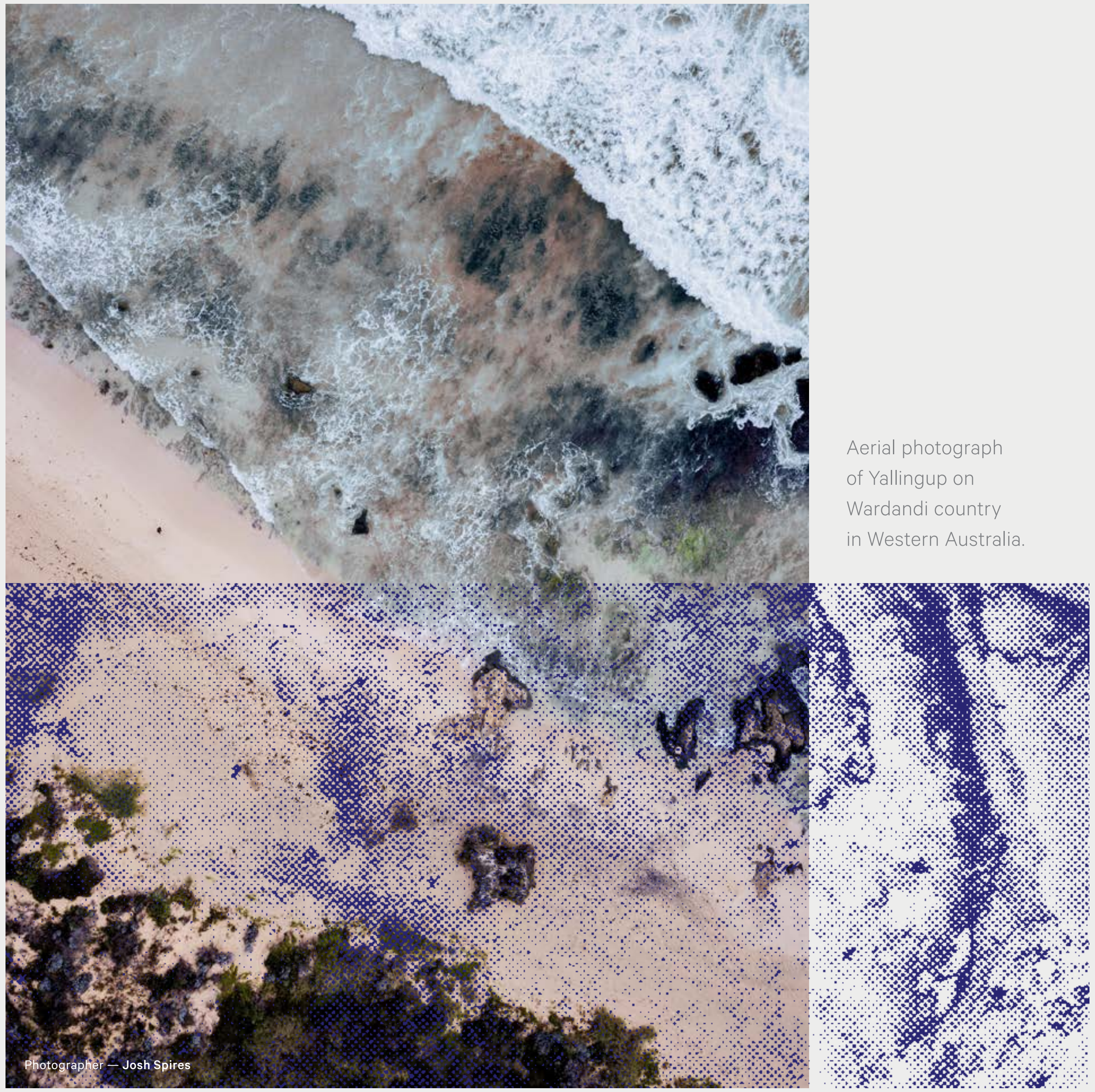
# 5-Year Investment Plan

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.




Aerial photograph of Yallingup on Wardandi country in Western Australia.

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Answering Australia's Geoscience Questions

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NCRIS National Research Infrastructure for Australia
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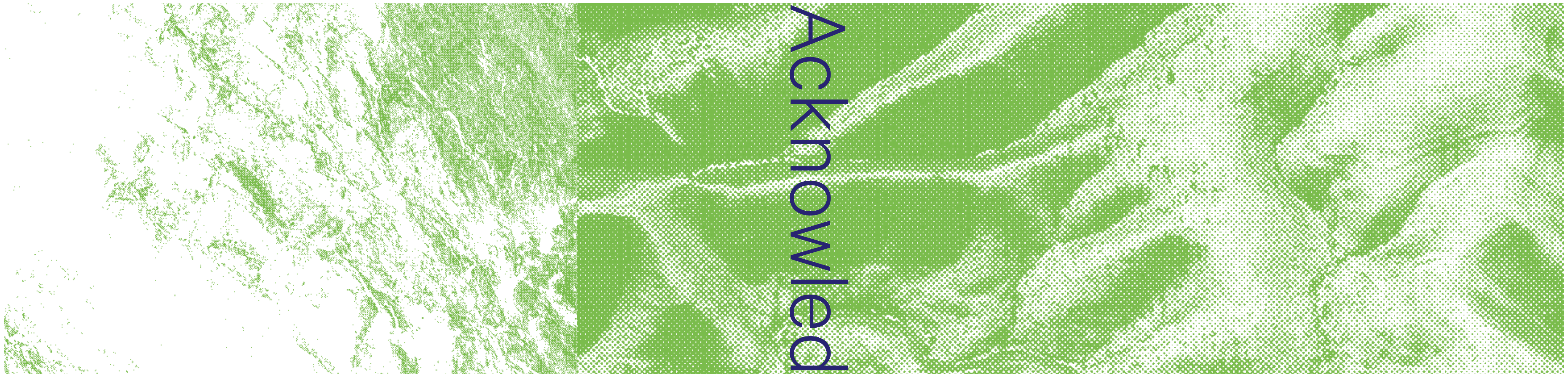




# Acknowledgments


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.

# Introduction

## This Investment Plan outlines new and continued investment needed in AuScope to enable geoscience research innovation in Australia across this decade.

We will use this document to guide operational and investment decisions in AuScope's Downward Looking Telescope (DLT), a concept to describe a newly integrated and augmented capability of instruments, services, data and analytics.

The DLT will form a component of a number of national and global capabilities. Nationally, it will directly integrate with new and existing capabilities in earth, environment, computation and data sciences that are enabled by the Australian Government's National Collaborative Infrastructure Strategy (NCRIS). These include the Terrestrial Ecosystem Research Network (TERN), the Integrated Marine Observing System (IMOS), the National Environmental Prediction System (NEPS), the National Computational Infrastructure (NCI), the Pawsey Supercomputing Centre and the Australian Research Data Commons (ARDC). It will also extend the national observing capacity of our partners at Geoscience Australia, CSIRO, and State and Territory Geological Surveys.

We will also work towards developing a new Global Research Infrastructure for geoscience, linking the DLT with the European Plate Observing System (EPOS), Incorporated Research Institutions for Seismology (IRIS), EarthCube, UNAVCO and other capabilities.

Recently, school students participated in a hands-on geoscience workshop at the ANU. Here we see students discovering how seismologists record earthquakes and research earthquake hazards using an AuScope seismometer

**Learn more —**
https://bit.ly/37WDBw5

Photographer — **Larisa Medenis**

# Background

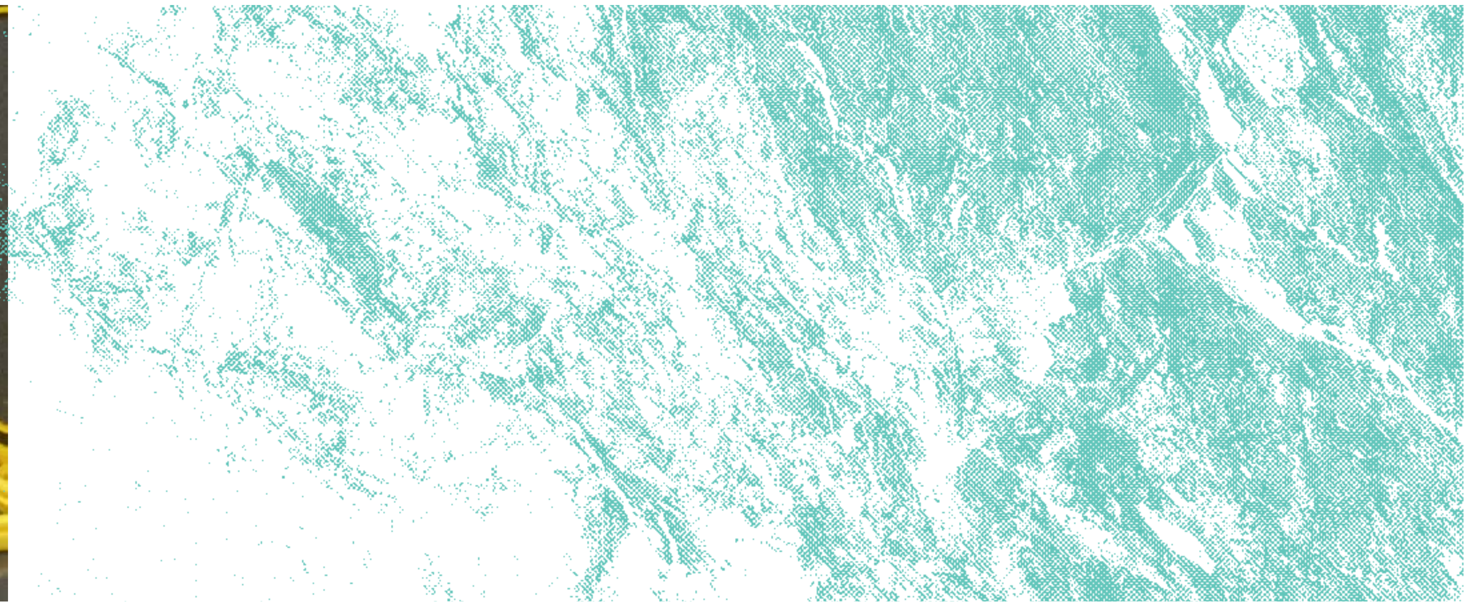
## Australia's geoscience community is driven to address key geoscience challenges facing Australians.

These challenges include food and water sustainability, minerals and energy security, and geohazards, tying in directly with the United Nations' Sustainable Development Goals (SDG's)[1]: (SDG #6) Clean Water and Sanitation, (SDG #7) Affordable and Clean Energy, (SDG #8) Decent Work and Economic Growth, (SDG #9) Industry, Innovation and Infrastructure, (SDG #13) Climate Action, and (SDG #15) Life on Land. The community is concerned with enhancing the resilience of all Australians to environmental change stemming from climate change and fostering a more profound and closer connection to the Australian landscape. High-quality geoscience data is at the heart of positioning Australia to meet these challenges.

During 2018 and 2019 AuScope convened numerous community-wide workshops across Australia to define how we will meet these decadal challenges. The outcome of these discussions is a robust community-wide endorsement to build an integrated DLT.

Here we propose a new generation of geoscience imaging, monitoring and analysis infrastructure that will underpin multiple integrated research programs and ultimately inform Australian decision makers in government, industry and academia. Significant Australian Government investment in the DLT via the National Research Infrastructure Program (NRI) is critical to supporting this endeavour and meeting a priority stated by the Chief Scientist in the National Research Infrastructure Roadmap, as well as an independent panel of geoscience experts in the Australian Academy of Science's Decadal Plan for Earth Sciences.

1. **The National Sustainable Development Council (2020):** sdgtransformingaustralia.com

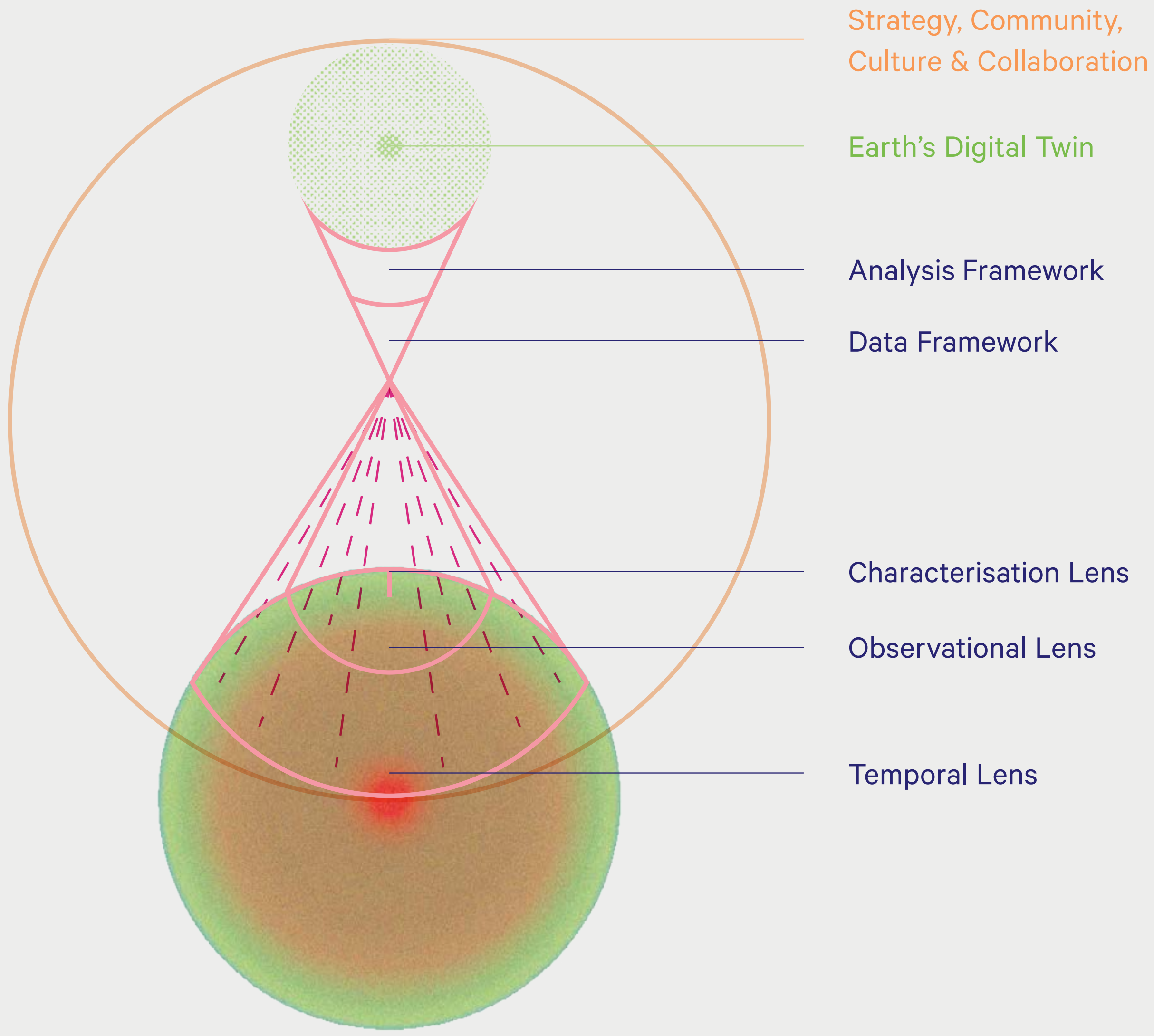


# Downward Looking Telescope

AuScope's Downward Looking Telescope (DLT) is a concept to describe our newly integrated and augmented capability that will be like a telescope, allowing 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

# Temporal Lens

## Networked physical and cloud-based analytical infrastructures that help researchers understand how Earth's evolution impacts our prosperity at its surface.

The DLT's Temporal Lens will comprise a suite of geochemistry and geochronology analytical services, data and analytics that will enable researchers to investigate the evolution of Earth, and other celestial bodies, through deep time with unprecedented accuracy. Importantly, it will enable researchers to help locate new critical mineral resources that will underpin sustainable infrastructure and innovation, provide new export opportunities, and support better climate forecasting models by providing high resolution records of the past.

Our challenge: Australia has many world-class geochemistry and geochronology laboratories, though the community recognise some technology gaps and unstandardised data delivery workflows across them. As such, users of data produced in these laboratories find it challenging to make useful data products such as national maps. Additionally, as some instruments approach end-of-life, the risk of ensuing critical data gaps increases.

This Temporal Lens will help to overcome these challenges through eight Programs.

AusLab will provide researchers with a 'one-stop-shop' for analytical services in Australia. It will include a register of national analytical research infrastructures, a support allocation system for analyses at a reduced cost, and a virtual laboratory service for sample submission and remote analysis. It will also include a data repository providing open data access, and data stewardship support for researchers.

AusLab, AusIsoLab, ANVIL, Ion Microbeam and AusDirt Programs will provide new analytical facilities to enable researchers to investigate Earth's composition to better understand how its processes — from core to surface — shape the passage and location of metals, energy, water, and even soil in the upper crust.

ChronAus and AusTime Programs will enable researchers to better understand the age of geological, environmental and climatic events throughout history. Together these facilities will underpin the development of National Maps, a new systematic approach to collection, analysis and delivery of isotopic and geochronological data across the continent.

For technical detail and cost estimates of each of the Programs in the Temporal Lens, please visit the Programs Technicalities & Costs table on Page 19.

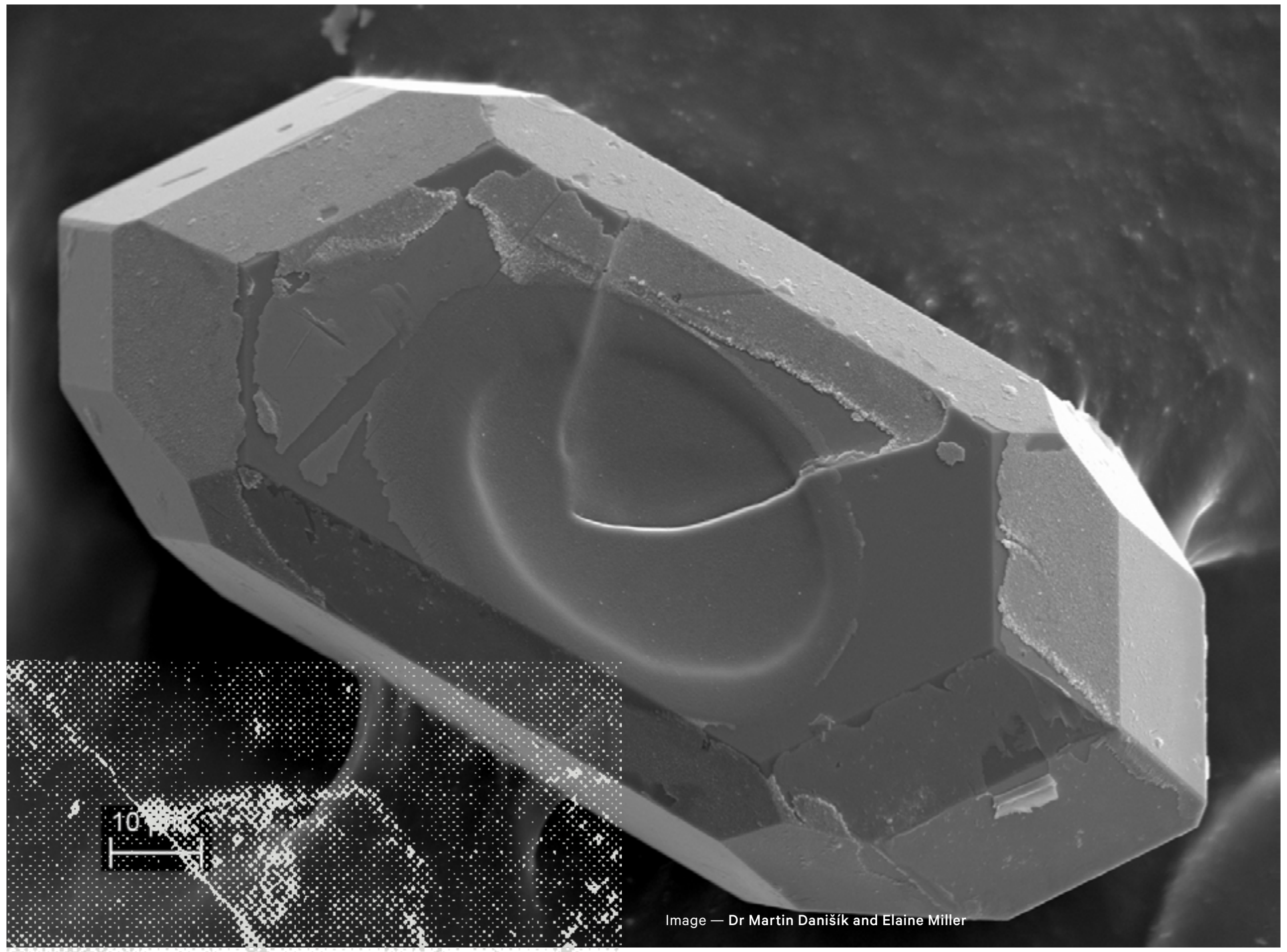



Image — Dr Martin Danišík and Elaine Miller

A photomicrograph showing a tiny zircon mineral from Turkish volcanics that researchers from Curtin University analysed in 2019 using NCRIS enabled age-dating instruments and laboratory services to help confirm one of the oldest eye-witnessed human sightings of a volcanic eruption in the world, some 47,000 years ago.

**Learn more —** https://bit.ly/2zXA83O

# Observational Lens

## Deployable and fixed geophysical and geospatial instruments that facilitate long-term and continent-wide earth imaging, allowing researchers to 'see' into earth.

**The DLT's Observational Lens will include a distributed array of geophysical sensors across the Australian continent that will monitor the physical properties of the Earth, and changes occurring over the decades ahead. This will enable researchers to better understand and even predict important natural and human-induced environmental changes and geohazards over time.**

Our challenge: Australia is a vast continent and whilst between AuScope, Geoscience Australia, CSIRO and various universities there are significant observational infrastructure systems in place, the coverage remains sparse and the rate of observation prohibitively slow. In order to provide the data density and richness required to allow predictive, near-real-time approaches for resource discovery, hazard management and continental-scale tectonic analysis, investment in the DLT is essential.

This Observational Lens will help to overcome this challenge through five Programs. First, it will image and monitor Australia at the continental scale through the **Geo-SuperSites Program** and the **Australian Plate Array (APA) Program**, allowing water balance assessments at the national, basin and sub-basin scales. These programs form the backbone of the DLT, and provide and long-term deployment of various geophysical, atmospheric, and hydrological sensors with real-time data telemetry. This provides researchers with time-series data to monitor atmospheric drivers of climate change, geohazards, water and the deep earth while also enabling new technology trials.

The Geo-Supersites Program will tie together transient or spot measurements collected at continental and local scale, as well as remotely sensed data from drones and satellites. 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.

The transportable component of the APA Program will seek to propel Australia to the forefront of international lithospheric and geodynamic research by completing the Australian Lithospheric Architecture Mapping Program (AusLAMP) and the AusArray Programs. Resulting datasets will enable the study of deep Earth and surface interactions and map and image the prospective search space for resources (minerals, energy and water) necessary to support a renewables-led economy.

Australia is currently leading the world in the application of this type of geophysical data to mineral exploration, but without this national data coverage we will loose our competitive advantage. The water balance at the national, basin and sub-basin scale addresses the critical issue of improving the monitoring of Australia's water resources, particularly in the subsurface. This multidisciplinary undertaking links satellite, ground and subsurface observations (with synergies across the DLT) to quantify surface-groundwater interactions and changes in subsurface water storage.

In addition a fleet of agile re-deployable specialist geophysical instruments will be developed for regional-scale measurements of Earth's properties, at surface and below. For the first time, multi-sensor drones and rovers will provide new research opportunities in areas that are difficult to access, and the ability to react rapidly to geohazards (landslips, earthquakes, etc.), or provide high resolution time-lapse monitoring to deliver unprecedented levels of change detection (**Drones & Rovers Program** and **Drones and Rovers — Pipelines Program**).

Mobile equipment deployments provide a means of rapid higher resolution infill studies designed to constrain the links between the deep earth, the surface and the atmosphere. Geophysics in the Australian Antarctic Territory seeks to expand the APA with the addition of GNSS stations to cover over 42% of Antarctica (in the **Antarctic Geophysics Program**), the extent of Australia's sovereign claim. Key drivers are to better predict future sea-level change impacts on Australia and our region and to understand the joint plate tectonic evolution of the Australian and Antarctic plates.

For technical detail and cost estimates of each of the Programs in the Observational Lens, please visit the Programs Technicalities & Costs table on Page 21.

Researchers from Monash University test a drone for use in geoscience and environmental science research. Together with the University and NCRIS peers, AuScope is building the Australian Scalable Drone Cloud to help such researchers collect, process and analyse national drone-enabled datasets.

**Learn more —**
https://bit.ly/3if5gMM

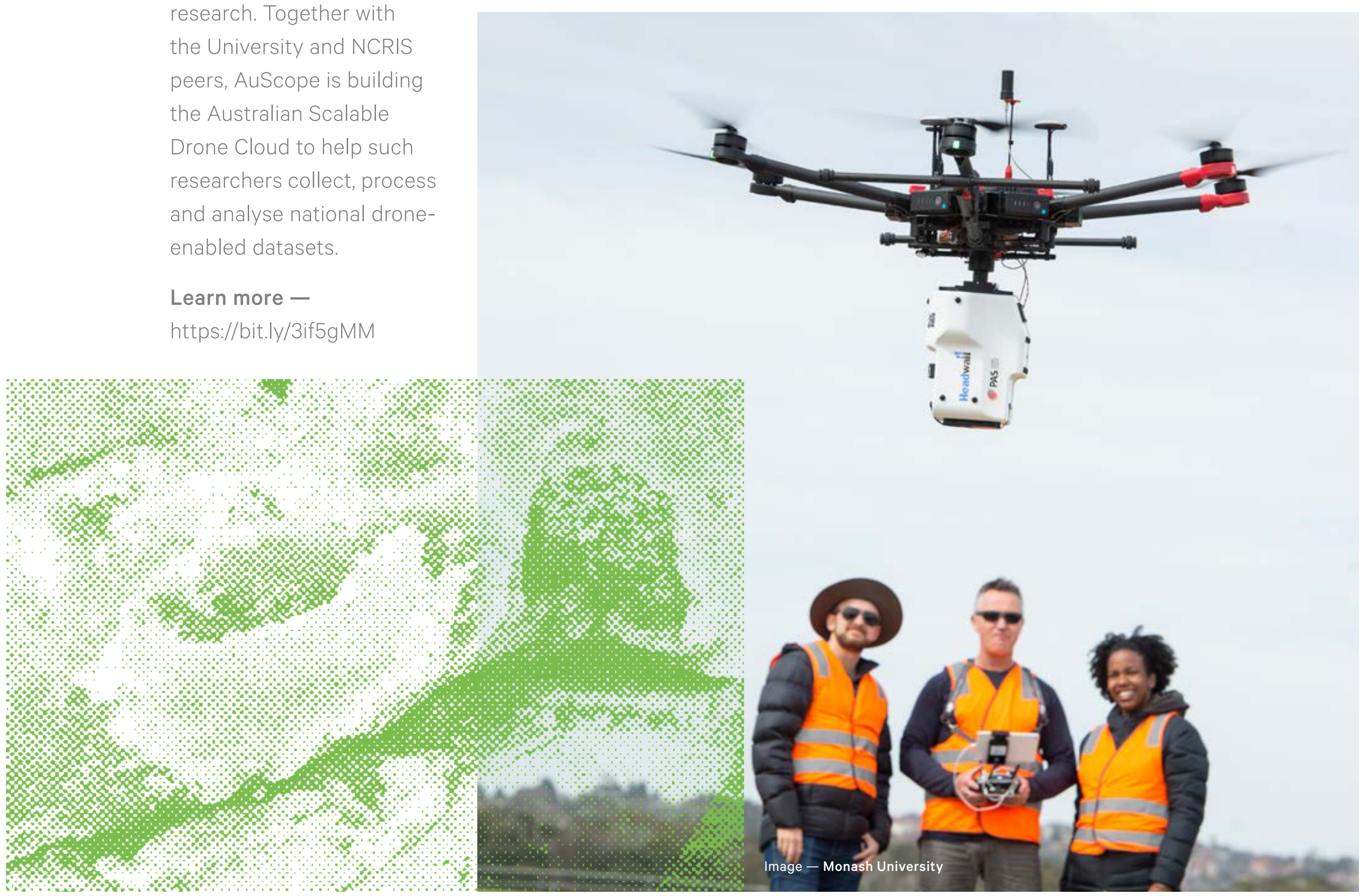


Image — Monash University

# Characterisation Lens

## Infrastructure to characterise the Earth's accessible crust through analysis of sample material or via borehole based measurements, imaging and sampling.

**The DLT's Characterisation Lens will provide researchers with the essential petrophysical properties necessary to accurately infer subsurface architecture and gain mechanistic insights into Earth processes.**

Our challenge: to characterise the shallow or accessible portion of Earth's crust across the Australian continent, which is currently largely limited to the domain of mineral and energy exploration companies. Typically, their approach to data acquisition is highly dependent on the commodity of interest, however, much potentially valuable data is either never collected or discarded, precluding use by others across research and industry. Providing support to geological surveys and academic geoscientists through borehole access, instrumentation and development of new characterisation technologies will revolutionise the quality and resolution of the data available from the shallow crust and the geological services it provides.

The Characterisation Program will help to overcome this challenge through five integrated Programs. First, the Mobile Petrophysics Program will provide a step-change in collecting petrophysical properties at core libraries, drill sites and geological outcrops. A Subsurface Litho-Sensor System (Litho-Sensor Program) will develop the next generation HyLogger-4 core scanner with extended imaging, spectral and geophysical functionality, coupled with advanced analytics, complementary to the BANDGAP Program, which will providing benchmark datasets, a deep crustal laboratory for in-situ measurements (described further on Page 10). The primary purpose is to pinpoint the distribution of water, sediment and soil needed for sustainable communities; unravel records of environmental and climate change; and predict subsurface mineralogy for resource exploration, geophysical data interpretation, and regional geology.

The Heatflow Program seeks to constrain thermal structure through rock property measurements and data acquisition with new generation instruments at onshore and offshore sites, as well as provide enduring research well instrumented for energy storage research and available for new instruments testing. Such constraints will place first-order controls on Earth processes to enable the development of interdisciplinary ties, while directly contributing to essential fields of research ranging from climate change to geodynamics and resource exploration and production.

The finest resolution of field data collection of the DLT is delivered by the BANDGAP Program which will provide ground-truthing from deep drill holes (deeper than three kilometres) to maximise the value from the imaging and monitoring Programs described above by providing a benchmark FAIR sample suite and dataset. Drill sites would also act as natural laboratories to trial new technologies and be used as monitoring stations. The petrophysics and subsurface Litho-Sensor Systems feed directly into this Program by contributing drill core data using petrophysics, micro-spectral, geochemistry and geophysics together with data analytics to validate relationships between geophysical measurements and physical and chemical rock properties, which is crucial for uncovering sustainable future resources.

Finally, the Hydro Geo Program will provide researchers with a groundwater laboratory for measuring hydrological properties of geological materials to improve quantification, preservation and management of Australian groundwater resources.

For technical detail and cost estimates of each of the Programs in the Characterisation Lens, please visit the Programs Technicalities & Costs table on Page 23.

Photographer — Jon Wah

Dr Alan Mauger explains to students in the NEXUS 2017 Program how the NCRIS enabled HyLogger system enables semiquantitative mineralogical scanning of geological drill core, with each metre adding to an open national database of 1.3 million metres of drill core scanned from around the Australian continent.

**Learn more —** www.auscope.org.au/nvcl

# Data Framework

## Capturing and creating Findable, Accessible, Interoperable and Reusable (FAIR) data from the three DLT Lenses, in preparation for researchers to make sense of it in the Analytical Framework.

The Australian geoscience community recognises the importance of research data management, instrumentation data pipelines and data access portals for future research. As such, the DLT's Data Framework, AuScope will i) capture data automatically at the point of creation, ii) hold data to FAIR data standards, iii) open data to community data repositories; and iv) deliver data as high-performance datasets for data-intensive research.

AuScope also recognises the importance of data stewardship over community created used and managed data. As such, we will build capacity within our geoscience community to safeguard geoscience data, develop a community of practice around that data, and support researchers in data life-cycle planning and management to ensure all new DLT data meets international standards for governance, quality, FAIR principles and data ethics.

A scientist scans the International Geo Sample Number (IGSN) of a sample using phone software at the John de Laeter Centre for Isotope Research (JdLC) to quickly access open data about it online.

**Learn more about IGSN —** https://bit.ly/31ddEa3

Video still — **Australian Research Data Commons (ARDC): https://bit.ly/37G0wM2**

"AuScope will continue to use best practice to manage data throughout the entire data life cycle — involving Big Data and artificial intelligence-based analysis approaches.

As an AuScope collaborator and geoinformatician, I am pleased to help in safeguarding data collected by AuScope and other government agencies, to advance stewardship locally, and to connect with data communities abroad to help make the most of data now, and in the future."

**Dr Lesley Wyborn**
The Australian Research Data Commons (ARDC), the National Computational Infrastructure (NCI) and Australian National University

**Learn more about data stewardship in geoscience:**
https://bit.ly/3fAsfAw

**Learn more about making scientific data FAIR:**
https://go.nature.com/2UXT89U

# Analysis Framework

## Enabling predictive geoscience through advanced modelling, allowing researchers to transform data provided by the DLT Lenses.

The DLT's Analytical Framework brings data to life. Here, data becomes interrogable through Inverse and Forward Modelling Platforms and their constituent Programs, with other analytics and computational tools — together a foundation for 4D modelling of Earth systems. Community will be at the centre of the Digital Framework, advancing a community of practice amongst domain experts; socio-technical policies and standards; research data management; a community cloud resource; and knowledge transfer via regular workshops, webinars, interactive training and professional development events.

For technical detail and cost estimates of each of the Programs in the Analysis Framework, please visit the Programs Technicalities & Costs table on Page 24. Alternatively, read on for a plain language summary of Forward and Inverse Modelling Platforms and their Programs, as well as a summary of Open Data, Codes and Software; and Community and Impact.

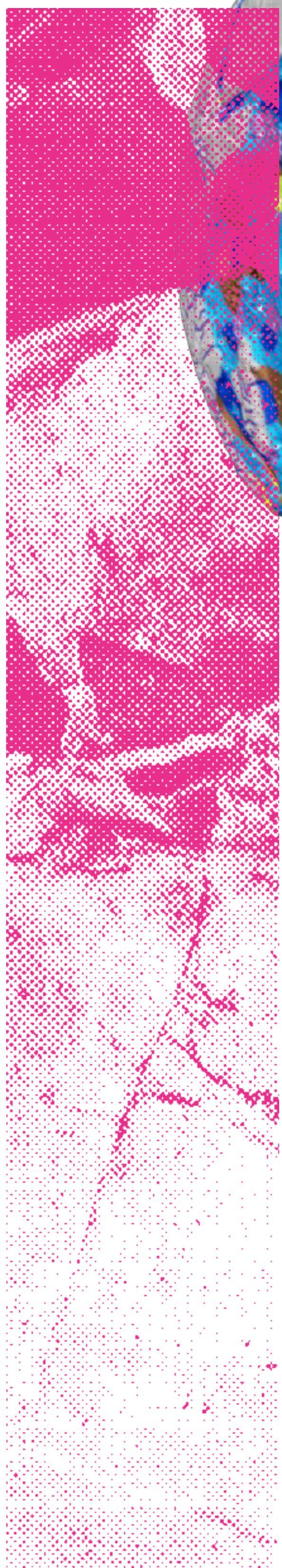
### Forward Modelling Platform

Additional investments (to those in AuScope's GPlates software) within the **Forward Modelling Platform** will provide tools for studying Earth's multi-scale processes.
A holistic view of research data management is encouraged within the Data Framework, with repositories, pipelines and portals co-designed by stakeholders across the full life-cycle of research data (creation, processing, analysis, storage, access and preservation).

The Forward Modelling Program will complement existing AuScope Programs, in particular, the Simulation Analysis and Modelling (SAM) Program. Several relatively small Programs will increase AuScope's current capability within the forward modelling community, enabling researchers to model the thermodynamic behavior of rocks and fluids during metasomatism and metamorphism using codes developed in the **Reactive Transport** and **ThermoCalc Programs**, thermochronologic models in the **Thermochronology Program**, groundwater models in the **Groundwater Program**, and glacial isostatic adjustment and multiphase transport models in the **GIA Program**.

GPlates global seafloor lithology (rock type) model enabled by NCRIS.

**Learn more —**
portal.gplates.org



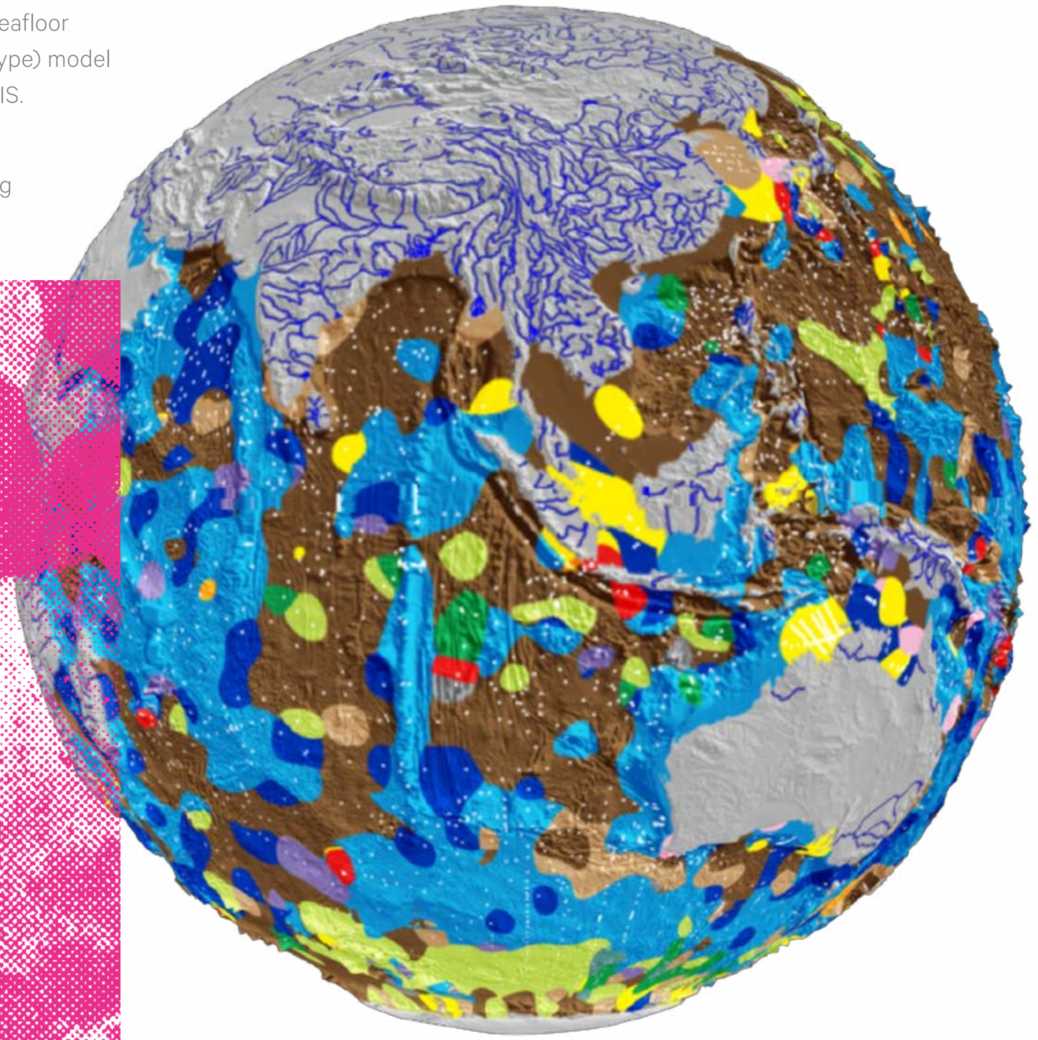


Image — **EarthByte**

### Inverse Modelling Platform

The community strongly supports the development of an **Inverse Modelling Platform** comprising four complementary elements: (i) inversion from 3D geologic models (**Loop Program**), (ii) data-driven simulation-based platform for Earth's interior (**Earth Interior Program**), (iii) the Common Framework for Inversion (**CoFI Program**), and (iv) the computational infrastructure for inverse geodynamics (**Geodynamics Program**). These tools will allow researchers to model the geology of the Earth in 3d, constrain the associated uncertainty and then use the models to predict geodynamic behavior of the Earth through time. Additionally, these Programs provide a critical link between the Forward Modelling Framework and the broader observational and data-driven AuScope Programs.

# Analysis Framework

## Open Data, Codes and Software

The software products of the Data and Analytical Frameworks will be open source data products including analytic, field and modelling data repositories will maintain FAIR principles expected of AuScope and the broader geoscience community.

These foundation principles will enable extensive community engagement. The Programs proposed here will have keen (and current) interest and activity with research (educational, government and industry), industry (government surveys, exploration) and policy groups (exploration, climate, water) within Australia and internationally.

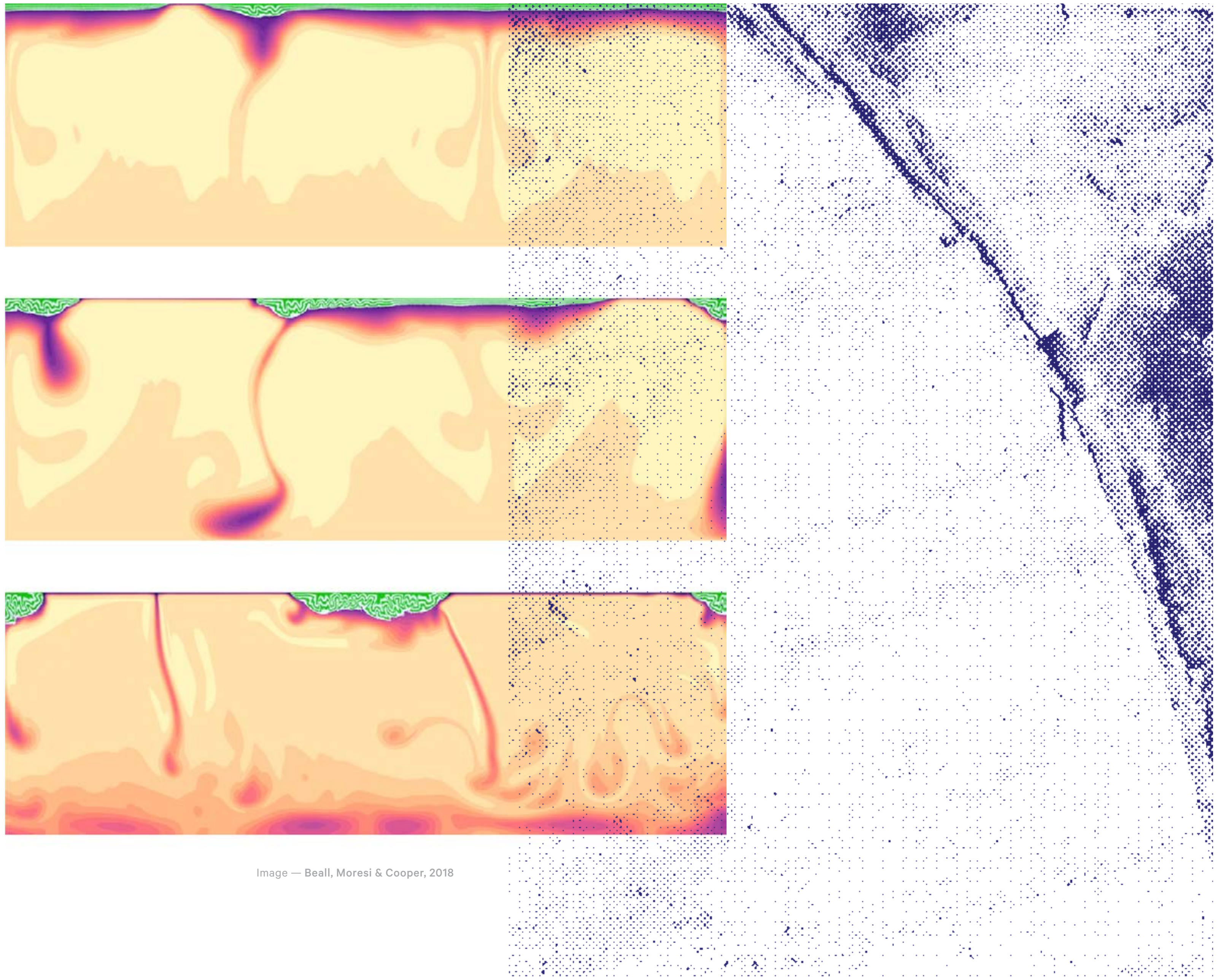


Image — Beall, Moresi & Cooper, 2018

Three part simulation of the formation of Earth's oldest, near-surface material in NCRIS enabled Underworld2 software at The University of Melbourne.

**Learn more —**
www.auscope.org.au/sam

## Community and Impact

Many of the Programs within the Analytical Framework are well progressed along a pathway to impact, with translation to applied research organisations, government agencies and industry built into their process. These include two projects funded by the Australian Research Council: the Loop Project (Linkage-funded) and the Basin Genesis Hub (Industrial Transformation Research Program-funded) which couples surface processes, Solid-Earth deformation and plate tectonic software packages. These community focused, interdisciplinary research programs have shown the ability of digitally-enabled geoscience to progress from traditional research outputs and outcomes, to a clear economic and environmental benefit. Industry and government agencies use community-developed geoscience digital infrastructure to inform their environmental and economic decisions.

"National, pre-competitive Earth Science data has been underpinned by AuScope for over a decade. These are mission-critical datasets that look downward into the Earth at all scales.

It is difficult to overstate the significance of such data in stimulating industry activity and ongoing exploration in Australia. We regularly access such data for our own decision-making in where and how to explore. These data also set Australia apart in a globally competitive landscape, where many other nations are considered to have high prospectivity in terms of natural resources but nowhere near the same caliber of pre-competitive data support. As a result, discoveries are made, supporting rural communities and creating jobs. The strength of the ties between AuScope, the state and federal geoscience surveys, CSIRO, universities and other NCRIS facilities is equally impressive.

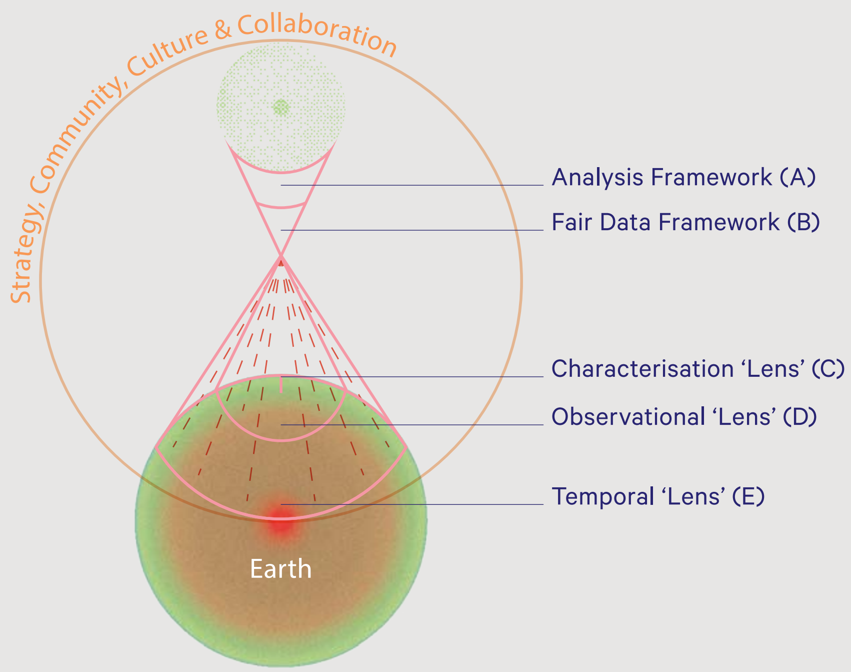
As a consequence I remain confident that Australia has a network of collaborative and forward-looking research institutes, that continue to develop flow-on benefits for the minerals industry in this country."

**Dr Steven Micklethwaite**
Discovery Manager
Anglo American

# Expanding the AuScope Model

The DLT augments and substantially extends the existing AuScope Model that we have developed over the last decade.

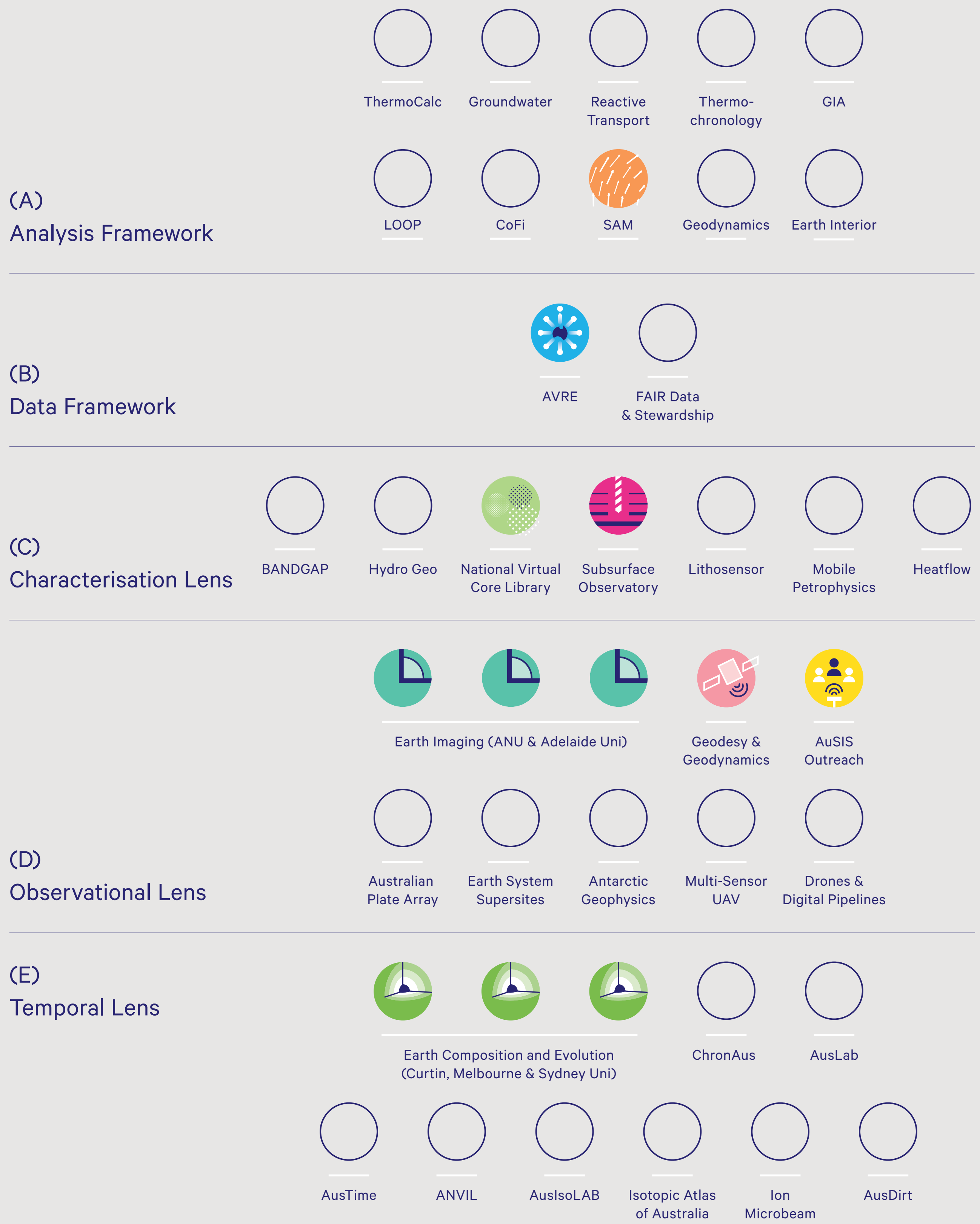
It has been designed to significantly enhance research instruments, services, data and analytics delivered by AuScope currently across our Geodesy and Geodynamics, Earth Imaging, Earth Composition and Evolution, National Virtual Core Library, AuScope Virtual Research Environment, and Simulation, Analysis and Modelling Programs. This enhancement can be summarised as a substantial increase in the (i) number of new Programs, (ii) level of integration between and across existing and new Programs, and (iii) level of spatial, depth and temporal imaging resolutions in new Programs.




## Existing & New DLT Programs

**Legend**

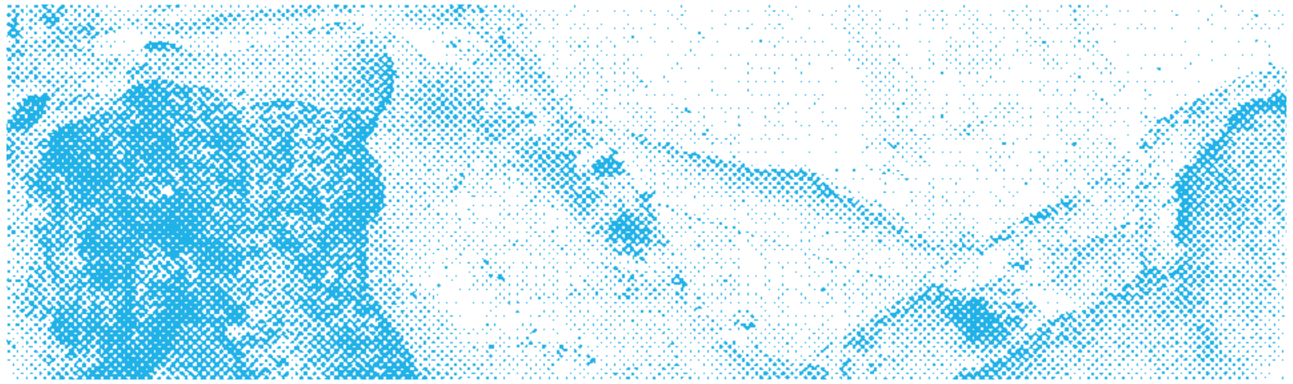
**Circles Full** — Existing Programs
**Circles Outlined** — Future Programs



# Programs Technicalities & Costs

## Temporal Lens

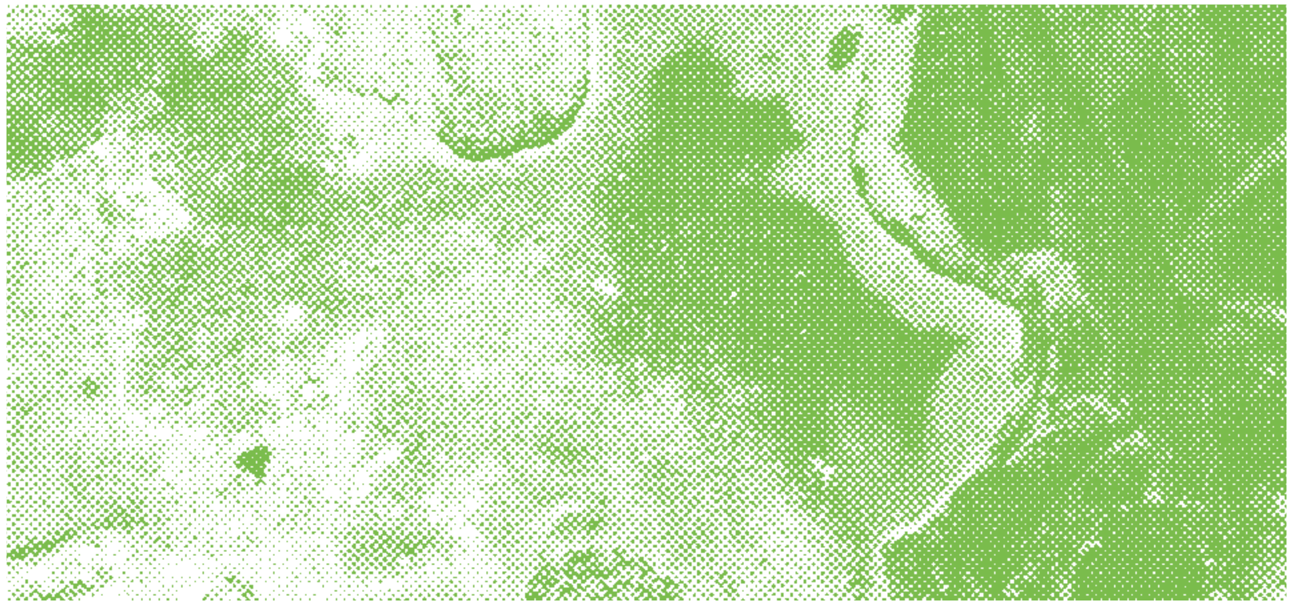
| PROGRAM NAME | TECHNICAL DESCRIPTION | $M |
|---|---|---|
| ANVIL | High-pressure experimentation provides a window into changes deep in the earth through time. It requires a combination of expertise, specialised equipment, advanced manufacturing capability, and appropriate facilities to analyse experimental charges. Equipment for high-pressure experiments is heavy, expensive to run and maintain, and is located in only a few centres distributed around Australia (Macquarie, ANU, Monash and Curtin universities). The Australian Virtual Experimental Laboratory (ANVIL) Program will provide a centrally coordinated virtual experimental research centre, enabling access to high-pressure experimental facilities for geoscientists at all Australian universities, government agencies, and other interested research organisations. ANVIL will open up the existing Australian laboratories to a wider user base by providing physical access or by performing syntheses-on-demand where visits by external users are not practical or appropriate. | 2 – 3 |
| AusDirt | AusDirt will apply cosmogenic radionuclides, stable metal isotopes, and luminescence dating in a novel strategy to quantify the millennial scale temporal and spatial dynamics of soil and sediment from source-to-sink across the Australian continent. This Program will leverage new state-of-the-art analytical facilities at the University of Wollongong, a strategic partnership with the ANSTO Centre for Accelerator Science, and support from the ARC Centre of Excellence for Australian Biodiversity and Heritage (CABAH), to generate a new and globally unique continental-scale geochronological database on soil production and sediment dynamics and storage in Australia's river systems. | 0.5 – 1.2 |
| AusIsoLab | This Program aims to establish a national laboratory platform with dedicated infrastructure and expertise on advanced isotope analysis of selected metals, as well as critical minerals (those containing Li, Cr, Co and Mo, for example), and their applications for both basic and applied research. Metals are principal components of many geological and biological systems, and their accumulation in the Earth's crust provides a valuable resource to the Australian economy. In addition, at low levels, metals act as important micro-nutrients in both marine and terrestrial environments, but elevated concentrations lead to toxicity and metal contamination problems. A critical overlap between both fields is common at active and past mine sites at which deep-earth metal is exposed to the ambient environment. Understanding both ore forming processes including tracing of subsurface mass movement over geologic time, and constraining the availability of metals in near-surface environments is crucial for a stable and sustainable economy, and healthy ecosystems and water resources in Australia. Recent advances in analytical instrumentation provide the means to utilise isotope distributions of metals (i.e. metal isotope ratios) as tracers of the distribution and abundance of remote, deep Earth resource and complex biogeochemical pathways of metals in rock-soil-water-plant systems. | 1 – 2 |
| AusLab | The Australian geoscience community is equipped with a vast array of world-class analytical facilities. To maximise the return of investment of this infrastructure, we propose to federate geoanalytical laboratories into a national platform – AusLab. AusLab will build on the AuScope Laboratory Network and will create a one-stop shop for the research and industry community to find analytical services and training opportunities, build national and international collaborations, foster interdisciplinary innovation and easily access datasets. This Program proposes to build the framework needed to ensure the success of AusLab. It will be materialised by a web interface hosting a portal for (i) proposal submission for analytical cost support, (ii) sample submission, and (iii) an open-access database for compiling the data produced under AusLab. This web interface will also display an interactive directory of analytical services available across the nation, advertisements for technical workshops around Australia and scientific activities for the general public (e.g. open days, laboratory tours). Finally, a cutting-edge online training platform using the latest innovation in mixed reality (MR) will be implemented as well as a strong science outreach/media component to promote the research conducted through AusLab. | 10 – 12 |
| AusTime | To be able to adapt to future climate change and ensure domestic and global sustainable growth, we need improved predictive capabilities. This can be achieved through a better understanding of past climate events of the Late Quaternary (the past million years of Earth's history). Geochronology is at the core of this endeavour since accurate and precise dating is paramount to achieve such knowledge of past climate, and the Australia geoscience community is endowed with world-class facilities for Quaternary geochronology. To achieve the full potential of Quaternary research in Australia, we propose to establish a national platform for Quaternary geochronology – AusTime. The aim is to (i) improve access for universities (in particular regional universities), government bodies and industry to analytical facilities; (ii) establish uniform national standards for geochronology data, from sample to publication; (iii) promote innovation in palaeo-climate and palaeo-environment research; (iv) provide the infrastructure for a high-resolution national-scale survey of past climatic and environmental changes; and (v) develop outreach activities for the general public (in particular high school students) and training programs for postgraduate students. | 0.75 – 2 |
| ChronAus | Constraining, timing, rates and tempo of physical and geochemical processes are essential to understand the Earth and planetary system as a whole from core to atmosphere. Enhanced and more available geochronology is essential to accessing the 4th dimension and understanding the 3D-structure of the Australian lithosphere. ChronAus will build a national geochronology infrastructure, building on the existing AuScope Earth Composition and Evolution Program, by networking and supporting already existing highly specialised laboratories (personnel, instruments and maintenance) with a demonstrated record for innovation in geochronometry. | 5 – 12 |
| Ion Microbeam | This Program aims to deliver realistic access and new levels of analytical and imaging resolution to the already world-class infrastructure in the area of national in-situ micro-geochemical analysis. The cutting edge of isotope and trace element geochemistry is focused on in-situ, high spatial resolution analysis of new isotope systems with the versatile Cameca-type ion microprobes and sub-ppm trace element analysis using NanoSIMS. This is to (i) identify the effects of fluid migration in Earth's mantle and crust on a nano-to-micrometre scale, (ii) Ancient Earth/Early life, (iii) reach the high spatial resolution necessary to study palaeoclimate and environmental evolution at the same temporal resolution than societal changes, and (iv) provide the planetary and cosmochemistry community with an integrated and versatile state-of-the-art instrument platform able to rival leading international laboratories. | 10 – 15 |
| Isotopic Atlas of Australia | The Isotopic Atlas of Australia represents a coordinated national approach to characterising the age and geological history of our continent. The work will be focussed towards the production of a series of national-scale, mutually-complementary isotopic maps. The data and knowledge derived from this Program will complement parallel investments in imaging the continent in 3D by providing sample-based evidence for the geological meaning of features seen in such 3D images which are, by their nature, a modern-day snapshot of the results of ~4 billion years of geological evolution. Appropriate interpretation of such images requires an understanding of relative and absolute timing (4D) of processes leading to the current crustal/lithospheric configuration. In short, images of the continent in its current state are of limited use if we do not know what we have imaged, or when the geological features in those images were formed. The improved continental-scale view of the physical and chemical evolution of our continent proposed here will provide attendant insights into the origin and preservation of economic and natural resources, allowing improved prediction of the likely locations of undiscovered resources. | 2 – 3.5 |



# Observational Lens

| PROGRAM NAME | TECHNICAL DESCRIPTION | $M |
|---|---|---|
| Antarctic Geophysics | Australia has a sovereign claim over 42% of East Antarctica, known as the Australian Antarctic Territory. This region is geophysically one of the least well observed regions on Earth, and yet the structure, heat and rheology of the solid Earth and sub-glacial sediment have first order controls on the future of the ice sheet and sea level. In turn, the ice sheet, which is up to three kilometres thick, hides major crustal boundaries which can only be revealed by remote measurements. Many such boundaries also inform the understanding of Australian deep continental structure, across the conjugate margin of the two former plate tectonic neighbours in Gondwana. This Program seeks to acquire and deploy geophysical equipment to the Australian Antarctic Territory, creating a unique database of geophysical measurements. This pioneering infrastructure concept, which links instrumentation and database-building for Australia's Antarctic Territory, will cover a region the size of continental Australia, peering beneath the ice sheet to reveal the Earth beneath in high resolution. Many of the areas targeted for infrastructure deployment will never have been visited by Australians – perhaps anyone – and will renew Australia's presence in Australian Antarctic Territory. The benefit of this unique infrastructure will is enabling world-leading science to better predict future sea-level change impacts on Australia and our region, and to understand the joint plate tectonic evolution of the Australian and Antarctic crust. | 2 – 3 |
| Australian Plate Array | The Australian Plate Array consists of co-located magnetotelluric (MT) and seismic data acquisition achieved through rolling but not necessarily co-current deployments. The resulting data infrastructure will revolutionise Australia's 3D deep Earth imaging of the electrical resistivity and elastic properties thereby transforming our understanding of the Australian Tectonic Plate. This data infrastructure and resulting models will provide a lithospheric context to integrate disparate geoscience datasets for: geodynamic investigation of the Australia plate; earthquake location; geohazards, including geomagnetically induced currents (GIC's); sea-level variations; and resource exploration. The goal is to complete the national coverage of MT and passive seismic (PS) sites across the Australian continent and surrounding ocean at ~50 kilometres station spacing. | 5 – 12 |
| Drones and Rovers — Pipelines | The sensing capabilities of drones, in a sense, epitomise the DLT for our Earth, transforming field geology (photogrammetry and LiDAR), geophysical surveys (aeromagnetics, gravity and electromagnetics) and remote sensing (hyperspectral and thermal). They address the critical scale gap between ground and satellite-based observations by collecting high resolution data (mm-cm scale) over large surface areas (one to two square kilometres and greater depending on platform), or acquiring geophysics at high line density and station spacing. This Program will deliver a fleet of remote sensing and geophysical equipment accessible to experts and non-experts alike. The infrastructure includes near real-time information delivery, via a virtual laboratory, by integrating the sensing capabilities with easy-to-use processing, visualisation and data analysis tools (including computer vision/deep learning techniques). The flexibility, access and ease of use of the infrastructure makes it ideal for enhanced observation, in line with the 2016 National Infrastructure Road Map and Resources 2030 Taskforce. This national infrastructure will make Australia world-leaders in the application of drones for our Earth and environment, providing vital research tools to meet our biggest challenges in ground water, resource discovery, geohazards and environmental stewardship | 2 – 3.5 |

| PROGRAM NAME | TECHNICAL DESCRIPTION | $M |
|---|---|---|
| Geo-SuperSites | An enhanced national network of real-time geophysical instrumentation and permanent infrastructure will lead to the development of a wide range of techniques and new high-quality, long-term, continuous atmospheric, surface and near surface observations. The advent of widespread uniform station deployments will lead to the effective integrated and complementary monitoring of the environment, mapping natural resources, mitigating natural hazards, new fundamental knowledge of how our Earth evolved through time, while educating the next generation of geoscientists who are technologically and scientifically proficient. The equally-spaced stations will provide continuous data streaming to a centralised data centre (such as auspass.edu.au) that quality controls the data and provides FAIR data to the Australian and global community. The data from these uniformly distributed permanent stations will also provide a longitudinal baseline and reference point for the vast wealth of geophysical data that the Australian continent is endowed with. Geo-Supersites will also incorporate geological components of a national Critical Zone Observatory network. The Critical Zone (CZ) is the vertical profile from fresh bedrock to plant canopies, which sustains most terrestrial life. Within the regolith, strongly mediated by biological processes, energy and water inputs from the atmosphere interact with weathering products from the lithosphere, causing the CZ structure and composition to evolve, changing the way energy, water, solutes and organisms are stored, transformed and transmitted. Inputs of energy and water to Australia's CZ's are changing. | 10 – 12 |
| Drones and Rovers | The development of autonomous multi-sensor drones and rovers will give Australia an edge in the global resource technology market and also place Australia at the forefront of the emerging space exploration industry. Rovers will be particularly effective in regional Australia where there's little topography or vegetation, especially if integrated with drones (from the Drones and Digital Pipelines Program). Such technology can be used to acquire co-located, scale consistent, fully integrated datasets suitable for utilisation in the application of next generation Big Data methodologies. Rovers provide a stable platform, necessary for the collection of high precision gravity data, but whilst deployed, can also collect a full suite of geophysical data products including: magnetics, magnetotellurics, radiometrics, ground penetrating radar, electromagnetics and passive seismic data. They can be fitted with geological sensors (e.g. hyperspectral spectrometers to identify mineralogy and portable X-ray fluorescence to identify geochemistry of samples). They can host atmospheric and climate sensors (e.g., air quality, temperature, humidity). Each rover can also act as a base station for multi-sensor drones, which are equipped with next gen, super light sensors, for example, magnetometers, aerial photography and radar. The drone component would gather data at higher resolution (e.g., mapping the ground surface and topography) which would provide critical data for the correction of the gravity data. This Program will bring together robotics expertise with METS stakeholder to create next generation multi-sensor platforms, which are required to provide high resolution, high precision data required to make new discoveries in an increasingly difficult sector. | 1 – 2 |



# Characterisation Lens

| PROGRAM NAME | TECHNICAL DESCRIPTION | $M |
|---|---|---|
| BANDGAP | Subsurface exploration is essential to locate and exploit groundwater, energy and mineral resources, but is currently impeded by a lack of coincident geophysical and geochemical datasets. Boreholes for Australian National Datasets in Geochemistry and Petrophysics (BANDGAP) will solve this challenge by providing benchmark datasets, a deep crustal laboratory for in-situ measurements and an ongoing opportunity to test new emerging technology. This Program will undertake two stages of drilling deep (deeper than three kilometres) diamond drill holes in regions of the continent in which ground-truth datasets would provide value to existing and planned geophysical surveys (e.g., Mount Isa), where long-standing questions remain about geophysical anomalies (e.g., Coompana), and in regions of deep cover (e.g., Capricorn Orogen). The mineralogy, geochemistry, and petrophysical properties of these cores will be characterised in detail at the same scale with a full suite of cutting-edge field and lab-based techniques to create a benchmark FAIR (Findable, Accessible, Inter operable and Reusable) dataset, which will be made accessible by leveraging existing digital infrastructure (the AuScope Discovery Portal). | 8 – 16 |
| Heatflow | The Heatflow Program will enable research into questions of national significance via state-of-the-art infrastructure for measuring crustal heat flow, temperature and rock thermal properties. It will provide resources to tackle challenges in fields as diverse as low emission future energy systems, glaciology, marine science, mineral exploration under cover, geohazard assessment, climate change, geotechnical engineering, managing groundwater resources, ore genesis, global tectonics, fossil fuel exploration, and others. The Program will cultivate a collaborative Australian heat flow research community, a community that is currently a small set of disjointed groups and individuals. The coordinated network of ongoing and new infrastructure will be findable and accessible to the broad research (and industry) community, and will foster collaboration between research groups tackling big science questions and those operating field, laboratory and digital systems, respectively. The Program will also bring new sensors, tools and testing sites to maturity, which will open new research avenues. | 3 – 7 |
| Litho-Sensor | Australia's subsurface contains hidden resources such as sediments for aggregate, groundwater aquifers, petroleum, minerals and metals, which support our productivity and sustainability. To develop these resources, AuScope's National Virtual Core Library (NVCL) rapidly characterises mineral abundances and compositions in drill cores and cuttings. This Program will leverage the NVCL to build a field-deployable Subsurface Litho-Sensor System to serve the groundwater, environmental, earth and marine science sectors.<br><br>The centrepiece of the Subsurface Litho-Sensor System is a next-generation HyLogger-4 which will be combined with expanded spectral libraries, new efforts to integrate Raman spectroscopy, micro-spectroscopy (micro-Raman and micro-near infrared to thermal infrared), existing core-scanning and geophysical capabilities, and advanced data analytics. This transformational science infrastructure will be used to: pinpoint the distribution of water, sediment, and soil needed for sustainable communities; unravel records of environmental and climate change; and predict subsurface mineralogy for resource exploration, geophysical data interpretation, and regional geology. | 2 – 4 |
| Mobile Petrophysics | A mobile petrophysical facility will add a significant new dimension to Australia's geoscience infrastructure, supporting earth sciences and providing critical data to support the challenges of resource exploration through cover. The facility will be designed to complement and be compatible with existing petrophysical measurement capabilities, which form part of AuScope's Australian Geophysical Observing System (AGOS) based at The University of Melbourne, and similar capabilities at The University of Tasmania, The University of Western Australia and the CSIRO in Perth. It comprises a self-contained mobile container unit, suited to a range of Program environments both onshore and offshore. It can be used on marine vessels and platforms, at drill sites, mines and core libraries/yards, allowing critical petrophysical datasets to be collected on site, thereby negating the need to ship pallets of core to major centres by road. | 1.5 – 2 |
| Hydro Geo | This Program aims to establish a national level laboratory to provide data on the hydro-physical properties of geological materials. This laboratory would have the capability to measure both unconsolidated and consolidated materials, and at hand specimen dimensions to ensure representativeness of the data at a catchment or basin scale. The methods employed would include, but not be limited to, measurement of hydraulic conductivity of primary and secondary porosity, the latter commonly related to weathering, induration or fractures. | 3 – 5 |

# Analysis Framework

| PROGRAM NAME | TECHNICAL DESCRIPTION | $M |
|---|---|---|
| Forward Modelling — Groundwater | Understanding the hydrological cycle is of high national significance in the driest inhabited continent on Earth. But the sheer scale and complexity of Australian groundwater systems limits the ability to manage these resources in an efficient and sustainable manner. The goal of this Program in the Forward Modelling Platform is to develop a fully coupled landscape evolution and groundwater modelling framework. The coupling of these systems will facilitate modelling of topographic erosion and deposition of sediments, and the response of groundwater flow within major aquifer systems in Australia. Linking surface processes with groundwater flow is crucial for having a fully integrated approach as water circulation beneath the Earth's surface is driven by topographic hydraulic head, 3D variations in stratigraphy, sediment composition and permeability. | 1 – 2 |
| Forward Modelling — ThermoCalc | The ThermoCalc Program in the Forward Modelling Platform will augment dynamic simulations of Earth materials and processes with accurate, detailed representations of thermodynamic and rheological properties, on a range of time- and length-scales by combining various forms of dynamic simulation, representing everything from tectonic processes to grain-scale reactive flow, with multi-dimensional phase equilibrium modelling. This will result in multi-faceted simulations of Earth-processes, that are realistic enough to be closely linked with a range of observational data, allowing for rigorous testing followed by prediction. | 0.5 – 1.2 |
| Forward Modelling — Thermo-chronology | The difficulty of quantifying the timing and magnitude of surface movements has hampered progress in understanding how the lithosphere reacts to the competing effect of tectonic processes that create topography and surface processes that destroy it. State of the art thermo-mechanical models have become very efficient at testing scenarios of tectonic evolution but the rates of surface uplift and subsidence are dependent on the rheological laws used to model the lithosphere. Uncertainties on the constitutive laws and the complex dependencies on temperature and pressure have so far limited the potential to quantitatively predict uplift and subsidence. Low temperature thermochronology can be used to quantitatively constrain the thermal histories of rocks and thus provide important information on tectonic uplift (or subsidence) by measuring the erosional (or burial) response and can also map the spatial and temporal pattern of geomorphic response of a landscape. This Thermochronology Program in the Forward Modelling Platform will improve the predictive potential and integration of Underworld and Badlands codes by developing a tool that enables the prediction of thermochonological data expected for a given thermo-mechanical simulation including surface processes (Coupled Underworld / Badlands). | 0.5 – 1.5 |
| Forward Modelling — GIA | Glacial Isostatic Adjustment (GIA) is the uplift/subsidence of the lithosphere as a result of large-scale deformation in the mantle in response to changing surface loads — particularly melting ice sheets. GIA needs to be accounted for in any interpretation of time-dependent surface deformation or satellite-inferred mass balance changes. The influence of GIA is strongest close to regions where the surface loads have changed but the effects can be detected globally. Australia currently has no capability to run GIA computations that include 3D models with realistic rheology of the lithosphere and mantle. This Program in the Forward Modelling Platform will build software to provide such capability for Australian researchers. It builds upon existing modelling capability in the Simulation, Analysis & Modelling Program for large-scale mantle dynamics. | 0.75 – 1 |
| Forward Modelling — Reactive Transport | Complex natural processes occurring in the Earth's interior have been traditionally characterised as sequences of "simple" discrete events (i.e. melt production, percolation, equilibration, differentiation, pooling, mixing). The main goal of this Program in the Forward Modelling Platform is to develop a predictive numerical platform to shift this perception towards a reactive transport paradigm, where the thermo-mechanical-chemical evolution of the system is a result of the integrated (and thermodynamically constrained) transport and reactive rates of its constituents. | 0.5 – 0.75 |

## Programs Technicalities & Costs — Continued

| PROGRAM NAME | TECHNICAL DESCRIPTION | $M |
|---|---|---|
| Inverse Modelling — CoFi | Applications of inversion and parameter estimation underpin many areas of Australian geoscience, including in geophysical imaging of seismic, magnetotelluric, electromagnetic, gravity data and other domains. In all areas, significant development effort is required to implement inversion methods for analysis of geophysical and geochemical data sets. This implementation effort is usually repeated by each organisation, group or researcher across university, industry and government sectors. What is currently lacking is a common language, or framework, to allow researchers from different domains easy access to advanced inference and machine learning algorithms. This Program in the Inverse Modelling Platform is aimed at creating the world's first Common Framework for Inversion (CoFI). | 1 – 4 |
| Inverse Modelling — Earth Interior | The Earth Interior Inversion Program in the Inverse Modelling Platform will develop the critical infrastructure required for fusing, analysing, inverting and interpreting multiple land-based (geochemical, geophysical, GPS, etc) and satellite (potential fields, etc) geoscientific datasets within an internally-consistent, computationally-efficient and physically realistic framework. This Program will therefore directly feed into large-scale predictive frameworks for deep Earth resources, such as hydrocarbon and giant ore deposits currently undetectable at the surface. | 0.75 – 1.5 |
| Inverse Modelling — Geodynamics | This Program in the Inverse Modelling Platform will build upon decades of AuScope funded research software infrastructure in geodynamics (e.g. Underworld, GPlates, CitcomS), through the development and support of a computational modelling infrastructure for "inverse geodynamics". Based upon a formal adjoint approach, CIIG will provide interested practitioners with access to, and support with, state-of-the-art finite element software libraries that rigorously integrate data (and uncertainties), from fields such as tectonics, stratigraphy, geochronology, seismology, geodesy and geochemistry, with multi-resolution, time-dependent, geodynamical models, through high-performance computing. CIIG will facilitate national and international collaboration, connecting researchers with data to those with models, thus underpinning a new-class of inter-disciplinary research and positioning Australian researchers at the leading edge of this emerging discipline. | 1 – 2 |
| Inverse Modelling — Loop | The aim of the Loop Program in the Inverse Modelling Platform is to support and develop infrastructure required for optimised Bayesian modelling of structural geological data to produce 3D probabilistic geometrical models of lithological and structural distributions in both data-rich and -poor geological domains. The Loop Program is an open-source codebase and an emerging community bringing together developers and geoscientists in the resources sector, academia and government organisations dealing with resources management at the global to basin to urban scales. | 0.5 – 3 |

# 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 |

## Glossary — Continued

| 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 |

| NAME | DESCRIPTION |
|---|---|
| **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 |
| **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

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

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