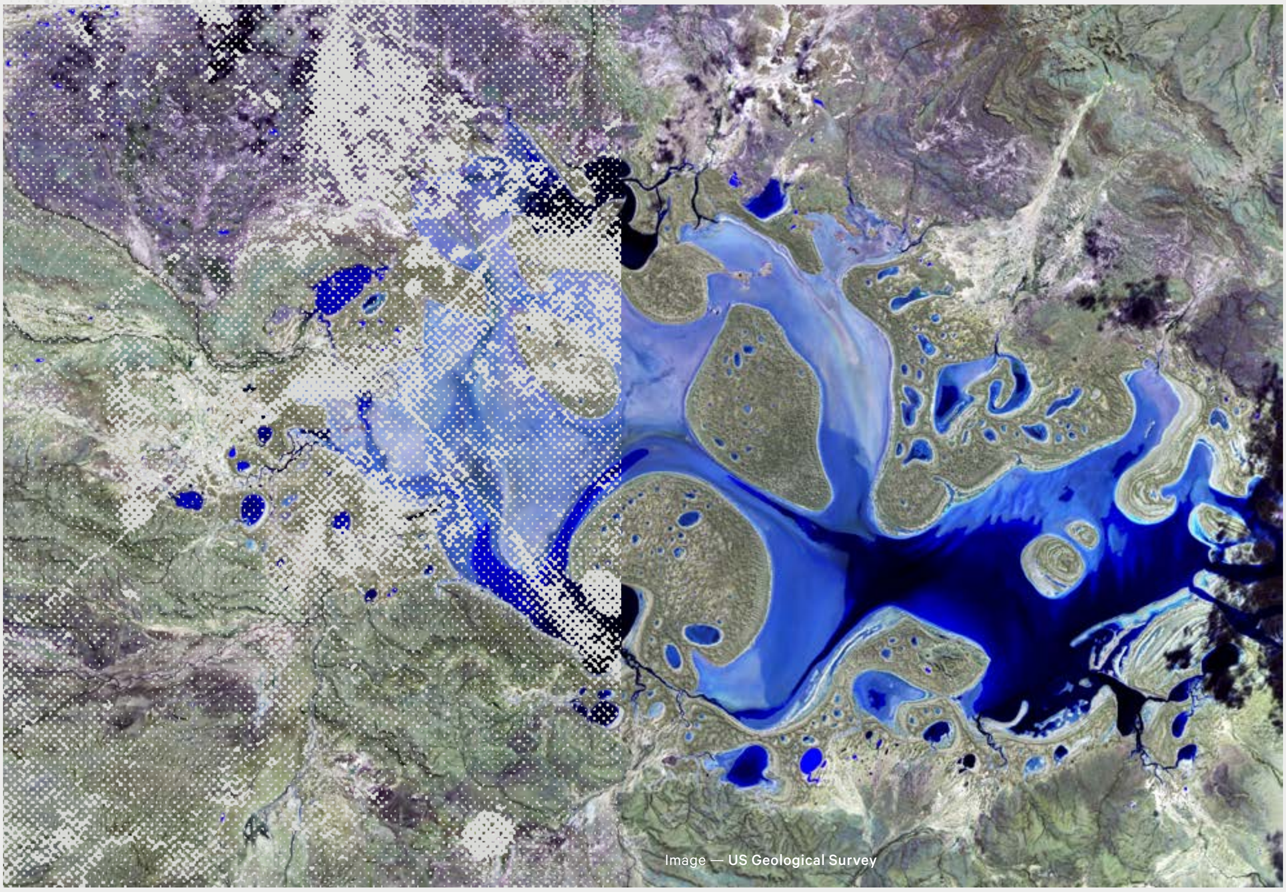
10-Year Strategy 2020 – 2030

AuScope

Answering Australia's Geoscience Questions

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

We acknowledge the Traditional Owners of the land on which our research infrastructure and community operate across the Australian continent, and pay our respects to Elders past and present. We recognise the connection they have with land, sea, sky and waterways for tens of thousands of years.



A false-coloured satellite image of an ephemeral lake known as Lake Carnegie on Martu country in Western Australia.

Image — US Geological Survey

10-Year Strategy
2020 – 2030

AuScope

Answering Australia's
Geoscience Questions

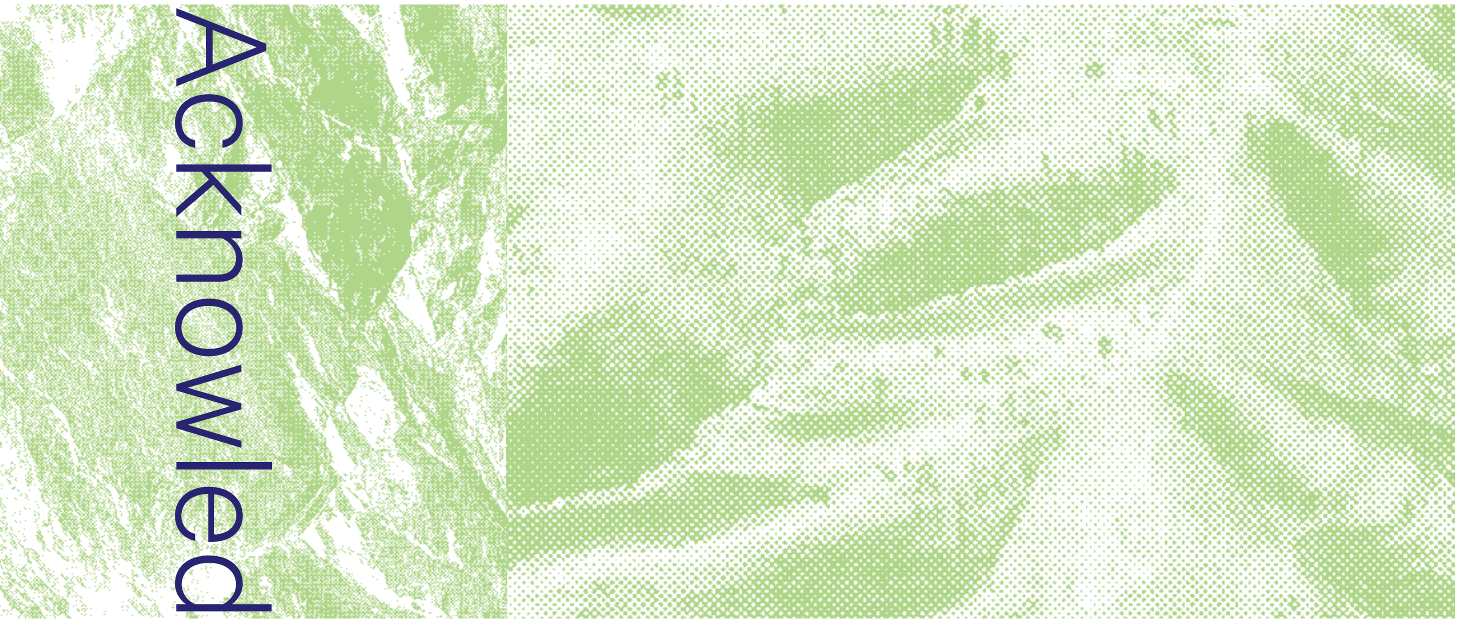
Authors: Tim Rawling, AuScope;
Australian geoscience community
Editors: AuScope Board of Directors
Producer & Editor: Jo Condon, AuScope
Designer: Luke Carson, Design By Bird

Published: August 2020

AuScope is enabled by the Australian Government via the National Collaborative Research Infrastructure Strategy (NCRIS), a program managed by the Department of Education, Skills and Employment (DESE).

NCRIS
National Research
Infrastructure for Australia
An Australian Government Initiative

Contents



Acknowledgements

We would like to acknowledge over 150 people representing the Australian geoscience community for contributing specialist and diverse knowledge to this 10-Year Strategy (Strategy) and the accompanying 5-Year Investment Plan (Investment Plan) during workshops, working groups and discussions between 2018 – 2020.

Working Groups

First, we would like to acknowledge the efforts of working group leaders including Dr Stephan Thiel, Dr Karol Czarnota, Dr Rebecca Farrington and Prof Anthony Dosseto.

Additionally, we would like to thank working group members including Dr Matthias Leopold, Prof Jason Beringer, Dr James Cleverly, Prof Wayne Meyer, Dr Talitha Santini, A/Prof Sally Thompson, Dr Robyn Schofield, Roy Anderson, A/Prof Leanne Armand, Dr Jim Austin, Dr Graeme Beardsmore, Nicholas Brown, Prof David Chittleborough, Marina Costelloe, Dr David Etheridge, Prof Graham Heinson, Prof Penelope King, Prof Matt King, Dr Ken Lawrie, A/Prof Steven Micklethwaite, A/Prof Meghan Miller, Dr Anthony Reid, Dr Nathan Reid, Prof Andrew Roberts, Dr Kate Robertson, Dr Michelle Salmon, Dr Kate Selway, Dr Jessica Stromberg, Prof Paul Tregoning, Dr Lesley Wyborn, Dr Alexei Gorbatov, Jingming Duan, Dr Nicholas Jones, Dr Ludovic Ricard, A/Prof Tom Raimondo, A/Prof Joanne Whitaker, Dr Derrick Hasterok, Dr Olivier Alard, Prof Vickie Bennett, Dr Antony Burnham, Dr Alexandru T. Codilean, Prof Leonid Danyushevsky, Dr Stewart Fallon, Dr Juraj Farkas, Prof Steven Foley, Dr Zoe Loh, Dr Erin Matchan, Dr Anaïs Pagès, Prof David Phillips, Prof Klaus Regenauer-Lieb, Dr Kok Piang Tan, Dr Geoff Fraser, A/Prof Oliver Nebel, Dr Laurent Ailleres, Dr Evgeniy Bastrakov, Prof Juan Carlos Afonso, A/Prof Rhodri Davies, Dr Ben Evans, Dr Rebecca Farrington, Julian Giordani, Dr Lachlan Grose, Dr David Lescinsky, Dr Ben Mather, Dr Yuan Mei, Dr Beñat Oliveira Bravo, Prof Anya Reading, Neil Symington, Dr Sara Morón and Dr Martin Andersen.

Extended Community

We would also like to thank many other national geoscience community members who have contributed to discussions during workshops and other events in this time.

Foreword

It is my great pleasure to present this Strategy on behalf of the AuScope team and the national geoscience community.

In 2018, AuScope's Board of Directors initiated a process to develop this Strategy and the accompanying Investment Plan, through a process of deep engagement with our community in academia, government and industry.

That engagement has allowed us to understand their research needs better and to define our role in enabling them to advance the Australian geoscience research sector according to national needs. These documents culminate that very productive process.

AuScope is a research infrastructure provider, but we are also playing an increasingly important role in science leadership and facilitating research collaboration within our sector. From developing formal links with international geoscience infrastructures, such as the European Plate Observing System (EPOS), to developing standards with Geoscience Australia and other NCRIS organisations including ARDC and NCI, our role has significantly evolved. In developing this Strategy, our community has endorsed this role, and we look forward to pursuing it over the coming decade.

This Strategy outlines the approach that AuScope will take to build the Downward Looking Telescope (DLT), a critical infrastructure system identified in the National Research Infrastructure Roadmap, the National Academy of Science's Decadal Plan for Australian Geoscience and most importantly, by the Australian geoscience research community. It also outlines the critical data, culture and collaboration needs surrounding the DLT that will act as the 'glue' to enable positively impactful geoscience.

When delivered, the DLT will change the way academic, government and industry geoscientists work in Australia, and it is inspiring to be part of that!

Dr Chris Pigram
Director & Chair on behalf of
the AuScope Board of Directors

20 April 2020

Photographer — **Robert Lang**

Dr Kate Robinson from the Geological Survey of South Australia with AuScope enabled marine magnetotelluric imaging instruments on board the Salt Water in 2019. These instruments allowed Kate and an international scientific team to image the seafloor in the Spencer Gulf and fill a knowledge gap about South Australia's geology and mineral prospectivity onshore.

Learn more — https://bit.ly/3dl1K0r

Vision, Mission

Our vision is to help enable a sustainable and resilient nation through predictive geoscience.

Our mission is to build an integrated and collaborative research platform that services, and facilitates theoretical and applied geoscientific research.

An AuScope enabled radio telescope in Yarragadee, one of three that help to enable Australia's high precision positioning capability that is now led by Geoscience Australia.

Learn more — https://bit.ly/3h4FbiQ

& Goals

1 — Enhance AuScope's capability to enable national geoscience innovation via the Downward Looking Telescope (DLT).

2 — Develop capacity for predictive geoscience by applying global data principles and data management best practice.

3 — Foster a connected community across academia, government, industry, science and society.

4 — Foster a diverse, innovative and inclusive culture, centred on purposeful innovation.

5 — Exchange knowledge and enable an inclusive future for both Indigenous and non-Indigenous Australians.

6 — Help to locate and better understand Australia's minerals, energy and groundwater services.

7 — Develop a global research capability for geoscience.

Challenge

Pressing climate, environmental and social issues, together with critical economic drivers will see unprecedented demands placed on Australia's geoscience community, and on the research infrastructure that supports their endeavour.

Humanity's ability to thrive on Earth is primarily due to a number of geological services the Earth provides to us. These include many things that we take for granted such as mineral and energy resources, groundwater, pore space storage and even crustal stability. Many of these services complexly interact and are increasingly susceptible to anthropogenic activities.

Viewing the crust in terms of the services it provides, gives us a new narrative for geoscience in the way that ecological services have for the environmental sciences. It focuses attention on the emerging need to define just how much Earth's crust can provide and thereby informs future choices concerned, for example, with provisioning a secure and sustainable energy supply.

Food, water and environmental security issues will become more urgent as Australians place more demands on these geological services provided by the shallow crust, and particularly in the context of accelerating climate and environmental changes and the population potentially doubling by 2066[1]. The need to audit Australia's groundwater resource, extract geothermal resources and store waste products in the subsurface will require sophisticated characterisation of the shallow crust and its dynamic stress state.

Our community will see a heightened need for new mineral discoveries in more difficult exploration environments, development of nascent clean energy and geological waste storage technologies. Transitioning to a low carbon economy will create great demand for critical minerals[2] — those including copper, cobalt and lithium that are essential for the development of electric vehicles, energy storage and power transmission from remote renewable energy sites. Thus, investment in AuScope by all Australians is critical to ensure that we have adequate resources for our collective future prosperity and sustainability.

1. **Australian Bureau of Statistics (2017):** https://bit.ly/3dmHmft
2. **Geoscience Australia (2020):** https://bit.ly/2NfczXg

AuScope-Focussed Sustainable Development Goals (SDG’s)

SDG #6 —
Clean Water & Sanitation

SDG #7 —
Affordable & Clean Energy

SDG #8 —
Decent Work & Economic Growth

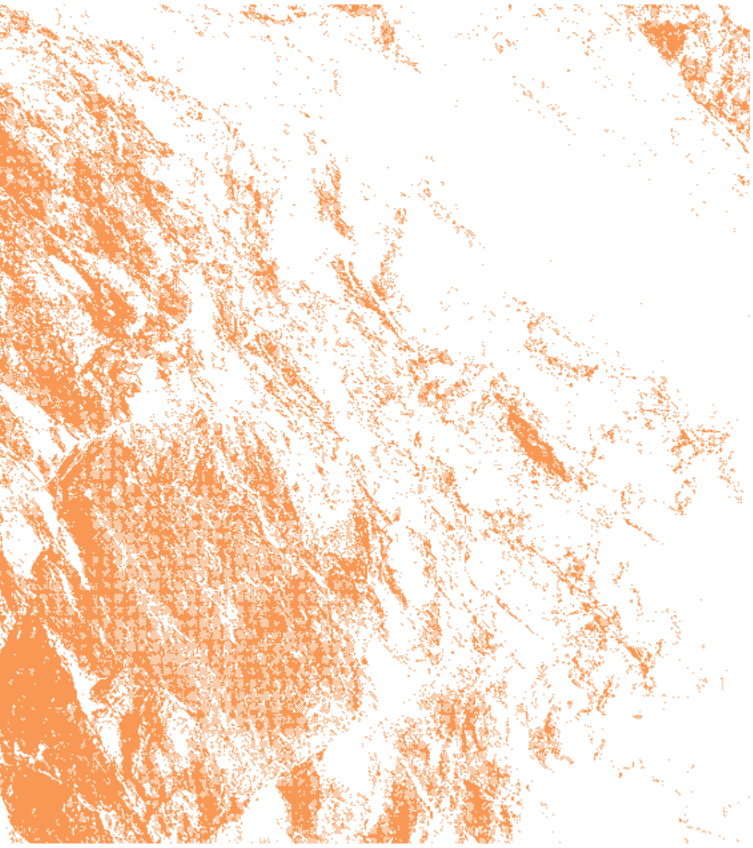
SDG #9 —
Industry, Innovation & Infrastructure

SDG #13 —
Climate Action

SDG #15 —
Life on Land

How is Australia tracking? The National Sustainable Development Council provides an independent, authoritative and transparent assessment of Australia’s progress towards the SDG’s.

Learn more — sdgtransformingaustralia.com



Humanity is at a critical stage in the transition to a more sustainable planet and society. Our actions in the next decade will determine our collective path forward.

Future Earth — https://bit.ly/2Mfq3lk

Context

This Strategy aligns with other key government, industry and scientific community strategies.

Firstly, AuScope aligns directly and fully with the Australian Government's 2016 National Research Infrastructure Roadmap (NRIR)[1] and its Government Response to the 2016 National Research Infrastructure Roadmap Research Infrastructure Investment Plan[2] (2018), which inform the National Collaborative Research Infrastructure Strategy (NCRIS), AuScope's single funding stream as one of 23 NCRIS projects servicing medical, energy and environmental science fields.

Secondly, AuScope aligns directly with the Decadal Plan for Australian Geoscience[3] (2018), which states that over the next decade Australia must develop a new understanding of, and innovative approaches to, sustainability. Further, it outlines the overarching challenges for geoscience to accurately predict how our planet will behave, including its response to anthropogenic actions, and to locate reserves of critical resources under cover rock.

This plan identifies four key national geoscience challenges:

— Food and water sustainability

— Australia's mineral resources future

— Australia's energy future

— Geohazards

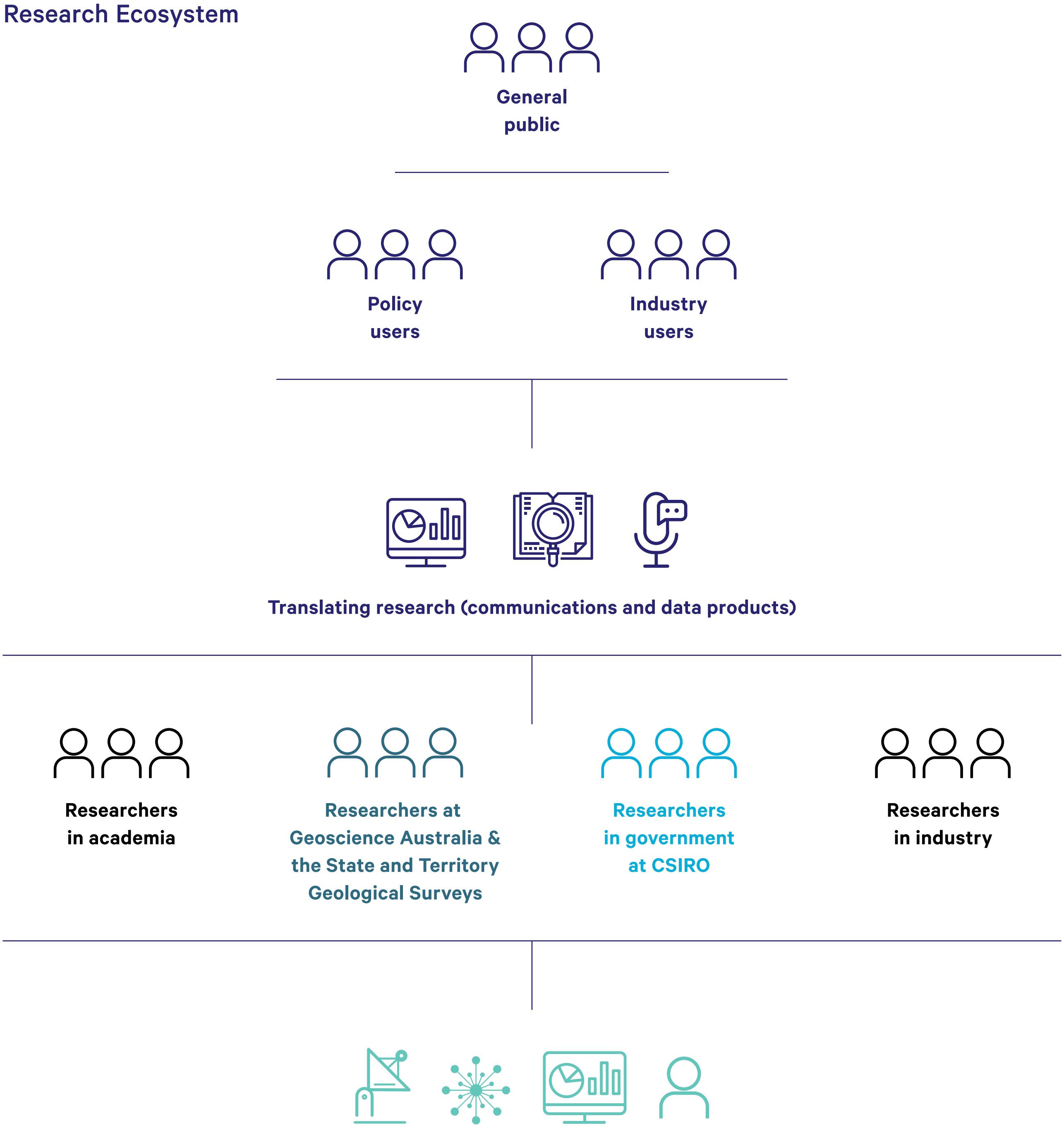
Already, AuScope partners including Geoscience Australia, CSIRO and State and Territory Geological Surveys provide excellent geoscience datasets, industry and government focused infrastructures and analytics to help address these challenges. However, in order to provide the research infrastructure system necessary to enable research addressing the national geoscience challenges, both the Decadal Plan for Australian Geoscience and the Chief Scientist of Australia's NRIR call for the development of AuScope's DLT to bridge the gap between industry and research-oriented capabilities.

Thirdly, AuScope aligns with the Australian Academy of Science's Women In STEM Decadal Plan[4] (2019) which offers a vision and opportunities to 2030 to guide stakeholders as they identify and implement specific actions they must take to build the strongest (diverse) STEM workforce possible to support Australia's prosperity.

Finally, AuScope recognises strategic threads with the AMIRA International Roadmap for Exploration Under Cover[5] (2017), Australia's Critical Mineral Strategy (2019)[6], the National Resources Statement[7] (2019), and the Australian Civil Space Strategy 2019 – 2028[8], (2019).

1. **Australian Government (2016):** *https://bit.ly/3do8vzw*
2. **Australian Government (2016):** *https://bit.ly/2NgHwu3*
3. **Australian Academy of Science (2018):** *https://bit.ly/3dqLevU*
4. **Australian Academy of Science (2019):** *https://bit.ly/3aRYBG1*
5. **Uncover Australia (2017):** *https://bit.ly/3dqDjPW*
6. **Australian Government (2019):** *https://bit.ly/2YkwwlK*
7. **Australian Government (2019):** *https://bit.ly/3hSra95*
8. **Australian Space Agency (2019):** *https://bit.ly/3eCR9yX*

Australian Geoscience Research Ecosystem



AuScope Capability — instruments, services, data and analytics that enable researchers to address fundamental and applied research questions in geoscience

AuScope, CSIRO, Geoscience Australia and State and Territory Geological Surveys find purpose in addressing Australia's decadal geoscience challenges.

AuScope's unique primary role amongst these key government funded geoscience agencies is to provide researchers with access to national research infrastructure.

AuScope's unique secondary role is to lead the geoscience community across academia, government and industry to collaborate, together with geospatial and environmental science communities on national challenges.

Opportunity

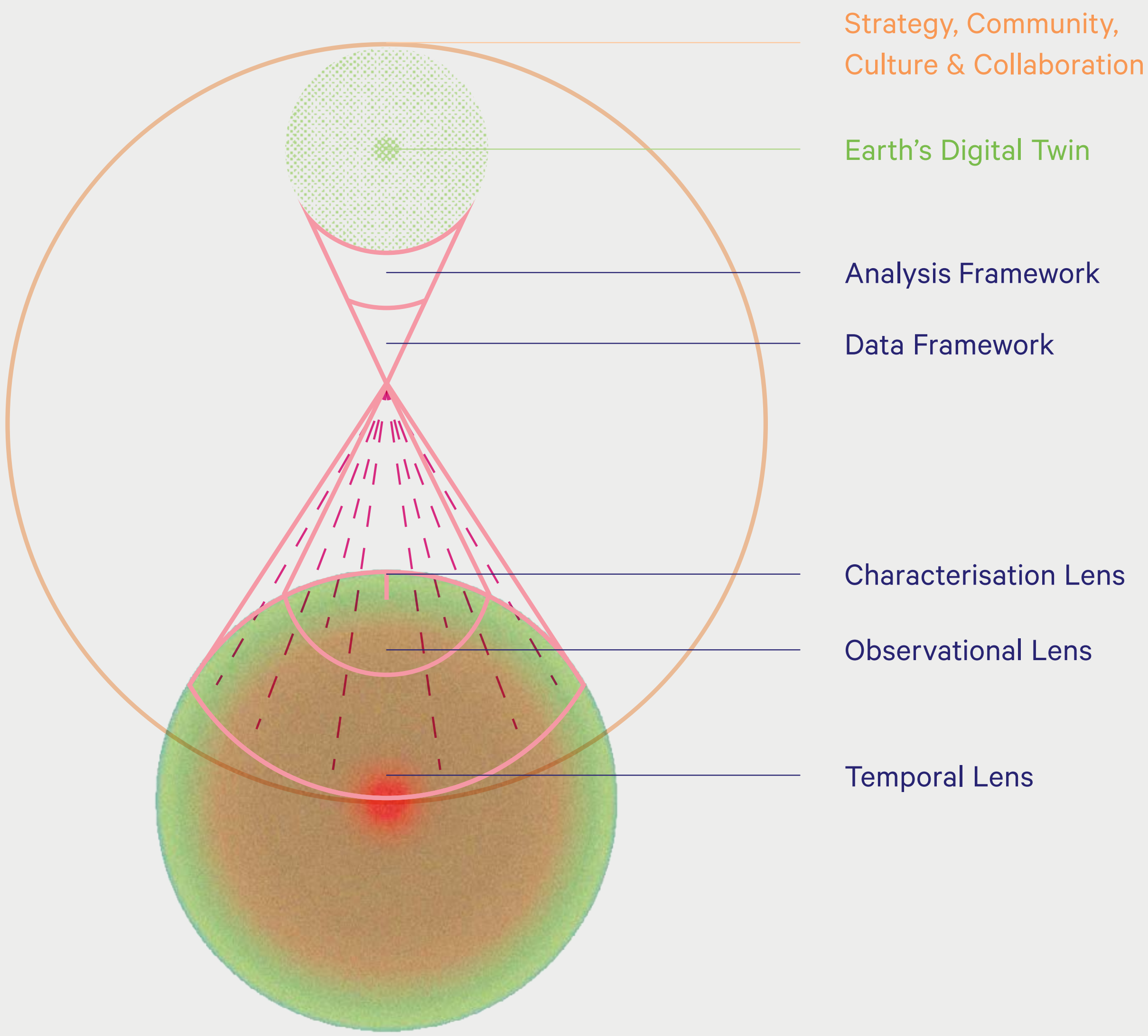
Goal 1 —

Enhance AuScope's capability to enable national geoscience innovation via the Downward Looking Telescope (DLT) —

An integrated and augmented capability, like a telescope that will allow researchers to 'see' into Earth rather than out into space using 'lenses'. Researchers can then capture, focus and analyse observational data.

Ultimately, researchers will be able to create a 'digital twin' of Earth, and understand how the Australian continent might service our growing minerals, water, energy and space needs in the decades ahead.

AuScope's Downward Looking Telescope



DLT Components

Temporal Lens — Will allow researchers to analyse the Earth's evolution through time

Observational Lens — Will allow researchers to observe changes in the structure of the Earth

Characterisation Lens — Will allow researchers to classify rocks based on their properties

Analysis Framework — Will allow researchers to model different geological processes

Data Framework — Will allow researchers to access and use diverse standardised data

Earth's Digital Twin — A concept to describe the digital Earth representation culminating DLT Components that enables predictive Australian geoscience for the common good

Strategy, Community, Culture & Collaboration — The strategic framework surrounding the DLT that will allow researchers to lead an agile strategy to addressing national geoscience challenges

Goal 1 Continued —

DLT Components

Temporal Lens

The temporal lens is an analytical infrastructure network that facilitates analysis of the Earth's evolution through time, on varying scales for different processes.

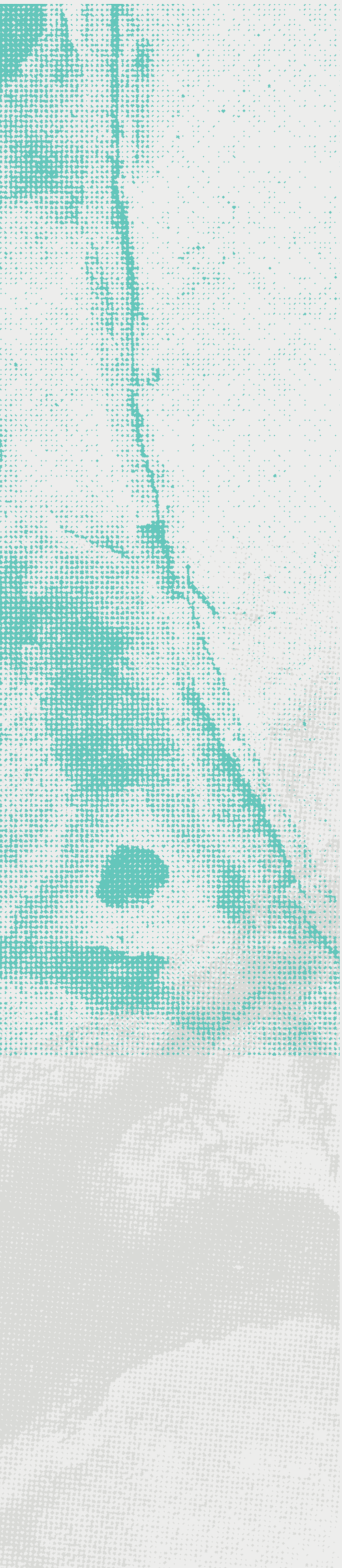
The AuScope Laboratory Infrastructure Network (AusLab) will provide a suite of specialist, primarily laboratory-based, geochemistry and geochronology analytical facilities. AusLab will provide analysis capabilities for investigating the composition of Earth's inner and outer spheres, as well as the ability to characterise the age of geological, environmental and climatic events from the Archean to present day. This will substantially build on existing laboratory capacity in the AuScope Earth Composition and Evolution program and will provide an integrated suite of analytical tools that provide capability across all areas of geochemical and geochronological science.

Observational Lens

Deployable arrays of geophysical and geospatial observational instruments and permanently instrumented Geo-SuperSites will provide continental-scale long term monitoring, imaging and a high-resolution geophysical rapid deployment capability.

Geo-SuperSites and long term array deployments image and monitor Australia at the continental scale and allow for quantification of groundwater balance at national-, basin- and sub-basin scales. The Super-sites will also provide the geological monitoring component to a new national Critical Zone Observatory network, in collaboration with the Terrestrial Ecosystem Research Network (TERN).

This national observation infrastructure will also provide a mechanism for syncing and calibrating space assets with drones and Internet-of-things (IOT) deployments in Australia. Agile instrument fleets will provide a means of rapid higher resolution infill studies designed to better constrain the links between the deep earth, the surface and the atmosphere. Multi-sensor drones and autonomous rovers will provide new research opportunities in areas that are difficult to access, and the ability to react rapidly to geohazards (for example, landslips and earthquakes) and provide high resolution time-lapse monitoring to deliver high precision change detection.



Characterisation Lens

This lens allows researchers to characterise the accessible crust by analysing sample materials, or via borehole-based measurements, imaging and sampling.

Field deployable and laboratory-based analytical tools will enable them to detect essential petrophysical properties in rock that are necessary for accurate inference of subsurface architecture and mechanistic insights into Earth processes. The characterisation lens will provide the finest resolution of field data collected by the DLT. Deep borehole access will provide rare ground truthing from depths (greater than three kilometres) and generate collaborative opportunities both nationally, with the MinEx CRC National Drilling Initiative, and internationally with the International Continental Drilling Program.

Data Framework

The Data Framework will capture, organise and focus all data from DLT Lenses so that researchers can analyse it in the Analytical Framework. Data collection will be: i) held to the Findable, Accessible, Interoperable and Reusable (FAIR) standard; ii) automated at both creation and capture, adhering to (or developing) community best practice; iii) open to community data repositories; and iv) delivered to facilitate data-intensive research using advanced analytical methods.

The creation of this FAIR Digital Twin of the Earth substantially builds on the AuScope Earth Model developed in the first generation of AuScope investments and will facilitate development of an Australian capability in predictive geoscience, as recommended in the Australian Academy of Science Decadal Plan for Earth Science.

Analytical Framework

This predictive capacity will be provided through the development of a suite of Forward and Inverse Modelling capabilities that allow researchers to transform Earth data provided by the DLT sensors into the Digital Twin. Specific software tools will facilitate simulation and modelling of geological data, geodynamics, Earth interior processes, groundwater, thermochronology data and isostatic processes. Data assimilation workflows to support predictive geoscience will be built into the existing AuScope Virtual Research Environment (AVRE) infrastructure.

Impact

After thirteen years of operation, AuScope has made significant impacts on Australia's economy, society and environment beyond its direct contribution to research. We are now poised to address challenges of this decade.

Back in 2006, AuScope set out to build an integrated research infrastructure system — much like the DLT but designed for the needs of researchers at the time. The community developed fleets of observational instruments for geodesy, geophysics and geospatial science, borehole access to the subsurface, laboratories for geochronology and petrophysics, data delivery pathways, and simulation and modelling codes.

Over a decade later, a Lateral Economics study[1] reviewed AuScope's impact, reporting significant economic benefits across natural resources, agriculture, shipping and aviation industries, as well as urban development and environmental monitoring: AuScope offers a net benefit of $3.7 billion, which is equivalent to $15 of benefit for every $1 in economic cost— a substantial return on investment, and consistent with other economic assessments of similar initiatives, in Australia and the United States.

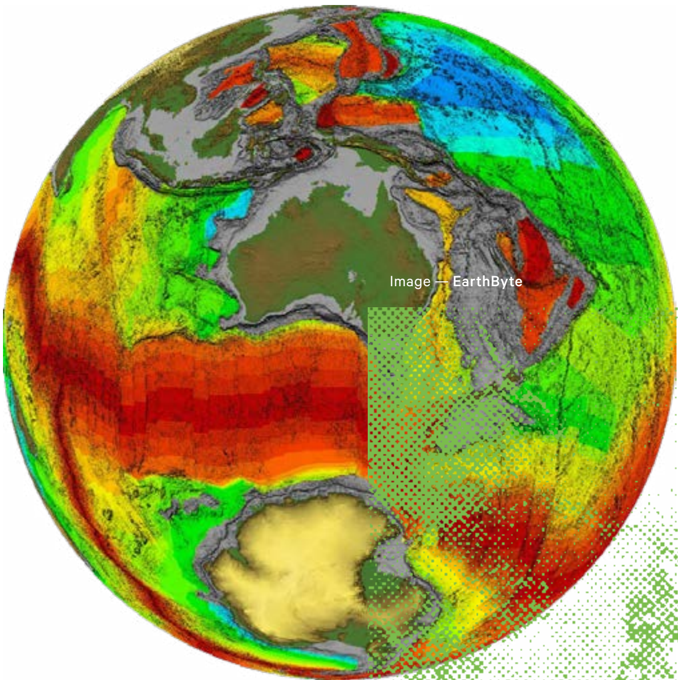


Image — EarthByte

NCRIS enabled GPlates software enables scientists and citizen scientists to replay Earth's history, piecing together its volcanic, tectonic and living histories to better predict movements in the future.

Learn more — www.auscope.org.au/sam

1. **Lateral Economics (2016):** *https://bit.ly/37QckeF*

Underpinning Australia's positioning capability

Australia lacked the infrastructure capacity to support rapidly growing location precision-related science. AuScope worked with Geoscience Australia and the University of Tasmania to invest in Very Long Baseline Interferometry telescopes and national Global Navigation Satellite System (GNSS) ground station coverage. This investment provided a platform for massive growth in spatially sensitive industries and allowed for the development of a dynamic national datum.

Looking deep into Earth's crust to help find Australia's critical minerals

Over 65% of Australia's mineralised rocks are buried beneath cover rock sequences that mask the location of mineral deposits critical to our nation's future prosperity and security. Auscope worked with researchers at the University of Adelaide, State and Territory Geological Surveys and Geoscience Australia to develop a national magnetotellurics geophysical imaging program, AusLAMP. This dataset resulted in the development of the first electrical conductivity model of the continent leading to a much better understanding of the geological architecture and in turn, the location of critical mineral deposits.

Building a mineralogical library to help find Australia's critical minerals

Australian mineral explorers spend millions of dollars drilling holes into the Earth but did not have the capacity to record and preserve all of the very valuable information these holes provide. AuScope worked with CSIRO to develop the HyLogger instrument, a semi-autonomous, semiquantitative mineral logging tool for drill core that is deployed in each Australian State and Territory Geological Survey. These tools, and the related data and analytics infrastructure, provide a mechanism for storing and preserving these valuable datasets, which were typically unavailable to the research community, stimulating new approaches to mineral exploration.

Modelling Australia's sedimentary basins to enable sustainable uses

Sedimentary basins are complex geological systems that are incredibly valuable sources of water and energy, but they are often poorly understood. AuScope investment into simulation and modelling code development, such as Underworld, GPlates and eScript, provided tools that allowed detailed investigation of how these basins form. The development of the Basin Genesis Hub project (funded by the ARC ITRH Program) integrated some of these tools to allow the simulation of Australia's basins and predict the location of the various resource systems they contain.

Connecting Australia's geochronology laboratories, community and data

While Australia has numerous outstanding geochronology research facilities, the lack of a common data infrastructure and workflow limited the ability for researchers to compile and compare data produced across these laboratories efficiently. AuScope worked with the community to develop a national geochronology network to establish standards, workflows and a FAIR data delivery mechanism. These tools not only facilitate the discovery of available data but provide a way for all laboratories to store and deliver their data for publication and collaboration.

Engaging Australia's future geoscientists

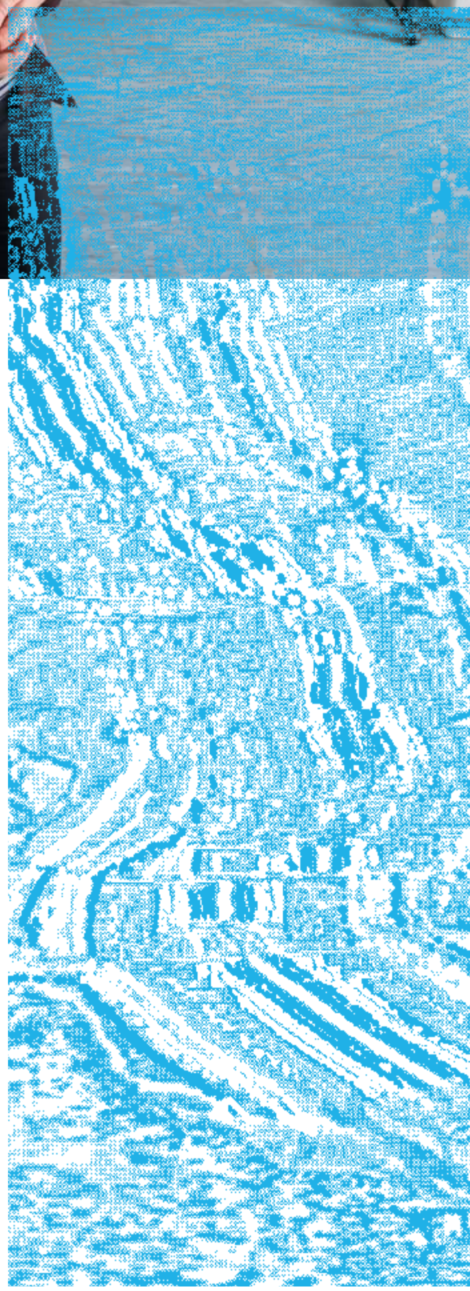
Geoscience is not widely taught in schools in Australia and universities are finding it increasingly challenging to attract first-year students, as they enroll in climate and environmental science instead. AuScope worked with the Australian National University to develop the Australian Seismometers in Schools (AuSIS) program. The project deployed research quality seismometers in 45 secondary schools across the country, many in regional areas. In doing so, not only have many students become interested in geoscience, but valuable new seismic data has been collected and delivered into the national monitoring network for researchers to use. This program has driven research outcomes and inspired the next generation of scientists, and, as a result, this is likely to have an impact for many decades to come.

Data

Image — The University of Melbourne

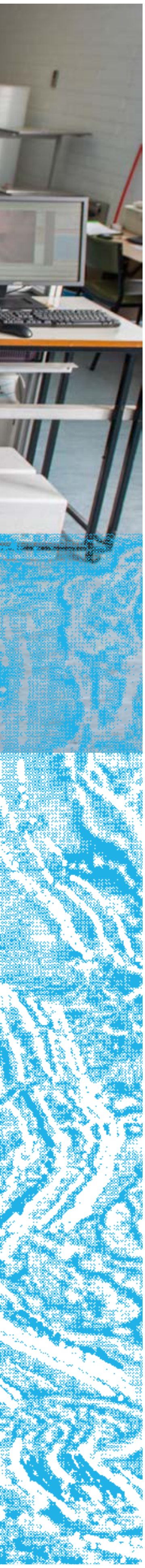
Dr Erin Matchan is a Data Science Coordinator in the AuScope Geochemistry Network (AGN) team and also manages the Ar-Ar Geochronology Laboratory at The University of Melbourne.

Learn more — www.auscope.org.au/ece



“Bringing together our nation’s diverse, valuable and hard-earned geoscience data, in a way that aligns with FAIR data principles, requires strong national leadership. From this, we then have an essential foundation for the exciting delivery of new models and perspectives of our continent.”

Dr Steve Hill
Chief Scientist
Geoscience Australia



Goal 2 —

Develop capacity for predictive geoscience by applying global data principles and data management best practice.

Context

Computational geoscience problems utilising HPC tend to be diverse, complex and ever-changing. Geoscience ranges in scales from the atomic to planetary and from nanoseconds to billions of years. Geoscience data is also highly variable and often bespoke, ranging in size from a few cells in a spreadsheet to multi-terabyte 4D seismic surveys.

Field-based observational data and other persistent time series data sources, such as geostationary hyperspectral payloads on drones or satellites, create discipline specific data processing and analytics challenges but also immense opportunities for integrative data driven research.

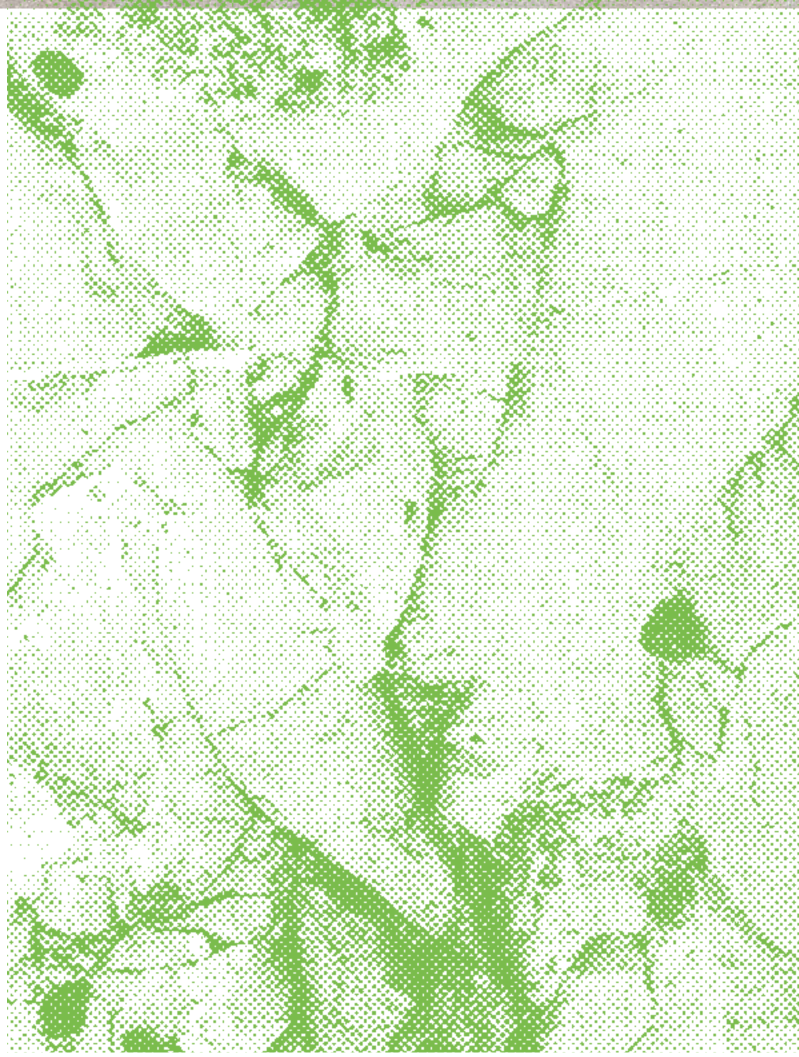
For the first time, these rich and FAIR datasets will be interrogable by artificial intelligence (AI) and machine learning (ML) techniques. Together with high performance computing (HPC) through organisations such as the National Computational Infrastructure (NCI), the Australian Research Data Commons, and Pawsey, as well as universities, industry clusters and now cloud based HPC from AARNet, Amazon and others, researchers will be well placed to realise predictive geoscience.

Implementation

1. AuScope will ensure that all data collected or created by AuScope projects will be freely available and conform to FAIR (Findable, Accessible, Interoperable and Reusable) data principles.
2. AuScope will develop a data assimilation environment to allow ingestion of geoscience data for constraint of *a priori* simulation models and modelling or simulation runs.
3. AuScope will, where relevant, utilise workflows that assign persistent identifiers and preserve full resolution datasets.

Community

Image — AuScope



Capacity development is essential for the sustainable research infrastructure development. AuScope's DLT will provide a focal point for our technical and academic staff and collaborators, and facilitate development of the next generation of digital tools for Australia's geoscientists.

Dr Rebecca Farrington
Coordinator, AuScope SAM Program
based at The University of Melbourne

Goal 3 —

Foster a connected community across academia, government, industry, science and society.

Context

AuScope is a unique 'connector' within the geoscience community, interacting across academia, government and industry, both locally and abroad, to enable collaboration second to infrastructure. While individual agencies and institutions may focus on internal innovation, AuScope works to ensure that knowledge and resources can be shared widely. We are privileged to work as a trusted broker of information and to connect and help lead this community towards innovation through collaboration.

Given AuScope's funding security provided by the Australian Government in 2018 in the National Innovation and Science Agenda (NISA), we are beginning to collaborate more widely and to grow our network to include a variety of new research partners.

Implementation

1. AuScope will foster inclusive discussion within the community about priorities, collaboration and investment planning.
2. AuScope will expand our team strategically within the available funding framework.
3. AuScope will collaborate with other NCRIS organisations to promote integrated cross-disciplinary research infrastructures.
4. AuScope will seek to better serve its future and citizen scientist community through development of outreach programs that span the full breath of supported geoscience.

Culture

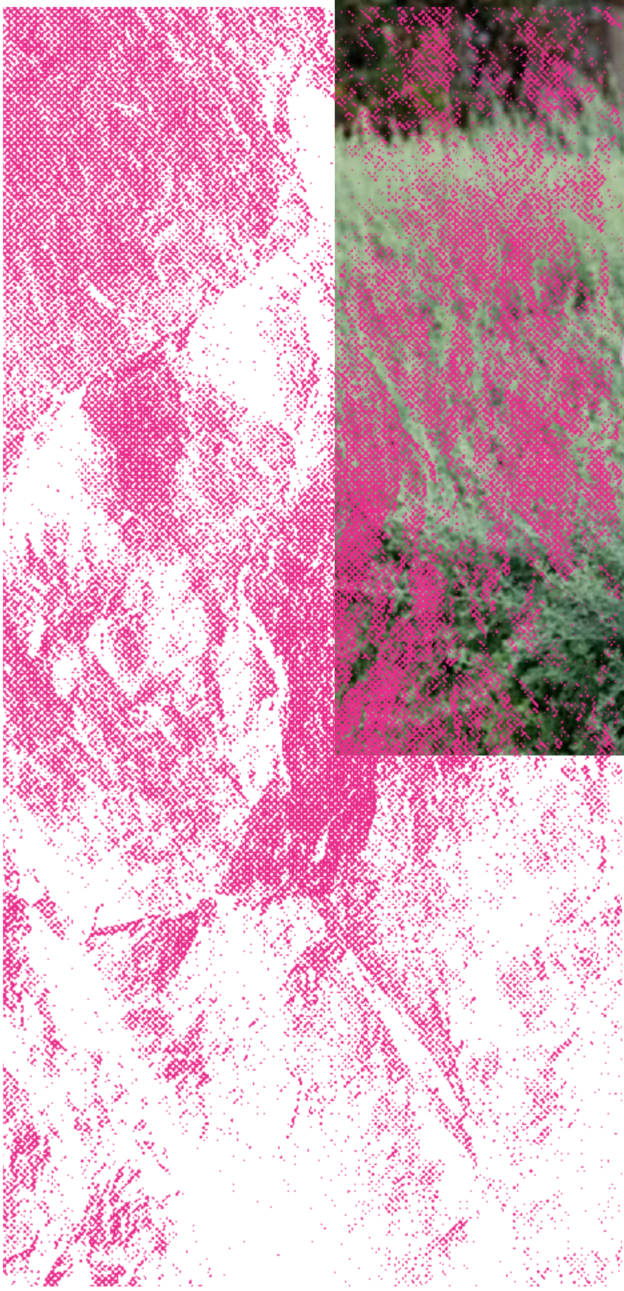


Image — Jo Condon

A/Prof Meghan Miller joined the AuScope leadership team in 2018 as Project Leader of the Earth Imaging Program. Based at the Australian National University, Meghan pursues observational seismology research, teaches earth science to university and school students and actively promotes diversity in science through a number of initiatives.

Goal 4 —

Foster a diverse, innovative, and inclusive culture, centred on purposeful innovation.

Context

We believe that it is important to position AuScope as a progressive organisation that is focussed on enabling purposeful research innovation for people and the environment.

With this focus, geoscience sub-disciplines like 'geo health' which join earth, environmental and health sciences come to the fore. This growing interdisciplinary field demands new holistic thinking from our community, as do our traditional disciplines and intersections.

Complex challenges require multidisciplinary responses, whereby we incorporate diverse voices and knowledge at every step of the infrastructure development process. We must lead with empathy and design a user-centred, robust and adaptable capability that can both enable research, and expedite it on an impact pathway.

Implementation

1. AuScope will cultivate a diverse and inclusive workforce by building diversity benchmarks into funding agreements. We will also provide opportunities for AuScope community to lead diversity, inclusivity and social engagement initiatives across our workplaces and deeper into society.
2. AuScope will enable science by leveraging innovative, cross-domain expertise in design and humanities and will draw on systems design and human-centered design methodologies to address strategy, operations, products and service challenges.
3. AuScope will develop infrastructure projects that support research directly or indirectly aligned with the UN Sustainable Development Goals.
4. AuScope will ensure a safe working environment for our Programs staff.

"Diversity drives innovation, so it is great to see that AuScope has a commitment to construct a diverse and inclusive environment. As an infrastructure user in the AuScope community, I am looking forward to actively fostering this culture for richer outputs."

Dr Sara Morón
Research Fellow, Basin Genesis Hub, The University of Sydney and the The University of Melbourne

Collaboration

Working with, and for Aboriginal and Torres Strait Islander people

Image — Dr Bruce Goleby

Cindy Watson from Oak Valley assisting Pip Mawby from the University of Adelaide with AuScope enabled magnetotelluric instrument installation on Maralinga Tjarutja Lands, South Australia.

Learn more — https://bit.ly/31c53Vc

Goal 5 —

Exchange knowledge and enable an inclusive and sustainable future for both Indigenous and non-Indigenous Australians.

Context

AuScope has engaged extensively with many Aboriginal and Torres Strait Islander (Indigenous) communities in our Earth Imaging[1] and Australian Seismometers in Schools[2] programs over the last decade. Our laboratory instruments have enabled researchers to create new knowledge about the geological timing of historical volcanic, asteroid impact and tsunami events that relate to early Indigenous settlements (i.e. at Budj Bim[3]). However, we recognise that Australian geoscience has been built on western ideas and practices, and that we have a long journey ahead to support Indigenous people to 'achieve equity, recognition and self-determination in Australian science[4]', namely geoscience.

We will continue to engage respectfully with Indigenous people across the lands and seas within our research infrastructure programs, and work together to develop opportunities to support positive outcomes for Indigenous people across the continent and islands beyond.

Implementation

1. AuScope will always seek to collaborate with Indigenous leaders and community before, during and after our research infrastructure activities and will be guided by the Our Knowledge Our Way Guidelines[5].
2. AuScope will provide appropriate funding support for mutually beneficial collaborations between researchers and Indigenous people across our programs.
3. AuScope will support the development of novel research programs that integrate Indigenous and western geoscience data and knowledge in the DLT.
4. AuScope will develop education and employment opportunities for emerging Indigenous geoscientists and other professionals in Australian geoscience.
5. AuScope will actively seek to engage Indigenous owned and led services for strategic, administrative and operational projects, where required and possible.
6. AuScope will build capacity within the Australian geoscience community to support Indigenous equity, recognition and self-determination in Australian geoscience.

1. AuScope Earth Imaging Program: *https://bit.ly/3hhMgww*
2. AuScope supported Australian Seismometers in Schools Program: *https://bit.ly/32BKBhs*
3. AuScope enabled Budj Bim research: *https://bit.ly/3hi8MFD*
4. Science, Technology, Engineering, Mathematics and Reconciliation: *https://bit.ly/3fNsxV6*
5. Our Knowledge Our Way Guidelines: *https://bit.ly/2XzXQfh*

Collaboration

Working with Industry Scientists

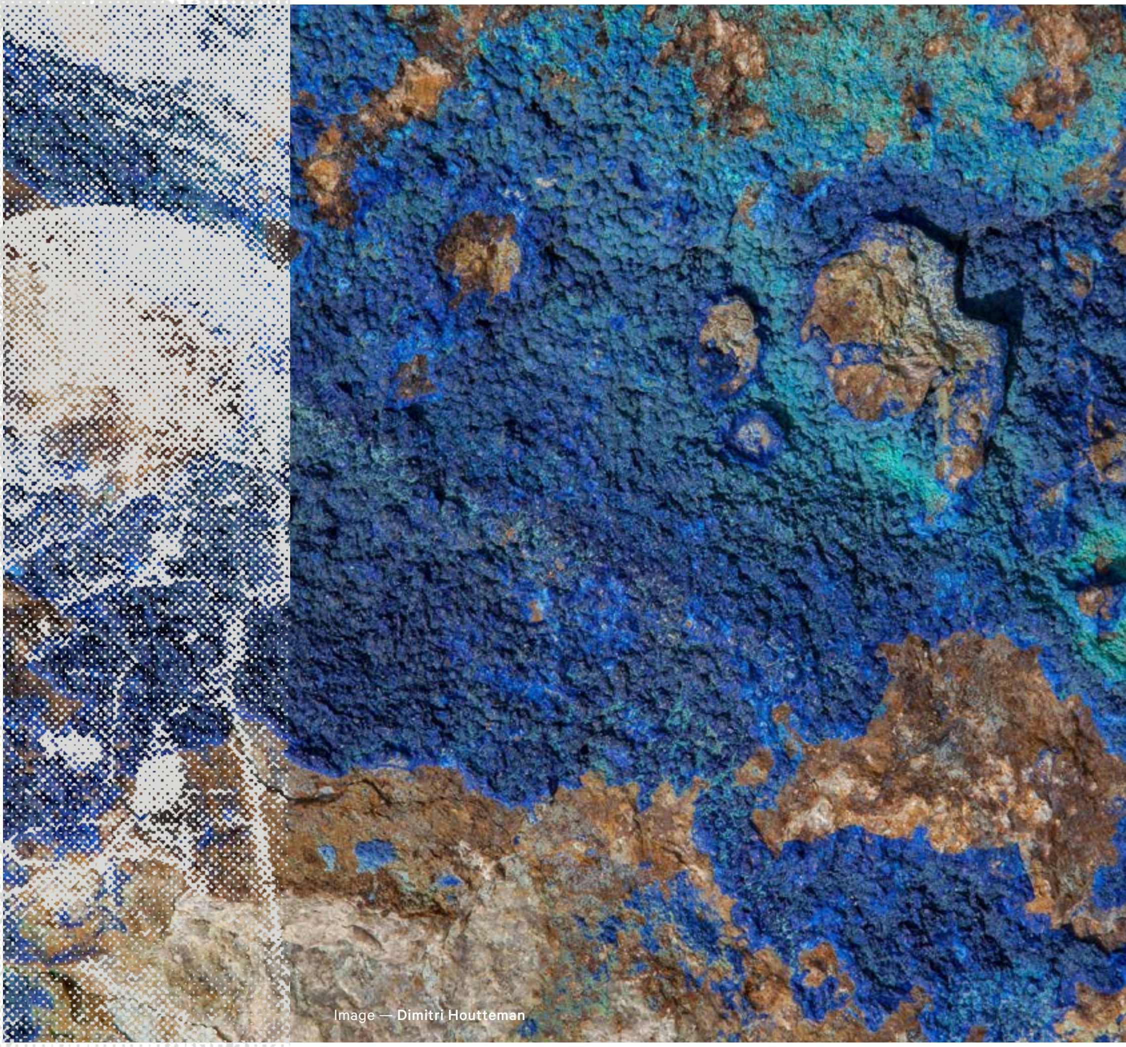


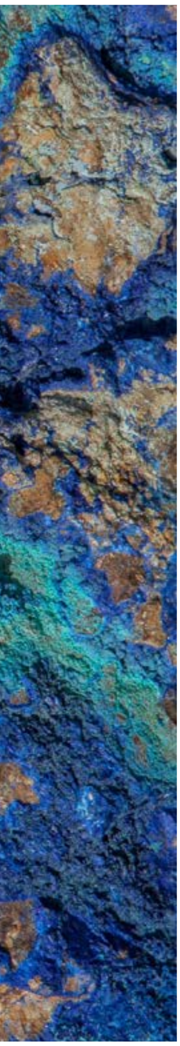
Image — **Dimitri Houtteman**

Australia is a world leader in the exploration, extraction, production and processing of critical minerals — those needed to grow emerging renewable energy, aerospace, defense, automotive (particularly electric vehicles), telecommunications and agri-tech sectors for global trade.

Learn more — https://bit.ly/36OWtwm

Goal 6 —

Help to locate and better understand Australia's minerals, energy and groundwater services.



Context

We must develop a national groundwater resource inventory and discover minerals to build tomorrow's low emission vehicles and energy systems, and manage the minerals, energy and water resources in geological basins carefully to ensure adequate reserves to meet future demand. These actions require significant research infrastructure support.

Discovering new mineral deposits and systems under thick cover rock sequences that extend over 80% of the Australian continent[1] represents one of the most significant opportunities for our nation. The challenge of exploring in these regions is logistically challenging and requires investment in both research and supporting infrastructure. In particular, as described in the Decadal Plan for Earth Science[2], we must develop a predictive geoscience capacity in order to have a significant impact in this space.

AuScope's close relationships with Geoscience Australia and all of the state government geological organisations, CSIRO, Uncover Australia and the MinEx CRC provide strong links to industry partners. We will grow and formalise these links with industry over the coming decade to ensure that future AuScope investments support the rapidly changing research needs of this critical sector.

Implementation

For the benefit of all Australians and the Australian environment, AuScope will:

1. Build the DLT to establish a predictive geoscience capacity in Australia.
2. Partner and collaborate with existing and new industry focussed research initiatives to provide infrastructure critical to their research programs.
3. Utilise or form advisory panels that include industry members to advise on the significance of existing and new programs to industry-relevant research.
4. Prioritise new projects that support research relevant to the discovery of "critical minerals" and other strategic resources, including groundwater and sustainable energy resources.
5. Work with government and academic partners to create industry-relevant national data assets that are open and delivered according to FAIR Principles[3].

1. Geoscience Australia (2020): *https://bit.ly/2V7Lw4z*
2. Australian Academy of Science (2018): *https://bit.ly/3dqLevU*
3. Australian Research Data Commons (2020): *https://bit.ly/2Yk8nMi*

Collaboration

Working with Scientists Abroad

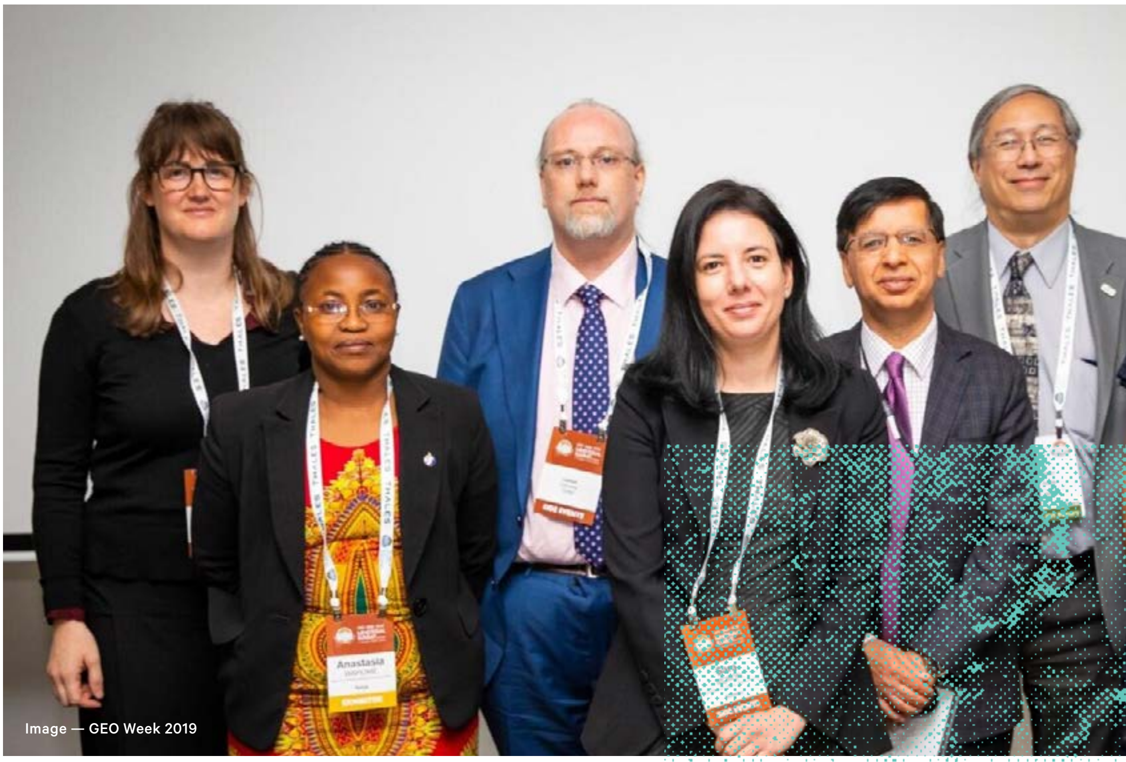


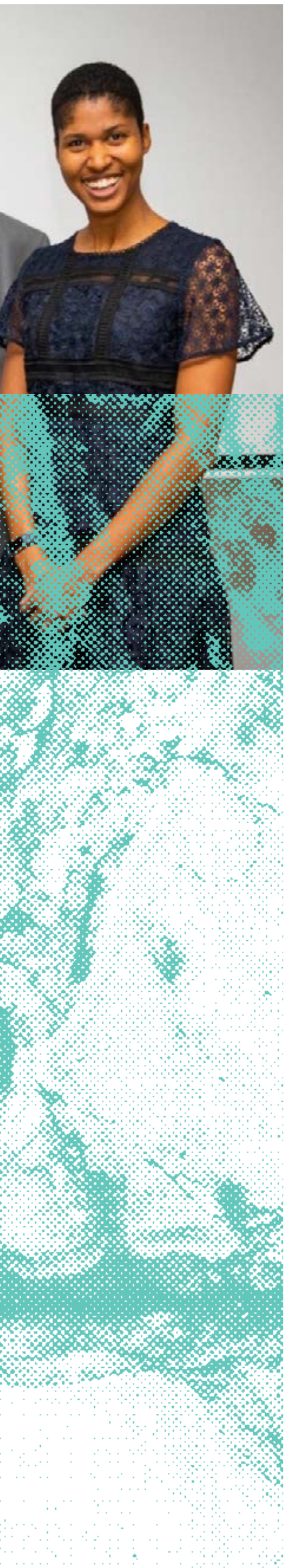
Image — GEO Week 2019

Combining ideas on Earth systems modelling for good: panellists at GEO Week 2019 discuss combining different types of earth modelling to help tackle the United Nations' Sustainable Development Goals including: Dr Rebecca Farrington (left) and Dr Sara Morón (centre) representing AuScope.

Learn more — https://bit.ly/37NLTXa

The collaboration between EPOS and AuScope will support the development of global geoscience data that meets FAIR (Findable, Accessible, Interoperable and Re-usable) principles by sharing solutions and adopting effective FAIR data management practices. This represents a ground-breaking step toward e-science innovation.

Dr Massimo Cocco
CEO, European Plate Observing System (EPOS)



Goal 7 —

Develop a global research capability for geoscience.

Context

AuScope has a number of research infrastructure peers around the world, many of which are already aligned with AuScope, for example the European Plate Observing System (EPOS). However, there is currently no Global Research Infrastructure (GRI) for geoscience, and therefore, an enormous opportunity exists to align our global community to develop strategies to enable GRI deployments and standards.

Implementation

1. AuScope will take a leading role in developing international geoscience collaboration.
2. AuScope will develop a formal collaborative relationship with EPOS — the most closely aligned international research infrastructure currently.
3. AuScope will pursue the development of a broader international network of research infrastructures including Incorporated Research Institutions for Seismology (IRIS), Earth Science Information Partners (ESIP), Earth Cube, Environmental Research Infrastructures (ENVRI) and UNAVCO.
4. AuScope will help to develop a GRI for the solid earth.

Glossary

NAME	DESCRIPTION
3D	Three Dimensions or Three-Dimensional
4D	Four Dimensions or Four-Dimensional
A/Prof	Associate Professor
Accessible Crust	The portion of the Earth's crust that is accessible to humanity through drilling or tunneling
AEM	Airborne elecromagnetic survey
AI/ML	Artificial Intelligence (AI) is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. Machine Learning (ML) is the study of computer algorithms that improve automatically through experience. Both AI and ML allow researchers and data analysts to rapidly analyse large datasets
Analytical Services	Service based model for analysis of samples for researchers
APA	Australian Plate Array geophysical imaging infrastructure
ARDC	Australian Research Data Commons, an NCRIS capability like AuScope for data
AusArray	National passive seismic imaging program
AuScope	NCRIS funded organisation dedicated to supporting research infrastructure investment for the earth and geospatial science communities in Australia
AusLAMP	The Australian Lithospheric Architecture Magnetotelluric Project
Basin	Geological structure usually filed with sediments that often contain groundwater and energy resource systems (e.g. Gippsland Basin)
Characterisation	The study of the composition and nature of rocks and other material
Cloud Based	Digital tools and infrastructure deployed across distributed "cloud" computer systems
Conjugate Margin	Mirrored passive margins, or continental edges, formed during continental rifting
Cover Sequences	Sediment that covers and often obscures older rocks
CSIRO	Commonwealth Science Industry Research Organisation
Data Stewardship	Management and oversight of an organization's data assets
Data Telemetry	Transmission of data from remote sites to base stations or data repositories
Deep Earth	The portion of the Earth that is deeper than the shallow crust
Digital Infrastructure	Infrastructure including software and hardware facilitating collection, transfer, storage, discovery, analysis and modelling of digital data
Digital Pipelines	Digital infrastructure facilitating movement, processing and storage of data
Digital Twin	A discoverable and searchable digital (data) representation of properties and composition of the Earth

NAME	DESCRIPTION
DLT	Downward Looking Telescope
Dr	Doctor
Drones	An aircraft that does not have a pilot but is controlled by someone on the ground, also know as Remotely Piloted Aircraft Systems (RPAS), Unmanned Aerial System (UAS), and Unmanned aerial vehicles (UAV)
EarthCube	US based geoscience cyberinfrastructure
EPOS	European Plate Observing System, an international equivalent to AuScope for the European Plate
Field-Deployable	An instrument that can be used outside of laboratories
GA	Geoscience Australia
Geochemistry	Earth science discipline relating to the chemistry of rocks
Geohazards	Hazards to humanity and society presented by natural earth processes, such as earthquakes, landslides and tsunamis
Geological Services	Resources or properties of the Earth that allow humanity to exist and prosper
Geoscience	Earth science disciplines encompassing geology, geophysics, geochemistry, geochronology and geodesy
Heat Flow	The nature of the way heat produced in the Earth is transmitted through rocks to the surface
Hydrological Properties	Physical properties of rocks and sediments that control the way fluids are contained within, or move through them
IMOS	Integrated Marine Observing System (IMOS), an NCRIS capability like AuScope for marine science
IOT	Internet of things; the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data
IRIS	Incorporated Research Institutions for Seismology (US)
LiDAR	A distance detection system which works on the principle of radar, but uses light from a laser
Longitudinal Baseline	Starting measurements for long-term observational studies
Magnetotellurics (MT)	Geophysical technique that allows imaging of the electrical conductivity of the Earth's crust
Mineral Deposits	Accumulations of minerals that can be economically mined or extracted
Multi-Sensor	Observational sensor deployments where more than one type of sensor is deployed at each site
National Maps	Continental-scale maps that geographically describe one or many geological attributes such as isotopic ratios
NCI	National Computational Infrastructure, an NCRIS capability like AuScope for computation
NCRIS	National Collaborative Research Infrastructure Strategy
NEPS	National Environmental Prediction System
NRI Roadmap	The Australian Government's National Research Infrastructure Roadmap (2018)
Open-Source	Software or data that uses an open development process and is licensed to include the source code
Passive Seismic	Earthquake monitoring infrastructure techniques that allow imaging of the Earth

Glossary — Continued

NAME	DESCRIPTION
Petrophysics	Earth science discipline relating to the physical properties of rocks
Physical Infrastructure	Physical tools including field deployed observational instruments and laboratory based analytical facilities
Prof	Professor
Rheology	The way in which material deforms and flows, especially non-Newtonian flow of liquids and plastic flow of solids
Rovers	A small remotely controlled vehicle that can move over rough ground
SDG	Sustainable Development Goal established by the United Nations
Sensor Array	Integrated fleet of instruments deployed in a structured way to sense or image the Earth
Solid Earth	The Earth's solid surface and its interior
Subsurface	Beneath the Earth's surface
Supersites	Field-based long-term observational infrastructure deployments that contain a number of co-located instruments
TERN	Terrestrial Ecosystem Research Network, an NCRIS capability like AuScope for environmental science
Time-Series Data	Data collected regularly over a period of time
UNavco	Non-profit university-governed consortium that facilitates geoscience research and education using geodesy
Water Balance	Accounting for volumes of water that is located in aquifer systems beneath the earth and in rivers streams and lakes on the surface of the Earth and the study of the interaction between them

Answering Australia's Geoscience Questions

AuScope

AuScope
School of Earth Sciences
University of Melbourne
Victoria 3010

Tw @AuScope
Ig @AuScopeToolkit
Li @auscope-limited

#AuScopeImpact
#NCRISimpact

auscope.org.au/strategy

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative