A Geological Survey of Western Australia Newsletter

JULY 2022 NUMBER 103

# Fieldnotes

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

www.dmirs.wa.gov.au/GSWA

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## WA-Array passive seismic program announced

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| | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of jurisdictions surveyed | 72 | 79 | 93 | 96 | 112 | 122 | 109 | 104 | 91 | 83 | 76 | 77 | 84 |
| Best practice mineral potential | 21 | 7 | 11 | 6 | 2 | 8 | 1 | 1 | 4 | 2 | 2 | 6 | 1 |
| Investment attractiveness | 17 | 7 | 5 | 5 | 1 | 5 | 1 | 3 | 5 | 2 | 1 | 4 | 1 |
| Policy perception | 19 | 17 | 12 | 3 | 5 | 10 | 8 | 9 | 17 | 5 | 5 | 11 | 4 |
| Geoscience database | 20 | 17 | 8 | 10 | 11 | 5 | 3 | 17 | 13 | 11 | 12 | 10 | 7 |

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Geological Survey of Western Australia

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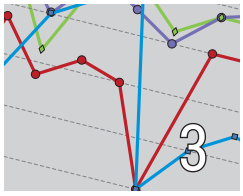
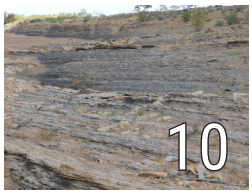
## REGULARS









## EDITORIAL TEAM

**Editor**

Robin Bower, Manager Editing and Publishing

**Design and layout**

Bec Hitchings, Desktop Publisher

**Graphics**

Michael Prause, Graphics Manager

### Contributors to this issue

Simon Johnson
Fawna Korhonen
Yongjun Lu
Ruth Murdie
Charmaine Thomas
Stephen White




# Access publications

## All publications

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

## Hard copies

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

## Fieldnotes

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

Access Fieldnotes by:

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

## GSWA eNewsletter

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

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


**Cover image**: Western Australia ranked world's top destination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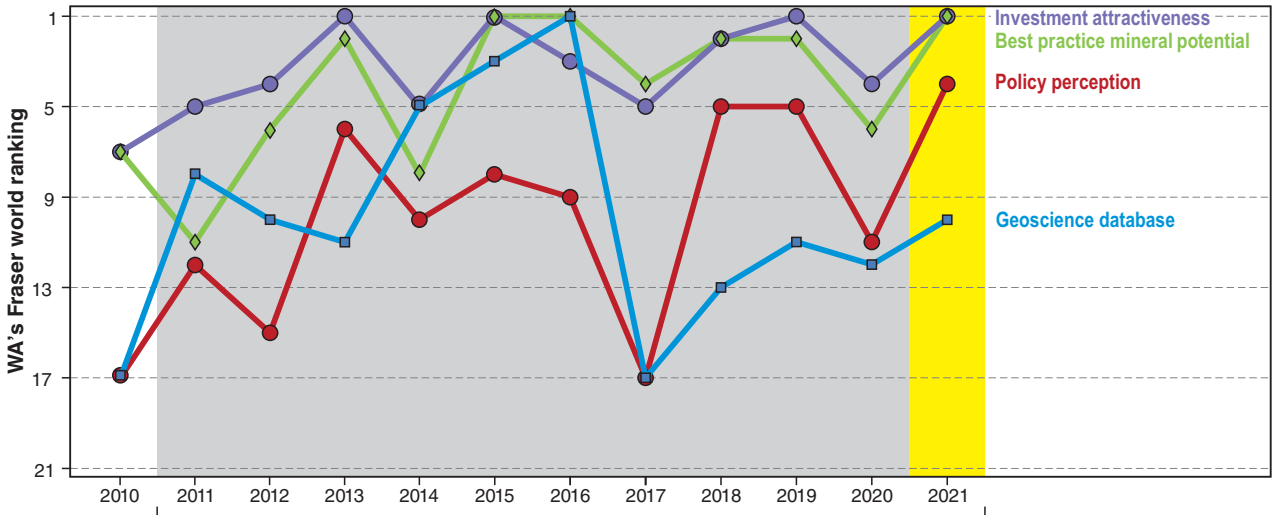
# Western Australia surges to the top

The Fraser Institute, a Canadian public policy think tank (ranked in the top 20 think tanks in the world), annually publishes its global 'Survey of Mining Companies' which ranks the investment climates of mining jurisdictions around the world. The ranking is based on the opinions of mining industry executives and managers, and in 2021, the survey was circulated to 2200 individuals. It received 290 responses providing sufficient data to rank 84 jurisdictions.

Western Australia ranked the world's top destination for investment based on the Investment Attractiveness Index, moving up from fourth place in 2020 (Fig. 1). The Investment Attractiveness Index is constructed by combining the Best Practice Mineral Potential Index, which rates the geological attractiveness of a region, and the Policy Perception Index, a measure of the government's attitude towards exploration investment. Individually, Western Australia ranked first in the Best Practice Mineral Potential Index and fourth in the Policy Perception Index. Western Australia has remained in the 'top 5' world rankings, and within the 'top 2' rankings within Australia for investment attractiveness for the past 11 consecutive years – a major achievement (Figs 1, 2).

The survey also rates the quality of the 'Geoscience Database'. Western Australia recovered slightly to 10th from 12th place in 2020 (Fig. 1). Western Australia's steady rise in 'Geoscience Database' ranking prior to 2017 is attributed to the rapid rise in the volume of pre-competitive geoscience data and knowledge produced with funding assistance from the Exploration Incentive Scheme.

The Geological Survey of Western Australia (GSWA) believes that the reason for the dramatic fall and slow recovery in the quality of 'Geoscience Database' ranking is that jurisdictions around the world have been learning from Western Australian systems, and that the rankings of those jurisdictions jump dramatically when they release their improved systems. However, GSWA is in the process of delivering a five-year, $10.6 million Geoscience Data Transformation Strategy, which will transform the collection, storage and delivery of all pre-competitive geoscience and statutory datasets, ensuring that the data are FAIR (Findable, Accessible, Interoperable and Reusable) and accessible to machine learning and artificial intelligence.




| | Fraser index | | | | | | | | | | | | | WA's world ranking | | | | | | | | | | | | WA's Australian relative ranking | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Number of jurisdictions surveyed | 72 | 79 | 93 | 96 | 112 | 122 | 109 | 104 | 91 | 83 | 76 | 77 | 84 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Best practice mineral potential | 21 | 7 | 11 | 6 | 2 | 8 | 1 | 1 | 4 | 2 | 2 | 6 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
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*Figure 1. Western Australia's Fraser world ranking and comparison of performance relative to other Australian jurisdictions*

**Fraser Institute's Policy Perception Index — Australian States only**

| Ranking | 2010–11 | 2011–12 | 2012–13 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SA | NT WA | WA | WA | WA | WA | WA | WA | WA | WA | WA | WA |
| 2 | WA | SA | SA | SA | SA | SA | SA | SA | SA | SA | SA | SA |
| 3 | NSW | NSW | NT | NT | Tas | NT | NT | Qld | Qld | NT | Tas | Qld |
| 4 | NT | Tas | Vic | Qld | NT | Qld | Tas | Tas | Tas | Qld | Qld | NT |
| 5 | | | | | | | Qld | NT | NT | Tas | NT | NSW |
| 6 | | | | | | | Vic | Vic | Vic | Vic | Vic | Tas |
| 7 | | | | | | | NSW | NSW | NSW | NSW | NSW | Vic |

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*Figure 2. A comparison of Western Australia's performance in the Policy Perception index relative to other Australian jurisdictions*

The Fraser Institute also includes an assessment of the mining industry's perceptions of the exploration permitting process in Canada, and a few other jurisdictions around the world including Australia and the United States. Western Australia ranked well within the jurisdictions surveyed. Over 50% of the survey respondents indicated that within Western Australia they were able to receive their exploration permits in under two months – significantly the best in Australia. The survey also revealed that most of the time, permitting decisions were made within prescribed timelines, that applicants were confident that permits would be approved, and that the permitting process was not a deterrent to investment. Significantly, though, respondents generally had perceived little change in permit approval times over the past decade.

Despite the highly positive outlook for Western Australia over the past number of years, GSWA is not resting on its laurels. GSWA aims to continue to invest in the collection of new, cutting-edge, high-quality pre-competitive geoscience datasets, such as the $5.6 million EIS funded AusAEM 20 km spaced data over Western Australia and the $12 million WA-Array project (see article in this Fieldnotes). This is happening while we are modernizing our data delivery systems, and streamlining and reducing the time of permitting approvals.

For more information, contact **Simon Johnson**.

# WA-Array announced

On 2 May 2022, the Western Australian Minister for Mines and Petroleum, Bill Johnston announced that, as part of the State Budget, the Western Australian Government will fund a statewide high-resolution passive seismic survey. It will provide $12 million over the next four years to kickstart the program.

WA-Array will be one of the largest passive seismic programs undertaken anywhere in the world. It will extend the work of the AusArray program started under the coordination of Geoscience Australia and state geological surveys to complete the national coverage. The program will deploy 165 broadband seismometers in a grid pattern at 40 km intervals. Each seismometer will be left in place for one year before being rolled over into the next area. The entire State will be mapped over a 10-year period between nine regional areas (Fig. 1).

Western Australia has no shortage of mineral resources, but most known deposits are near the surface. The WA-Array program will make it easier to locate deeper resources. The data will be used to provide an image of the geological structure from a few metres depth down to, and including, the lithosphere–asthenosphere boundary, making a fundamental dataset for mapping mineral systems, including critical minerals such as lithium, cobalt and nickel. Western Australia's future requires optimal strategic planning which balances the competing land uses required for the State's transition to a low-carbon economy; locations for renewable energy projects including a future renewable hydrogen export industry, must be balanced against exploring and developing future mines and associated potential downstream processing operations.

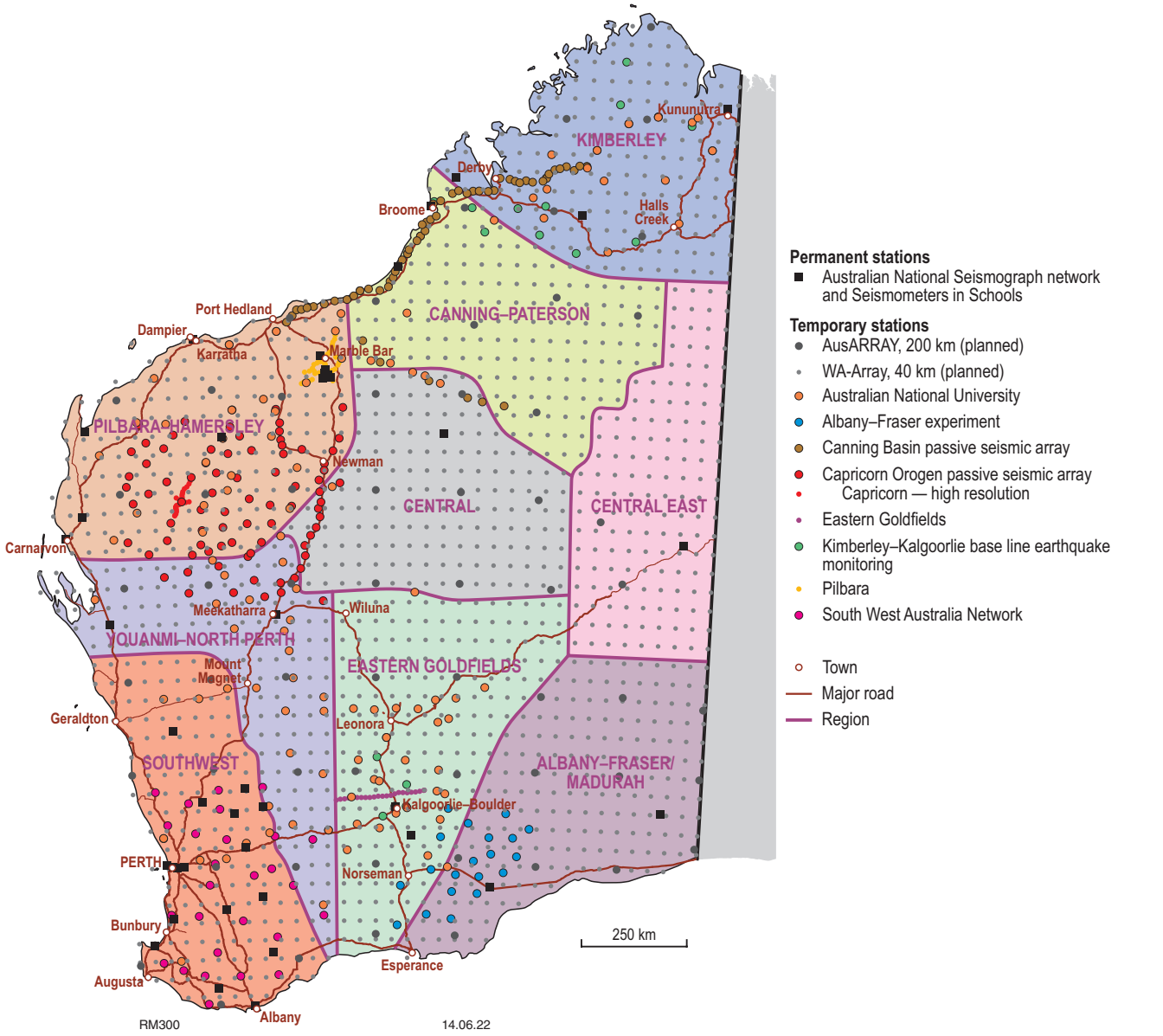



*Figure 1. Planned location of the WA-Array 40 km grid across the State. It will take nine deployments over the next 10 years to complete*

# Passive seismic program

The intention of the WA-Array program is to help unlock a new generation of resource discoveries, and will provide fundamental data that will help evaluate competing land uses as new renewable energy hubs are developed. As Western Australia is one of the most seismogenic regions in Australia, this data will also assist in evaluating the State's seismic hazard risk for disaster management planning, and provide data for the National Seismic Hazard Assessment, which, in turn, is used to develop building codes for earthquake resilience (Fig. 2).

For more information, contact **Ruth Murdie**.

*Figure 2. Installation of a seismic station on a remote pastoral homestead*

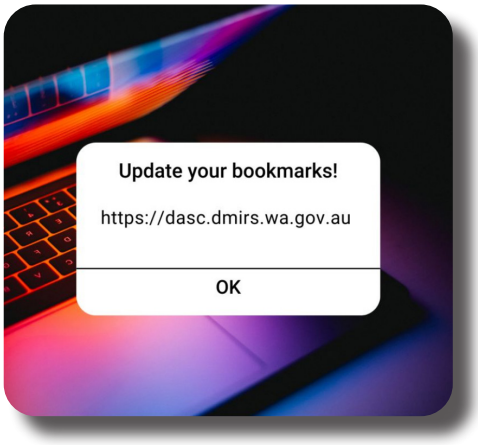
# Data and Software Centre

## New link for Data and Software Centre

The Data and Software Centre (DASC) was successfully migrated to the cloud on 16 June 2022. The URL changed from **<https://dasc.dmp.wa.gov.au/dasc>** to **<https://dasc.dmirs.wa.gov.au>**. This migration is in alignment with the WA Government's digital strategy that seeks to provide all people with a convenient, smart and secure online service.

To support DASC users there was a 'soft launch' of the system in late March, which provided a three-month grace period to update any links or favourites to the new URL. The Geoscience team received positive feedback from members of the public indicating that the soft launch transition ran smoothly.

For more information including FAQs about the DASC migration, please visit the homepage at **https://dasc.dmirs.wa.gov.au/** or view a short video about the changes here: **https://vimeo.com/689172713**. Alternatively, contact the support team at **geoview@dmirs.wa.gov.au.**



# Space rocks and Archean time travel

The ancient, low-relief terrain of Western Australia provides an almost optimal environment for preserving meteorite impact structures over millions of years. **Meteorites — alien invaders**, compiled as an ArcGIS StoryMap, is a virtual tour exploring the evidence for past meteorite impacts. Some of the youngest meteorite impacts, such as Wolfe Creek estimated to be about 300 000 years old, are evident by the craters they gouged in to the landscape. Older meteorite impact structures are invisible at the surface but are revealed by their geophysical signatures. The oldest known meteorite impact structure preserved on Earth is the 2.23 billion-year-old Yarrabubba impact structure, identified by a distinctive aeromagnetic pattern, outcrop and microscopic shock structures, and direct isotopic dating of zircons trapped in rock that melted and resolidified at the impact site.

The Yilgarn Craton dominates the southwestern part of Western Australia and is renowned for its granite–greenstone geology. A new ArcGIS StoryMap, **Deep time in the Murchison region, Western Australia**, delves into the evolution of the granite–greenstone terrane, punctuated by massive intrusions of mafic magma sourced from the mantle. The tour visits 12 classic locations where parts of the geological history are uniquely revealed. A 30-second animation at the end, racing through nearly 1.5 billion years of crust-forming processes, culminates in stabilization of a long-lived craton, into which today's spectacular weathered landscapes are etched. Woven around the geology are snippets of local Aboriginal connections to Country and snapshots from the colonial gold rush era.

Both of these virtual tours draw their inspiration from previous Geological Survey of Western Australia products, reworked for the StoryMap format and aimed at a non-specialist audience. The virtual tours open directly in an internet browser — there's no app to download — and are valuable for anyone who wishes to gain a greater appreciation for the landscapes of Western Australia.

## How to access

**Meteorites — alien invaders** by SC Goss and **Deep time in the Murchison region, Western Australia** by SR White are available free through your internet browser.

Details about these and other GSWA virtual tours are available in the **Vitual tours** section of the DMIRS eBookshop.

For more information, contact **Stephen White**.


*Figure 1. Scenes from the meteorite impact structures (top) and Murchison region (bottom) StoryMaps, and examples of graphical content used to tell these stories*

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# In situ dating of biotite sheds light on low-temperature tectonothermal events

A pilot study to date biotite and apatite using the Rb–Sr isotope system was recently conducted in collaboration with the Timescales of Mineral Systems Group and John de Laeter Centre at Curtin University. This technique offers a powerful new tool to determine the age at which a major rock-forming mineral (e.g. biotite) grows in a deformation–metamorphic (or metasomatic) fabric (Fig. 1). These in situ analyses preserve microstructural information, and can be integrated with other geochronometers and pressure (*P*)–temperature (*T*) constraints to better define the overall *T*–time (*t*) evolution. Eleven samples across the state were selected, representing a variety of geologic settings and ages.

The results show that this technique can assist with identifying low-temperature events that may not be captured by other commonly used decay systems, such as U–Pb. Specifically, our results support the occurrence of a c. 500 Ma metamorphic event in the Marboo Formation, Lamboo Province; 633–615 Ma thermal events in the Paterson Orogen; a c. 1139 Ma cooling age in the Madura Province; a c. 2477 Ma cooling age in the Youanmi Terrane; and a c. 580 Ma event resulting in isotopic resetting in the South West Terrane.

## How to access

**Record 2022/6 In situ biotite and apatite Rb–Sr geochronology of metasedimentary and meta-igneous rocks in Western Australia** by J Liebmann, CL Kirkland, FJ Korhonen, DE Kelsey, K Rankenburg, P Duuring and R Quentin de Gromard is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

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

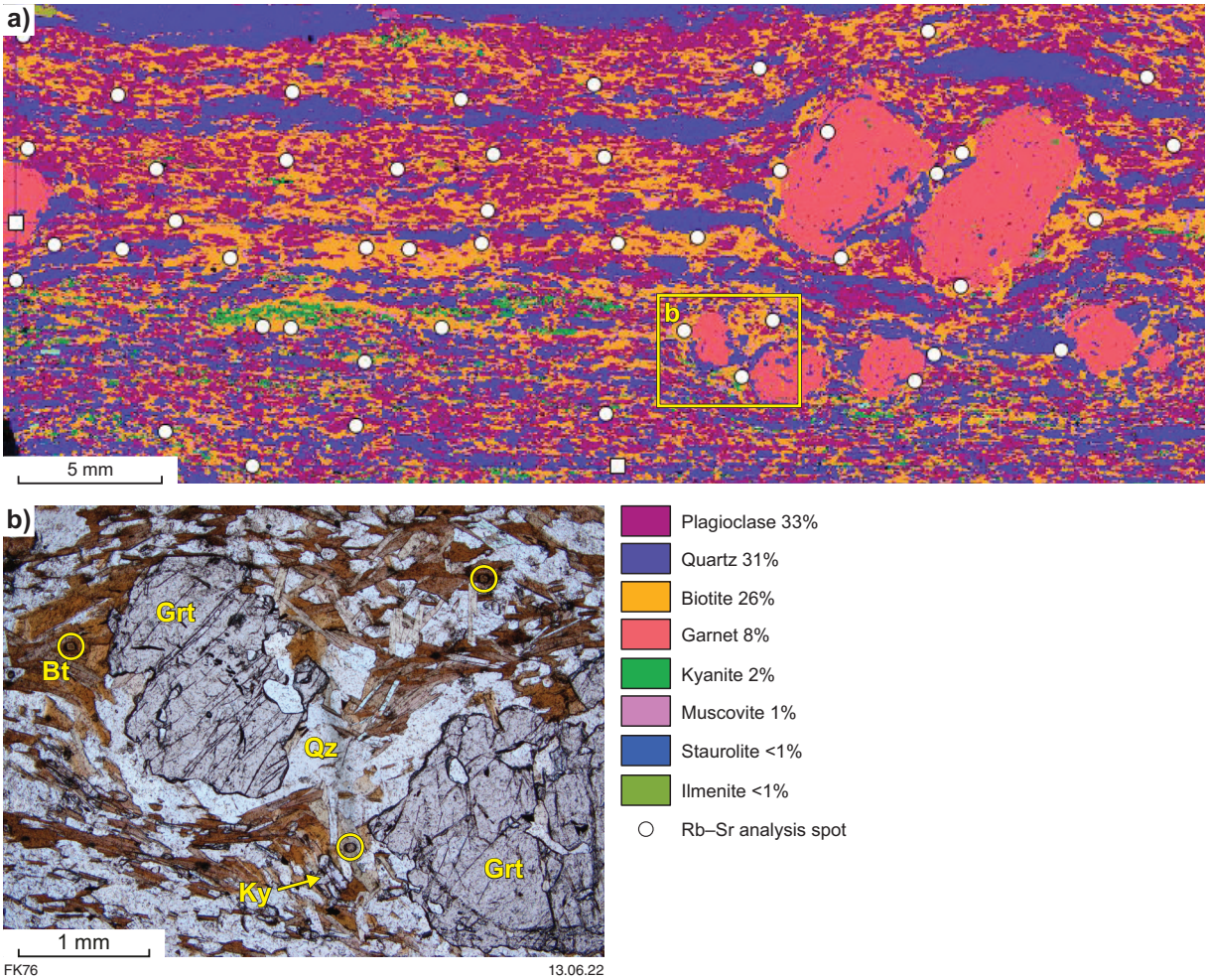



*Figure 1. Rb–Sr analysis spot locations in biotite from a kyanite-bearing garnet semipelitic schist (South West Terrane; GSWA 224771): a) spot locations (white circles) shown on a TESCAN Integrated Mineral Analyser (TIMA) image of an entire thin section. Mineral proportions calculated with the TIMA software; b) photomicrograph in plane-polarized light, with yellow circles highlighting laser pits in biotite. Abbreviations: Bt, biotite; Grt, garnet; Ky, kyanite; Qz, quartz*

# A new geodynamic model for the Kimberley region

New U–Pb and Lu–Hf isotope data for detrital zircons from metasedimentary rocks of the Lamboo Province have been used to test collisional and intraplate geodynamic models for Paleoproterozoic development of the Kimberley region (Fig. 1). The 1870–1840 Ma turbiditic metasedimentary rocks deposited across the Western, Central and Eastern Zones of the Lamboo Province yield remarkably consistent detrital zircon age signatures, with a dominant 1875–1860 Ma age component and a subsidiary c. 2500 Ma age component. These rocks also have similar Lu–Hf isotope values across all three zones, consistent with a common source for the sedimentary protoliths. The close similarities in provenance suggest that all three zones of the Lamboo Province developed in a continental intraplate setting prior to the 1838–1808 Ma Halls Creek Orogeny, which has previously been interpreted to represent a collision between an exotic Kimberley Craton and the proto-North Australian Craton. Comparable provenance signatures of coeval metasedimentary rocks across the broader North Australian Craton suggest that assembly of the main cratonic elements was complete prior to c. 1885 Ma.

## How to access

**Report 215 Geochronology of metasedimentary and igneous rocks in the Lamboo Province, Kimberley region: reassessing collisional geodynamic models** by Maidment, DW, Lu, Y, Phillips, C, Korhonen, FJ, Fielding, IOH, Wingate, MTD, Kirkland, CL, Murphy, R, Tilhac, R, Poujol, M and Zhao, J is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

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

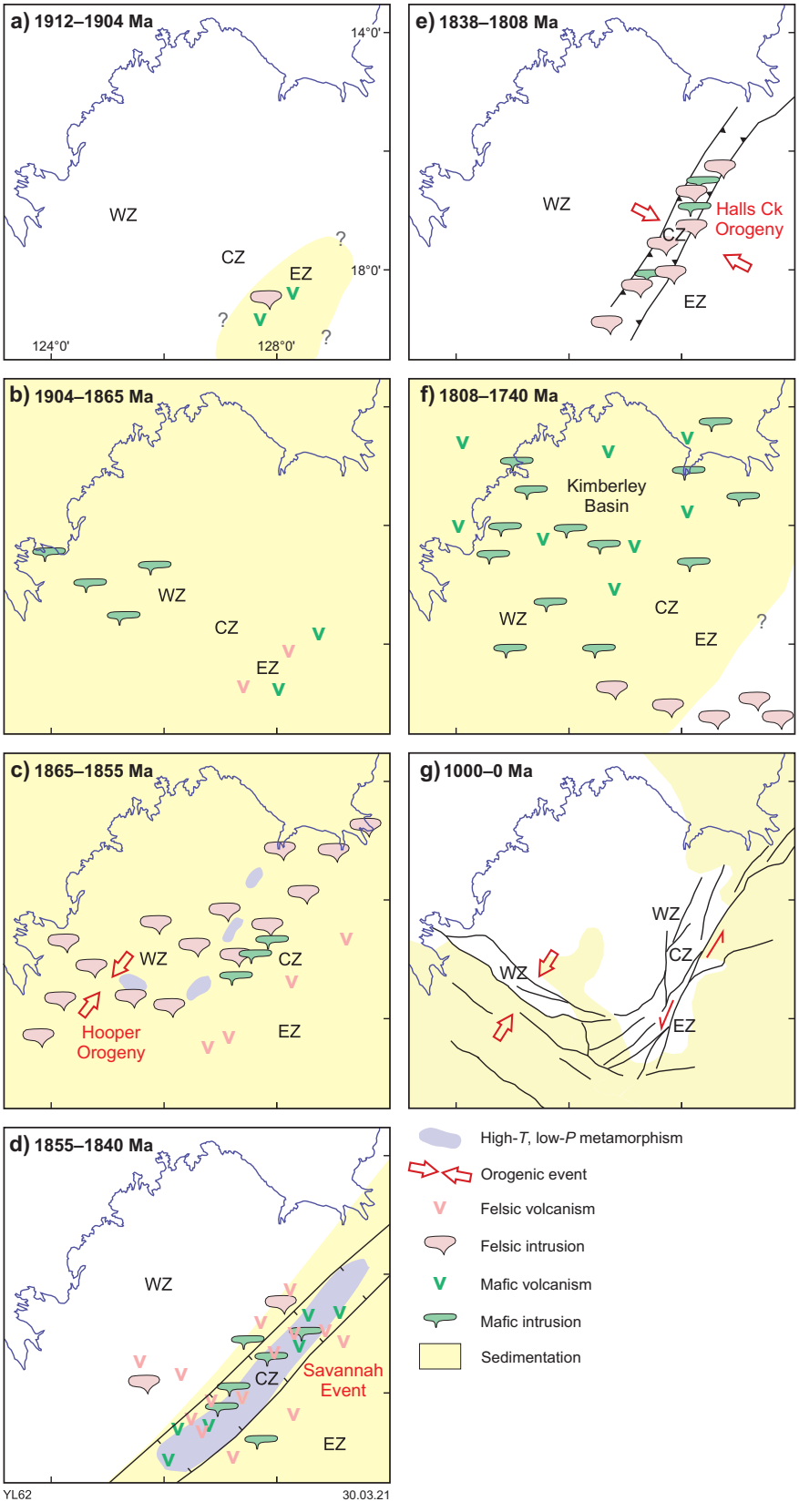



*Figure 1. Schematic evolution of the Lamboo Province: a) intraplate extension, bimodal magmatism at 1912–1904 Ma; b) subsidence and deposition of Marboo Formation Unit 1, Saunders Creek Formation, Brim Rockhole Formation and older Tickalara Metamorphics at 1904–1865 Ma; c) onset of sedimentation (Marboo Formation Unit 2, Tickalara Metamorphics, Biscay Formation), bimodal magmatism in Western Zone, mafic magmatism in Central and Eastern Zones, transient compressional event in Western Zone at 1865–1855 Ma; d) extension partitioned into Central Zone rift, deposition of Tickalara Metamorphics, Koongie Park Formation and Olympio Formation, mafic magmatism in Western Zone, bimodal magmatism and high-T, low-P metamorphism in Central Zone, alkaline felsic volcanism in Eastern Zone at 1855–1840 Ma; e) compression partitioned into Central Zone during Halls Creek Orogeny at 1838–1808 Ma; f) regional subsidence and deposition of Kimberley Basin at 1808–1740 Ma; g) multiple orogenic events since 1000 Ma (Yampi, Wunaamin Miliwundi and Alice Springs Orogenies), exhumation of Lamboo Province. Abbreviations: WZ, Western Zone; CZ, Central Zone; EZ, Eastern Zone*

# Revisiting the Permian potential

The Permian is one of the thickest and most widespread of pre-breakup strata across the Southern and inboard Northern Carnarvon Basins, although it is not yet confirmed to have sourced economic accumulations of hydrocarbons. This Report is a review of Permian source-rock intervals, and includes a collation and interpretation of basic data needed for source-rock evaluation, including Total Organic Carbon (TOC), Rock-Eval data, organic petrography (visual maceral abundances and vitrinite reflectance) and palynological data. Additionally, new pre-competitive data were collected from previously unsampled Permian rocks in the Southern and inboard Northern Carnarvon Basins.

The objective of the study was to improve the spatial and depth coverage of Permian source-rock data, particularly in understudied parts of the basins. This Report confirms that the best Permian source intervals are thin mudstone interbeds within overall heterolithic or sandy packages. New areas with good source intervals have been identified both onshore and offshore.

The review of new and legacy organic petrography and visual kerogen analyses confirms a mixed kerogen assemblage in Permian source rocks. It has found that the liquid potential of these rocks, as determined from Rock-Eval data only, has likely been underestimated.

## How to access

**Report 230 Source-rock potential of Permian rocks in the Southern and Northern Carnarvon Basins** by CM Thomas is available as a free downloadable PDF from the Department of Mines, Industry Regulation and Safety (DMIRS) eBookshop.

For more information, contact **Charmaine Thomas**.

*Figure 1. Outcrop of the Lower Permian Wandagee Formation, where some shale interbeds were shown to be organically rich and have fair source-rock potential*


*Figure 2. Rock samples collected from outcrop of the Lower Permian Bulgadoo Shale, which showed nearly 3% Total Organic Carbon. However, most of this organic matter is inertinite, making it an unsuitable source rock*

# New release of quantitative metamorphic data across the State

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

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

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

## How to access

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

For more information, contact **Fawna Korhonen**

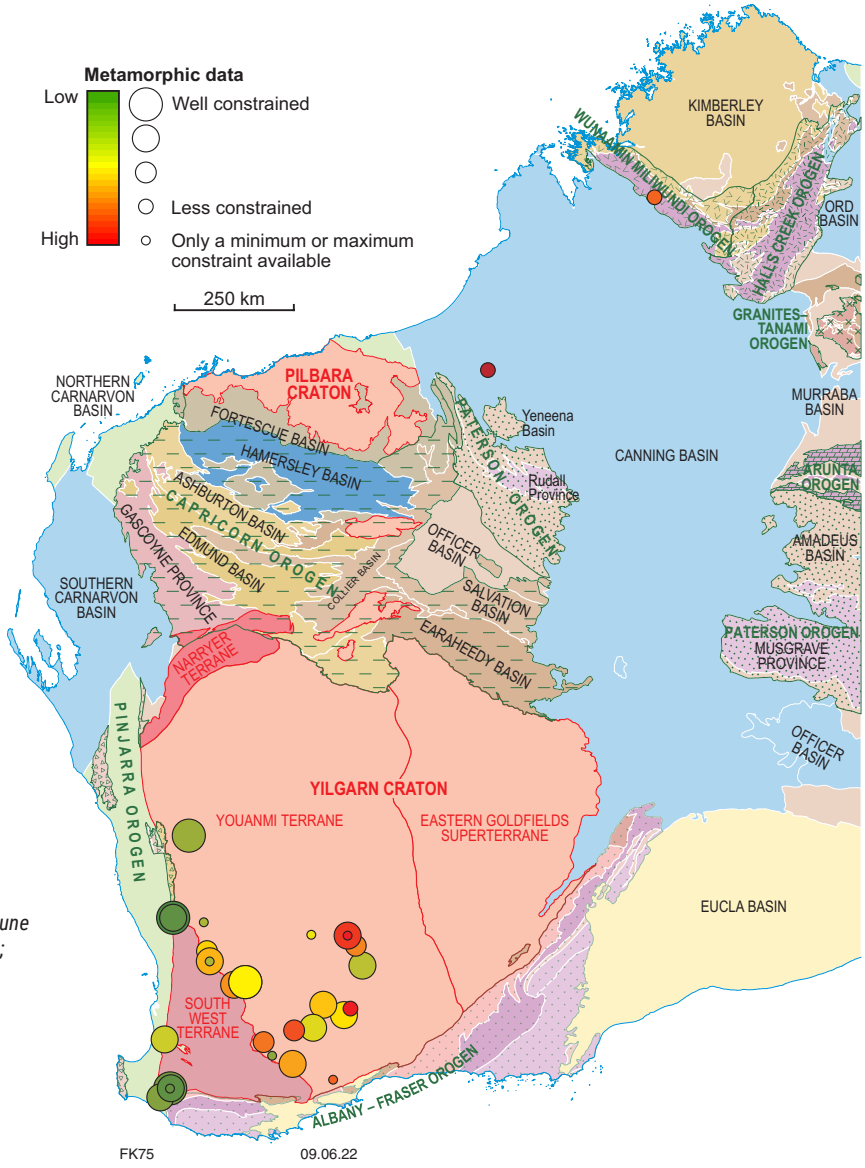



*Figure 1. Simplified tectonic map of Western Australia, showing sample locations and metamorphic data as of June 2022. Data plotted are median apparent thermal gradient; temperature and pressure data are also available in the Metamorphic History data layer*

# Product releases

## • REPORTS •

**Report 215 Geochronology of metasedimentary and igneous rocks in the Lamboo Province, Kimberley region: reassessing collisional geodynamic models**
*by Maidment, DW, Lu, Y, Phillips, C, Korhonen, FJ, Fielding, IOH, Wingate, MTD, Kirkland, CL, Murphy, R, Tilhac, R, Poujol, M and Zhao, J*

**Report 223 Alteration and Cu–Au mineralization at the Obelisk prospect, Paterson Orogen, Western Australia**
*by Duuring, P, Guilliamse, JN, Kelsey, DE, Fielding, IOH and Fonteneau, L*

**Report 226 Geochemical characterization of the magmatic stratigraphy of the Kalgoorlie and Black Flag Groups — Ora Banda to Kambalda region**
*by Smithies, RH, Lowrey, JR, Sapkota, J, De Paoli, MC, Hayman, P, Barnes, SJ, Champion, DC, Masurel, Q, Thébaud, N, Drummond, M and Maas, R*

**Report 230 Source-rock potential of Permian rocks in the Southern and Northern Carnarvon Basins**
*by Thomas, CM*

**Report 231 Regolith–landform mapping of the west Kimberley Craton: application of geophysics and spectral remote sensing**
*by de Souza Kovacs, N and Cudahy, TJ*


## • RECORDS •

**Record 2022/1 GSWA work program 2022–23**

**Record 2022/2 Geology and mineralization potential of the Gerry Well greenstone belt (Collurabbie region), northeastern Yilgarn Craton**
*by Grech, LL, Lu, Y, Wang, Y, Gao, Y, Qian, B, You, M and Beardsmore, TJ*

**Record 2022/3 Extreme rare earth element enrichment in altered basaltic rocks of the Eastern Goldfields**
*by Smithies, RH and Lowrey, JR*

**Record 2022/6 In situ biotite and apatite Rb–Sr geochronology of metasedimentary and meta-igneous rocks in Western Australia**
*by Liebmann, J, Kirkland, CL, Korhonen, FJ, Kelsey, DE, Rankenburg, K, Duuring, P and Quentin de Gromard, R*

**Record 2022/7 Compilation and geological implications of the major crustal boundaries map and 3D model of Western Australia**
*by Martin, DMcB, Murdie, RE, Kelsey, DE, Quentin de Gromard, R, Thomas, CM, Cutten, HN, Zhan, Y, Lu, Y, Haines, PW and Brett, JW*

**Record 2022/8 Eastern Goldfields greenstone geochemical barcoding project — notes to accompany 2022 data release**
*by Lowrey, JR and Smithies, RH*

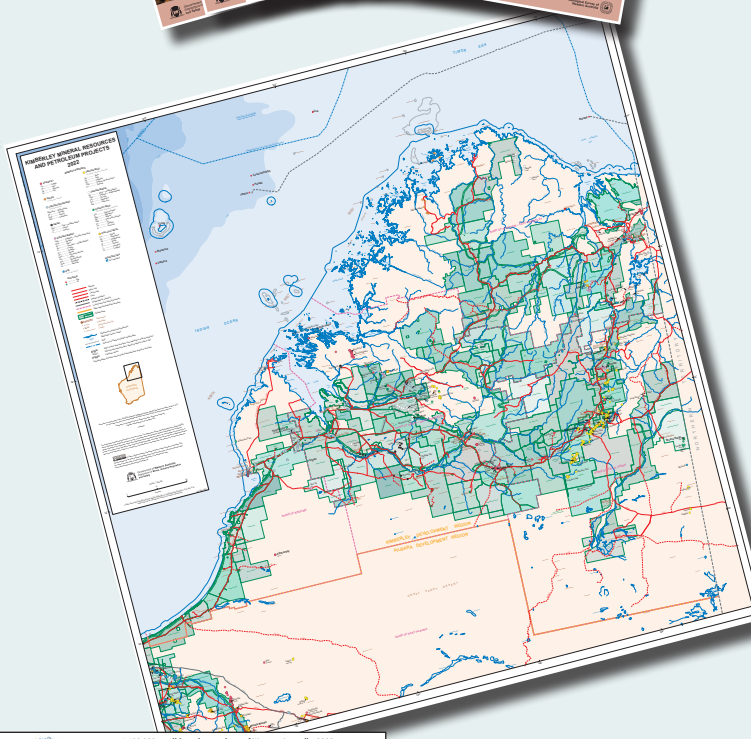
**Record 2022/9 Yilgarn Granite Project — notes to accompany 2022 data release**
*by Lowrey, JR, Smithies, RH and Champion, DC*


## • MAPS •

**Aboriginal land, conservation areas, mineral and petroleum titles and geology, Western Australia – 2022**
*by Ridge, KJ*

**Kimberley mineral resources and petroleum projects 2022**
*by Pal, T, Wyche, NL, Murray, SI and D'Ercole, C*

**Petroleum Titles map Western Australia — April 2022**



## • DIGITAL LAYERS •

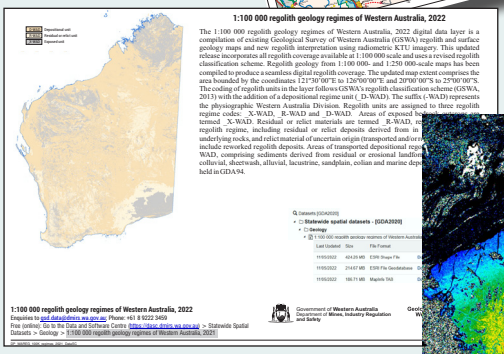
**1:100 000 regolith geology regimes of Western Australia, 2022**
*by de Souza Kovacs, N*

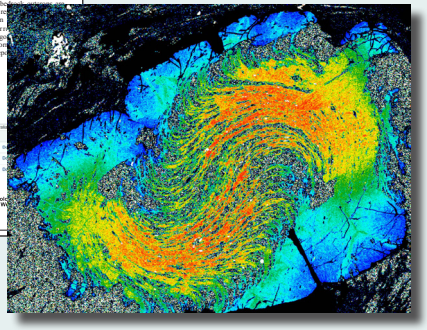
**1:100 000 State interpreted bedrock geology of Western Australia**

**Resource Estimates for Projects**

**Resource Estimates for Projects (gold)**

**Zircon oxygen isotope map of Western Australia**



## • ONLINE PRODUCTS •

**Metamorphic history information, 2022**

**Deep time in the Murchison region, Western Australia (Geology Explorer)**
*by White, SR*

**Meteorites — alien invaders (Geology Explorer)**
*by Goss, SC*