

RECORD 2020/1

# GEOLOGICAL SURVEY WORK PROGRAM FOR 2020–21



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

Geological Survey of  
Western Australia





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

Record 2020/1

# GEOLOGICAL SURVEY WORK PROGRAM FOR 2020–21

Perth 2020



**Geological Survey of  
Western Australia**

**MINISTER FOR MINES AND PETROLEUM**  
**Hon Bill Johnston MLA**

**DIRECTOR GENERAL, DEPARTMENT OF MINES, INDUSTRY REGULATION AND SAFETY**  
**David Smith**

**EXECUTIVE DIRECTOR, GEOLOGICAL SURVEY AND RESOURCE STRATEGY**  
**Jeff Haworth**

#### REFERENCE

**The recommended reference for this publication is:**

Geological Survey of Western Australia 2020, Geological Survey work program for 2020–21: Geological Survey of Western Australia, Record 2020/1, 68p.

**ISBN** 978-1-74168-904-4

**ISSN** 2204-4345

#### Disclaimer

This product uses information from various sources. The Department of Mines, Industry Regulation and Safety (DMIRS) and the State cannot guarantee the accuracy, currency or completeness of the information. Neither the department nor the State of Western Australia nor any employee or agent of the department shall be responsible or liable for any loss, damage or injury arising from the use of or reliance on any information, data or advice (including incomplete, out of date, incorrect, inaccurate or misleading information, data or advice) expressed or implied in, or coming from, this publication or incorporated into it by reference, by any person whosoever.

#### Published 2020 by Geological Survey of Western Australia

This Record is published in digital format (PDF) and is available online at <[www.dmirs.wa.gov.au/GSWApublications](http://www.dmirs.wa.gov.au/GSWApublications)>.



© State of Western Australia (Department of Mines, Industry Regulation and Safety) 2020

With the exception of the Western Australian Coat of Arms and other logos, and where otherwise noted, these data are provided under a Creative Commons Attribution 4.0 International Licence (<http://creativecommons.org/licenses/by/4.0/legalcode>).

#### Further details of geoscience products are available from:

Information Centre  
Department of Mines, Industry Regulation and Safety  
100 Plain Street  
EAST PERTH WESTERN AUSTRALIA 6004  
Telephone: +61 8 9222 3459 Email: [publications@dmirs.wa.gov.au](mailto:publications@dmirs.wa.gov.au)  
[www.dmirs.wa.gov.au/GSWApublications](http://www.dmirs.wa.gov.au/GSWApublications)

**Cover image:** Packing up the campsite in a claypan about 5 km south of Minilya in the southern Pilbara (photo by Olga Blay, DMIRS)

## Contents

Executive summary .....	1
<b>PART ONE Economic recovery program</b>	
Economic recovery program .....	4
<b>PART TWO Detailed work programs</b>	
GS10 Energy Geoscience and Carbon Strategy .....	7
GS12 Land Use Planning .....	8
GS14 Statutory and Resource Information .....	9
GS20 Mineral Systems Studies .....	10
GS52 East Yilgarn .....	11
GS53 State Geoscience and Chief Geoscientist .....	13
GS54 Geochronology and Geochemistry .....	14
GS55 Geophysics Acquisition and Processing .....	15
GS58 West Yilgarn .....	16
GS62 3D Geoscience .....	18
GS63 Pilbara and Hamersley .....	19
GS64 Geoscience Mapping Through Cover .....	20
GS65 Proterozoic Margins .....	21
GS80 Editing and Publishing .....	23
GS81 Mapping and Events .....	23
GS82 Graphics .....	23
GS83 GIS Services .....	23
GS84 Spatial Systems .....	23
GS87 Data Capture .....	23
GS88 Data Integrity .....	23
GS89 Spatial Projects .....	23
GS90 Native Title .....	23
GS85 Resource Investment Information .....	25
GS91 Mineral Exploration Information Management .....	26
GS92 Statutory Petroleum Exploration Information .....	27
GS94 and GS96 Core Library Services .....	28
GS95 HyLogger and the National Virtual Core Library .....	29
<b>PART THREE Exploration Incentive Scheme – detailed work programs</b>	
ES20 Government Co-funded Exploration Drilling .....	31
ES21 Stakeholder Engagement .....	33
ES30 Airborne and Ground Geophysical Surveys .....	34
ES31 Deep Seismic Survey Program .....	35
ES34 Regolith and 3D Paleosurface Mapping .....	36
ES36 Participation in MinEx CRC .....	37
ES38 Proterozoic Margins .....	40
ES42 3D Lithosphere Visualization Project .....	41
ES43 Mineral Systems .....	42
ES46 Enhanced Geochronology and Isotopic Mapping .....	44
ES47 Petroleum Systems .....	46
ES49 Greenstone Geochemical Barcoding Project .....	48
ES51 Yilgarn Granite Project .....	49

## Figures

1. Outline of completed and planned bedrock geology mapping, East Yilgarn project .....	12
2. Simplified geological map of the northern Youanmi Terrane showing existing mapping and current working areas .....	17
3. Gravity image showing the project areas covered by ES38 Proterozoic Margins .....	22
4. Perth Core Library usage statistics since 2004–05 for the number of clients, pallets accessed and core laid out .....	28
5. EIS Co-funded Exploration Drilling program statistics and timeline .....	32
6. AusAEM20–WA location map .....	34
7. AusAEM20–WA 2020–21 proposed Stage 1 survey area .....	34
8. Location of ‘The Gap’ .....	39

## Appendix

GSWA collaborative research projects .....	51
--	----





# Geological Survey work program for 2020–21

## Executive summary

As I prepare this summary, Western Australia is in the middle of a pandemic. The resources sector, especially the exploration industry, has suffered a 7.4% loss in employment due to mandatory restrictions introduced to stop the spread of COVID-19. Most impacted are the small- to medium-sized enterprises (SME) and the Mining, Equipment, Technical and Services (METS) sector. Petroleum companies have been doubly impacted, with the COVID-19 pandemic combining with a simultaneous collapse in the crude oil market and prices dropping from US\$69/barrel in January to US\$22/barrel in April.

While iron ore and gold prices have increased, the battery metals and critical mineral commodities have generally borne the brunt of the market fallout, and it is in these areas that the State and Commonwealth Governments are developing recovery strategies.

This year (2020), possibly for the first time in its history (except perhaps during the world wars), the Geological Survey of Western Australia (GSWA) has cancelled its field season. This is mainly due to regional travel restrictions and concern for possible effects on remote communities when accessing native title lands. The uncertainty as to how long these restrictions will remain in place compelled GSWA to decide to invest in updating and installing its communication equipment and focus on delivering products.

GSWA has taken these events and issues into account when developing its 2020–21 work program. This year you will see the program move into three distinct themes, namely the Accelerated Geoscience program, business improvement and business as usual.

### Accelerated Geoscience program

A program of accelerated geoscience data synthesis and delivery in areas of new and emerging mineral potential will see a number of dedicated geoscientists from across GSWA concentrate their efforts on four main projects:

- publication of existing data into geographic information system (GIS) layers
- data integration and analyses – the Yilgarn Craton
- statewide critical minerals prospectivity study
- energy systems including petroleum, geothermal and carbon capture and storage.

The results will be published as GIS layers available online within current GSWA systems, as well as within three standalone Geological Exploration Packages (GEP). These packages will include a Southwest Yilgarn GEP, East Yilgarn GEP and Critical Minerals GEP, and will facilitate use for all levels of technical competency and software, from prospectors to Tier 1 companies.

### Business improvement

This theme includes a series of short-term, big-win data synthesis projects. These projects aim to increase mineral prospectivity across the State by integrating pre-existing geoscience datasets and delivering them in ways that can be used by exploration companies to develop and generate new exploration targets.

## Business as usual

These are standard services and products that need to be completed as part of GSWA's service delivery requirements. This will also include the Exploration Incentive Scheme (EIS) programs, such as the Co-funded Exploration Drilling program.

In 2020–21, the Geological Survey and Resource Strategy budget totals \$31.37 million (excluding departmentally funded projects). The GSWA allocation of this budget is \$27.49, which is a combination of recurrent GSWA related projects and EIS funding.

Staffing will comprise:

- 180 permanent full-time equivalent (FTE)
- nine permanent part time in 2020–21 (6.03 FTE)
- eight FTE staff funded from the EIS
- six contract full or part time
- ~14 short-term fee-for-service contractors (as of 1 July 2020).

We anticipate approximately 34 active collaborative research projects partly funded by GSWA, in addition to the ongoing nine National Collaborative Framework agreements.

GSWA plans to publish the following flagship products:

- Manuscripts 28
- Maps 4
- Digital data layers 4
- Data packages 7
- Online data releases 5

GSWA will also deliver the following:

- Release of map symbol database to manage colours and patterns for regolith and rock units
- Release of geochronology and mineral geochemistry data via an online application
- Implement the new Geocentric Datum of Australia 2020 (GDA2020) for the Department of Mines, Industry Regulation and Safety's (DMIRS) Geoscience and Titles Information spatial datasets
- Complete the electronic lodgement of survey field books under Regulation 120E of the *Mining Regulations 1981*
- Decommission NORM2 format data files and move to ESRI geodatabase files
- Replace Tengraph maintenance modules with ArcPro maintenance processes in support of decommissioning Tengraph Old.

The post-COVID-19 economic recovery for Western Australia has become a major challenge for GSWA, and one that will certainly impact on products delivered in the coming year. GSWA is meeting this challenge head-on. In keeping with the State and Commonwealth Government's strategic intent around battery and critical minerals, GSWA has designed the 2020–21 work program to leverage our vast data stores to deliver timely, focused and interoperable geoscience data for the industry.

*Jeff Haworth*

Executive Director

Geological Survey and Resource Strategy

---

*Note: all currencies are Australian dollars unless otherwise indicated.*

# **PART ONE**

## Economic recovery program

# Economic recovery program

*Managers: Michele Spencer and Simon Johnson*

*Team members: Minerals and Petroleum, Regional Geoscience Directorates staff*

As a consequence of current travel and operational restrictions, GSWA will reprioritize its 2020–21 work program specifically to aid economic recovery and stimulate the exploration industry by using its extensive, pre-competitive geoscience datasets and archived rock collection. GSWA will deliver new interpretive datasets, across all areas of geoscience, in a number of key regions of the State in which we are already working, in order to accelerate our understanding of the region's geology and mineral prospectivity.

GSWA will, however, continue to provide its key statutory and regulatory business functions as well as a number of other core projects critical for economic recovery. It is anticipated that no additional funding will be required to facilitate this modified work program. The majority of resources can be sourced within GSWA, although some staff may need to be moved temporarily to new areas and the program will provide all GSWA staff with an opportunity for upskilling within the division.

## Planned work program

The modified GSWA work program for 2020–21 will be structured around two main streams, both focusing on creating and adding value for the resources industry through data-driven exploration:

1. **Accelerated Geoscience** – a program of accelerated geoscience data synthesis and delivery, in areas of new or emerging mineral potential including areas with critical mineral prospectivity.
2. **Business improvement** – a series of short-term, big-win, data synthesis projects that aim to increase mineral prospectivity across the State by integrating pre-existing geoscience datasets and delivering them in ways which can be utilized by exploration companies to develop and generate new exploration targets.

## Accelerated Geoscience program

The Accelerated Geoscience program will see dedicated geoscientists from across GSWA concentrate their efforts on four main projects:

- Publication of existing data into GIS layers
- Data integration and analyses – the Yilgarn Craton
- Statewide critical minerals prospectivity study
- Energy systems including petroleum, geothermal and carbon capture and storage.

The results will be published online as GIS layers available in current GSWA systems, and within three standalone GEP. These will include a Southwest Yilgarn GEP, East Yilgarn GEP and Critical Minerals GEP, which will facilitate use for all levels of technical competency and software, from prospectors to Tier 1 companies.

### Publication of existing data into GIS layers

This project will deliver numerous, previously non-digital datasets as new, spatial datasets. The outcome will improve our understanding of the prospectivity of the State which will feed into other projects in the Accelerated Geoscience stream.

### Data integration and analyses – the Yilgarn Craton

The Yilgarn Craton is one of Western Australia's most prospective regions, and contains significant deposits of gold, nickel, lithium, copper–zinc, iron ore, tantalum, aluminium and uranium. Recent high-grade gold and nickel discoveries in the craton's far eastern (Gruyere, Tropicana, Neale) and southwestern margins (Julimar), have shown that these two poorly exposed and geologically not well-understood regions are likely to be as prospective as the craton's interior (i.e. Eastern Goldfields). Despite both regions being covered by a thick blanket of regolith, GSWA holds a vast amount of geoscientific data relating to the bedrock and regolith geology with the potential for uncovering significant, new mineral deposits.

The minerals industry is increasingly aware that the new era of Tier 1 deposits is likely to be under deep cover. Working to the UNCOVER plan, the Accelerated Geoscience program will deliver new integrated geoscience datasets for the southwest and far eastern Yilgarn Craton margins. The work will incorporate the results of ongoing work in the Eastern Goldfields, as well as performing new analyses on archived samples, which will accelerate our understanding of these regions and will define new areas of high mineral prospectivity.

### Statewide critical minerals prospectivity study

Both the State and Federal Governments have outlined a list of minerals that are deemed critical for emerging high-tech applications and that are considered essential for economic and industrial development over the next decade. Western Australia is well placed to capitalize on increasing demand for critical minerals as we transition globally to low-carbon technologies. Knowledge of the geological addresses where these deposits are likely to be located not only reveals emerging exploration plays but allows the government the foresight to manage land for strategic industrial purposes such as downstream processing.

The aim of this project is to catalogue the known critical mineral resources of the State to better understand the mineral systems in which they occur and the associated alteration systems. These genetic associations can then be explored in existing GSWA datasets to provide a series of prospectivity maps for individual critical minerals. The results aim to stimulate and increase investment into the critical minerals sector by defining new exploration targets and opening up new parts of the State to exploration.

### **Energy systems**

This project will investigate the prospectivity of the State's potential energy resources and will include low-carbon technology and geothermal projects.

The petroleum industry has been one of the most affected by COVID-19, having a simultaneous supply and demand shock caused by an oil price war that coincided with the start of the pandemic. This project aims to produce a graphical summary of the State's well data in addition to other GIS layers that will directly benefit petroleum industry exploration. Other initiatives relate to decarbonization such as CO<sub>2</sub> geosequestration.

## **Business improvement program**

This program aims to streamline our digital business by synthesizing and publishing key, spatial digital datasets to enhance the mineral prospectivity of the State.

## **Products planned for release**

- Numerous raw and interpreted spatial geoscience data layers highlighting the mineral and petroleum prospectivity of key areas of the State, delivered online in GeoVIEW.WA
- Standalone Southwest Yilgarn Geoscience Exploration Package (USB)
- Standalone East Yilgarn Geoscience Exploration Package (USB)
- Standalone statewide critical minerals Geoscience Exploration Package (USB)

# PART TWO

## Detailed work programs



# GS10 Energy Geoscience and Carbon Strategy

*Manager: Deidre Brooks*

*Team members: Norman Alavi, Richard Bruce, Louisa Dent, Ameer Ghori, Peter Haines, Arthur Mory, Leon Normore, Charmaine Thomas, Yijie (Alex) Zhan*

The primary goal of the Energy Geoscience and Carbon Strategy branch is to develop consistent, basinwide stratigraphic, structural and petroleum system frameworks for Western Australia's onshore sedimentary basins. The aim is to encourage increased exploration for energy resources such as petroleum, coal and geothermal energy resources, as well as identify areas for potential CO<sub>2</sub> sequestration and thus secure the State's energy future.

The team works in collaboration with other divisions of DMIRS and other organizations, including the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Western Australian Energy Research Alliance, The University of Western Australia (UWA), Curtin University, Northern Territory Geological Survey (NTGS), Geological Survey of South Australia, Geological Survey of New South Wales and Geoscience Australia (GA).

The current focus of the branch is the Amadeus, Canning, Carnarvon and Perth Basins. All these basins have proven petroleum systems but are underexplored, particularly in the case of the vast Canning Basin and the Western Australian side of the Amadeus Basin. The branch has recently commenced a new geological assessment of the Officer Basin and is interpreting results to better understand the petroleum potential.

During the 2020–21 financial year, GSWA is committed to accelerating geoscience projects that can deliver meaningful data in useful formats to the energy and minerals industries. This is to assist the take up of company exploration following the COVID-19 economic disruption and the oil price crash of early 2020. The projects described below are categorized as belonging to 'business as usual', because the Accelerated Geoscience program is included in a separate section of this Record. A list of projects that have been delayed due to the Accelerated Geoscience program is also presented.

The Energy Systems Atlas is an Accelerated Geoscience project that will be established during 2020–21. This atlas will consist of GIS layers within GeoVIEW.WA and the Western Australian petroleum and geothermal management system (WAPIMS) relating to energy such as oil, gas, geothermal, CO<sub>2</sub> sequestration, helium and hydrogen. Layers showing data availability, plots of key data types, and existing structure maps will be the focus for the year. Other interpretive information will be added as studies are completed in future years.

A key 'business as usual' project the branch will continue to be involved with in 2020–21 is the post-well analysis and interpretation of Waukarlycarly 1 (see ES47 Petroleum Systems), a stratigraphic well drilled in the Waukarlycarly Embayment during 2019, in the western margin of the Canning Basin. The drilling of this well was funded by the Commonwealth Government Exploring for the Future

program (EFTF) and was operated by DMIRS, in particular the geoscientists within this branch. A related ES47 project that will continue in 2020–21 is the interpretation of the Kidson Sub-basin seismic survey, which was acquired in 2018 and co-funded by the EIS and EFTF.

## Planned work program

### Business as usual projects

Projects listed at the end of this section were the focus of geoscience studies during 2019–20 and will be released in 2020–21. All data produced from these projects will be incorporated into the Energy Systems Atlas.

Projects that will continue to provide relevant data that can eventually feed into the Energy Systems Atlas in future years include: compilation of a Digital Core Atlas for Waukarlycarly 1 and Nicolay 1 (both in the Canning Basin); age and composition of the basement underlying the Canning Basin; structure, stratigraphy and prospectivity of the Amadeus Basin; Permian and Triassic source rocks of the Carnarvon Basin; sedimentological description of the Harvey 2, 3 and 4 cores; Mesozoic unearched book; Perth Basin field guide.

### Projects on hold for 12 months due to Accelerated Geoscience projects

- Compilation of data and a review of the Lucas Outlier and Prices Creek Group of the Canning Basin based on fieldwork
- Stratigraphy and correlation of the Fairfield Group
- Stratigraphy and biostratigraphy of the Permian Byro Group (Carnarvon Basin)
- Bonaparte Basin Carboniferous stratigraphy

## Products planned for release

- Middle Carboniferous – Permian (Grant Group and Reeves Formation) palynostratigraphy (Report)
- Cobb Embayment of the Canning Basin (Record)
- Sally May 2 Digital Core Atlas (digital product)
- 3D structural model of the southern Perth Basin (digital product)
- 3D structural model of the southwest Canning Basin (digital product)
- Petroleum source rocks of Western Australia (Report)

# GS12 Land Use Planning

*Manager: Samantha Carter  
Land Use Management: Mike Critch*

*Land Use Geoscience: Steven Batty, Mark Fleming, Jordana Gardiner-Haukohl, David Hamdorf,  
Shane Kenworthy, Lisa Kirby, Kevin Ridge, Hannah Wallace*

Land Use Planning plays a key role in providing geological information, advice and approval to assist in government decision making related to the most appropriate use of land. The provision of relevant geological information to State and local government authorities, planners and the community contributes to Western Australia's economic sustainability and helps to ensure that the interests and rights of all parties are recognized.

Proposals for land subdivisions and other land use changes are routinely received from State and local government authorities. Each proposal is examined, its implications for access to mineral and energy resources assessed, recommendations, advice and, where necessary, approvals made accordingly.

Roles of the Land Use Planning branch include:

- providing geological input to other government activities such as mapping, and advice to support planning policies, strategies and schemes
- providing approvals and recommendations for proposed land tenure and land use changes throughout the State
- assisting with the development of land use planning policy both within DMIRS and across government
- publishing resource potential for land use planning mapping and the provision of mapping of strategic basic raw materials, and other strategic mineral and petroleum resources, for inclusion into State planning policies, and regional and local planning strategies and schemes.

## Planned work program

The branch will continue to provide information, advice, assessment and approval in response to routine requests from other government agencies, and continue to be involved in the following priority government projects:

- South West Native Title Settlement
- Plan for our Parks conservation initiative.

Funding will continue for the South West Native Title Settlement project to fund one additional geologist to facilitate the branch's role in this project. It is anticipated that there will continue to be substantial land approvals and recommendations associated with this project.

Plan for our Parks is a major conservation initiative comprising a minimum of five million hectares of new conservation reserves.

The branch will continue to engage collaboratively with other government agencies, including local government to help to clarify roles, streamline administrative arrangements and to provide strategic land use planning advice.

## Product planned for release

- Aboriginal land, conservation areas, mineral and petroleum titles and geology, Western Australia – 2021 (map)

# GS14 Statutory and Resource Information

*Manager: Nicole Wyche*

*Team members: Cecilia D’Ercole, Amanda Jones, Sue Murray, Jutta Pagel, Sarah Sargent, Caroline Strong*

The Statutory and Resource Information (SRI) branch tracks mineral exploration and mining activities in Western Australia by collating data on mineralized sites, exploration and mining projects, mineral resources and mineral production. This allows DMIRS to provide data and specialist technical advice on most mineral commodities. Data users include other DMIRS divisions, other government agencies, research organizations and a range of industries and individuals. The SRI branch also has a regulatory role, performing compliance assessments relating to the *Mining Act 1978* and related legislation and providing industry advice.

A key component of this work is the maintenance and enhancement of Western Australia’s mines and mineral deposits information database (MINEDEX). MINEDEX is a core DMIRS business system that provides a broad range of searchable data on minerals industry activity (current and historic), and hosts compliance documents such as environmental registration files. MINEDEX provides spatial and textual data for internal use, and public data is made available for external users. MINEDEX also generates unique site and project identification codes used throughout DMIRS to reference activities for compliance reporting in departmental business systems, including the Environmental Assessment and Regulatory System (EARS), the Royalties Management System (RMS) and the Safety Regulation System (SRS). MINEDEX also provides nightly updates of spatial data for use in DMIRS spatial data applications, including TENGRAPH and GeoVIEW.WA, and provides data downloads via the Data and Software Centre.

Compliance applications processed by the branch include mineralization and resource reports submitted in support of mining lease applications, applications for expenditure exemptions, extensions of term, retention licences, retention status, combined reporting and special prospecting licences. The branch also assesses sterilization reports submitted with mining proposals.

The SRI branch also produces commodity-related publications including the annual Mines — operating and under development and Major resource projects maps, the Atlas of mineral deposits and major petroleum resources book and map (produced every second year), investment opportunity commodity flyers, and posters showcasing trending exploration results.

## Planned work program

In 2020–21, the branch will focus on the following core business tasks:

- population of MINEDEX with current industry activity data
- management of the RMS production report and the data generated by this report
- servicing other DMIRS databases via MINEDEX data
- completion of the Mining Act and related assessments
- providing specialist information to internal and external stakeholders on mining industry activities
- specialist publications (see product list below).

## Business improvement

The following projects are planned to improve our service delivery:

- MINEDEX training has been added to the DMIRS online systems training schedule
- MINEDEX SQL reports used to extract resource estimate data from MINEDEX will be improved and documented with the goal of making this information easy to extract. This work is required in preparation for future applied projects (e.g. live map layers of resource estimates)
- Production of the Major projects map will be revised to make this product more consistent.

## Products planned for release

- Major resource projects, Western Australia 2021 (map)
- Mines – operating and under development, Western Australia 2021 (map)
- Significant exploration activity in Western Australia (poster for GSWA Open Day and Diggers and Dealers)
- Atlas of mineral deposits and major petroleum resources (book and map)
- Investment opportunity/commodity flyers

# GS20 Mineral Systems Studies

*Manager: Trevor Beardsmore*

*Team members: Paul Duuring, Joshua Guiliamse, Lena Hancock, Sidy Morin-Ka*

The Minerals Exploration Geoscience branch focuses on mineral systems in Western Australia, with the objectives of building metallogenic models and improving our understanding of the geodynamic environment of ore formation, thereby assisting with making exploration targeting in greenfields areas more predictive. Such work typically involves fieldwork (mapping, core logging and sampling) and laboratory studies (petrology, geochronology and isotope chemistry), and is supported by, and supplements, existing databases. The branch makes extensive use of the GSWA HyLogger (Project GS95) to assist with detailed studies of alteration assemblages in diamond drillcore and other specimens from mineral deposits. The work in this area has been complemented by projects funded by the EIS (reported herein under ES43 Mineral Systems). All mineral systems knowledge is ultimately made available for the benefit of resource companies, research groups, other government agencies and the wider community. This knowledge is disseminated via Geological Information Series (GIS) packages, and internal and external publications.

## Planned work program

The branch has a well-established program that studies Western Australian terrane-scale metallogeny and selected mineral systems, to provide new knowledge that assists with prospectivity evaluation and targeting of mineralization. Current projects include:

- metallogeny of hydrothermal rare earth element (REE) mineralization in northern Western Australia
- regional prospectivity for orthomagmatic (komatiite- and mafic intrusion-hosted) nickel sulfide deposits
- evaluating prospectivity for bedrock gold systems using detrital gold ‘fingerprinting’
- targeting Archean banded iron-formation (BIF)-hosted iron ore systems
- metallogeny of the Paterson Orogen.

The branch integrates these activities with other GSWA geoscience programs. It also works with other government and academic institutions, and an expanding network of affiliated exploration and mining companies via collaborative Mineral Systems-oriented research projects funded by the EIS (see ES43 Mineral Systems).

The branch also continues to develop its recently created online Mineral Systems Atlas and associated Guide. The Atlas contains GIS-based map layers of significant geological ‘proxies’ for critical metallogenic processes, for the komatiite-hosted nickel and BIF-hosted iron mineral systems. Other mineral systems are being systematically analysed (drawing upon other in-house and external expertise where possible), and readily created subsets of defined mappable geological proxies are being created.

The rare-element pegmatite and orthomagmatic vanadium systems will be added to the Mineral Systems Atlas in 2020–21. The branch will also continue its involvement with current EIS-funded collaborative studies, including the ‘gold fingerprinting’ study of gold nuggets from the Pilbara Craton (see ES43 for a project description). The Paterson Orogen metallogeny study will complement GSWA’s contribution to Projects 8 and 9 of the Mineral Exploration Cooperative Research Centre (MinEx CRC; see ES36 Participation in MinEx CRC), by documenting the geological setting and characteristics of Cu–Au mineralization (e.g. at the Obelisk and Citadel prospects), using drillcore stored at the Perth Core Library and sourced from resource companies working in the region.

The other ‘regular’ Mineral Systems programs will be placed on hold for 2020–21, and the branch will instead be integrated into GSWA’s Accelerated Geoscience initiative, a program of rapid data delivery developed to support the recovery of the resources industry during and beyond the COVID-19 pandemic. The branch will lead Project C — critical minerals prospectivity — tasked with delivering GIS-based data packages relevant to REE, lithium, tantalum, potash and other critical mineral mineralization. Branch staff will also lead or be involved in mineral systems-oriented themes in most other Accelerated Geoscience projects. See Part one Economic recovery program for a complete description of the initiative.

## Products planned for release

- Rare-element pegmatite and orthomagmatic vanadium mineral systems (added to the Mineral Systems Atlas and Guide)
- Mineralization characteristics of the Obelisk Cu–Au prospect (Report)



# GS52 East Yilgarn

*Manager: Jyotindra Sapkota*

*Team members: Matthew De Paoli, Melissa Drummond*

The Eastern Goldfields Superterrane (EGST) occupies the eastern third of the Archean Yilgarn Craton and is widely considered a typical Archean upper crustal granite–greenstone terrane. This highly mineralized region contains world-class gold and nickel deposits, and significant deposits of other commodities including base metals, REE, lithium, uranium, gemstones and industrial minerals.

The EGST is divided into four tectonostratigraphic terranes bounded by high-strain zones; from west to east: the Kalgoorlie, Kurnalpi, Burtville and Yamarna Terranes. The present terrane configuration is traditionally interpreted to reflect accretion of a number of pre-existing ‘continents’ in a series of collisional events between c. 2800 and 2650 Ma. The effects that mantle plumes may have had on the magmatic stratigraphy of the greenstones is reflected by the local abundance of komatiites and associated basalts. However, systematic geological mapping and the acquisition of a substantial body of geochronological and geochemical data, indicate that evolutionary models involving rifting of an autochthonous basement also need to be (re)evaluated. These different models can lead to different interpretations of the nature of magma source regions and the evolution of trans lithospheric structures that form pathways for mineralizing magmas and fluids.

Basalt-dominated greenstone sequences are mapped, intersected in drillcores and recognized in geophysical surveys throughout the EGST. However, linking geological events (e.g. depositional/crystallization or deformation events), stratigraphy or structures within and between individual greenstone belts remains one of the most significant challenges towards a better geological understanding of the region. Only in the Kalgoorlie Terrane, between Norseman and Agnew, has a significant stratigraphic correlation been attempted. Here, most of the exposed greenstones belong to the 2801–2690 Ma Kalgoorlie Group, which comprises the lowermost mafic–ultramafic sequence in most individual greenstone belts. These sequences are not physically contiguous but have a broad similarity in rock types, stratigraphic variations and age, and so have been distinguished as subgroups of the Kalgoorlie Group. Greenstone

sequences older than 2800 Ma are also locally exposed around Leonora (~2817 Ma), Menzies (>2803 Ma) and Norseman (~2930 Ma). Above the Kalgoorlie Group, the Black Flag Group (2690–2665 Ma, equivalent to the Mount White Group in the Agnew–Lawlers region), comprises mainly turbidite-type deposits, and felsic volcanic and volcanoclastic rocks. Younger siliciclastic to felsic volcanoclastic sequences, such as the Scotty Creek Formation (Agnew–Lawlers region), the Navajo Sandstone (southwest of Kalgoorlie), the Merougil Formation (west of Kambalda), and the Kurrawang Formation, overlie the Black Flag Group along low-angle unconformities.

## Planned work program

Work aimed at generating a seamless bedrock stratigraphic interpretation across the EGST at 1:100 000 scale (Fig. 1) is currently suspended. Geological studies in 2020–21 will focus on the area covered by the high-resolution seismic survey conducted in early 2019 by GSWA, between Ora Banda and Kambalda. Detailed structural, metamorphic, geochemical, geochronological and isotopic data will be collected from outcrop and diamond drillcore to support the geological interpretation of the seismic data, together with the formulation of a model for the geological evolution of the area. After field verification, the available company geological maps and drillhole data will be used to consolidate GSWA’s mapping and stratigraphic interpretation in selected areas. The greenstone geochemical barcoding program will work towards a geochemical fingerprint of local to regional magmatic greenstone stratigraphy and support regional correlation. Work is ongoing to create a virtual field guide of important geological localities in the East Yilgarn.

## Products planned for release

- East Yilgarn GIS 2020 (including updated interpreted bedrock geology layers across the northern part of the region imaged by the seismic survey)
- Explanatory notes and stratigraphy update

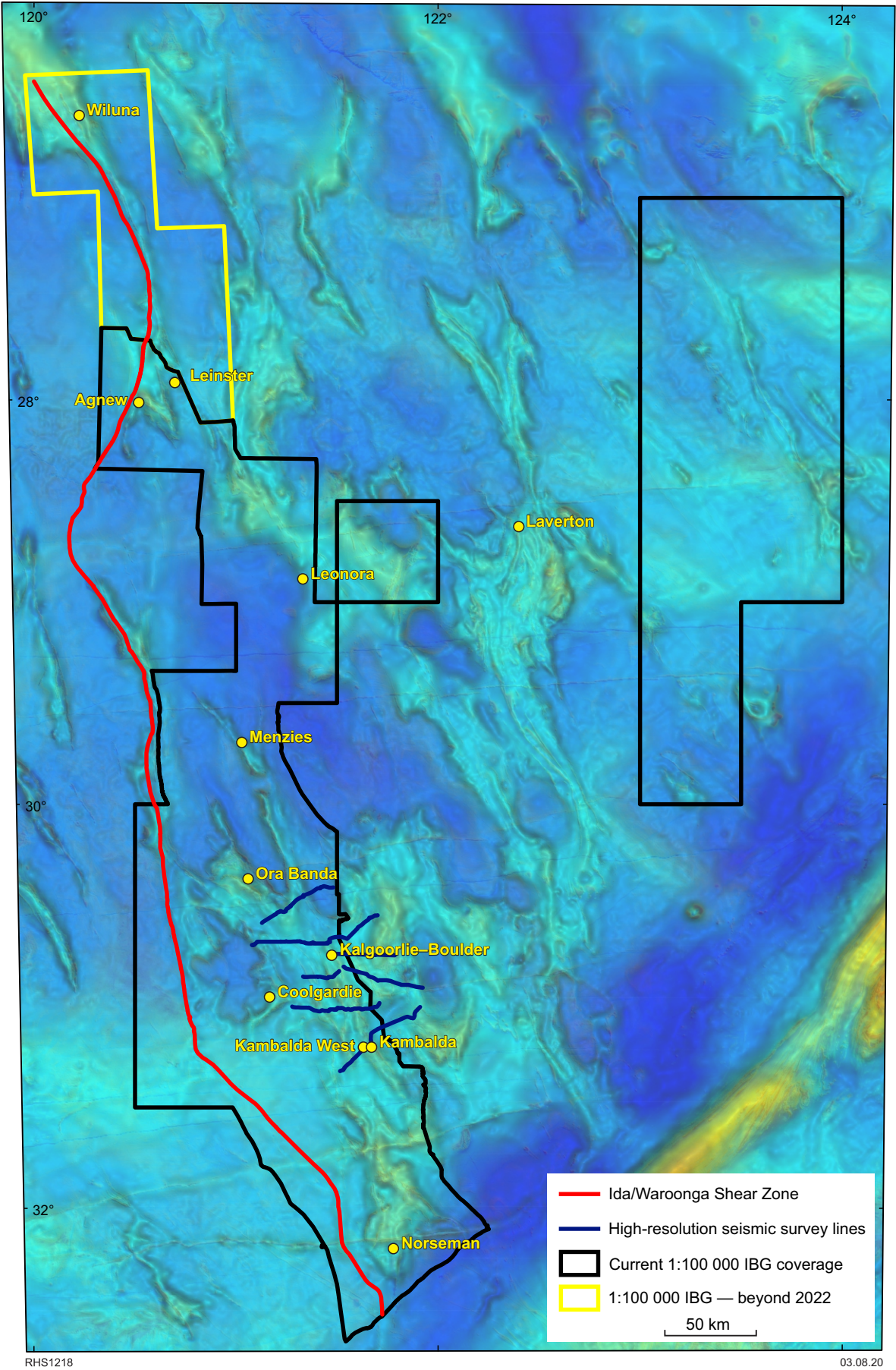


Figure 1. Outline of completed and planned bedrock geology mapping, East Yilgarn project, draped over a composite gravity-aeromagnetic image. Abbreviation: IBG, interpreted bedrock geology

# GS53 State Geoscience and Chief Geoscientist

*Manager: Fawna Korhonen*

*Team members: Heidi Allen, Huntly Cutten, Terry Farrell, Sarah Martin, Angela Riganti*

The State Geoscience branch is responsible for maintaining a coherent geological framework for Western Australia and ensuring that the geoscience information delivered by GSWA is relevant, appropriate and of a high standard. This includes delivering GSWA geoscience as multithemed products developed and extracted from information stored in GSWA databases, with single-layer datasets, documents and static, printed or downloadable maps only part of the total product. The role of the State Geoscience branch in achieving this are twofold. They work with project teams and groups as appropriate, guiding and overseeing development and population of GSWA databases, coordinating capture of spatial and textual legacy data, contributing to products as appropriate, validating database content, reviewing and approving manuscripts and spatial products, and coordinating work that spans more than one project. They work independently on geological problems not part of current GSWA project work and on statewide geological issues and datasets. To that effect, in mid-2019 a new Paleontology section was added to the branch in order to address paleontological and geoheritage issues more efficiently and effectively across the State. The work of the State Geoscience team is thus partly process, with definable standards but no clearly defined outcomes, and partly program, for which there are outcomes. Explanatory Notes System (ENS) content management and monitoring, legacy data capture and management of quality control and product relevance are the processes; whereas outcomes and products arise from delivery of State-level datasets.

## Planned work program

The planned work program for 2020–21 will be significantly reduced, with much of the State Geoscience team focused on the Accelerated Geoscience program.

Despite this, a number of ‘business as usual’ activities will continue resulting in the annual release of the Western Australian field observation database (WAROX); an update to the 1:500 000 tectonic units and orogenic events layers in GeoVIEW.WA; and the completion of a geochronology, isotope and mineral chemistry (WAGIM) database that will allow all external stakeholders to access and search our extensive geochronology and mineral chemistry data as well as access the geochronology and metamorphic history records. The paleontology section will continue work on statewide issues including the palynology of the southern Perth Basin and the paleontology and stratigraphy of the Kalbarri area. Considerable time will be invested in cataloguing the current condition of the State’s vulnerable geoheritage sites along with improving approval and permitting times.

## Products planned for release

- Update of the 1:500 000 tectonic units and orogenic events layers in GeoVIEW.WA
- Completion of the geochronology, isotope and mineral chemistry database (WAGIM)
- Ongoing paleontology analysis including interpretation on the Waukarlycarly 1 stratigraphic drillhole
- Extended ENS content (including regolith)
- Delivery of geochronology and metamorphic history records through ENS
- Kalbarri unearthed (non-series book)



# GS54 Geochronology and Geochemistry

*Manager: Michael Wingate*

*Team members: Imogen Fielding, Frances James, Jack Lowrey, Yongjun Lu, Marlene Papiccio, Sandra Romano, Tom Scillieri, John Williams*

Geochronology, isotope geology and geochemistry are integral components of GSWA's geoscience programs and mineralization studies. The geochronology program determines precise and accurate ages of minerals, rocks and geological events to understand the geological history of Western Australia and contribute to enhancing the prospectivity of the State. Geochemical studies of rocks and regolith are essential for understanding the sources and petrogenesis of igneous suites, the relationships within and between igneous suites, the sources (provenance) and compositional characters of sedimentary rocks and regolith, and for constraining metamorphic modelling.

Geochronological techniques are applied to constrain the timing of magmatism, metamorphism, deformation and mineralization, using a range of isotope systems (e.g. U–Pb, Ar/Ar and Re–Os) and a variety of minerals (zircon, baddeleyite, monazite, titanite, hornblende, feldspars and micas). The Sensitive High-Resolution Ion Microprobe (SHRIMP) instruments in the John de Laeter Centre at Curtin University are used extensively by GSWA for U–Pb geochronology. GSWA also uses laser ablation inductively coupled mass spectrometry (LA-ICP-MS) instruments in the John de Laeter Centre to date detrital zircons, to date monazite and xenotime in thin sections in support of metamorphism and pressure–temperature–time (P–T–t) studies, and to measure the trace element compositions of minerals.

Whole-rock geochemistry is typically carried out for the complete set of major element oxides and a large suite of trace elements, but may also be restricted to certain element

groups (e.g. precious metals, platinum group elements) depending upon project requirements. Analytical services are outsourced to several Perth-based laboratories with the main techniques applied being X-ray fluorescence (XRF) spectrometry for major elements and some trace elements, and ICP-MS for trace elements. All data are compiled in the WACHEM database and made available through the online GeoChem Extract application.

Geochronology and geochemistry results and derivative materials are used extensively in GSWA's isotope geology studies, led by Yongjun Lu (see ES46 Enhanced Geochronology and Isotopic Mapping). These include specialized isotope geochemistry studies, including whole-rock Sm–Nd, Lu–Hf and Pb isotope analyses, zircon Lu–Hf and oxygen isotope analyses, and Re–Os mineral analyses. These investigations are conducted in collaboration with external university laboratories.

The Laboratory section, managed by John Williams, supports the varied aspects of GSWA's geochronology, geochemistry and isotope geology programs with world-class sample preparation services provided in house by the GSWA laboratory at Carlisle. The Laboratory section also manages archiving and retrieval of materials in GSWA's extensive sample collection to support numerous in-house and external research projects, and coordinates petrographic services for geologists.

Project work for GS54 is funded through ES46. Accordingly, details of the work program are discussed within ES46.

# GS55 Geophysics Acquisition and Processing

*Manager: David Howard*

*Team member: John Brett*

The role of the Geophysics Acquisition and Processing section is to plan and manage regional geophysical data acquisition projects, to prepare datasets for delivery to the public and internal users, and to provide internal processing, interpretation services and advice as required.

The section will continue to manage the airborne geophysics index data repository (MAGIX) and the submission, archive and release of airborne and some ground survey datasets supplied by the exploration industry.

## Planned work program and products

The planned acquisition program for 2020–21 is described separately under program ES30 (Airborne and Ground Geophysical Surveys). All new data acquired will be included in updates to the relevant statewide compilation datasets.

# GS58 West Yilgarn

*Manager: Tim Ivanic*

*Team member: Jack Lowrey*

The Youanmi Terrane in the western part of the Archean Yilgarn Craton comprises an extensive Archean granite–greenstone terrain that contains significant deposits of gold, iron ore, nickel, copper, lead, zinc, tungsten, molybdenum, bismuth, vanadium, titanium, beryllium, lithium, tin, tantalum and uranium. The region clearly has the potential for more discoveries of these commodities. The Youanmi Terrane has a long and complex geological history. An understanding of the tectonic evolution of the region, including its structure and stratigraphy, is essential to understanding the controls on formation and distribution of mineralization.

Youanmi Terrane greenstones were deposited between 2.99 and 2.71 Ga and can be subdivided into four main time intervals:

1. 2.99 – 2.91 Ga, for example the Madoonga and Gossan Valley Formations
2. 2.82 – 2.80 Ga Norie Group
3. 2.80 – 2.74 Ga Polelle Group
4. 2.74 – 2.71 Ma Glen Group and Marda Complex.

Felsic plutonic rocks intruded during each of these time periods followed by voluminous plutonism from 2.7 – 2.6 Ga, which led to cratonization of the Yilgarn Craton. Much of the geoscientific work conducted so far in the Youanmi Terrane has concentrated on its Neoarchean greenstone sequences. However, there is a large temporal gap in the understanding of the crustal evolution of the proto-Yilgarn Craton and its architecture during the Mesoarchean from 3.1 to 2.9 Ga. Most rocks of this age within the Yilgarn Craton are in less well-known portions of the Youanmi Terrane, typically where data density is low and map coverage relatively poor.

Thus, the main objective of the West Yilgarn project is not only to expand the existing understanding of Neoarchean rocks but also add a new level of interpretation to the Mesoarchean history of the Youanmi Terrane.

This new interpretation will offer a wider appreciation of the configuration of the protocraton onto which the voluminous Norie, Polelle and Glen Groups were deposited, and through which the giant layered intrusions at 2.8 Ga were channelled. An expanded temporal framework with documentation of new magmatic suites will allow for an improved context for exploring terrane endowment by volcanogenic massive sulfide, nickel, iron and gold mineral systems.

## Planned work program

Most activities within this program will be suspended over the 2020–21 period with efforts redirected to the Accelerated Geoscience projects within the economic recovery program. However, limited geochemical and geochronological sampling will be undertaken in the southern and western Youanmi Terrane in order to target and characterize 3.1 – 2.9 Ga geology (Fig. 2). The aim is to understand the petrogenesis and geodynamic history of these rocks in relation to the existing stratigraphic and magmatic framework developed in the northern Youanmi Terrane.

Cooperative projects will continue, including geochemical, metamorphic and structural studies in the northern Youanmi Terrane, 3D modelling in the western Youanmi Terrane and structural and isotopic studies in the Narryer Terrane.

## Products planned for release

- [Youanmi Terrane stratigraphy and explanatory notes update including the Gossan Hill Formation \(Golden Grove\)](#)

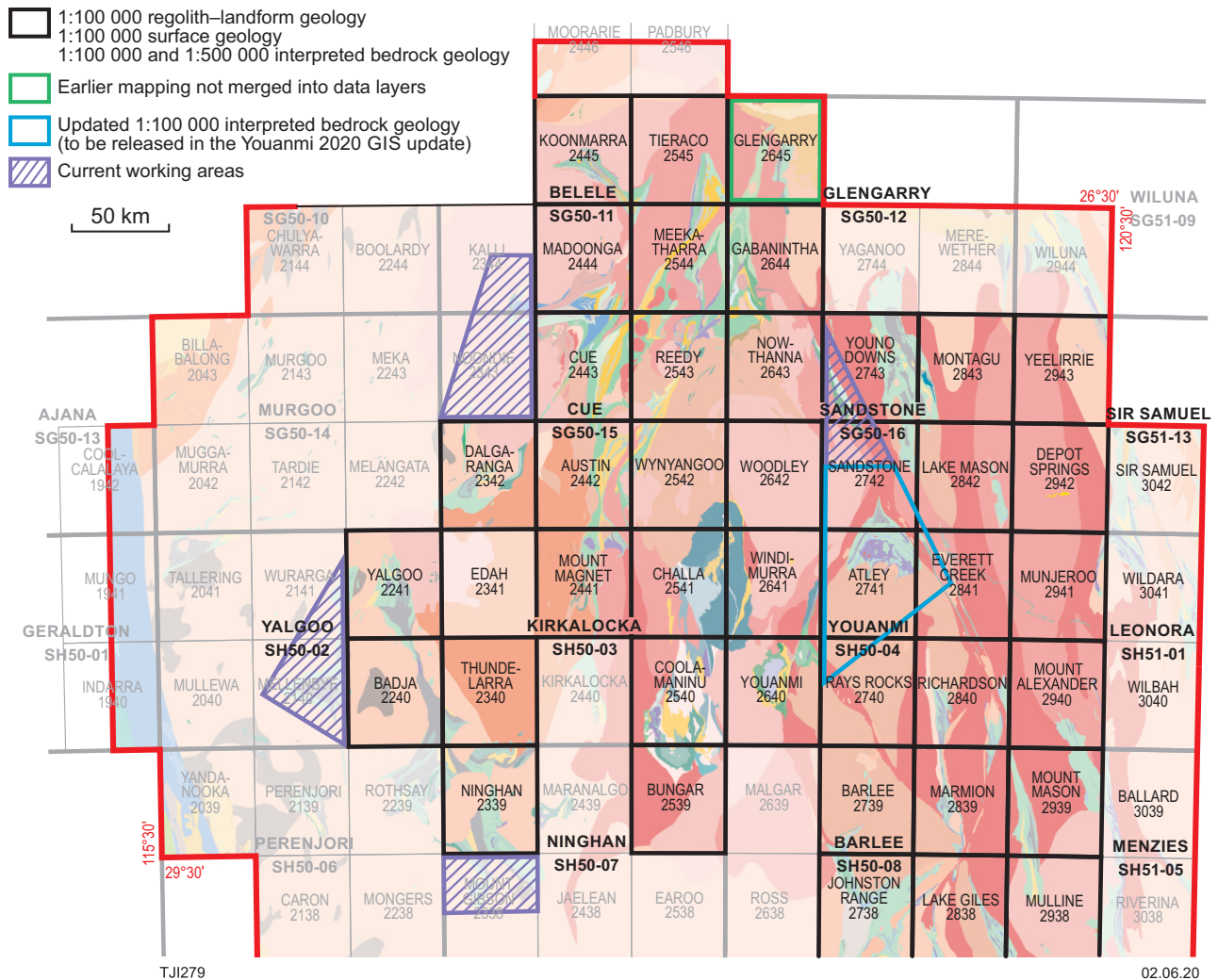


Figure 2. Simplified geological map of the northern Youanmi Terrane showing existing mapping and current working areas

# GS62 3D Geoscience

*Manager: Ruth Murdie*

*Team members: Lucy Brisbout, Klaus Gessner, Huaiyu Yuan (Macquarie University), Ivan Zibra*

The 3D Geoscience section aims to increase the knowledge of Western Australia's subsurface through the integration of geophysical, geological and geochemical data in 3D structural models. The program objective is to employ targeted structural mapping and 3D structural modelling techniques to allow the extension of knowledge from exposed and well-understood areas to inaccessible or data-poor parts of the Earth's crust and to visualize and model relevant portions of the solid Earth in Western Australia. These techniques, including 3D structural analysis, modelling and numerical simulation, will also test the validity of conceptual models and interpretations.

An important aspect of the program is cooperation with leading research institutions that complement GSWA's capabilities in data acquisition, analysis and modelling. In addition to collaborating with GA, GSWA engages with Macquarie University, the Institute of Geology and Geophysics at the Chinese Academy of Sciences (IGG-CAS), The Australian National University (ANU), the Department of Fire and Emergency Services (DFES), Monash University and UWA on passive source seismology and magnetotelluric surveys. Collaborative projects are funded through the EIS under the ES42 Lithosphere Visualization Project. 3D Geoscience activities often involve data acquired through structural mapping and passive seismic monitoring programs.

## Planned work program

The 3D Geoscience section will continue to contribute to regional mapping project teams, specifically in the area surrounding the Canning Basin and the Yilgarn Craton. Geophysical sections and detailed structural mapping will complement the seismic data acquired in the Eastern Goldfields.

Following the release of high-resolution seismic data and the acquisition of passive seismic and magnetotelluric data in the Eastern Goldfields, work will continue on the interpretation of the 2019 Kalgoorlie seismic lines using 3D visualization software and drillcore. GSWA will initiate a project to integrate these products with results from the geochemical barcoding and regional mapping activities with the ultimate goal to generate a 3D model of the Kalgoorlie area. These activities will be carried out in close collaboration with 'Yilgarn 2020' a MRIWA-sponsored, four-year project led by the Centre for Exploration Targeting (CET) at UWA.

Fieldwork is planned for the deployment of new passive seismic networks in Western Australia with the aim of defining the large-scale architecture of Western Australia.

Acquisition and analysis of passive seismic data will continue in collaboration with Macquarie University and IGG-CAS in the Pilbara Craton, Paterson Province, Wunaamin Miliwundi Orogen (formerly King Leopold Orogen), and Canning and Kimberley Basins.

Deployment of passive seismic stations will commence in the southwest Yilgarn Craton as part of a collaboration with ANU, GA and DFES for Australian Research Council (ARC) project LP180101118 Enhanced 3D seismic structure for southwest Australia.

3D geomodelling will focus on outcomes from passive seismic work carried out in collaboration with UWA, including the Capricorn Orogen passive array (COPA) and the Perth Basin project. We will continue to develop 3D stochastic modelling for the next generation of 3D modelling software by being part of ARC project LP170100985 Enabling 3D stochastic geological modelling (3D-Loop), a large Monash University-led international project for reducing risk for the resources industry.

## Products planned for release

- Step back in time to the Yangibana paleochannel: a 3D model using passive seismic data (Record, with GS64)
- Eucla basement petrophysical data and potential field modelling (Record)
- Tectonomagmatic evolution of the Ida Fault (Record)
- A passive seismic experiment in the Perth Basin, Western Australia (Report)

# GS63 Pilbara and Hamersley

*Manager: Heather Howard*

*Team members: Olga Blay, Arthur Hickman, David Martin*

The Pilbara Craton, northwest Western Australia, provides the world's best-preserved geological record of late Eoarchean to Neoarchean crustal evolution. The Eoarchean to Mesoarchean granite–greenstone terrane contains several of the world's oldest examples of porphyry-style mineralization, volcano-sedimentary base metal deposits, BIF, gold mineralization and pegmatite-hosted lithium, tantalum and niobium. It also hosts fossil evidence of the earliest life on Earth. Geological mapping of the granite–greenstone terranes at 1:100 000 scale was completed in 2005, along with a major revision of the stratigraphy, structure and crustal evolution. Current work aims to make these data more accessible in digital format.

The granite–greenstones of the Pilbara Craton are unconformably overlain by the 2775–2630 Ma volcano-sedimentary Fortescue Group and the conformably overlying 2629–2420 Ma Hamersley Group of the Mount Bruce Supergroup. This supergroup incorporates the world's best-preserved sequence of Archean ultramafic to felsic volcanic deposits, and arguably the world's most continuous transect across the Archean–Proterozoic boundary. The prominent BIF, and the contained iron enrichments, are among the most economically important mineral deposits on the Australian continent.

The stratigraphy of the Fortescue Group has been previously described in detail by GSWA and a rift to passive margin setting suggested. Mantle plumes have been proposed to explain the evolution of the Fortescue Basin. A convergent setting for BIF and mafic and felsic rocks in the upper part of the Hamersley Group has been proposed, but the debate on stratigraphic definition, tectonic setting and evolution of the Mount Bruce Supergroup remains largely unresolved.

The main objective of the Pilbara and Hamersley project is to increase our understanding of the Fortescue and Hamersley Groups in terms of their context within the

wider Mount Bruce Supergroup, and more recent work in the Capricorn Orogen. The project seeks to use significant stratigraphic and structural data to review the relationships between the volcanic and sedimentary units, integrating this with petrogenetic constraints on magmatism to better understand the tectonic evolution of the Mount Bruce Supergroup.

## Planned work program

Stratigraphically controlled, high-precision geochemical, isotopic and geochronological data will be obtained from outcrop and diamond drillhole sampling to construct a 'magmatic stratigraphy' of the Mount Bruce Supergroup in key areas that can be extended to a regional scale. Targeted mapping, particularly on the eastern margin of the Pilbara region, will be carried out and detail added to the digital map layers as it becomes available.

Work will continue towards a new release of the Northwest Pilbara GIS package to include 1:100 000 interpreted bedrock geology layers. Continued geochemical data collection and interpretation will focus on a reassessment of the tectonic setting and geological evolution of the Fortescue and Hamersley Groups to be included in new Records.

## Products planned for release

- Northwest Pilbara GIS, 2020 (includes 1:100 000-scale layers)
- Explanatory notes to accompany the 1:500 000 and 1:250 000 interpreted bedrock geology (IBG) digital map layers for the north and south Pilbara, respectively



# GS64 Geoscience Mapping Through Cover

*Manager: Richard Chopping*

*Team members: Nadir de Souza Kovacs, Emily Finch (UniSA Embedded Researcher), Sara Jakica*

Geoscience Mapping Through Cover commenced in 2018–19 and is aligned with the work of GS65 Proterozoic Margins. It is linked to ES36 Participation in the MinEx CRC, and contributes to the understanding of the MinEx CRC project area for Western Australia ('The Gap' – see GS65 Proterozoic Margins). Activities will be conducted within MinEx CRC, with support for the National Drilling Initiative (NDI), and conducted through ES36. Collaborative research will be funded through the EIS from two project areas: ES34 Regolith and 3D Paleosurface Mapping.

The mapping of different regolith types and thickness is integral to geoscience studies and exploration. Regolith mapping includes the use of orthophotos, satellite imagery (e.g. ASTER) and geophysical data that images near-surface cover (e.g. airborne electromagnetic [AEM], passive seismic) linked to field-based studies and analysis of drillcore. A scale-independent regolith–landform classification scheme has been developed and is applied regardless of the geological terrain, and a new module for regolith units has been developed within ENS. The compiled maps and documentation provide context for landscape evolution studies and dating of regolith materials, with an aim to produce 3D and 4D models of the regolith in case study areas.

Over the past decade, GSWA has demonstrated the application of single-station passive seismic (using Tromino instruments) to provide estimates of the depths to various horizons or basement in shallow cover and up to a depth of 1 km. The focus for 2020–21 will be to continue applying passive seismic approaches to understand regolith mapping using near-surface geophysics in areas of interest for the MinEx CRC drilling project and other key areas of GSWA interest. This will include coordination of work to jointly use passive and active seismic methods around recently acquired reflection lines, for example, the Kidson line in northern Western Australia or the Eastern Goldfields high-resolution seismic survey near Kalgoorlie. Additionally, joint interpretation with other available geophysics to better define thickness of cover will be undertaken to support NDI (ES36) drilling programs.

An ongoing collaborative project with the John de Laeter Centre at Curtin University is the development of the (U–Th)/He technique for geochronological analysis of secondary iron oxides in weathering systems.

Iron oxide-rich duricrust and pisolithic material form a suitable geochronological proxy that provides a time-integrated record of the weathering processes that have shaped regolith formation. The results are used to determine if the age of this material varies significantly on a regional scale, and how this relates to landscape evolution and past climatic conditions. Combined with regolith mapping, these data and their interpretations will help detect the distribution of economic mineral signatures in the cover. It is anticipated that this approach will be applied within the southern Yilgarn Craton within the 2020–21 field season, subject to access to suitable case study areas.

## Planned work program

- Regolith–landform mapping to be conducted under the auspices of any special geoscience program to support MinEx CRC NDI (ES36) drilling programs; this work will include field-based studies, legacy drillcore analysis and satellite imagery interpretation
- Further application of small-array passive seismic data acquisition to map regolith layers and paleochannels in conjunction with geophysical data, and to provide estimates of depth to basement
- Dating of regolith materials using the (U–Th)/He method, in collaboration with the John de Laeter Centre
- A targeted geochemical sampling approach, in conjunction with geochronology and geochemistry sampling, will be used during regolith mapping and regolith profile studies. This will provide information about paleoweathering patterns and local geochemical dispersion patterns from bedrock.

## Products planned for release

- State 1:500 000-scale digital regolith map – new compilation methodologies (Record)
- Assessment of the Kimberley ASTER Version 2: geoscience products for regolith–landform mapping (Report)
- Step back in time to the Yangibana paleochannel: a 3D model using passive seismic data (Record, in collaboration with GS62 3D Geoscience)



# GS65 Proterozoic Margins

*Manager: Raphael Quentin de Gromard*

*Team members: Dave Kelsey, Chris Phillips*

The Proterozoic Margins section amalgamates the activities of the former GS56 North Australian Craton and GS61 Albany–Fraser Orogen and Eucla basement projects, and resides within the 4D Geodynamics branch. The primary objective is to investigate and map the geology of the remote greenfields regions in the vicinity of the Northern Territory and South Australian border (Fig. 3), informally known as ‘The Gap’, and to provide essential data and knowledge towards GSWA’s commitment to the NDI of the MinEx CRC (see GS64 and ES36). Collaborative projects with leading research institutions will be funded through the EIS under the ES38 Proterozoic Margins project.

Much of the region is covered by younger basins and regolith, and a major component of the work program of ES38 is to interpret geophysical data and produce interpreted bedrock geology maps. This work incorporates knowledge gained from field mapping and drillcore analysis, with particular emphasis on using EIS co-funded drillcore housed at the Perth Core Library. The project builds on the successful approach developed in the Albany–Fraser Orogen and Eucla basement projects. Currently, the West Arunta region and the Paterson Orogen are the main focus of new work, while structural and metamorphic analysis of the east Albany–Fraser Orogen is continuing, although these projects will be slowed this financial year to focus on the economic recovery program.

One of the aims of the Proterozoic Margins section is to open up new frontiers in mineral exploration by understanding the magmatic, sedimentary and tectonic environments. This provides fundamental information to enable exploration teams to evaluate prospectivity and generate new project areas, and search for potential targets.

## Planned work program

Although a large proportion of resources will be focused towards the economic recovery program, limited sampling and analysis of diamond drillcore from the West Arunta and Paterson Orogens will continue. This work links with the activities of the MinEx CRC and the MRIWA M521 project (CET, UWA), which is focusing on basin evolution, geophysical data interpretation and numerical modelling.

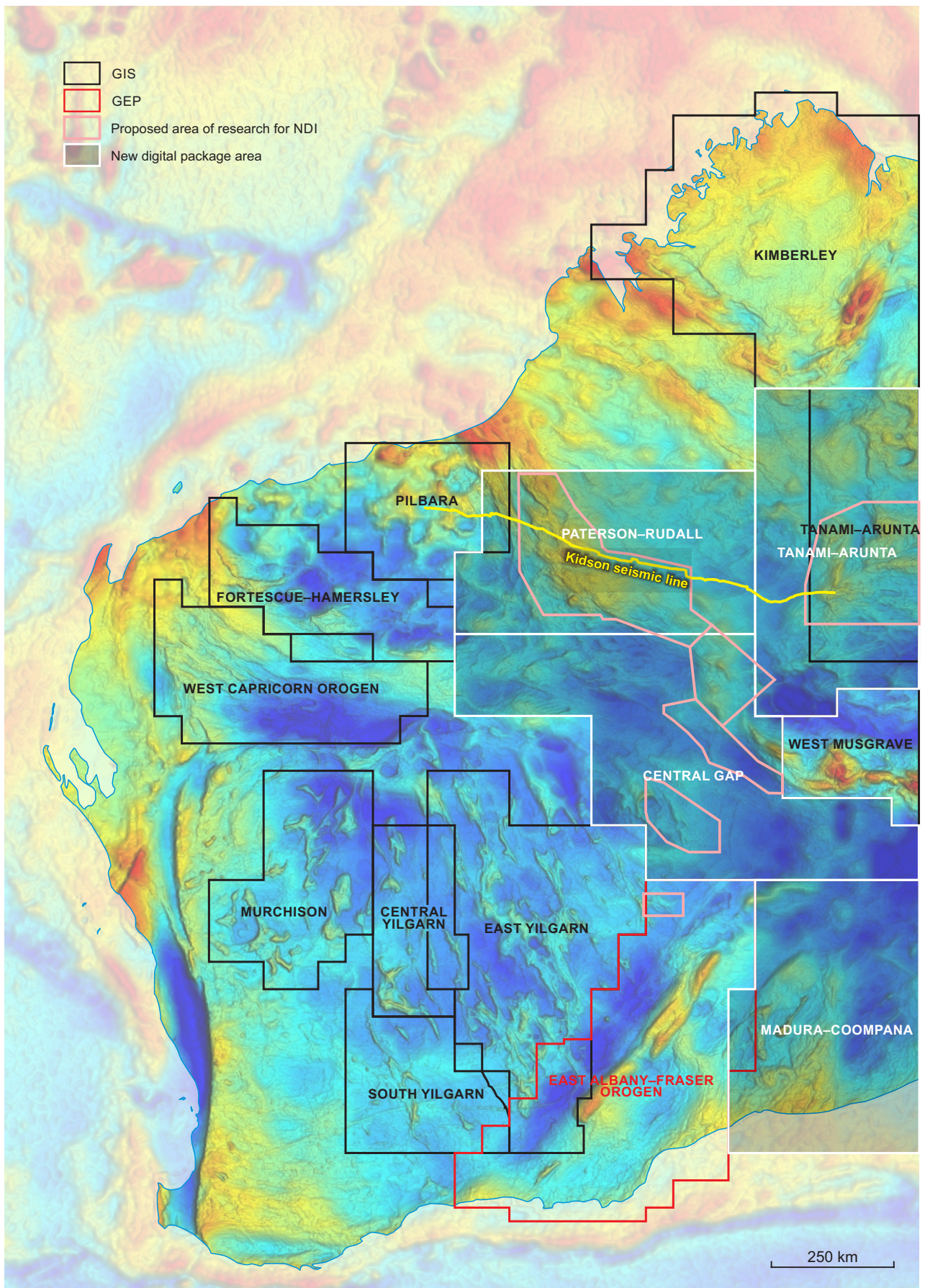
In the east Albany–Fraser Orogen, detailed structural and metamorphic analysis is in progress, with emphasis on defining and understanding the events of the Mesoproterozoic Albany–Fraser Orogeny and their links to mineralization, and the kinematic and magmatic history of crustal-scale shear zones. This work links with the now-completed MRIWA M470 project (Curtin University), and with its successor, MRIWA M470a.

Detailed work on drillcores from the Eucla basement is complete.

The progressive extension of the digital 1:250 000 Geological Series mapping of the Kimberley region will be suspended until next financial year. Fieldwork will recommence in the 2021–22 financial year, and will mark the start of a new focus on the Tanami region of northern Western Australia, beginning with mapping in the Mesoproterozoic Birrindudu Basin. Targeted stratigraphic logging and sampling for detrital zircon geochronology through sedimentary units in the Birrindudu Basin will redefine a currently poorly understood area of Western Australia.

## Products planned for release

- ENS entries for the Kimberley Basin
- Sedimentology and stratigraphy of the Kimberley Basin (Report)
- Hart–Carson Large Igneous Province, Kimberley Region (Report from external authors)



CS439

29.05.20

Figure 3. Gravity image showing the project areas covered by ES38 in red outlines. The region is informally defined as 'The Gap', reflecting the basement regions between the North Australian, West Australian and South Australian Cratons



# GS80 Editing and Publishing

## GS81 Mapping and Events

## GS82 Graphics

## GS83 GIS Services

## GS84 Spatial Systems

## GS87 Data Capture

## GS88 Data Integrity

## GS89 Spatial Projects

## GS90 Native Title

*General Manager: Stephen Bandy*

*Team members: Ireen Akter, Matt Aravidis, Ryan Aston, John Bennett, Dennis Bettesworth, Xavier Bezu, Robin Bower (Manager GS80), Derek Canham, Shaun Coldicutt (Manager GS81), Neil Dinnison, Sean Doherty, Greg Dutkiewicz, Bhumita Fadadu, Annick Francois, Kiran Gavni, June Graham, Erin Gray, Kay Greenberg, Wendy Hampton, Gary Hartley, Bec Hitchings, Joe Hogen-Esch, Dean Hubbard, Stewart Jefferys, Callan Joiner, John Kirk, Jason Knott, Irena Lesiak, Deenikka Loprese, Leo Liu (Manager GS84), Annabelle Lopez, Frank Matera, Sue Mulligan, Sreedhar Nallan, Lucio Poallotta, Suzanne Panton, Andrew Pollard (Manager GS90), Michael Prause (Manager GS82), Tanya Quaglia, Amanda Roscoe, Phil Sinagra, Martin Stephen, John Stevens, Bernd Striewski, Adam Symonds, Dale Rayner, Daniel Then (Manager GS83), Brad Tapping, Craig Wainwright (Manager GS87 and GS88), Stephen White, Graham Wyles*

Experienced, well-qualified staff are critical to the quality and delivery of geoscience and titles information. These staff members include geoscience editors, cartographers, graphics officers, product designers, desktop publishers, database managers, geospatial officers, online coordinators, business analysts and GIS specialists.

These program areas reside in the Geoscience and Titles Information branch, which is responsible for:

- production of all GSWA products, including geoscientific maps, Reports, Records and data packages for delivery as digital media, and via the internet; in addition, the team creates high-quality graphics for display and promotion, and prepares pamphlets, catalogues, flyers and other exhibition materials
- acquisition and integrity of both mineral and petroleum titles information within TENGRAPH
- development and maintenance of quality assurance processes that align with national and international standards. In cooperation with internal and external geoscience groups, the branch develops the data models and standards required for spatial geoscience information management. The branch's data specialists manage GSWA spatial geoscience databases and develop web-based applications to deliver these data.

## Planned work program and products

The team will continue to produce geoscientific maps, manuscripts, digital datasets and promotional materials as follows:

- Manuscripts 28
- Maps 4
- Digital data layers 4
- Data packages 7
- Online data releases 5

The following online geoscience and titles information will be released:

- Map Symbol System to internally manage colours and patterns for regolith and rock units

- Implement the new Geocentric Datum of Australia 2020 (GDA2020) for Geoscience and Title spatial datasets
- System for the electronic lodgement of survey field books
- Decommissioning of NORM2 data file exchange format
- Replace TENGRAPH maintenance modules with ArcPro maintenance processes in support of the decommissioning of TENGRAPH Old
- Online access to legal survey documents and surveyor field books.

# GS85 Resource Investment Information

*Manager: Gaomai Trench*

*Team member: Sarah Goss*

The objective of GS85 Resource Investment Information is to facilitate the provision of resource-related information to investors for mineral and petroleum investment in Western Australia to accelerate exploration and development of new resources. This involves providing geoscientific, policy and regulatory information to assist with attracting new resource investment.

Activities are undertaken individually by GSWA or in cooperation with ‘Australia Minerals’ (the collective name given to investment collaboration between the State and Territory geological surveys and GA). Activities undertaken by the branch include:

- preparing Western Australian investment-oriented presentations for delivery at virtual conferences or in person at overseas events
- conducting geoscientific, government policy and regulations-focused investment workshops and seminars for investors
- responding to investor requests for geoscience, policy and regulation information and advice
- collaborating with the Department of Jobs, Tourism, Science and Innovation (JTSI), Austrade and other government offices at a State, national and international level to provide advice and information on Western Australia’s resources industry and mineral endowment
- collecting, analysing and reporting high-level foreign investment, information and advice to DMIRS to ensure alignment with State and federal foreign policy.
- RIU Explorers Conference (February 2021)
- NAPE Summit (February 2021)
- Prospectors and Developers Association of Canada Annual Convention, Trade Show and Investors Exchange (PDAC) (March 2021)
- Mines and Money Asia in Hong Kong (April 2021)
- APPEA 2021 Oil and Gas Conference (April 2021)
- India–Australia Mineral Resources Investment Forums in Mumbai, New Delhi and Kolkata (in cooperation with Austrade and Australia Minerals – April or May 2021)
- AMEC Convention (June 2021)
- China Mining Conference (2021)
- North Asia Mining Seminar, including Beijing (China), Tokyo (Japan) and Seoul (Korea) in 2021 (in cooperation with Austrade and Australia Minerals), (tentatively planned for September 2020 or May 2021)
- China International Gold Conference (July 2021).

In 2020–21, it is anticipated that economic recovery from COVID-19 will see strong investment in mining. While iron and gold have both fared well thus far during the pandemic, battery, energy and critical minerals were all impacted by unstable stock markets and border closures, resulting in a lack of investment and project delays. A consequence of the small to medium explorers failing to gain investment in their programs was that METS companies suffered through lack of work throughout Australia. Western Australia was not as heavily impacted as other states with a recorded 7.5% loss of employment in the mining sector. As the State recovers, investment into future batteries, energy and critical minerals will continue to be the focus of the State Government’s strategy and therefore, the focus of the work program for this branch.

## Planned work program

A number of national and international events and conferences have been affected by the COVID-19 pandemic with subsequent travel bans and border closures. In 2020–21, the project will fund Western Australia’s presence in some capacity at a number of key national and international events (it is not clear whether attendance will be virtual or in person):

- RIU Good Oil Conference (September 2020)
- Diggers and Dealers Mining Forum (October 2020)

# GS91 Mineral Exploration Information Management

*Manager: Julia Thom*

*Team members: Monique Brouxhon, Subashni De Biran, Dale Finnigan, Narelle Gardiner, Fiona MacCorquodale, Robert Pizzi, Christine Suchodolski*

DMIRS has a statutory obligation to manage the collection, storage and release of company exploration reports containing geoscience information on mining tenements in Western Australia; this function is performed by GSWA. The archive of statutory exploration information is a valuable resource, providing a means whereby companies can assess the potential of an area and develop exploration strategies using legacy data, which minimizes duplication of exploration effort and enables more efficient exploration.

The reports and information also provide valuable input to a number of GSWA mapping and resource assessment projects and activities.

The Mineral Exploration Information section also manages the company mineral drillhole and surface geochemistry database, which contains all company drilling and surface geochemistry data that has been submitted to DMIRS in digital format.

In addition, the section manages the processes that allow internal and external stakeholders to view and sample the valuable mineral core collection housed in the two core libraries.

## Planned work program and outcomes

Planned activities and outcomes are to:

- review and release surrender reports and their associated annual reports as they are received, together with the fourteenth annual release of reports under the provisions of Regulation 96(4) of the Mining Act, commonly known as the ‘sunset clause’; this will ensure that access to this historical data increases
- release reports that relate to exploration on dead tenements, although many of these relate to tenements under the *Mining Act 1904*, to which the ‘sunset clause’ does not apply
- continue to review the mineral exploration reports for compliance with the Guidelines for Mineral Exploration Reports on Mining Tenements, to ensure all data is included in the report prior to archiving, and it is then ready for release via the ‘sunset clause’ or normal cancellation process

- expand the reviewing process to allow reviewing geologists to enter information from company exploration reports into the MINEDEX database
- convert all non-optical character recognition (OCR) reports in WAMEX to searchable text
- work on improvements to the WAMEX database to make it more usable and user friendly
- work towards cleansing and harmonizing geochemistry data in the Mineral Drillholes database to allow the data to be more effectively extracted and used
- investigate the development of a database or suitable searchable repository of camp-scale 3D models submitted with mineral exploration reports
- continue training in the use of the WAMEX and mineral drillhole and surface geochemistry databases in both Perth and Kalgoorlie, and develop and deliver training and exercise manuals on those databases
- develop a core library database, in collaboration with WAPIMS, for mineral core with links to the mineral drillhole and WAMEX databases, to enable better searching for drillcore and a more efficient and less manual process of managing, viewing and sampling the mineral core
- continue to identify and collect historical drillcore suitable for the Perth and Kalgoorlie core libraries
- continue the capture of attribute information for legacy mineral exploration core submitted to the core libraries in Perth and Kalgoorlie.

As part of the Accelerated Geoscience program, the WAMEX team will assist the South West Yilgarn group with the identification and extraction of data from legacy reports.

# GS92 Statutory Petroleum Exploration Information

*Manager: Felicia Irimies*

*Team members: Alan Bloore, Fiona Dodd, George Karniewicz, Yanrong Li, Janine Malligan, Richard O'Brien, Yasinta Situmorang*

The Petroleum Exploration Information section is involved with the monitoring, administration and release of petroleum and geothermal data submitted under the *Petroleum and Geothermal Energy Resources Act 1967* (WA) and the *Petroleum (Submerged Lands) Act 1982* (WA), covering onshore and territorial sea.

From 1 January 2012, the National Offshore Petroleum Titles Administrator (NOPTA) assumed responsibility for a range of regulatory and administrative functions for Commonwealth Waters that had previously been the responsibility of the designated authorities. This includes the regulation of documentary information and petroleum mining samples (petroleum data), in accordance with Part 7 and Part 8 of the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 (RMA Regulations).

Under the State–Commonwealth National Collaboration Framework, DMIRS will continue to provide services to the Commonwealth in the handling of core, cuttings and thin sections that relate to petroleum exploration in offshore Commonwealth-controlled waters, and will continue to make those samples available for viewing, further sampling and loan. DMIRS is also assisting NOPTA and GA to develop and maintain the National Offshore Petroleum Information Management System (NOPIMS), with very close links to the Western Australian petroleum and geothermal information management system (WAPIMS) and the Core Information Management System (CIMS).

The section adds quality-assured geoscience information to the WAPIMS database, undertakes transcription and scanning programs related to State activities, and ensures data submitted are complete and in a format easily used by explorers. It also manages the release of data online through WAPIMS, including documents related to offshore activities occurring before 1 January 2012.

Priorities for transcribing and scanning legacy data are set in part by the future activities of GS10 Energy Geoscience and Carbon Strategy and the Specific Area Gazettes conducted by the Resource Tenure Group.

## Planned work program and outcomes

The section will continue loading legacy scanned and transcribed data for access via the web and add new data as received, continue quality control for onshore well log data submitted from industry and create reports and data packages, available through WAPIMS.

As part of the Accelerated Geoscience program, the WAPIMS team will be working on the Energy Systems Atlas in collaboration with Energy Geoscience branch.

Planned activities and outcomes are to:

- collaborate with NOPTA/GA in regards to better integration of our systems (WAPIMS, NOPIMS, National Electronic Approvals Tracking System [NEATS], Petroleum Geothermal Register [PGR]):
  - CIMS – create one sampling approval system for all material stored at the Perth Core Library at Carlisle (mineral, State and Commonwealth petroleum)
- continue creating enhancements to WAPIMS including:
  - upload the scanned seismic sections (depending on DMIRS data storage capacity)
  - create forms and public reports to release online all the public geoscientific data captured in WAPIMS (State and Commonwealth)
  - add new map layers
  - add new data to 'Data By Depth' functionality
- continue vectorizing all the onshore line sections without digital data to SEG-Y; priorities based on work done by Energy Geoscience and Carbon Strategy branch
- continue data transcription program including the remaining nine track tapes
- continue accessioning the thin sections submission for State and Commonwealth wells and release them to the public
- continue sampling approvals for State and Commonwealth activities and monitor retrieval of the analysis reports and the slides generated
- assist in relocating Western Australian core from GA to the Perth Core Library
- relocate thin sections relinquishment collection to Carlisle and plan for future scanning of the collection
- review and update Guidelines for petroleum data submission and release based on Parts 8 and 9 of the Mines and Petroleum Regulation Amendment Regulations 2018.



# GS94 and GS96 Core Library Services

*Perth Core Library, Carlisle Manager: Paul Stephenson*

*Team members: Bill Anderson, Fiona Dodd, Peter Drobek, Simon Fanning, Jackie Fleming, Mark Harrison, Andy Leighton, Josh Williams*

*Joe Lord Core Library, Kalgoorlie Manager: Debbie Caple*

*Team members: Ben Rooney*

DMIRS core libraries at Carlisle (Perth) and Kalgoorlie house important collections of samples of representative geology and mineral endowment of Western Australia. These collections have been sourced over many decades from government stratigraphic drilling, mineral industry donations, the EIS Co-funded Exploration Drilling program, petroleum industry onshore and offshore drilling, geothermal drilling, water bores and geotechnical drilling. This constitutes a significant source of pre-competitive geoscience information that exhibits the mineral and energy prospectivity of the State, and encourages innovative resources exploration.

The Perth Core Library is the western hub of the National Offshore Petroleum Data and Core Repository (NOPDCR), and will store two-thirds of all Commonwealth-managed petroleum core derived from offshore drilling from around Australia. This is managed under two agreements between DMIRS, GA and NOPTA, providing a significant step towards a seamless service to the petroleum exploration industry.

The Perth Core Library is used by DMIRS, industry and academia as a geoscience training facility, and also houses the HyLogger spectral scanner, one of the six nodes of the National Virtual Core Library (NVCL) that collects extensive, objective, pre-competitive mineralogical data from archived drillcore.

Usage of the Perth Core Library at Carlisle remains at very high levels, with all the main indicators increasing during 2018–19 (Fig. 4).

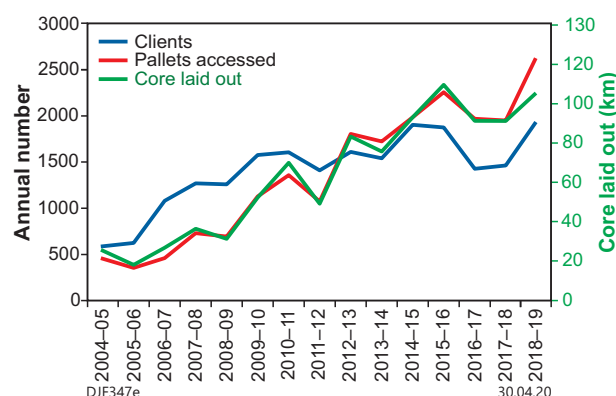
The core libraries at Carlisle and Kalgoorlie also house the extensive core generated since 2009 from the EIS Co-funded Exploration Drilling program. After a short six-month confidentiality period, this core is a great boost to explorers and academia, providing new core from greenfield areas and allowing testing of new ideas and concepts.

## Planned work program and outcomes

At the core libraries in 2020–21, work will continue to maintain the same level of service to stakeholders.

Developments include:

- potentially receiving donations from Exxon Mobil of core and cuttings from Victoria and Tasmania (~250–300 pallets); discussions between Exxon Mobil and GSWA are in progress
- a new outdoor viewing area at Kalgoorlie due to be completed mid-2020
- a new forklift, and Almonte cutting saw has been acquired at the Perth Core Library, also shade sails were installed in July 2019 for outside viewings
- the relocation of petroleum slides and residues from Mineral House to Carlisle
- the Joe Lord Core Library shade sails are due to be installed in May 2020. The asphalt has been relaid
- the expansion of the Joe Lord Core Library to go ahead
- potentially having the slides that belong to the core store in Kalgoorlie located at the core library to enable customers the opportunity of having them available when viewing core
- provide a microscope setup in the Joe Lord Core Library.



**Figure 4.** Perth Core Library usage statistics since 2004–05 for the number of clients, pallets accessed and core laid out

# GS95 HyLogger and the National Virtual Core Library

*Manager: Lena Hancock*

*Team members: Edward Rogers, Michael Wawryk*

The GSWA HyLogger facility is one of six State and Territory geological survey-based nodes that were established in 2009 as part of the National Collaborative Research Infrastructure Strategy (NCRIS), to provide objective mineralogical data and interpretations from drillcore (and other rock samples), thereby improving our understanding of the composition of the Australian crust. HyLogger technology collects mineral reflectance spectra in the visible near-infrared (VNIR), short-wave infrared (SWIR) and thermal infrared (TIR) spectral ranges, and provides objective, semi-automated interpretation of mineralogy by comparing these data to a reference library of mineral spectra using The Spectral Geologist (TSG) software. High-definition digital images of the core are simultaneously obtained. The data are processed and posted to a dedicated national database (the AuScope NVCL portal) and to GeoVIEW.WA, where they can be viewed using open-access software. Full datasets are also available upon request. The list of scanned datasets and the links to the drillcore images are updated every six months and are available on the DMIRS website.

## Planned work program

The facility will continue to collect and interpret spectral data from drillcore that contributes directly to increasing the knowledge of Western Australian geology, and mineral and petroleum systems. Material to be analysed will include that requested by GSWA staff, academic researchers, students and industry engaged in collaborative or other research with GSWA (including core obtained as part of the EIS). Priority of scanning is determined by a GSWA committee in order to balance the competing objectives, demands and priorities of users.

Other regular activities for 2020–21 will include periodic uploading of processed HyLogger data to the NVCL database, ensuring the release of non-confidential data to the AuScope national portal and to the GeoVIEW.WA HyLogger layer.

In collaboration with CSIRO, HyLogger staff will deliver to GSWA, academic and industry personnel two workshops promoting the use of hyperspectral technology. These will be conducted either in-person in the Perth and Kalgoorlie core libraries or virtually using an online platform.

The HyLogger team will be involved with GSWA's Accelerated Geoscience program, undertaking scientific studies using HyLogger technology to contribute to the mineral prospectivity and regolith–landform evolution maps, which are to be part of the data packages being produced for the South West Terrane, far eastern Yilgarn Craton and critical minerals. High-quality, standardized products will be created by reprocessing existing and newly acquired HyLogger data using the latest unmixing algorithms provided with the TSG software, and regenerating core images to higher resolution.

HyLogger staff will also commence the systematic collection of geochemical data from scanned drillcore using portable XRF technology, thereby increasing the information available for drillcore archived in the core libraries, and complementing mineralogical interpretations from hyperspectral data. An evaluation of the use of pXRF geochemical data will be provided in a GSWA Record.

## Products planned for release

- Using pXRF in DMIRS core libraries for drillcore geochemical data (Record)

# **PART THREE**

## **Exploration Incentive Scheme**

### **– detailed work programs**

# ES20 Government Co-funded Exploration Drilling

*Manager: Charlotte Hall*

*Team member: Monique Brouxhon*

This program supports innovative drilling by companies in underexplored areas. It is designed to stimulate geoscience-based, targeted exploration, and contribute to the economic development of underexplored areas in Western Australia, where additional drilling and exploration activities will lead to new geoscience information and discoveries.

The program is preferentially funding high-quality, technical and soundly based projects that promote new exploration concepts and technologies. Proposals from applicants are assessed by an independent panel based on geoscientific and exploration targeting merit and data generated.

An advisory committee, chaired by the Deputy Director General of the Resource and Environmental Regulation Group in DMIRS and consisting of representatives from the main industry representative groups and research sector, provides advice to the department on program guidelines and feedback from industry. The committee, which meets twice yearly, also ensures that the program is relevant to the exploration industry.

The co-funded drilling program also undergoes a transactional and probity audit on the co-funding twice a year by an external auditor. The probity audit ensures the selection process is transparent, impartial and defensible for any round. The transactional audit reviews the process and control in the administration of the refund payments for previous rounds made in the previous six months.

The program refunds up to 50% of direct drilling costs capped at \$30 000 for genuine prospectors, \$150 000 for multi-hole projects, and \$200 000 for deep single-hole projects.

As a result of feedback from applicants in Rounds 1 (2009) and 2 (2010), and industry representatives, two rounds of co-funding per year started in 2011 across either a financial or calendar year. This resulted in an increase in the number of offers made in a financial year and in the number of projects completed (Fig. 5a). Successful applicants are required to complete the proposed drilling project within 12 months. Interim and final drilling reports plus core, where cored drilling is undertaken, are submitted to DMIRS before payment of the refunds. Final reports and core are released to open file after a six-month confidentiality period, which begins at the time the first invoice is approved for payment.

## Planned work program 2020–21

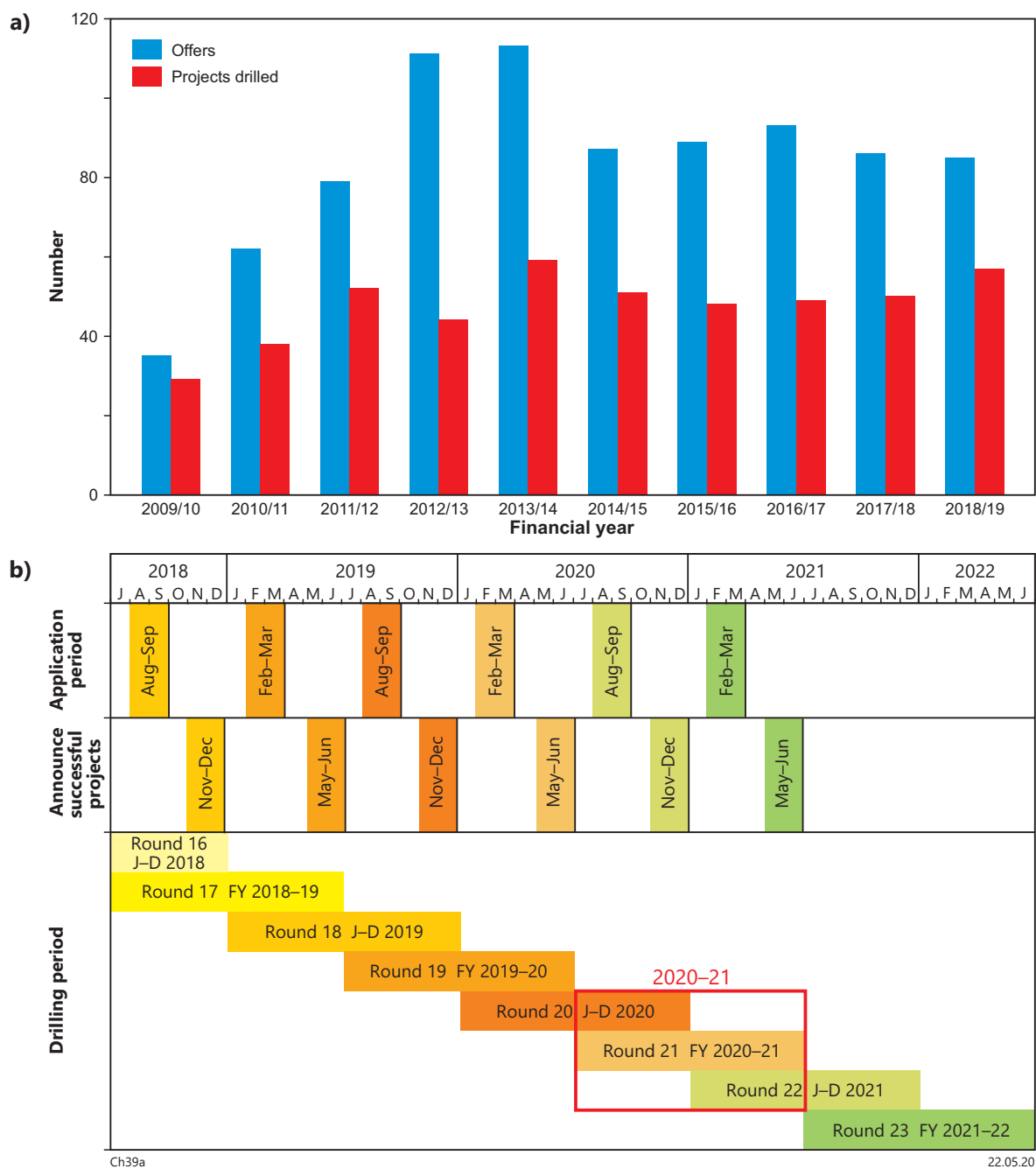
During 2020–21, drilling from three rounds will be undertaken by exploration companies. As can be seen in Figure 5b (highlighted by the red rectangle), three rounds overlap the reporting year. Successful applicants of Rounds 20 and 21 are currently in the process of drilling. Round 20 applicants have until December 2020 to complete drilling, while Round 21 applicants will be required to drill by 30 June 2021.

The 2020–21 financial year is likely to see an impact on drilling completion rates by the COVID-19 restrictions (regional boundaries limiting travel, and biosecurity) and delays in heritage clearances. For the co-funded drilling, this will mean delivery of drillcore to the core libraries will be delayed. Companies will be advised to undertake a two-tranche payment option to ensure eligibility for any refund.

The website will also be updated to notify future applicants of co-funded drilling that applications will not be accepted where current File Notation Areas (FNA) on TENGRAPH Web exist for proposed national parks under the Government's Plan for our Parks program.

Other work will include:

- final closure of Round 19 including receipt of all final reports to WAMEX, issue of final payments and receipt of diamond core if drilled. Applicants have three months after the drilling period ends to complete analytical and scientific data acquisition to allow inclusion in the final report
- completion of Rounds 20 and 21 drilling periods, including receipt of interim and final reporting requirements
- submissions for applications open for Round 22 (August 2020) and Round 23 (February 2021) (Fig. 5b)
- release of co-funded drilling reports, not confidential, to DMIRS online WAMEX open-file database
- engagement of an independent body to do an economic review of the EIS for 10 years (since 2009)
- audits by an external auditor on the probity of the selection process for Rounds 21 and 22 and transactions for the last 12 months
- summary of 2020–21 co-funded drilling for inclusion in the Geological Survey Annual Review 2019–20.



**Figure 5. EIS Co-funded Exploration Drilling program statistics and timeline: a) number of projects offered funding vs projects actually drilled, by financial year; b) schedule of Rounds 16–23. Red box indicates the three rounds which are part of the 2020–21 financial year. Abbreviations: J–D, January–December; FY, financial year**

# ES21 Stakeholder Engagement

*Manager: Michele Spencer*

*Team member: Jenna Meehan*

The Stakeholder Engagement Strategy aims to increase our geoscientific knowledge to improve Western Australia's economic growth and development through various tourism and resources sector opportunities. Through the strategy, we will continue to build resilient strategic partnerships and improve dissemination practices.

Our goal is to ensure our science can be fully utilized by our stakeholders, providing our expertise, data and information to stimulate economic growth and jobs. Ensuring that the economic, social and scientific value of our work is recognized is pivotal to our success. We will achieve our goal by developing new methodologies, technologies and data products, by delivering these through a variety of new 'technology' platforms.

## Planned work program

Our aims are to:

- strengthen connections with stakeholders using social media. We will use Facebook to disseminate the science, technology, engineering and mathematics (STEM) approach to learning, geotourism and public interest matters; while LinkedIn will be used to communicate related industry, government and research matters. We will increase our digital presence with regular information updates, including promotional videos to increase GSWA's reputation and visibility. This will ensure that stakeholders have access to relevant information, and are able to engage with us in a meaningful and effective manner
- disseminate technical information to targeted industry stakeholders via webinars, information sessions, workshops, electronic direct mail campaigns and online tutorials
- identify and develop collaborations with like-minded research partners and government bodies (e.g. Tourism WA, Department of Biodiversity, Conservation and Attractions, local shire councils)
- implement initiatives that will encourage and promote compliance, with regulatory requirements and obligations (e.g. exploration reporting, geoheritage infraction). We will communicate achievements, milestones, discoveries and good news stories
- advocate for geotourism projects and activities in Western Australia, providing a platform for visitors and scientific communities to access information (using interpretation signage, publications, interactive maps, QR code web links, self-guided tours) to enable a more comprehensive understanding and appreciation of geological processes and landscape evolution
- support local schools and education providers to build awareness of GSWA, and encourage students to develop an interest in STEM.

## Products planned for release

- Calendar 2021
- Virtual tours
- John Forrest National Park geotrail



# ES30 Airborne and Ground Geophysical Surveys

*Manager: David Howard*

*Team member: John Brett*

The Airborne and Ground Geophysical Surveys component of the EIS encompasses the acquisition and processing of aeromagnetic, radiometric, gravity and airborne electromagnetic (AEM) data on a regional scale for statewide coverage at increasing levels of resolution. Currently, all these regional surveys are undertaken in collaboration with GA under National Collaboration Framework (NCF) agreements.

Medium-resolution (200–400 m line-spacing) aeromagnetic and radiometric coverage of the State was completed in June 2013. A ‘second-generation’ gravity coverage of the State at a 5–8 km wavelength resolution was completed in 2019 (the first generation was the BMR 11 km coverage published in 1975). The current focus has shifted to broad-scale AEM surveys, extending GA’s 2017–20 Exploring for the Future AusAEM surveys. These form part of a collaborative, national goal of the Commonwealth, State and Territory geological survey agencies to acquire AEM data at 20 km line-spacing or less across the Australian continent.

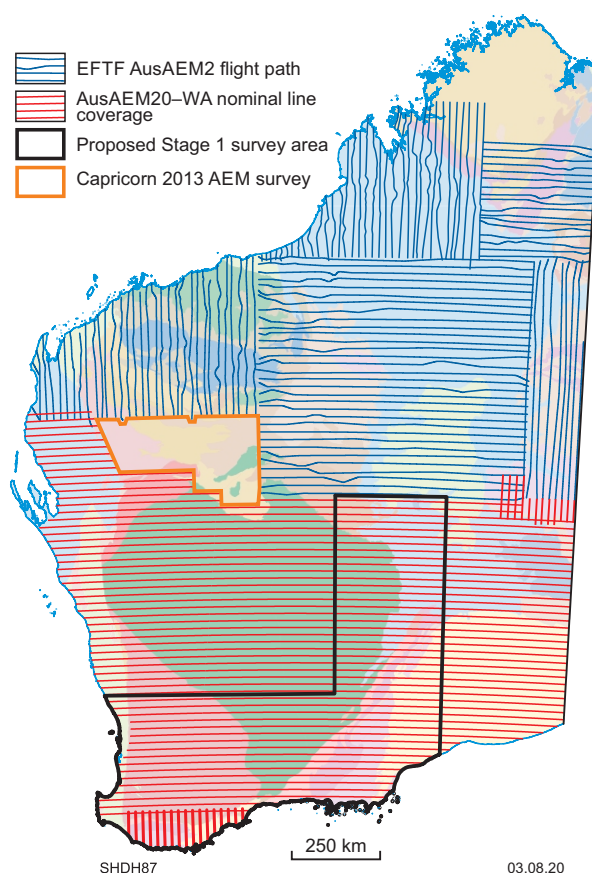
AusAEM20–WA (Fig. 6) is the Western Australian component of this Australian 20 km Airborne Electromagnetic Survey Objective (AusAEM20).



**Figure 6. AusAEM20–WA location map. Abbreviation: AEM, airborne electromagnetic**

## Planned work program

AusAEM20–WA Stage 1 is programmed to commence in 2020–21 over the eastern Yilgarn and the South West (Fig. 7). The Stage 1 areas were chosen to coincide with the Accelerated Geoscience program. The remainder of the southern part of Western Australia and the small area in the northern Kimberley will be surveyed in later stages.



**Figure 7. AusAEM20–WA 2020–21 proposed Stage 1 survey area**

# ES31 Deep Seismic Survey Program

*Manager: Simon Johnson*

*Team members: Lucy Brisbout, Richard Chopping, Klaus Gessner, Ruth Murdie*

The aim of the Deep Seismic Survey program is to obtain geophysical data that underpins the understanding of the geological evolution of the lithosphere in Western Australia over some four billion years of Earth's history. The objective of ES31 is to acquire, process, analyse and publish data that allow GSWA to integrate geophysical and geological information across the West Australian, North Australian and South Australian Cratons and the intervening Neoproterozoic and Phanerozoic basins. These data also contribute to understanding the localization of mineral systems within the upper crust. In addition to collaborating with GA on the active source seismic acquisition, GSWA engages with Macquarie University, ANU and UWA, particularly on passive source seismology and magnetotelluric surveys. GSWA activities that derive from the data acquired and processed in ES31 are also described in the GS62 3D Geoscience and ES42 3D Lithosphere Visualization Project sections of this Record.

GSWA is also in the planning stage of coordinating future acquisition of passive source seismic and magnetotelluric data with GA under the Australian Passive Seismic Array project (AusARRAY) and the Australian Lithospheric Architecture Magnetotelluric project (AusLAMP) initiatives. Funds are committed to provide logistical and cultural heritage clearance for acquisition sites in the east of the State. Funds have also been committed to support a collaborative passive source seismic study in the southwest of the State, with ANU, GA and DFES.

## Products planned for release

- Reprocessed data of the deep seismic surveys BMR91-EGF01, BMR91-EGF02 and BMR91-EGF03 and of the 1993 New Norcia survey

## Planned work program

Passive source seismic and magnetotelluric data will continue to be acquired in the Eastern Goldfields in a collaborative project with UWA led by Mike Dentith. This three-year research project commenced in July 2018 to complement the high-resolution seismic survey in the Eastern Goldfields described in the ES37 section of this Record. To complement geophysical imaging in the Eastern Goldfields and the southwest Yilgarn Craton, GSWA will fund the reprocessing of legacy seismic data.

# ES34 Regolith and 3D Paleosurface Mapping

*Manager: Richard Chopping*

*Team members: Nadir de Souza Kovacs, Emily Finch (UniSA Embedded Researcher), Sara Jakica*

This EIS program funds collaborative research with leading research institutions that complement GSWA's capabilities in regolith, surface and landscape mapping, including data acquisition, analysis and modelling under the GS64 Geoscience Mapping Through Cover and ES36 Participation in MinEx CRC projects. In addition to collaborating within the MinEx CRC, GSWA engages with other institutions including the John de Laeter Centre at Curtin University and CSIRO.

The detailed work program for the 2020–21 financial year is presented under GS64 Geoscience Mapping Through Cover and ES36 Participation in MinEx CRC, with the ES34 Regolith and 3D Paleosurface Mapping project funding the following collaborative research program:

- Interpreting regolith geochemistry results for the West Arunta region acquired using the CSIRO Ultrafine+™ process.

# ES36 Participation in MinEx CRC

*Manager: Richard Chopping*

*Team members: Nadir de Souza Kovacs, Emily Finch (UniSA Embedded Researcher), Sara Jakica*

ES36 commenced in 2018–19 and is linked to GS64 Geoscience Mapping Through Cover. The MinEx CRC was granted by the Commonwealth Government in March 2018 and brings together industry, government and research organizations. It represents a 10-year investment in the next generation of mineral system discovery research. The CRC, which commenced in January 2019, comprises three programs: Drilling Technologies, Data from Drilling and the NDI. GSWA is a participant in Program 3, the NDI and also Project 6, automated 3D modelling.

Research in the three programs in MinEx CRC includes:

- developing more productive, safer and environmentally friendly drilling methods to discover and drill-out deposits, including coiled tubing drilling technology
- developing new technologies for collecting data while drilling and bringing forward mine production
- implementing the NDI — a world-first collaboration of geological surveys, researchers and industry that will undertake drilling in underexplored areas of potential mineral wealth in Australia
- interpreting regolith geochemistry results for the West Arunta region acquired using the CSIRO Ultrafine+ process.

Find further information about the MinEx CRC on the [MinEx CRC website](#).

## MinEx CRC Program 3

The NDI is designed to maximize the benefits of collaborative work across the geoscience research community, CSIRO, GA and geological survey organizations across Australia. The NDI vision is to drill multiple holes using new technologies developed by the MinEx CRC to map the regional geology and architecture of greenfields regions, and define the potential for mineral systems in 3D. The NDI will generate a large amount of new data and add value to existing data. There are three projects that encompass the NDI:

Project 7 — maximizing the value of data and drilling through cover

Project 8 — geological architecture and evolution

Project 9 — targeting mineral systems in covered terranes.

The aims of Project 7 are to:

- develop a web platform and data management system that can operate in near real time
- develop advanced mineral system data analytics so that the maximum amount of geoscientific information can be extracted from the legacy and NDI drilling programs
- maximize the efficiency and value of drilling by developing algorithms and tools that can optimize drill program design and provide drill target rankings relative to the key science questions.

This streamlined approach to managing and integrating the many layers of complex drilling data will enable objective analysis and result in significant efficiency gains as well as the ability to modify drilling programs in real time.

The aim of Project 8 is to provide new pre-competitive geoscience data in the NDI case study areas to increase data confidence and improve geological understanding. An understanding of the relationships between regolith, basin cover and basement, through new knowledge of mineralogy, geochemistry, petrophysics, hydrology and geochronology, will be used to reconstruct landscape evolution through time and to map the depths to key boundaries and cover thickness. Determination and development of the most rigorous methods for characterizing and mapping buried geology will be a key feature, and will enable predictions of buried geology through novel drilling techniques, and by understanding its expression in cover sequences and geophysical data.

The aim of Project 9 is to develop methodologies to detect and understand the footprints of buried mineral systems using the extensive datasets generated through Project 8. This will involve establishment of a new generation of multiscale (province, district and links to deposit scale) exploration targeting models for selected mineral systems that represent and quantify the spatial variations in architectural/structural, stratigraphic, geophysical, geochemical, mineralogical and isotopic (collectively geological) characteristics of each mineral system type.

Project 9 will provide advice on the most valuable data types, sampling media and densities to map footprints of relevant mineral systems. It will also integrate temporal and spatial geoscientific data for specified regions with existing understanding of ore-forming processes to create maps of mineral potential, using improved knowledge- and data-driven prospectivity mapping techniques, and test exploration targeting models and mineral potential maps by using MinEx CRC drilling technology and research.

## Project 6

Project 6 of the MinEx CRC is developing tools to support the automatic creation of 3D models. This project sits within the data from drilling program of the CRC, and aims to develop algorithms and software that enable the integration of drillhole and other data to create first-pass 3D models that are reproducible, provide uncertainty estimates and draw upon a broad range of datasets. Project 6 is also related to the international [Loop consortium](#).

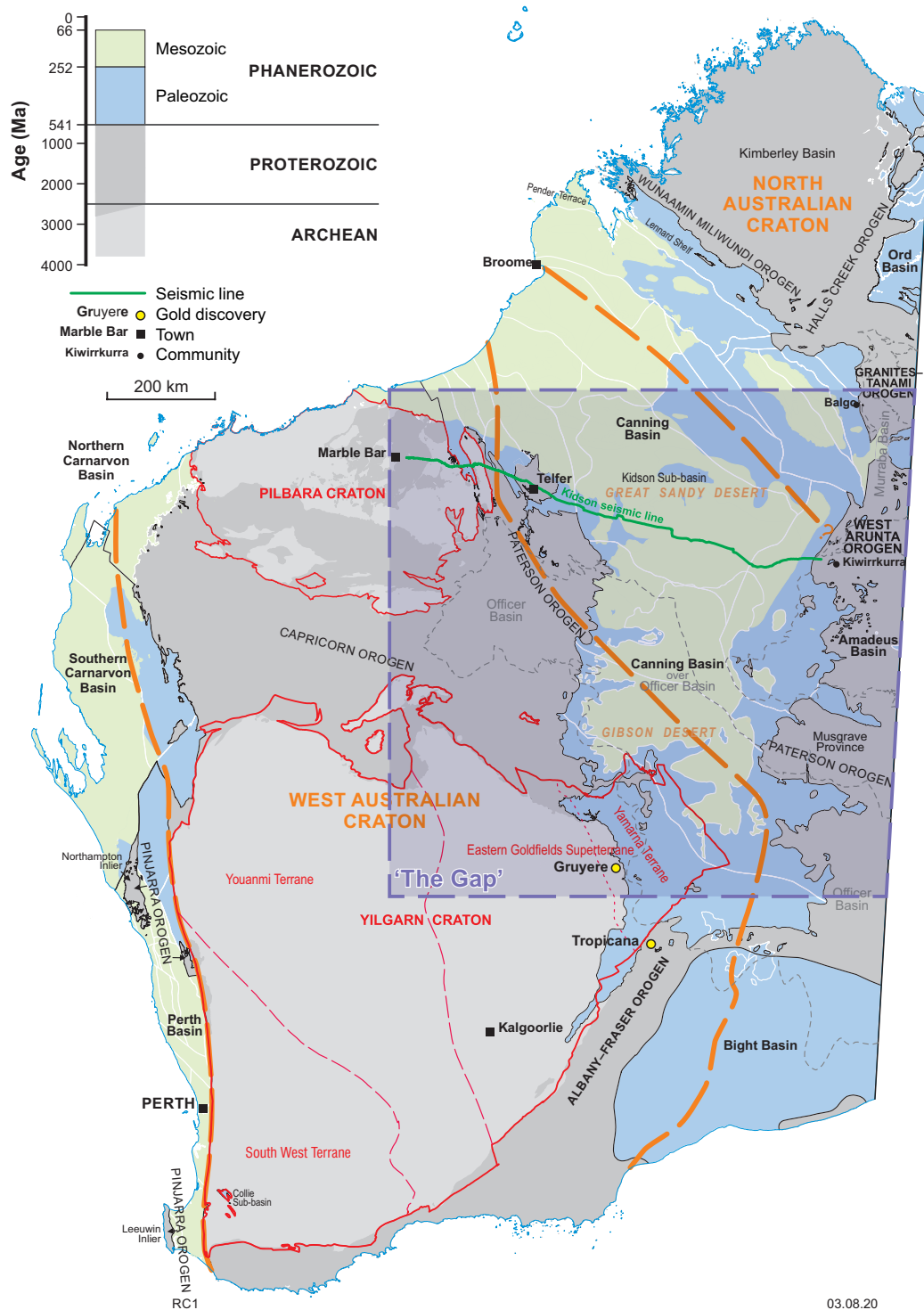
## The NDI in Western Australia

Although resource rich, Western Australia contains much of Australia's most remote and underexplored regions, particularly those that lie under regolith and basin cover. Increasingly, geological surveys will be expected to undertake mapping in covered terranes using drilling technologies. The NDI in Western Australia will focus on how to undertake such mapping programs efficiently and effectively. Focus will be on the region that underlies the Canning Basin, including the Officer and Amadeus

Basins, and basement rocks of the Paterson and West Arunta Orogens, the far eastern edge of the Yilgarn Craton (Yamarna Terrane), and the Warri–Anketell Gravity Ridge, which appears to form a link between the Paterson Orogen and Musgrave Province (Fig. 8). This area is informally defined as 'The Gap'. This work will align with other project work including GS64, GS65, GS10 and external collaborative projects through the Minerals Research Institute of Western Australia (MRIWA).

## Planned work program

Drilling within the NDI will be undertaken in two parts, with the first scheduled for the 2021 field season and the second for the 2023 field season. Exact timing and location of drilling will be subject to land access and drill rig availability. Work within the 2020–21 financial year will involve supporting the planning for these drilling campaigns through data compilation and establishing foundations for a mineral systems analysis of broad region of 'The Gap'. It is anticipated any accelerated special program will support the first NDI drilling program.



**Figure 8.** Location of 'The Gap', which is the informal name for the region of the remote desert country of central eastern Western Australia. Beneath the Canning Basin are the sedimentary basins of the Amadeus and Officer basins, and the basement rocks of the Paterson and West Arunta orogens, the far eastern edge of the Yilgarn Craton and the Warri-Anketell Gravity Ridge, which appears to form a link between the Paterson Orogen and the Musgrave Province. Note: the King Leopold Ranges (and Orogen) have been renamed the Wunaamin Miliwundi Ranges to honour Aboriginal culture



# ES38 Proterozoic Margins

*Manager: Raphael Quentin de Gromard*

*Team members: Dave Kelsey, Chris Phillips*

This EIS program funds collaborative research with leading research institutions that complement GSWA's mapping and analytical capabilities under the GS65 Proterozoic Margins project. In addition to collaborating within the MinEx CRC, GSWA engages with other institutions including Curtin University and CET at UWA.

The detailed work program for the 2020–21 financial year is presented under GS65 Proterozoic Margins with the ES38 Proterozoic Margins project funding the following collaborative research programs:

- MRIWA M521 project (CET), focuses on basin evolution, and geophysical data interpretation and numerical modelling
- MRIWA M470a project (Curtin University) uses a multiscale approach to define and understand the controls on mineralization in the Fraser Zone, in the Albany–Fraser Orogen.

# ES42 3D Lithosphere Visualization Project

*Manager: Klaus Gessner*

*Team members: Lucy Brisbout, Ruth Murdie, Huaiyu Yuan (Macquarie University), Ivan Zibra*

This EIS program funds collaborative research with leading research institutions that complement GSWA's capabilities in data acquisition, analysis and modelling under the GS62 3D Geoscience program. In addition to collaborating with GA, GSWA engages with Macquarie University, IGG-CAS, ANU, DFES, Monash University and UWA on passive source seismology and magnetotelluric surveys. The detailed work program for the 2020–21 financial year is presented under GS62 3D Geoscience, with the ES42 Lithosphere Visualization Project funding the following collaborative research programs:

- Australian Research Council (ARC) project LP180101118 Enhanced 3D seismic structure for southwest Australia
- ARC project LP170100985 Enabling 3D stochastic geological modelling (3D-Loop).

# ES43 Mineral Systems

*Manager: Trevor Beardsmore*

*Team members: Olga Blay, Paul Duuring, Lena Hancock, Sidy Morin-Ka, Michael Wingate*

Under this program, GSWA collaborates with other government, university and industry partners to study specific aspects of Western Australian mineral systems. These projects are partly to fully funded by the EIS, with the Minerals Geoscience branch managing in-house participation. Projects underway or pending for 2020–21 include:

- Pilbara gold fingerprinting (\$25 000 per annum over two years)
- MRIWA M532 — Geology, mineralogy and metallurgy of eMaterial resources in Western Australia (\$50 000 per annum over two years)
- Rare earth resource potential of northern Australia (\$20 000 per annum over three years)
- Critical metals (lithium, tantalum, niobium, tungsten, REE) in the western Yilgarn Craton (\$100 000 for one year). This project is a component of GSWA's 2020–21 Accelerated Geoscience program.

## Planned work program

The Pilbara gold fingerprinting project aims to characterize the provenance and metallogenesis of gold mineralization across the Pilbara Craton, using morphometry, microstructure, associated minerals and trace element composition of bedrock-hosted and placer gold grains/nuggets. Gold-bearing specimens provided by industry partners are visually inspected, then mounted in resin, cut and polished, and analysed quantitatively for a suite of trace elements using LA-ICP-MS and energy dispersive X-ray spectroscopy (SEM-EDX), and calibrated using certified gold standards. With the assistance of John Watling (TSW Analytical), this project will provide a world-first database of gold trace-element chemistry. Results are expected to assist in identifying the type and origin of basement-hosted gold deposits, the sources of paleoplacer gold in Fortescue Group rocks, and an evaluation of the prospectivity of the Pilbara for significant undiscovered gold deposits. During 2020–21, data collection and analysis will be completed, the geochemical database will be developed, and the final report(s) documenting the study will be drafted.

GSWA is also sponsoring MRIWA project M532 — Geology, mineralogy and metallurgy of eMaterial resources in Western Australia — in collaboration with Curtin University, Lithium Australia NL, Rio Tinto Limited and AXT Pty Ltd. The project is largely operated by the John de Laeter Centre at Curtin University, and is intended to provide a comprehensive understanding of the geology and mineralogy of Western Australian lithium–caesium–tantalum (LCT) pegmatite-hosted lithium deposits, develop practical geometallurgical models to optimize the sustainable development of these deposits, and verify the suitability of field portable analytical devices for determining lithium abundance and distribution during exploration.

The project comprises three modules:

1. classification and geology of LCT pegmatites
2. mineralogy and deportment of economic and deleterious elements
3. physical and chemical processing behaviour.

GSWA is collaborating most closely with module 1, assisting with the development of a database documenting the geological setting of LCT pegmatite mineral systems in Western Australia (age, isotope geodynamics, degree of mineral fractionation, petrological, geochemical variations, post-emplacement histories), and comparing Western Australian eMaterial deposits with global counterparts. The project will be completed by mid-2021.

GSWA will also be a collaborator in the ARC Linkage project 'Rare earth resources of northern Australia', with the University of Adelaide, ANU, GA and the Geological Surveys of New South Wales and Queensland, and a number of REE-focused resource companies. University researchers propose to combine experimental petrology, numerical modelling of lithosphere architecture and magma evolution, and petrological and geochemical studies of prospective or known areas of unconformity-related and peralkaline volcanic REE mineralization across northern Australia, to develop comprehensive metallogenic models and exploration tools. Case studies will include the Browns Range and John Galt REE deposits in the East Kimberley – West Tanami region of northern Western Australia, and it is with these studies that GSWA will be most closely affiliated.

In the 2019–20 financial year, GSWA had commissioned CSIRO to re-analyse approximately 3200 laterite samples from the western Yilgarn Craton using modern analytical techniques including Ultrafine+, to determine lithium and several other critical metals (i.e. tin, tungsten, REE) that could not be reliably measured in previous analytical campaigns using older technologies. The study combines conventional geochemical analysis, indicator mineral chemistry, and studies of regolith characteristics and deportment of critical metals in primary critical mineral deposits. The intent is to understand the formation of critical metal anomalies in the regolith, and their significance as indicators of the size and quality of potential underlying mineralization, hence assess critical metal potential value in the region, and provide a tool that might be applied to critical metals exploration at the regional scale. The results of this study will be made available in the 2020–21 financial year.

## Products planned for release

- Physical and crystallographic characteristics of Pilbara gold grains used in the gold fingerprinting study (Record/s)
- Pilbara gold geochemistry database
- Cobranded GSWA–MRIWA Report for Project M532
- Other results from the REE (ARC Linkage) and LCT pegmatite (MRIWA) projects will be published in external publications
- Western Yilgarn laterite geochemistry database, including element abundance maps; joint CSIRO–GSWA Report describing the results of the Western Yilgarn laterite geochemistry study

# ES46 Enhanced Geochronology and Isotopic Mapping

*Manager: Michael Wingate*

*Team members: Imogen Fielding, Frances James, Yongjun Lu, Marlene Papiccio, Sandra Romano, Tom Scillieri, John Williams*

This project complements GSWA's geochronology studies (see GS54) with the addition of Lu–Hf and oxygen isotope and trace element analysis of zircons, Sm–Nd isotope analysis of whole-rock samples, and additional isotope-related techniques (such as whole-rock Lu–Hf and lead isotopes) conducted in collaboration with university research groups.

Variations in radiogenic isotope compositions (mainly Sm–Nd and Lu–Hf) provide information on the nature of the sources of magmatic rocks, allowing magmatic rocks derived from the mantle to be distinguished from those derived by reworking of older crust. Knowledge of crustal evolution is also important for understanding mineralization, because the addition of juvenile material from the mantle into the crust is commonly associated with mineralizing events. Stable isotopes, mainly oxygen, are used to distinguish material derived from near-surface or supracrustal environments from mantle-derived material. These techniques enable the construction of a range of isotopic maps at different scales, which are powerful in imaging lithospheric and crustal architecture, identifying metallogenic terranes and favourable geodynamic environments, and constraining the 4D evolution of the lithosphere.

The ES46 project also includes measurement of whole-rock geochemical and zircon trace element compositions of Archean granitic rocks in Western Australia, to understand water content, pressure, temperature and oxidation state of magmas, all of which control magma fertility for ore formation, and can be used as exploration indicators in remote or covered terrains.

The ES46 project is funding the work for GS54. Accordingly, the work program for GS54 is included here. The majority of analytical work under ES46 and GS54 is conducted at the John de Laeter Centre at Curtin University, and the Centre for Microscopy, Characterisation and Analysis (CMCA) at UWA.

## Planned work program

The GS54 program will generate U–Pb zircon, baddeleyite and monazite ages in support of GSWA geoscience programs across Western Australia. The timely release of geochronology results will be maintained, through both rapid, brief, in-house reports and the geochronology record series, published online via GeoVIEW.WA, eBookshop and the Data and Software Centre. The laboratory will process samples for geochronology, whole-rock geochemistry and isotope geochemistry as required by GSWA geoscience programs. The Greenstone Geochemical Barcoding Project (ES49) is the largest single user of whole-rock geochemistry, with >1000 samples analysed each year.

The ES46 program will continue analyses of Lu–Hf, Sm–Nd, and oxygen isotopes in 2020–21. Isotope data generated by this program will be checked for accuracy and consistency, provided to GSWA projects, and published on the DMIRS website as they become available. Existing and new zircon oxygen isotope data will be released in tabulated form via GeoVIEW.WA and in the annual Compilation of geochronology information data package. The results will be integrated with geological and geochemical data and gravity, aeromagnetic, seismic and magnetotelluric datasets, to advance our understanding of crustal architecture, geological evolution and mineralization. Syntheses will be published as Reports or Records and will inform other GSWA and external publications.

GSWA is a supporting partner, with the John de Laeter Centre, AuScope, Australian Research Data Commons (ARDC) and UWA, in a 2018–20 project to secure, digitize and make publicly available sample materials and associated data records in the McNaughton Legacy SHRIMP Mount Collection. GSWA will play a key role as custodian of physical specimens, which will be made available in 2020 to the public via GeoVIEW.WA.

Following the success of a pilot project in which (U–Th)/He techniques were used to date iron oxide minerals in lateritic duricrust at the Boddington gold mine (GSWA Record 2018/13), a two-year project with the John de Laeter Centre will formally commence in July 2020 to expand applications and extend regolith dating across Western Australia.

A three-year ARC Linkage project ‘New tools for old rocks: first cycle provenance information’ is underway, and will enhance stratigraphic understanding of sedimentary sequences through novel provenance fingerprinting using K-feldspar (lead isotopes) and apatite (U–Pb, strontium isotopes and grain chemistry). This statewide project already involves case studies in the Pilbara and Yilgarn Cratons and the Canning and Northern Carnarvon Basins.

GSWA contributed to the recent success of an ARC Large Infrastructure and Equipment Fund (LIEF) grant to establish an Australian-first collision-reaction-cell multicollector ICP-MS facility at Curtin University, which will provide a range of isotope analyses at unprecedented precision. GSWA has also committed support to a new multi-institutional LIEF grant application, the results of which will be announced in late 2020. The proposal is to establish a Curtin–Melbourne facility incorporating next-generation, multicollector mass spectrometers and ultraclean gas line systems, capable of revolutionizing  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology. The installation at Curtin University will be optimized to analyse ultrasmall and potassium-poor samples, such as tiny inclusions in ore minerals and feldspars and pyroxenes in mafic igneous rocks, which cannot be dated by other methods.

Related to this LIEF proposal is GSWA’s ongoing participation in the NCRIS-sponsored AuScope National Argon Map (NAM) program, which aims to generate an open-source locational  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology database for the Australian crust to support resource exploration and increase our geological understanding of the Australian continent. GSWA has already submitted samples and nominated a wide variety of additional samples for analysis under this program.

Development of a new geochronology, isotopes, mineral chemistry and metamorphic history database application (WAGIM) will continue. The application will organize and deliver geochronology, isotope and mineral chemistry, and metamorphism data. New geochronology records will be produced ‘on-the-fly’, together with the most up-to-date geological context information, by a module in ENS within GeoVIEW.WA. The WAGIM database will also facilitate publication of ‘external’ geochronology data, via a dedicated layer in GeoVIEW.WA.

## Products planned for release

- Compilation of geochronology information, 2021 (data package)
- Geochronology records and U–Pb datasets released to online applications (GeoVIEW.WA)
- Whole-rock geochemistry analyses released to online applications (GeoChem Extract and GeoVIEW.WA)
- Lu–Hf, Sm–Nd and oxygen datasets released as part of the Compilation of geochronology information, 2021 (data package)
- Lu–Hf and oxygen isotope datasets released to online applications (GeoVIEW.WA and GeoChem Extract)
- Zircon trace element datasets released to online applications
- Release of the McNaughton Legacy SHRIMP Mount Collection via GeoVIEW.WA
- Geodynamic setting of the Lamboo Province (Report)



# ES47 Petroleum Systems

*Manager: Deidre Brooks*

*Team members: Norman Alavi, Richard Bruce, Iain Copp, Louisa Dent, Ameer Ghorri, Peter Haines, Arthur Mory, Leon Normore, Charmaine Thomas, Yijie (Alex) Zhan*

The objective of this program is to collect pre-competitive data to assist in determining the State's potential for petroleum and alternative energy sources that might provide for the State's growing energy requirements. This program comprises a number of distinct subprograms.

During 2019–20, an EIS-funded project to assess the parameters influencing reservoir quality in the Permian sandstones of the northern Perth Basin was finalized and included ichnology, XRD, petrography, HyLogger spectral analysis, influence of temperature and depositional environment on distribution of clays and detailed core logging. The results have been incorporated into a Report for release in 2020–21.

Geophysical projects that continue from the previous financial year into 2020–21 incorporate pre-competitive data which was funded through the EIS in 2018. These projects aim to improve the structural and stratigraphic definition of the Canning and Carnarvon Basins and include:

- seismic interpretation of Kidson Sub-basin and Crossland Platform, using the EIS co-funded acquisition of the Kidson seismic survey and EIS-funded, newly reprocessed 2D seismic lines in the Kidson Sub-basin, Cobb Embayment and northwestern Canning Basin
- seismic interpretation of the Southern Carnarvon and northern Perth Basins, using EIS-funded, newly reprocessed 2D seismic lines in the Southern Carnarvon Basin and the Coolcalalaya Sub-basin of the northern Perth Basin, and incorporating results from the recently released EIS-funded Carnarvon Basin SEEBASE product.

Following the Kidson Sub-basin seismic acquisition, stratigraphic drilling of Waukarlycarly 1 was undertaken in late 2019 in the western Canning Basin. This is located on the new seismic line and will improve understanding of the stratigraphy and petroleum potential of the Waukarlycarly Embayment and the underlying basement. The drilling costs were not funded by the EIS; however, the post-well analysis for Waukarlycarly 1 to be performed in 2020–21 will be funded by the EIS. These analyses include CA-ID TIMS geochronology to precisely date ash beds intersected in the well and additional biostratigraphy, reservoir and source rock analysis that may be required to infill gaps in the data acquired during 2019–20.

Finally, an EIS-funded Canning Basin collaborative core analysis project in 2015–16 is still yielding new information and a Report on a new Nambeet Formation reference section will be published in 2020–21. Work will commence on a new reference section for the Goldwyer Formation with anticipated release in 2021–22.

## Planned work program

EIS-funded regional geological and geophysical studies for the Canning, Perth and Carnarvon Basins will continue.

## Canning Basin

The planned studies in the Canning Basin are to:

- publish and finalize the interpretation of the new 2D regional deep crustal seismic line across the Kidson Sub-basin and incorporate the results into a regional mapping project
- continue interpreting the 2018 EIS-funded newly reprocessed 2D seismic lines in the Kidson Sub-basin, Cobb Embayment and the northwest portion of the Canning Basin
- finalize and release a Report on the new Nambeet Formation reference section based on the results of the 2015–16 collaborative core analysis project
- commence work on defining a new Goldwyer Formation reference section based on the results of the 2015–16 collaborative core analysis project and the Waukarlycarly 1 stratigraphic well
- continue to work on Records of the results of the petrophysical assessment of the CO<sub>2</sub> geosequestration potential of the Ordovician intersected in Theia 1 and Olympic 1 wells, and the Devonian in Senagi 1 well in the Canning Basin, based on the results from the 2015–16 collaborative core analysis project and the EIS-funded petrophysical interpretation in 2018. This is the project that was put on hold in 2019–20 due to the drilling of Waukarlycarly 1.

## Perth Basin

The planned outcome from studies in the Perth Basin is to publish the results of the 2019–20 EIS-funded project to study the parameters influencing the reservoir quality of the Permian sandstones of the northern Perth Basin.

## Southern Carnarvon Basin

Planned studies in the Southern Carnarvon Basin include commencement of interpretation of the 2018 EIS-funded, reprocessed 2D seismic lines and to incorporate the results, along with the 2018 EIS-funded Carnarvon SEEBASE product, into a wider interpretation project to improve the definition of the stratigraphy and structure of the onshore portion of the basin. The results of this project will be included as new pre-competitive data supporting future acreage releases.

## Products planned for release

- Waukarlycarly 1 interpretive well completion report (Report)
- Parameters influencing the reservoir quality of Permian sandstones in the northern Perth Basin (Report)
- New reference section for the Nambeet Formation, Canning Basin (Report)
- Seismic interpretation of the Canning Basin, Kidson Sub-basin seismic survey (Record)

# ES49 Greenstone Geochemical Barcoding Project

*Manager: Hugh Smithies*

*Team members: Lauren Grech, Jack Lowrey*

The Greenstone Geochemical Barcoding Project is an initiative under the EIS that aims to geochemically characterize greenstone stratigraphy throughout the EGST. This project will substantially increase the amount of high-quality, multi-element, geochemical data for greenstones, targeting available diamond drillcores that sample the most geologically well-constrained, or best-understood, parts of various greenstone belts. This has initially been undertaken in the Kalgoorlie–Kambalda region, but will ultimately extend throughout the EGST. Through detailed geochemical sampling of diamond drillcore we hope to establish a geochemical 'barcode' of the stratigraphy (including local variations) in these better-known sections of greenstone belts. The ultimate goals of this project are to:

- establish whether local and/or regional greenstone stratigraphies are geologically valid, and understand the geological reasons for any local and regional stratigraphic variations
- provide a reasonable geochemical proxy for stratigraphy that will allow users to better establish where a particular lithology or lithological association fits in a local or regional stratigraphy

- provide a data-rich, high-quality geochemical dataset regionally representative of all magmatic rock types that will help further develop our understanding of petrogenetic processes in greenstone evolution and associated mineralization.

## Planned work program

Work within ES49 will concentrate in the western and central parts of the EGST, but also support other regional Yilgarn Craton geoscience programs. The work in the Kalgoorlie Terrane will assist with, and complement, the interpretation of the high-resolution seismic survey that was conducted in early 2019 by GSWA, between Ora Banda and Kambalda.

## Product planned for release

- [Greenstone Geochemical Barcoding project data release \(Record\)](#)

# ES51 Yilgarn Granite Project

*Manager: Hugh Smithies*

*Team member: Jack Lowrey*

The Yilgarn Granite Project is an initiative under the EIS that aims, in the first instance, to provide high-quality geochemical data relating to the granitic rocks that dominate the Archean Yilgarn Craton, and subsequently, to provide interpretation (digital data, GIS layers, Reports) that attempts to place these data within the context of crustal scale structure, source regions and economic mineral fertility. The project will cover the entire Yilgarn Craton. The first stage of the project will involve the re-analysis of archive granite samples from both GA and GSWA. The ultimate goals of this project are to:

- provide complete coverage of the Yilgarn Craton in terms of modern, high-quality, major- and trace element data (including lithium) on granitic rocks, and at the same time, expand the coverage of whole-rock Sm–Nd isotope data
- identify, within this new dataset, potential proxies for crustal source composition, melting conditions and for fertility in terms of producing precious and strategic mineral deposits.

## Planned work program

Work within ES51 will concentrate on re-analysing about 3000 granite samples collected by and currently archived with GA.

## Product planned for release

- Yilgarn Granite Project data release (Record)

# **APPENDIX**

## **GSWA collaborative research projects**



# ARC collaborative agreements



## **ARC Centre of Excellence for Core to Crust Fluid Systems – CE11E0070**

**Project manager:** Suzanne O'Reilly (Macquarie University)

**Partner researchers/institutions:** Simon Wilde (Curtin University), Campbell McCuaig (CET, UWA), Chris Kirkland (CET, Curtin), Huaiyu Yuan (Macquarie University, CET)

**GSWA contacts:** Klaus Gessner, Michael Wingate

**Duration of project:** 2011–17 (extended to 2022)

### **Project description**

A world-leading **Centre of Excellence** driving innovative interdisciplinary research towards a new understanding of Earth's origins, fluid budgets and evolution, and delivering outcomes of tangible benefit to society.

### **GSWA sponsored projects**

- 3D crustal architecture of Western Australia
- Zircon Lu–Hf constraints on Precambrian crustal evolution in Western Australia

### **Outputs — planned or actual**

Co-branded GSWA Reports and international journal papers; GSWA geochronology records

## **ARC Discovery project DP200101104 – Deciphering the tectonic record of the early Earth\***

**Project manager:** Fawna Korhonen

**Partner researchers/institutions:** Curtin University

**GSWA contacts:** Fawna Korhonen, Simon Johnson

**Duration of project:** 2020–25

### **Project description**

This project aims to decipher how and why plate tectonics emerged, and how any precursor tectonic system modulated planetary heat loss. The project expects to generate new knowledge regarding the tectonic record of the early Earth using pressure–temperature–age constraints from truly ancient (2.8 – 4.0 billion years old) metamorphosed rocks in the Pilbara Craton and the Narryer Terrane, as well as other localities worldwide. Expected outcomes of this collaborative international project include the development of a conceptual geodynamic model for the early Earth. This should provide significant benefits in permitting a better understanding of the where and why of Australia's natural resources, in training a new generation of Earth system scientists, and in broadening public awareness of fundamental Earth science.

### **Outputs — planned or actual**

Metamorphic history records for each metamorphic sample (once theses are published)

---

\* Project postponed due to COVID-19 – fieldwork will start in 2021 although GSWA is providing vintage sample material in 2020 in lieu of late commencement.

***ARC Linkage project LP130100722 – Earth's best-preserved Archean boninites: do they finally resolve the Archean mantle plume–plate controversy?***

**Project manager:** Derek Wyman (University of Sydney)

**Partner researchers/institutions:** Jack Lowrey (PhD candidate, University of Sydney / GSWA)

**GSWA contact:** Tim Ivanic

**Duration of project:** 2014–18 (extended to 2020)

**Project description**

This study will look at the geochemistry of mafic rocks in the Murchison Domain of the Yilgarn Craton. Subduction typically starts in the modern Earth with the eruption of chemically distinctive rocks known as boninites. This project will study remarkably well-preserved 2.8 billion-year-old boninites from Western Australia that may finally establish whether modern-style plate tectonics operated in the first half of Earth's history.

**Outputs — planned or actual**

Peer-reviewed journal papers; conference proceedings; GSWA Open Day posters; PhD thesis; GSWA Report  
Lowrey, JR, Ivanic, TJ, Wyman, DA and Roberts, MP 2017, Platy pyroxene: new insights into spinifex texture: *Journal of Petrology*, v. 58, no. 9, p. 1671–1700.

Lowrey, JR, Wyman, DA, Ivanic, TJ, Smithies, RH and Maas, R 2020, Archean Boninite-like Rocks of the Northwestern Youanmi Terrane, Yilgarn Craton: Geochemistry and Genesis: *Journal of Petrology*, doi:org/10.1093/petrology/egaa002.



***ARC Linkage project LP170100985 – Enabling 3D stochastic geological modelling (Loop)***

**Project manager:** Klaus Gessner

**Partner researchers/institutions:** Monash University

**GSWA contact:** Klaus Gessner

**Duration of project:** 2018–21

**Project description**

We will develop a new open-source 3D implicit geostructural simulator and modelling platform that will address the entire 3D geological modelling workflow, from guiding efficient observations and field sampling to the production of a series of consistent 3D geological models with uncertainty assessment and characterization.

**Outputs — planned or actual**

Open-source 3D geological simulator and modelling software package



***ARC Linkage project LP180100199 – New tools for old rocks: first cycle provenance information***

**Project managers:** Simon Johnson, Michael Wingate and Hugh Smithies

**Partner researchers/institutions:** Chris Kirkland (Curtin University)

**GSWA contact:** Simon Johnson

**Duration of project:** 2020–23

**Project description**

The aim of this research is to enhance stratigraphic understanding of sedimentary sequences in Western Australia through application of novel provenance fingerprinting tools in K-feldspar (lead isotopes) and apatite (U–Pb, strontium isotopes and mineral chemistry). While much stratigraphic characterization has been based on detrital zircon ages and their correlation to basement sources, two major limitations are apparent: a) zircon may be multicycle, blurring source–sink relationships; b) zircon may be absent in mafic lithologies thus biasing investigations. In this work, K-feldspar and apatite provenance investigation will be undertaken on a statewide basis and include case studies in the Yilgarn Craton and Canning and Northern Carnarvon Basins.

**Outputs — planned or actual**

Johnson, SP, Kirkland, CL, Evans, NJ, McDonald, BJ and Cutten, HN 2018, The complexity of sediment recycling as revealed by common Pb isotopes in K-feldspar: *Geoscience Frontiers*, v. 9, p. 1515–1527, doi:10.1016/j.gsf.2018.03.009.

Numerous high-quality, open-access journal articles at various stages throughout the project, some probably published six months to one year after project end



***ARC Linkage project LP180101118 – Enhanced 3D seismic structure for southwest Australia (SWAN)***

**Project manager:** Klaus Gessner

**Partner researchers/institutions:** ANU, GA, DFES

**GSWA contact:** Klaus Gessner

**Duration of project:** 2020–23

**Project description**

The objective of this work is to delineate the 3D structure of the crust and lithosphere located in the southwestern part of Western Australia, using a full range of seismic imaging techniques.

**Outputs — planned or actual**

External publications, Report

***ARC Linkage project LP190100146 – Evolution of Proterozoic multistage rift basins – key to mineral systems***

**Project manager:** Mark Jessell (UWA)

**Partner researchers/institutions:** UWA, Monash, University of Sydney, CSIRO, Independence NL, BHP Billiton, Anglo American PLC, MRIWA

**GSWA contact:** Klaus Gessner

**Duration of project:** 2020–24 (four years from signed agreement)

**Project description**

This project will deliver a new quantitative and integrated exploratory framework for the mineral industry in Australia's frontier sedimentary basins by integrating the latest advances in laboratory experimental tectonics with thermo-mechanical numerical, surface process and geophysical modelling. The project will use northern Australian basins as a natural laboratory to address the fundamental processes involved in the development of sedimentary ore systems. The project will investigate how they can be detected by modern exploration techniques using a multidisciplinary approach with a team of experts with backgrounds in mineral and petroleum systems.



***ARC Linkage project LP190100635 – Rare earth resources of northern Australia***

**Project manager:** Trevor Beardsmore

**Partner researchers/institutions:** Adelaide University, GA, GSNSW, GSQ, resource companies

**GSWA contacts:** Trevor Beardsmore, Sidy Morin-Ka

**Duration of project:** 2020–22

**Project description**

Combine experimental petrology, numerical modelling of lithosphere architecture and magma evolution, and petrological and geochemical studies of prospective or known areas of unconformity-related and peralkaline volcanic REE mineralization across northern Australia, to develop comprehensive metallogenic models and exploration tools. Case studies will include the Browns Range and John Galt REE deposits in the East Kimberley – West Tanami region of northern Western Australia. It is with these studies that GSWA will be most closely affiliated.

**Outputs — planned or actual**

External publications

# MinEx collaborative agreements



## ***MinEx CRC Program 3: National Drilling Initiative***

**Project manager:** Richard Chopping

**Partner researchers/institutions:** Multicollaborative project

**GSWA contact:** Richard Chopping

**Duration of project:** 2018–28

### **Project description**

MinEx CRC will create new opportunities for mineral discovery by delivering more productive, safer and environmentally friendly drilling methods and new technologies for collecting data while drilling, and exploration data on never-before-sampled rocks that are hidden but prospective for minerals. A key component of this CRC is the NDI, linking state and federal geological surveys with researchers in drilling and deriving meaning from data to develop new methodologies to map under cover. The NDI will focus on drilling in each partner state, and will conduct three major research streams:

- Project 7: Maximizing the value of data and drilling through cover
- Project 8: Geological architecture and evolution
- Project 9: Targeting mineral systems in covered terranes.

The GSWA involvement in MinEx CRC includes additional involvement in Project 6 (discussed below). GSWA will house an embedded researcher from University of South Australia in 2019–22 who will contribute to this research.

### **Outputs — planned or actual**

Compilation of geoscientific data for ‘The Gap’ region (Paterson Orogen – Canning Basin – west Arunta Orogen – west Musgrave Province)

New geological, geochemical, geochronological and petrophysical samples/data obtained through MinEx CRC drilling techniques



## ***MinEx CRC Project 6: Automated 3D Modelling***

**Project manager:** Klaus Gessner

**Partner researchers/institutions:** Multicollaborative project

**GSWA contacts:** Richard Chopping, Klaus Gessner

**Duration of project:** 2019–22

### **Project description**

As part of MinEx CRC Project 6, GSWA will be involved in the development of automated 3D modelling methodologies. This project is related to the ARC Linkage project for 3D stochastic modelling.

### **Outputs — planned or actual**

Regional-scale 3D map constructed from GSWA data using MinEx CRC developed tools

# MRIWA collaborative agreements



## ***MRIWA project M446 – 4D evolution of Western Australian ore systems: Re–Os sulfide geochronology***

**Project manager:** Neal McNaughton (John de Laeter Centre, Curtin University)

**Partner researchers/institutions:** Neal McNaughton, Svetlana Tessalina, Fred Jourdan, Vitor Barrote (PhD candidate; John de Laeter Centre, Curtin University); Thermo Fisher Scientific

**GSWA contact:** Michael Wingate

**Duration of project:** 2016–19 (extended to 2020)

### **Project description**

The aims are to provide benchmark geochronology for metals exploration in Western Australia to complement the extensive 2D and 3D geological mapping and data of GSWA and industry. This sulfide geochronology project provides a new opportunity to introduce direct dating of ore sulfides along with fingerprinting metal sources, and will fill a major gap in 4D analysis of mineralized terrains, a topic recognized as a national deficiency. The specific aims are for two deposit types, volcanogenic massive sulfides and orogenic gold.

### **Outputs — planned or actual**

Peer-reviewed journal papers; conference proceedings; MRIWA Report



## ***MRIWA project M448 – 4D evolution of Western Australian ore systems (WA4D): rutile – pathfinder to ores***

**Project manager:** Neal McNaughton (John de Laeter Centre, Curtin University)

**Partner researchers/institutions:** Neal McNaughton, Noreen Evans, Fred Jourdan, Jennifer Porter (PhD candidate; John de Laeter Centre, Curtin University); Independence Group NL

**GSWA contact:** Michael Wingate

**Duration of project:** 2015–18 (extended to 2020)

### **Project description**

This project will use publicly available geochemical data on rutiles formed in different ore and unmineralized environments to build a geochemical database, and to add new geochemical data for rutiles from Western Australian ore systems and barren rocks. From this database, existing geochemical discriminants of mineralization will be tested, and by virtue of the enhanced capabilities of the modern analytical techniques to be employed, new discriminants will be developed for each ore commodity that will shed light on the origin of the formation of rutile. The project will target Western Australian ore systems for new data, to compare and contrast against published data, and will include:

- rapid/automated rutile identification and in situ analysis
- verification of rutile mineralization ages by other geochronology methods (U–Pb, Ar–Ar)
- sponsor-initiated case studies of rutile geochemical/age discriminants for gold and base metal exploration in Western Australia
- feedback to 4D metallogenic mapping.

### **Outputs — planned or actual**

Peer-reviewed journal papers; conference proceedings; MRIWA Report





### ***MRIWA project M470a – A multiscale approach to controls on mineralization in the Fraser Zone, Western Australia\****

**Project managers:** Katy Evans, Chris Kirkland (Curtin University)

**Partner researchers/institutions:** MRIWA, Independence Group NL, MG Creasy, Curtin University

**GSWA contact:** Raphael Quentin de Gromard

**Duration of project:** 2020–23

#### **Project description**

This program of research will focus on the partially covered and highly prospective Fraser Zone, Western Australia. The project will consist of four modules:

1. Architecture and stratigraphy: cutting-edge split stream LA-ICP-MS instrumentation and new mineral isotope systems will produce a reliable chronostratigraphic and tectonothermal framework, in the context of a well-constrained lithospheric architecture.
2. The tectonothermal evolution of the Fraser Zone: application of new thermodynamic models with high-resolution, high-throughput, element maps of mineralized and unmineralized samples to quantify variations in pressure, temperature, time and space in the Fraser Zone.
3. Controls on tenor: process-based conceptual models of crust–magma–fluid interactions based on detailed site data from our partner organizations. A data science approach will be necessary here to optimize information from the large existing datasets. The outputs will be a quantitative understanding of the processes that control the grade of mineralization, and tools to recognize the presence of mineralization from indirect evidence.
4. Regolith from the Silver Knight deposit will be used to develop a gossan/alteration model for the Fraser Zone deposits with predictive capacity.

This MRIWA-funded research program will build on existing investment by GSWA and Western Australia's research institutions to provide an exceptional value proposal.



### ***MRIWA project M521 – Lithospheric and crustal-scale controls on multistage basin evolution: impacts on mineralizing systems***

**Project managers:** Weronika Gorczyk, Mark Jessell (CET, UWA)

**Partner researchers/institutions:** MRIWA (UWA/First Quantum Minerals / Fortescue Metals Group)

**GSWA contact:** David Kelsey

**Duration of project:** 2018–22

#### **Project description**

This project will use an integrated basin studies approach, combining interpretation of multiple regional datasets (e.g. new seismic reflection, drillcore, gravity, magnetics) with numerical modelling to investigate multiscale (lithospheric and crustal) and multistage deformation processes. These will provide insight into the link between basement and basin evolution, and subsequent mineralization processes. The 'natural laboratory' used for this study is primarily the Paterson Orogen, in central Western Australia.

#### **Outputs — planned or actual**

The project will produce six-monthly reports and comprehensive MRIWA reports

---

\* Project on hold due to COVID-19 – the five PhD students assigned to this project are in Brazil, UK, Italy, US and Germany, and with the field season reduced, this project will be paused.



***MRIWA project M532 – Geology, mineralogy and metallurgy of eMaterial resources in Western Australia***

**Project manager:** Trevor Beardsmore

**Partner researchers/institutions:** John de Laeter Centre, Curtin University; AXT Pty Ltd

**GSWA contact:** Trevor Beardsmore

**Duration of project:** 2020–23

**Project description**

To develop a geometallurgical framework for Western Australian lithium pegmatite deposits that will lead to improved efficiencies in exploration, mineral beneficiation and processing techniques.

**Outputs — planned or actual**

External publications, Report

## Other collaborative agreements



### *Ar/Ar dating of pyroxene*

**Project manager:** Michael Wingate

**Partner researchers/institutions:** John de Laeter Centre, Curtin University

**GSWA contact:** Michael Wingate

**Duration of project:** 2017–20

#### **Project description**

To test whether Ar/Ar analysis of pyroxene can be used to date mafic and ultramafic rocks that cannot be dated by other methods.

#### **Outputs — planned or actual**

GSWA publication and journal article



### *Critical minerals (Li, Ta, Nb, W, REE) in the western Yilgarn Craton*

**Project manager:** Trevor Beardsmore

**Partner researchers/institutions:** CSIRO

**GSWA contacts:** Trevor Beardsmore, Paul Duuring

**Duration of project:** 2020–21

#### **Project description**

CSIRO will re-analyse approximately 3200 laterite samples from the western Yilgarn Craton using modern analytical techniques, to determine lithium and several other critical metals (i.e. tin, tungsten and REE) that could not be reliably measured in previous analytical campaigns using older technologies. The study will combine conventional geochemical analysis with the UltraFine+ methodology, indicator mineral chemistry, and studies of regolith characteristics and deportment of critical metals in primary critical mineral deposits. The intent is to understand the formation of critical metal anomalies in the regolith, and their significance as indicators of the size and quality of potential underlying mineralization, hence assess critical metal potential value in the region, and provide a tool that might be applied to critical metals exploration at the regional scale.

#### **Outputs — planned or actual**

Joint CSIRO–GSWA Report; western Yilgarn laterite geochemistry database; external publications



### *Crustal evolution of Western Australia*

**Project manager:** Chris Kirkland

**Partner researchers/institutions:** Curtin University

**GSWA contact:** Michael Wingate

**Duration of project:** 2015–20

#### **Project description**

The project aims are to:

- produce contoured, time-dynamic hafnium isotopic maps from selected regions of Western Australia
- implement secondary ion mass spectroscopy oxygen analyses of GSWA mounts and contribute to isotopic data.

#### **Outputs**

Co-branded Reports and GIS layers: hafnium isotopic maps and oxygen isotopic analyses; Western Australian atlas of crustal evolution; Magmatic petrogenesis of the Rudall Province; Isotopic signature of crystalline basement of the Eucla Basin



### ***CSIRO Ultrafine+ soils Phase 2***

**Project manager:** Richard Chopping

**Partner researchers/institutions:** Ryan Noble (CSIRO)

**GSWA contact:** Nadir de Sousa Kovacs

**Duration of project:** 2019–21 (outputs delayed to 2020–21 financial year)

#### **Project description**

Supporting the MinEx NDI Western Australian focus area, undertaking UltraFine+ re-analysis of West Arunta regolith geochemistry samples, and other samples collected during geophysical deployments.

#### **Outputs — planned or actual**

Geochemical analyses in WACHEM, Records or Reports

### ***Current state of knowledge on the Mesozoic of Western Australia***

**Project manager:** Deidre Brooks

**Partner researchers/institutions:** Curtin University

**GSWA contact:** Arthur Mory

**Duration of project:** 2017–19 (waiting on deliverables)

#### **Project description**

The aim is to contribute to the understanding of the geology of the Mesozoic era within Western Australia, by researching and documenting the current status of knowledge. This will be published in GSWA's Western Australia unearthed series.

#### **Outputs — planned or actual**

Publication as part of the Western Australia unearthed series



### ***CWAS Canning passive seismic deployment — phase 3***

**Project manager:** Klaus Gessner

**Partner researchers/institutions:** Huaiyu Yuan (Macquarie University)

**GSWA contact:** Klaus Gessner

**Duration of project:** 2019–21

#### **Project description**

The project will provide seismic velocity data for the active-source seismic model of the Kidson line and will provide depth information to constrain the architecture of the central Canning Basin, and its margins. The project will be essential to arrive at a better understanding of the basement of the Canning Basin and its potential for mineral systems.

#### **Outputs — planned or actual**

Seismic models of the western margin and central part of the Canning Basin, including crustal thickness maps, crustal shear wave velocity model and body-wave tomographic model down to 400 km depth



### ***Do the mineral systems in the southern Kalgoorlie Terrane have a camp-scale geophysical signature?***

**Project manager:** Michael Dentith (UWA)

**Partner researchers/institutions:** UWA

**GSWA contact:** Klaus Gessner

**Duration of project:** 2018–19 (extended to 2020)

#### **Project description**

Geophysical data will be collected, processed and interpreted from the region between Kalgoorlie–Kambalda–Norseman. This experiment will research whether there is a distinctive crustal-scale geophysical signature of the mineral systems in this area, which is notable for its numerous large mineral deposits. Identifying such a signature will demonstrate a means for identifying other, as yet unknown, camps in Western Australia and hence encourage greenfields exploration in the State.

#### **Outputs — planned or actual**

Co-branded Reports and Records



### ***Earth composition and evolution — preservation of legacy collections project***

**Project manager:** Michael Wingate

**Partner researchers/institutions:** John de Laeter Centre and Curtin Library, Curtin University

**GSWA contact:** Michael Wingate

**Duration of project:** 2018–20

#### **Project description**

The project will protect, preserve and enable re-use of a collection of SHRIMP mounts from dozens of ore genesis studies, as well as supplementary materials (researcher notes, interpretation, images, etc.). These mounts are globally significant, as many of the deposits are now mined out, inaccessible or too expensive to revisit. The collection will be archived by GSWA, with materials discoverable via GeoVIEW.WA and AuScope.

#### **Outputs — planned or actual**

Physical sample collection, plus digitized information and metadata, suitable for publication as a spatial data layer by GSWA and AuScope



### ***Feasibility of passive seismic and temperature monitoring using cemented fibre optic cable in Harvey 3 well***

**Project manager:** Deidre Brooks

**Partner researchers/institutions:** Curtin University

**GSWA contact:** Deidre Brooks

**Duration of project:** January 2020 – October 2020

#### **Project description**

Distributed fibre optic sensing is an emerging technology enabling reliable long-term monitoring and surveillance of the subsurface. It can be used to monitor changes in strain, temperature and some other physical properties at high sampling rates both spatially and temporally. Measuring dynamic strain referred to as distributed acoustic sensing (DAS) allows the conversion of a single optical fibre into an array of optical acoustic sensors with very small receiver intervals, broad frequency range and high enough sensitivity. Such receiver arrays can be used to monitor local and regional seismicity as well as detect distant seismic events.

Deployment of the seismic receiver array along deep vertical wells allows seismic sensors to be in a quiet environment with no surface wave contamination.

The following activities are planned at Harvey 3 well:

- Continuous passive seismic acquisition of DAS and distributed temperature setting (DTS) covering several days.
- Data analysis focusing on demonstration of the feasibility of passive monitoring for characterization of the subsurface and analysis of performance of cemented cable.
- Liaison with CSIRO and UWA to use data collected from nearby Harvey wells and passive seismic monitors.

#### **Outputs — planned or actual**

Raw and processed seismic data converted to generic data format (SEG-Y); short Report summarizing findings; presentation to industry forum on results

### ***Harvey 2 well water production and injection testing***

**Project manager:** Deidre Brooks

**Partner researchers/institutions:** Karsten Michael (CSIRO)

**GSWA contact:** Deidre Brooks

**Duration of project:** January 2020 – June 2020 (extended to October 2020)

#### **Project description**

A multi-day water production and injection of the Harvey 2 well to establish the feasibility of future experiments at the in situ lab site.

#### **Outputs — planned or actual**

CSIRO will provide:

- an interpretation of hydraulic properties, boundary conditions and formation water quality of the perforates interval in Harvey 2
- either, confirmation that Harvey 2 is suitable for future injections experiments or, if this should not be the case, a plan for alternative well intervention/completion
- the corrosion log showing thickness of tubing and casing in Harvey 2 and an appendix in the Report

### ***K–Ar dating of fault rocks***

**Project manager:** Huntly Cutten

**Partner researchers/institutions:** Horst Zwingmann (Kyoto University); Tonguc Uysal, Andrew Todd (ARRC, CSIRO)

**GSWA contacts:** Huntly Cutten, Michael Wingate

**Duration of project:** 2015–22

#### **Project description**

This project will involve K–Ar (and possibly Rb–Sr) dating of fault rocks, fault gouge and slickenside surfaces, to determine the ages of the most recent fault movements in low-grade rocks of the Edmund and Collier Basins, in which deformation events could previously be dated only indirectly. The project is planned to be expanded to include the eastern Capricorn Orogen basins, and additional Western Australian terranes.

#### **Outputs — planned or actual**

Peer-reviewed journal papers; two Reports

Cutten, HN, Johnson, SP, Thorne, AM, Wingate, MTD, Kirkland, CL, Belousova, EA, Blay, OA and Zwingmann, H 2016, Deposition, provenance, inversion history and mineralization of the Proterozoic Edmund and Collier Basins, Capricorn Orogen: Geological Survey of Western Australia, Report 127, 74p.

Cutten, HN, Zwingmann, H, Uysal, T, Todd, A (in prep.), Dating Proterozoic fault movement using K–Ar geochronology of illite separated from fault gouge, Report.



### ***Mapping sulfur sources in selected Precambrian terranes of Western Australia to enhance predictive targeting for gold and base metal mineralization***

**Project manager:** Marco Fiorentini (CET, UWA)

**Partner researchers/institutions:** CET, UWA

**GSWA contact:** Trevor Beardsmore

**Duration of project:** 2014–17 (extended to 2020)

#### **Project description**

The aim of this project is to spatially constrain sulfur sources of gold and base metal mineralization in key terranes of Western Australia.

#### **Outputs — planned or actual**

Peer-reviewed journal papers, conference proceedings, Report, Thesis submitted — Report pending

### ***Narryer Terrane isotopes project***

**Project manager:** Hugh Smithies

**Partner researchers/institutions:** Tony Kemp (UWA)

**GSWA contacts:** Hugh Smithies

**Duration of project:** 2012–20

#### **Project description**

Field inspection/sampling of the Narryer gneisses, zircon isotope work (geochronology, oxygen isotopes and hafnium isotopes, both whole grain and laser ablation) and whole-rock hafnium, neodymium and lead isotope studies.

#### **Outputs**

Report and external papers

Kemp, AIS, Wilde, SA and Spaggiari, CV 2019, The Narryer Terrane, Yilgarn Craton, Western Australia: review and recent developments, *in* Earth's Oldest Rocks, second edition *edited by* M van Kranendonk, V Bennett and E Hoffmann: Chapter 18, p. 401–433, Elsevier, doi:org/10.1016/B978-0-444-63901-1.00018-6.

Rowe, ML 2016, Petrology and geochemistry of the Eoarchaean Manfred Complex: origin and components: Geological Survey of Western Australia, Record 2016/22, 150p.

**National Virtual Core Library – Western Australian node****Project manager:** Lena Hancock**Partner researchers/institutions:** AuScope with NCRIS funding, CSIRO**GSWA contact:** Lena Hancock**Duration of project:** Ongoing**Project description**

GSWA houses, manages and operates a HyLogger-3 semi-automated core logging facility as part of the NVCL project. GSWA owns the HyLogger, maintains it and provides operational staff as a co-investment in the project. The aim is to systematically capture hyperspectral data for all mineral and petroleum drillcore in its Perth and Kalgoorlie core libraries. GSWA provides data and interpretations to the NVCL, GeoVIEW.WA and other third parties.

**Outputs — planned or actual**

Geoscience publications using HyLogger data; procedural publications

**Oxygen isotope analyses of zircons****Project manager:** Michael Wingate**Partner researchers/institutions:** UWA, CMCA**GSWA contact:** Michael Wingate**Duration of project:** Ongoing**Project description**

This project will add value to zircon Lu–Hf analyses by using zircon oxygen isotopes to distinguish material derived from near-surface or supracrustal environments from material derived from the mantle.

**Outputs — planned or actual**

Contributions to GSWA publications and journal articles

**Paleoproterozoic mafic magmatism of the Kimberley Basin, Western Australia****Project manager:** Catherine Spaggiari**Partner researchers/institutions:** Karin Orth (University of Tasmania)**GSWA contacts:** Catherine Spaggiari, Chris Phillips**Duration of project:** 2012–15 (draft Report delivered late 2019, in progress)**Project description**

The main aims are to:

- map the distribution and relationships of the extrusive mafic rocks and sedimentary interbeds
- constrain the spatial and temporal relationships of the different magmatic phases within the Hart Dolerite Sill
- search for the plumbing and drivers that lead to the eruption and intrusion of 300 000 km<sup>3</sup> of magma
- understand the role of mafic volcanism in the development of Australia and in particular the North Australian Craton.

**Outputs — planned or actual**

Orth, K, The Hart–Carson Large Igneous Province, Kimberley Region, northwestern Australia: Report (planned; with a contribution from Susan Belford)



### ***Pilbara gold fingerprinting***

**Project manager:** Trevor Beardsmore

**Partner researchers/institutions:** TSW Analytical

**GSWA contact:** Lena Hancock

**Duration of project:** 2019–21

#### **Project description**

To characterize the provenance and metallogenesis of gold mineralization across the Pilbara Craton using morphometry, microstructure, associated minerals and trace element composition of bedrock and placer gold grains.

#### **Outputs — planned or actual**

Records for donated gold samples from exploration and mining companies and a final Pilbara gold Report that will be released to the public by end of June 2021

### ***Seismic acquisition using distributed acoustic sensing in an urban environment***

**Project manager:** Mike Dentith (UWA)

**Partner researchers/institutions:** UWA

**GSWA contact:** Klaus Gessner

**Duration of project:** 2017–20

#### **Project description**

The project uses passive seismic, ambient noise-based methods to map large-scale structure, especially depth to basement. Concurrently, the seismic monitoring data will also be used as a comparative study that aims to demonstrate that instead of using seismic instruments, seismic monitoring can be undertaken using existing fibre-optic cable infrastructure. Distributed acoustic sensing is an emerging technology for seismic wavefield measurement that relies on conventional optical fibre cables to create ‘virtual’ strain-rate sensors at every few metres along the cable.

#### **Outputs — planned or actual**

GSWA Report



### ***(U–Th)/He dating of secondary iron oxides in lateritic duricrust in Western Australia***

**Project manager:** Richard Chopping

**Partner researchers/institutions:** John de Laeter Centre, Curtin University

**GSWA contacts:** Richard Chopping, Michael Wingate

**Duration of project:** 2020–21

#### **Project description**

To develop a geochronological framework for interpreting the weathering, landscape evolution and paleoclimate history of Western Australia by (U–Th)/He dating of secondary iron oxides in lateritic duricrust throughout Western Australia.

#### **Outputs — planned or actual**

Digital dataset along with GSWA products and external publications; raw data and dating results reported in Microsoft Excel and PowerPoint format

# National Collaborative Framework (NCF) agreements

## ***AusAEM20–WA Project Agreement Western Australian component of Australian 20 km airborne electromagnetic surveys, GA Ref: 004495***

*Falls under the NCF CMCG40003A PA4*

**Project manager:** David Howard

**Partner researchers/institutions:** GA

**GSWA contacts:** David Howard, John Brett

**Duration of project:** 2019–21 (two 12-month extensions)

### **Project description**

The project is a continuation of previous agreements NCF CMCG40003A PA4 and CMCG4003A 000668-1 — GA Ref 003995, described below.

The current focus of national geophysics has shifted to very widely spaced, broadscale AEM surveys, extending GA's 2017–20 EFTF AusAEM surveys, as part of a collaborative, national goal of the Commonwealth, state and territory geological survey agencies to acquire AEM data at 20 km line-spacing or less across the Australian continent.

AusAEM20–WA is the Western Australian component of this Australian 20 km Airborne Electromagnetic Survey objective (AusAEM20). AusAEM20–WA Stage 1 is programmed to commence in 2020–21 over the eastern Yilgarn and the South West of Western Australia.

### **Outputs — planned or actual**

Survey datasets including point data, grids, images and inversion products

## ***Australia Minerals Project Agreement GA Ref: 003938***

*Falls under head agreement CMC G40003A – 000668-1*

**Project manager:** Anthony Budd

**Partner researchers/institutions:** GA

**GSWA contact:** Executive Director, GSWA

**Duration of project:** 2018–21 (one option for extension of two years)

### **Project description**

Australia Minerals is a collaborative group of Australian state and territory government geological surveys that is an outworking of the Geoscience Working Group (GWG) under the Energy Council of the Council of Australian Governments. Australia Minerals promotes minerals investment in Australia by participating in international and domestic conference, mining trade shows and investment seminars. GA coordinates the participation of Australian Minerals at events.

The project:

- promotes Australia to make it the preferred destination for minerals investment, particularly at the exploration stage
- advocates opportunities in greenfields areas, mineral provinces and commodities revealed by new geoscience information or changes in market demand
- targets all market segments responsible for guiding investment decisions in minerals.

Committees include GWG.

***Land access in Western Australia project agreement, GA Ref: 004637 (AUSLAMP and AUSARRAY)***

**Project managers:** Klaus Gessner, David Howard

**Partner researchers/institutions:** GA

**GSWA contacts:** Klaus Gessner, David Howard

**Duration of project:** 2019–25 (six years initial term with option for two 12-month extensions)

**Project description**

The Australian Passive Seismic Array (AUSARRAY) is a collaborative national survey that acquires seismic waveform data. The moveable array of ~130 broadband seismic stations are arranged in a grid, spaced ~55 km apart and deployed for a 12-month period.

Australian Lithospheric Architecture Magnetotelluric Project (AUSLAMP) is a magnetotelluric survey acquiring long-period magnetotelluric data at ~3000 sites across Australia to map the electrical conductivity of the continent in 3D.

***Management of National Offshore Petroleum and Greenhouse Gas Data Repository – National Offshore Petroleum Data and Core Repository CMCG4003A – P3***

*Open file data*

**Partner researchers/institutions:** GA (two-way agreement)

**GSWA contact:** Stephen Bandy (General Manager, Geoscience and Titles Information)

**Duration of project:** 2020–23

**Project description**

NOPIMS manages both confidential and open-file data. Confidential data is restricted to NOPTA (CMCG4003A – P1) and GA. Open-file data (CMCG4003A – P3) is available to the public to query and download offshore petroleum data.

***NCF Collaborative Head Agreement Ref: CMCG40003A – 000668-1***

**Project managers:** Director Regional Geoscience; Executive Director, GSWA

**Partner researchers/institutions:** GA

**GSWA contacts:** Director Regional Geoscience; Executive Director, GSWA

**Duration of project:** 2017–22 (ongoing but renewal of contract required to continue)

**Project description**

The primary objective of this Head Agreement is to facilitate collaboration between governments through various projects for integrated service delivery in order to improve:

- agencies delivery of services to customers
- efficiency and effectiveness of government services.

This Head Agreement describes the process and limits for forming a project with GA under this agreement.

Committees include:

- Chief Government Geologist Committee (attended by Stephen Bandy)
- Head Agreement Management Committee.



### **NOPIMS – National Offshore Petroleum Information Management System Project Agreement CMCG4003A – P4**

*Information and communication technology (ICT) development*

**Partner researchers/institutions:** NOPTA and GA (three-way agreement)

**GSWA contact:** Stephen Bandy (General Manager, Geoscience and Titles Information)

**Duration of project:** Ongoing

#### **Project description**

Under the agreement, DMIRS provides services to the Commonwealth (GA and NOPTA) to deploy a petroleum information management system using DMIRS infrastructure with functionality comparable to WAPIMS.

This agreement is for the ongoing development and maintenance of the system with all costs associated related to ICT Common Use Agreement personnel.

### **NOPTA – Offshore Petroleum and Greenhouse Gas Data Management Project Agreement – National Offshore Petroleum Data and Core Repository CMCG4030 – P1**

*Confidential data*

**Partner researchers/institutions:** NOPTA and GA (three-way agreement)

**GSWA contact:** Stephen Bandy (General Manager, Geoscience and Titles Information)

**Duration of project:** Ongoing

#### **Project description**

NOPIMS manages both confidential and open-file data. Confidential data is restricted to NOPTA (this agreement) and GA. Open-file data is available to the public to query and download offshore petroleum data including:

- well activity and completion reports and data
- survey reports and data
- titles reports and general study reports.

Some key aspects of the agreement are:

- DMIRS will host NOPIMS using DMIRS ICT infrastructure.
- NOPIMS delivers capabilities for:
  - industry data discovery and delivery
  - data management
  - physical sample management
  - confidential information (CMCG4003A – P1) and open information (CMCG4003A – P3) metadata management.

NOPIMS will contain confidential and open information on wells, geophysical surveys and other related exploration and production data.

**Western Australian Airborne Electromagnetic Surveys Project Agreement  
CMCG4003A 000668-1, GA Ref: 003995**

*Falls under the National Collaboration Framework CMC G40003A PA4*

**Project manager:** David Howard

**Partner researchers/institutions:** GA

**GSWA contacts:** David Howard, John Brett

**Duration of project:** 2019–20 (two 12-month extensions)

**Project description**

The Agreement is an administrative instrument for the extension of GA's **AusAEM2 program** of AEM surveys into Western Australia. The surveys are part of GA's **EFTF program** to develop capability to predict unknown resources and further develop Australia's energy, minerals and groundwater potential in northern Australia.

**Outputs — planned or actual**

All outputs will be announced and managed by GA

This Record is published in digital format (PDF) and is available as a free download from the DMIRS website at <[www.dmirs.wa.gov.au/GSWApublications](http://www.dmirs.wa.gov.au/GSWApublications)>.

Further details of geoscience products are available from:

Information Centre  
Department of Mines, Industry Regulation and Safety  
100 Plain Street  
EAST PERTH WESTERN AUSTRALIA 6004  
Phone: +61 8 9222 3459 Email: [publications@dmirs.wa.gov.au](mailto:publications@dmirs.wa.gov.au)  
[www.dmirs.wa.gov.au/GSWApublications](http://www.dmirs.wa.gov.au/GSWApublications)

