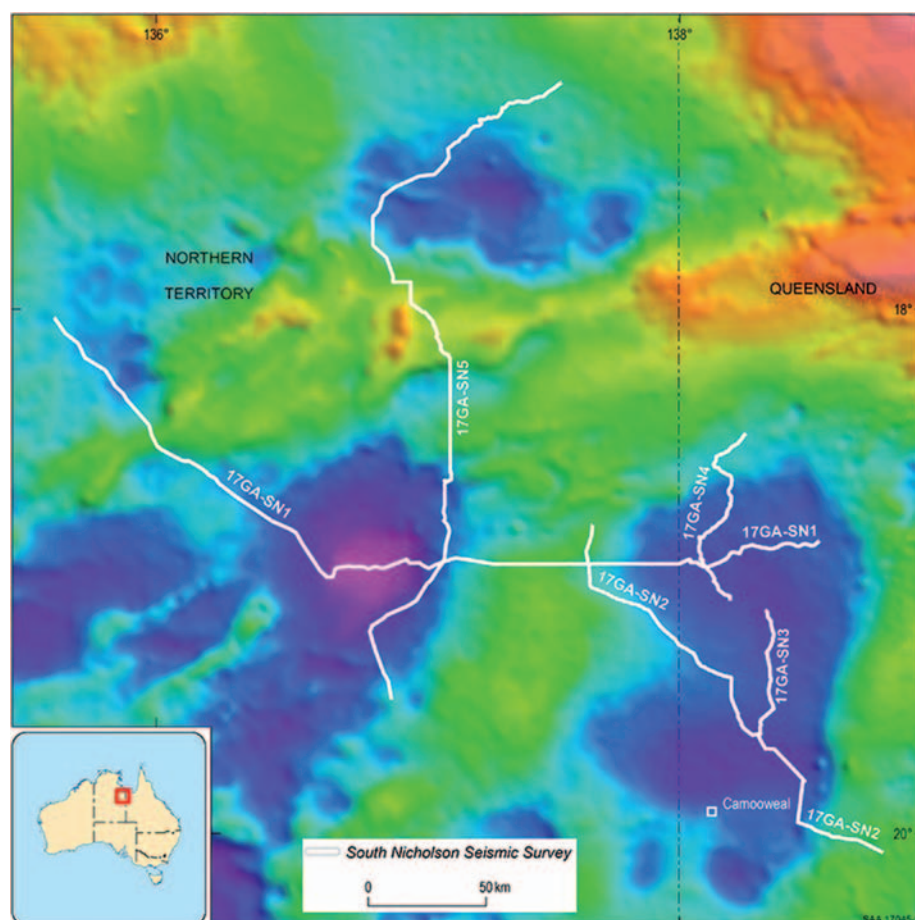


Figure 1. South Nicholson Seismic Survey 2017 location with coloured Bouguer gravity image from the National Gravity dataset.

data were the first data to be released through the Exploring for the Future Program. The public release of the final processed seismic data is expected in early-mid 2018.

Further information on the Exploring for the Future program is available in this edition of *Preview*.

Mineral exploration

The National Mineral Exploration Strategy was endorsed by the COAG Energy Council in June 2017. This strategy emphasises the importance of pre-competitive data and tools in reducing exploration risk to attract exploration investment in greenfields areas. The Strategy along with head agreements between GA and each of the state and the NT geological surveys allows excellent inter-jurisdictional collaboration and as such GA is a project partner in many of the large geophysical activities across Australia (Figure 2). GA manages the deeds, panels, contract and procurement process, QA/QC requirements and storage and delivery of the data. This is a significant part of our geophysical work and it ensures geophysical data are

well maintained, consistent and seamless, high quality and available in the National databases.

Figure 2 shows the recent surveys and activities across the entire continent, which includes the significant injection of work from the Exploring for the Future program. The quantum of work to date at end 2017 includes >2 million line km of airborne magnetics and radiometrics, >300 000 line km of air gravity, 2000 ground gravity stations, almost 100 000 line km of airborne electromagnetics (AEM), 1100 km deep crustal reflection seismic, reprocessing of 5500 km of seismic, 180 long-period MT and 500 broadband MT sites acquired. In the first half of 2018 we expect to acquire a further 1 million line km of airborne magnetics/radiometrics, 100 000 line km of air gravity, 1530 line km of deep seismic and 40 000 line km of AEM. This data acquisition program is a tens of millions of dollars investment by Government in pre-competitive data and is a major contribution to revealing the prospective geology of Australia.

Of particular note in 2017 was the commencement of the AusAEM and

AusARRAY surveys, which are wide-spaced airborne electromagnetic data (20 km nominal line spacing) across much of Northern Australia, and deployment of 120 new portable passive seismic recorders and 10 semi-permanent recorders respectively. A fleet of 35 new long-period magnetotelluric instruments were also purchased and these recorders are currently deployed as part of the ongoing AusLAMP project. These new national datasets will complement existing magnetic, gravity and radiometric datasets that have been instrumental in many mineral discoveries. Completion of these new national maps will position Australia as the best imaged continent on the planet, and will ensure Australia remains a highly desirable investment destination for minerals and other resource exploration and discovery.

Many of the geophysical datasets are being collected on a scale not previously attempted. Data processing, modelling and interpretation on such a large scale requires innovative computing solutions. All code is being made available on the GitHub shareware site and will be incorporated into the Australian National Virtual Geophysical Laboratory (ANVGL). The first of these is the machine learning codes GA developed in collaboration with Data61 which are available at <https://github.com/GeoscienceAustralia/uncover-ml>. GA ran a successful workshop on *Inverse Methods for Cover Thickness Determination* in Perth in December 2017, which gave users the skills and codes to run passive seismic (trans-dimensional), MT and AEM inversions.

Groundwater exploration

GA uses airborne electromagnetics (AEM) to rapidly map and identify fresh groundwater resources and managed aquifer recharge (MAR) opportunities in 'frontier' areas of Australia and deliver sustainable management outcomes in a wide variety of landscapes and geological settings. In Australia, the application of electromagnetic methods for hydrogeological investigation is complicated by the highly salinised nature of many landscapes, and variable weathering and cementation that can significantly modify the hydraulic properties of sediments.

To overcome these issues, GA is using a novel multi-disciplinary, multi-physics, systems-based approach to map, characterise and assess hydrostratigraphic, structural and groundwater elements

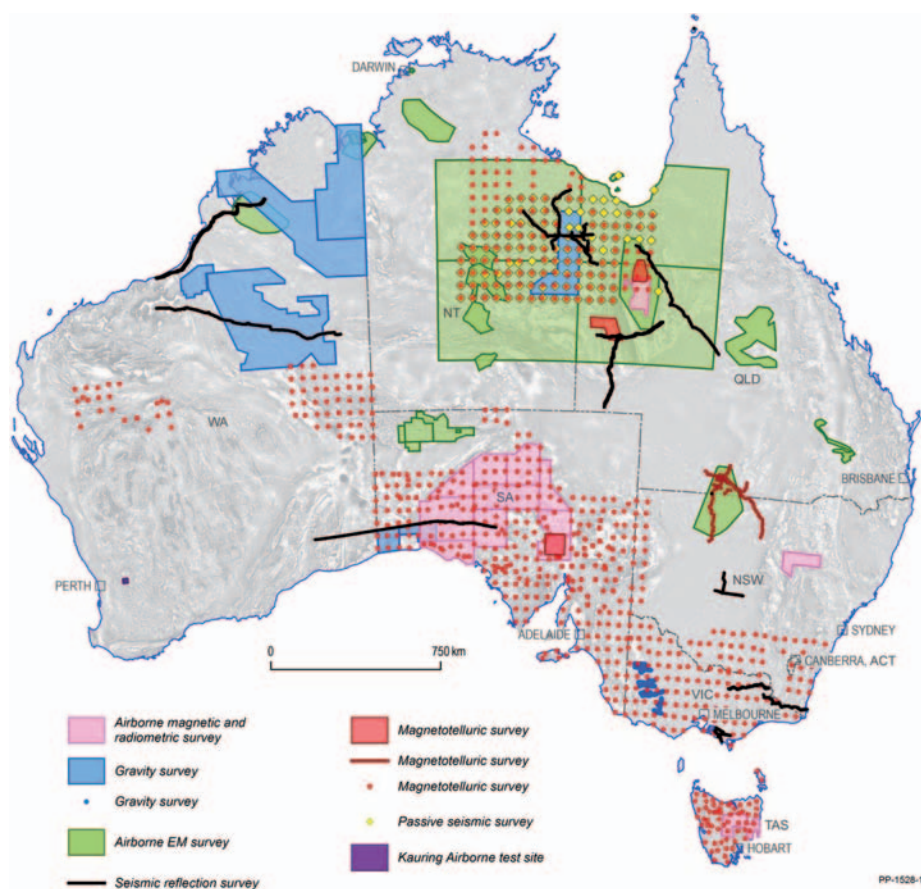


Figure 2. Map of significant recent and current onshore geophysical surveys on grey-scale TMI that are led by GA's Mineral Systems Branch with funding from Exploring for the Future and Initiative funding from the states and Northern Territory governments.

in the shallow sub-surface in 3-dimensions. GA is also utilising new ground geophysical sensors such as ground magnetic resonance (GMR), complementing AEM and providing key aquifer and aquitard properties using non-invasive techniques. These non-invasive methods help reduce costs while enabling the production of a series of advanced hydrogeological information products that can be used to target more selective drilling and pump tests, and hydrogeochemical and hydrogeological investigations.

These approaches have been successfully applied in the Lower Darling Valley, New South Wales, and Fitzroy River and Ord Valley, Western Australia and are currently being applied as part of the Exploring for the Future program (see the Exploring for the Future article elsewhere in this issue of *Preview*).

Offshore geophysical activity

GA continues to acquire pre-competitive geophysical data on Australia's continental margin. Most recently data acquisition has taken place over the Lord Howe Rise as part of a collaborative project with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

The objectives of the International Ocean Discovery Program (IODP) deep stratigraphic drilling are to:

- define the role and importance of continental crustal ribbons, like the Lord Howe Rise, in plate tectonic cycles and continental evolution;

- recover new high-latitude data in the southwest Pacific to better constrain Cretaceous paleoclimate and linked changes in ocean biogeochemistry; and
- test fundamental evolutionary concepts for sub-seafloor microbial life over a 100-million-year timeframe.

The aim of the project is to drill a deep stratigraphic well through a rift basin on the Lord Howe Rise, off eastern Australia. This seismic acquisition follows that performed in 2016 (GA0354) (Figure 3) for which the well site seismic reflection data is available for download via NOPIMS (<http://www.nopims.gov.au/>) or email (ausgeodata@ga.gov.au). This new site survey (GA0363) involved high-resolution seabed and shallow sub-sea floor mapping, collection of shallow (<20 m below-sea floor) sediment cores and underwater video at the sites being considered for drilling. Information from this detailed mapping and sampling will be used to understand the geotechnical properties of the seabed affecting drilling operations and contribute to the environmental permitting process for the drilling project. These data will also contribute valuable baseline environmental information describing deep-water habitats in a remote area of Australia's maritime jurisdiction (<http://www.ga.gov.au/about/projects/energy/lord-howe-rise>).

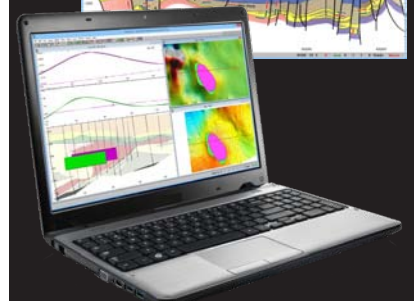
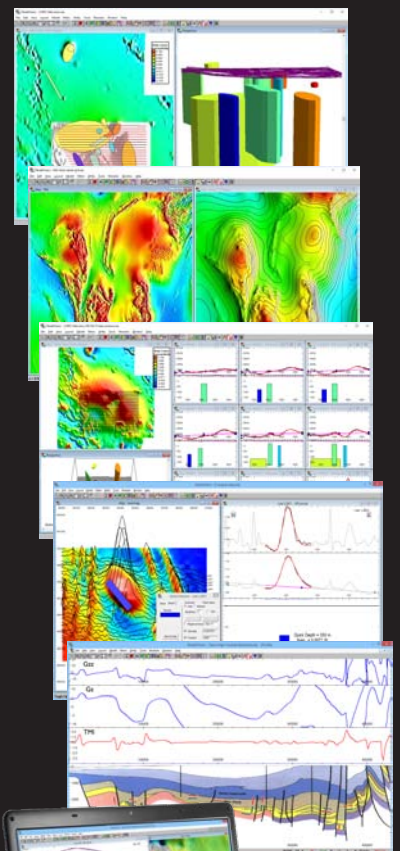
More information about Geoscience Australia's geophysical programs can be obtained from Murray Richardson: murray.richardson@ga.gov.au, (02) 6249 9229.

Please visit us at AEGC booth 75 and 76.

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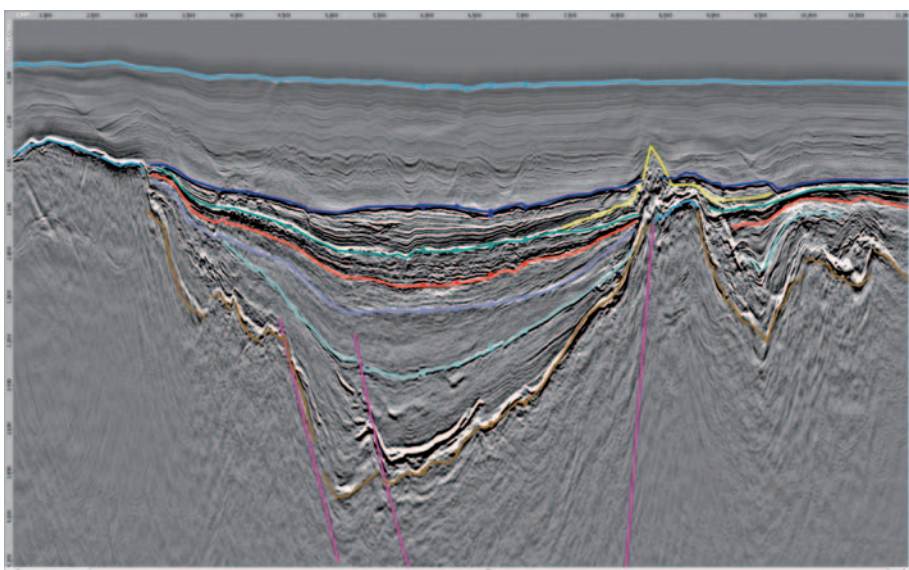
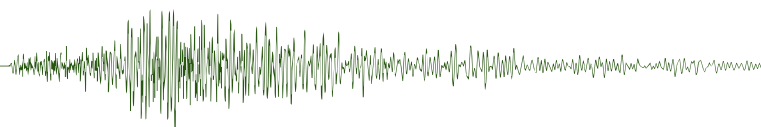


Figure 3. GA0354 Lord Howe Rise Site Survey PreSTM.



News from the Geological Survey of South Australia

State images

In 2017 a new edition of South Australia's gravity grid was released. The new grid utilised a gridding methodology developed in the Geological Survey of South Australia, namely supervised variable density gridding. Approximately 530 000 ground gravity stations were used in the grid in a systematic, iterative process that combines GIS geoprocessing with minimum curvature gridding. A report book detailing the methodology has been released and is now available, along with grids and data package at

<https://goo.gl/zXQPok>. The recently acquired Coompana gravity survey will be integrated into the next edition of the South Australian gravity grid.

Airborne Surveys

The Gawler Craton Airborne Survey commenced in January 2017 and will conclude in 2018 (Figure 2). The survey is currently the largest in South Australia's history, with 1.87 million line kilometres of magnetic, radiometric and elevation data collected at 200 m line spacing with

a nominal terrain clearance of 60 m. The survey is setting new benchmarks in the way the South Australian government works with landholders and survey contractors resulting in high quality community information and data (Figure 3). The survey results display significant improvements in clarity and geological detail. Collaboration with CSIRO will add significant value to the data by producing a range of analytic and interpretive products, including magnetic depth-source models.

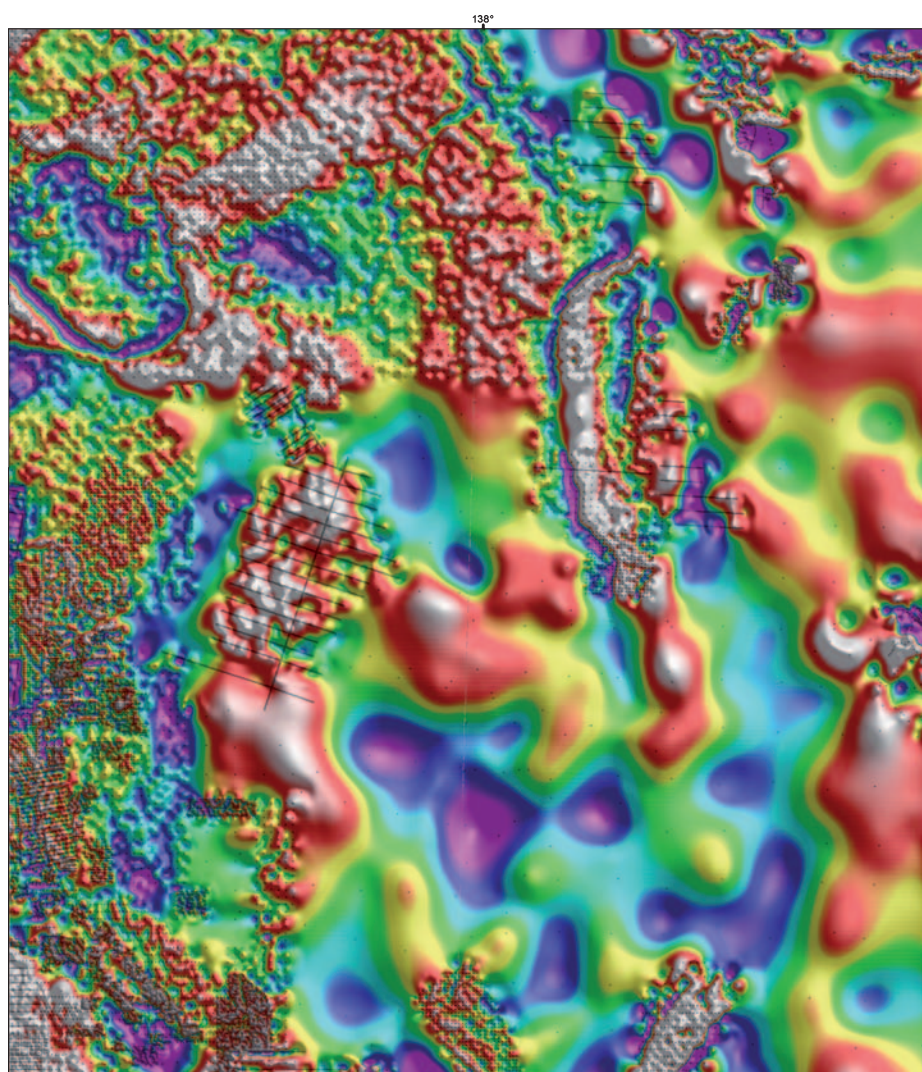
Lithospheric Architecture Team

The Australian Lithospheric Architecture Magnetotelluric Program (AusLAMP) has covered about 95% of South Australia, with about 30 long-period MT sites remaining in the APY Lands. In 2017, the PaceCopper funded extension of the grid to the north-east of the state has improved our understanding of the north-eastern boundary of the Gawler craton and illuminated the poorly understood lithosphere beneath the Cooper Basin.

Outcomes in the form of 3D inversion resistivity models of the crust and mantle were presented at the Geological Survey of South Australia (GSSA) annual showcase event, Discovery Day, in December 2017, as well as at the international AGU conference in New Orleans, USA. Integration of the results with other geological data sets will be presented at the upcoming AEGC conference in Sydney, February 2018.

An outcome of the AusLAMP surveys is detailed in-fill magnetotelluric surveys using broadband equipment across areas of enhanced crustal conductivity. In 2017, the University of Adelaide conducted the Curnamona in-fill survey along a 2D EW profile funded by the GSSA PaceCopper program to map enhanced conductivity pathways into the upper crust associated with the Benadgerie Ridge.

The GSSA's own PaceCopper-funded Olympic Domain in-fill survey will begin in March 2018 covering an area spanning roughly 100 km x 100 km with over 330 broadband and audio-magnetotelluric stations. The aim of the survey is to map the upper and mid-crustal conductivity zones to the surface based on low-resolution conductive zones underneath the Stuart Shelf from AusLAMP surveys. The data will be augmented by 3 km



Gravity of South Australia 2016 (1VD)

GDA94, South Australia Lambert Conformal Conic

Ground Gravity Stations

Bouguer Gravity 1VD

0.0448 -0.0815

0 10 20 30 40
Kilometres



Figure 1. Portion of the 2017 South Australian state wide gravity grid (1VD), illustrating the seamless result of the supervised variable density gridding process on gravity stations at a range of densities and configurations.

The Gawler Craton Airborne Survey is now 53% complete

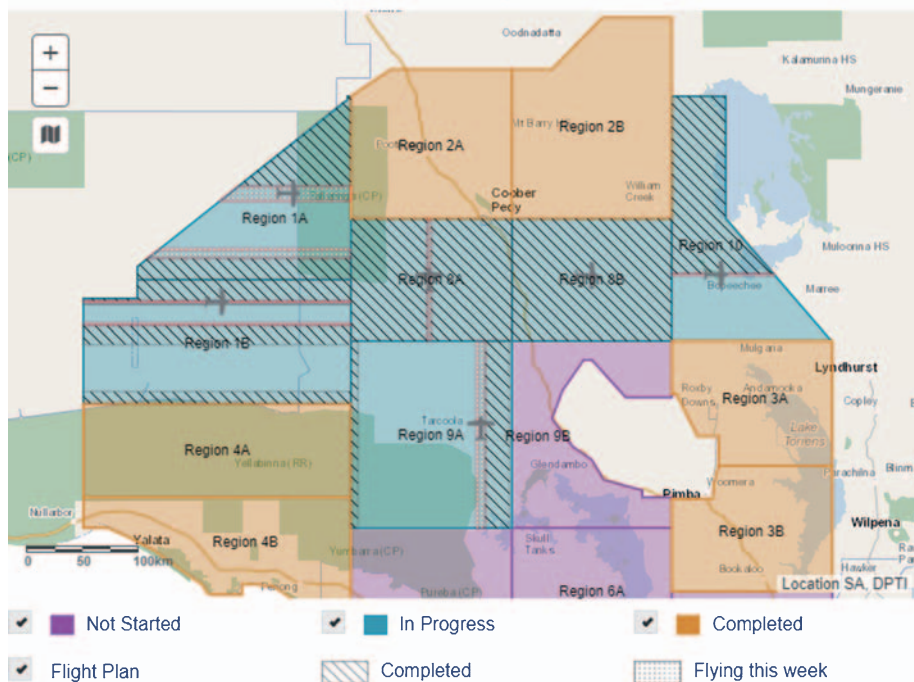


Figure 2. The Gawler Craton Airborne Survey Community Information webpage. The web page delivers near-real-time information on survey aircraft activity and locality while also providing direct links to data downloads. Subscription to email updates is available, notifying subscribers of survey milestones and data releases. The webpage is located at <http://www.minerals.statedevelopment.sa.gov.au/gcas>.

spaced airborne EM data collected in December 2017.

In 2018, the Lithospheric Architecture Team will convert the MT data acquisition programs into 3D resistivity models and seek integration to isotope geochemical data sets, potential field geophysical data and is collaborating on new insights gained from satellite gravity data.

Other news

In 2016 SARIG was redesigned so that users with tablet devices could use the system as well as desktop users. Geophysical surveys conducted in South Australia continue to be uploaded to SARIG and are available for free download. If users require assistance using SARIG please don't hesitate to

contact Customer Services ([Resources. customerservices@sa.gov.au](mailto:customerservices@sa.gov.au)).

The Geological Survey of South Australia will be moving offices in 2017. Currently located at 101 Grenfell Street, Adelaide, staff will be moving to 11 Waymouth Street, Adelaide, a short distance from the current office. The geophysical team is currently involved in transferring a large amount of data from older media (including ExaByte and Colorado tapes) to network storage.

Two AEM surveys flown by SkyTEM over the Fowler and Olympic Domains in South Australia are being QC'd by GA and should be available soon for public consumption via SARIG. The surveys were designed to map (at a reconnaissance scale):

- trends in regolith thickness and variability;
- trends in cover sequence thickness, character and variability;
- basement/bedrock paleo-topography;
- variations in bedrock conductivity;
- the continuity of key bedrock conductive units under cover; and
- the ground water resource potential of the region.

Stay tuned to *Preview* for more news on these surveys!

Laz Katona, Kate Robertson, Stephan Thiel and Philip Heath
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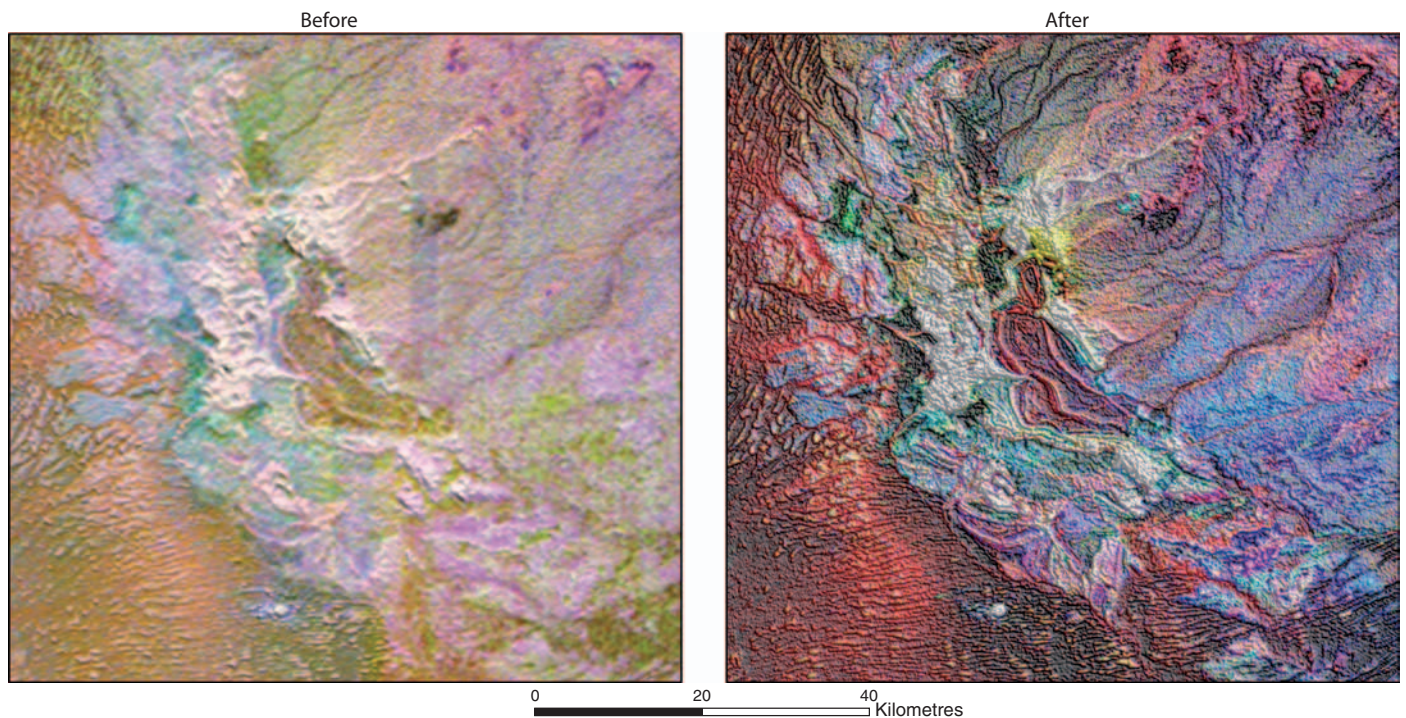


Figure 3. Ternary radiometric image of the Peake and Dennison Ranges comparing the previous best available image (left) with the new image acquired by the Gawler Craton Airborne Survey (right). The clarity and detail of geological features and landforms in the image is unsurpassed.

Geological Survey of Western Australia: regional and crustal-scale geophysical programs, 2018

Since 2009, the Government of Western Australia's Exploration Incentive Scheme (EIS) has enabled the Department of Mines, Industry Regulation and Safety's (DMIRS) Geological Survey of Western Australia (GSWA) division to undertake an extensive and accelerated program of regional and crustal-scale geophysical data acquisition projects throughout the State.

These projects are an integral component of GSWA's strategy to enhance Western Australia's precompetitive and public-use information-base with the ultimate aim of providing statewide 'surface-to-mantle' geoscience information at the best resolution affordable.

Figure 1 illustrates the range of existing datasets and planned geophysical programs that GSWA is undertaking with active assistance from its national counterpart, Geoscience Australia (GA), and leveraging support from a number of other national and state institutions.

These encompass:

- Complete State coverage with airborne magnetic and radiometric surveys at sub-500 m line spacing, with targeted areas at 100 m line spacing.
- An ongoing program to extend gravity coverage of the State with ground and airborne gravity surveys at 2.5 km spacing; with the objective of completing state coverage by 2020.
- Airborne electromagnetic surveys over targeted areas with additional surveys in the north of the State under consideration for joint funding as part of Geoscience Australia's 'Exploring for the Future' program.
- Crustal-scale reflection seismic transects across key geological regions. The Canning Basin is a currently active area of interest with a GSWA/GA jointly funded 900 km transect across the Kidson sub-basin to be completed in 2018.
- Crustal scale, long period magnetotelluric transects across major geological structures with more work under consideration as part of the Australian Lithospheric Architecture Magnetotelluric Project.
- Reprocessing of key regional vintage seismic lines in the Canning and Southern Carnarvon Basins is currently

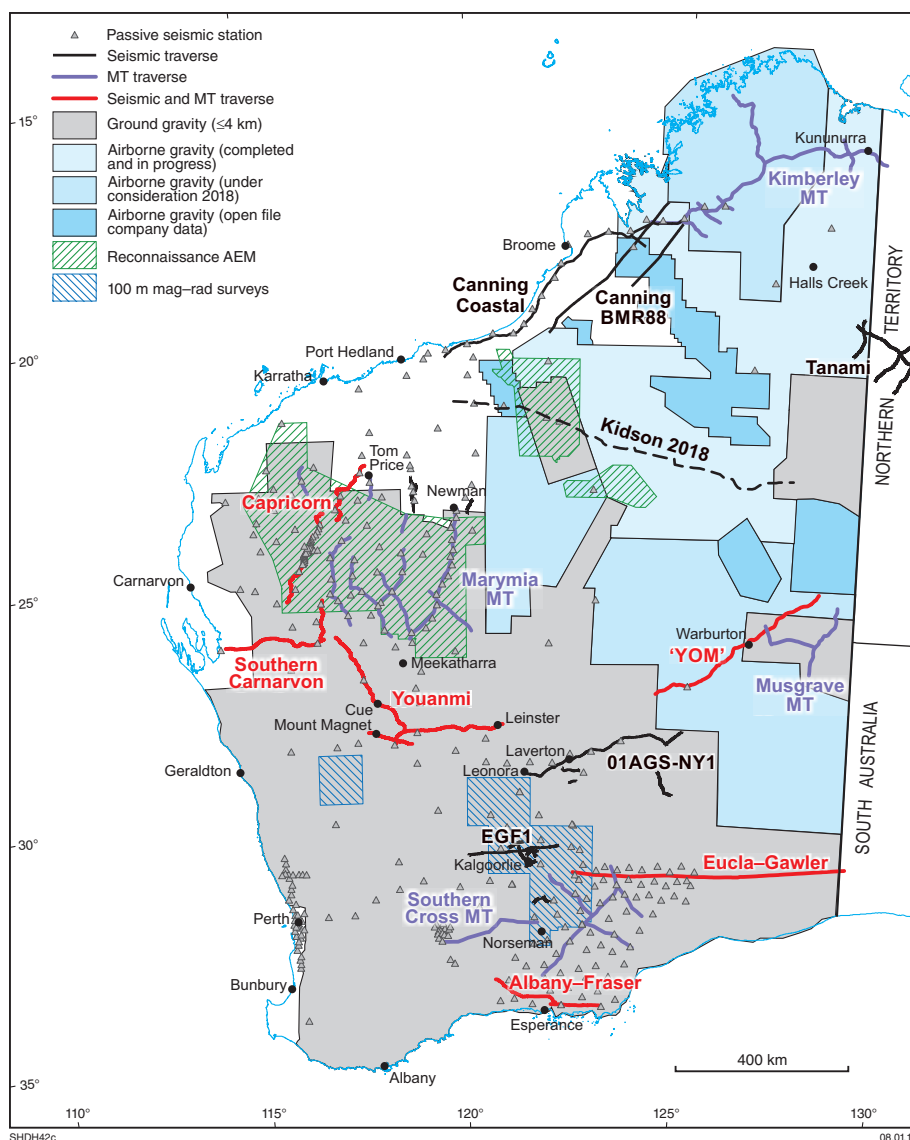


Figure 1. Regional and crustal-scale geophysical programs in Western Australia, 2018.

underway. Further reprocessing may be considered dependant on results of the current projects.

- Transects and networks of temporary broad-spectrum passive seismic stations for crustal and lithosphere scale interpretation, and which complement the reflection seismic transects. The current network is monitoring along the Canning Coastal line and there are plans to cover the Kidson sub-basin transect as well.

All raw data and processed statewide or individual survey images data are publicly available online through

GSWA's or GA's various data delivery systems and the Australian Geoscience Information Network (AusGIN):

- GeoView.WA: www.dmp.wa.gov.au/geoview
- GADDS: www.ga.gov.au/gadds
- AusGIN: www.geoscience.gov.au/

Analyses and geological interpretations of these data by GSWA and its partners are available from the various project pages on the GSWA website at www.dmp.wa.gov.au/gswa.

For more information please email: geophysics@dmirs.wa.gov.au.

Overview of new and upcoming geophysics in the Northern Territory

Over the past 4 years the Northern Territory Geological Survey (NTGS) has acquired 4 km spaced ground gravity data over approximately 900 000 km² of the NT and two magnetic and radiometric surveys funded through the Northern Territory Government's \$23.8 million *Creating Opportunities for Resource Exploration* (CORE) initiative (Dhu and Hallet, 2017). These surveys were acquired in collaboration with Geoscience Australia through a National Geoscience Agreement. The four-year CORE initiative was launched in 2014 and aimed at maximising opportunities for the exploration, discovery and development of new mineral and petroleum resources within the NT. Recently work has focussed on integrating and interpreting these new geophysical data with a range of products to be released in 2018.

Frogtech Geoscience has been contracted to update the SEEBASE® (Structurally Enhanced view of Economic BASEment) suite of products over the greater McArthur Basin (Figure 1). This project incorporates both the new potential field geophysics acquired through the CORE

initiative and significant work undertaken by industry in the region including new drilling and seismic data. The final products including the SEEBASE® depth-to-basement grid (Figure 2) will be released in March 2018, supported by a workshop at NTGS's Annual Geoscience Exploration Seminar in Alice Springs (19–21 March; www.ages.nt.gov.au). The NTGS/Frogtech Geoscience greater McArthur Basin geological workshop will discuss key results from the SEEBASE® update and the definition of the Beetaloo Sub-basin.

The NTGS is collaborating with CSIRO on geophysical acquisition, processing and interpretation projects in the Batten Fault Zone. The Batten Fault Zone is in north-eastern NT (Figure 1) and contains the world class McArthur River Pb-Zn-Ag mine, hosted within the HYC Pyritic Shale Member of the Barney Creek Formation. Over 40 publicly available, industry acquired AEM datasets have been assessed and reprocessed, where possible using EMFlow (Macnae et al., 1988), and for more recent data, using Geoscience Australia-Layered Earth Inversion (GA LEI, Brodie and Fisher 2008). This work involved compiling adequate system characteristic descriptions and assessing suitability for inversion or transformation (Ley-Cooper et al., 2016) and then interpreting these data to determine their suitability for mapping the Barney Creek Formation (Munday et al., 2017). The reprocessed AEM datasets and associated system descriptions will be made publicly

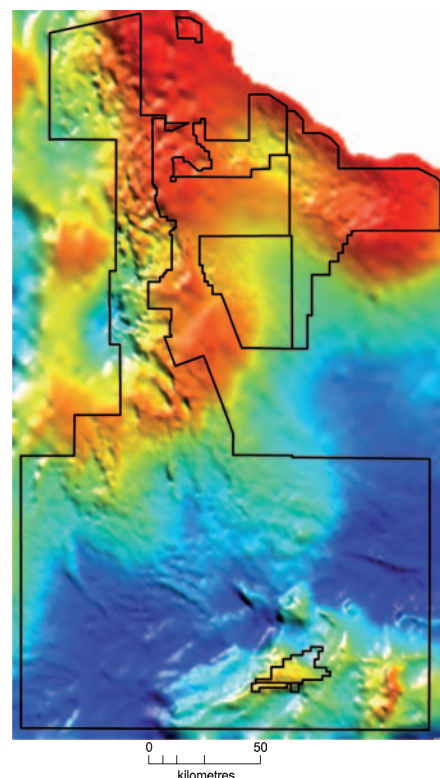


Figure 3. New, higher resolution ground gravity data in the greater McArthur Basin.

available in a new Digital Information Package (DIP): 'Reprocessing of historical AEM surveys in the Batten Fault Zone', and accompanied by an interpretation record.

A new, higher resolution ground gravity survey has also been completed in the Batten Fault Zone. The Batten Fault Zone gravity survey acquired over 7000 new gravity readings, infilling the South

McArthur gravity survey at 2 × 2 km spacing with selected traverses acquired at 500 m spacing (Figure 3). This data is now available (Figure 3). This data is now available and will feed into the geophysical and structural interpretation of the Batten Fault Zone to be released mid-2018.

The NTGS Geophysics and Drilling Collaborations (GDC) is also supporting a range of smaller scale geophysical surveys through co-funding of industry projects (www.dpir.nt.gov.au/mining-and-energy/geoscience-projects-and-initiatives/geophysics-and-drilling-collaborations). Round 10 of the GDC is currently underway

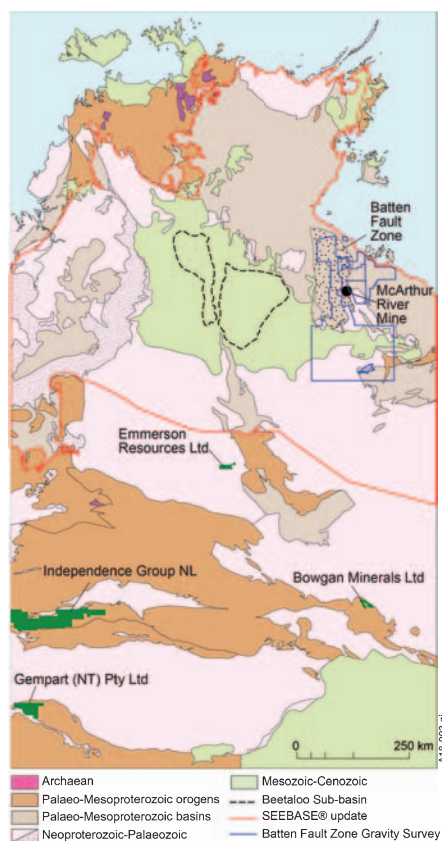


Figure 1. Location of greater McArthur Basin and NTGS Geophysics and Drilling Collaboration projects.

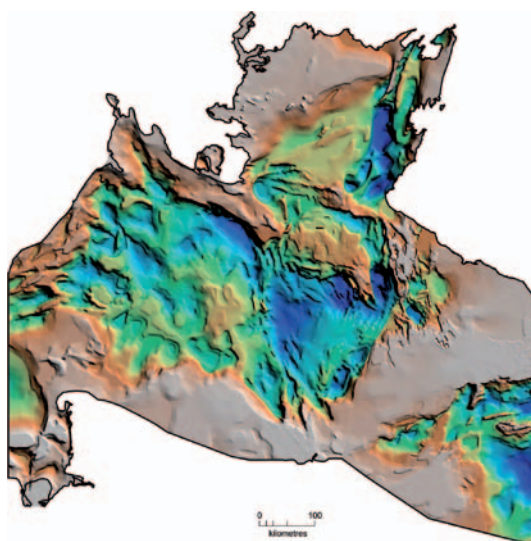


Figure 2. SEEBASE® depth-to-basement grid in the greater McArthur Basin.

News

(Figure 1), with AEM (Independence Group NL and Gempart NT), 3D IP (Emmerson Resources) and ground gravity (Bowgan Minerals Ltd) surveys.

All data and products are available on request from NTGS (geoscience.info@nt.gov.au) and many are available for download at www.geoscience.nt.gov.au/gemis or through the STRIKE web mapping system (www.strike.nt.gov.au). Geophysical data and grids acquired through collaboration with Geoscience Australia are available for download via the Geophysical Archive Data Delivery System (GADDs).

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Geological Survey of Queensland: update on the Strategic Resources Exploration Program

Last year the Queensland Government's [Strategic Resources Exploration Program](#) was announced, with funding aimed at promoting discoveries in North West Queensland. Details of the 4-year program include:

- \$3.6 million to drive exploration for gas in basins in the north-west including the Georgina, South Nicholson and Isa Superbasin
- \$4.275 million on mineral geophysics projects
- \$1.45 million on mineral geochemistry programs
- \$3.6 million for a new Collaborative Exploration Initiative.

The [Collaborative Exploration Initiative](#) broadens on the scope of our Collaborative Drilling Initiative from the past. This means that there will be funding available not only for drilling, but for geophysical and geochemical programs in under-explored areas of the north-west that will provide a benefit to the regions understanding. Round 1 has closed and projects are underway, however it is anticipated that applications for future rounds will be opening later in 2018.

The first minerals geophysics project under the new program will be the acquisition of new 1 km grid spaced ground gravity data in the Lawn Hill area (Figure 1). The selected area is immediately north of the currently 2 km spaced gravity data available in the Mount Isa area. The data is expected to assist with resolving high density targets within structural trends in an area prospective for silver, lead and zinc and will supplement AEM data collected by the Geological Survey of Queensland (GSQ) last year.

Geophysical inversions of last year's Cloncurry Magnetotelluric (MT) data will be released shortly. Products available for download will include various conductivity depth slices, and sections as well as a 3D conductivity volume. The processed EDI files can also be obtained from [QDEX Data](#).

The flying of the Cloncurry and Mary Kathleen airborne magnetic and

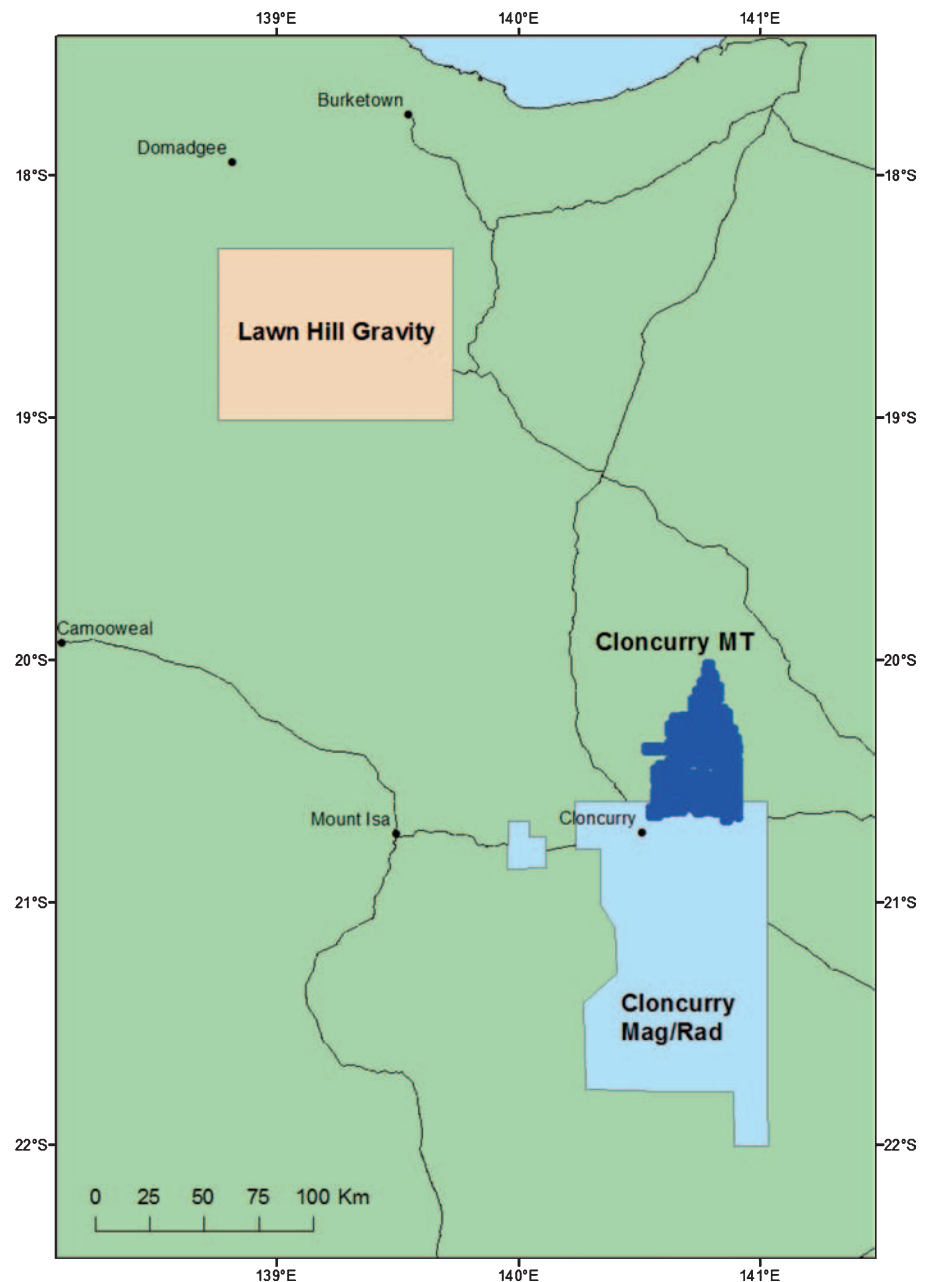


Figure 1. Location of upcoming and newly released GSQ datasets.

radiometric surveys has been completed (Figure 1). Data for both surveys is currently undergoing QA/QC checking. These high resolution surveys (100 m and 50 m spacing) provide a seamless coverage over the area and show good improvement on the previous Mount Isa Mines Open Range survey acquired in the 1990s. Data for both surveys will be releases on QDEX Data

once the final checks have been completed.

We look forward to seeing you all in Sydney for the AEGC2018, you can find us at the Australian Minerals booth.

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New products and data from the Geological Survey of New South Wales

The Geological Survey of New South Wales (GSNSW) collects, manages and distributes geological, geophysical, geochemical and geospatial data to inform government, resource industries and the community about the state's geology, and mineral and energy resources.

Important regional projects are supported by the New Frontiers Initiative, which is funded by industry through mineral and petroleum annual rental fees. New Frontiers aims to improve knowledge of under-explored areas within NSW, which includes acquisition of precompetitive geophysical data that provides essential support for geoscience mapping and mineral exploration.

Some GSNSW key achievements from the past year are outlined below, as well as major upcoming and ongoing projects.

New MinView released

MinView is a web mapping application which provides free access to view, search and download a comprehensive range of geological and geoscientific data for NSW. It also provides a range of supporting reference data by which to contextualise the geoscientific data including present and past exploration and mining titles, areas available or not available for exploration, and cadastral information. Data available from MinView includes geological maps, mineral occurrences, drillhole and sample locations, geological observations, geochronology, statewide geophysical imagery and geophysical survey areas.

MinView draws together a vast array of different data types and formats from the department's existing databases, with the intention of providing easy public access to all validated, non-confidential data from a single online map interface (Figure 1). You can interactively view, search and download our data or choose to build a custom map, which can be shared as a unique URL or annotated and then printed in hardcopy.

Access MinView at: <https://www.resourcesandenergy.nsw.gov.au/miners-and-explorers/geoscience-information/services/online-services/minview>

Contact: trisha.moriarty@planning.nsw.gov.au, (02) 4931 6598.

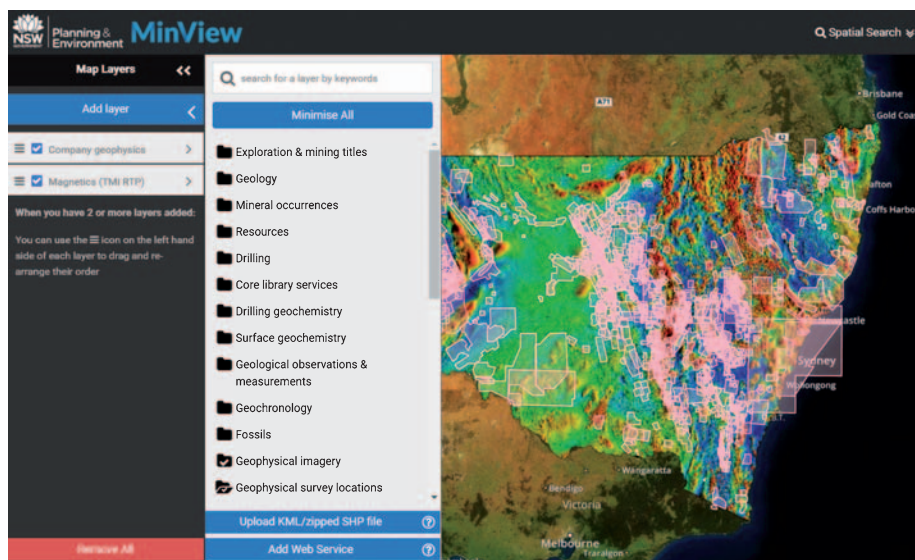


Figure 1. Screenshot of MinView showing the data layer selection menu. The map window shows a statewide airborne magnetic image overlain by company airborne geophysical survey boundaries.

Coonabarabran geophysical data now available

In November 2017, GSNSW was pleased to announce the public release of the Coonabarabran Project data. Airborne magnetic, radioelement and

digital elevation data was acquired around Coonabarabran and Gilgandra between May and July 2017. The project was undertaken in collaboration with Geoscience Australia and has improved the quality of geophysics coverage in this part of NSW by replacing low-

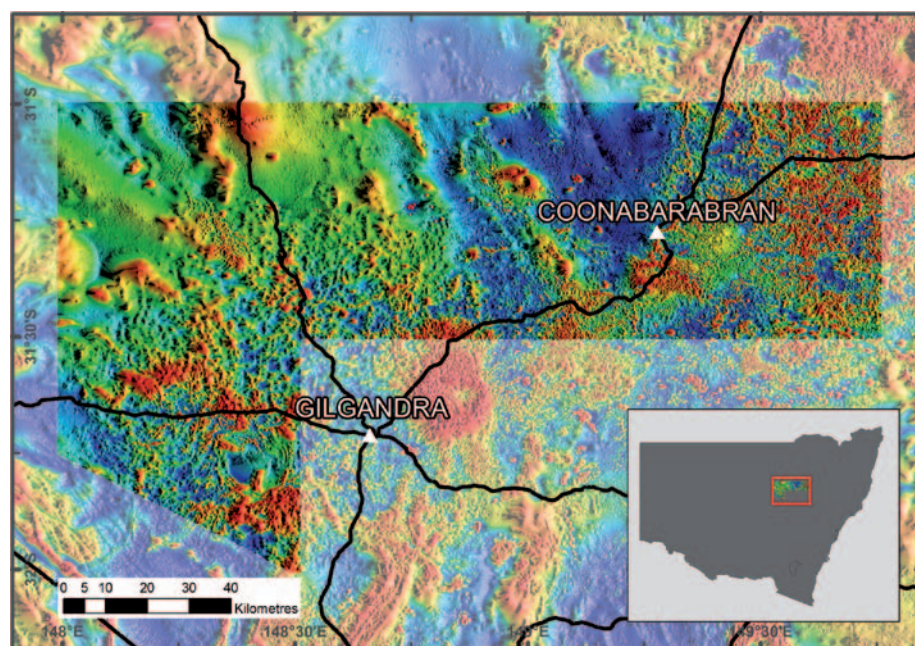


Figure 2. Image of the new Coonabarabran Total Magnetic Intensity data overlaid on surrounding older magnetic data. Cooler (blue) colours indicate lower magnetic values and warmer colours represent higher magnetic intensity values.

resolution data collected in the early 1980s (Figure 2). The data will be used to map geology, landforms and soils, and to inform land use assessments. The Office of Environment and Heritage and GSNSW have been using the Coonabarabran magnetic and radioelement data to map volcanic rocks and soils in the Warrumbungle National Park.

These data are available as georeferenced imagery, grids and ASEG GDF data. The new data is available on the NSW Government statewide geophysics data package, which is available for \$110 plus postage. Alternatively, grids and located data can be downloaded for free via the GADDS website at <http://www.geoscience.gov.au/>.

Contact: astrid.carlton@planning.nsw.gov.au, (02) 4931 6732.

Southern Thomson Orogen Project: stratigraphic drilling

Stratigraphic drilling in the southern Thomson Orogen was completed in September 2017. Seven drillholes successfully sampled basement rocks of the Thomson Orogen, beneath the Eromanga Basin, in the Bourke–Hungerford area of remote northwest NSW (Figure 3).

The drilling program is part of a cross-border collaborative project between GSNSW, the Geological Survey of Queensland and Geoscience Australia. It is part of the national UNCOVER Initiative, which aims to reverse the decline in Australia's known mineral reserves by providing new information to government, explorers and the wider community about undercover regions.

Rocks of the southern Thomson Orogen in NSW are potentially prospective for copper, lead–zinc, gold and other metals, however mineral systems are masked by younger sedimentary rocks of the Eromanga Basin. The project initially acquired and analysed airborne

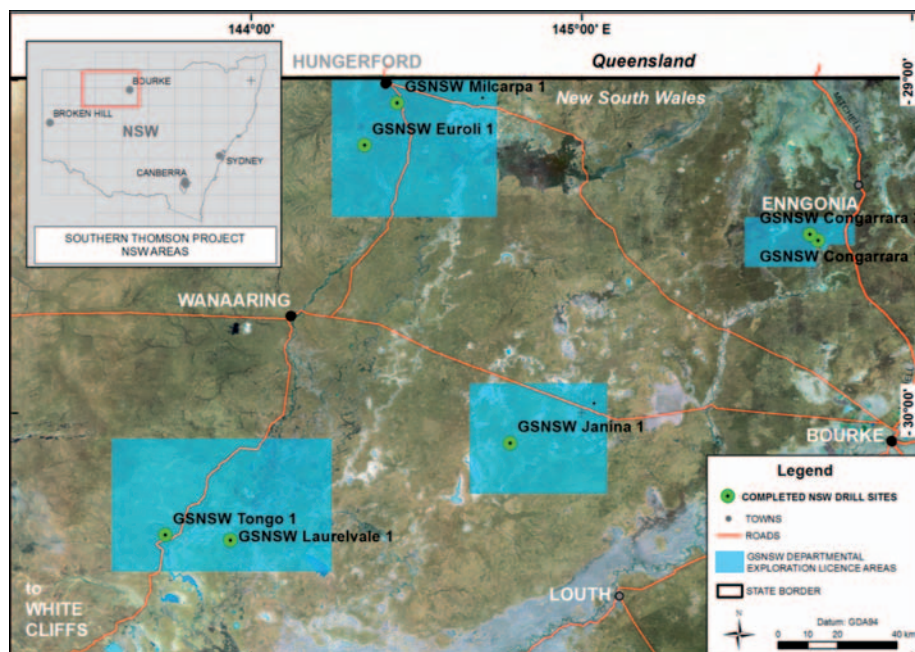


Figure 3. Drill sites in the Bourke–Hungerford region.

and ground-based geophysical data and undertook surface geochemical sampling, field mapping and satellite image analysis to define areas to be tested by drilling within this vast (300 by 300 km) region.

The drilling program tested a variety of distinctive basement signatures in airborne magnetic and electromagnetic data (Table 1). Drilling methods involved a combination of rotary mud drilling through cover sequences and diamond drilling of underlying basement rocks, to provide around 50 m of representative basement core samples from each site. Wireline geophysical logs were run in the holes prior to casing. All cores are being comprehensively sampled for mineralogy, geochemistry and geochronology as well as being scanned by the Hylogger™.

A Southern Thomson Orogen Project workshop displaying drillcore and presenting results from the drilling will be run in at GSNSW's Londonderry core library as part of NSW Minerals Week on 9 May 2018.

Contact: chris.folkes@planning.nsw.gov.au, (02) 4931 6777.

South East Lachlan Crustal Transect to commence in March

A new deep-crustal seismic survey is planned for southern NSW and north-eastern Victoria. The GSNSW and the Geological Survey of Victoria are collaborating with Geoscience Australia and AuScope Limited (part of the National Collaborative Research Infrastructure Strategy) on the South East Lachlan Crustal Transect. Two seismic reflection lines are designed to cross major geological boundaries and fault zones and will complete the east–west deep crustal seismic coverage across the Australian continent (Figure 4). Data will be acquired in Victoria between Benalla and Tubbut (~360 km) and in NSW between Delegate and Eden (~120 km).

The survey requires careful planning and execution to move the seismic survey equipment and acquisition team through the rugged terrain of the Australian Alps and the Snowy Mountains. Route planning, stakeholder briefings, land access and tendering are currently underway. Data acquisition is expected to commence in March 2018 and take about 70 days to complete, with initial results available 12 months later.

Contact: ned.stolz@planning.nsw.gov.au, (02) 4931 6554 or Cameron.Cairns@ecodev.vic.gov.au, (03) 9452 8972.

Table 1. Summary of drilling results

Site ID (ref. Figure 1)	Total depth (m)	Basement lithology
GSNSW Milcarpa 1	290.9 m	Rhyodacite
GSNSW Euroli 1	153.7 m	Metasedimentary schist
GSNSW Tongo 1	312.8 m	Granodiorite
GSNSW Laurelvale 1	386.8 m	Siliciclastic turbidite
GSNSW Janina 1	222.2 m	Granite
GSNSW Congarrara 1	119.6 m	Mixed metasedimentary and altered intrusive, gneissic textures
GSNSW Congarrara 2	317.9 m	Muscovite–biotite granite

AusLAMP magnetotelluric acquisition underway in NSW

GSNSW is participating in the AusLAMP project to create a conductivity model of the deep Australian lithosphere. In 2016, GSNSW established a National Collaboration Framework Agreement with Geoscience Australia to acquire and model over 300 long-period magnetotelluric stations across NSW. To date 77 stations have been acquired in southern and far western NSW (see Figure 5). In 2018 acquisition is focussing on sites in central-western NSW with 10 magnetotelluric units currently deployed in the West Wyalong area. The survey will then move north and west to cover the prospective Tasmanides belt.

Contact: ned.stolz@planning.nsw.gov.au, (02) 4931 6554.

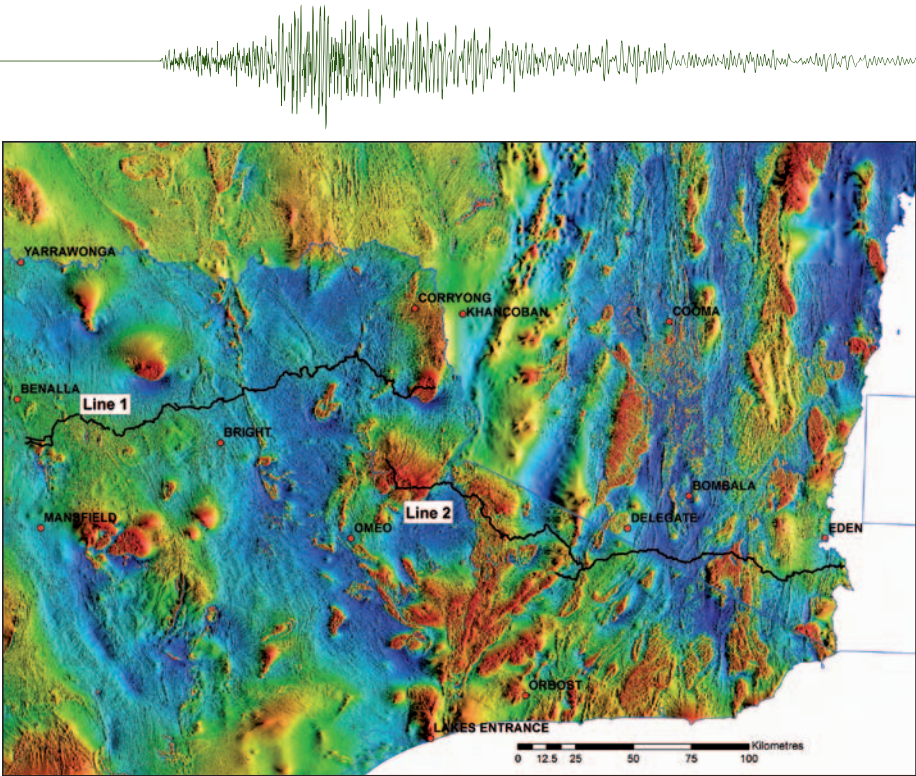


Figure 4. Location of the proposed South East Lachlan Crustal Transect seismic survey (black lines) displayed over an airborne magnetic TMI image of eastern Victoria and southern NSW. The NSW–Victoria border is shown in blue and towns are labelled in black.

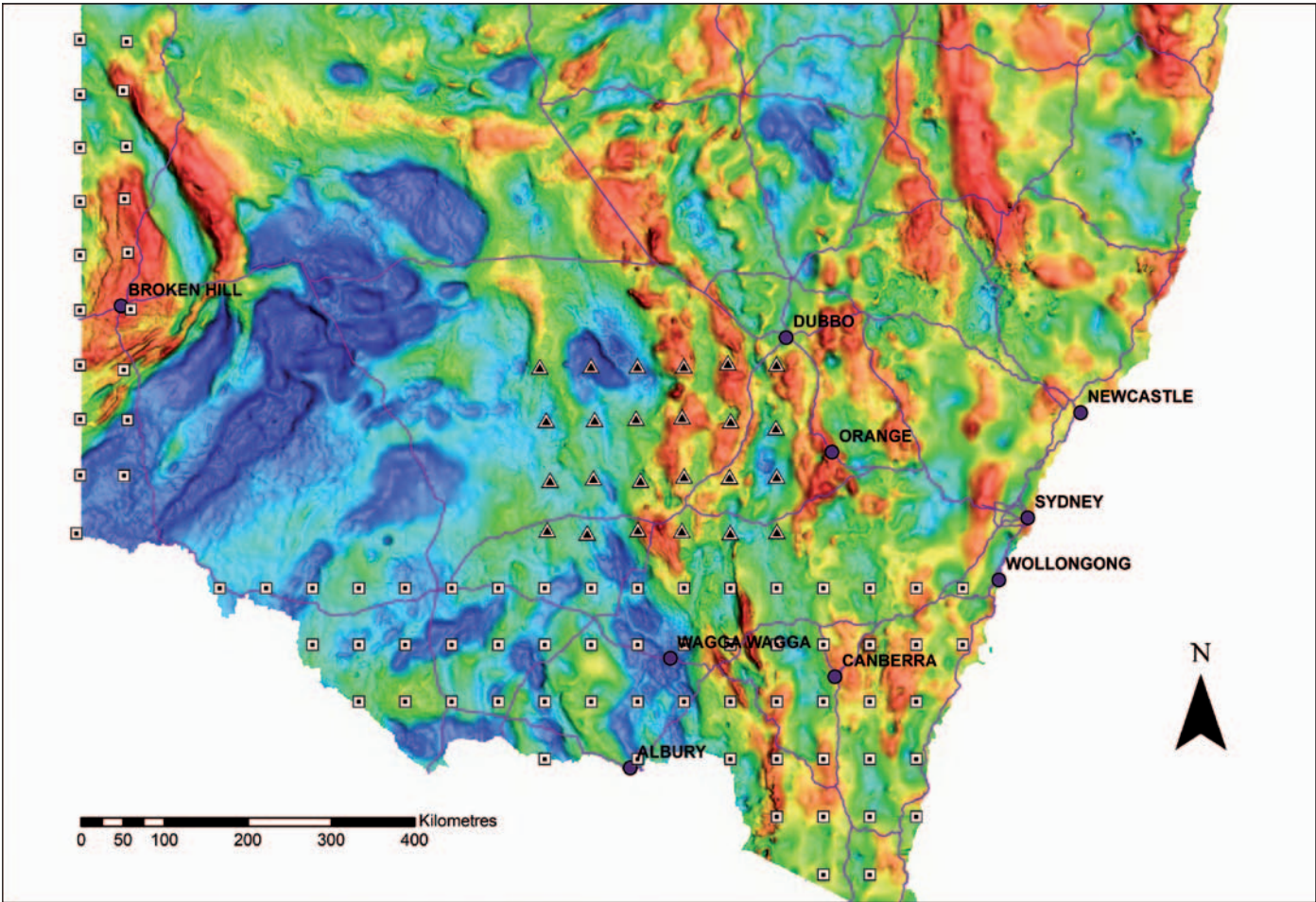


Figure 5. Location of AusLAMP MT sites in NSW overlain on isostatically corrected Bouguer gravity image. Squares are sites from 2016–2017 and triangles are the sites being acquired in 2018.

News from the Geological Survey of Victoria

Victorian Gas Program: airborne survey

The Geological Survey of Victoria (GSV) is planning to acquire airborne geophysical data (airborne gravity and/or gravity gradiometry) over the Otway Basin in 2018. The airborne gravity/gradiometry survey will be conducted over approximately 18 000 km² of the Otway geological basin, including State onshore and offshore areas and Commonwealth waters. It will extend from the western margin of the Otway Ranges in Victoria to the South Australian border (Figure 1).

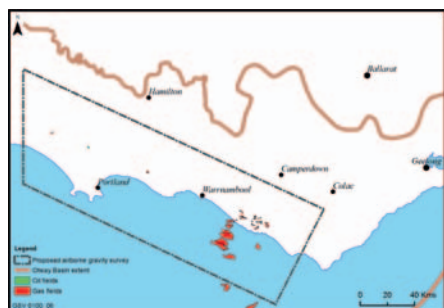


Figure 1. Map showing the proposed area of the Otway Basin Gravity/Gradiometry Survey.

The survey is part of the \$42.5 million Victorian Gas Program, which will deliver a comprehensive program of geoscience and environmental research and related activities - including community engagement, resource planning and regulatory reform - in support of commercial exploration for further gas discoveries off the Victorian coast. The survey is one component of a precompetitive geoscience data package that will underpin petroleum acreage release in State waters in 2018.

All study results from the Victorian Gas Program will be made publicly available.

For more information go to the website:

www.earthresources.vic.gov.au/earth-resources/victorian-gas-program or email: vgp@ecodev.vic.gov.au.

Eastern Victorian Geoscience Initiative

The South East Lachlan Crustal Transect (SELCT) is a deep crustal seismic survey that is part of the GSV's Eastern Victorian

Geoscience Initiative. The survey is due to begin near Benalla in early 2018. See the GSNSW update in this issue for more news on this exciting collaboration between GSV, GSNSW, Geoscience Australia and AuScope Limited.

Stavely Project

The Victorian Government has co-funded mineral exploration projects under its TARGET Minerals Exploration Initiative to further enhance the understanding of the geology and potential mineral deposits in western Victoria, and to encourage investment and new projects in regional Victoria.

The Government will soon be releasing thousands of square kilometres of ground for minerals exploration in the Stavely region (Figure 2), which has been identified as having potential for copper, other base metals and gold mineralisation, through a competitive, merit-based international tender.

Investors and explorers can access free pre-competitive and open-file reports,

maps, interpretations, 3D models and data from the Earth Resources Online Store, Earth Resources Search Assistant and GeoVic – GSV's free web mapping application for searching and displaying geospatial databases and images provided by GSV. Geoscience data and reports generated by the Stavely Project are available through the project webpages at: www.earthresources.vic.gov.au/earth-resources/geology-of-victoria/gsv-projects/the-stavely-project and www.ga.gov.au/scientific-topics/minerals/unlocking-resource-potential/stavely-project.

Full text addresses for the resources mentioned above are:

<http://earthresources.vic.gov.au/earth-resources/maps-reports-and-data/download-reports-maps-and-data>
<http://earthresources.vic.gov.au/earth-resources/maps-reports-and-data/search-tool>
<http://earthresources.vic.gov.au/earth-resources/maps-reports-and-data/geovic>

Suzanne Haydon

Geological Survey of Victoria

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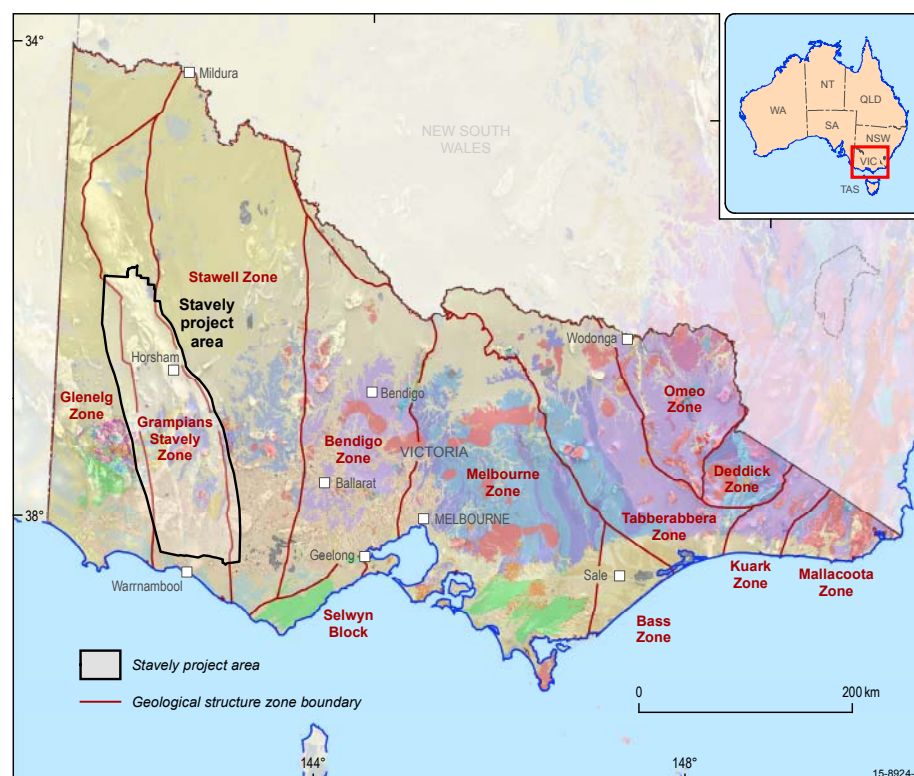


Figure 2. Map showing the location of the Stavely Project area in Victoria with simplified geology and structural zones (modified from Vandenberg et al., 2000, GSV Special Publication, by Geoscience Australia).

Mineral Resources Tasmania: 3D geophysical modelling stimulates exploration

Mineral Resources Tasmania (MRT) continues to develop high resolution regional 3D models to stand alongside provision of traditional geophysical surveys, geological mapping and other value-added pre-competitive geoscientific data. This has directly stimulated and improved the focus of mineral exploration in Tasmania. In the instance described here, results from a previous study (Rosebery Region 3D model, reported in earlier issues of *Preview*) identified a significant negative gravity residual within the study area, a highly mineralised district in western Tasmania (Figure 1). This modelling outcome has led directly to new commercial greenfields drilling.

Geological setting

The area targeted for more detailed modelling, containing the gravity anomaly

residual from the earlier regional study, is outlined in red on Figure 1. Structurally it is dominated by the N- to NNW-striking Huskisson Syncline, which at its core comprises Silurian-Devonian Eldon Group sediments overlaying the Gordon Limestone. Allochthonous fault bound slices of serpentinitised ultramafic complexes are located to the west and east of the syncline with the Meredith Granite (which intruded the sequence in the Devonian) located north of the syncline.

Regionally the study area encompasses some of the most highly and diversely mineralised crust on the planet. The Rosebery polymetallic ore mineral system, which occurs within the Cambrian Mount Read Volcanic Belt – now in its ninth decade of continuous mining, is interpreted to be the product of volcanism following collision of a proto-Tasmanian micro-continent (represented by

Neoproterozoic Crimson Creek Formation and older units) with an oceanic island arc (represented by serpentinitised ultramafic units) around 520 Ma. In the late Devonian the region was intruded by granites. This led to additional metallogeny, including the world’s largest underground tin deposit (Renison).

Tributary Creek gravity anomaly

In 2013, preliminary regional 3D modelling highlighted a significant negative gravity residual (Figure 2) near the southwestern Huskisson Syncline. The geometry of modelled low density Devonian granite was varied to account for this feature. This inversion process resulted in a substantial change to the previous granite model in the form of a spine underlying this region (Figure 3, white ellipse). Depth to this crest at its shallowest is estimated to be ~1000 m with the potential for granite possibly intruding ultramafics and/or Gordon Group carbonates. Either scenario has potential for generating mineralised systems.

Drill targeting

Following MRT reporting of this modelling, in 2017 Yunnan Tin began

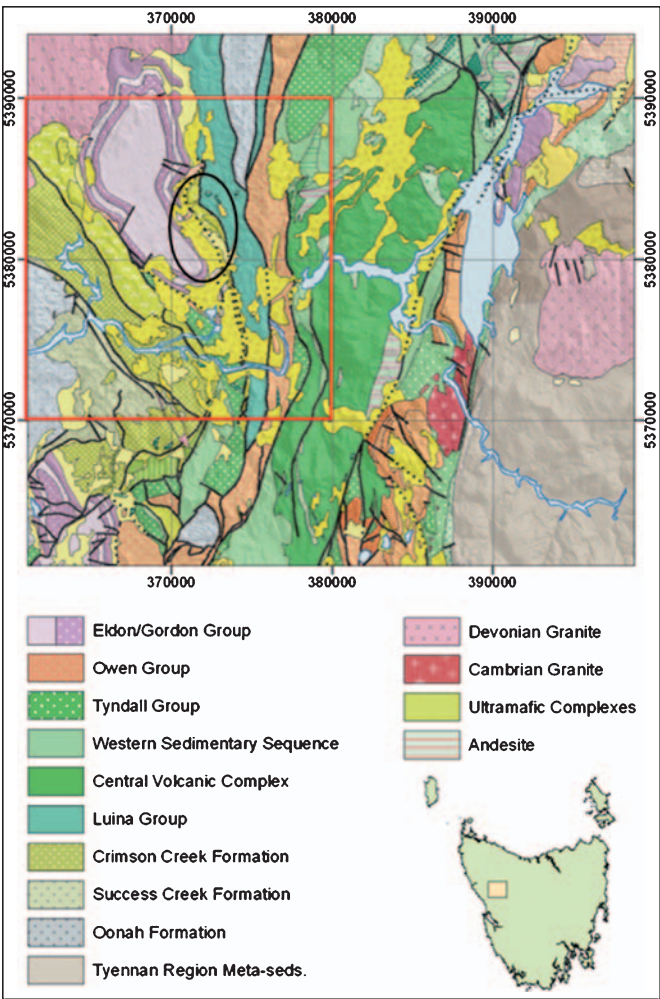


Figure 1. Location and geology of the 3D model area.

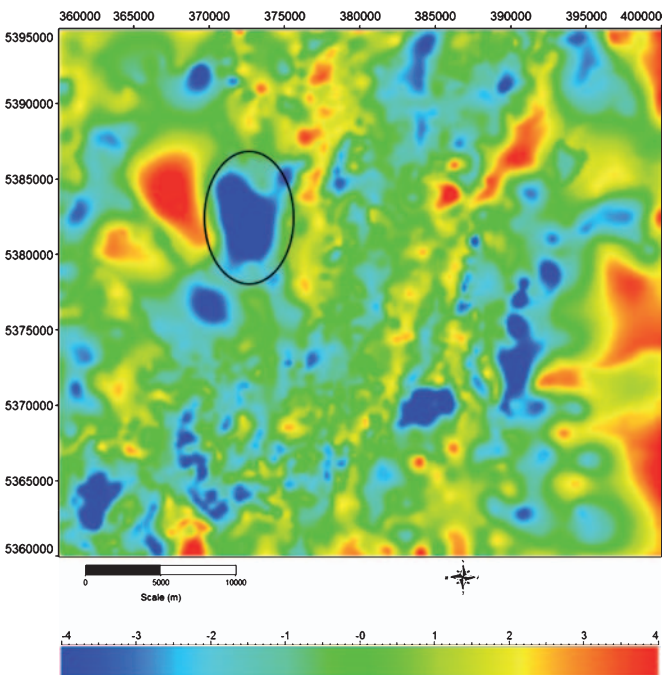


Figure 2. Residual gravity following removal of 3D geological model response. The significant negative feature (black ellipse) is here referred to as the Tributary Creek gravity anomaly (TCGA). Colour ramp legend in mGals.

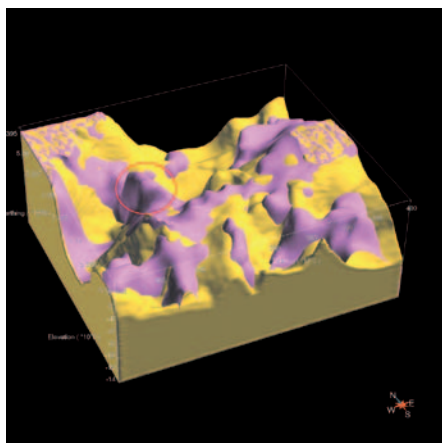


Figure 3. Modelled granite surfaces with pink representing new and yellow old. Red ellipse highlights the TCGA.

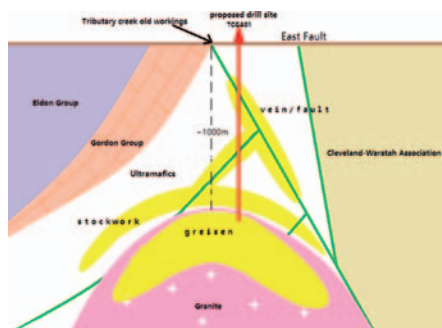


Figure 4. Conceptual drill cross section of the TCGA with potential ore deposit types (image courtesy Joe Xie, Yunnan Tin).

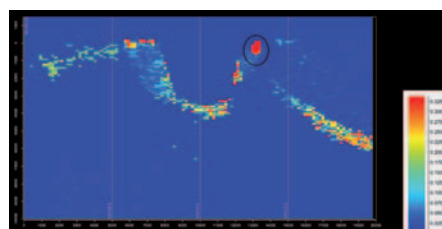


Figure 5. Sectional view of the recovered magnetic susceptibility model, highly magnetic ultramafic units. Black ellipse represents the location of the TCGA and the volume targeted by diamond drill hole TCGA01. Colour ramp legend in SI units.

an exploration campaign to investigate the anomaly. This commenced with detailed ground gravity (~100 m spacing) confirming the location and character of the TCGA. Figure 4 represents a schematic cross section of the TCGA locality illustrating concepts of potential mineral systems and deposition sites. Figure 5 is a sectional view of the 3D magnetic inversion result, indicating susceptibility variation within the modelled generally highly magnetic ultramafic units. Note the especially

magnetised portion (red pixels), which is coincident with the TCGA gravity low. This volume was an additional target of Yunnan Tin's drilling.

Drilling results

Depth to granite was estimated at ~1000 m. Diamond drilling intercepted serpentinite (Figure 6) and several fault and shear zones, as predicted by the model. However, drilling was abandoned at 582 m due to the very high hydraulic load factor the drilling rod experienced in poor ground conditions associated with the faulting. Hand lens inspection of core identified the lithology as fairly uniform serpentinite with abundant calcite, talc, magnetite and asbestos. No visible mineralisation was observed. The hole was regularly traversed by shear zones, particularly the last ~170 m. Major structural zones were logged at 413–418 m, 497–499, 538–544.5 m and 568 m to EOH at 582 m.



Figure 6. TCGA01 drill core (serpentinite). Image courtesy of Joe Xie and Yunnan Tin.

Geochemical analyses of core

MRT staff conducted HyLogger and XRD analyses of TCGA01, using in-house facilities. The core contained significant asbestos and was sealed with PVA glue as a precautionary safety measure. A reconnaissance investigation showed that the PVA can confuse the automated mineral interpretation of TIR spectra. Nevertheless, HyLogger results showed that the core is primarily composed of lizardite plus carbonate. Downhole plots of carbonates (Figure 7) show that magnesite is the dominant species. Carbonates become slightly more common approaching the bottom of the hole. Calcite, dolomite and siderite were tentatively identified and occur near the bottom of the hole. Mg-rich hydrated carbonates occur in broken core and on joint/shear faces.

XRD analyses were undertaken to confirm the identity of the carbonates. Results confirm the presence of magnesite and dolomite towards the bottom of the hole within the major fault zone (Figure 8). These minerals frequently occur as alteration products resulting from low temperature hydrothermal and/or metasomatic effects. Other carbonates identified include sjogrenite, pyroaurite and brugnatellite, which are typical background products from the original (pre-granite intrusion) serpentinisation process. No siderite was identified.

Discussion

Drilling did not reach the target depth of 1000 m due to drilling difficulties associated with the fault zones intersected. Geochemical analyses of core identified several varieties of carbonates, though not the presence of sulphides. Magnesite and dolomite are low to mid temperature hydrothermal/metamorphic alteration products. Magnesite is evidence of fluid evolution to lower temperatures and higher CO₂ concentrations. Comparison and experimental results on the alteration/metamorphism of serpentinite indicates that a decrease in temperature from approximately 500 to <350°C, and an increase in CO₂ content from 0 to 3%, is required for magnetite dissolution. The fluid source for magnesite in hole TCGA01 is unknown. A possible mechanism for the formation of magnesite could be convection of meteoritic waters induced by a nearby magmatic source. Another possibility is low temperature hydrothermal fluids from a magmatic source encountering limestone, which would enhance CO₂ concentration and magnesite dissolution. The nearby Gordon Group limestone is a candidate CO₂ source and the shear zones within serpentinite could act as fluid conduits with magnesite crystallising out of solution as a result of decreasing fluid temperature.

Summary

Yunnan Tin's investigation of the TCGA shows how MRT's development of high precision regional 3D models is stimulating exploration. Drilling, unfortunately, did not reach depths of potential mineralisation sites due to technical issues, so this aspect of the model remains untested. However, it did confirm the 3D model ultramafic geometry. First petrophysical results from the new drill core are in line with

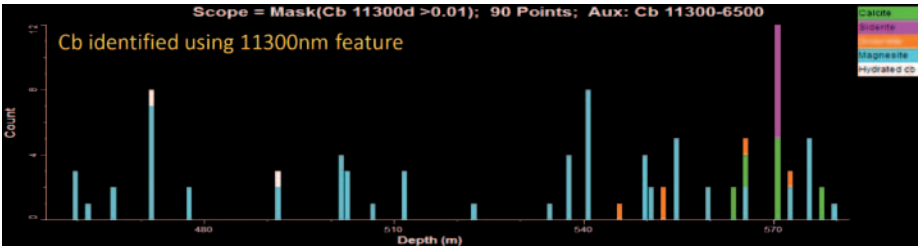
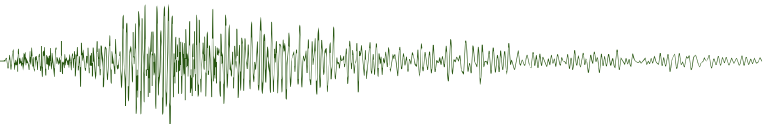


Figure 7. Carbonate (Cb) abundances from HyLogger scanning of TCGA-01, showing magnesite (aqua) as generally dominant, with other species including dolomite (orange), calcite (green) and notably siderite (magenta) becoming more common approaching the bottom of the hole.

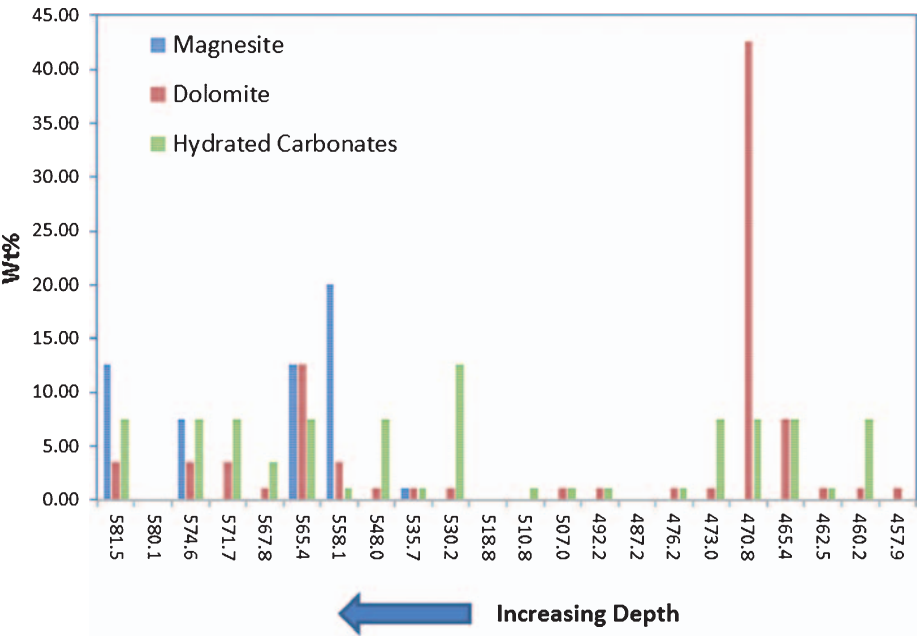


Figure 8. XRD results confirming magnesite and dolomite as the dominant species becoming more common approaching the bottom of the hole.

magnetic property expectations, however the implications of sample densities near the lower end of the modelled range for ultramafics (indicating total serpentinisation) are yet to be determined. Results from drilling suggests that the magnesite/dolomite found in shear/fault zones at the bottom of TCGA-01 could represent the distal part of a hydrothermal system arising from granite intrusion. Further exploration is required to understand the nature of this system.

Thanks to Joe Xie of Yunnan Tin and MRT staff including Ralph Bottrill, David Green, Richie Woolley and Lia Unwin.

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Mark.Duffett@stategrowth.tas.gov.au

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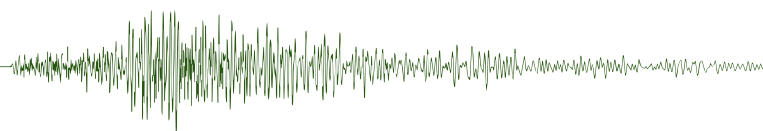
Update on geophysical survey progress from Geoscience Australia and the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current on 14 December 2017)

Further information on these surveys is available from Murray Richardson at GA via email at Murray.Richardson@ga.gov.au or telephone on (02) 6249 9229.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km ²)	End flying	Final data to GA	Locality diagram (Preview)	GADDS release
Andamooka	GSSA	GA	Sander Geophysics	23 Feb 2017	81 396	200 m 60 m E-W	14 560	6 Jun 2017	Final data QA/QC in progress	183: Aug 2016 p. 34	TBA
Barton	GSSA	GA	Thomson Aviation	22 Jan 2017	111 758	200 m 60 m E-W	20 560	11 May 2017	Final radiometric data QA/QC in progress	183: Aug 2016 p. 34	TBA
Fowler	GSSA	GA	Thomson Aviation	18 Feb 2017	95 009	200 m 60 m E-W	17 360	2 Jun 2017	Final radiometric data QA/QC in progress	183: Aug 2016 p. 34	TBA
Torrens	GSSA	GA	Sander Geophysics	4 Mar 2017	79 990	200 m 60 m E-W	14 800	15 Jun 2017	Final data QA/QC in progress	183: Aug 2016 p. 34	TBA
Coonabarabran	GSNSW	GA	UTS Geophysics	17 May 2017	50 827	250 m 60 m E-W	11 000	30 Jul 2017	Nov 2017	184: Oct 2016 p. 23	Nov 2017
Tasmanian Tiers	MRT	GA	TBA	TBA	Up to an estimated 66 000	200 m 60 m N-S or E-W	11 000	TBA	TBA	TBA	National Collaborative Framework Agreement between GA and MRT is being updated. The survey has been deferred to occur between Oct 2017 and Mar 2018
Isa Region	GSQ	GA	GPX	3 Jul 2017	120 062	100 m 50 m E-W	11 000	5 Nov 2017	Raw edited data made available to GA on 7 Dec 2017	188: Jun 2017 p. 21	TBA
Tallaringa N (1A)	GSSA	GA	TBA	26 Oct 2017	97 762	200 m 60 m E-W	17 320	40.3%	TBA	190: Oct 2017 p. 26	TBA
Tallaringa S (1B)	GSSA	GA	TBA	26 Sep 2017	145 042	200 m 60 m E-W	26 010	41.5%	TBA	190: Oct 2017 p. 26	TBA
Coober Pedy (8A)	GSSA	GA	TBA	18 Sep 2017	90 627	200 m 60 m N-S	16 140	96.2%	TBA	190: Oct 2017 p. 26	TBA
Billa Kalina (8B)	GSSA	GA	TBA	10 Oct 2017	90 625	200 m 60 m N-S	16 140	94.2%	TBA	190: Oct 2017 p. 26	TBA
Childara (9A)	GSSA	GA	TBA	5 Nov 2017	135 021	200 m 60 m N-S	23 910	15.2%	TBA	190: Oct 2017 p. 26	TBA
Lake Eyre (10)	GSSA	GA	TBA	2 Oct 2017	91 800	200 m 60 m E-W	16 180	52.1%	TBA	190: Oct 2017 p. 26	TBA

TBA, to be advised.



News

Table 2. Gravity surveys

Survey name	Client	Project management	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km ²)	End survey	Final data to GA	Locality diagram (Preview)	GADDS release
Tanami-Kimberley	GSWA	GA	Thomson Aviation	16 Jun 2017	49 825	2500 m line spacing	110 000	31 Oct 2017	Raw edited data made available to GA on 8 Dec 2017	The survey area covers the Billiluna (all), and parts of the Lucas, Cornish, Mount Bannerman, Mount Ramsay, Noonkanbah, Lansdowne, Lennard River, Derby, Charnley and Yampi 1:250 k standard map sheets	TBA
Kidson Sub-basin	GSWA	GA	CGG Aviation (Australia)	14 Jul 2017	72 933	2500 m line spacing	155 000	TBA	70.7%	The survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan 1:250 k standard map sheet areas	TBA

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km ²)	End flying	Final data to GA	Locality diagram (Preview)	GADDS release
East Kimberley	GA	GA	SkyTEM Australia	26 May 2017	13 723	Variable	N/A	24 Aug 2017	Nov 2017	TBA	TBA
AusAEM (Year 1)	GA	GA	CGG	TBA	59 349	20 km with areas of infill	TBA	TBA	32.9%	186: Feb 2017 p. 18	TBA
Surat-Galilee Basins QLD	GA	GA	SkyTEM Australia	2 Jul 2017	4627	Variable	Traverses	23 Jul 2017	Nov 2017	188: Jun 2017 p. 21	TBA
Stuart Corridor, NT	GA	GA	SkyTEM Australia	6 Jul 2017	9832	Variable	Traverses	12 Aug 2017	Nov 2017	188: Jun 2017 p. 22	TBA
Olympic Domain	GSSA	GA	SkyTEM Australia	14 Nov 2017	3181	1.5 & 3 km E-W	33 200	21 Nov 2017	TBA	190: Oct 2017 p. 27	TBA
Fowler Domain	GSSA	GA	SkyTEM Australia	Early Dec 2017	3057	5 km NW-SE	15 000	5 Dec 2017	TBA	190: Oct 2017 p. 27	TBA

TBA, to be advised.

Table 4. Magnetotelluric (MT) surveys

Location	State	Survey name	Total number of MT stations deployed	Spacing	Technique	Comments
Northern Australia	Qld/NT	AusLAMP	150	50 km	Long period MT	The survey covers the area between Tennant Creek and Mount Isa

Reprocessed seismic data in the Tennant Creek region

The Tennant Creek crustal reflection seismic survey was co-funded by the Northern Territory Government through the Creating Opportunities for Resource Exploration (CORE) initiative and Emmerson Resources Limited. HiSeis Pty Ltd acquired the 60 km 2D seismic line (Line 101), proximal to the Tennant Creek town site and mining facilities, from 14 June to the 21 June 2015. Geoscience Australia, as part of the Exploring for the Future Program, provided specialised hard-rock seismic data processing to image deep crustal

structures and sedimentary layers at the near surface.

The objective of the 2D survey was to define the regional scale structures contributing to the mineralisation in the area and target previously unidentified areas of prospectivity in the Tennant Creek Mineral Field, as well as demonstrate the value of seismic reflection for the minerals industry and to the geoscience community.

10 s stack and migrated data and a 20 s stack are provided as Tiff images and

SEG-Y format. Depth conversions were performed on the migrated data and 30 km depth SEG-Y and 5 km depth Tiffs are included. Meta data including coordinates for all data sets, data processing streams and velocity files are included.

The data were released in December 2017 and are available as a single zip file (347 Mb file size) from the GA website at <https://ecat.ga.gov.au/geonetwork/srv/eng/search> by entering 115103 (the eCat ID number) into the search box.