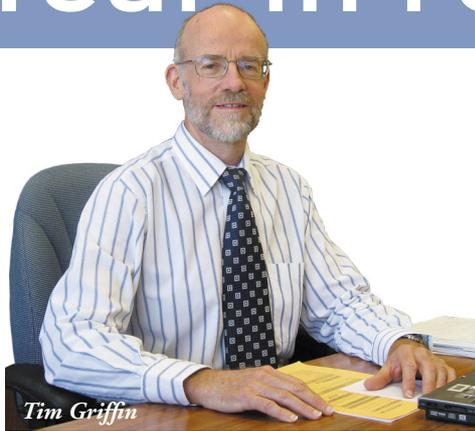


2007-08

Year in review



Throughout 2007–08 the development of new resource projects in Western Australia continued apace, with investment predominantly in production infrastructure — mines and processing facilities, petroleum production facilities, ports, roads, and railways. It is estimated that more than \$100 billion-worth of such investment has been planned for Western Australia over several decades to meet the expected demand from emerging economies, dominated by China.

Investment in mineral exploration in Western Australia, which is the main consumer of the pre-competitive geoscience data collected and distributed by the Geological Survey of Western Australia (GSWA), rose by 45% in 2007–08 to \$1260 million. For the first time exploration expenditure on iron ore has exceeded that on gold. Western Australia's share of total exploration expenditure in Australia now stands at 51%. However, the tightening of the credit market and a retreat in the price of mineral commodities starting in early 2008 saw a decline in the number of Initial Public Offerings for exploration companies during the first six months of 2008. This trend will continue into 2008–09 impacting on the amount of exploration being carried out, particularly by junior explorers. This decline in investment in exploration will affect the long-term sustainability of the State's resources industry, which needs to discover new deposits to replace those currently being mined and developed.

The focus of GSWA's mapping programs is therefore increasingly on the greenfields areas of Western Australia, such as the Musgrave, west Arunta, and the eastern margin of the Yilgarn Craton. The aim in these difficult-to-access areas is to reduce the risk for explorers and improve the efficiency of exploration to ultimately lead to an increased discovery rate of mineral deposits. Providing up-to-date precompetitive geoscience datasets is designed to assist in the identification of exploration targets.

A major issue for GSWA during 2007–08, which impacted on the number of geoscience products we delivered, was retaining the staff that we have, and attracting new staff in what remains a very competitive job market. Despite geoscientists being recognized as a 'Specified Calling' with their positions attracting an additional pay loading from Government, we lost a total of 20 staff, including experienced geologists and cartographers, while being able to replace only 10. A number of positions remain unfilled, notably in geophysics and regolith geology, as well as specialist GIS cartographers. If the loss of experienced staff continues it will ultimately impact on our ability to provide the products and the robust geological interpretations required to contribute to regional exploration models.

GSWA publications

During 2007–08 GSWA published:

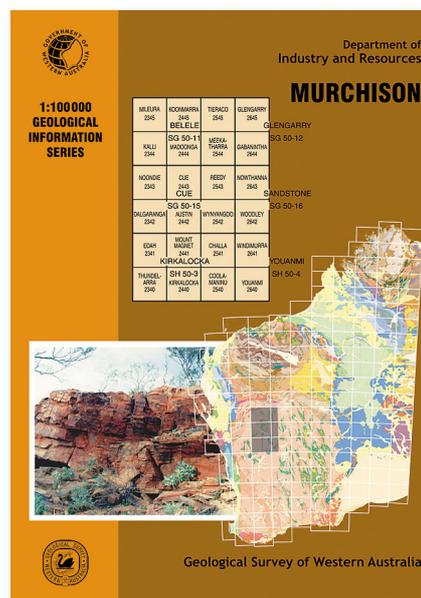
- 19 geoscience maps including seven geological series maps at 1:100 000 scale
- 35 records, reports, and other publications
- 19 digital information packages.

The loss of experienced geoscientists from the Geoscience Mapping Branch together with the loss of cartographers resulted in the production of only seven of our flagship 1:100 000-scale geological series maps, rather than the 14 that were planned. It is expected that the shortfall will be made up during 2008–09.

One of the 1:100 000 maps published, MARBLE BAR, marks the end of 1:100 000-scale geological series map production from the Pilbara Craton mapping project, which began in 1994. It is the final piece in the 35-map East Pilbara ‘jigsaw’. The authors, Arthur Hickman and Martin Van Kranendonk, are to be congratulated for the achievement of this milestone. The Marble Bar area is recognized internationally as providing the best window on Early Earth processes and the evolution of life 3500 million years ago.

Of the 19 digital information packages, six constituted part of the 1:100 000 Geological Information Series (GIS). Notable among these was the first release of a package for the Murchison mapping project in the northwest Yilgarn Craton, an area that has seen exploration success in recent years for gold and for base metals. Other GIS releases were updates for the west Musgrave, the Central Yilgarn, and the west Capricorn, and 2007 and 2008 updates for the west Tanami. These packages now provide, where available, interpreted bedrock geology, regolith, and surface geology layers nominally at 1:100 000 scale, as well as interpreted bedrock geology layers at 1:500 000 scale. Cross sections and all field observations are included, together with layers for tectonic units, 1:2 500 000 geology, geochronology, geochemistry, and mineral deposits, mineral occurrences, and exploration activities. Geophysical and remotely sensed imagery is provided together with selected GSWA publications (including maps). The west Tanami update was released with new 1:100 000- and 1:500 000-scale interpreted bedrock geology layers covering an additional four 1:100 000 map sheet areas. A newly compiled regolith layer was not available at the time of release, and this will delay the release of 1:100 000-scale geological series maps covering the area.

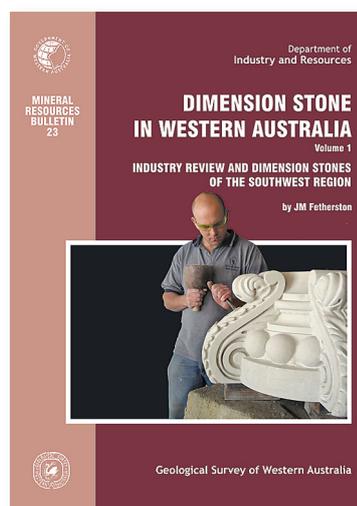
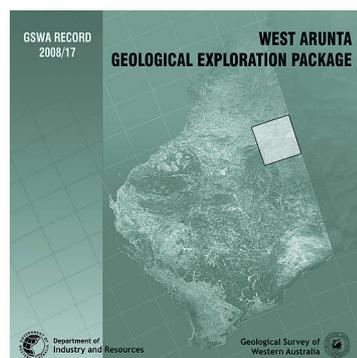
A significant release for 2007–08 was the west Arunta Geological Exploration Package. This package contains the results of a helicopter-assisted soil geochemistry program in the Kiwirrkura area in the Gibson Desert, close to the Western Australian–Northern Territory border. Reconnaissance work by Geoscience Australia identified the area in the mid-1990s as having potential for iron-oxide–Cu–Au



(IOCG) mineralization. Advantage was taken of the availability of a helicopter to visit outcrops in this very remote greenfields area. Observations were combined with magnetic, radiometric, and gravity imagery to produce a new interpreted bedrock geology map layer for the west Arunta Orogen. Recent work by the Northern Territory Geological Survey to the east provided a framework for understanding the local geology.

Another significant release was *Dimension stone in Western Australia* Volume 1, (Mineral Resources Bulletin 23). This well-illustrated volume by Mike Fetherston, GSWA's industrial minerals specialist, discusses the history of the use and methods of extraction of dimension stone as well as technical properties, testing, petrography, processing, production trends, current and potential markets, and conservation procedures. Volume 1 also includes descriptions of dimension stones of the Southwest region. Volume 2, due for release in 2008–09, will provide descriptions of dimension stone quarries and prospects from the rest of Western Australia.

GSWA products released during 2007–08 can be downloaded directly from our website <<http://www.dmp.wa.gov.au/GSWA>>, either from the Data and Software Centre <<http://mapserver.dmp.wa.gov.au/datacentre/>>, or from the maps and books search <<http://www.dmp.wa.gov.au/787.aspx>>, or they may be ordered online via the ebookshop <<http://www.dmp.wa.gov.au/ebookshop/>>. They may also be obtained directly from the Information Centre at Mineral House in Perth.



Geological mapping programs

During 2007–08 mapping programs continued in the Archean rocks of the Yilgarn Craton. The Murchison team made progress to the south and west of Meekatharra, mapping in the Weld Range and the Cue area. The East Yilgarn team continued work in the Mount Venn, Yamarna–Mount Gill, Dorothy Hills, and Irwin Hills greenstone belts at the northeast margin of the Yilgarn Craton.

In the Gascoyne Complex, fieldwork was concentrated on the central part where mapping has revealed the continuation of the same Archean to early Paleoproterozoic gneisses as basement either side of the Chalba Shear Zone, consistent with the results of a magnetotelluric (MT) survey (published as GSWA Record 2007/16). Mapping also confirmed the importance of Mesoproterozoic and Neoproterozoic reworking. Mapping in the overlying Edmund and Collier Basins has shown that the lower Edmund Group stratigraphy in the Jilawara Sub-basin, which hosts the Abra deposit, can be recognized further west.

In the Granites–Tanami Orogen mapping of the Paleoproterozoic basement is now complete. Work on the overlying Mesoproterozoic and Neoproterozoic basins has highlighted problems with previous stratigraphic correlations, which may be resolved by detrital zircon geochronology studies. In the Musgrave Complex, mapping, combined with geochronology, has shown that a major west-northwesterly trending structural zone may separate different basement regions. It has also become apparent that the 1075 million year-old Giles Suite magmatic event involves complex interaction between mafic and felsic magmatism, and between magmatism and deformation. It is also clear that contrary to earlier models,

intrusion of these layered mafic–ultramafic bodies, which are prospective for Ni–Cu, and Cr–PGE mineralization, was at a relatively shallow crustal level.

Geophysical surveys

In 2007–08 there were delays to the airborne geophysics acquisition program, which resulted in 263 000 line-km being flown rather than the 350 000 line-km planned. The main delay was to the South Kimberley survey, and surveys covering the Byro and Dumbleyung areas were brought forward. Acquisition was augmented by the purchase of 213 000 line-km of company data adjacent to the surveys being flown and to planned surveys. It is expected that all three surveys commenced in 2007–08 will be released early in 2008–09.

In addition to the 400 metre line spacing airborne magnetic and radiometric surveys, a helicopter-assisted ground gravity survey at nominal 2.5 km spacing was completed over the west Musgrave Complex.

Also released during 2007–08 were the first versions of merged radiometric anomaly grids of potassium, thorium, and uranium, and of a merged magnetic anomaly grid, covering Western Australia, both with 80-m cell size and generated from government and selected open-file datasets. These both used Geoscience Australia 250-m cell size grids for continental Australia as their base reference for compilation.

Geochemistry

As noted above GSWA carried out a helicopter-assisted soil geochemistry program in the west Arunta early in 2007–08, the first such program since 2001. This very remote area is in the Gibson Desert and is mostly covered by sandplain, some with well-developed dunes. Sampling was focused where the regolith was relatively thin, and geophysical images, combined with surface mapping, showed more prospective Proterozoic rock to be near the surface. Results from 522 sample sites were made available as a download from the Data and Software Centre in February 2008. Several new areas were identified with potential for IOCG mineralization, and for mafic intrusion-related Ni and PGE mineralization.

A major development during 2007–08 was the roll-out of an online Geochemistry Database Search which can be accessed from the Data and Software Centre <<http://geochem.doir.wa.gov.au/geochem>>. GSWA's Geochemistry Database is updated daily and contains in excess of 17 000 analyses, including multi-element analyses of both whole-rock and regolith samples. These data can provide base level information for mineral exploration surveys. Analyses can be accessed through either a simple spatial search (specifying bounding latitude and longitude, or through the selection of individual 1:250 000-scale map sheets), or by downloading



the whole database. The output format can be easily incorporated into other databases, or accessed by third-party software. The data are matched to related metadata, such as sample number, rock type, and sample preparation, and to laboratory batch data by unit of measurement, lower level of detection, analytical technique, and quality-control data.

Regional geochemical surveys are a proven tool for mineral exploration. The National Geochemical Survey of Australia (NGSA) was carried out under Geoscience Australia's Onshore Energy Security Program, and will provide the first complete geochemical coverage of Australia. As large areas of the State lack any coverage, our participation in the national survey will start to fill in the gaps. The NGSA is designed to collect transported regolith samples at the outlet of large catchments. The samples will be analysed for more than 60 elements, and the resulting database will be used to compile an atlas of geochemical maps for use by the mineral exploration industry to target its exploration. GSWA began to collect samples for the survey during 2007–08, and is planning to complete sampling by the end of 2008, with analysis of the samples completed during 2009.

Geochronology

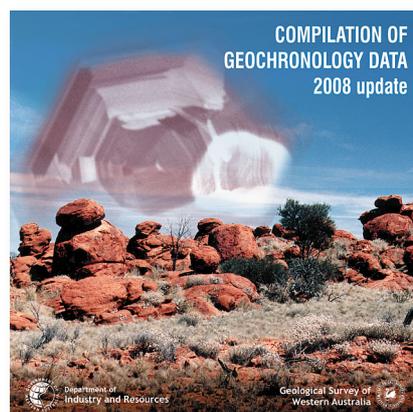
Geochronology continues to be an important aspect of GSWA's mapping programs. A total of 50 new geochronology reports were released during 2007–08, all U–Pb zircon ages determined via Sensitive High-resolution Ion Microprobe (SHRIMP). These included samples from the west Musgrave, the Bangemall Supergroup, the Tanami, and the Murchison and Eastern Goldfields in the Yilgarn Craton.

The geochronology coverage of the State is summarized in GSWA's latest annual 'Compilation of Geochronology' update for June 2008. The update also includes an extract from Geoscience Australia's OZCHRON database. Geochronology data can also be downloaded from the Data and Software Centre on GSWA's website <<http://mapserver.doir.gov.au/datacentre>>.

Mineral systems studies

Mineral systems studies in 2007–08 concentrated on the Gascoyne Complex, an area which is the focus of a long-standing mapping program by GSWA. The studies are integrated with the mapping program, aiming to construct descriptive and genetic models of ore systems. Building a mineral systems genetic model provides insights into the geodynamic environment of ore formation, and allows predictions to be made that can enhance exploration targeting.

Mineral systems investigated in the Gascoyne Complex included tungsten (scheelite) and magnetite skarns at Nardoo Well; rare metals (Ta, Bi, Be) and U in pegmatites (Morrissey Hill and Mortimer Hills); Mo–Cu–W–Pb intrusion-related occurrences in shear zones within the Minnie Creek Batholith; polymetallic quartz veins at Mangaroon and Mortimer Hills; and carbonatite-related REE and U at Gifford Creek.



Petroleum systems studies

During 2007–08 the main focus of the Petroleum Systems Studies Group was in the Canning Basin, where some long-held views on the geological framework of the basin have been overturned. An example of this is the long-held view that the Worrall Formation unconformably overlies the Carribuddy Group which has now been disproved; it conformably overlies it. These changes in understanding will help to raise the profile of this under-explored frontier basin, reducing technical and financial risks for explorers.

In addition there is an increasing need to develop expertise and knowledge to meet the growing interest in geothermal energy and unconventional gas prospectivity studies, and to provide information and advice on carbon capture and storage, coal seam methane, and in-situ coal gasification.

Transcription of legacy seismic tapes continued and is expected to be completed during 2008–09. The Perth Core Library met an increasing demand for viewing petroleum cores.

Land access

GSWA carried out mineral prospectivity studies on whole or part pastoral leases purchased by the Department of Environment and Conservation (DEC) for inclusion into the conservation estate. These sheep or cattle stations are chosen by DEC for their broad regional biodiversity value, and some contain historical mining centres, current mines, and advanced projects that are expected to become future mines. Consultation with stakeholders took place with the aim of excluding mines and advanced projects from the proposed new conservation reserves. In September 2007, Government agreed to the creation of conservation reserves over 25 DEC-purchased areas, mostly as conservation parks.

MINEDEX

A major achievement for GSWA during 2007–08 was the release of a new and improved version of the MINEDEX database system for Western Australian mines, mineral deposits and prospects. The new MINEDEX is the result of two and a half years of design and programming work involving GSWA staff and a contract IT company. It is simpler and easier to use than the old system and will provide industry experts and professionals with more in-depth information while allowing extensive searching, reporting, and exporting of mining industry data. It combines three existing minerals-related systems: MINEDEX, WAMIN, and WABMINES and provides information on mining projects and their owners, mineral resources, location, production data, and geological attributes, with links to other Departmental and GSWA systems.

Web delivery of products and reports

During 2007–08 delivery of GSWA precompetitive geoscience data products via the Internet was improved through the enhancement of the Data and Software Centre. Less-complex browsing has been provided, and more data are available, in more formats, and more frequently updated, often on a daily basis. Google Earth KML/KMZ files and ESRI SDE export files have been included alongside the MapInfo TAB files, ESRI shape files, and CSV files already available. Where possible, hyperlinks are included with Google Earth data format so that the user can click on the Web link while viewing MINEDEX data and view the relevant page in MINEDEX.

Web Map Services (WMS) are now available from the Data and Software Centre under a series of headings that include WA Geoscience, WA Mineral, WA Petroleum, WA Airborne geophysics, and WA Administration. All deliver online, real-time access to spatial information based on Open Geospatial Consortium's (OGC) implementation specifications for WMS.

Enhancements were made to GeoVIEW.WA, GSWA's Web-based tool that provides customers with the ability to view, query, and map a number of integrated State-wide geoscientific and related datasets online. There is now a Publications search tool, which allows the user to find GSWA publications associated with a geographic region in WA, and to view them in Digital Paper. Theme-based views for mining titles, geoscience, geophysics, petroleum, and mines and deposits allow users to quickly change between views for a particular area of interest, with no need to change the Table of Contents. By selecting a theme GeoVIEW.WA will automatically change the visible layers, while allowing you to turn on other layers as you wish. Data can be downloaded either from the Data and Software Centre, or via an Extract button that extracts the visible data layers clipped to the map-view extent as an ESRI shape file.

Kalgoorlie '07

For GSWA the most significant geoscience meeting in Western Australia during 2007–08 was the Kalgoorlie '07 conference in September 2007, of which GSWA was a sponsor. About 300 delegates gathered to discuss developments in the understanding of the geology of the Yilgarn Craton over the last decade. Invited speakers presented talks on every aspect of Yilgarn geology from regional geology and landscape evolution to mineral systems and exploration targeting. Speakers came from a range of organizations such as Geoscience Australia, CSIRO, predictive mineral discovery*Cooperative Research Centre (*pmd***CRC*), Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME), the WA Centre for Exploration Targeting (CET) at UWA, other academic institutions, and a number of mineral exploration and mining companies. GSWA was well represented with seven of our geologists making presentations on a range of subjects including regional geology, geochemistry, geochronology, and geophysical interpretation.



GSWA also led two field excursions: a half-day excursion across the classic Kalgoorlie stratigraphy at Mount Hunt just south of Kalgoorlie; and a five-day, 1200 km traverse across the Yilgarn Craton from the typical greenstone stratigraphy of the Eastern Goldfields around Menzies to the ancient detrital-zircon locality at the Jack Hills in the Narryer Terrane. Along the way the excursion visited characteristic features of the various terranes within the Yilgarn Craton. GSWA produced excursion guides, which can be downloaded from our website, for all the Kalgoorlie '07 excursions, including a trip that examined structural controls on gold mineralization, led by Richard Blewett and Karol Czarnota of Geoscience Australia.

Promotional events

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

In 2007–08, GSWA participated with 'Team Australia' at the Prospectors and Developers Association of Canada (PDAC) in Canada and at China Mining, and had a presence at other international promotional events at NAPE (North America Prospect Expo) in Houston, PETEX (Petroleum Experts), and the Mining Journal's 'Australia Day' in London.

Within Australia, besides the annual GSWA and Petroleum Open Days presented by the Department in Perth, GSWA was present at Mining 2007 in Brisbane, Diggers and Dealers and Kalgoorlie '07 in Kalgoorlie, and the RIU Explorers Conference, the APPEA conference, and the AMEC National Congress all held in Perth.

The future

GSWA's primary focus will continue to be on attracting mineral and energy exploration investment to the State with the aim of making Western Australia the preferred destination for explorers, be they local, interstate, or international.

For mineral explorers the challenge is that undiscovered ore bodies are most likely covered by either regolith or by younger sedimentary basins, and will have little or no surface expression. Discoveries in greenfields areas will rely increasingly on innovative use of datasets such as satellite imagery, more-detailed airborne and ground geophysical surveys, hyperspectral mineral mapping, and soil geochemistry surveys, as well as the introduction of new techniques and technologies for 3D visualization and modelling. Such innovation will come from well-funded, integrated research efforts between GSWA, the other state and territory geological surveys, Geoscience Australia, CSIRO, university earth science departments, and mineral and energy exploration companies.

As well as established collaborations with the John de Laeter Centre for Mass Spectrometry and CET, GSWA will collaborate with two new mineral and energy centres of excellence in WA for which the Premier, as Minister for Science and Innovation, announced funding in February 2008. The Centre for 3D Mineral Mapping (C3DMM) is a joint venture between CSIRO and CET, and has been granted \$1.5 million over four years. It aims to further develop the relatively new mineral exploration method of hyperspectral sensing of the infrared and near-infrared parts of the electromagnetic spectrum as a tool to generate low-cost, highly specific maps of surface mineralogy that could be used to identify zones of alteration. The Centre will capitalize on drillhole data to be generated and stored in the National Virtual Core Library to generate 3D mineral maps.

The WA Geothermal Centre of Excellence is a joint venture between CSIRO, UWA, and Curtin University of Technology. It was awarded \$2.3 million over three years to build capacity and knowledge within Western Australia to undertake exploration and development of shallow 'wet' and deep 'dry' geothermal resources. GSWA will provide pre-competitive geoscience information and will undertake

collaborative work on deep geothermal resources. Establishment of the centre of excellence complements the first acreage release, covering the Perth Basin, for the exploration and development of commercial geothermal resources.

GSWA has also been involved in successful applications for three Australian Research Council Linkage grants. All of the projects start in July 2008 and will cover subjects from either end of the geological time scale ranging from Archean gold, platinum, nickel, and iron deposits in the Yilgarn Craton to petroleum exploration in the Devonian of the Canning Basin.

These collaborations follow on from GSWA's sponsorship of the influential *pmd**CRC, which will wind up its activities on 30 September 2008 after seven years of operation. The *pmd**CRC held a series of workshops before a final conference on 11–12 June in Perth at which it presented summaries of the results from its projects. For GSWA the main focus has been on the flagship Yilgarn projects, but there were many positive outcomes of the CRC for the future of mineral exploration in Western Australia, particularly in terms of philosophy of approach and of work practices.

GSWA sees its future in applying the mineral systems approach, particularly in remote greenfields exploration areas where the aim is to reduce risk and thus attract explorers. Answering the first two of the *pmd**CRC 'Five Questions' (*Geodynamics* and *Architecture*; the other three are Fluids reservoirs, Flow drivers and pathways, and Transport and deposition) fits very well with the role of GSWA to provide robust interpretations of geological evolution and tectonic settings, which will contribute to the development of successful regional exploration models.



TJ Griffin
Executive Director