

Fieldnotes

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Government of **Western Australia**
Department of Mines and Petroleum

Geological Survey of
Western Australia



ISSN 1325-9377

ISBN (PRINT) 978-1-74168-328-8
ISBN (PDF) 978-1-74168-327-1

New format Explanatory Notes for the Gascoyne Province

In June 2010, the Geological Survey of Western Australia released Explanatory Notes for the Gascoyne Province in a new format representing a break from GSWA's tradition of publishing explanatory notes for individual map sheets. The new format notes include a description of every lithostratigraphic unit mapped in the province, as well as an account of the tectonic events that have affected it. The notes are a forerunner of what customers will eventually be able to produce routinely from GSWA's Geology Online database, which is currently being developed under the Exploration Incentive Scheme (EIS).

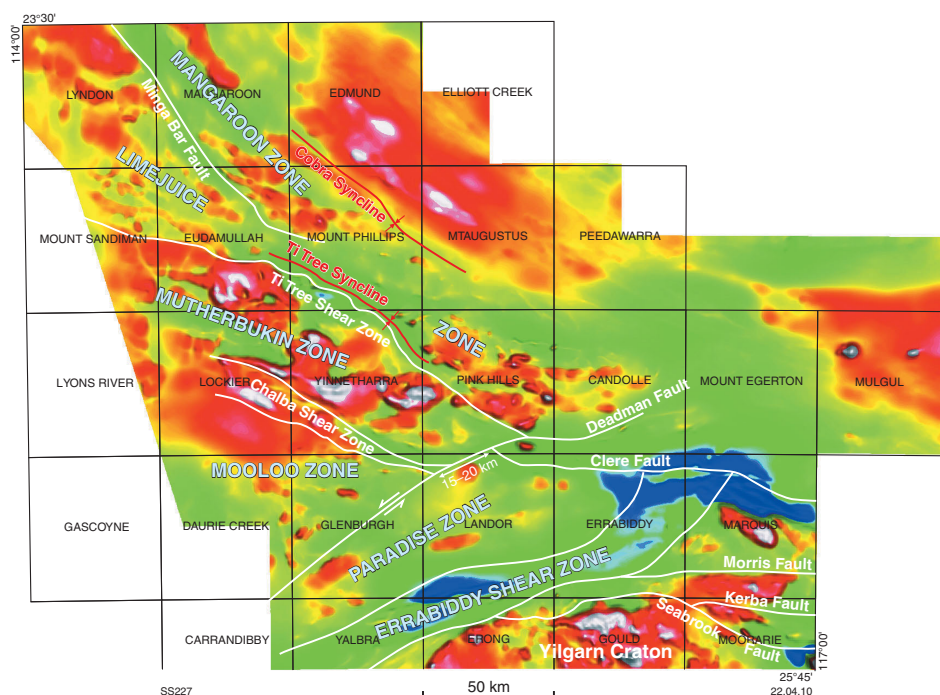
The Gascoyne Province is a major zone of tectonism between the Archean Yilgarn and Pilbara Cratons, comprising six fault-bounded zones of granitic and medium- to high-grade metamorphic rocks. Although the province is commonly regarded as a Paleoproterozoic entity, recent isotopic dating has revealed it has an extended history of reworking and reactivation until the late Neoproterozoic.

The current GSWA remapping program is increasing the geological understanding of the Gascoyne Province with the aim of encouraging more effective mineral exploration. Geological mapping is sufficiently detailed for display at 1:100 000 scale, and has been accompanied by extensive programs of Sensitive High Resolution Ion Microprobe

(SHRIMP) U–Pb zircon, monazite and xenotime geochronology, whole-rock geochemistry, and isotope geochemistry. Under the EIS, new regional geophysical datasets are being collected, including gravity, magnetotellurics and a deep crustal seismic survey.

The results of the mapping are provided in digital GIS packages that are updated periodically, together with the publication of hardcopy 1:100 000 geological series maps. Until now Explanatory Notes for the Gascoyne Province have only been available for 1:100 000 map sheets within the EDMUND 1:250 000 map sheet area together with KENNETH RANGE. Our digital mapping is expanding seamlessly across the Gascoyne Province, and highlights the need for a State-wide database of Explanatory Notes for each stratigraphic unit, tectonic unit and tectonic event that can be updated periodically to reflect the current state of knowledge.

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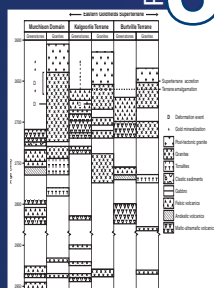


A 1000 m upward continuation model of reduced to pole (RTP) aeromagnetic data over the Gascoyne Province, showing the location of major faults.

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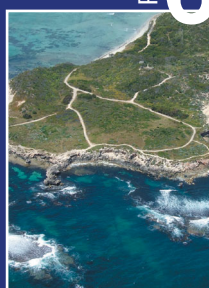
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In each T-BREAK we look at the latest in information technology that GSWA is using to better serve customers around the world. See more at the Department of Mines and Petroleum's DMP website at <<http://www.dmp.wa.gov.au>>.

DigitalPaper: a primer

Many of us use GSWA's DigitalPaper server as an easy way of viewing or downloading documents and maps from the GSWA archive. But do you know why we use DigitalPaper?

Speed and quality

DigitalPaper is the fastest way to stream documents to clients anywhere, quickly delivering sometimes large files via the Internet. DigitalPaper is different from other document delivery systems in that in view mode the entire document is not downloaded to the user's computer – instead, documents and maps become image files that can be individually streamed. The process is interactive: DigitalPaper changes the images depending on what the user wants to see, meaning that a user can quickly view an entire map or just an area without having to download the original large, high-quality, detailed file – DigitalPaper will stream whatever you want to see very quickly. As many of our users are on mine sites with slower Internet connections, this saves spending lots of time downloading entire files. **However, DigitalPaper also allows users to download the original files (in high-quality Adobe PDF) to their PC if they wish.**

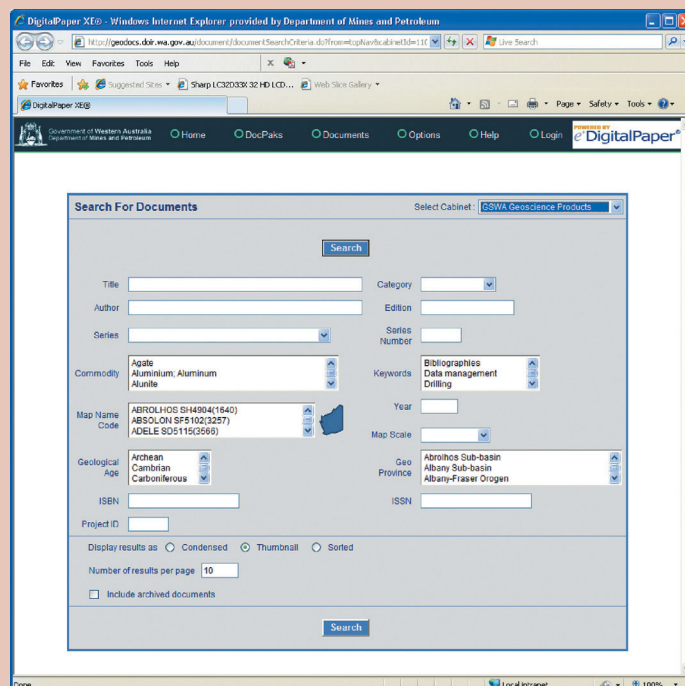
Individual cabinets

DigitalPaper allows a vast archive of documents to be stored, searched on and delivered to users, which is perfect for GSWA. We have several document cabinets, each with a different function: Geoscience Products, with an inclusive archive of nearly all GSWA

documents – some reaching back to the 1890s; Promotional Material, featuring high-quality posters and brochures prepared for conferences and seminars attended by GSWA; and Geochronology Reports. Each has its own detailed, accurate search that makes finding what you are looking for quick and easy.

If you haven't used DigitalPaper before, try it out! Go to the Department of Mines and Petroleum website at <<http://www.dmp.wa.gov.au>> go to the GSWA section and click on any of the 'Access Geoscience Products' links.

For more information, contact Ryan Aston (ryan.aston@dmp.wa.gov.au).



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The stratigraphic units and tectonic events from the Gascoyne Province were entered into a prototype of the database (WA Geology Online), and form the basis for the new format Explanatory Notes. These comprise two parts: a front end containing a synthesis of the geological evolution of the Gascoyne Province, and a back end consisting of detailed descriptions of each lithostratigraphic unit and tectonic event.

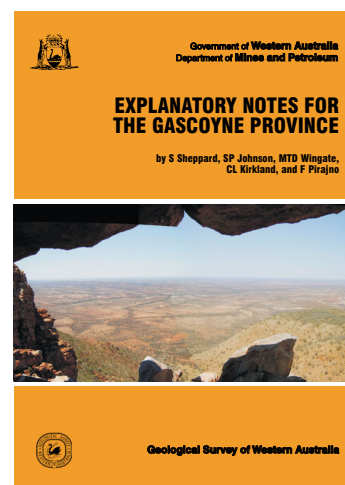
The front end begins with an introduction to the current program and previous work, a definition of the Gascoyne Province, and a nomenclature for the metasedimentary rock packages, granitic supersuites and orogenic events. This is followed by a summary of the geological history of, and tectonic models for, the province, as well as the crustal architecture of the region. The mineral systems in the province are outlined, and a discussion of future work and gaps in our knowledge wraps up the front end.

The back end comprises descriptions of every individual stratigraphic unit in the Gascoyne Province contained in the 2009 update of the West Capricorn Geological Information Series package. Each of the nearly 170 units is described under the headings 'Legend narrative', 'Summary', 'Distribution', 'Lithology', 'Contact relationships', and 'Geochronology'. A list of references relating to each unit is also given. For each tectonic event, there is an account of the

'Distribution', 'Description', 'Geochronology' and 'Tectonic setting', with a list of supporting references.

When the production version of WA Geology Online is completed, GSWA geologists will be able to edit existing units and add new units and their descriptions directly into the database. Users will be able to query the database graphically or textually, and extract the stratigraphic units and tectonic events of interest, in effect having access to a 'live' set of Explanatory Notes across Western Australia. The notes will continue to grow and evolve as new work is done.

For more information, contact Steve Sheppard (steve.sheppard@dmp.wa.gov.au).



Yilgarn tectonic history under review at 5ias

Recent mapping and newly acquired data by GSWA have provided an opportunity to reassess the tectonic history of the Yilgarn Craton. Current models for the evolution of the craton came under review during the recent Yilgarn–Superior Workshop (Wyche, S, 2010, GSWA Record 2010/20) held in Perth as part of the 5th International Archean Symposium. The workshop was organized by Stephen Wyche, the Manager of GSWA's Yilgarn mapping teams, in collaboration with John Ayer from the Ontario Geological Survey, and included speakers from industry and universities, GSWA, Geoscience Australia, the Ontario Geological Survey, the Geological Survey of Canada, Géologie Québec, and CSIRO.

Archean tectonics is the subject of an ongoing 'debate' — more than 40 years old and ranging across all five International Archean Symposia — as to whether or not plate tectonics operated on the early Earth, prior to 2.5 Ga. This debate has had a polarizing effect, simplifying and generalizing what was an extremely complex early Earth system that evolved over a very long period of time (2 billion years). Two main crust-forming processes are known to operate throughout the geological record — plume-derived plateaux and subduction-derived arcs. Evidence that plate tectonics was in operation in the Archean is well documented, but taking a plate-tectonic end-member view of all Archean tectonics ignores the evidence for crustal growth through the formation and accretion of mantle plume-derived oceanic plateaux. Each Archean (and post-Archean) craton and terrane should be assessed on the basis of its own geological history, with tests applied and analysed for each type of growth mechanism, and continually reassessed in light of new data.

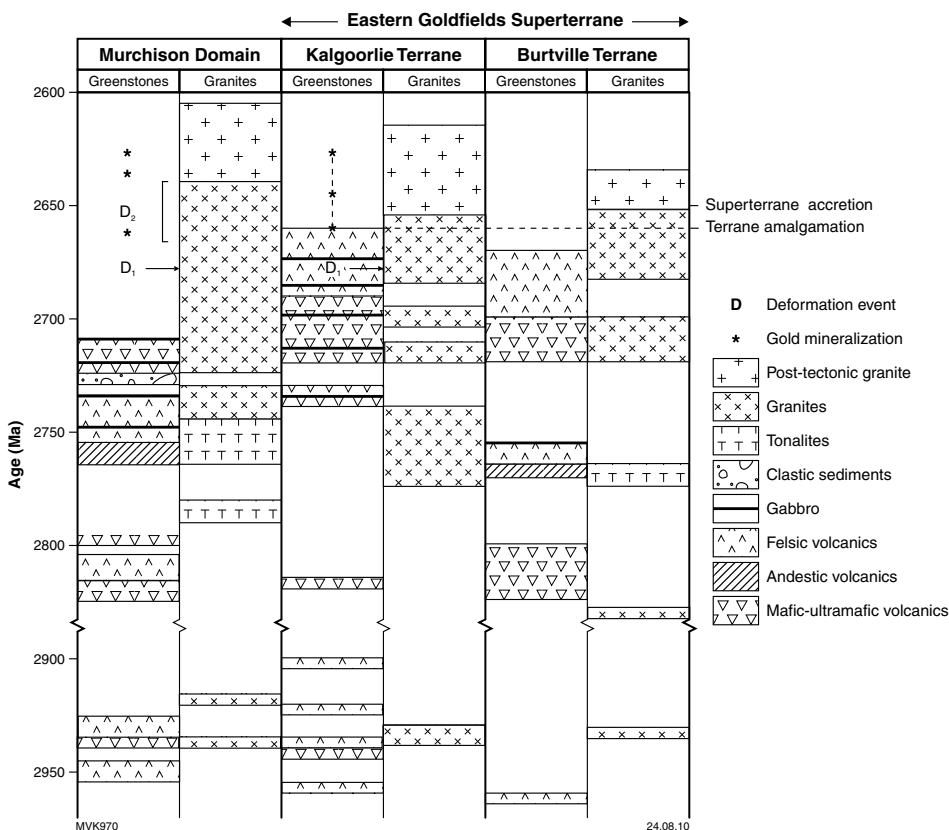
Models of Yilgarn Craton development illustrate this continuing analytical process. Early models invoked a rift setting for greenstone deposition on a basement of older crust. A subsequent model suggested that greenstones were derived from uprising mantle plumes, followed by widespread crustal melting, granite genesis, and internal reorganization to form the characteristic granite dome-greenstone syncline pattern. More recent models have suggested that the craton evolved through outboard amalgamation of a series of distinct terranes to form the Eastern Goldfields Superterrane (EGS), which then accreted onto an older piece of unrelated crust in the orogenic foreland (Yuanmi Terrane). These models are based on differences in volcanic geochemistry and neodymium model ages across the craton, and widespread evidence for compressional deformation.

Newly acquired data by GSWA in the previously little-known northwestern (Murchison domain of the Yuanmi Terrane) and far eastern (Burtville and Yamarna Terranes, see the following article on pages 4 and 5) parts of the Yilgarn Craton have provided an opportunity to reassess current models of Yilgarn Craton evolution. The first major surprise was that, despite containing an older history of volcanism and plutonism (2.95–2.74 Ga), the Murchison Domain also contains a younger volcanic and plutonic history that overlaps with similar events in the EGS, including 'pre-accretionary' komatiitic volcanism and 'syn- to post-accretionary' granitic magmatism, shearing, and gold mineralization (see figure). Significantly, much of the EGS felsic volcanism interpreted to represent the products of arc magmatism has compositionally and temporally similar granitic equivalents in the Murchison Domain. The second surprise is the

discovery of 'pre-accretion' structures in Murchison Domain that are the same age as extensional structures from across the whole of the craton, at c. 2675 Ma. The third is that the older history of the Murchison Domain is similar to that of the Burtville Terrane, as well as to other parts of the EGS (see figure).

These discoveries suggest that current tectonic models of the Yilgarn Craton evolution may require significant modification and highlight the complexities involved in interpreting the tectonic development of Archean crust.

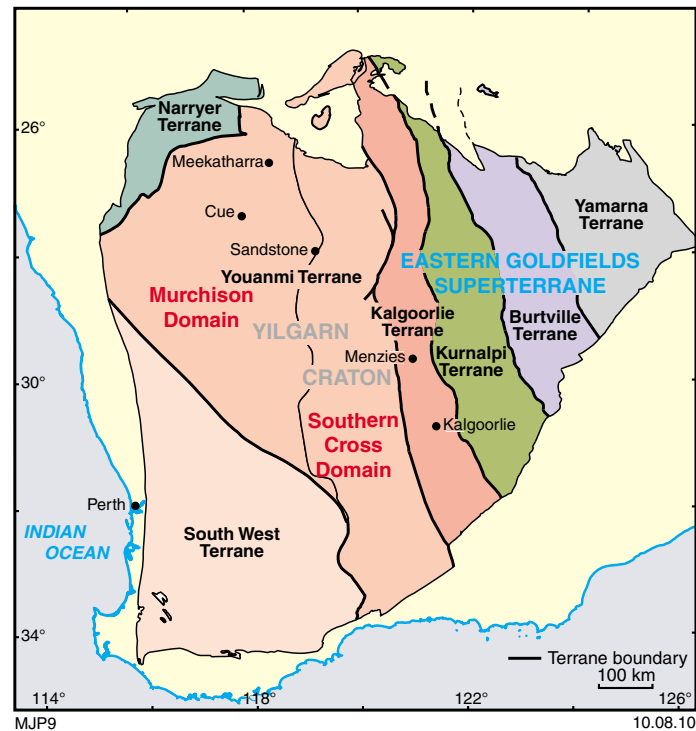
For more information, please contact
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Comparative time-event diagram for parts of the Yilgarn Craton, showing overlapping histories for what have been considered separate terranes.

New insights from the northeast Yilgarn Craton

The GSWA program of mapping in the northeastern Yilgarn Craton has led to several new interpretations that have considerable significance for the architecture and geodynamic evolution of the craton. These interpretations may also have implications for the prospectivity of the region. Key to the new interpretations are SHRIMP U–Pb radiometric ages, which allow the precise age of the rocks to be determined.



Tectonic subdivisions of the Yilgarn Craton

New tectonic subdivisions in the northeast Yilgarn Craton

The northeastern Yilgarn Craton was originally defined by Cassidy et al. (2006; GSWA Record 2006/8, 8p) as a single entity, the Burtville Terrane, which was poorly understood due to the lack of work in the region at the time. New work by GSWA, indicates that the region comprises two terranes that have distinct greenstone ages.

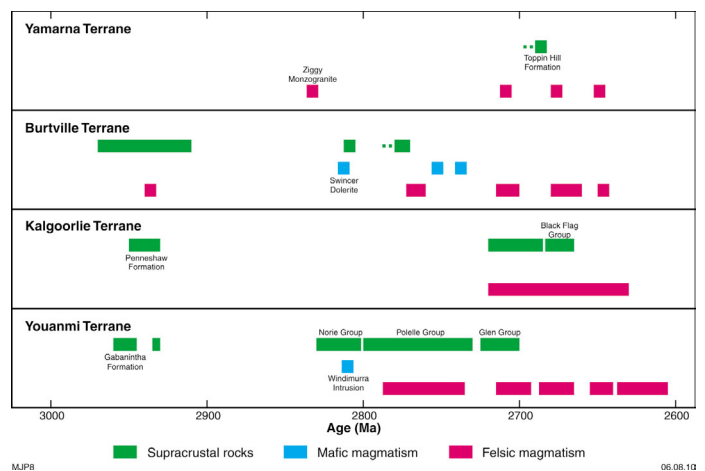
The original Burtville Terrane is now replaced by the more westerly redefined Burtville Terrane and the Yamarna Terrane in the east. The Burtville Terrane is bounded by the Hootanui Fault to the west, and the Yamarna Shear Zone to the east. This terrane contains several greenstone belts that comprise ultramafic to felsic volcanic rocks, mafic intrusive rocks, siliciclastic sedimentary rocks, and minor banded iron-formation. Geochronology indicates that these rocks are older than c. 2735 Ma, with several volcano-magmatic cycles recognized. These include:

- a sequence of c. 2969–2910 Ma basaltic rocks with minor felsic volcanic rocks and quartzite in the northeast Burtville Terrane
- c. 2810–2800 Ma mafic magmatism and volcanism in the central Burtville Terrane, and mafic to felsic volcanism in the western part of the terrane

- felsic volcanism and magmatism across the Burtville Terrane at c. 2770 Ma, with the volcanic rocks overlying, and often interbedded with basaltic and ultramafic rocks. This was followed by mafic magmatism at c. 2755 and c. 2735 Ma.

Unfortunately, the different aged rock packages occur in different greenstone belts, making it difficult to construct a single stratigraphy for the Burtville Terrane.

To the east of the Yamarna Shear Zone is the Yamarna Terrane, where the greenstone belts contain a package of volcanic rocks that range from ultramafic to felsic compositions. The felsic volcanic rocks are called the Toppin Hill Formation, and have been dated at 2683 ± 5 Ma. The volcanic sequence is overlain by siliciclastic sedimentary rocks of the Tobin Formation.



Time-space plot showing the major magmatic events across the Yilgarn Craton

The geochronology shows that the greenstone rocks of the Yamarna Terrane are younger than those in the Burtville Terrane; an observation that indicates the Yamarna Shear Zone is a terrane boundary separating two blocks with distinct greenstone histories. Both terranes have a shared history of granite magmatism from c. 2715 Ma, suggesting they were adjacent by this time.

Possible correlations across the Yilgarn Craton

Despite their differences, the Yamarna and Burtville Terranes have affinities with other terranes in the Yilgarn Craton.

The greenstones of the Yamarna Terrane are similar in age and character to those in the Kalgoorlie Terrane. In the Kalgoorlie area, a c. 2720–2690 Ma mafic to ultramafic rock package, which includes the Lunnon Basalt, Kambalda Komatiite, Devons Consol Basalt, and Paringa Basalt, is overlain by the c. 2685–2665 Ma felsic volcanic Black Flag Group. This is the same age as the Toppin Hill Formation in the Yamarna Terrane, and suggests that the underlying mafic to ultramafic rocks in both terranes may be of a similar age.

There are some older rocks exposed within the Yamarna and Kalgoorlie Terranes. For example, the c. 2832 Ma Ziggy Monzogranite forms a small, shear bounded body adjacent to the Dorothy Hills greenstone belt in the Yamarna Terrane. In the Kalgoorlie Terrane,

the c. 2950–2930 Ma Penneshaw Formation has been recognized at Norseman, and a >2749 Ma komatiite-bearing sequence has been observed near Wiluna. However, these rocks tend to be minor and have been interpreted as exposed basement slices.

In contrast to the Yamarna Terrane, the Burtville Terrane shares affinities with the rocks of the Youanmi Terrane that occurs to the west of the Kalgoorlie Terrane. Similarities include:

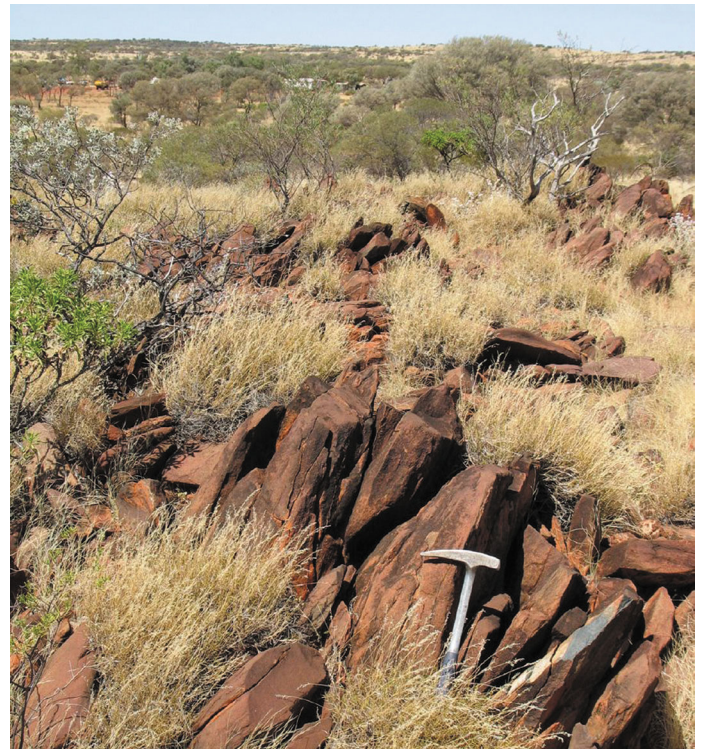
- The c. 2969–2910 Ma package in the Burtville Terrane was contemporaneous with:
 - the c. 2960–2945 Ma felsic Gabanintha Formation which hosts the base metal mineralization at Golden Grove
 - the c. 2934–2929 Ma felsic volcanic rocks which host the base metal mineralization at Mount Gibson.
- The c. 2810–2800 Ma package in the Burtville Terrane was contemporaneous with:
 - the c. 2814–2800 Ma Norie Group in the Youanmi Terrane near Meekatharra, which is composed of a lower basaltic unit that is overlain by felsic volcanoclastic rocks and banded iron-formation
 - the c. 2810 Ma mafic Windimurra Igneous Complex, which hosts V–Cr–PGE mineralization.
- The c. 2770–2735 Ma package in the Burtville Terrane was contemporaneous with:
 - the c. 2800–2730 Ma Polelle Group in the Youanmi Terrane near Meekatharra, which comprises a lower basaltic unit that is overlain by <2760 Ma felsic volcanic and volcanoclastic rocks
 - the c. 2736 Ma Kathleen Valley Gabbro in the eastern Youanmi Terrane.

Geodynamic implications

The age and lithological characteristics of the terranes in the northeast Yilgarn Craton support the arc accretion model of Barley et al. (2003; AMIRA Project P624), where it was suggested that the original Burtville Terrane was a continental-rift fragment that was reaccreted onto the ‘ancestral’ Yilgarn Craton. These authors did not recognise the origin of the older rifted fragment and its affinity with the Youanmi Terrane. They also did not recognize the presence of the younger Yamarna Terrane, which appears to form an extensional basin, filled with rocks similar in age and character to those in the Kalgoorlie Terrane.

The fundamental differences in the rocks of the two terranes in the northeast Yilgarn Craton also suggest that different mineral systems may be encountered in each. Exploration strategies effective in the Youanmi Terrane may prove effective in the Burtville Terrane, whereas those from the Kalgoorlie Terrane may prove best for the Yamarna Terrane.

For more information, contact Mark Pawley
(mark.pawley@dmp.wa.gov.au).



C. 2969–2910 Ma basalts from the Ulrich Range in the northeast Burtville Terrane



Fragmental felsic volcanoclastic rocks of the c. 2770 Ma Palkapiti Formation, Burtville Terrane



Pegmatoidal leucogabbro of the c. 2755 Ma Mapa Igneous Complex, Burtville Terrane



Fragmental basalts from Dorothy Hills in the < 2720 Ma Yamarna Terrane

Understanding the coastline — Perth to Cape Naturaliste

The coast is a dynamic environment; both the position and shape of the shoreline are ephemeral. They change in response to variations in sea level, sediment supply and transport, and wave and swell patterns. So it is important to understand the nature of the coastline in order to assess its stability and susceptibility to erosion and deposition. To achieve this understanding we must integrate information about coastal geomorphology with data from coastal dynamics and nearshore sediment budgets.

Shorelines in southwest Western Australia are wave-dominated and can be broadly categorized into two types — rocky and sandy coasts. Gneissic rocks between Cape Naturaliste and Dunsborough form smooth slopes with boulders at the base of the cliffs. In contrast limestone, which occurs between Perth and Bunbury, erodes into vertical cliffs that can be undercut and are susceptible to collapse. Rock platforms, which are only exposed at low tide, are common in coastal limestone.

Sandy coasts are more dynamic and display a wide range of landforms. Large-scale landforms such as cusped forelands and transgressive dune barriers formed during periods of higher and lower sea levels in response to the waxing and waning of the polar ice caps. As sea level rose sediment was pushed ashore and deposited as a foreshore wedge. Locally this sediment enclosed embayments and formed coastal lakes like Lake Preston and Lake Clifton south of Mandurah.

There are three types of beaches along the southwest coast: wave-dominated sandy beaches on high-energy coasts such as those between Fremantle and Trigg that undergo rapid erosion and accretion in response to storm events; low-wave, sheltered coasts such as those north of Sorrento and south of Fremantle, which usually do not recover fully after erosion; and perched beaches such as those at Cottesloe and North Beach, which are characterized by a thin layer of sand over a rock platform.

One of the major concerns in managing coastal environments is determining the response of the coastline to predicted rises in sea level. Without good long-term planning, coastal communities and infrastructure could be at risk of erosion and flooding caused by sea-level rise.



Rocky limestone coast of Cape Peron



Sandy coast south of Binningup

The interaction between the geomorphological and geological makeup of the coast governs how the shoreline will respond to climate change. For rocky coasts, the main factor governing rates of recession is the geological nature of coastal cliffs. Along sandy coasts geomorphological parameters are more important.

Once the nature of the coastline has been determined, indices based on the present stability of coastal landforms and their susceptibility to erosion can be used to indicate the general risk of the coast to erosion.

For more information, contact Bob Gozzard (bob.gozzard@dmp.wa.gov.au).

Western Australia Regional Geophysics Surveys 2010–11: August update

Airborne Magnetic and Radiometric Surveys

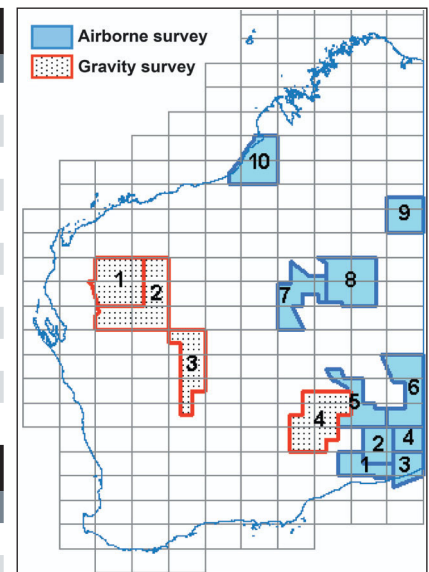
ID	Area/Name	Lines	Size (km)	Status	Start	End	Release
1	Madura 2010	200 m; E/W	102 000	Survey	Jul-10	Nov-10*	Jan-11*
2	Loongana 2010	200 m; E/W	113 000	Survey	Jun-10	Nov-10*	Feb-11*
3	Eucla 2010	200 m; N/S	88 000	Survey	Jul-10	Oct-10*	Dec-10*
4	Forrest 2010	200 m; N/S	75 000	Survey	Jun-10	Sep-10*	Dec-10*
5	Jubilee 2010	200 m; N/S	180 000	Survey	Jun-10	Jan-11*	Apr-11*
6	Waigen–Mason 2010	400 m; N/S	113 000	Survey	Jun-10	Nov-10*	Feb-11*
7	Madley–Herbert 2010	400 m; N/S	95 000	Survey	Jul-10	Oct-10*	Jan-11*
8	Morris–Cobb 2010	400 m; N/S	125 000	Survey	Jul-10	Dec-10*	Mar-11*
9	Stansmore 2010	200–400 m; N/S	114 000	Survey	Jul-10	Nov-10*	Feb-11*
10	Lagrange–Munro 2010	400 m; N/S	103 000	Contract	Aug-10*	Nov-10*	Jan-11*

Ground Gravity Surveys

ID	Area/Name	Spacing	Size (stns)	Status	Start	End	Release
1	Gascoyne North 2010	2.5 km grid	7 292	Release	Mar-10	May-10	15-Jul-10
2	Gascoyne South 2010	2.5 km grid	9 700	Contract	Aug-10*	Nov-10*	Dec-10*
3	Sandstone 2010	2.5 km grid	6 300	Contract	Aug-10*	Nov-10*	Dec-10*
4	Albany–Fraser North 2010	2.5 km grid	9 200	Contract	Aug-10*	Oct-10*	Dec-10*

Information current at: 10 Aug 2010

* Estimated date



Data access

Download final data releases from the Geophysical Archive Data Delivery System at www.ga.gov.au/gadds. Download preliminary and final grids and images from the GSWA website at <http://www.dmp.wa.gov.au/geophysics>.

Subscribe to the GSWA mailing list to keep informed of preliminary and final data release dates.

For more information, contact David Howard (david.howard@dmp.wa.gov.au).

Working together in the Eucla Basin

The Eucla Basin is located on the southern margin of the Australian continent, extending ~2000 km from Western Australia into South Australia. Onshore, the basin contains a succession of marine and coastal sediments up to 550 m thick. The margins and hinterland of the basin are characterized by a number of paleovalleys that drained the Precambrian Yilgarn Craton, Gawler Craton, Albany Fraser Province, Musgrave Province and Officer Basin.

The Eucla Basin and the rocks beneath it are becoming a focus for GSWA and industry work. The South Australian component of the basin has long been a target for heavy mineral sand (HMS) exploration, with several significant discoveries along the eastern margin of the basin, at various stratigraphic levels. There has been some exploration in Western Australia, but generally with less success than across the border. The Department of Primary Industries and Resources South Australia (PIRSA), recently completed a regional study and map of South Australian paleodrainage and paleoshorelines, including the eastern Eucla Basin and its hinterland, focused on HMS and uranium. GSWA has not revisited the western part of the basin, other than for a regional review, since the late 1960s which resulted in Bulletin 122 by Dave Lowry, published in 1970.

PIRSA and GSWA have recently commenced a collaborative study of the western part of the basin, so that an integrated picture of the basin and its economic potential can be achieved. Baohong Hou, the principal investigator of the basin in PIRSA, has just finished an extended visit to GSWA to mine the data held by GSWA, so that he can build a model of the entire basin and its resources, rather than just the eastern half. Baohong was encouraged by the amount of information held by GSWA, and available for incorporation into a co-branded report. Already, there is additional data on the degree of west-to-east tilting of the basin as a whole.

GSWA's contribution is access to the information — which even in these broadband days is easier to find on the spot at times — expert advice on GSWA databases and access to them, and regional knowledge of Western Australian geology. Holes drilled under the EIS program to investigate the basement to the Eucla Basin may also be of interest, as they provide additional information on the subsurface geology of the basin, even though the main target may be the basement.

For more information, contact Roger Hocking (roger.hocking@dmp.wa.gov.au).

RECORDS

Record 2010/15 Geology and petroleum prospectivity of State Acreage Release Areas L10–6 to L10–9, Canning Basin, Western Australia

by P Haines and KAR Ghori

Record 2010/18 5IAS Abstracts volume

edited by IM Tyler and CM Knox-Robinson

Record 2010/20 5IAS Yilgarn — Superior workshop — Abstracts

compiled by S Wyche

NON-SERIES PUBLICATIONS

Geology and petroleum prospectivity of State Acreage Release Area L10–11, Carnarvon Basin, Western Australia

Prospectivity of state acreage release area L10–12, onshore northern Perth Basin

5IAS: Handbook for Archean drillcore at the GSWA core library

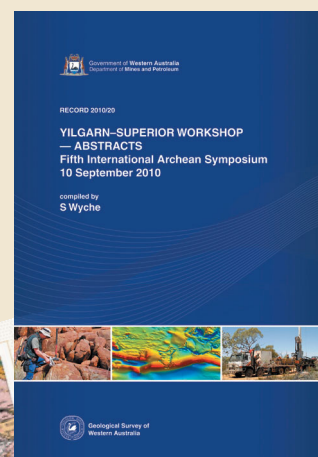
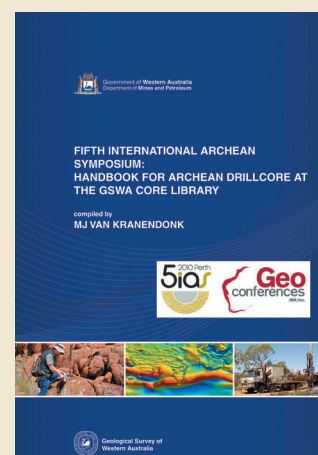
compiled by MJ Van Kranendonk

GEOLOGICAL MAPS

Pink Hills 1:100 000 geological series map

DATA PACKAGE

State petroleum acreage release September 2010



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