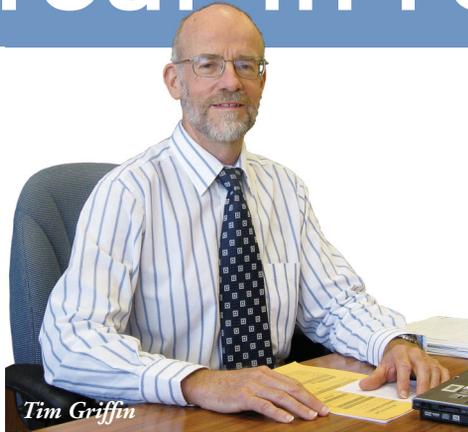


2008-09

Year in review



Much changed in the mineral and energy sector in Western Australia during 2008–09. The global financial crisis, low commodity prices, and the tightening of equity and credit markets had a severe effect on exploration expenditure. As I write this review, however, the outlook for 2009–10 is brighter. Most commodity prices are rising, and there is optimism in the resources sector that the economic downturn caused by the financial crisis is over, at least in Australia, particularly because of the strength of China's economy.

A major change for the Geological Survey of Western Australia (GSWA) was the breakup of the former Department of Industry and Resources following the change of Government in September 2008. The promotion and regulation of the resources industry in Western Australia was transferred into the Department of Mines and Petroleum, emphasizing the policy of the new Government to encourage exploration and mining of all minerals in Western Australia. I was privileged to be the Acting Director General during the establishment of the new Department from December 2008 to June 2009, and during that time Rick Rogerson acted as Executive Director of GSWA, which included the additional responsibility for the successful introduction of the Government's Exploration Incentive Scheme.

The Exploration Incentive Scheme (EIS), the most significant event for GSWA during 2008–09, started in April 2009 when the Western Australian Government provided funding from their Royalties for Regions program to GSWA for this new five-year \$80 million initiative. EIS is managed by GSWA, and the work program over the period 2008–09 to 2012–13 is dominated by pre-competitive geoscience programs including coverage of the State by airborne magnetic and radiometric surveys at 400-metre (or less) line spacing, a series of deep seismic lines, a drilling subsidy to assist mineral and energy explorers in undeveloped parts of the State who are using innovative targeting methodologies, and stratigraphic drilling by GSWA. A significant part of the new funding will be used to develop cutting-edge regional geoscience products using the new geophysical data integrated with traditional 2D geoscience studies. The aim is to produce a real 3D understanding of crustal architecture and, with improved geochronological, geochemical, and isotopic data coverage, the 4D geodynamic history as a guide to regional-scale exploration models and resources targeting. About \$24 million of the funding will be of direct benefit to petroleum and energy exploration with the remainder focused on mineral exploration. EIS is discussed in more detail in the article by Margaret Ellis that follows this review. Margaret has been appointed as the Coordinator of the scheme.



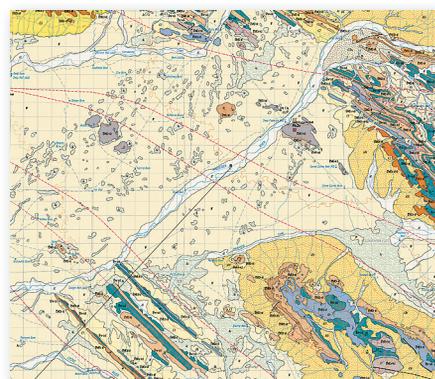
A Review of GSWA, carried out in 2007 under the previous Government, was released during 2008–09. Its recommendations are largely met by EIS.

GSWA publications

During 2008–09 GSWA published:

- 31 geoscience maps including 14 geological series maps at 1:100 000 scale
- 26 records, reports, and other publications
- 19 digital information packages.

Staff turnover, which affected the delivery of planned products in 2007–08, stabilized in the changed economic climate of 2008–09. This allowed production to return to normal levels, and regain some of the ground lost.

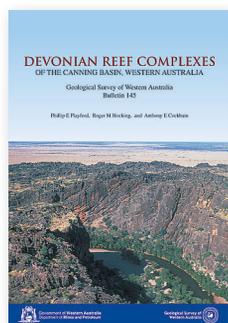


Part of Mount Augustus 1:100 000 map sheet

Our flagship 1:100 000 geological series included the release of three maps that cover parts of the Murchison Domain, a first for this underexplored portion of the Yilgarn Craton. Geological Series maps are now routinely produced by combining digital compilations of Interpreted Bedrock Geology and Regolith layers. Both of these digital layers are now standard in the Geological Information Series packages containing all the digital information available for areas covered by recently released 1:100 000-scale geological maps.

Of the 19 digital information packages released, four represented updates of Geological Information Series packages for the Central Yilgarn, East Yilgarn, Pilbara, and the west Musgrave.

The release of 26 records, reports, and other publications did not meet our planned target of 35 new releases; however, the shortfall was offset by the increased number of external publications authored by GSWA staff. This reflected a strong commitment by GSWA to maintain the high professional skills of staff through supporting involvement in national and international geoscience meetings, including the Australian Earth Sciences Convention held at the Perth Convention Centre in July 2008 and the inaugural Global Geotourism Conference held in Fremantle in August 2008. As well as having a significant presence at both conferences, highlighting work by GSWA geoscientists and their collaborators, GSWA also sponsored and published field guides and provided leadership for associated field excursions.



Perhaps the most significant publication of 2008–09 was Bulletin 145 *Devonian reef complexes of the Canning Basin, Western Australia* authored by a former Director of GSWA, Phil Playford, together with GSWA's Chief Geoscientist Roger Hocking, and former Assistant Director Tony Cockbain. The Devonian reef complexes of the Canning Basin form a spectacular belt of rugged limestone ranges that extend for some 350 km along the northern margin of the basin. They have become known as the 'Devonian Barrier Reef' and constitute what is regarded as one of the world's best preserved ancient barrier reef systems. For Phil Playford

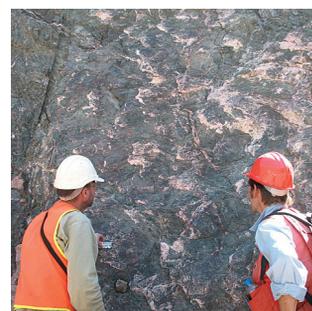
Year in review

the bulletin represents the culmination of more than 50 years of his studies of the reef complexes. Systematic research began in 1956, with West Australian Petroleum Pty Ltd, with GSWA carrying out mapping and field studies in 1962–63, published as GSWA Bulletin 118 in 1966. More field work was undertaken in the area in the 1970s and 80s, with a major effort following Phil's retirement as GSWA Director in the 1990s. Many staff and students from Australian and overseas universities have worked with GSWA on the region. The Devonian reef complexes are highly prospective for zinc and lead, and several deposits have been mined, including Pillara, Goongewa, and Cadjebut. Where the reefs extend into the subsurface they are also prospective for petroleum, with a small oilfield discovered at Blina. They are regarded as a model for similar reefs that host prolific oilfields and zinc–lead deposits elsewhere in the world. The Bulletin will be therefore essential reading for both mineral and petroleum explorers and has already received very positive reviews from around the world.

Geological mapping programs

During 2008–09 our mapping programs continued in the Archean rocks of the Yilgarn Craton. In the Murchison new mapping in the Reedy and Meekatharra areas, along with newly acquired geochronology, has helped in the recognition of a new stratigraphic framework. Mapping commenced on the Windimurra and Narndee layered mafic–ultramafic intrusions and their surrounding country rocks. In the Eastern Goldfields, mapping of the easternmost part of the Eastern Goldfields Superterrane was completed, with new geochronology suggesting that the 'Burtville Terrane' may consist of two distinct crustal elements. A new field program commenced in the Bullfinch–Forrestania and Lake Johnston greenstone belts, which will provide a link between existing 1:100 000 maps in the Eastern Goldfields and the northern Southern Cross and the Murchison Domains of the Youanmi Terrane.

GSWA is funding a component of an ongoing research project on the thermo-barometric evolution of the crust of the Yilgarn Craton by Dr Ben Goscombe, a Visiting Research Associate at Adelaide University. This project is the follow-on from the highly regarded metamorphic study of the Eastern Goldfields Superterrane undertaken by Ben in collaboration with the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRIC). As well as constraining models of crustal processes and tectonic settings, an understanding of the metamorphic history of the Yilgarn Craton will aid the generation of mineral exploration models for this world-class mineral province.



Examining a fault surface

Mapping in the Gascoyne Province was concentrated in the southeast and confirmed that the Ti Tree Syncline is a major structure separating zones with different structural styles and metamorphic histories. Other highlights were the discovery of mafic volcanic rocks in the Morrissey Metamorphics, the construction of a robust stratigraphy for the Mount James Formation, and the confirmation of widespread late Archean to early Paleoproterozoic granitic gneisses as basement to the Gascoyne Province north and south of the Chalba Shear Zone.

In the Edmund and Collier Basins sedimentary facies variations within the Kiangi Creek Formation point to a major, fault-bound sediment–source area to the east of the Abra polymetallic deposit. Mapping has also revealed the presence of a lenticular body of proximal felsic volcanoclastic breccia and sandstone within the

Ullawarra Formation in the upper Edmund Group. This is at a similar stratigraphic level to felsic volcanic rock that has recently yielded an age of 1460 Ma, within error of the 1465 Ma age for the Narimbunna Dolerite that intrudes the Edmund Group.

Mineral systems studies continued in the Gascoyne Province including the Minnie Creek molybdenum deposit and the Gifford Creek alkaline complex, which contains uranium-bearing carbonatites. Work also commenced on the giant Magellan lead deposit in the Yerrida Basin and continued on the Abra polymetallic deposit in the Edmund Basin.

A multi-disciplinary approach is being applied to the eastern Albany–Fraser Orogen and adjacent southeastern Yilgarn Craton to compile an Interpreted Bedrock Geology map combining new geophysical data and targeted field work, and with a specialist team also using the latest geochronology, isotopic analyses, and geochemistry. The area covers a region that stretches from the Tropicana gold deposit in the north to the southwestern end of the Fraser ‘Complex’. The aim is to establish the main lithotectonic units and the timing of magmatic and metamorphic events.

In the Musgrave Province, GSWA’s mapping in the 1960s and early 1970s identified two huge caldera structures — interpreted to have been formed when volcanoes collapsed into underlying magma chambers during massive eruptions more than 1070 m.y. ago. The Scamp Caldera and the Palgrave Caldera are both larger than the one associated with the Yellowstone Supervolcano in the northwestern USA. GSWA’s Musgrave mapping team has begun detailed remapping in the Palgrave area to refine the model and has identified spectacular volcanoclastic units made up of thick pyroclastic flow deposits, including ignimbrite, pumice-rich beds, thick beds of obsidian, and thick and laterally extensive lahar deposits. Angular blocks of dacite up to 5 m across suspended in an ash matrix attest to the force of the eruptions. The deposits point to a series of gigantic eruptions, with the potential for the occurrence of large-scale hydrothermal mineral systems commonly associated with such large volcanoes.

Geophysical surveys

During 2008–09, 398 468 line km of airborne geophysical data were released, including surveys in the South Kimberley, Byro, and Dumbleyung areas flown in 2007–08, as well as from the 2008–09 survey in the Esperance–Balladonia area. These were the final surveys to use the pre-competitive geoscience mapping initiative funding that commenced in 2004–05. This initiative increased the 400 m line-spacing (or better) airborne and radiometric coverage of WA from 30% to in excess of 75%. Completion of coverage of Western Australia will now take place under EIS and mobilization for several surveys was underway in the latter part of 2008–09.

A gravity survey of the Musgrave region collected on a 2.5-km grid was released, together with the collection and release of the Windimurra survey in the Murchison, also on a 2.5 km grid. A gravity survey was collected in the Cunderdin area under EIS, which included the Kauring Airborne Gravity Test Range within it.

Year in review

Geochemistry

Sampling for the National Geochemical Survey of Australia continued in 2008–09 and to date 276 samples have been collected from a total of 447 sites in WA. Progress was slowed dramatically by the need to negotiate access onto Aboriginal lands and areas covered by determined Native Title or by Native Title claims, predominantly in the central and northern parts of the State. These negotiations are ongoing.

Under EIS, GSWA purchased the entire TerraSearch surface and downhole geochemistry database for WA. The exploration geochemistry data were captured from open-file company reports, and validated in terms of sample location and data quality. The dataset covers large areas of the State and includes more than 1.1 million data points, most of which are multi-element geochemistry from drillholes.

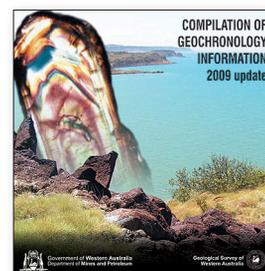
GSWA has acquired a field-portable XRF spectrometer, which can analyse for some 32 elements. One of the main applications is screening samples for geochronology use by measuring the Zr abundance in a rock to get an indication of the presence of either zircon or baddeleyite. The second major application of the instrument is identification of parent lithology from a weathered rock, which can be critical when working in the deeply weathered terrains common in the Archean of the Yilgarn Craton.



Hand-held XRF spectrometer

Geochronology

In 2008–09, 117 samples were dated, and 74 geochronology records were completed. Records are now routinely uploaded (after peer review and editing) to GeoVIEW on the DMP website as they are completed, rather than waiting for an annual release on DVD. Geochronology records can be downloaded from the Data and Software Centre <www.dmp.wa.gov.au>, along with an extract from Geoscience Australia's OZCHRON database. The annual *Compilation of Geochronology* update on DVD will still be available to customers.



Curtin University of Technology, GSWA, and The University of Western Australia were successful in obtaining an Australian Research Council (ARC) Linkage Grant to develop a tectonothermal and mineralization history for the Gascoyne Province and the Bangemall Supergroup. The project, to be led by Professor Birger Rasmussen, will integrate his team's state-of-the-art SHRIMP phosphate geochronology using monazite and xenotime with GSWA's on-the-ground experience in the Capricorn Orogen. GSWA geochronologists will gain from the transfer of knowledge concerning this dating technique.

Land use geoscience

Many demands are placed on land for use by our modern society. Conflicting demands can be resolved when land use planning is applied sensibly to ensure the most efficient use is made of the land and its resources. The South West of WA, from Geraldton to Albany, is experiencing an unprecedented demand

for urban, rural residential, and industrial land and the public infrastructure to support it. Development along the coastal plain between Geraldton and Dunsborough is accelerating, with the potential to sterilize important deposits of raw materials.

GSWA has begun to upgrade its geological mapping along the coastal plain, initially concentrating on the area between Perth and Dunsborough, and will produce a set of maps depicting particular aspects of the geology, and showing themes of particular interest such as minerals and construction material resources, geohazards, and groundwater vulnerability to contamination. This information is being passed on to planners and developers in a way that is easily understood by non-geologists so that its proper use can be incorporated into local and regional planning policies and frameworks.

Petroleum geology

The focus of activities during 2008–09 was the Canning and Amadeus Basins. Detailed studies of the Canning Basin continued, with a number of new discoveries. Studies included the re-interpretation of the Carribuddy Group, where the Worrall Formation is shown to conformably overlie the Carribuddy Group. Work on the Grant Group revealed the difficulties in correlating individual members and it may be best regarded as an undifferentiated unit. An analysis of oil obtained from mineral drilling in the Admiral Bay Fault Zone suggested it was sourced from the Goldwyer Formation, whereas previously the Bongabinni Formation was regarded as the main source. Studies of the Acacia Sandstone suggested its provenance was from adjacent Neoproterozoic basins rather than the North Australian Craton.

During the year, 3103 documents (representing 175 GB of information) were loaded into WAPIMS. The total number of publicly available documents is now 16 626 (650 GB). Worldwide, there were 3900 registered users of WAPIMS (in March 2009).

MINEDEX and WAMEX

The new MINEDEX database was continually enhanced during the year with added functionality, and has proved particularly useful for uranium explorers in WA following the policy change to allow uranium mining.

Following a smooth transition to the upgraded version of WAMEX to manage mineral exploration reporting, a new version of WAMEX Online with a spatial front-end was launched in February 2009. WAMEX now contains over 48 000 reports on open file in digital format. During 2008–09, 3894 digital reports were received, whereas 1507 were released to open file, including 1207 Sunset Clause reports. Another 2704 reports previously available on microfiche were scanned and made available.

Promotional events

GSWA continued to target major national and international mineral and petroleum exploration events as part of its role to promote the prospectivity of Western Australia and attract exploration investment to the State.

Year in review

In 2008–09 GSWA participated with Team Australia at the Prospectors and Developers Association of Canada (PDAC) and at China Mining, and had a presence at other international promotional events including NAPE (North America Prospect Expo) in Houston. A promotional visit to India was included during the year in recognition of the increasing importance of this market to WA.

Within Australia, besides the annual GSWA Seminar and Poster Display and Petroleum Open Day presented by the Department, GSWA was present at Mining 2008 in Brisbane, Diggers and Dealers in Kalgoorlie, the RIU Explorers Conference, and at the AMEC National Congress held in Perth.



GSWA Seminar and Poster Display

The future

The Exploration Incentive Scheme has put GSWA in an unrivalled position to collect, interpret, and distribute up-to-date, relevant, high-quality pre-competitive geoscience information for the resources exploration industry in Western Australia. It will allow us to apply new technologies to meet many of our objectives at a much faster rate than previously expected, and also introduce new geoscience concepts for regions of known mineralization as well as the underexplored regions of the State.

In managing a doubling of GSWA's budget over the next four years under EIS, a challenge will be to ensure there is no detrimental impact on our ongoing projects and programs. GSWA remains firmly focused on encouraging mineral and energy exploration in underexplored areas of the State with the aim of maintaining Western Australia as the preferred destination for explorers. GSWA's other role of providing expert advice to better inform land use decision-making will also be enhanced by the vast amount of new geoscience information being collected and analyzed.

One focus of GSWA activities is the completion of the airborne magnetic and radiometric coverage of WA at 400 m, or better, line-spacing. This is long overdue, and equivalent data are generally already available for other jurisdictions in Australia. There will be an expansion of other datasets including field mapping to improve geological coverage at 1:100 000 scale. In addition, gravity surveys, deep-crustal seismic traverses, magnetotelluric surveys, soil-geochemistry surveys, regolith mapping, geochronology, and isotopic studies using the latest equipment and concepts will enhance our capability to generate robust 3D geological models of the upper crust, with the potential to identify favourable zones for hosting mineralization beneath regolith cover or under thin sedimentary basins.

We are planning to modernize, expand, and integrate our systems to allow our geoscience databases to be accessed and interrogated online, and for our customers to be able to create their own customized geoscience reports and maps. Upgrading of the WAPIMS and WAMEX databases will streamline the release of information in a more usable form for the exploration industry. Of particular importance will be access to mineral drillhole information and related geochemistry.

There will be an expansion of cooperative projects between GSWA and other government geoscience organizations, including Geoscience Australia and CSIRO, and with university earth science departments.

These projects will focus on the provision of strategically important information, particularly for exploration targeting in underexplored regions, and in emerging areas such as tight gas, geothermal energy, and carbon dioxide geosequestration, where skills are in short supply.

GSWA is already playing a key role in providing expert advice and assisting with the coordination of WA projects to develop knowledge in the areas of carbon dioxide capture and storage. We are involved in how to identify the best places to sequester carbon dioxide — both for coal-fired power plants and the LNG industry.



Drill rig

Our aim is to develop an integrated approach for the delivery of new and expanded datasets and information, along with interpretations of the crustal architecture that will be usable and relevant to a range of users across the minerals and energy sector, and the broader community in general. By doing this we can provide a long-term economic base for WA that, not only relies on the export of minerals and energy commodities, but also can export its expertise and services to the resources sector worldwide.



Tim Griffin
Executive Director