A Geological Survey of Western Australia Newsletter

OCTOBER 2023 NUMBER 108

Fieldnotes

Government of Western Australia
Department of Mines, Industry Regulation and Safety

www.dmirs.wa.gov.au/GSWA

Archean Granites Project

pages 3, 4

New co-funding for State geophysical acquisition

page 5

New release — Atlas of mineral deposits and major petroleum projects 2023

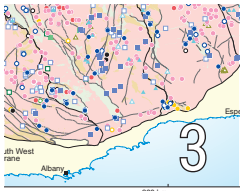
page 6

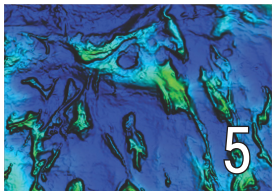
Systematic study of Early Ordovician trilobite assemblages

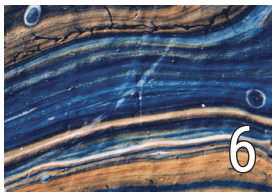
page 10

Geological Survey of Western Australia

What's inside







EDITORIAL TEAM

Editor
Robin Bower, Manager Editing and Publishing

Design and layout
Bec Hitchings, Desktop Publisher

Graphics
Michael Prause, Graphics Manager
Adam Symonds, Graphics Officer

Contributors to this issue

Heidi Allen
Louisa Collins
Klaus Gessner
Sarah Goss
Jack Lowry

Access publications

All publications

Download maps, reports and digital information free from our **website**.

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** – there will be a Fieldnotes page with a link to the latest issue
- browsing previous issues from the **eBookshop**.

GSWA eNewsletter

The GSWA eNewsletter is an online newsletter delivered roughly once a month that contains information on workshops, field trips, training, events and the latest releases of maps, books and digital data packages. If you would like to stay informed about new products, services and other news, please **subscribe**.

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**.

Cover image: The 'Suspended Table' formation of Lake Cave (see page 11)

ISSN 1834-2272 ISBN 978-1-74168-022-5

Classifying Archean granitic rocks and assessing spatial trends and relationships of granite classes from the Yilgarn Craton

Australian Government
Geoscience Australia

EXPLORATION INCENTIVE SCHEME

The Archean Granites Project (previously Yilgarn Granite Project) is an initiative under the State Government Exploration Incentive Scheme (EIS) that aims to provide complete and detailed coverage of the Yilgarn and Pilbara Cratons in terms of modern, high-quality, major and trace element data (including Li) from felsic intrusive rocks. The vast majority of the data generated during the first three years of this project (n = 3577; Fig. 1) have been derived from reanalysing archived materials, mainly from Geoscience Australia's (GA) Yilgarn Craton granite collection (now housed with the Geological Survey of Western Australia [GSWA]), using the best whole-rock chemical assay methods commercially available. For most elements, detection levels have lowered by an order of magnitude or more compared to the original methods reported in legacy GSWA and GA published datasets. With each field season, GSWA is adding to this dataset with newly collected granitic samples from outcrops and drillcores from across the Yilgarn and Pilbara Cratons.

This year, the Archean Granite Project has produced two sibling Records. The first Record titled **Systematic classification of Yilgarn Craton granitic rocks** details a new automated granite classification scheme developed using high-quality whole-rock geochemical data and based on compositional boundaries defined by earlier granite classifications by GA. The clear advantage of this approach is the ability to rapidly classify granitic rocks, with a high level of confidence, based on geochemistry, where additional geological context is limited. The calculations used to classify samples are provided as supplementary files to enable users to rapidly classify their own datasets (note: samples of highly altered or weathered granites or samples incorporating more than one lithology [i.e. exploration datasets] are prone to spurious classifications). These classifications can be used by mineral explorers where identifying specific classes of granitic rocks might be important within a mineral system context – such as the relationship between sanukitoids and gold mineralization in the Yilgarn Craton. This automated classification approach is also expected to improve the efficiency of regional geological mapping studies in the Yilgarn and Pilbara Cratons, and potentially elsewhere.

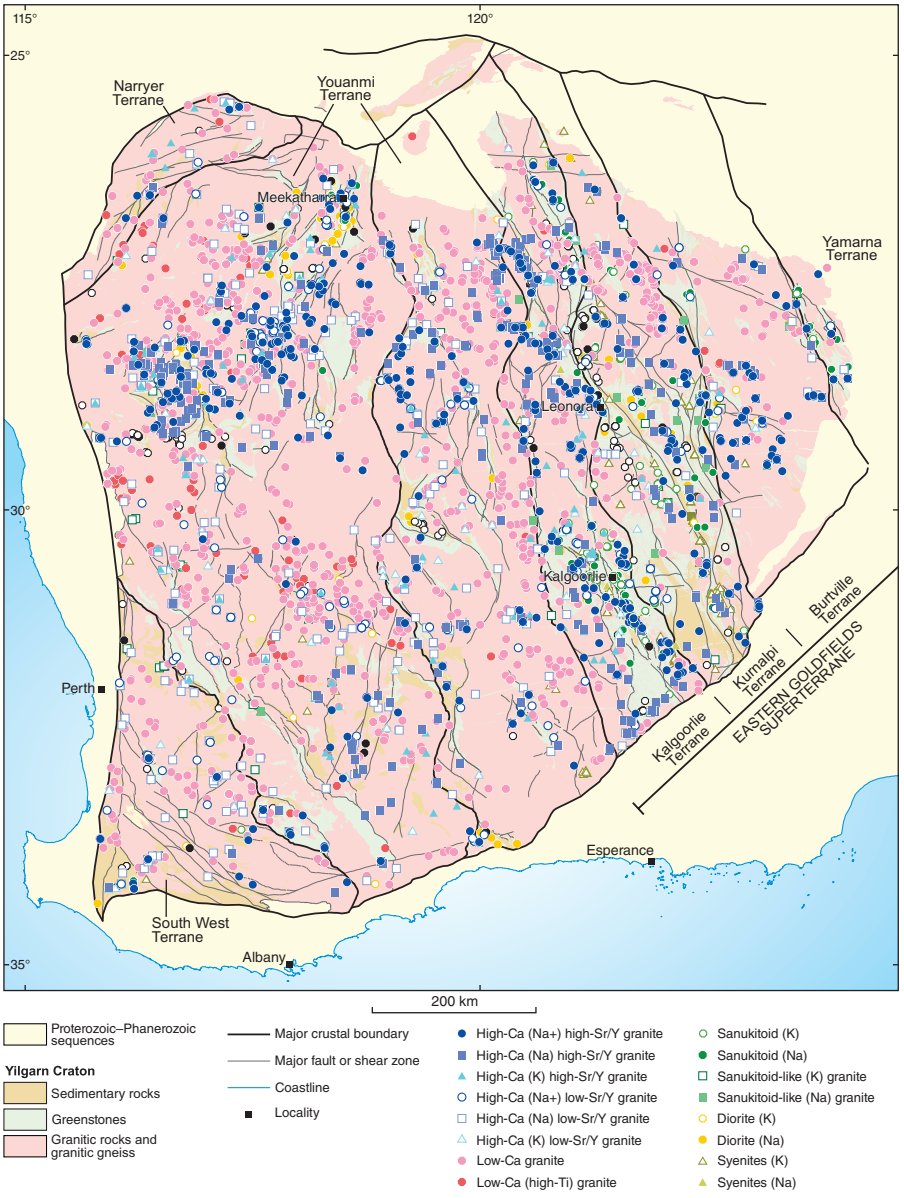


Figure 1. Summarized bedrock geology of the Yilgarn Craton showing the fully classified dataset. Note that where several samples are from a single locality, only the 'top' symbol is visible. Appendix 1 of Record 2023/5 includes a layered PDF that permits the user to select the granite classifications that are displayed

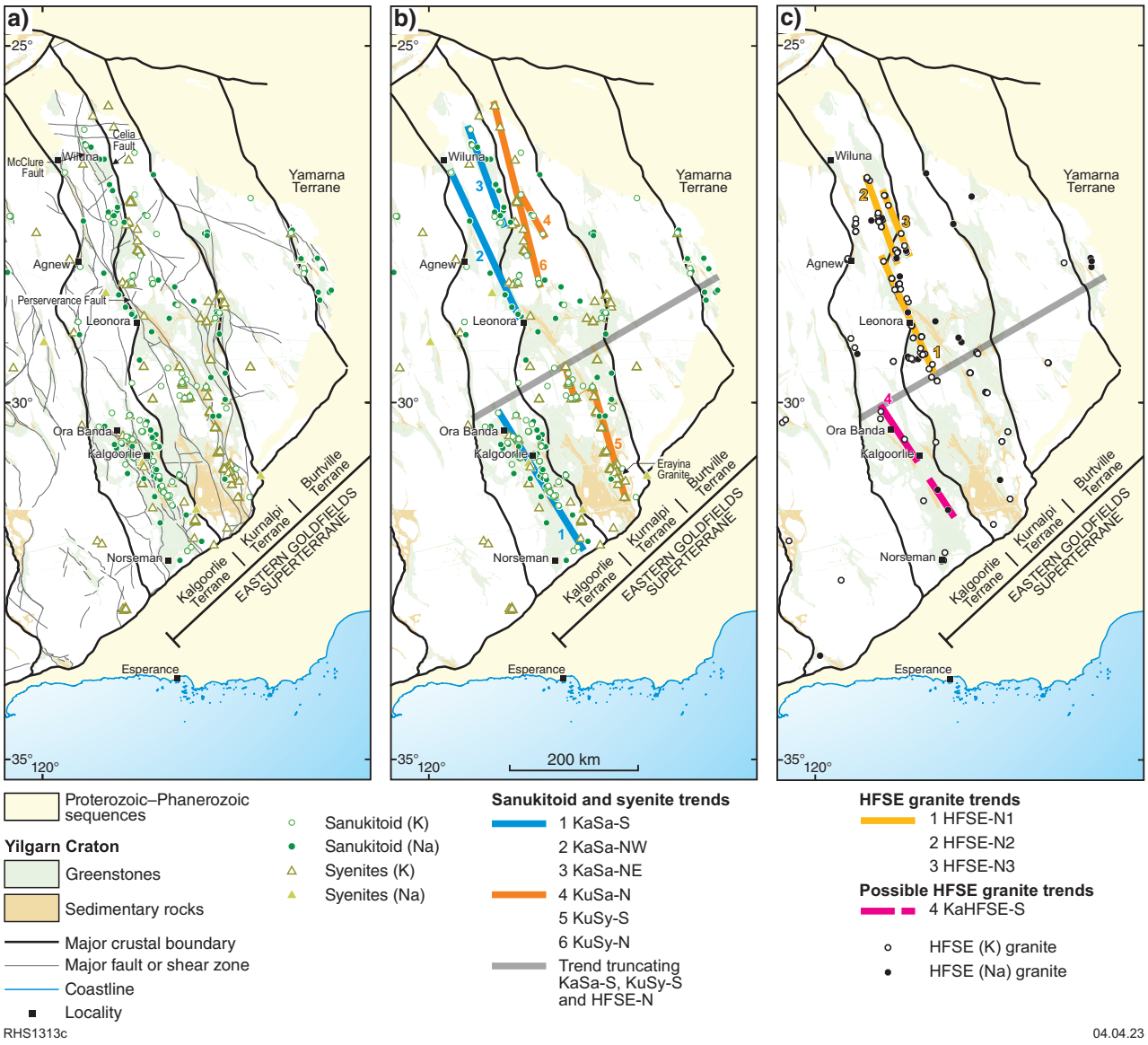


Figure 2. Summarized bedrock geology of the eastern Yilgarn Craton showing: a) the distribution of syenites and sanukitoids; b) the distribution of syenites and sanukitoids and inferred linear distribution trends; c) the distribution of high-HFSE granites and inferred linear distribution trends

The second Record titled **Spatial trends and relationships emerging from the systematic classification of granitic rocks of the Yilgarn Craton** presents GSWA's preliminary interpretations of recently acquired and classified granite geochemistry data, including spatial patterns identified within and between specific classes of granitic rocks, which highlight local to craton-wide trends (e.g. Fig. 2) that are interpreted to reflect variations in bulk source compositions, lithosphere-scale architecture and melting conditions.

How to access

Record 2023/12 Systematic classification of Yilgarn Craton granitic rocks by JR Lowrey, RH Smithies, DC Champion and KF Cassidy and **Record 2023/5 Spatial trends and relationships emerging from the systematic classification of granitic rocks of the Yilgarn Craton** by RH Smithies, JR Lowrey, DC Champion, Y Lu and K Gessner are available as free downloadable PDFs, with data included as electronic appendices, from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Jack Lowrey** or **Hugh Smithies**.

New co-funding for State geophysical acquisition

The Co-funded Geophysics Program (CGP) is a new competitive program of the Exploration Incentive Scheme (EIS) that will support geophysical exploration in the Western Australian mineral resources sector.

The CGP aims to provide new information on greenfields regions of the State for exploration of new mineral resources by refining regional structures including basin or province margins, identifying geophysical anomalies under cover, redefining regions for new deposit types, and defining target geometries and depth.

The EIS will allocate around $2 million per year to the CGP, and the co-funding amount will be 50% of the actual costs up to a capped value of $250 000 per project.

The CGP will run as one Venture per year, with applications for Venture 1 opening Monday 5 February 2024 for projects running between 1 June 2024 and 31 May 2025. Each application period will have a specific area from which the Venture will accept applications – the Venture Release Area (Fig. 2). The Co-funded Geophysics Program for Venture 1 will accept applications from Release Area 1 (Fig. 2).

In all Ventures, higher preference will be given to:

- Greenfields projects (exploration in unexplored or underexplored areas, away from known deposits or mines)
- Regional to camp-scale projects
- Projects targeting critical minerals.

How to access

For more information, and to view the CGP guidelines, please visit **Co-funded Geophysics Program (CGP).**

For more information, contact **Charlotte Hall**.

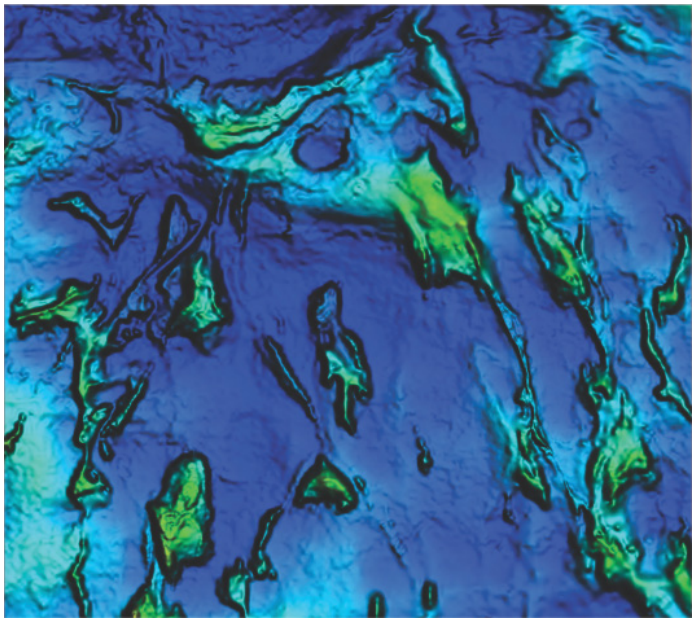


Figure 1. Segment of GSWA acquired statewide gravity data from the Yilgarn

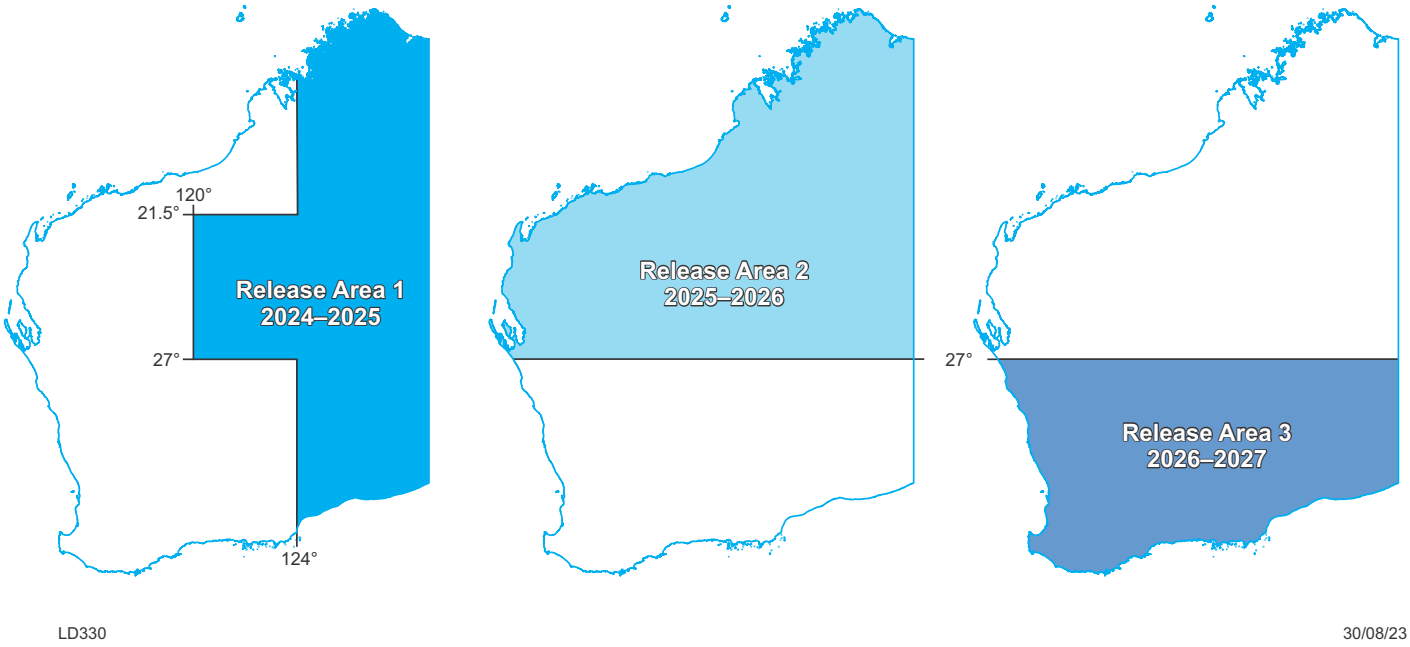


Figure 2. Venture Release Areas – Venture 1, 2024–25 accepting applications from Release Area 1

Western Australia Atlas of mineral deposits and major petroleum projects 2023

The **Western Australia Atlas of mineral deposits and major petroleum projects 2023** is a comprehensive reference for researchers, policymakers, investors, and the resource industry. This biennial release is a compilation of the important mineral deposits and petroleum projects in Western Australia. It is set against a background of simplified geology and topographic information. The Atlas shows the location, commodity and ownership details of the mineral deposits and major petroleum projects located across Western Australia.

The mineral deposit sites, in this publication, have either a resource estimate or historical production data available. Major petroleum projects in this publication are identified by a representative well for that project. All the sites have been broadly grouped into 12 distinct commodity groups, including Petroleum and Infrastructure, each with a unique symbol which is displayed on the maps.

Optimal statewide coverage of mineral and petroleum site information in this book format is achieved by scaling up the basemap and dividing into 1:1 500 000-scale tiles arranged as double-page spreads. These are supplemented with three map pages at 1:750 000 to show greater detail in areas of more dense exploration and mining activity for the Leonora, Kalgoorlie and South West coastal regions.

The background geological map used in this Atlas is adapted from the Geological map of Western Australia 2015 (1:2 500 000 scale). Higher resolution 1:500 000 State interpreted bedrock geology data layers can be accessed on GeoVIEW.WA. **GeoVIEW.WA**.

Sources of information

Mineral and construction material information is extracted from the Department of Mines, Industry Regulation and Safety (DMIRS) Mines and Mineral Deposits (**MINEDEX**) database. The MINEDEX database records the spatial location and commodities along with other attributes including ownership and mineral resource estimates of all mines and deposits across Western Australia.

Information on petroleum fields in Western Australia (onshore and State Waters), and for adjacent offshore waters controlled by the Commonwealth, is derived from the DMIRS Western Australian Petroleum and Geothermal Information Management System database (**WAPIMS**) and on the **Petroleum and Geothermal section** of the DMIRS website. Only major petroleum projects are shown, and are identified by a representative well for that project.

Commodity groups are arranged alphabetically in the Atlas Reference and Commodity Group index. The index categorizes named sites by their stage of development. Commercial ownership of named sites and projects is also listed in the index.

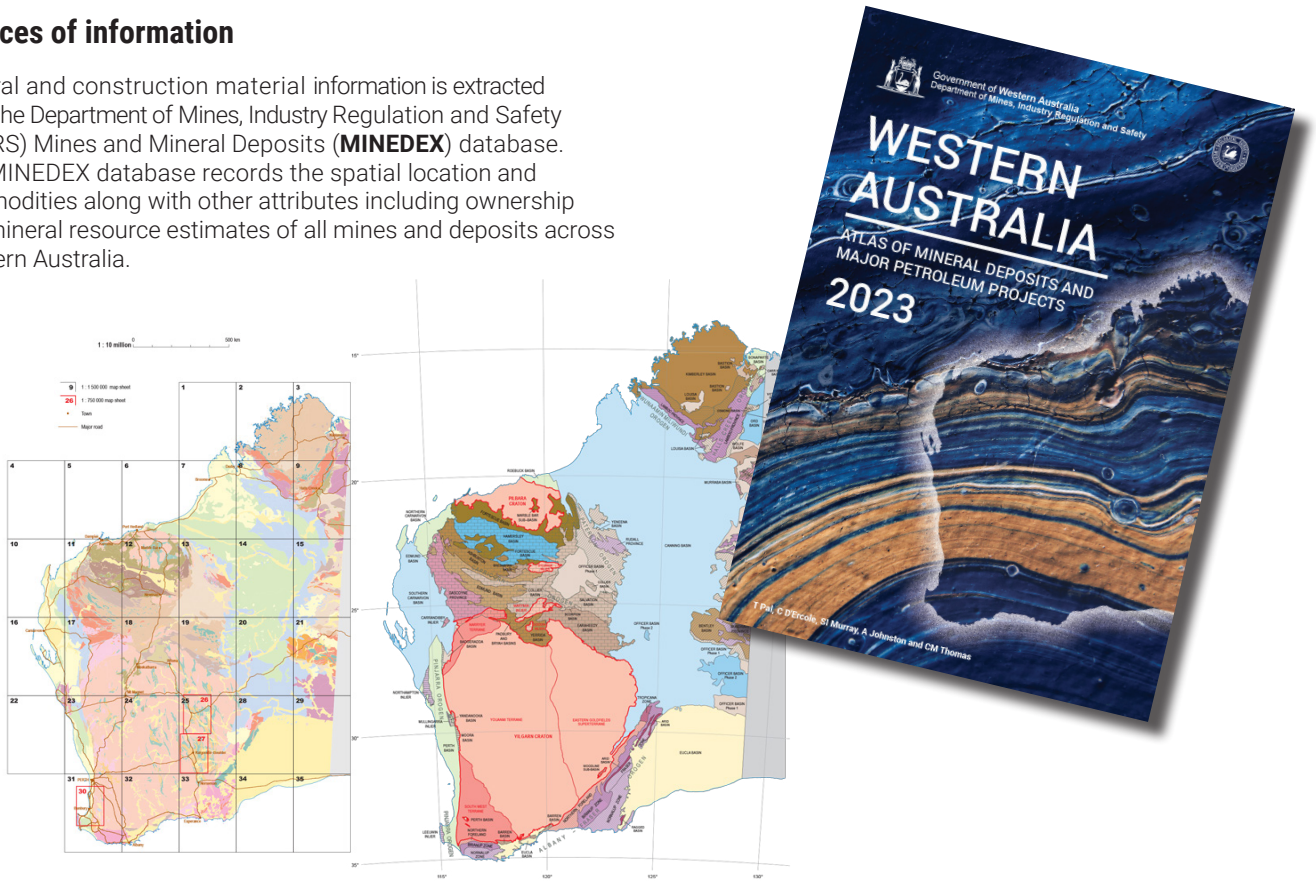
How to access

Western Australia Atlas of mineral deposits and major petroleum projects 2023 by Pal, T, D'Ercole, C, Murray, SI, Johnston, A and Thomas, CM is available as a free downloadable PDF from the DMIRS **ebookshop**. You can also order a free hardcopy book for the cost of postage via the same link.

For more information

For enquiries regarding the status of the sites and projects included in this book, please email **MINEDEX**.

For enquiries about information on fields in offshore waters, email the **National Offshore Petroleum Titles Administrator** or **Geoscience Australia**.



Innovations in mineral exploration showcased

The 6th International Archean Symposium (**6IAS**) is the premier international scientific gathering for geoscientists interested in the early Earth. It was held from 25–27 July 2023 at The Esplanade Hotel in Fremantle. The symposium was followed by Target 2023, a one-day conference focused on showcasing innovations in mineral exploration that aid the discovery of new tier-one deposits, and broaden the search space under cover.

The 6IAS program reflected more than a decade's worth of advances in the understanding of how the early Earth evolved and provided future directions for Precambrian geoscience for the decade to come. The symposium continued the series of highly successful IAS meetings presented every decade by Geoconferences (WA), a volunteer-run non-profit association dedicated to promoting Western Australian geoscience, in particular Precambrian geology, by arranging conferences, symposia and other meetings.

Originally planned for 2020, the organizers decided to postpone 6IAS until the global pandemic allowed a return to the tried and tested recipe of combining face-to-face conferences with field trips that showcase the rich geological heritage of Western Australia. The symposium was attended by 355 geoscientists from across the globe, who delivered more than 120 talks and 50 posters at 6IAS. Target 2023 was also a huge success with 220 attendees in a smaller venue – both events reached capacity limits.

GSWA staff were heavily involved in 6IAS and Target 2023, including as authors of oral presentations and posters, as organizers of four field trips and two workshops, as representatives in the GSWA exhibition booth, and as members of the organizing committee.

The GSWA-guided field trips included:

- **Pilbara Craton: evolving Archean tectonic styles** led by Martin van Kranendonk (University of New South Wales) and Hugh Smithies (GSWA)
- **Redefining Archean terrane boundaries: A radical update within the Yilgarn Craton** led by Raphael Quentin de Gromard and Tim Ivanic (GSWA; Fig. 1)
- **Out with the old, in with the new — a traverse across the Archean-Proterozoic boundary in the Mount Bruce Supergroup** led by David Martin and Heather Howard (GSWA)
- **A traverse across the Yilgarn Craton in Western Australia – from the Jack Hills to the Youanmi Terrane** led by Tony Kemp (UWA) and Ivan Zibra (GSWA)

Two well-attended workshops run by GSWA were the 'Archean-Proterozoic boundary core workshop' organized by David Martin and Heather Howard at the Perth Core Library and the 'Archean Fault Rocks' workshop organized by Ivan Zibra, Klaus Gessner (GSWA) and Mark Jessell (UWA) at the Peace Be Still Retreat in Chittering (Figs 2, 3).

Figure 1. Talks and posters by GSWA staff (at our booth) made a significant contribution to the scientific program of both the 6IAS and Target 2023 events

How to access

GSWA publications related to 6IAS and Target 2023 are available as free downloadable PDFs from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop:

1. Gessner K, Johnson, TE, Hartnady MIH and Wiemer, D (compilers) 2023, 6IAS: 6th International Archean Symposium – abstracts: Geological Survey of Western Australia, Record 2023/8,196p.
2. Martin, D McB and Howard, HM 2023, 6IAS: Out with the old, in with the new — a traverse across the Archean–Proterozoic boundary in the Mount Bruce Supergroup: Geological Survey of Western Australia, Record 2023/2, 58p.
3. McFarlane, H, Begg, G and Montsion, R (compilers) 2023, Target 2023 abstract volume: Geological Survey of Western Australia, Record 2023/14, 18p.
4. Van Kranendonk, MJ and Smithies, RH 2023, 6IAS: Pilbara Craton, evolving Archean tectonic styles — field guide: Geological Survey of Western Australia, Record 2023/6, 88p.
5. Zibra, I and Kemp, AIS 2023, 6IAS: A traverse across the northern Yilgarn Craton in Western Australia – from the Jack Hills to the Youanmi Terrane: Geological Survey of Western Australia, Record 2023/4, 44p.

For more information, contact **Klaus Gessner**.

Figure 2. Participants of the field trip 'Redefining Archean terrane boundaries: A radical update within the Yilgarn Craton' discussing melting and processes forming the upper crust of the South West Terrane at an outcrop that displays schollen-textured metatexite migmatite with tonalite and amphibolite in Balgaling Reserve, Toodyay Shire, South West Terrane

Figure 3. GSWA geologist, Ivan Zibra, presenting the local geology at the Archean Fault Rocks workshop in Chittering

Western Australian paleontology in the spotlight

Palaeo Down Under is the quadrennial conference organized by Australasian Paleontologists dedicated to showcasing the latest developments in paleontological research, education and outreach within Australasia. Each conference focuses on the paleontology of the host state. For Paleo Down Under 3 (PDU3), hosted in Perth, Western Australia, the program featured numerous iconic paleontological sites of Western Australia, both during the conference and in pre- and post-conference field trips.

The conference's plenary lectures covered a wide range of topics including:

- the earliest record of life on Earth known from Western Australia's Pilbara region and its application to the quest for signs of life on Mars
- the exceptionally preserved Gogo fish fossils
- latest research on mode of accretion for modern microbialites, with a particular emphasis on those found within the UNESCO World Heritage site of Shark Bay.

Notable conference program highlights included presentations from Geological Survey of Western Australia's (GSWA) Paleontology section, offering updates on the 'string of beads' *Horodyskia* fossils. This included the documentation of a new occurrence from the North Australian Craton and insights into trilobite biostratigraphy from the Barnicarndy 1 drillhole. Additionally, results from a pilot study integrating 3D scanning into GSWA systematic paleontological studies and geoheritage projects were commended by conference attendees.

The pre-conference field trip, led by Heidi Allen, David Flannery (Queensland University of Technology), and David Martin (GSWA), was a 10-day journey through Western Australia's remarkable 3.5-billion-year record of life. The trip began with visits to modern microbialite sites at Lake Thetis and Shark Bay, followed by stops at a *Horodyskia* 'string of beads' locality, fossils potentially representing some of the oldest complex life forms. Participants also explored a spectacular Conophyton reef locality with conical stromatolites exceeding 8 m high and wide. The journey concluded with visits to the best-preserved Archean microbialites on Earth in the Neoarchean Tumbiana Formation (Fig. 1), as well as the State's, and currently the world's, oldest microbialites documented in the Paleoarchean Strelley Pool (Fig. 2) and Dresser Formations.

Figure 2. Conical stromatolites of the Strelley Pool Formation within the Trendall Geoheritage Reserve, Professor Alan Collins for scale. Permits are required to enter State Geoheritage Reserves. Photo by Julian Galvez Serna

A post-conference trip showcased more iconic Western Australian paleontology experiences, including visits to the awe-inspiring arthropod trackways within Kalbarri National Park, also taking in the modern microbialites at Lake Thetis.

How to access

The conference abstract volume is available for download from **PDU3 | Australasian Palaeontologists.**

For more information, contact **Heidi Allen**.

Figure 1. Outcrop of the stromatolitic Neoarchean Meentheena Member, Tumbiana Formation, Pilbara region, Western Australia visited on the PDU3 pre-conference field trip. Photo by Julian Galvez Serna

Systematic study of Early Ordovician trilobite assemblages

AUSTRALIAN MUSEUM

Barnicarndy 1 is a stratigraphic drillhole located within the Barnicarndy Graben of the Canning Basin in central–north Western Australia. Drilled in 2019, funded as part of Geoscience Australia's Exploring for the Future initiative, and operated by the Geological Survey of Western Australia (GSWA), this project has yielded valuable insights into the geological history of the Canning Basin.

Intersected stratigraphy in Barnicarndy 1 ranges in age from Neoproterozoic to Cenozoic, with a 2100 m section of continuous core locally fossiliferous with trilobites, brachiopods, graptolites, bivalves, cephalopods, gastropods, ostracods and trace fossils (Fig. 1). Previous systematic paleontological studies of conodonts recognized three biozones extending from the upper Tremadocian into upper Floian (Lower Ordovician) including the *Jumudontus gananda, Oepikodus communis* and *Paroistodus proteus* biozones in the Nambeet Formation. A comprehensive paleontological study of trilobites from Barnicarndy 1 has further refined the age of intersected stratigraphy in the Nambeet Formation, in addition to yielding data from the previously unconstrained Fly Flat Member and infilling the conodont data.

Figure 1. Partial pygidium of Sanbernardaspis excalibur *Smith and Allen, 2023 holotype GSWAF55744, 2110.94 m at the Barnicarndy 1 wellsite. Photo by Peter Haines*

Twenty-three trilobite taxa were described from Barnicarndy 1 drillcore. This includes one new genus, *Veeversaspis* Smith and Allen, 2023, and six new species: *Asaphellus zheni* Smith and Allen, 2023, *Madiganaspis lauriei* Smith and Allen, 2023, *Norasaphus (Norasaphus) jagoi* Smith and Allen, 2023, *Rodingaia leggi* Smith and Allen, 2023, *Sanbernardaspis excalibur* Smith and Allen, 2023, and *Veeversaspis jelli* Smith and Allen, 2023 (Fig. 2). The trilobite fauna can be divided into three stratigraphically distinct assemblages in Barnicarndy 1; the *Apatokephalus* sp.– *Veeversaspis jelli* Assemblage (2177.50 – 2382.94 m depth), *Asaphellus trinodosus* Assemblage (2030.07 – 2177.52 m depth), and *Asaphellus zheni* Assemblage (1595.83 – 2001.88 m depth). The two stratigraphically lowest assemblages are consistent with a late to latest Tremadocian age. The third, and highest, assemblage is consistent with a mid-Floian age.

These newly described trilobite assemblages largely agree with previously published conodont age estimates for the Nambeet Formation in Barnicarndy 1. However, refinement of the conodont ages has been provided by integrating the trilobite data. The contribution also provides age constraints on the Fly Flat Member for the first time and does not distinguish it biostratigraphically from the base of the overlying Samphire Marsh Member. The study demonstrates the stratigraphic utility of using multiple taxonomic groups for more robust biostratigraphic age estimates, and a more refined result.

This taxonomic contribution has applications for future Ordovician biostratigraphy in the Canning Basin, and age equivalent stratigraphy, in addition to paleogeographic investigations and understanding more about the biosphere during the Great Ordovician Biodiversification Event; further work on this fauna is ongoing.

How to access

Early Ordovician trilobites from Barnicarndy 1 stratigraphic well of the southern Canning Basin, Western Australia by Patrick M Smith and Heidi J Allen is open access.

For more information, contact **Heidi Allen**.

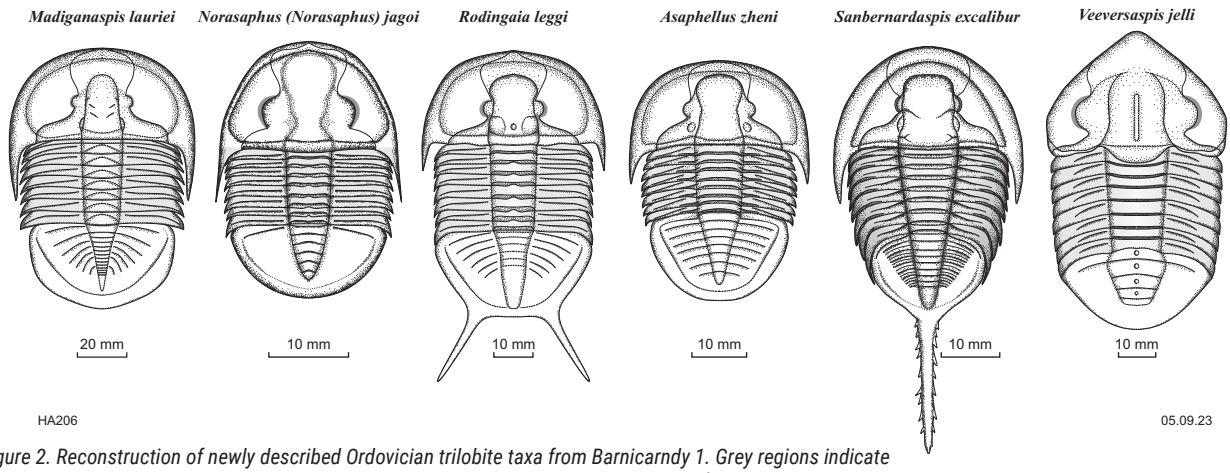


Figure 2. Reconstruction of newly described Ordovician trilobite taxa from Barnicarndy 1. Grey regions indicate reconstruction based on similar taxa, as thoracic and genal spine regions were missing for some species

Caves of the Leeuwin–Naturaliste Ridge

This StoryMap is the newest release in the Geology Explorer series published by the Geological Survey of Western Australia (Fig. 1).

Figure 1. The 'Suspended Table' formation of Lake Cave

There are more than 150 limestone caves along the stretch of coastline between the Cape Naturaliste and Cape Leeuwin lighthouses in the southwest of Western Australia. The StoryMap explores how caves form, the secrets hidden inside them and why these particular caves are here – all within the Tamala Limestone (Fig. 2).

Figure 2. The 'Organ Pipes' formation of Jewel Cave

We'll have a peek into some of the caves in this region that you can actually visit (Fig. 3), discover the ancient fossil remains of long extinct megafauna that once roamed the land, and see how caves can provide a unique record of past climates over the last several thousand years.

We also look at the link between caves and culture. Indigenous Australians have been using caves for tens of thousands of years as places to cook, shelter, bury their dead, and to record their history with rock art. Devil's Lair cave provides the earliest known evidence of human occupation in Western Australia, with Aboriginal groups first occupying the cave more than 47 000 years ago.

How to access

Caves of the Leeuwin–Naturaliste Ridge by Goss, SC is available to view on the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Sarah Goss**.

Figure 3. Geology map showing the location of caves covered in the caves tour

Future-focused geoscience

Come with us to the 25th annual GSWA Open Day. This event serves as a catalyst for knowledge exchange, collaboration, innovation and networking.

Bringing you more diverse presentations on topics that matter to you, another insightful panel discussion, and more opportunities to get hands-on with some of the latest technology.

Whether you are a seasoned geoscientist, an early-career professional, a passionate student, or an industry representative seeking to expand your knowledge base, GSWA Open Day promises to be an enriching and transformative experience.

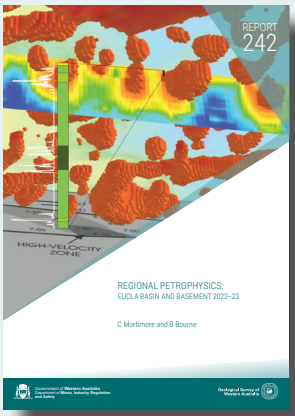
This event sold out in 2021 and 2022. Tickets are on sale until 10 November 2023, and there will be no door sales.

#GSWA2023

Time: 9 am to 6 pm
When: Friday 17 November 2023
Where: Hyatt Regency Hotel, East Perth
Cost: $75 (all inclusive)

Product releases

• PUBLICATIONS •



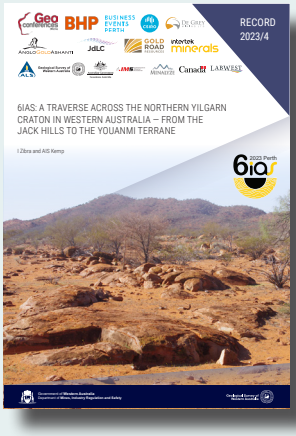
Report 242 Regional petrophysics: Eucla Basin and Basement 2022–23
Mortimore, C and Bourne, B

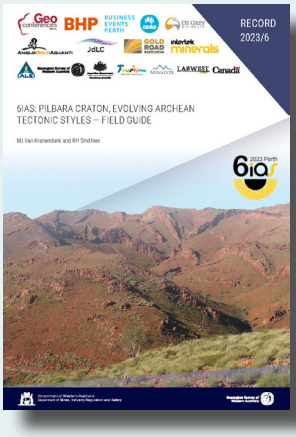
Record 2023/4 6IAS: A traverse across the northern Yilgarn Craton in Western Australia, from the Jack Hills to the Youanmi Terrane – a field guide
Zibra, I and Kemp, AIS

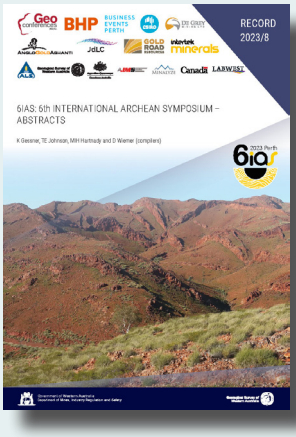
Record 2023/6 6IAS: Pilbara Craton, evolving Archean tectonic styles – a field guide
Van Kranendonk, MJ and Smithies, RH

Record 2023/8 6IAS: 6th International Archean Symposium – abstracts
Gessner, K, Johnson, TE, Hartnady, MIH and Wiemer, D

Record 2023/14 Target 2023 abstract volume
McFarlane, H, Begg, G and Montsion, R







• MAP •

Western Australia Atlas of mineral deposits and major petroleum projects 2023
Pal, T, D'Ercole, C, Murray, SI, Johnston, A and Thomas, CM

Can be ordered online for the cost of postage

• ONLINE PRODUCT •

Caves of the Leeuwin–Naturaliste Ridge (StoryMap)
Goss, SR