AuScope acknowledges the Traditional Custodians of the land on which our community and research infrastructure are located across Australia, and we pay respects to their Elders past and present.

This is a technical long-form version of the AVRE build new projects. A shorter, plain language version can be found here.

AVRE builds new digital geoscience research tools

The AuScope Virtual Research Environment (AVRE) is bringing together Australian universities and publicly funded research agencies to explore new applications and technologies in geoscience research. Image: Photo by Ryan Quintal on Unsplash edited by AuScope.

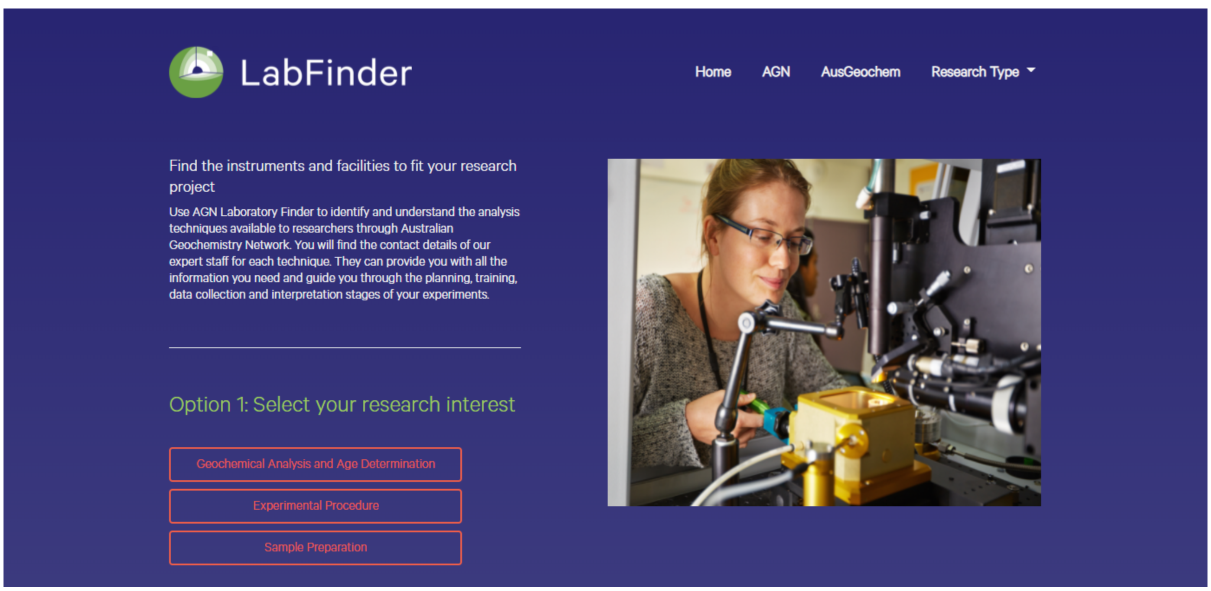
Overview

The AuScope Virtual Research Environment (AVRE) Build Program was devised as a vehicle to promote low-barrier collaboration projects with Australian universities and publicly funded research agencies and to provide an avenue for exploring new applications and technologies that could become part of the broader AVRE portfolio.

These projects achieved greater user acceptance and ongoing adoption through the personalised approach to development that engages project proponents at all stages of the solution design and development lifecycle. This has lowered the barriers, both legal and financial, to collaboration between institutions with minimal overheads.

By creating small project teams involving users with a vested interest in the project outcomes and a focus on a tailor-made solution for a defined problem. With the AuScope and enabled by the NCRIS, in three years of AVRE Build Program existence, we developed a suite of tools ranging from data management systems to Cloud infrastructures supporting complex data analysis and numerical modelling workflows that directly benefit research communities in a variety of disciplines and enabling free collaboration between scientists, institutions, and the new generation of geoscience researchers. The following story provides a high-level overview of the AVRE Build Program's achievements over the last three years and the impact it has had on Australian research.

AuScope Geochemistry Network – Laboratory Finder



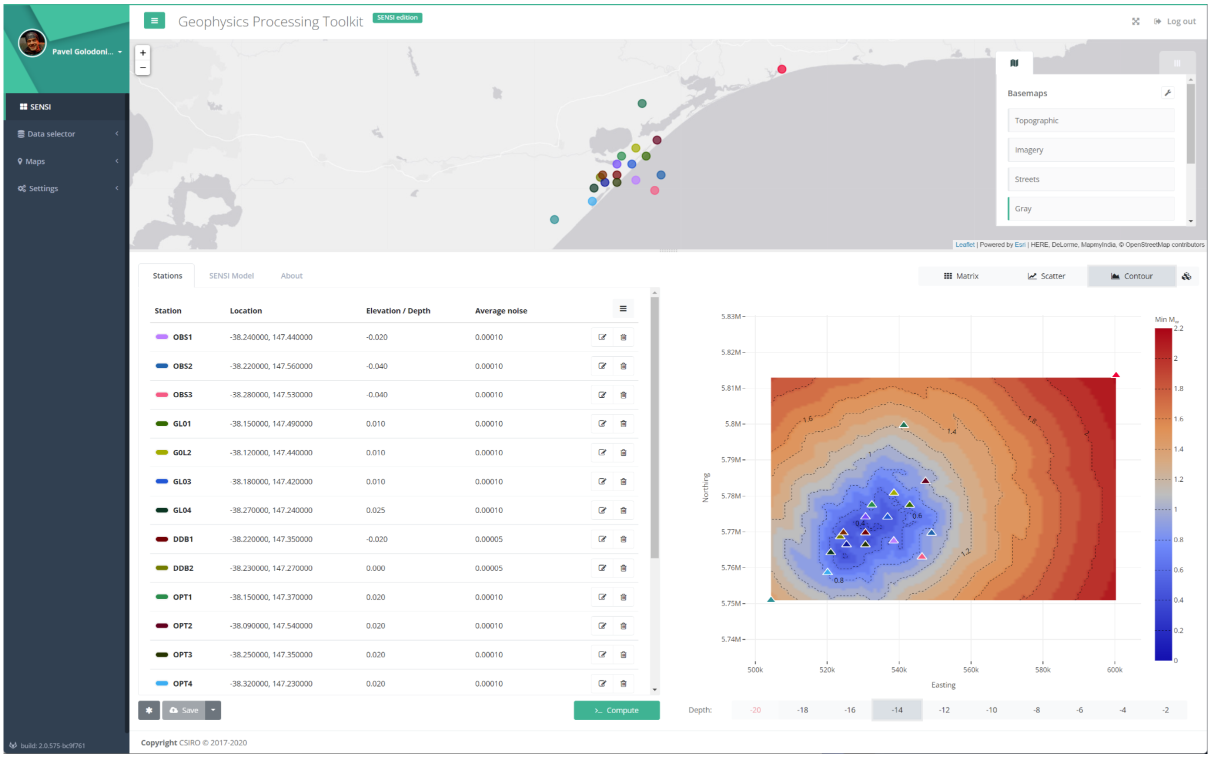
The Laboratory Finder – a novel platform to connect users of Australian laboratories, a product developed with the AuScope Geochemistry Network. Image: Pavel Golodoniuc

The AuScope Geochemistry Network (AGN) is an Australian consortium of Earth Science institutes cooperating to develop a national geochemistry research infrastructure. The AGN was established in response to a national expression of a need for better organisation and coordination of geochemistry laboratories and data. This required an online system to be developed and adopted by the AGN to enable organisation of detailed information about participating laboratories, their equipment, analytical capabilities, and custodian contact information.

The AGN researchers have approached the AuScope Virtual Research Environment (AVRE) program through its Build activity to develop a product that would address that problem. LabFinder was developed using free and open-source software, leveraging prior work and further expanding its capability. The AGN Lab Finder is an adaptation of Technique Finder originally developed by Intersect for Microscopy Australia. It is a Cloud-hosted web application that enables users to identify the techniques most suited to their research, based on a researcher-centric approach.

The AVRE collaborated with AGN to develop and change the original Technique Finder for specific user needs, introducing an indexing mechanism and search functionality allowing researchers to utilise their analytical capability requirements to efficiently locate and identify laboratories with the equipment necessary to their research. Collaboration and involvement of the AGN team in the technical design process aided in building a product satisfying AGN-specific technical requirements, while utilizing open-source tools significantly improved the efficiency of the project team leveraging previous successes of Microscopy Australia.

Seismic Network Design Web App (SENSI)



Seismic network modelling and design in an interactive web-based environment based on the Geophysical Processing Toolkit (GPT) and EASI Hub. Image: Pavel Golodoniuc

Contrary to the popular belief that Australia is safe from earthquakes, it experiences a magnitude 6 or greater event every 6-8 years on average, which poses a considerable risk if one of these events were to hit an urban centre. This risk with large uncertainties is already factored into, for example, property insurance where the cost of reinsurance with earthquake coverage is significant. However, if the seismic hazard can be analyzed more accurately, mitigation measures such as updating building codes can be enacted to minimize losses, and therefore, overall costs to the economy. Because smaller earthquakes are far more common in nature than larger ones, detecting and locating smaller earthquakes is imperative to build better seismic hazard models, which require well-designed seismic networks with clear monitoring specifications of earthquake magnitude detection thresholds and their spatial coverage.

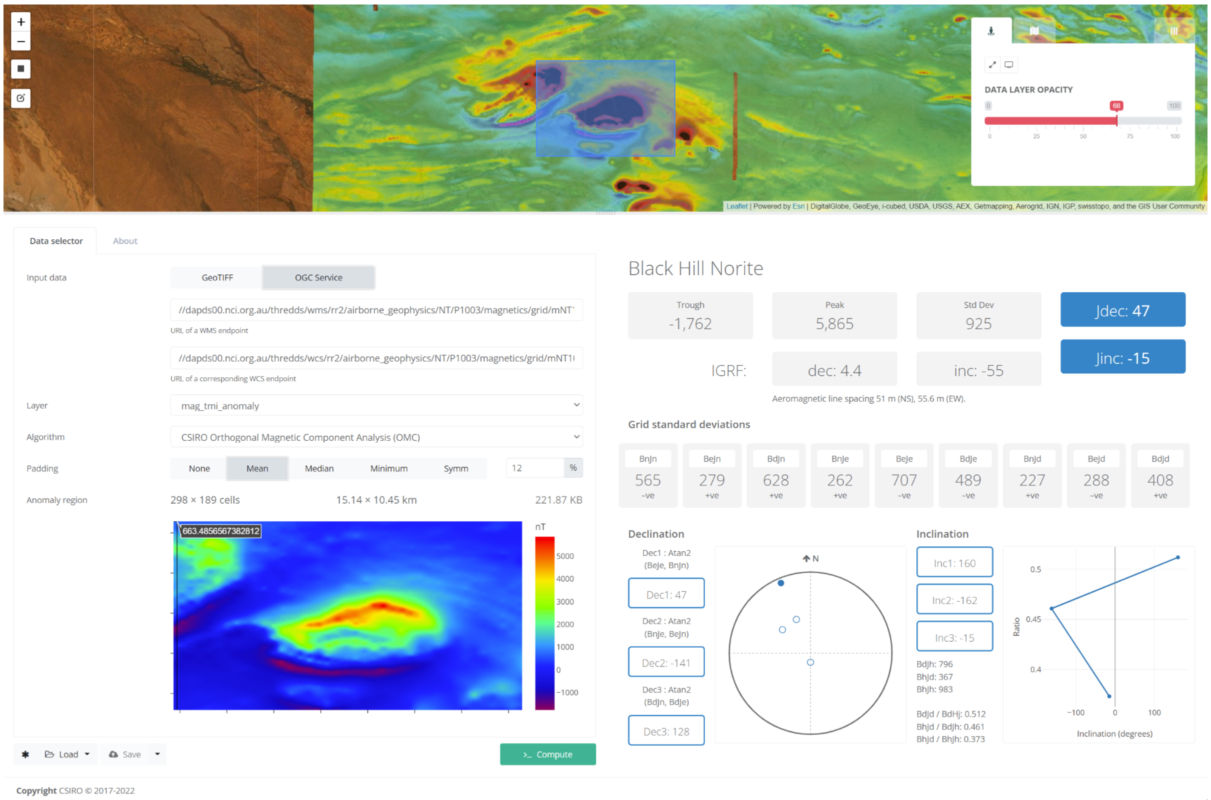
For seismic monitoring to be cost-effective, these specifications need to be optimised using seismic wave propagation theory well before seismometers are deployed in the field.

AuScope AVRE Build Program team has collaborated with researchers from the seismology group at the University of Melbourne on developing a new open-access, cloud-based seismic network design application called SENSI that enables testing of the detection and location sensitivity of seismic networks before and during deployment considering various network-specific physical inputs such as network geometry, ambient seismic noise, and wave propagation medium properties. The utility of this web application is already demonstrated in the Gippsland region in Victoria, Australia, where the University of Melbourne is using it to optimise seismic monitoring at both local and regional scales for academic and industry purposes. Therefore, other seismic network operators designing cost-effective monitoring solutions will benefit from the use of SENSI.

The AVRE Build team has built an application leveraging a previously developed Geophysical Processing Toolkit (GPT) as an application platform and harnessed the scalability of a Cloud environment provided by the Earth Analytics Science and Innovation (EASI) Hub, which minimised the overall development time. The GPT application platform provided the groundwork for a web-based open-access application interface and enabled interactive visualisations to facilitate human-computer interaction and experimentation. The use of open-access technologies and efficient collaboration between CSIRO and the University of Melbourne have demonstrated the potential to develop comprehensive seismic monitoring solutions that achieve target outputs cost effectively.

Footnote: The research, operations, and seismic monitoring infrastructure development carried out by the University of Melbourne were supported by Australian National Low Emissions Coal Research and Development, a grant from the Education Infrastructure Fund administered and coordinated by CO2CRC, and AuScope.

Magnetic Component Symmetry Analysis Tool



The Magnetic Component Symmetry (MCS) Analysis Tool – is another example that leveraged the Geophysical Processing Toolkit (GPT) and EASI Hub. Image: Pavel Golodoniuc

Low-elevation aeromagnetic surveys, acquired on a large scale by Geoscience Australia and State and Territory Surveys, map the expression of subsurface magnetizations and are the basis for many geological studies across Australia. The survey data itself is not the end product but provides input to analysis and interpretation studies that derive new insights about subsurface geology. The most significant recent advances in the interpretation of magnetic field data have been in the ability to recover estimates of magnetization direction from it. CSIRO has recently developed a new method known as Orthogonal Magnetic Component (OMC) analysis or “the grid-flip method” that has yet to be applied to regional Australian magnetic field data sets.

AuScope AVRE Build Program team has collaborated with the CSIRO’s Ore Body Potential Fields team to develop the Magnetic Component Symmetry (MCS) Analysis Tool – a web-based application to seamlessly integrate with the Geoscience Australia’s Geophysical Archive Data Delivery System (GADDS) that provides access to the magnetic intensity survey data and to couples it with the numerical codes executed in a cost-effective Cloud environment. The developed application provides tools for survey data visualisation, data subsetting, anomaly selection, and graphical display of the results, i.e. source magnetization direction for the anomaly.

The provision of this analysis is complimentary to the existing CSIRO-generated Australian Remanent Anomalies Database (ARAD) which is provided through both the AuScope and the Australian Geological Survey Organisations Network (AGSON) web portals. The analysis is also an exemplar of an application developed for the processing of the magnetic grids supplied by Geoscience Australia's GADDS system.

The MCS Analysis Tool is extensible and allows for the inclusion of separate but complementary numerical methods, e.g., Helbig analysis.

NVCL Mineral Spectral Library

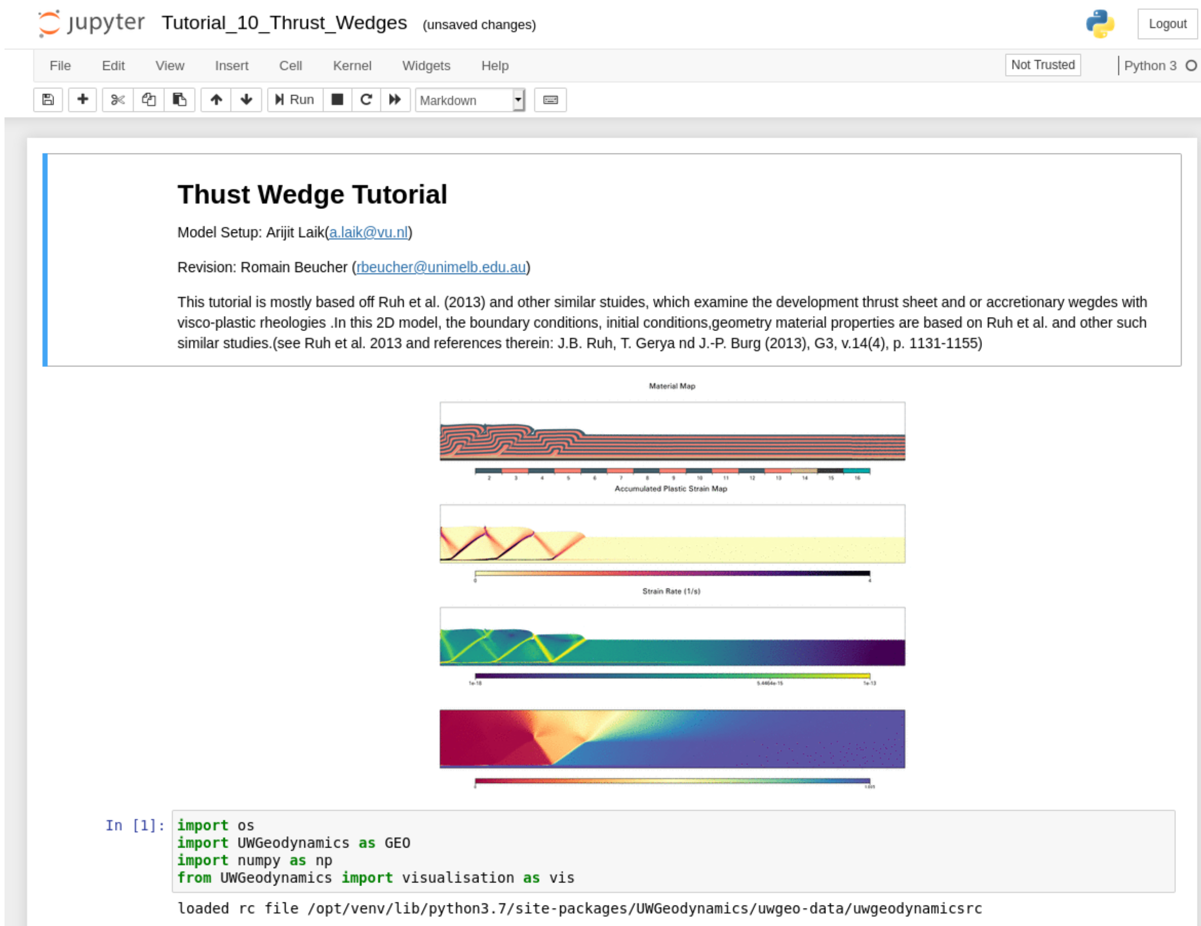
The NVCL Mineral Spectral Libraries is a collection of calibrated spectral signatures of reference mineral samples. Image: Pavel Golodoniuc

The Australian and international geoscience community is using reflectance spectral signatures of reference mineral samples to efficiently and objectively identify and characterise mineral groups and species through proximal and remote spectral sensing technologies. Applications range from regional mineral exploration using spaceborne technologies to identifying deleterious minerals encountered in ore processing plants and soil classification for land use management.

The CSIRO-led National Virtual Core Library (NVCL), an NCRIS-funded AuScope infrastructure program supporting Australian researchers, has initiated the creation of an accessible collection of reflectance spectral signatures acquired from validated reference mineral samples. The NVCL team works in collaboration with the NVCL nodes in Australia and researchers to capture, validate and characterise spectral mineral signatures. These mineral signatures are built into a large online collection that can be specialised to form geological province and mineral system spectral reference libraries (SRL). This online SRL aims to support the geoscience community with high-quality and validated library spectra that are required for rapid whilst objective mineral characterisation.

The AVRE Build Program worked in collaboration with the NVCL team to rebuild the legacy application designed to run on a single platform into a modern web-based platform-independent application hosted in a cost-efficient Cloud environment. The AVRE Build team re-engineered the application and its internal SRL database to use cost-efficient Cloud technologies, cutting-edge application development and database management practices while introducing new features for building personalised mineral reference libraries. The resulting application has brought the NVCL Mineral Spectral Library in line with modern technologies and significantly minimised maintenance and operational costs and continues to be in high demand among geologists and mineralogists.

Scalable Cloud Research Environment



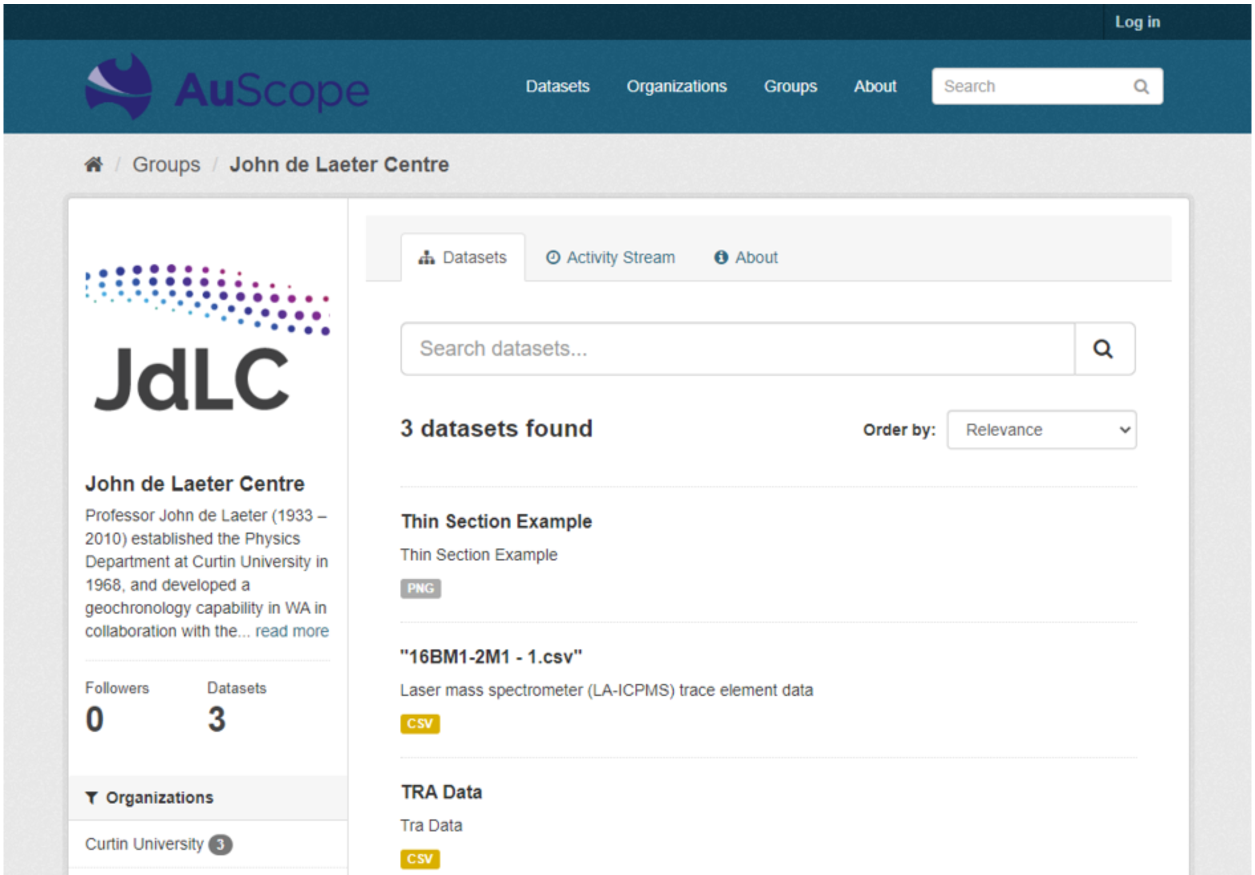
Jupyter notebook powered educational tutorial. Image: Geoffrey Squire

Geosciences, including Geology, continue to evolve and advance with the advent of new technologies and numerical methods. The complex numerical methods also require new approaches to teaching methods. Universities and research institutions have largely adopted Cloud technologies to provide students with a preconfigured environment for learning about and experimenting with new modelling methods and technologies.

The Australian National University (ANU) required a scalable Cloud research environment that would provide students with the necessary software, computational power, storage, and a flexible interface for configuring, modifying and running numerical codes. The AVRE Build team collaborated with ANU on the project to develop a Cloud-based research environment for education, research and data exploration using Jupyter Hub. Some of the key requirements included a persistence layer so that data and computed results can be saved and shared, independent software environments for each student or researcher that can be instantiated easily on demand, and software (i.e. numerical codes) that can be pre-configured as necessary.

The AVRE Build team developed a format for the declarative description of software environments and a system using those definitions to automate software configuration and deployment. By auto-generating user interfaces for configuration, including smart-prefilling of configurable values, and making research software easy to access in the Cloud, this has significantly improved the flexibility and accessibility of numerical codes and contributed to the improvement of teaching methods that introduce students to the use of modern Cloud technologies.

Data Repository and Catalog Pilot



Data repository and catalogue based on an open-source CKAN system, a pilot project in collaboration with the AuScope Geochemistry Network and Curtin University's John de Laeter Research Centre. Image: Pavel Golodoniuc

Through the AVRE Build Program, the AuScope Geochemistry Network (AGN) coordinator at Curtin University's John de Laeter Centre (JdLC) worked with the CSIRO team to develop a repository and data catalogue capable of data entry, Cloud storage, data harvesting and data dissemination. The team devised a web-based solution based on an open-source CKAN data repository and catalogue that implements the FAIR principles for data, i.e. Findable, Accessible, Interoperable and Reusable, allowing for broader integration within the AGN ecosystem of services as well as with external services including AuScope's Discovery Portal and the Australian Research Data Commons (ARDC) catalogues. With the variety of research capabilities at the JdLC, an efficient data cataloguing tool with data storage capacity was identified as a need and the pilot project with AVRE to build such a solution was started.

The solution has addressed a few technical challenges, including integration with the Australian Access Federation (AAF) authentication service allowing users to use their institutional credentials to access the system, a custom information model to accommodate JdLC-specific metadata requirements, and integration with a third-party AARNet CloudStor cloud storage service for extra large files.

The project provided a platform for both collaborating parties to learn about the intricacies of complex data management practices in geochronology research and resulted in the addition of a tool into the AVRE toolkit that can be adapted to other sciences with relative ease. The solution developed for the AGN here has since been superseded by another AGN product: AusGeochem, a platform that added geospatial context to datasets and includes privacy control and visualisation tools alongside sample management features such as IGSN integration.

AUTHORS

Written by Dr Pavel Golodoniuc, Dr Januka Attanayake, Dr Alexander Prent; and edited by Peter Warren, Geoffrey Squire, Jo Condon, and Philomena Manifold.

FURTHER READING

- Developing the Seismic Network Design App

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