



Department of Energy, Mines,
Industry Regulation and Safety



Geological Survey of
Western Australia

Fieldnotes

Quarterly news for Western Australia's
exploration industry and geoscience community



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Acknowledgement of Country

The Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) respectfully acknowledges Aboriginal peoples as being the traditional custodians of Western Australia. We acknowledge the enduring connection Aboriginal people continue to share with the land, sea and sky through both their ancestral ties and custodianship to Country. We pay our respect to Elders both past and present, and acknowledge the value brought to our department through the collective contribution of Aboriginal and Torres Strait Islander peoples across Western Australia.

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Cover image

A seismometer (under the tub) and digitiser, both loaned from the ANSIR equipment pool, just ready to start recording on the WA Array project

ISSN 1834-2272
ISBN 978-1-76148-055-3

Access publications

All publications

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Hard copies

Maps, USB data packages and various premium publications are available to purchase as hard copies from the eBookshop or the First Floor Counter at Mineral House, 100 Plain Street, East Perth WA 6004. An online cart and payment system is in place. Records, Reports, Bulletins and other non-series books cannot be purchased in hard copy but are all available as PDFs to view and download free of charge.

Fieldnotes

Fieldnotes is a free digital-only quarterly newsletter published by the Geological Survey of Western Australia (GSWA). The newsletter provides regular updates to the State's exploration industry and other geoscientists about GSWA's latest work, programs, products and services.

Access Fieldnotes by:

- subscribing to the [GSWA eNewsletter](#) — linked to the latest issue.
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GSWA eNewsletter

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GSWA publishes a vast amount of pre-competitive geoscience information on the State, contributing to billions of dollars' worth of resources for exploration and development. To find more information about publications and maps we publish, go to our [website](#).

Keep up-to-date



Seismic activity with the Southwest Australia Seismic Network (SWAN)

The word craton is derived from the ancient Greek κράτος, meaning “strength”. Geologically, cratons are synonymous with strength and longevity; they are the stable hearts of continents.

Recent and on-going seismic activity within the southwestern Yilgarn Craton therefore presents a conundrum: why is the craton deforming internally rather than transferring the stress and strain to its margins? Western Australia’s Wheatbelt region has in fact been the most seismically active region in continental Australia over the last half century. In this time, alongside countless smaller, largely imperceptible earthquakes, the southwest Yilgarn Craton has hosted several notable large earthquakes.

The effects of the 1968 Meckering magnitude 6.5 earthquake remain visible in the towns of Meckering and York more than fifty years later. Multiple earthquake swarms (prolonged, localised series of typically small earthquakes without a well-defined main shock) have similarly been observed. With 90% of the state’s population concentrated in the southwest, the potential for large, damaging earthquakes poses a risk. The amplification of seismic wave amplitudes as they transit through sediment piles compounds this risk for the Perth metropolitan area and other population centres located atop the Perth Basin.

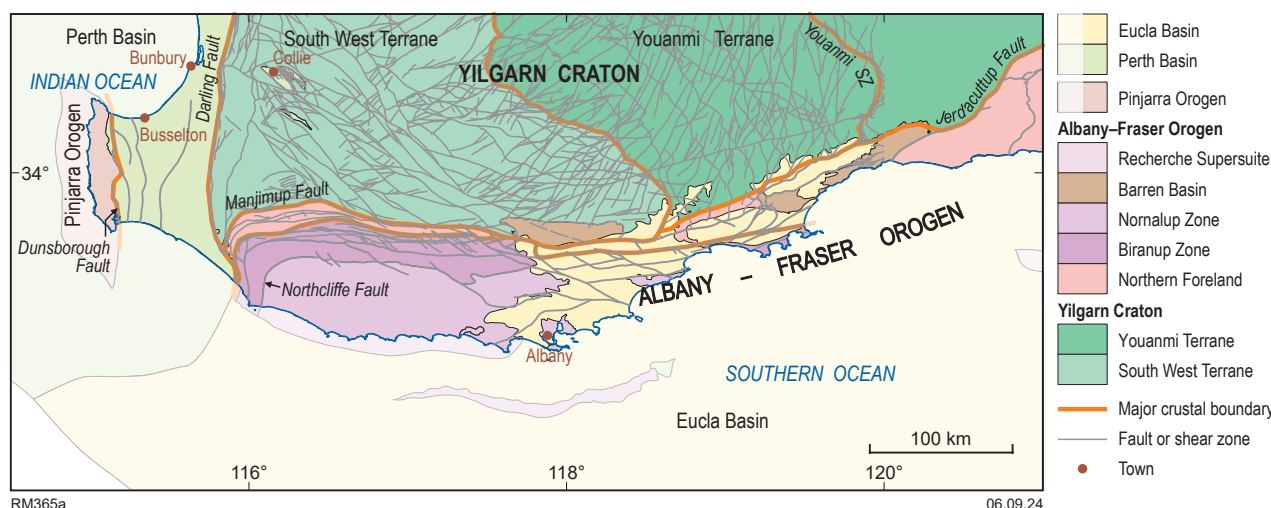
A collaboration between the Australian National University, the Geological Survey of Western Australia, the Department of Fire and Emergency Services (DFES) of Western Australia, and Geoscience Australia,

the Southwest Australia Seismic Network (SWAN) was born out of a desire to improve understanding of seismic hazard and seismic risk, and hence earthquake preparedness, across southwestern Western Australia. The experiment saw the deployment of 27 broadband seismographs across the Wheatbelt region from mid-2020 to late 2023, recording both local and teleseismic (i.e., distant earthquakes from the plate boundaries encircling Australia, and beyond) earthquake data.

Techniques applied and products developed included seismicity mapping to identify earthquakes and earthquake swarms – and hence faults – and faulting mechanisms for the larger earthquakes recorded; regional 3D crustal and lithospheric mantle structure to shed light on the internal structure of the Yilgarn Craton; site classification and attenuation modelling to better predict anticipated ground motion in response to the occurrence of future large earthquakes. A melding of this information culminated in DFES updating their hazard guidance, regional risk profiles and engagement material to improve earthquake preparedness. The SWAN project has ultimately established and fostered a collaborative network whose knowledge will enhance the emergency sector’s ability to plan for, and respond to, earthquakes in Western Australia.

How to access

Report 255 South West Australia Network (SWAN): passive seismic imaging and hazard analysis is available to download from the eBookshop.



Generalised tectonic subdivisions and associated major crustal boundaries of the southwest of Western Australia

Understanding the stratigraphic well Barnicarndy 1, Barnicarndy Graben

Collaborative work continues between the Geological Survey of Western Australian (GSWA) and Curtin University with the publication of **Record 2024/6 Mineralogy and petrology atlas of sedimentary rocks from stratigraphic well Barnicarndy 1 using the TESCAN Integrated Mineral Analyzer (TIMA)** by Zhen Li, Brent McInnes and Leon Normore. The TIMA instrument provides a non-destructive automated scanning electron microscopy/energy dispersive X-Ray spectrometry (SEM/EDX) technique for 2D mineralogical characterisation of sedimentary rock samples. This high-resolution mineralogic characterisation enables effective sample/domain screening of minerals for in situ laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) uranium–lead (U–Pb) of carbonate minerals, zircon, apatite and rutile, and rubidium–strontium (Rb–Sr) dating of biotite.

The petrological atlas or database of sedimentary rocks created for this project includes quantitative mineralogy, grain size distributions and 2D porosity data. Samples were selected from existing core plug ends and thin section stubs from the Barnicarndy 1 well to provide direct comparison with standard optical petrographic interpretations and routine core analysis data. The TIMA automated mineralogy results are presented in the following order for each sample: 1) back-scattered electron (BSE) image; 2) secondary electron (SE) image; 3) mineralogical model; 4) grain-size analysis (all phases); 5) grain-size analysis (dominant phase); 6) grain-size distribution of mineral candidate(s) for in situ geochronology.

Mineralogical model mapping (Fig. 1) provides a panoramic image of the primary phases and a legend of the modal mineral abundance listed in order of volume of phase percentage.

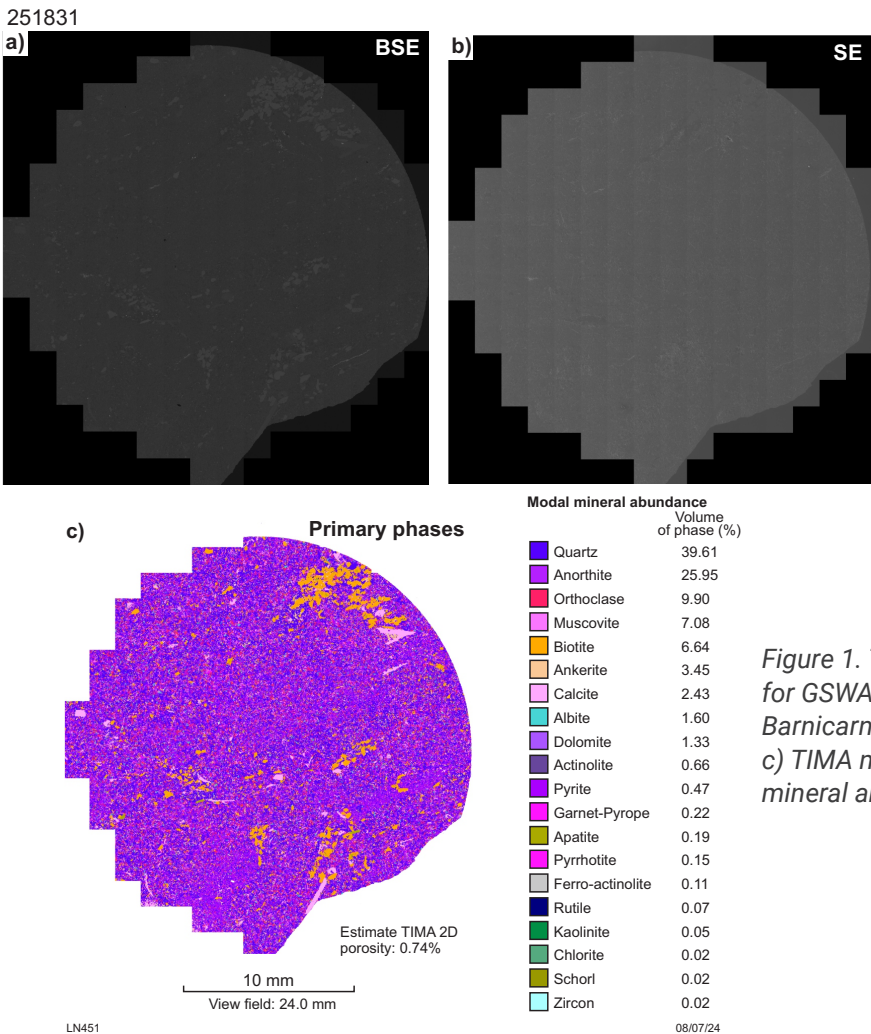


Figure 1. TIMA automated 2D mineralogy results for GSWA sample 251831 from 1500.78 m in the Barnicarndy 1 well: a) BSE image; b) SE image; c) TIMA mineralogical model mapping with modal mineral abundance

Each mineral phase can be selected individually, creating an image of each grain in descending size down to a specified grain size, as well as the grain size distribution chart (Fig. 2). This can be particularly useful for effective screening and selection tool for in situ geochronology on a variety of mineral grains, including ankerite, calcite, dolomite, biotite, apatite, zircon and rutile. The petrographic context of the minerals being dated in situ, assists with the interpretation of the age results applicable to metamorphism, hydrothermal alteration, timing of mineralization events and paragenetic sequence.

TIMA-derived porosity data has also been measured in this report and have been compared to conventional

3D mercury/ helium porosimetry techniques. Potential discrepancies in the datasets have been caused by grain plucking, artificial rock/grain fracturing, or due to comparison of 3D volumes to 2D surfaces. TIMA porosity can provide a rapid pre-cursor screen assessment for further higher precision 3D porosimetry analysis.

This ongoing project helps provide a detailed understanding of the mineralogy, petrology, and geochronology of stratigraphic well Barnicarndy 1, Barnicarndy Graben, western Canning Basin to further promote exploration for mineral and energy resources and test the potential for carbon capture and storage in this region.

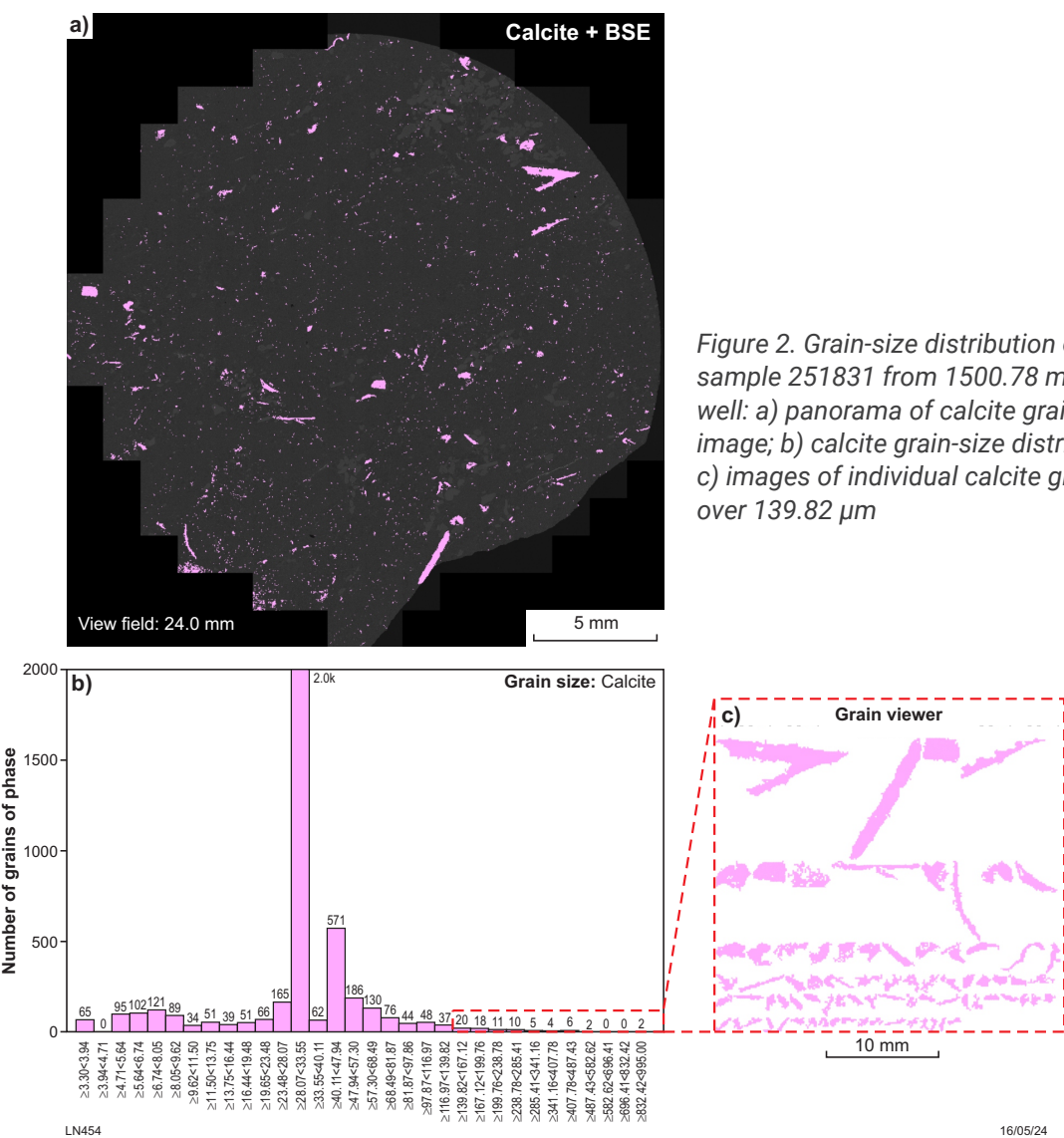


Figure 2. Grain-size distribution of calcite in GSWA sample 251831 from 1500.78 m in the Barnicarndy 1 well: a) panorama of calcite grains overlying BSE image; b) calcite grain-size distribution chart; c) images of individual calcite grains with grain sizes over 139.82 µm

For more information contact **Leon Normore**.

A showcase of geology from the Archean to the modern day

In October, GSWA hosted the annual Geoscience Working Group (GWG) meeting. The GWG comprises the Directors/Executive Directors of the State and Territory Geological Surveys and the Chiefs of Minerals and Natural Hazards and Energy Divisions, Geoscience Australia, as well as the Chief Executive Officer of Geoscience Australia.

Each year the GWG meets to discuss collaborative geoscience data acquisition programs, promotion and marketing plans, geoscience research programs, trialling of new exploration technologies, and

standards for management and delivery of geoscience information.

The meetings rotate between each state and territory and include field trips to highlight geology and facilitate discussion. This year included field trips to the Lake Clifton thrombolites, the South West Hub Carbon Capture and Storage research site in Harvey, the Proterozoic Leeuwin Inlier, and Archean exposures straddling the boundary between the South West and Youanmi Terranes near Toodyay.



Looking at the details of the Lake Clifton thrombolites

Annual Geoscience Working Group Meeting



GWG members and field trip leaders at Canal Rocks



Where the magic happens. GWG meeting in Yallingup



Pointing out the axial fold hinge at Sugarloaf Rock

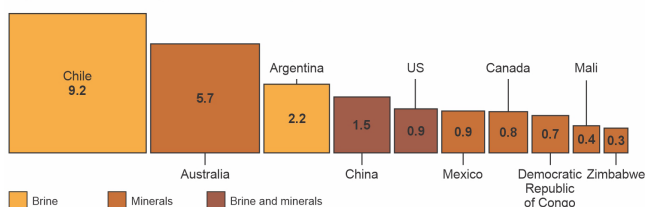
Lithium: Western Australia's drive to green energy technologies

According to NASA data, the past eight years have been the warmest on record, continuing the long-term trend of the Earth rapidly heating up. The consequences are already evident, ranging from numerous forest fires to severe flooding.

Western Australia is also already experiencing the impacts of climate change. Without adopting far-reaching remedial measures to curb increasing global warming, Western Australia will continue to get hotter and drier and experience longer fire seasons and a rise in sea level.

In the face of the current climate crisis, the transition to clean energy technologies will be crucial to limit the rise in the global average temperature to 1.5°C. Lithium (Li) plays a vital role as its unique chemical properties make it an invaluable component for energy storage systems. At the heart of this technology are Li-ion batteries, which have become indispensable in the area of portable electronics, electric vehicles (EVs) and grid-scale energy storage.

Top 10 countries with largest lithium reserves (mmt)



Top 10 countries with the largest lithium reserves in million metric tonnes (mmt), derived from hard-rock, continental brines, and a combination of continental brines and hard-rock sources

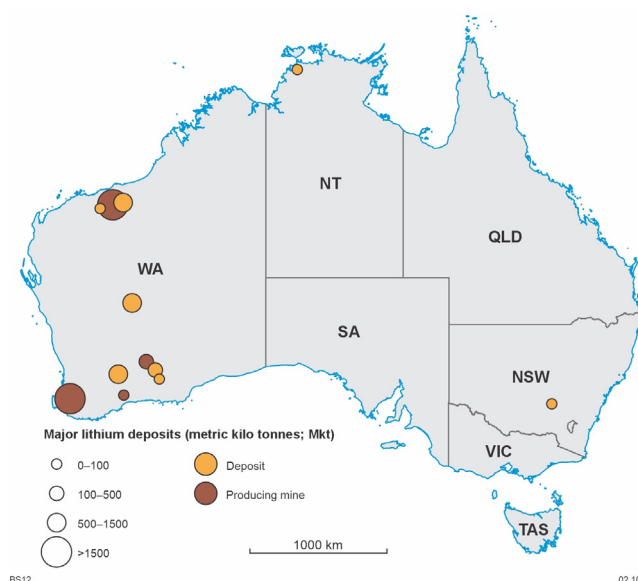
With lithium becoming the driving force behind EVs, by 2030 batteries will account for 95% of the global Li demand, with the total global demand annually increasing by about 25%.

Currently, almost all lithium mining takes place in Australia, South America and China. In 2020, 98% of the globally produced lithium originated from these regions, with Australia accounting for almost 47%.

Among these main players of lithium mining, Australia has the second largest lithium reserves in the world, amounting to 5.7 million metric tonnes (mmt).

In the 2022–2023 financial year, Australia produced 431 000 metric tonnes of lithium carbonate (Li_2CO_3) equivalent (LCE), with more than 99% of the country's lithium exports originating from mines in Western Australia.

This StoryMap briefly discusses Western Australia's role as a major supplier of lithium to the world and the various aspects lithium mining in the State. It covers the State's history of lithium mining, the economically significant hard-rock deposits from which lithium is extracted, their geological setting in the Archean mafic–ultramafic greenstone belts, and the major locations of lithium deposits and prospects in Western Australia, which host 95% of Australia's lithium resources.



Major lithium deposits in metric kilo tonnes (Mkt) in Australia as of March 2023

How to access

A link to **Lithium: Western Australia's drive to green energy technologies** by B Striewski, is available at the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) eBookshop.

Super Pit StoryMap collection: tales of rocks and riches

This StoryMap collection is the newest release in the Geology Explorer series published by the Geological Survey of Western Australia. There are three StoryMaps in the collection; the main Story about the Fimiston Super Pit and two sub-Stories, one about the history of the Golden Mile and another about the process of how gold is mined.



Photo courtesy of Northern Star Resources

Aerial view of the Super Pit showing its close proximity to the township of Kalgoorlie in the top left

The formation of the Kalgoorlie Super Pit gold mine's significant gold deposit is a tale of ancient igneous activity, the mammoth forces of nature, some hot chemistry, and the thrill of treasure seeking in the gold rush era.

Today it provides us with an enormous window into the Earth's geological history as one of the largest open pit gold mines in the world. The Fimiston Open Pit, or the 'Super Pit' as it is commonly known, is one of the largest and highest producing gold mines in Australia.

Located in Kalgoorlie, Western Australia, it is currently about 3.5 km long, 1.5 km wide, and more than 600 m deep.

Where did the gold come from? How has it impacted the surrounding area? How does it influence the Australian economy? and what is in store for its future?

The 'History of the Golden Mile' StoryMap describes the history of the gold rush in Kalgoorlie.

Alluvial gold was first discovered on the slopes of Mount Charlotte in June 1893 by Irish prospectors Paddy Hannan, Thomas Flanagan and Dan O'Shea. The discovery sparked the Western Australian

Kalgoorlie gold rush and unearthed one of the richest goldfields in the world, often referred to as the Golden Mile.

Thousands of eager fortune-seekers flooded into the area resulting in a massive increase in population with an associated building boom. We discuss how this boom in population led to overcrowding and disease, and the huge increase in need for resources such as timber and water.

In 1898 an unprecedented engineering marvel was undertaken — what became known as 'The Golden Pipeline'. It was the brainchild of Charles Yelverton O'Connor, an Irish-born engineer. The steel pipeline delivers water through a series of pump stations from Mundaring Weir, on the outskirts of Perth, to the eastern goldfields, 560 km to its east. The pipeline continues to operate today.

The story How is gold mined? looks at the process from mining, to processing, and ingot creation based on the Super Pit.

Gold mining at the Kalgoorlie Super Pit is openpit mining, where huge machinery is used to remove surface waste rock, then other machinery is used to mine the ore body.



Photo courtesy of Eastern Goldfields Historical Society

The building of the Golden Pipeline

How to access

Links to **The Kalgoorlie Super Pit**, **The history of the Golden Mile** and **How is gold mined?** by SC Goss, is available on the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) eBookshop.

Critical geoscience for all Western Australians

GSWA Open Day was held on Friday, 15 November 2024 at Pan Pacific Perth. Over 90 organisations were represented across all major stakeholder groups. For the second year in a row, GSWA Executive Director Michele Spencer hosted the full-day conference. Kerry-Ann Winmar Welcomed us to Country before The Hon David Michael MLA, Minister for Mines and Petroleum; Ports; Road Safety gave the opening address. GSWA's Director Geoscience Fawna Korhonen delivered a keynote highlighting future strategies.

Keynote presenters included Nicole Roocke, CEO of the Minerals Research Institute of Western Australia, who explored the integration of artificial intelligence in geoscience, and David Robinson of Geoscience Australia, who discussed Australia's resource development and discovery future.

Session two centred on the GSWA CO₂ Storage Atlas of Western Australia, led by Deidre Brooks. Courtney Brennan and Julie Cass delved into the development of data interpretation products and the use of well data to evaluate reservoir quality for CO₂ storage. Robert Iasky explored methods for identifying underground "traps" that can securely contain CO₂. These insights underscored how GSWA is leveraging geology for climate action, aligning with the State's decarbonisation goals.

The fireside chat with WA Array offered a glimpse into this ambitious project. Team WA Array – Ruth Murdie,

John Paul O'Donnell, Reza Ebrahimi, and Huaiyu Yuan – discussed new Phase 1 data and future directions with session host Richard Chopping. They showcased technical achievements and their collaborative teamwork while responding to the interactive Q&A.

The final session focused on ongoing research and featured an afternoon keynote from Professor Ken Collerson of Victory Metals Australia. Erin Gray presented the Statewide heavy mineral map before Hugh Smithies introduced a new paradigm for understanding lithium pegmatites within Archean geology.

Matt Clarke outlined how subtle geochemical clues ('sniffs') in sedimentary rocks can signal the presence of economically significant copper deposits. Charmaine Thomas presented the Perth Basin's 3D geological model, developed using data from the SW1 seismic survey. Tony Perry closed the session by showcasing geoscience data relationship mapping through knowledge graphs, allowing integration of diverse datasets enabling more efficient data discovery.

Q&A sessions hosted through Slido allowed delegates to submit questions in real-time, vote on the most popular ones, and interact directly with presenters. Almost 100 questions were submitted throughout the day.

GSWA Open Day 2024's program supports the State's commitment to addressing global challenges through innovative solutions. The connections and insights from this year's conference will undoubtedly inspire further innovation and collaboration in the years to come.

Presentations are available through the **DEMIRS YouTube Channel**.

Join us again in 2025, date to be released soon.

For more information, contact **Sabrina Bednarski**.



Nicole Roocke, Michele Spencer, Andrew Chaplyn, and Richard Sellers in the foyer of Pan Pacific Perth before the start of GSWA Open Day 2024

A deep dive into the Yilgarn Craton's significant gold deposits

The Gold24 post-conference workshop, held at the GSWA Joe Lord Core Library, brought together a diverse and engaged group of geologists, providing a unique opportunity to delve deep into six of the Yilgarn Craton's most significant gold deposits. The strong turnout was a testament to the importance of these sites in shaping our understanding of Western Australia's mineral wealth.

Alicia Verbeeten (GSWA Manager East Yilgarn) kicked off the workshop with an overview of the regional stratigraphy and the broad structural framework within the Kalgoorlie Terrane, providing the foundation for subsequent discussions within the broader geological context of the craton.

The spotlight then shifted to in-depth presentations on each of the six featured gold deposits. Paul Edmonds (Geology Superintendent-Growth) from Northern Star Resources delivered a compelling analysis of the Golden Mile deposit, highlighting its historic significance. Paul's presentation served as a powerful reminder of the Golden Mile's status as a world-class gold deposit and highlighted the critical role that ongoing exploration plays in sustaining and expanding such exceptional resources.



Alicia Verbeeten (GSWA Manager East Yilgarn) presenting an overview of the stratigraphy of the Kalgoorlie Terrane

Next up, Brad Daddow (Geology Manager) from Evolution provided an engaging overview of the Kundana deposits, illustrating their high-grade veins and structural controls, which have posed both challenges and opportunities in their development.

Jed Bridges (Geology Superintendent-Growth) from Northern Star Resources delivered an engaging talk on the Kanowna Belle gold mine emphasizing its exploration history and noting how many people had passed over this remarkable deposit before its eventual discovery. This was followed by Jay Stafford (Senior Exploration Geologist) from Gold Fields, who covered the Invincible gold deposit with a focus on its unique geological setting and the importance of recent drilling results in refining its geological model.

Grayden Smith (Senior Mine Geologist) from Gold Fields brought his expertise to bear on the Wallaby gold deposit, providing an interpretation of its magmatic and hydrothermal alteration zones. Finally, Kyle Prentice (Senior Geologist) from Gold Road Resources wrapped up the deposit-specific talks with a comprehensive look at the Gruyere gold deposit, exploring its large-scale potential and outlining key developments in its mining lifecycle.



Participants of the Gold24 post-conference workshop examining diamond core following the related presentation

All of these talks were centred around diamond core displays, allowing participants to directly observe the host rocks, alteration and mineralisation of these remarkable gold deposits.

The workshop closed on a high note, fostering engaging discussions, networking opportunities, and a shared appreciation for the geological diversity and potential within the Yilgarn Craton. Participants left with new insights, practical knowledge, and a renewed sense of enthusiasm for future exploration and development efforts.

Publications

Report 255 South West Australia Network (SWAN): passive seismic imaging and hazard analysis
compiled by Murdie, RE and Miller, MS

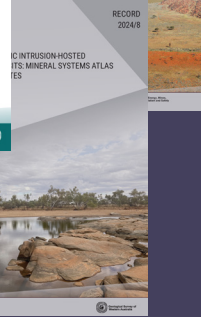
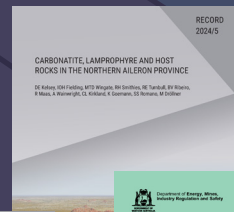
Record 2024/5 Carbonatite, lamprophyre and host rocks in the northern Aileron Province

Kelsey, D, Fielding, IOH, Wingate, MTD, Smithies, RH, Turnbull, RE, Ribeiro, BV, Maas, R, Wainwright, A, Kirkland, CL, Goemann, K, Romano, SS and Dröllner, M

Record 2024/7 GSWA Open Day conference program

Record 2024/8 Mafic-ultramafic intrusion-hosted Ni-Cu-PGE deposits: a mineral system analysis
Grech, L

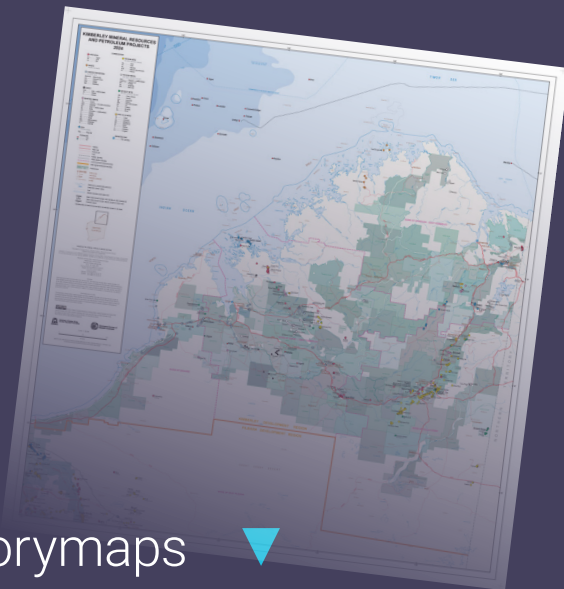
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Maps

Kimberley Mineral Resources and Petroleum Projects 2024

Pal, T, Murray, SI, D'Ercole, C, Johnston, A and Mathrubhavan Sasi, R



Storymaps

Lithium: Western Australia's drive to green energy technologies
Striewski, B

The Kalgoorlie Super Pit collection
Goss, SC



Tales of rocks and riches

Posters

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Hall, C

MINEDEX – Investor information (GSWA Open Day 2024)
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WAMEX company ground gravity data harmonisation (GSWA Open Day 2024)
Brett, JW and Thom, J

WA Array, Phase 1, South West Yilgarn (GSWA Open Day 2024)
Murdie, RE, O'Donnell, JP, Ebrahimi, R and Yuan, H

Flyers

Western Australia – Selected exploration and mining highlights, July 2024
Pal, T, Murray, SI, D'Ercole, C, Mathrubhavan Sasi, R, Johnston, A and Jones, A

Platinum Group Elements: investment opportunities, Western Australia
Pal, T, D'Ercole, C and ,Murray SI

