A Geological Survey of Western Australia Newsletter

APRIL 2023 NUMBER 106

Fieldnotes

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

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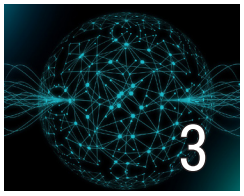

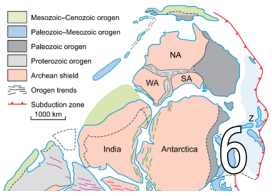

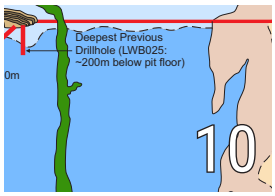

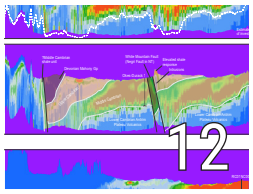

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Access publications

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 use of innovative technology is driving product development

ISSN 1834-2272 ISBN 978-1-74168-007-2

GSWA and innovative technology

Technological tools and platforms help us communicate our understanding of the Earth, its geology and dynamic landscapes. Geotourism is a rapidly growing market for these kinds of innovative communication technologies.

Technologies facilitating geotourism are being adapted from disciplines as varied as engineering and the arts. Established and emerging technologies are also changing the way professional geoscientists work.

Added benefits

While it is not suggested that being in the field can be replaced altogether, the ability to 'visit' or experience different geotourism locations via augmented reality (AR) or virtual reality (VR) has huge advantages (Figs 1, 2). For people unable to get into the field for family, cost and time constraints, or people with a disability, AR and VR have allowed them to learn and experience while not being on the ground. Different languages can also be incorporated within the technology using Google Translate, enhancing collaboration among users.

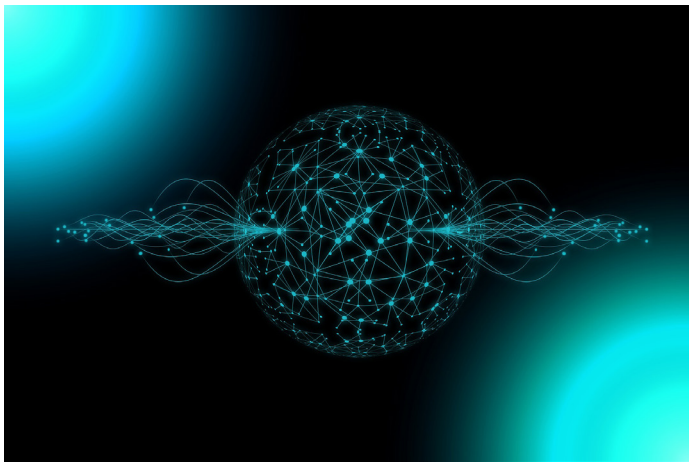


Figure 1. Artificial intelligence has been around for a while and is constantly morphing into adaptive technology

Figure 2. Augmented reality can play an important role in immersive experiences

GSWA tours and trails

Virtual tours using ArcGIS StoryMaps

Virtual tours can enhance the appreciation of geotourism by guiding users through an area they may want to visit in reality, or allow virtual access to sites that are otherwise closed to the public. Guides can use their smartphones to livestream tours of geological sites providing visitors an immersive experience that allows them to explore in real time, even from half a world away.

The Geological Survey of Western Australia (GSWA) has incorporated StoryMaps into its annual work program. This interactive platform combines maps, images, and text to tell compelling stories about geoscience topics. StoryMaps are accessed through any standard internet browser. With the ability to add multimedia content such as videos and interactive graphics, StoryMaps have become a powerful tool for communicating complex geoscience concepts to a wider audience (Fig. 3).

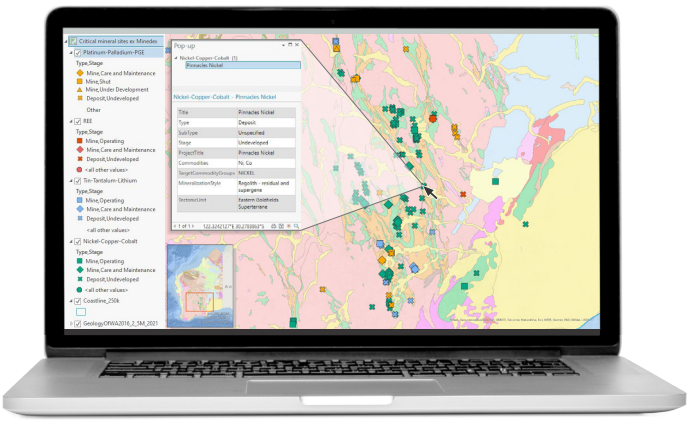


Figure 3. Webmaps are adding an extra dimension for user engagement in online products

Figure 4 shows the ever-expanding suite of systems and products evolving via technological advancements. StoryMap products repurpose previously released books, maps and datasets for non-specialist audiences, and are designed to support a greater involvement in geotourism both locally and globally.

The range of topics covered includes unique rocks and landscapes, precious minerals, climate change, and geologic history. Combined with ArcGIS Pro, which allows seamless sharing of data into the ArcGIS Online cloud environment, maps are readily customized to suit the story and the audience. The resulting dynamic, interactive graphics and map tours invite users to actively engage with the story content, alongside text and image content tailored to suit the format and layout.

See GSWA virtual tours and StoryMaps on the **DMIRS eBookshop**.

Technology for geotourism

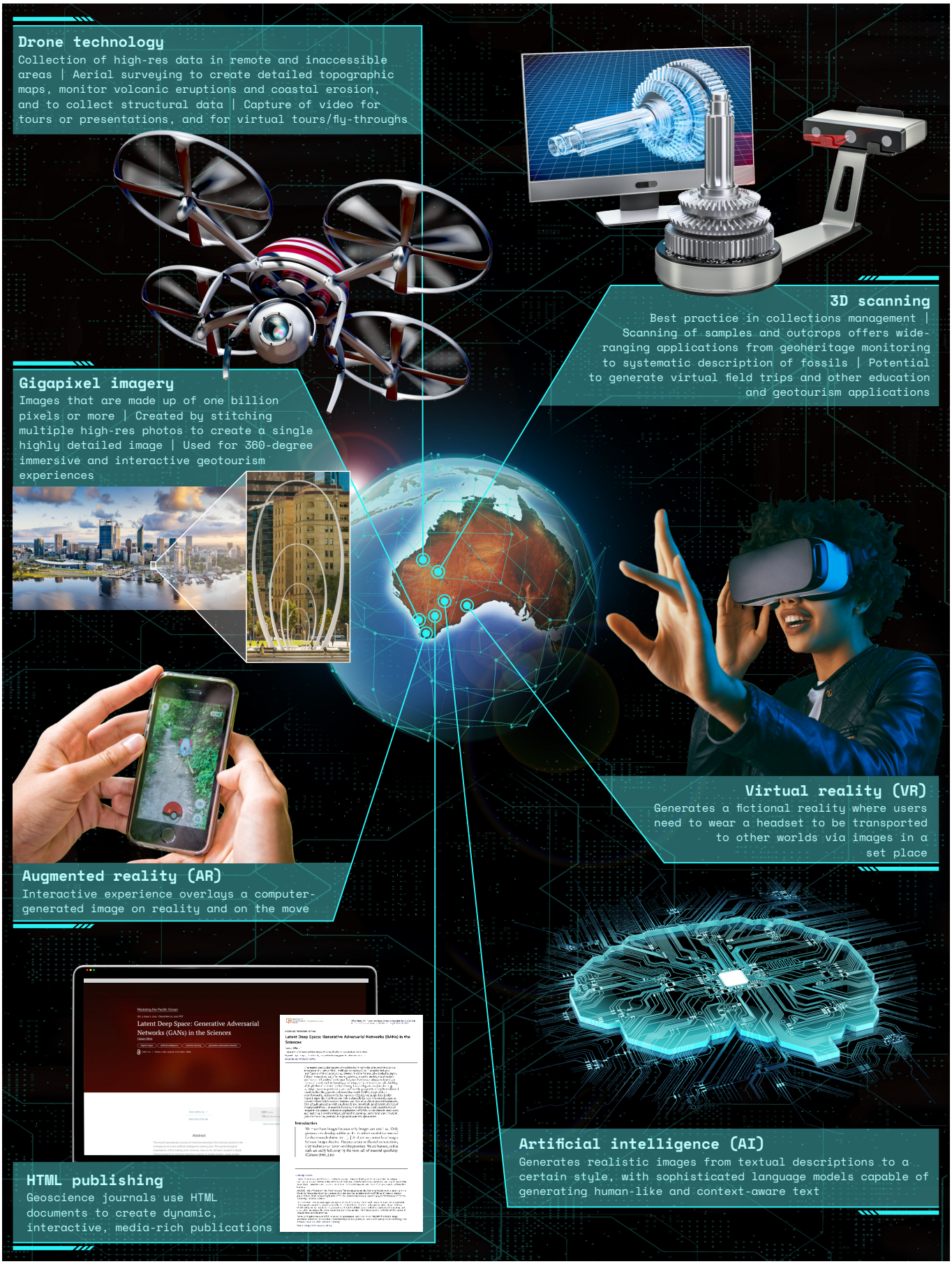


Figure 4. The range of innovative technologies is ever expanding

Apps

Apps have become increasingly popular as a way to make geoscience information accessible to the public by using them for:

- Geological timescales; locations of minerals, rocks and fossils; soil survey data; interactive geology maps; and geological glossaries – all are readily accessed via interactive apps
- Geoscience education in schools
- Enhancing the geotrail experience with maps and interactive features that help users to better understand the geological history of an area and appreciate the unique features of the landscape.

Seismologists are using apps and smartphone sensors to detect and record earthquakes, which can be used to improve earthquake early warning systems and better understand seismic activity (Fig. 5). In an example of citizen science, some apps allow the public to report the felt effects of earthquakes, contributing to the data seismologists use to understand how and why earthquakes occur.

Figure 5. Apps allow users to take the experience with them

Geotrails on your phone

GSWA has produced several geotrails hosted by Western Australian app company, Everythere. Geotrails are self-guided tours of geological features or landmarks that encourage trail users to learn about the Earth's geological history and landscapes as they travel. The app versions of these geotrails are adaptations of previously published books or pamphlets. By delivering geotrails through an app, users get a more interactive and personal experience than by using the printed versions alone (Fig. 6).

Check out GSWA's geotrails on the app:

John Forrest National Park

Geology of Rottnest Island

Stepping Stones

Figure 6. The John Forrest National Park geotrail on the Everythere app

What's next?

As technology continues to evolve at its lightning pace, more exciting systems will develop and allow us to explore and experience geotourism in innovative ways.

GSWA staff will be presenting at the Australian Earth Sciences Convention, 27-30 June 2023.

For more information, contact **geotourism@dmirs.wa.gov.au**.

*3D model of Sugarloaf Rock using **Sketchfab***

Mesozoic transformation of Western Australia

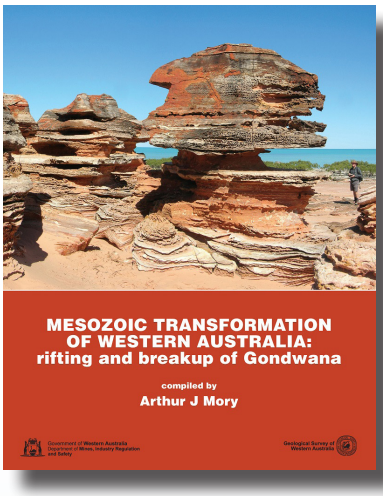
'Mesozoic transformation of Western Australia: rifting and breakup of Gondwana' is the latest release under the WA unearthed series aimed at geologists, and particularly newcomers to the State, to enable them to get a quick understanding of the geology and economic potential of various terrains. In this volume, much of the narrative concerns the offshore North West Shelf, Australia's premier hydrocarbon province. Because of subdued tectonic events, the most significant resources in, or uses of, onshore Mesozoic strata are heavy mineral sand deposits on the Dampier Peninsula, water resources and gas storage.

Mesozoic transformation of Western Australia spans 252 to 66 Ma, an era represented by sedimentary deposits that cover about 23% of the onshore part of the State and virtually all offshore basins, with the Upper Jurassic – Cretaceous extending beyond the continent onto oceanic crust. These sedimentary successions are up to 15 km thick in offshore depocentres and the Perth Basin, and contain only minor igneous rocks apart from areas near the continent–ocean boundary where intrusions are abundant. A series of paleogeographic reconstructions paired with isopach images illustrates the Mesozoic depositional and structural history of the State and its surrounding waters – each represent 'time slices' derived from regional correlations largely based on biostratigraphic studies. The four main phases of basin evolution are: Triassic intracratonic rifting; Early–Middle Jurassic rifting; Late Jurassic – Early Cretaceous breakup and separation; and lastly, trailing-edge rifting and marginal sag. However, these phases are not synchronous, as there are differences between some areas in their timing, especially with the progressive breaking away of continental fragments from north to south. Whereas the main text is largely concerned with geological evolution, there is also a series of boxes detailing other aspects such as mineralization, other resources, fossils, impact features and provenance.

How to access

Mesozoic transformation of Western Australia: rifting and breakup of Gondwana by Mory, AJ is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop from where a hardcopy may be ordered for $33 (including GST) plus postage.

For more information, contact **Arthur Mory**.



Outcrop of Bunbury Basalt 2 km northwest of Black Head, southern Perth Basin (photo by Peter Haines)

Western Officer and Perth Basins SEEBASE Reports

In 2005, Frogtech Geoscience completed the Structurally Enhanced View of Economic BASEment (OZ SEEBASE) project, which resulted in a continental-scale depth-to-basement grid highlighting the Phanerozoic basins across Australia. With the acquisition since then of many new potential field, seismic and well datasets, as well as more recent Geological Survey of Western Australia (GSWA) seismic interpretation, GSWA contracted Geognostics Australia Pty Ltd to revise the SEEBASE model of the western Officer Basin (within State jurisdiction) and the Perth Basin, which also includes offshore areas in Commonwealth Waters.

The two SEEBASE projects have markedly increased the resolution of the depth-to-basement model compared to the 2005 version, and have improved identification of major structures, basement faults, crustal architecture and basement composition. These new products form a valuable pre-competitive dataset for both the minerals and energy industries.

How to access

Report 235 western Officer Basin SEEBASE structural study and GIS and **Report 236 Perth Basin SEEBASE structural study and GIS** are available on the Department of Mines, Industry Regulation and Safety eBookshop. The digital layers and ArcMap projects are available as USB packages and can be ordered via eBookshop at the same location as the Reports. Digital layers include the various interpreted basement-related layers, and processed and filtered magnetic and gravity datasets. The interpreted basement layers will eventually be added to the Energy Systems Atlas, an interactive online map viewer available via **Western Australian Petroleum and geothermal Information Management System** (**WAPIMS**).

For more information, contact **Deidre Brooks**.

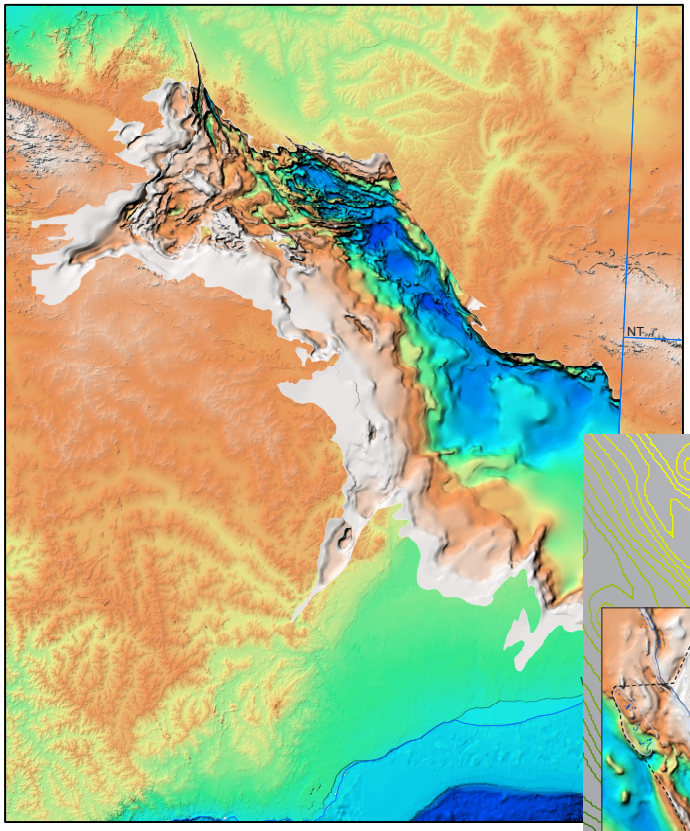


Figure 1. Depth-to-basement map of 2022 SEEBASE project of the western Officer Basin, superimposed on the digital elevation model

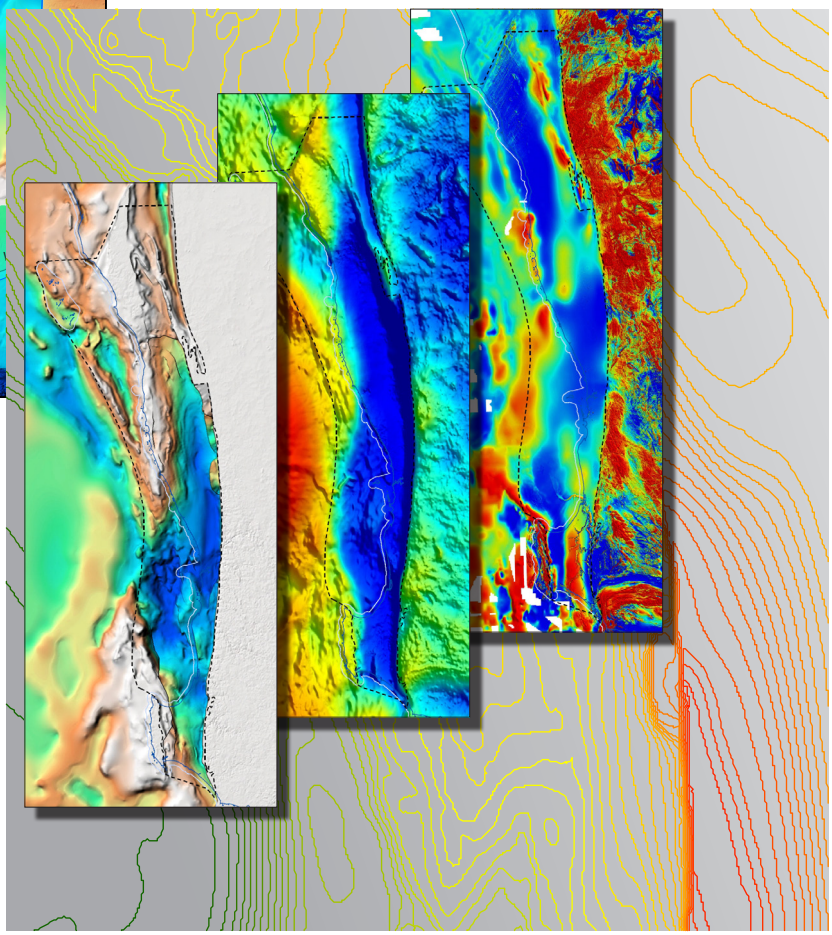


Figure 2. The depth-to-basement, Bouguer gravity anomaly and reduced-to-pole magnetic images from the 2022 Perth Basin SEEBASE project (left to right)

Isotopes in gold: constraining the age and source of gold mineralization

In order to fingerprint the age and source of selected gold mineralization sites across Western Australia, a collaborative study with the John de Laeter Centre at Curtin University measured the Pb and Os isotopic composition, the platinum group elements (PGE) and other trace elements of 24 gold nuggets and their galena inclusions (Fig. 1) from the Kurnalpi Terrane, Pilbara Craton, and Capricorn Orogen.

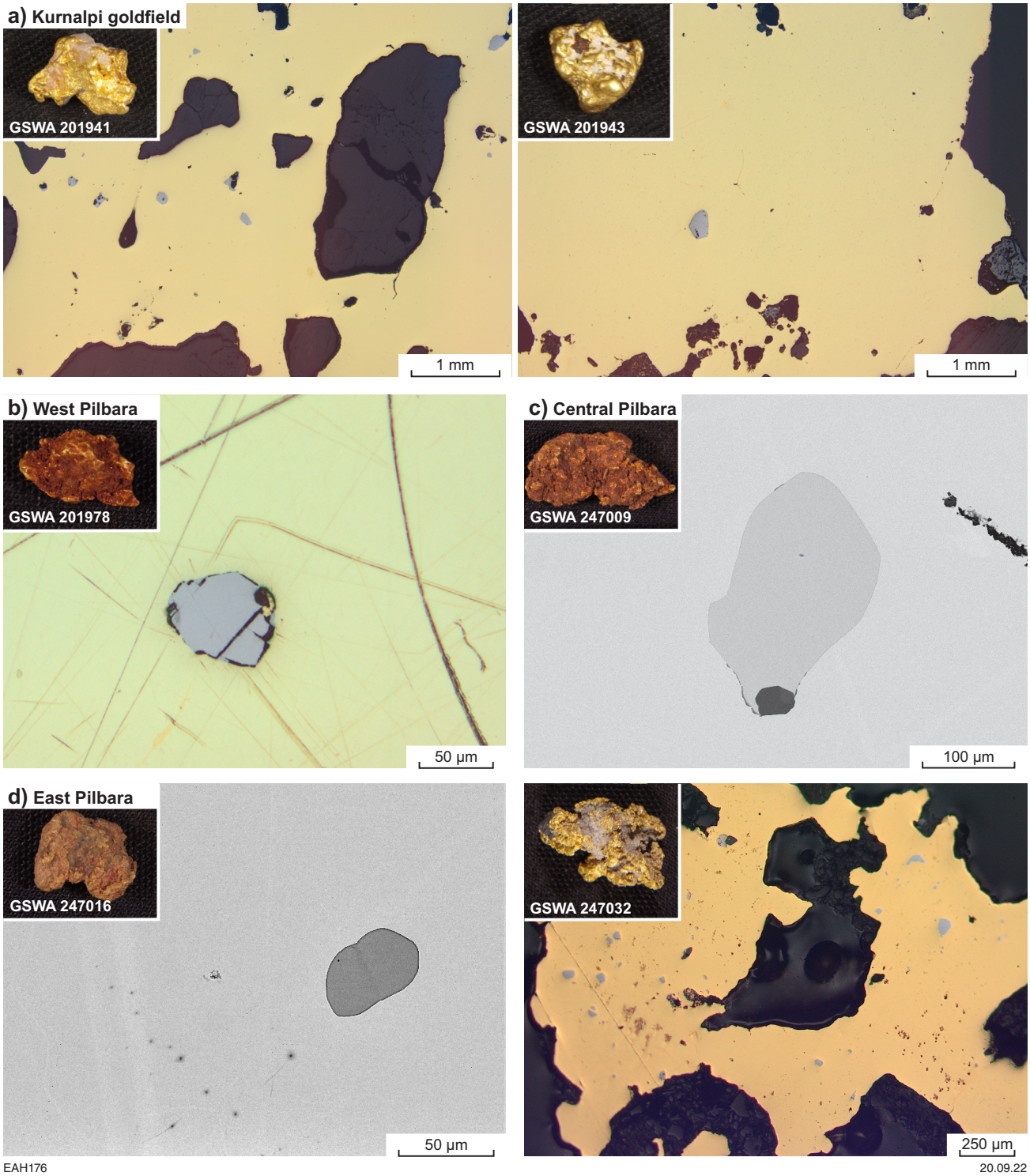


Figure 1. Gold nuggets with galena inclusions selected for isotope analysis. Reflected-light photomicrographs (a, b and d) and BSE images (c and d) of polished gold surfaces showing galena inclusions (grey). Insets show the gold nuggets

In the Kurnalpi Terrane, the gold grains and their galena inclusions display the most primitive Pb isotope compositions with Neoarchean model ages similar to ages of the host rocks, suggesting a common origin between gold nugget and bedrock mineralization (Fig. 2). The source μ ($^{238}U/^{204}Pb$) values for galena inclusions and gold nuggets are also similar to values for volcanic-hosted massive sulphide (VHMS) deposits at Teutonic Bore and Nimbus, indicating a predominantly mantle-derived source for Pb (Fig. 2a).

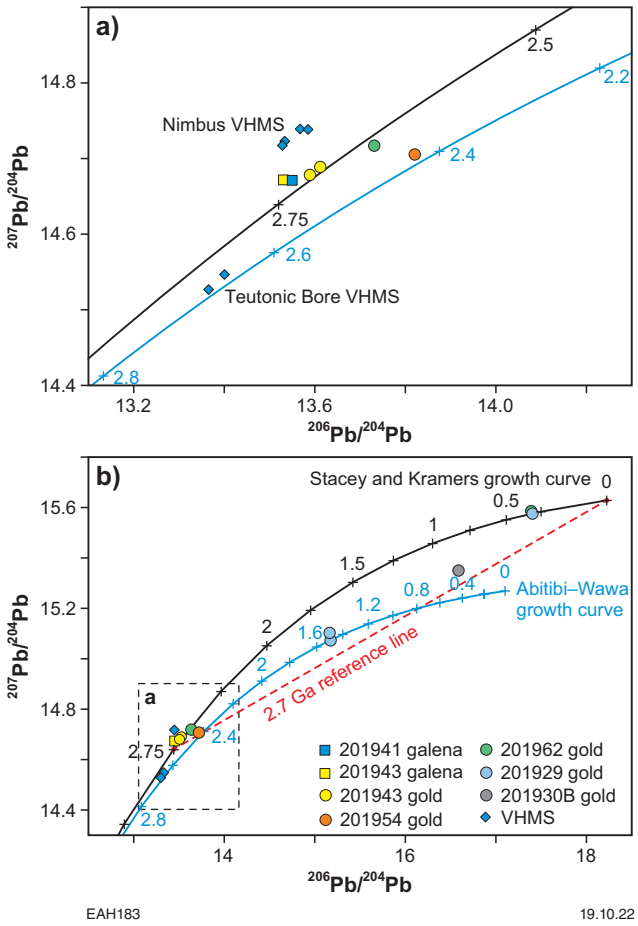


Figure 2. The Pb isotope compositions of gold and galena inclusions from Kurnalpi Terrane. The galena from the c. 2.7 Ga VHMS deposits at Teutonic Bore and Nimbus are shown for comparison in (a)

The Pilbara gold yielded Pb model ages of 2.91–2.25 Ga, indicating a complex history with overprinting by younger events. Gold samples from the Capricorn Orogen show no evidence of alteration or overprinting by geological events since their formation. A nugget from the Mount Olympus area yielded a model age of c. 1.7 Ga, which is consistent with the young mineralization event at the Paulsens gold mine.

How to access

Report 229 Isotopic fingerprinting of native gold from Western Australia by Tessalina, SG, Hancock, EA, Ware, B and McNaughton, NJ is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Lena Hancock**.

Petrophysical data from diamond core through Mt Weld REE deposit

A new petrophysical report is available on the 1000 m deep Exploration Incentive Scheme (EIS) co-funded diamond hole (MWEX10270) drilled by the Lynas Corporation at its Mt Weld rare earth element (REE) deposit in the Eastern Goldfields (Fig. 1).

Report 238 contains a datasheet on 86 samples taken down the length of the core, a photo of each sample and a description of the methods. Also included are figures summarizing hyperspectral data along the entire length of the hole (Fig. 2).

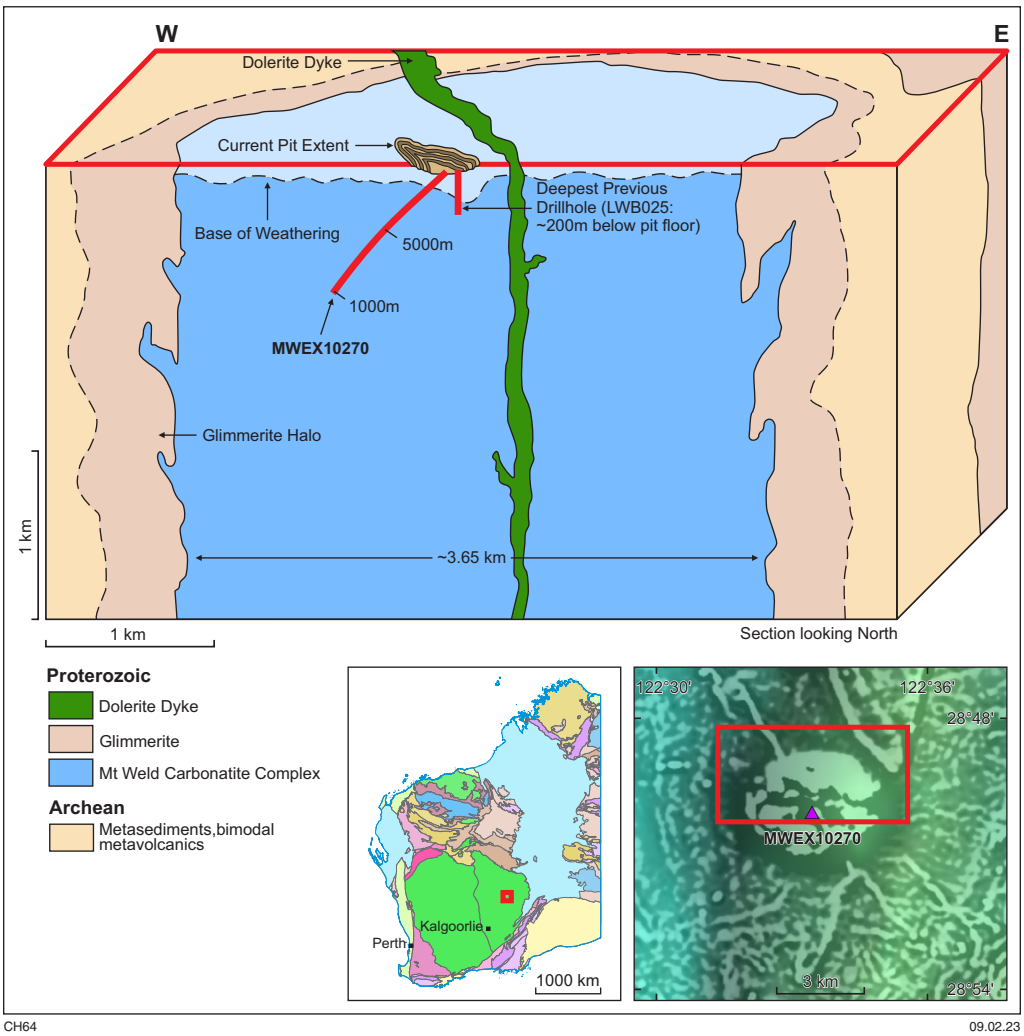


Figure 1. Location of drillhole MWEX10270 northeast of Kalgoorlie. Plan view of the collar location on Bouguer gravity data (colour) draped with 1VD total magnetic intensity data (grey scale). The red outline is projected on to the schematic cross-section that shows the trace of the drillhole (cross-section image is modified from an ASX release by Lynas Rare Earths, 2 August 2021)

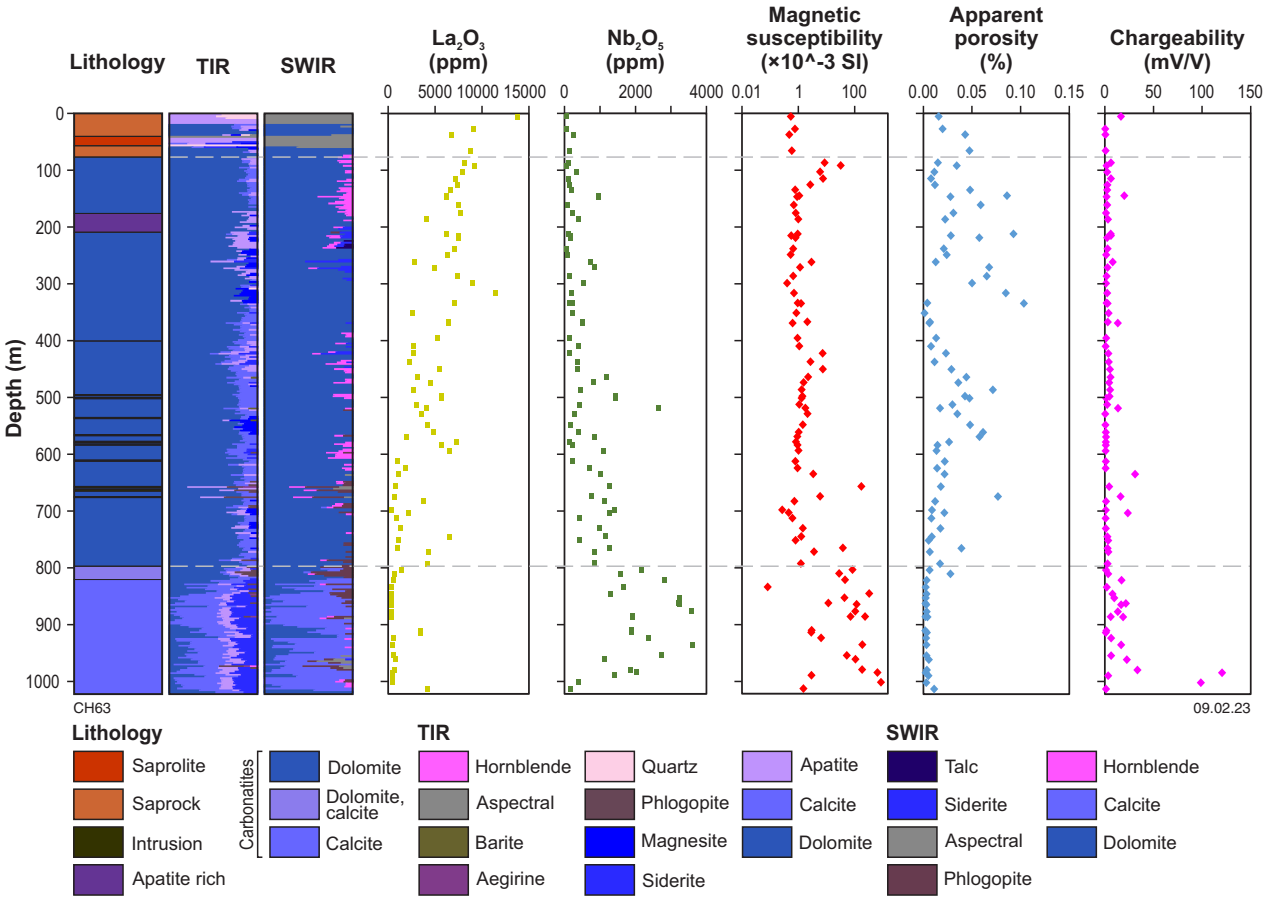


Figure 2. Composite image with changes in lithology, hyperspectral data, La and Nb oxide and petrophysical properties of diamond hole MWEX10270 with depth

The Report, authored by Terra Petrophysics, provides analytical data on petrophysical properties that include:

- induced polarization (chargeability) and galvanic resistivity
- inductive conductivity
- magnetic susceptibility
- remanent magnetization
- dry bulk density
- apparent porosity
- P-wave sonic velocity.

The Geological Survey of Western Australia (GSWA) has a five-year program to collect petrophysical data from EIS co-funded drillcore, GSWA stratigraphic drillcore or from company-held core on request from GSWA. Core selection for petrophysics is primarily chosen where data can assist in:

- modelling of geophysical data in regions with cover
- interpretation of recent or upcoming 2D seismic lines
- classification of regional stratigraphy (often in conjunction with geochemistry).

The current program commenced in 2021. Terra Petrophysics was awarded the tender for the data acquisition, and the project is funded by the EIS. All datasets relating to Report 238 are also available in MAGIX registration number **72201**.

All cores sampled for petrophysics have HyLogger data and most have open-file company assay data, available from the **Mineral Exploration reports database** (**WAMEX**). The final EIS co-funded drilling report in WAMEX on MWEX10270 is A129908.

How to access

Report 238 Regional petrophysics: Mt Weld 2021–22 by Trunfull, J, Bourne, B and Mortimore, C is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

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

An integrated interpretation of selected features

The 2019–20 regional airborne electromagnetic survey spanned the area from 25°S to 16°S and provided valuable geophysical data for the Canning, Ord, Kimberley and northern Officer Basins, and the basement units of the North and West Australian Cratons. The data acquisition was funded by the Commonwealth Government's Exploring for the Future program.

The survey images subsurface structures down to 600 m through lateral and vertical variations of electrical conductivity (Fig. 1). These variations add extra dimensions to deep stratigraphy and structures, especially in areas where there is a lack of drillhole and seismic data. Across the survey area, the AEM profiles show a high level of consistency between electrical responses and stratigraphic units in both lateral and vertical dimensions. The consistency provides opportunities for the integrated interpretation of geological features when combined with other types of data.

With integration of the AEM and pre-existing dataset, this Report highlights the use of AEM to interpret geological features by selecting 20 localities including specific structures, stratigraphy, mineral deposits and physiographic features across the survey area (Fig. 2). The selection of localities was based on geological interests, exploration prospectivity and potential storage sites. The AEM survey provides new information to identify unknown strata and fault reactivation, constrain the thickness of stratigraphic units, and aid in the interpretation of tectonic history. The AEM interpretation of the selected localities can help with future work of similar electromagnetic responses from unknown features to reduce uncertainties in geological interpretation.

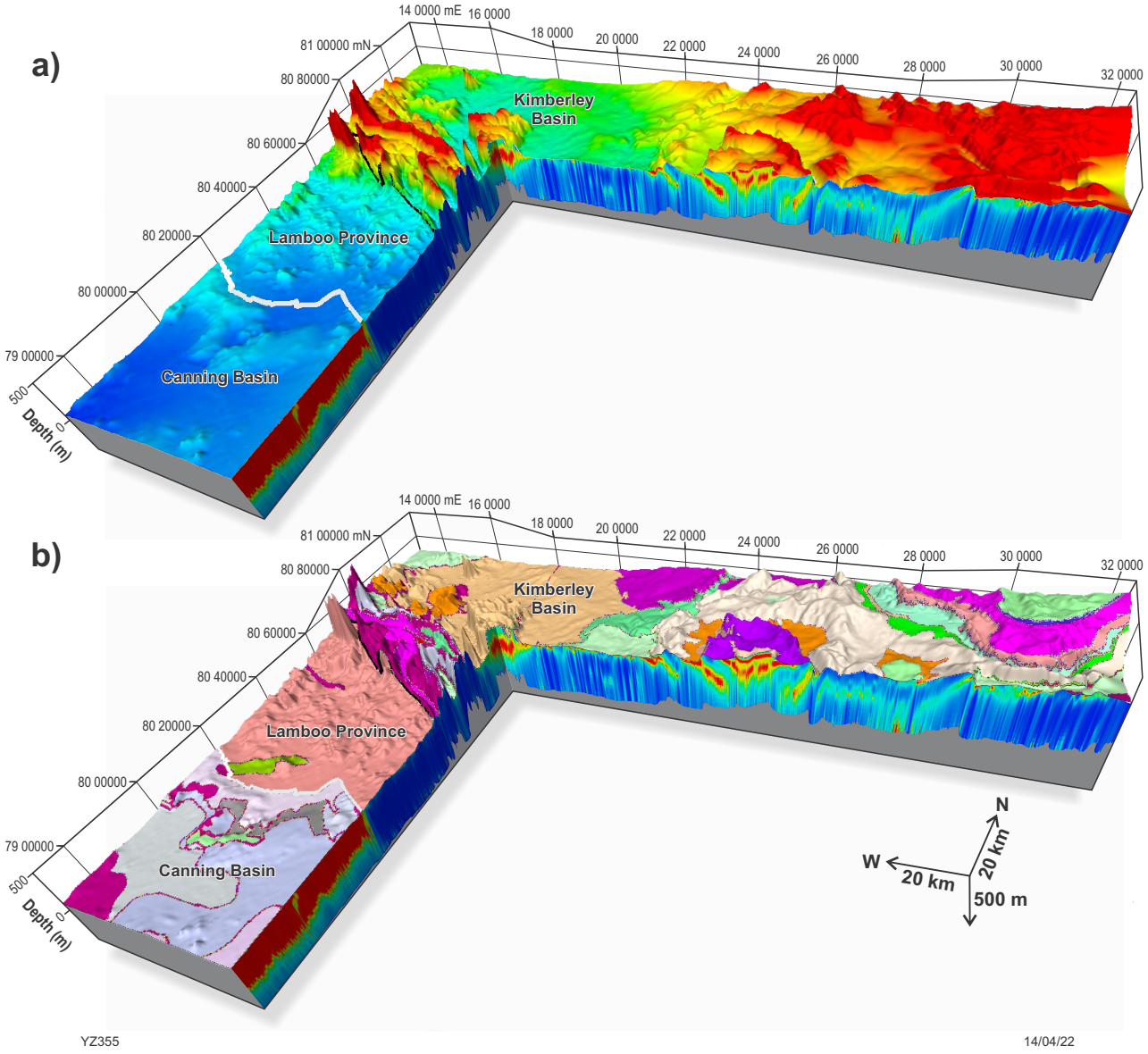


Figure 1. AEM conductivity in 3D: a) surface elevation vs AEM sections; b) lateral correlation between geology and AEM anomalies. Note that the northerly trending AEM profile provides a marked boundary of conductivity between the Canning Basin and Lamboo Province. The syncline shown on the westerly trending profile in the Kimberley Basin can be correlated to the ring-like structure that was likely caused by differential erosion between sandstone and shale

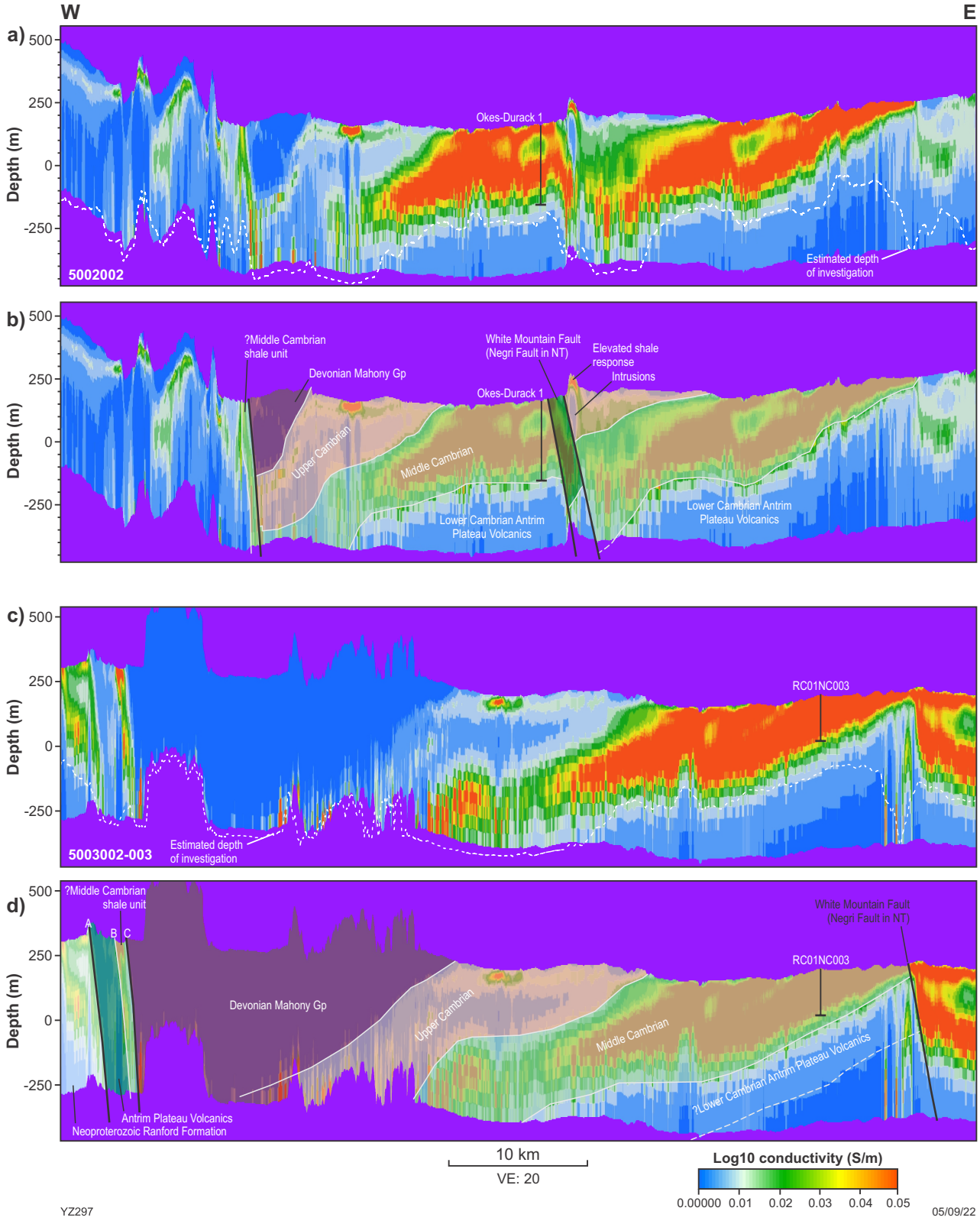


Figure 2. AEM profiles showing the stratigraphy of the Hardman Syncline after integration with drillholes and outcrop geology

How to access

Report 234 Airborne electromagnetic survey, northern Western Australia: an integrated interpretation of selected features by Zhan, Y is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Alex Zhan**.

Product releases

• PUBLICATIONS •

Report 229 Isotopic fingerprinting of native gold from Western Australia
Tessalina, SG, Hancock, EA, McNaughton, NJ and Ware, BD

Report 234 Airborne electromagnetic survey, northern Western Australia: an integrated interpretation of selected features
Zhan, Y

Report 235 western Officer Basin SEEBASE structural study and GIS
Geognostics Australia Pty Ltd

Report 236 Perth Basin SEEBASE structural study and GIS
Geognostics Australia Pty Ltd

Report 237 Deep-learning identification of anomalous data in geochemical datasets
Puzyrev, V, Duuring, P, Howard, SHD, Lowrey, JR, Ormsby, WR, Then, D and Thom, J

Report 238 Regional petrophysics: Mt Weld 2021–22
Trunfull, J, Bourne, B and Mortimore, C

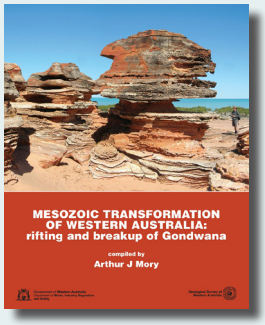
Record 2022/13 Petrophysical evaluation of the Permian and Ordovician in Olympic 1, Canning Basin, Western Australia
Cass, JM, Normore, LS and Dent, LM

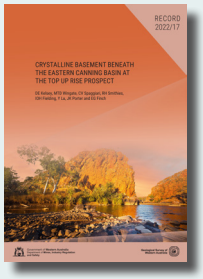
Record 2022/16 Characterization of ballast stones from the wreck site at Trial Rocks
Wingate, MTD, Lu, Y, Fielding, IOH, Maas, R and Smithies, RH

Record 2022/17 Crystalline basement beneath the eastern Canning Basin at the Top Up Rise prospect
Kelsey, DE, Wingate, MTD, Spaggiari, CV, Smithies, RH, Fielding, IOH, Lu, Y, Porter, JK and Finch, EG

Mesozoic transformation of Western Australia: rifting and breakup of Gondwana
Mory, AJ
Physical copy is available to buy for $33 (inc. GST) plus postage

Paleontology Reports





• DATA PRODUCTS •

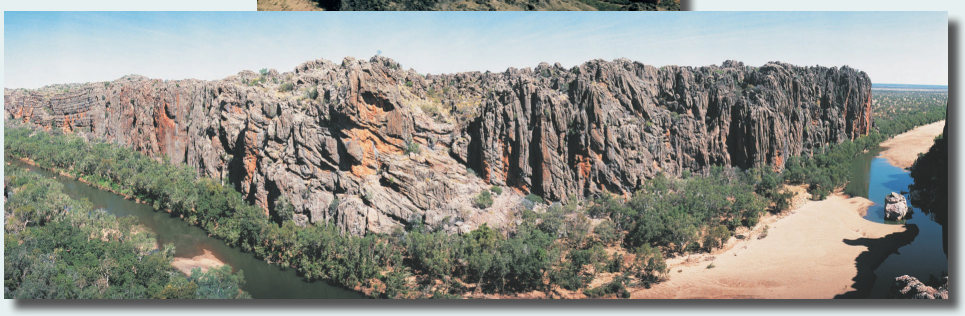
1:500 000 tectonic units

• ONLINE PRODUCTS •

The Boogardie Orbicular Granite – oldest in the world
Goss, SC

Western Australia's fossil great barrier reef
White, SR

Western Australia's fossil great barrier reef



The Boogardie Orbicular Granite – oldest in the world