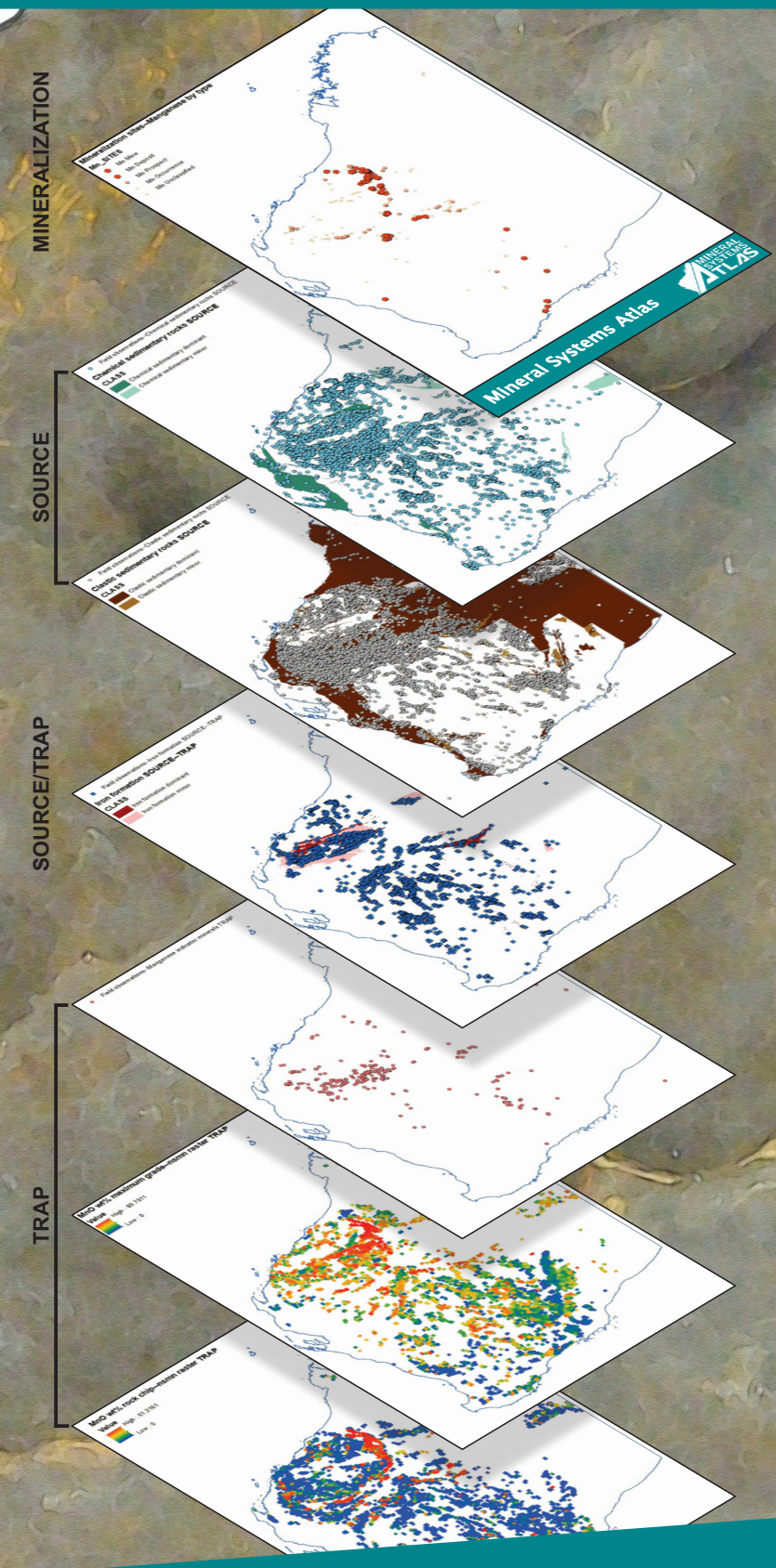
A Geological Survey of Western Australia Newsletter

JANUARY 2023 NUMBER 105

Fieldnotes

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

www.dmirs.wa.gov.au/GSWA



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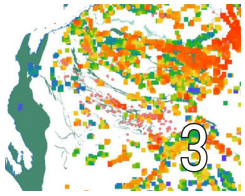

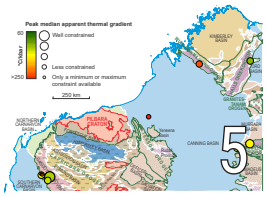

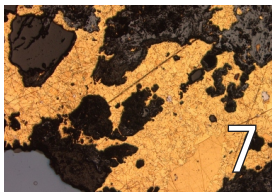

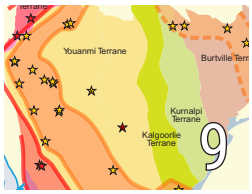

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Access publications

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: To help explorers with regional-scale targeting, our Mineral Systems Atlas provides exploration-relevant spatial data in a logical conceptual framework. Geological proxy layers in GIS format are labelled according to the critical processes needed to form potentially economic mineralization, as shown in this selection of layers from the manganese mineral system

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Navigating your way to discovery

As it becomes harder and more expensive to get boots on ground for mineral exploration, smart and effective use of existing data is growing in importance. In a region such as Western Australia, there is a virtual ocean of publically available geoscience data that can aid those wishing to understand or discover mineral deposits. However, this ocean of data presents a problem in itself: how can one efficiently navigate this data ocean without being lost or drowned by giant waves of pre-competitive datasets? Finding the desired datasets takes time, and interrogating and filtering them to the pertinent information can take even longer.

The Mineral Systems Atlas (MSA) seeks to be a wayfinder for those wanting an expedited path to information deemed critical for mineral system analysis. As the name suggests, the MSA uses a mineral system approach to provide exploration-relevant spatial data regarding prospectivity for a given system. By selecting, curating, filtering and symbolizing datasets to features deemed critical by subject matter experts, the MSA saves users time and effort, allowing them to focus more on target generation rather than data wrangling. These data can be viewed as layers within an online browser-based interface (Fig. 1), or downloaded as a data package for use in GIS software.

Each system is accompanied by an online MSA Guide and GSWA Record. The online guide presents information on each spatial layer, the primary data from where it was derived, and any filters or query models used (Fig. 2). The Records provide a succinct overview of the mineral system, along with a mineral system tree, which for each part of a system (e.g. source, pathway) denotes the critical processes, their constituent process, the targeting elements, and their mappable proxies.

The MSA currently has the following systems: komatiite-hosted nickel, iron formations, rare-element pegmatites (Li—Ta—Sn), layered intrusion-hosted vanadium, manganese, and evaporite brine-related potash. In development is the mafic-hosted Ni—Co—Cu—Pt group elements system, crustal architecture layers, prospectivity heatmaps, and further additions to existing systems.

The MSA data are available via the browser-based MSA Viewer (similar to GeoVIEW.WA), or as data package downloads from the Data and Software Centre (DASC) 'Statewide spatial datasets' section. Records are available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop. The MSA Guide can be found on the MSA page of the DMIRS website.

For more information, contact **Warren Ormsby**.

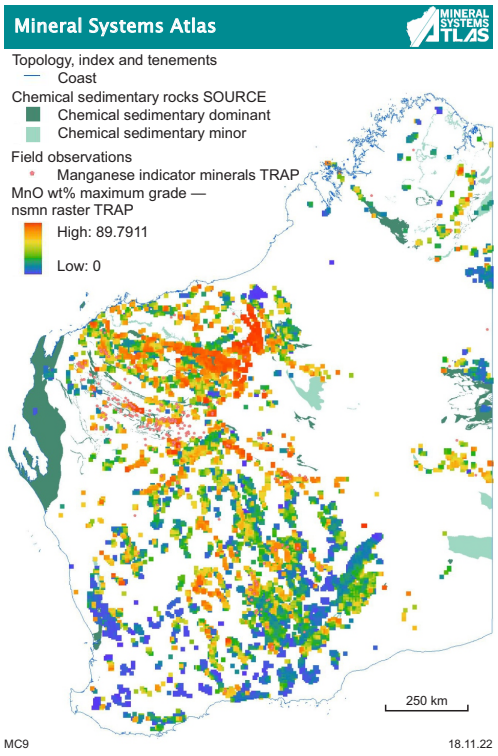


Figure 1. Screenshot of the Mineral Systems Atlas Viewer, showing three layers available for the manganese system: a) chemical sedimentary rocks; b) GSWA field observations of manganese indicator minerals; c) mean neighbourhood statistics raster of maximum MnO wt% grade down hole from the WAMEX database

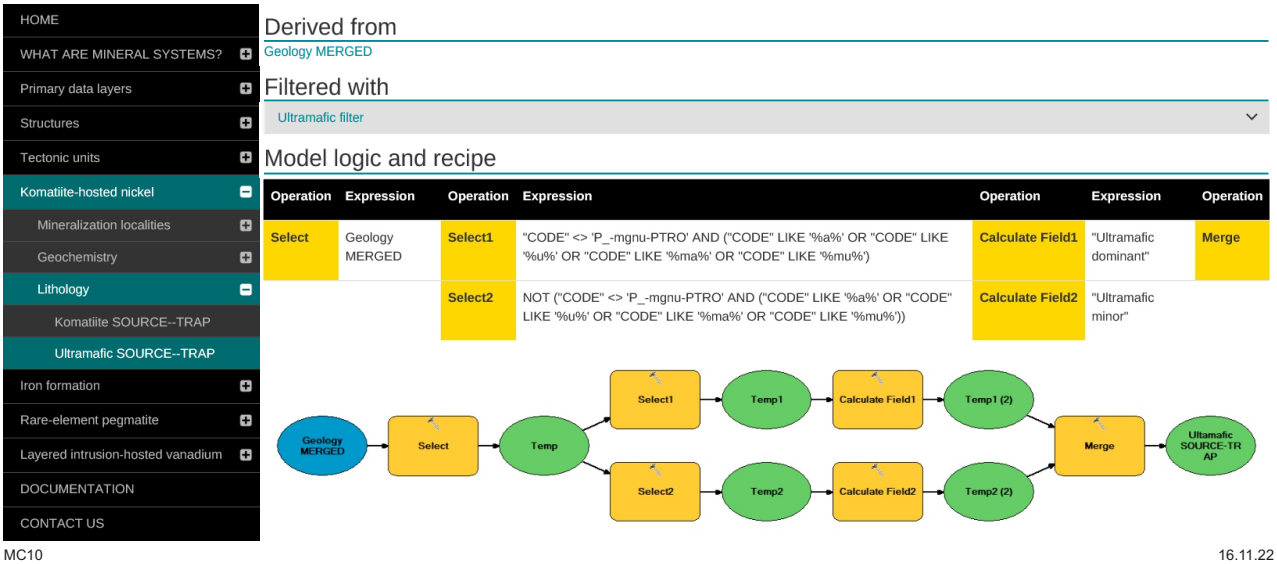


Figure 2. Screenshot of the Mineral Systems Atlas Guide showing the model logic and recipe used in filtering ultramafic lithologies from a merge of GSWA's 1:100 000 and 1:500 000 State interpreted bedrock geology layers. The Guide complements the GIS platform by describing the derived data layers

Critical metals exploration gets a boost

The 20-year-old collection of ~2800 laterite samples from the western Yilgarn Craton lacks many of the geochemical analytes that are now widely regarded as important pathfinders for critical metals.

The Geological Survey of Western Australia (GSWA), through a recent collaboration with CSIRO, has responded to this knowledge gap by reanalysing powders from the original laterite samples – extending the list of analytes and, in many cases, improving the detection limits for existing elements.

The analytical list now includes lithium and platinum, while several elements such as barium, tantalum, and tin were reanalysed to achieve much lower detection limits, resulting in more precise definition in samples with low abundance. The examples of Pt and Li illustrate previously unrecognized geochemical trends, including a central East–West band of Pt anomalism, plus Li enrichment in the southeast (Fig. 1). In addition to these improvements in geochemistry, spectral data have been collected using the HyLogger-3 system for most of the samples. The spectral data indicate significant spatial differences in mineralogy on a regional scale, with the prevalence of kaolinite in the northeast of the study area, trending towards gibbsite dominance in the southwest.

It is envisaged that these new additions to the existing laterite geochemistry database will encourage further study and boost critical metals exploration in the western Yilgarn Craton.

Report 233 Critical metals in laterite related to pegmatite mineral systems of the western Yilgarn Craton (Li, W, Sn, Ta, REE) by Otto et al. is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop. There is also a downloadable file containing the digital appendices.

The **Laterite Geochemistry** digital data are also available as a free download from the **Data and Software Centre via Datasets — Statewide spatial datasets — Geochemistry — GSWA laterite geochemistry, 2022**, as ESRI shapefiles and MapInfo TAB files.

For more information, contact **Paul Duuring**.

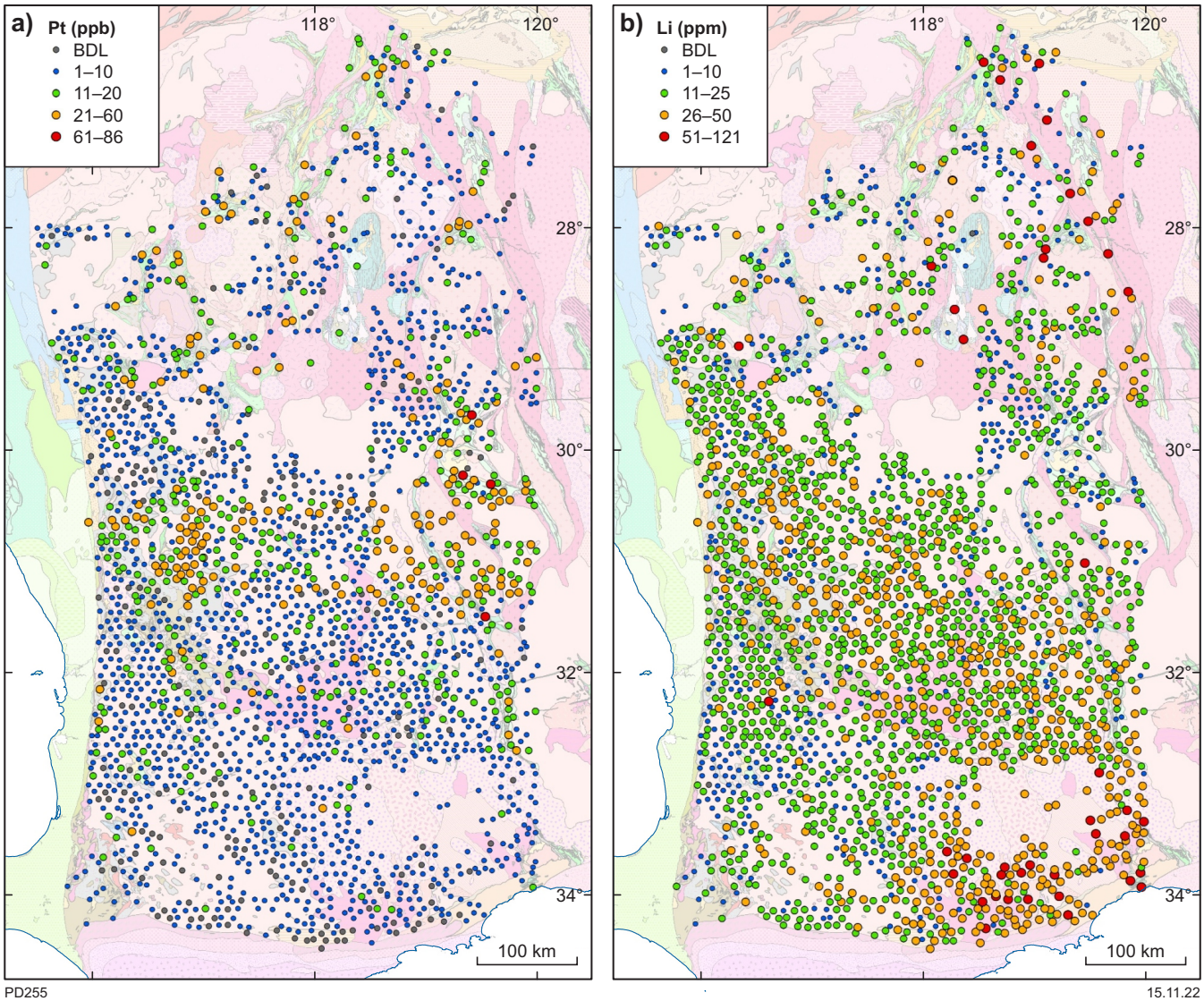


Figure 1. Example spatial plots of new geochemical data (Pt and Li) sourced from laterite samples in the western Yilgarn Craton

Data available as a digital layer

There is a new release available of Metamorphic History Records for selected samples across Western Australia and an updated Metamorphic History data layer. They are now viewable in GeoVIEW.WA (Fig. 1).

Quantifying the pressure (*P*)–temperature (*T*)–time (*t*) conditions recorded by metamorphic rocks is an important aspect of geoscience investigations at the Geological Survey of Western Australia. Mineral assemblages and their textural relationships provide a record of the *P*–*T* conditions that can be used to decipher tectonic and geodynamic processes. The development of improved thermobarometric techniques has enhanced our ability to retrieve more precise and reliable *P*–*T* data, which can be integrated with age, chemical and textural information from datable minerals to better define *P*–*T*–*t* paths. The apparent thermal gradients calculated from metamorphic data relate directly to the thermal regime, which can be used to infer geodynamic setting and heat source; whereas the overall shape of the *P*–*T*–*t* path reflects the relative rates of burial and heating vs cooling and exhumation. Together these data can be used to define a sequence of geological events and to identify tectonothermal drivers.

The Metamorphic History Records include detailed petrography, methodology and results for a sample. Metamorphic data, including *P*, *T*, metamorphic facies, assemblage, age, and calculated thermal gradients, are available in each Record and the Metamorphic History data layer in GeoVIEW.WA.

How to access

Metamorphic History Records are available as free downloadable PDFs from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop. The **Metamorphic History dataset** is best accessed using **GeoVIEW.WA** or can also be downloaded from the **Data and Software Centre**.

For more information, contact **Fawna Korhonen**.

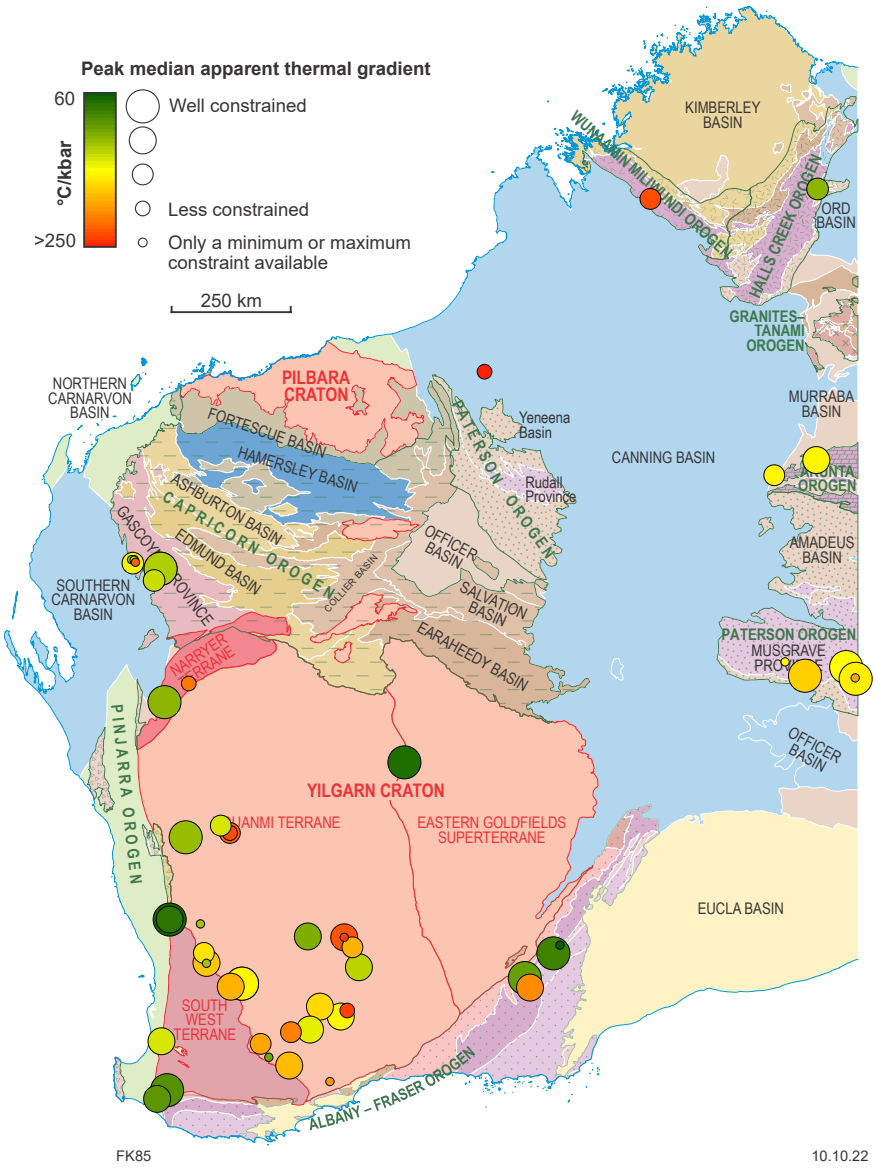


Figure 1. Simplified tectonic map of Western Australia, showing sample locations and metamorphic data as of September 2022. Data plotted are median peak apparent thermal gradient; temperature and pressure data are also available in the Metamorphic History data layer

Komatiite-hosted Ni–Cu–PGE deposits

Western Australia is home to world-class komatiite-hosted Ni–Cu–PGE deposits, such as Kambalda, Perseverance and Mount Keith. Geological Survey of Western Australia (GSWA) Record 2022/14 succinctly captures current thinking on the formation of these types of deposits, with particular emphasis on six identified critical processes controlling their genesis and mappable proxies of these processes. Proxies available from GSWA datasets are provided in the Mineral Systems Atlas and can be downloaded from the **Data and Software Centre**. Further details on these layers can be found in the **Mineral Systems Atlas Guide**.

The six critical aspects identified by the mineral systems analysis are:

1. Source

Formation of komatiitic magmas is critical as it provides the source of the metals. These require a high degree of mantle melting of asthenospheric mantle. Today, they present as areas of laterally extensive ultramafic rocks. Mapping geochemical indicators of the olivine cumulate-rich rocks (e.g. MgO wt%, Ni/Cr, Ni/Ti) that are typically found associated with high-flux magma pathways, can help with identifying suitable ultramafic source rocks.

2. Active pathway

Lithospheric-scale structures are necessary to transport komatiitic magmas through the crust. GSWA has recently published mapping of major crustal boundaries that may represent some of these former magma pathways.

3–5. Trap processes

The formation of high-flux magma pathways can also facilitate the following three trap processes (Fig. 1):

- *Chemical scrubber trap*. The addition of sulfur to the source magma via crustal assimilation is required to induce saturation. Geochemical proxies for this process compare elements that are enriched in the continental crust to those that are enriched in the mantle such as ratios of Zr/TiO2, La/Sm, Th/Nb and Th/Yb.
- *Chemical/physical scrubber trap*. This involves the sequestration of metals into sulfide solutions after sulfur saturation and requires a high level of interaction between silicate magmas and sulfide droplets as well as efficient mixing.
- *Physical throttle trap.* The physical concentration of metal-rich sulfide solutions is also needed to form economically viable deposits. Areas of change in komatiite channel morphology can represent areas where heavier sulfides may have accumulated.

6. Modification

After formation, structural and hydrothermal processes commonly modify nickel orebodies. Deformation may remobilize massive sulfide zones into fold hinges and along fault zones, and hypogene fluid alteration may form sulfide veins or veinlets away from the main mineralization.

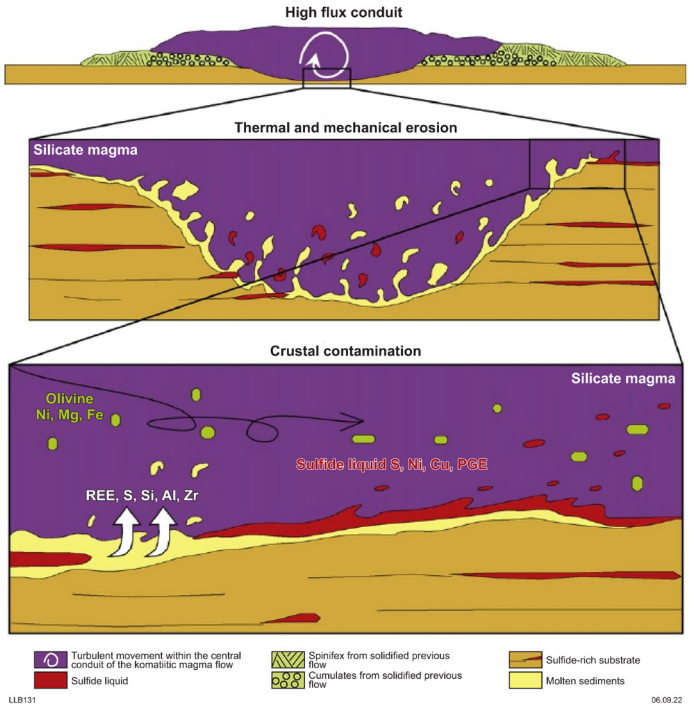
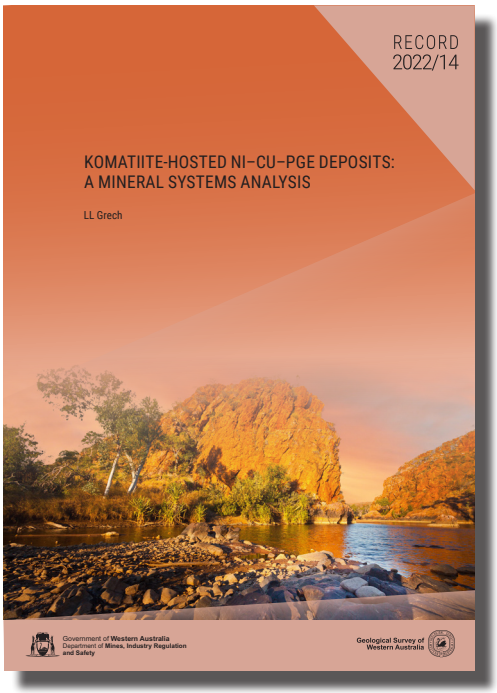


Figure 1. Schematic diagram of the formation of komatiite-hosted Ni–Cu–PGE deposits (from Le Vaillant et al., 2016)

By describing the links between these processes and providing a set of mappable proxies, this Record helps inform exploration strategies for komatiite-hosted Ni–Cu–PGE deposits.

Record 2022/14 Komatiite-hosted Ni–Cu–PGE deposits: a mineral systems analysis by L Grech is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Warren Ormsby**.



Pilbara gold fingerprinting

The first six Mineralogy Records describe mineralogy of small gold nuggets and grains from the Pilbara Craton. They were released as part of the Geological Survey of Western Australia (GSWA) Pilbara gold fingerprinting study. They include site geology and morphometry (Fig. 1a), microstructure (Fig. 1b), associated minerals and quantitative silver and trace element composition of bedrock-hosted and placer gold grains. Over 100 gold samples were donated by the Creasy Group, Artemis Resources, Macarthus Minerals, Castle Minerals, and Blackstone Minerals. A total of 67 Mineralogy Records will be released this year. Subsequently, a Pilbara gold fingerprinting Report will be released.

The characterization of the provenance and metallogenesis of gold mineralization across the Pilbara Craton assists in the investigation of:

- type and origin of basement-hosted gold deposits
- sources of paleoplacer gold in Fortescue Group rocks
- prospectivity for undiscovered gold deposits.

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

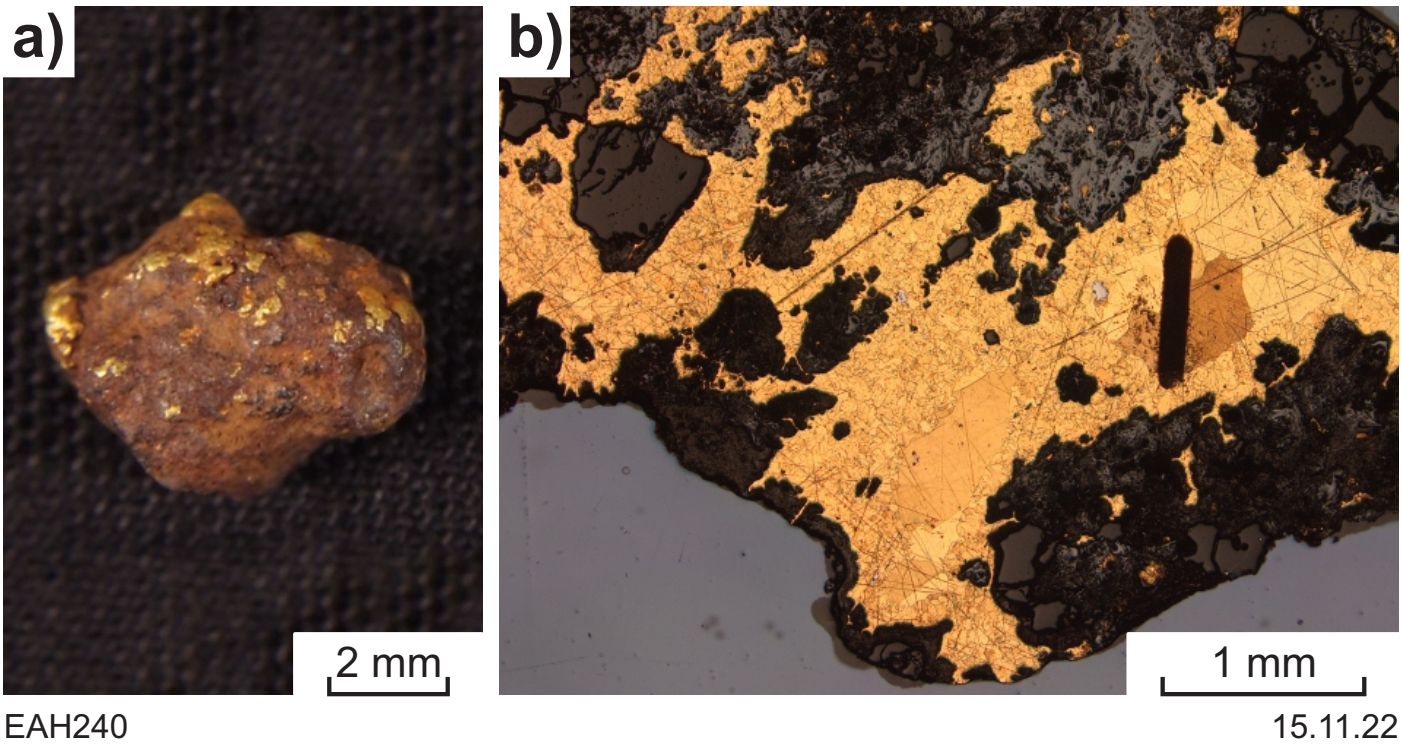


Figure 1. A gold grain from sample 201969 recovered from colluvium at the Coolyia Creek prospect, Marble Bar Sub-basin: a) 7 x 5 x 3 mm well-rounded intergrowth of gold, quartz and Fe-oxide minerals; b) finely crystalline microstructure of cut and polished surface of the gold grain with remnants of more coarsely crystalline gold towards the centres, indicating near-complete recrystallization by mechanical and chemical supergene processes, such as corrosion. Dark grey – quartz and Fe oxide minerals; light grey – small inclusions of cobaltite; dark elongate line – laser ablation track produced during LA-ICP-MS analysis

New release of Geochronology Records across the State

Precise and accurate geochronology of minerals and rocks is essential to determine the timing of geological events and to understanding the geological history of Western Australia. Since 1994, geochronology has been a fundamental component of the Geological Survey of Western Australia's (GSWA) geoscience programs and mineralization studies, and has contributed to enhancing the prospectivity of the State.

In the 2021–22 financial year, GSWA released 102 Geochronology Records with a total of 1892 records now publicly available in GeoVIEW.WA (Fig. 1). One highlight is that four geochronology samples from the Julimar PGE–Ni–Cu–Co deposit in the South West Terrane defined a new age of c. 2670 Ma for ultramafic magmatism and orthomagmatic mineralization in the Yilgarn Craton. This represents a period of nickel mineralization never before seen in Western Australia. This opened up a new search space for PGE–Ni mineralization in the poorly explored western Yilgarn Craton. See GSWA Geochronology Records **203747**, **248203**, **248205**, and **248207**.

The Sensitive High-Resolution Ion Microprobe (SHRIMP) facility in the John de Laeter Centre at Curtin University is used for U–Pb geochronology. GSWA also uses laser ablation inductively coupled mass spectrometry (LA-ICP-MS) instruments in the John de Laeter Centre and in the Centre for Microscopy, Characterization and Analysis (CMCA) at The University of Western Australia to date detrital zircons, analyse metamorphic phosphate minerals such as monazite and xenotime in thin sections.

How to access

Geochronology Records are available as free downloadable PDFs from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop. The Geochronology dataset is best accessed using **GeoVIEW.WA** or can be downloaded from the **Data and Software Centre**.

For more information, contact **Yongjun Lu**.

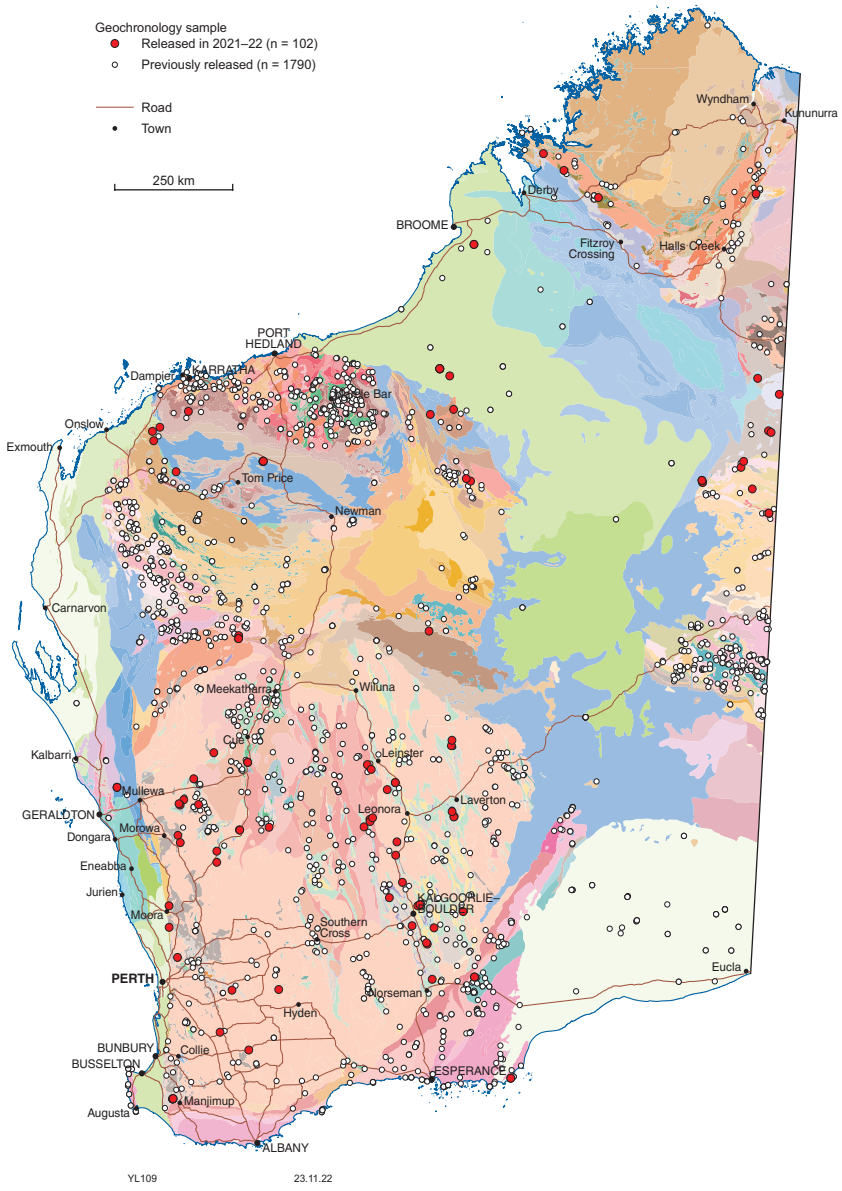


Figure 1. Locations of new and previously released geochronology samples, shown on the 1:2.5 million interpreted bedrock geology map

Formation of the Yilgarn Protocraton

New geochronology from across the western Yilgarn Craton demarcates, in time and space, a 100 Ma period of extensive but sporadic magmatism followed by 100 Ma of quiescence. By 2920 Ma, abundant new crust had been added to what we suggest was a coherent Yilgarn protocraton that would remain relatively untouched until 2825 Ma, with deposition of the Norie Group. We describe the stratigraphic–magmatic framework of several volcano-sedimentary greenstone belts and granitic suites in the Youanmi Terrane from 3018 to 2920 Ma and suggest a rift tectonic setting in light of new Hf isotopic data. We named the greenstones and granites of this time interval the Southern Cross Supergroup and Thundelarra Supersuite, respectively. The Southern Cross Supergoup has many significant deposits, including Golden Grove (Cu–Pb–Zn–Ag–Au), Lake Johnston (Ni–Co), Mt Gibson (Au with minor base metals), Anabelle Volcanics (Cu–Au) and Wongan Hills (Cu–Pb–Zn–Ag–Au).

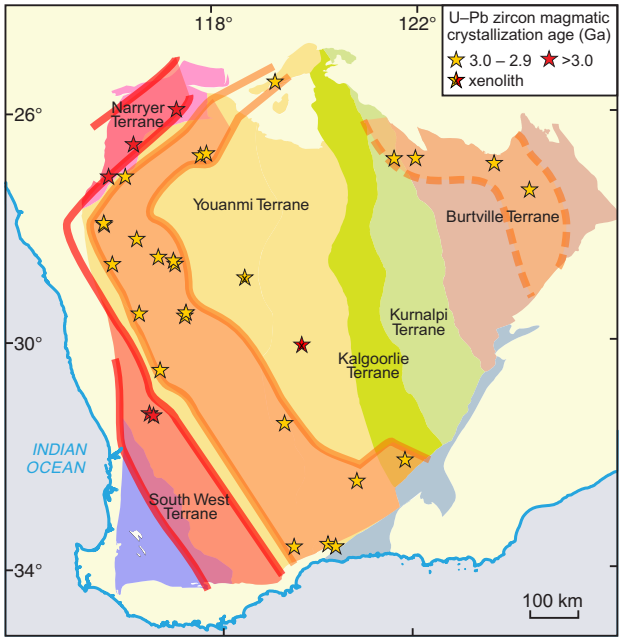
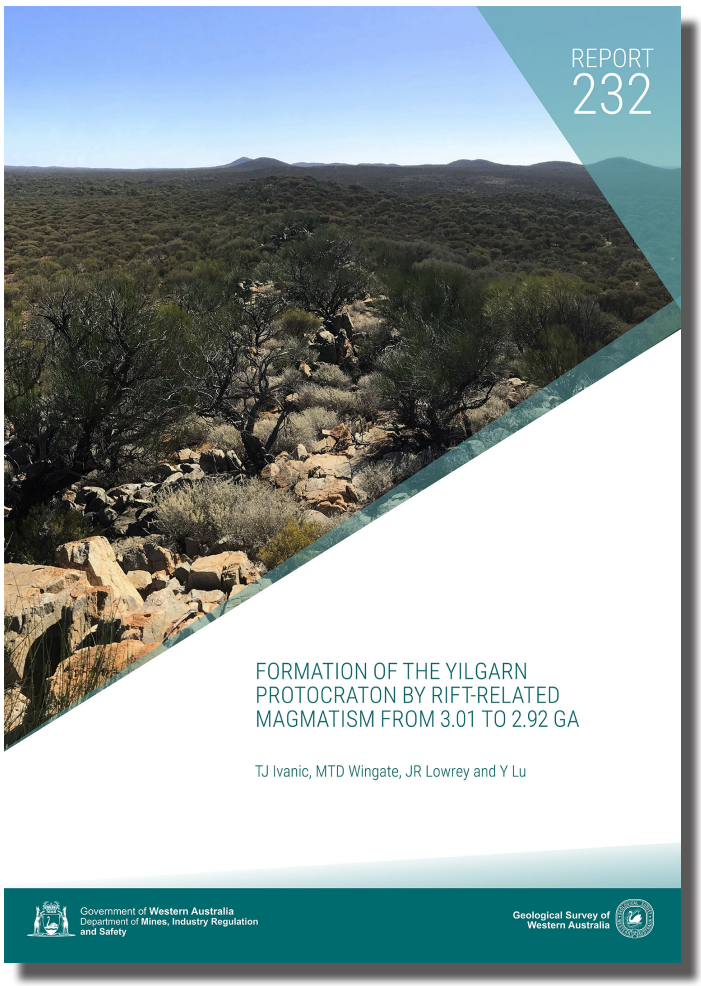


Figure 1. Distribution of >2.9 Ga magmatic ages within the Yilgarn Craton

GSWA Report 232 details the spatial, temporal and stratigraphic context for these old greenstone packages of the Southern Cross Supersuite across large parts of the western Yilgarn Craton, in particular, the Youanmi Terrane. Geochronology samples from these packages and tonalite–trondjhemite–granodiorite (TTG) plutons from the Thundelarra Supersuite help to constrain the time–space evolution of this magmatic episode. Magmatism is interpreted to have been focused into volcanic centres, which are also sporadic in time throughout this ~100 Ma period. Although our results shed light on these, further work is required for a thorough understanding of these significant geological units.

Report 232 Formation of the Yilgarn protocraton by rift-related magmatism from 3.01 to 2.92 Ga by Ivanic, TJ, Wingate, MTD, Lowrey, JR and Lu, Y is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Tim Ivanic**.



Product releases

• PUBLICATIONS •

Report 227 Tectonomagmatic evolution of a major Archean terrane boundary: the Ida Fault, Yilgarn Craton
Zibra, I, Kemp, AIS, Smithies, RH, Rubatto, D, Korhonen, FJ, Hämmerli, J, Johnson, TE, Gessner, K, Weinberg, RF, Vervoort, JD, Martin, L, Romano, S and Wingate, MTD

Report 232 Formation of the Yilgarn protocraton by rift-related magmatism from 3.01 to 2.92 Ga
Ivanic, TJ, Wingate, MTD, Lowrey, JR and Lu, Y

Record 2022/5 Manganese: a mineral system analysis
Brown, T, Duuring, P, Morin-Ka, S and Strong, CA

Record 2022/12 GSWA 2022 extended abstracts: advancing the prospectivity of Western Australia

Record 2022/14 Komatiite-hosted Ni–Cu–PGE deposits: a mineral systems analysis
Grech, LL

Record 2022/15 Evaporite brine-related potash: a mineral systems analysis
Clarke, M

Record 2022/18 'Earth, Sea and Sky'– the biennial meeting of the Specialist Group in Geochemistry, Mineralogy & Petrology (SGGMP)
Barnes, SJ and Gessner, K (compilers)

GSWA calendar 2023
GSWA annual review 2021–22

• DATA PRODUCTS •

Laterite geochemical database for the western Yilgarn Craton 2022

Metamorphic History information

Mineralogy Records 2022
*Contact **Lena Hancock***

Mineral Systems Atlas products

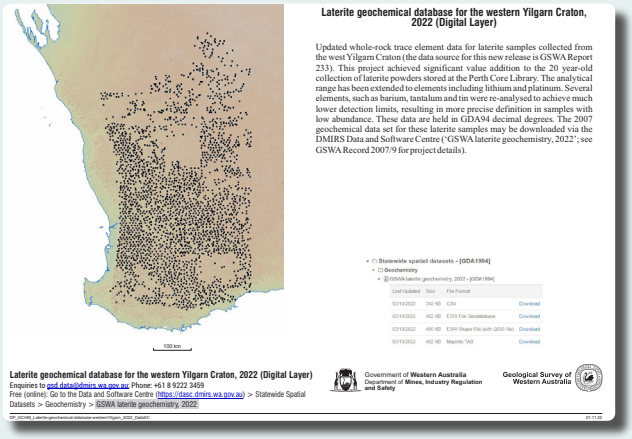
Evaporite brine related potash system – GIS layers

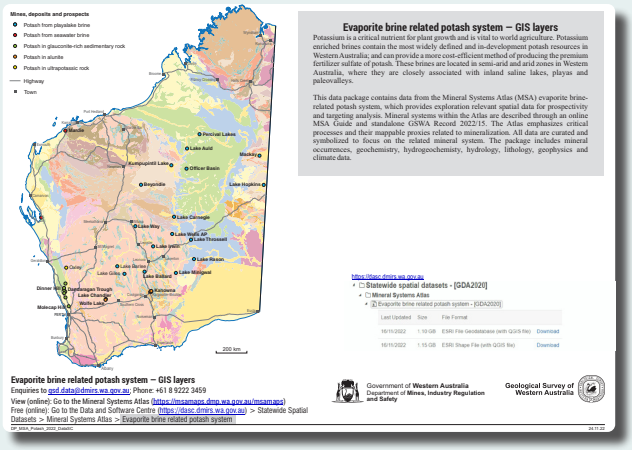
Manganese systems – GIS layers

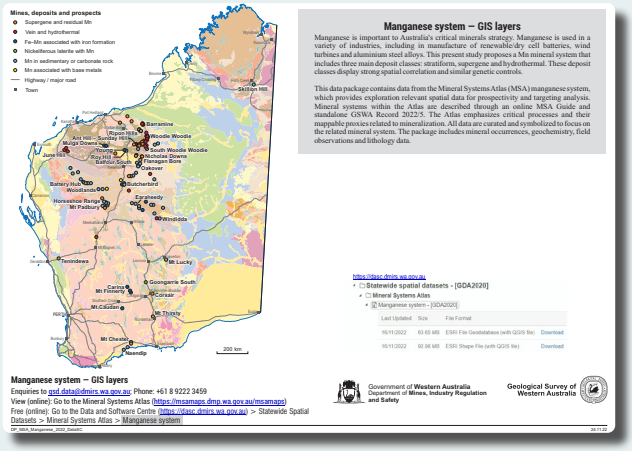
• POSTERS/FLYERS •

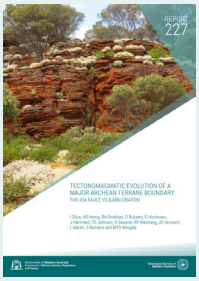
WA-Array (flyer)
Murdie, RE

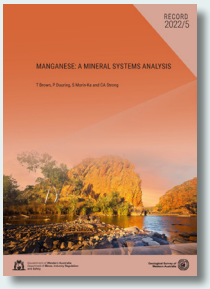
WA-Array seismic monitoring regions (poster)
Hall, C

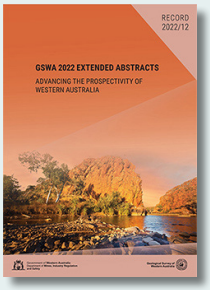


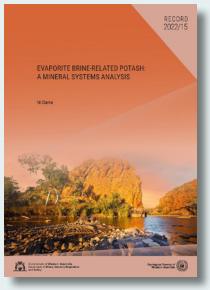


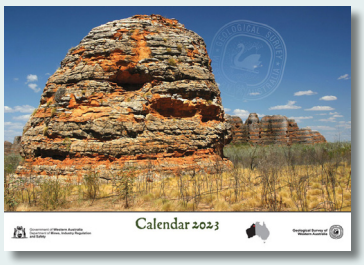


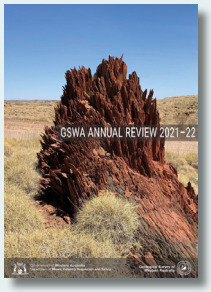












DMIRS applications training, Perth 2022–23

In-person training in the use of DMIRS online systems is scheduled for **Thursday 27 April 2023.**

Registrations will open in early 2023. Find more information on the DMIRS website.