



Unlocking Australia's hidden mineral resource potential

Australia's economic prosperity is highly dependent on the continent's remarkable endowment of mineral and energy resources. Maintaining this prosperity requires effective exploration that leads to new discoveries to provide an ongoing 'pipeline' of resource development. Unfortunately, the percentage of global expenditure for minerals exploration in Australia has declined over the past decade, particularly for non-ferrous commodities and in frontier or greenfield regions. One factor for the decline in expenditure has been the perception that Australia is 'mature', i.e. has limited prospects for big new discoveries.

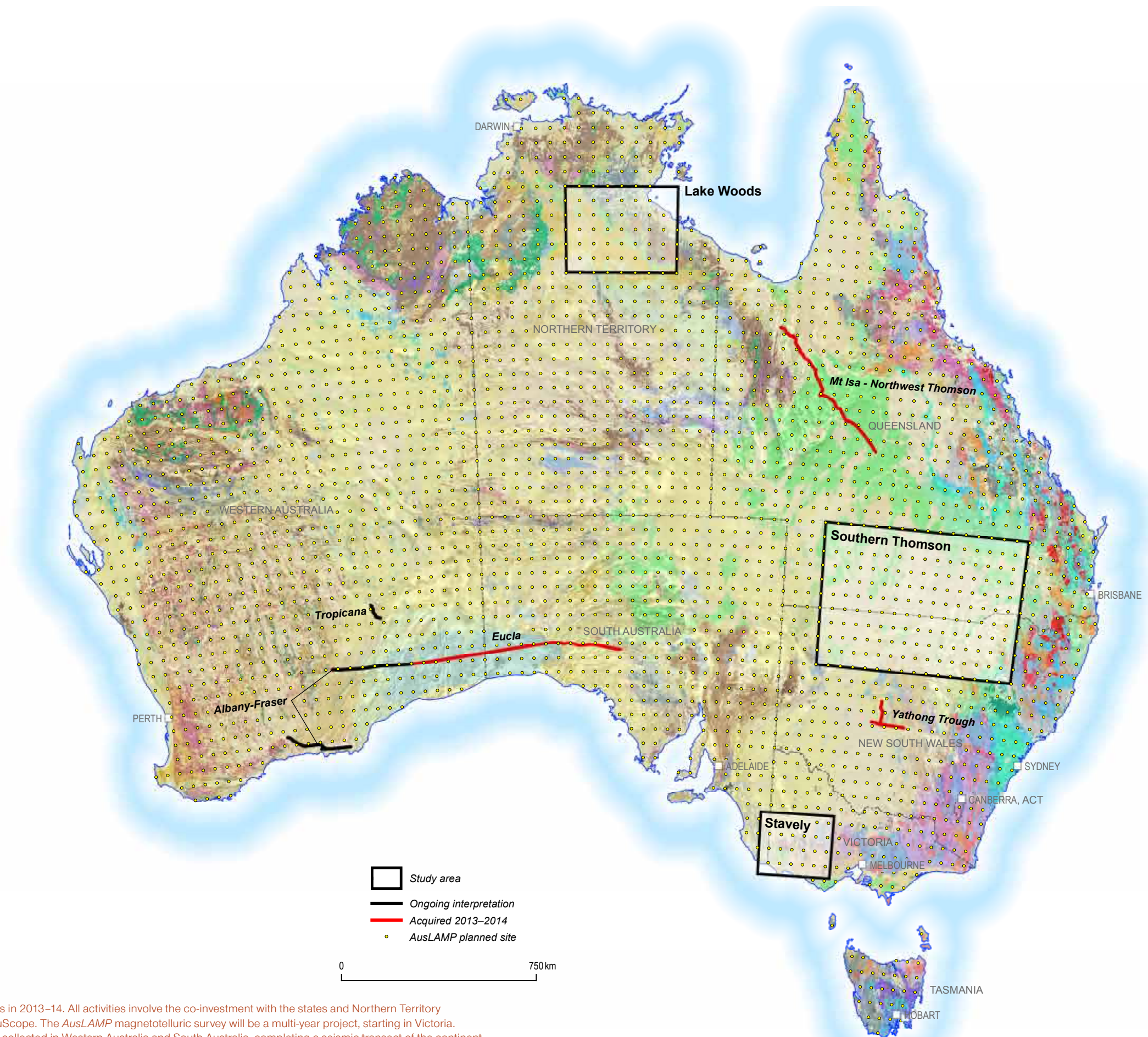
Most of the existing mineral resource base that has been discovered and developed only occurs from outcropping or near outcropping geology. Such geology comprises approximately 20% of the land area, with the remaining 80% of the continent covered by a veneer of regolith or sediments, much of it only a few hundred metres thick. The fact that prospective rocks lie, for the most part, untested beneath this cover creates a tremendous opportunity for new mineral discoveries.

Geoscience Australia, in collaboration with the state and Northern Territory geological surveys and the research community, will seek to reveal the hidden potential of Australia's buried but prospective geology. The work will involve the acquisition, processing, interpretation and delivery of new pre-competitive geoscience data sets that develop and test geological models and key indicators of mineral resource potential in the subsurface.

The work will be directed at the four inter-related initiatives identified by the National Mineral Exploration Strategy and the Australian Academy of Science, with particular emphasis on the first two.

These initiatives are:

1. Characterising Australia's cover—new knowledge to confidently explore beneath the cover.
2. Investigating Australia's lithospheric architecture—a whole-of-lithosphere architectural framework for mineral systems exploration.
3. Resolving the 4D geodynamic and metallogenic evolution of Australia—understanding ore deposit origins for better prediction.
4. Characterising and detecting the distal footprints of ore deposits—towards a toolkit for minerals exploration.



Location of pre-competitive activities in 2013–14. All activities involve the co-investment with the states and Northern Territory geological surveys, together with AuScope. The *AusLAMP* magnetotelluric survey will be a multi-year project, starting in Victoria. Deep seismic reflection lines will be collected in Western Australia and South Australia, completing a seismic transect of the continent, as well as North Queensland and central New South Wales. The Albany–Fraser Orogen lines in southeast Western Australia will be interpreted and results delivered. The southern Thomson and Stavelly regions are highlighted for drilling and detailed geophysical and surface geochemical data acquisition. Lake Woods will be a focus for groundwater geochemical sampling and analysis.

Australia's cover

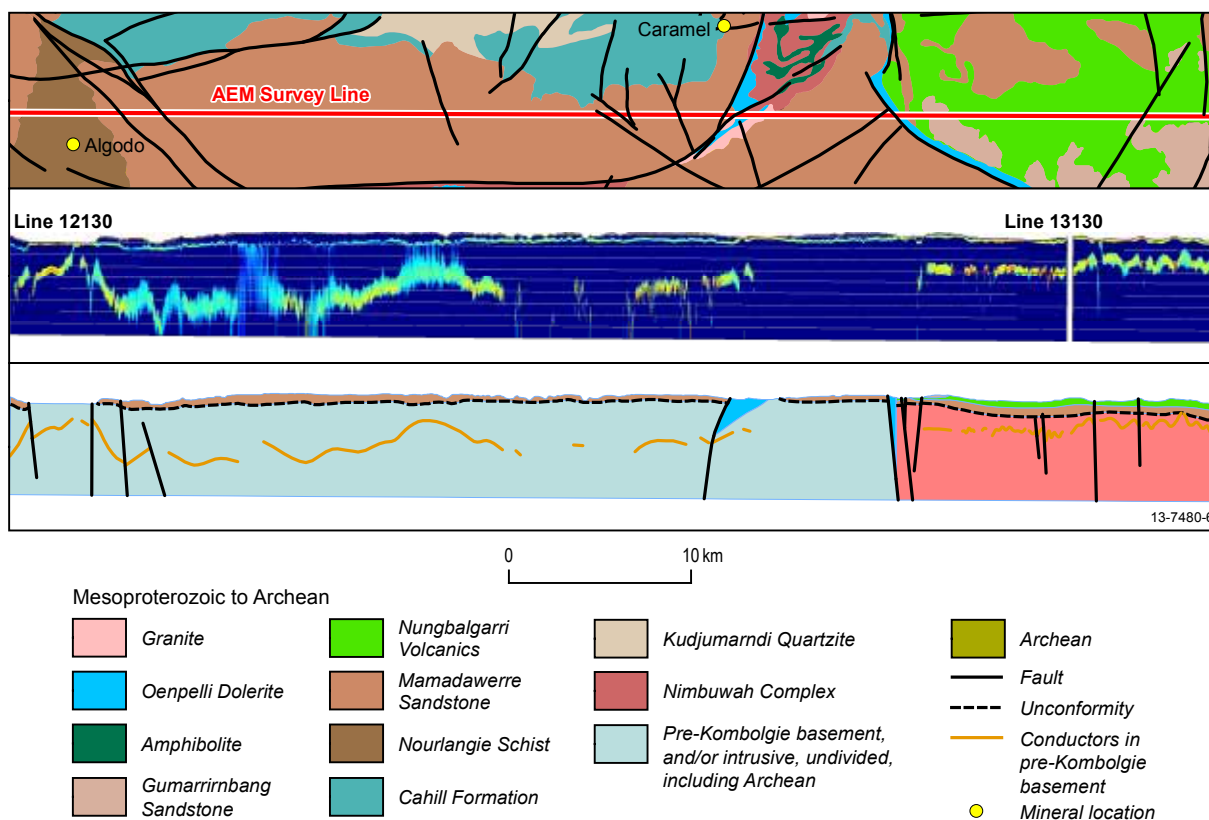
The Australian continent is estimated to be 80% covered by Cenozoic and younger rocks. Where basement rocks crop out, many are deeply weathered. One of the first-order challenges for industry is being able to reliably predict at the deposit-, district-, province-, and continent-scales: 1) the depth to prospective basement, and 2) the character of the overlying cover.

Methods will be developed to improve the cover depth and character predictions at the district-scale through new data acquisition and experimentation. A range of methods will be used and predictions made prior to validation by drilling. The southern Thomson Orogen and the Staveland region of western Victoria will be the first areas to be drill tested, with other terranes to be tackled in subsequent years.

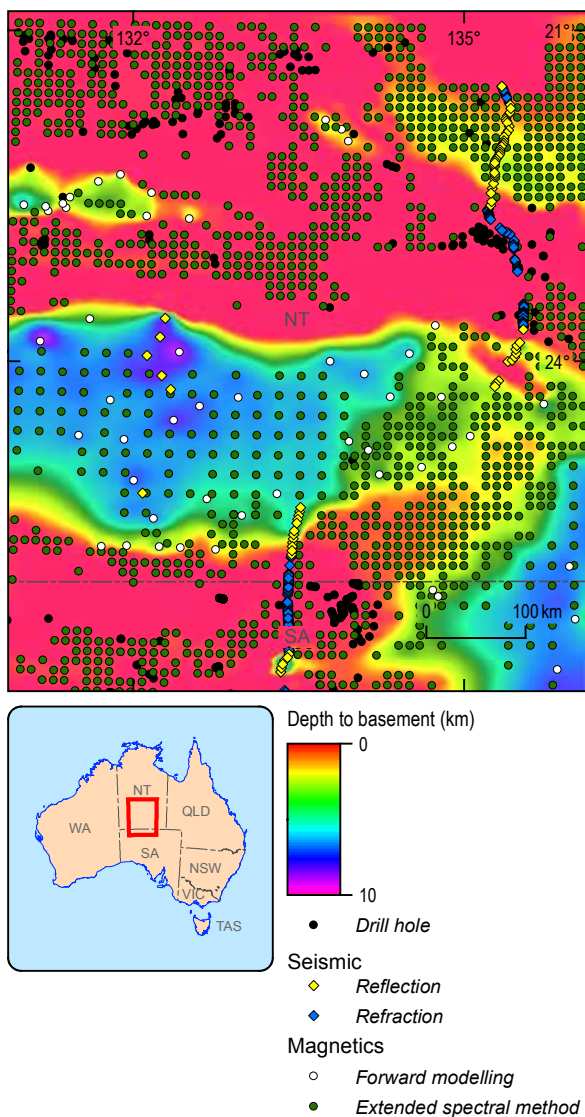
Methods will be developed to improve province-scale cover depth and character predictions. One method being considered for baseline cover mapping is a very-broad spaced (nominal 110 km) Airborne Electromagnetic (AEM) survey for the entire continent. A National AEM survey is analogous to the AWAGS reference survey for magnetic and radiometric data. Before this method is 'rolled out' nationally, a test area will be acquired across the southern Thomson Orogen. The results will be integrated with the other multi-disciplinary regional-scale cover studies in the same region.

Ground conditions and cover character change dramatically across the continent, making it difficult to easily produce a consistent map of cover thickness across Australia. By integrating the knowledge acquired at the regional-to province-scales across many areas of the continent, Geoscience Australia plans to generate a seamless national map by integrating the smaller scale cover maps with larger scale data. Where possible, the map will be constrained by drilling. This cover thickness map will provide explorers with a first-order screening tool for the whole continent.

To improve exploration success in greenfield areas, Geoscience Australia will also develop techniques to map the geochemistry of thin cover (<5 m depth) by applying multi-covariate modelling and advanced sample designs (Latin hypercube) to existing datasets. The techniques will be tested initially in the southern Thomson Orogen, and later used to produce new national maps of near-surface cover, focusing on key regolith geochemical components such as carbonate, silica, iron, potassium, uranium and thorium. These maps will link to a new National Regolith Map, which will integrate all existing regolith maps from across the States and Territories. Together these surface materials maps will assist explorers in understanding landscape evolution at the district- to province-scale and in designing and interpreting geochemical sampling programmes.



Mapping depth and character of cover in the Northern Territory using Airborne Electromagnetics (AEM).



Depth to basement (in kilometres) in central Australia. Depths determined by drilling, magnetic modelling and seismic data.

Australia's lithospheric architecture

To successfully target major new economic mineral deposits under cover requires a better understanding of the architecture of the whole lithosphere that focuses magmas and fluids to produce large deposits or deposit clusters. Geoscience Australia will augment its national pre-competitive geoscience datasets by acquiring a combination of high-resolution data along key transects of poorly understood geology and low-resolution data over very broad areas.

The ultimate goal of this theme is to create a new 3D map (model) of Australia's lithosphere. The 3D map will be built by integrating the new pre-competitive data and existing data with pre-existing regional-scale 3D geological maps. The 3D map will provide the spatial framework for understanding the geodynamic and metallogenic evolution of Australia.

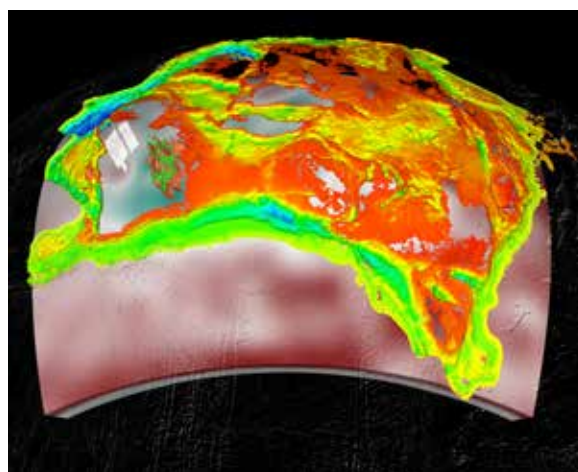
Broad area and national initiatives

A key new initiative will be the commencement of *AusLAMP*—a Geoscience Australia and collaborator survey of long-period magnetotelluric data at a nominal scale of a half degree grid (55 km) across the continent. These data will provide a consistent continental-scale image of the electrical and magnetic structure of the entire Australian continental lithosphere and will provide insights to 'big' structures, particularly in the mantle lithosphere where other techniques such as seismic reflection provide little signal.

The survey will commence in Victoria and the nation-wide programme is expected to take between four and six years to complete, depending on the level of co-investment from collaborators. Data and processed products will be released throughout the project life span.

The building blocks of Australia are rooted in the deep fabric of the continent. The ancient foundations of Australia's continental crust can be mapped through isotopic tracers that provide the age when the precursor source (igneous) rock separated from the primitive mantle.

Compilation of existing samarium–neodymium (Sm–Nd) data for granites across the continent, together with new isotopic analyses of other systems (hafnium, oxygen, lead), will enable the major crustal elements and their boundaries to be better defined. Such knowledge will provide first-order constraints on the location of deep-cutting structures, which form a key input to area selection for specific mineral systems, such as nickel-sulphide deposits.



Three dimensional (3D) map of Australia to 350 km depth. Coloured upper layer shows depth of basins.

High-resolution transects

Geoscience Australia will co-invest with partners in the acquisition, processing and interpretation of high-resolution geophysical transects across key areas of the continent.

Geoscience Australia, the Geological Survey of Western Australia and the Geological Survey of South Australia will collaborate on a deep seismic reflection and magnetotelluric data traverse of the Nullarbor Plain.

This data-poor region is entirely undercover and thus poorly understood in terms of geology and mineral prospectivity. The survey will image the basement and several geological boundaries that are fundamental to the understanding of the evolution of the

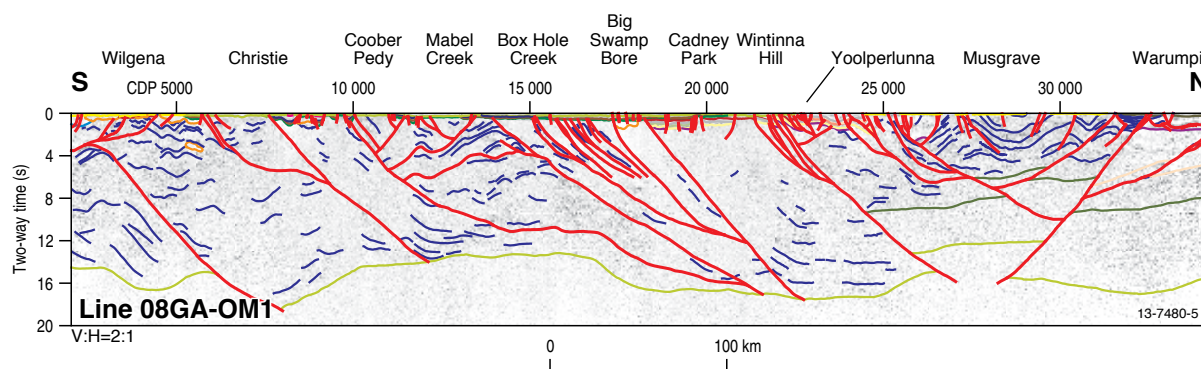
continent. The survey represents the final segment in an east-west deep seismic reflection transect of continental Australia.

Adding to the nation's seismic and magnetotelluric database, Geoscience Australia will provide acquisition support and state-of-the-art processing of a series of deep seismic reflection and magnetotelluric surveys in central New South Wales, northwest Queensland and northwest Western Australia. These data will be acquired in 2013–14 with processing and data release by 2014–15.

In future years transects could be acquired across north-eastern Victoria, northern Tasmania and/or the central Northern Territory.



Vibroseis trucks acquiring deep seismic reflection data in the Flinders Ranges, South Australia.



Interpretation of deep seismic reflection profile from the northern Gawler Craton to the Musgrave Province. Approximate depth of profile is 60 km, with Moho shown in green, major faults in red, form lines in blue.



Drilling cover in the Frome Embayment, South Australia.

Regional Drilling Projects

In addition to other pre-competitive datasets, stratigraphic drilling will be acquired in key regions. The drilling will test geological models of undercover greenfield regions and also provide valuable core samples for a range of analytical studies.

The selection of these regions has been guided by a range of factors, including:

- whether a pre-competitive geoscience programme can change industry behaviour
- the likely thickness of cover (<500 m)
- the level of co-investment from jurisdictions
- cross-border opportunities for collaboration
- estimated mineral potential, and/or
- degree of basic knowledge gaps.

Geoscience Australia is continuing its investment as a research partner in the Deep Exploration Technologies Cooperative Research Centre (DET CRC). The DET CRC is developing innovative drilling and analysis technology with the aim of making drilling faster, cheaper and more informative for Australian conditions. Geoscience Australia will continue to support this research by using the DET CRC capability to undertake its regional drilling acquisition.

Stavely Zone Drilling Project

Prospective Cambrian igneous rocks of the Delamerian Orogen lie beneath relatively shallow cover rocks in western Victoria. Geoscience Australia and the Geological Survey of Victoria plan to drill a series of stratigraphic holes into these basement

rocks to test geological and mineral system models. The drilling tests include determining the stratigraphic continuity of the prospective Stavely Volcanic Complex, sampling buried intrusions that are possible hosts to porphyry-epithermal mineralisation and testing key structures in the region. The results from these drill holes will add significantly to the pre-competitive knowledge base of this greenfield region.

Following a phase of planning and analysis, drilling will commence in autumn 2014. Acquisition of local geophysical data will assist in the drill planning, especially in determining the nature and depth of cover rocks. The results will also inform the overall goal of improving cover predictions. The drilling will be fully cored and subject to the full-spectrum of geological, geophysical, geochemical and geochronological analysis.

Final results will be delivered by June 2015, and will include a comprehensive report, data package and 'explorer kit'. The project will also benefit from early results from the *AusLAMP* national magnetotelluric initiative.

Southern Thomson Orogen Drilling Project

The Thomson Orogen is a large area that lies to the north and west of the Lachlan Orogen in New South Wales, South Australia, Northern Territory and Queensland. Much of it is under the cover of younger sedimentary basins (some up to several kilometres thick) and is thus a poorly understood element of Australia's geology.

The southern Thomson Orogen project will be undertaken by Geoscience Australia, the Geological Survey of New South Wales and the Geological Survey of Queensland in the southern part of the orogen, around the border region of the two States. Activities will include synthesis and integration of available datasets, as well as the acquisition of an ensemble of geophysical and geochemical datasets to allow prediction and testing of models of cover thickness and character, and styles of basement geology. The new understanding derived from this project will inform many future activities, especially those concerned with cover thickness determination and characterisation. A mineral systems analysis will also be conducted to assess the likely mineral potential of the region and to help shape the selection of drilling sites. Drilling, informed by the integrated analysis, is planned for 2014–15.

The region is the focus of a pilot project for the National AEM map as part of the broader goal for improving depth-to-basement predictions. Final results from the southern Thomson Orogen project are planned for delivery in mid-2016.



The Sensitive High-Resolution Ion Microprobe (SHRIMP) for precise age determination of Australia's rocks.

4D geodynamic and metallogenic evolution of Australia

Geoscience Australia will continue to build on the temporal framework of the continent's geology through the ongoing operation of the world-class SHRIMP geochronological facility. The focus of age determinations will be on the regional geology of greenfield areas, in particular those being examined by drilling, and rocks that inform on key mineral systems.

Geoscience Australia has been developing methodologies to assess mineral prospectivity through a mineral systems approach, which will be tested at the regional-scale in the two drilling project areas. At the continental-scale, the focus will be on assessments of key mineral systems associated with mafic-ultramafic igneous rocks (including nickel, copper, platinum-group elements, chromium etc.), felsic igneous rocks (including copper, gold, tungsten, antimony etc.) and alkaline igneous rocks (such as lithium, rare-earth elements and diamonds). The first national assessment of Australia's 'critical metals' will be released in 2013.

Geoscience Australia will build on a desk-top assessment of the potential of Australian salt lakes and groundwater systems to host key elements by undertaking a sampling and analysis programme in key salt lakes in the Northern Territory. The aim is to collect pre-competitive data on these under-sampled groundwater systems with the focus on potash, lithium, boron and uranium.

Distal footprints of ore deposits

Geoscience Australia's university and CSIRO partners have well-established projects tackling this theme. Geoscience Australia will continue to play a role by acquiring and compiling baseline geoscientific data that define regional background characteristics of the continent. These baseline data are essential for identifying anomalism associated with the footprints of mineral systems. The data include characterising type sections of geology and populating national

databases such as OZCHEM (geochemistry), OZCHRON (geochronology), STRATINDEX (stratigraphy) and new surface geochemistry maps. Geoscience Australia will also compile its regional rock property holdings and deliver a database.

The 'out years'

Negotiations are underway with the state and Northern Territory geological surveys for future regional pre-competitive geoscience activities.

Geoscience Australia will continue to co-invest in a number of greenfield regions, including an annual regional stratigraphic drilling programme. Possible project areas might include the basement geology beneath the onshore Carpentaria Basin in the Northern Territory, the basement to the Eucla Basin and covered parts of the western Gawler Craton in South Australia, the southern extensions of Mt Isa in Queensland and the covered parts in northwest Tasmania.

The *AusLAMP* magnetotelluric data will continue to be collected and an assessment will be made of the broad-spaced AEM project in the southern Thomson Orogen and its ability to solve the cover depth challenge. A focus will also be made on applying an ensemble of techniques to covered regions in other parts of Australia to determine the most suitable and cost effective methods for determining the depth and character of cover across the diversity of Australian geology.

For further information contact:
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