



AUSGEO

news

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ARCHAEAN MICROBES
reset our lineage

'JUNK' *probed*
for landform changes

MUD dwellers
Agents for GIANT deposits?

Also: Mapping giants merge, direct entry to databases, four marine planning ventures...

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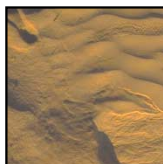


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Weathering and erosion, and transportation and deposition of sediments have been involved in a huge cover up of the Australian continent. In places, a complex landscape of peaks and valleys is buried beneath 150 metres of weathered soil and sediment. This 'junk' or geological cover is known as the regolith. See the article on the opposite page.

Photo: On the way to Charlotte Pass, Kosciuszko National Park, New South Wales. *Photo courtesy Gary Scaroni*

COVER UP

penetrated to reconstruct

LANDSCAPE HISTORY



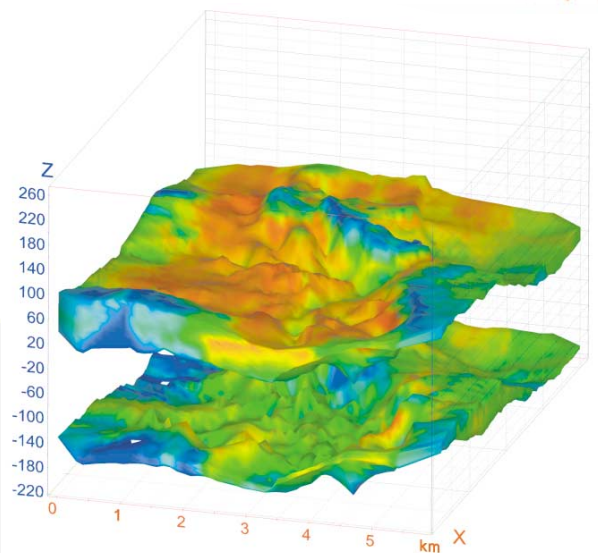
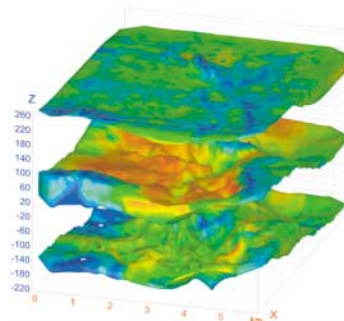
There has been a cover up in Australia—a geological one—that has been going on for a few billion years. Weathering, erosion and sediment have broken down and covered up hard rock and mineral deposits. The extent of this cover is not understood and it is a barrier to mineral discovery. With geophysical tools, this cover called the regolith can be penetrated.

Regolith formation

The regolith is the loose, weathered soil and sediments that sit between the Earth's surface and the bedrock. Its depth depends on the landscape's evolution, but in some parts of Australia it is 150 metres deep.

Landscape processes that went on both in ancient times and nowadays are responsible for the composition of the regolith. The regolith is formed at or near the surface by weathering and erosion, and transportation, deposition and cementing of materials. Its formation is different from that of most rocks, which develop by processes deep in the Earth.

Ultimately, though, the regolith is derived from bedrock. And although the surface of many parts of Australia appears relatively flat, the regolith can disguise a complex landscape of peaks and valleys that house a variety of materials including minerals and salt (figure 1).



▲ **Figure 1.** The three layers are transported material, weathered rock and slightly weathered rock. The top of the upper layer is the present landscape, which is very flat. When the top layer (transported material) is peeled back, the old landscape is revealed and shows hills and valleys.

The colours represent the conductivity of the regolith, obtained from an airborne electromagnetic survey. Areas of high conductivity are the red colours. These reds may be showing places with a higher salt content. *Diagram: John Wilford*



Important junk

To many geologists the regolith is the junk on top that obscures their view of the hard rocks. To mineral explorers who don't know how to use the regolith to find deposits, it can be a barrier that wastes their money trying to drill the right targets (figure 2).

To regolith scientists, however, it is the record of most of the later geological history of the continent. Engineers, environmentalists and farmers also have an interest in the regolith.

Roads, building foundations, tunnels and dams are built in the regolith. Soil types and soil quality are affected by regolith materials, and so is water that travels through it. In a parched continent like Australia, precious groundwater flows through the regolith often gathering or increasing its salt load on the way.

Environmental issues such as water quality and salinity cannot be understood solely through soil surveys. They require a good understanding of regolith materials.

Some regolith materials are of economic importance. These include bauxite, uraniferous calcrete, nickeliferous laterite and opal, and occasionally diamonds, gold and tin.

Dr Colin Pain, leader of the AGSO – Geoscience Australia based CRC LEME, says regolith maps of the Australian continent are needed to make sense of what is seen at the present-day surface and what is shown on geology maps.

'We need to know something about the regional distribution of regolith materials because it is the basis on which a lot of our national maps were produced and on which a lot of our policy decisions are made', he says.

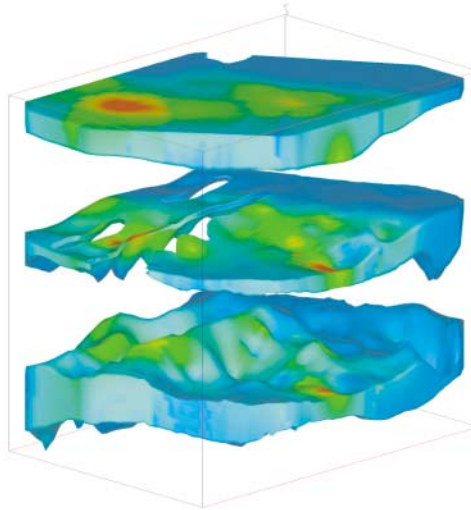


Figure 2. The top layer of the regolith has been transported from elsewhere and covers a layer of weathered rock. The red colours show that gold in the underlying rock has been chemically moved up into the overlying transported material. Chemical signals help mineral explorers to find deposits at depth.
Diagram: John Wilford

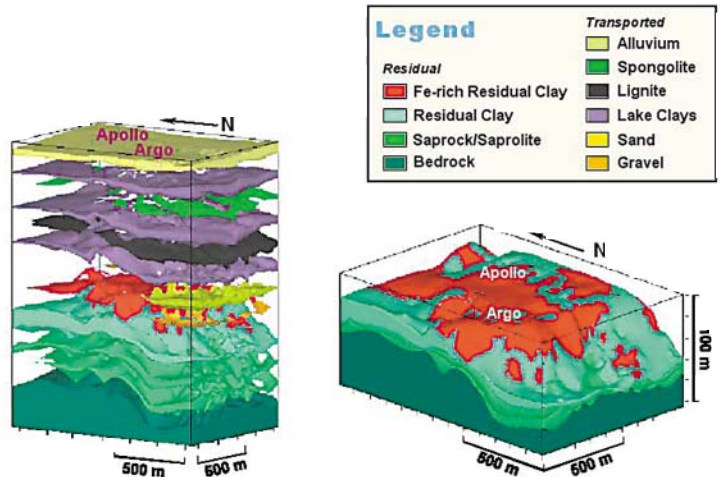


Figure 3. The right-hand diagram shows the old landscape in which a series of layers formed along the edge of an old valley. The left-hand diagram is the modern landscape. It is much flatter than the old one, because of the layers of transported material.
Diagram: Alison Britt & David Gray, CSIRO





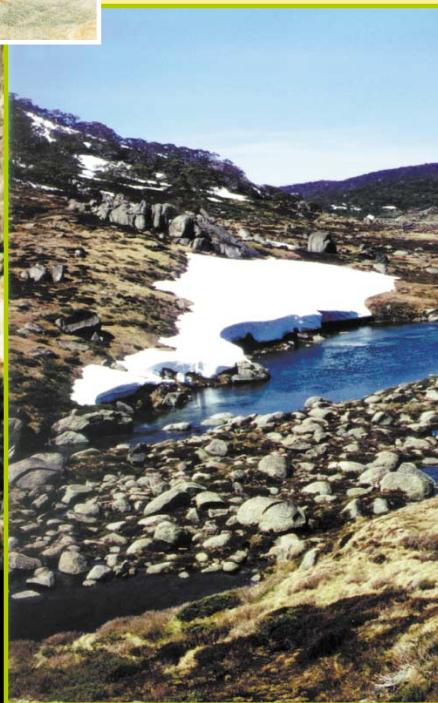
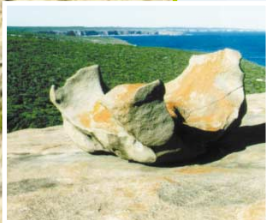
Mapping tools

Dr Pain says Australia has 'an awful lot of regolith' and even though he would like to see continental coverage at the 1:250 000 scale, he doesn't believe it is possible because of the cost and person hours required.

'We simply don't have the capacity to tramp over every part of the Australian landscape', he says.

As well, the surface can be covered in vegetation, making it difficult to survey, and often there are few outcrops to indicate what the underlying rocks are like.

These drawbacks are being overcome by using geophysical tools (such as radiometrics, airborne electromagnetics or AEM, magnetics and seismic surveys) to 'see' below the surface and through the regolith to the Earth's crust.



Radiometrics (gamma-ray spectrometer surveying) measure amounts of potassium, uranium and thorium in the near surface. This tool differentiates rock units and whether soil is in situ or has been transported to its current site. AEM can show the conductivity of the upper 100 to 200 metres. Ore bodies are often conductive, as is salt water. The magnetics show the palaeo-channels (old water courses) and highlight materials with a magnetic signature. Sometimes this tool directly detects ore bodies. Seismic surveys shows what is at depth—the potential rock types and what the crust is like.

'Although we get a great deal of information from these geophysical tools', says Dr Pain, 'the trick is making the connection between what we find in the geophysical images and what we see in the field.'

The geophysical information has to be tested by 'ground truthing'. This involves field work, analysing cores or samples taken from mineral exploration company drill holes in different parts of Australia, and building a picture of what the landscape once looked like.





Interpretation caution

CRC LEME is using geophysical survey data to build 3D regolith models of parts of Australia. These reconstructions or models show the location of soil and rock layers, possible barriers to water flow, as well as palaeo-valley floors and palaeo-drainage (figure 3).

They are proving useful in landscapes with a salinity problem.

'If there is a salinity situation, you get a realistic picture of where salt is stored, how it is getting into valley floors, by what pathways it surfaces, and the rate at which this is happening', says Dr Pain.

Interpretations of regolith models (e.g. as an aid to tracing salt stores) can be problematic, though. Sometimes the regolith topography has been inverted by millions of years of weathering and erosion. In other words, the sub-surface peaks and ridges were once the lowest part in a very old landscape.

For example, in north Queensland 29 million years ago, basalt from volcanic eruptions filled up valleys. For millions of years rivers coursed along the edges of the basalt eroding material that was much softer. Eventually the basalt valley fill became a series of ridges with alluvium on top. Similarly, hard materials such as iron and silica that accumulate and cement together in the lowest part of the landscape can become high points after millions of years of erosion.

'To understand the regolith you have to look at the processes that gave rise to the materials in the landscape and then the modifiers—the weathering, the cementing and the water moving through it—that affect those materials', says Dr Pain.

'Regolith changes have important implications for interpreting the landscape and interpreting the geochemistry for mineral exploration.'

Further research

Dr Pain says the Australian landscape needs to be divided into regolith landform systems that appear to work in a fairly similar way, so that rules developed in one region can be applied to a like region.

But he says at this stage they don't know how far can they extrapolate the detailed district studies they've done into a wider landform context.

'Nevertheless, we are getting a much better understanding of the broader scale in terms of the nature of soils, dispersion of palaeo-channels and basins, and evolution of topographic highs and various ridges', he says.

He also says that there is a need for research into the chemistry of weathering environments because various microbes that live in the regolith may be influencing changes taking place.

'The silcrete and ferricrete story, for example, may have a biological component', he says.

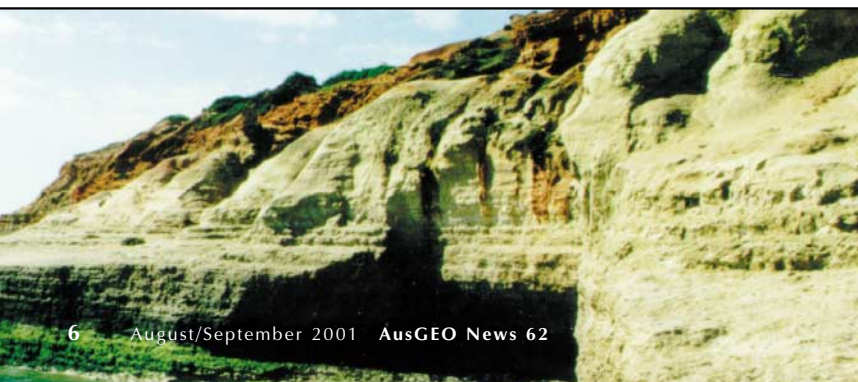
Dr Pain also believes the regolith probably has recorded climatic change right back to when Australia was part of the super continent, Gondwanaland.

'The regolith is not the last hiccup in geological history', says Dr Pain.

'It has developed over the same time scale as biological evolution and plate tectonics.'

The regolith therefore could prove fertile ground for research into weathering, climate change and changes in Earth's atmosphere.

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ARCHAEAN MICROBES

show we're *older* than we think

Tell-tale signs of microbes that inhabited Earth's oceans almost three billion years ago have been found in shales in the Pilbara Craton in Western Australia.

Molecular fossils (the chemical remnants of microbe cell walls) suggest that these simple organisms had diversified biologically 500 million to a billion years earlier than previously thought, and that some were adding oxygen to the oxygen-starved atmosphere by photosynthesis.

Geochemical analyses at AGSO – Geoscience Australia, particularly the doctoral research of Jochen Brocks, show that the earliest forms of single-celled eucaryotes (the ancestors of animal and plant life) are at least 2.7 billion years old. This research resets our lineage on the tree of life.



The Tassie Queen mine near Marble Bar in the Pilbara, and some of the best preserved Archaean rocks on Earth. The exposed shales (Mt Roe Formation, Fortescue Group) are 2.78 billion years old.

Molecular clues

The tree of life has three main branches: one for bacteria (bacteria), one including methane-producing micro-organisms (archaea), and one for animals, fungi and plants (eucarya). Each branch produces distinctive molecular fossils.

Over time as the microbes decayed, their remains in muddy sediments on the seabed were pressed together by more layers of sediment and heat to form shale. This process also chemically changed the microbe remains.

Sterols are found in eucaryote cell walls. The molecular fossils of sterols are steranes. If fossil steranes prove to be indigenous to three-billion year old rocks, then eucaryotes would be that age. Similarly, bacteria would have existed at that time if hopane is found (the chemical derivative of hopanepolyols found in bacteria cells).

Of course, the molecules don't have to be as old as their host rock. They can invade or 'contaminate' the host rock at a later date.

Rock sampling

Fossil molecules of bacteria and eucaryotes are unstable in high temperatures. When they undergo thermal stress, they can turn into gas and graphite.

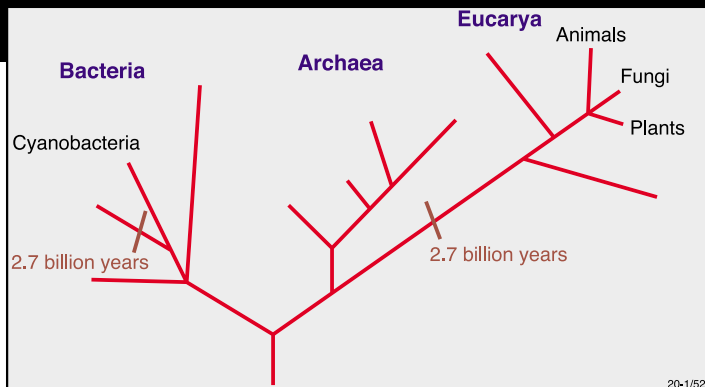
Most rocks of Archaean age (4.5 to 2.5 billion years old) have been subjected to high temperatures and undergone many changes since formation. It is hard to trace molecular fossils in such rocks. The best preserved Archaean rocks known are in the Pilbara Craton.

'I could hardly believe it when I saw these fresh-looking 2.7 billion-year-old rocks', says Jochen Brocks.

'These rocks are horizontal, completely undeformed, and have suffered temperatures of only 200 to 300°C.'

The first samples for study were taken from a 700-metre drill hole near Wittenoom. Further samples were collected 200 kilometres to the south-east, 100 kilometres to the south-west, 70 kilometres to the north-west, and 200 kilometres to the north-east in the Pilbara. To ensure rocks with a similar history were collected, sampling was closely spaced. Adjacent rocks (black shales, chert, basalt, sandstone and vein dolomite) from depths of between 600 and 1800 metres were analysed.

The tree of life with its three main branches: bacteria, archaea and eucarya. Pilbara molecular fossils set the minimum age for bacteria and eucarya at 2.7 billion years.



A gorge in Karijini National Park, in the Pilbara's Hamersley Basin. The 2.5 billion-year-old rocks are banded iron formations. These rocks are interbedded with shales that house molecular fossils. *Photo courtesy Roger Buick*



Indigenous molecules

The black shales were rich in organic matter. They had an organic (or kerogen) content of up to 11 per cent. There were no significant traces of organic matter in adjacent rocks.

'It was hard to accept that these molecular fossils were indigenous to 2.7 billion-year-old shales, so I looked for contamination from the drilling process or migration of a younger oil that would give the bitumen signal I was seeing', says Mr Brocks.

A similar signal was identified in all shale samples, which represent roughly a 50 thousand square kilometre area.

'These same typical signatures were found in seven drill cores and two mine samples, that were drilled for different companies, collected by different people, and stored in various locations', says Mr Brocks.

If there was any drilling additive or contaminant, or younger oil had migrated into the shale, all adjacent, equally porous rocks would have been tainted and given a bitumen signal. Instead, they were clear.

As well, to reach sample locations, oil from the nearest post-Archaeal basin would have had to travel great distances. This journey would have been through rocks that were last metamorphosed about 2.45 million years ago and therefore probably sealed to oil migration.

'In the entire Pilbara Craton there are no potential petroleum source rocks younger than 2.4 billion years, and we know they were never deposited over the top in sufficient thickness to generate oil', says Mr Brocks.

'I am sure that the molecules are indigenous to the black shales.'

Hopananes and steranes

The Pilbara molecular fossils are abundant in hopananes, with very high concentrations of 2 α -methylhopananes—which signal the presence of cyanobacteria. These bacteria are photosynthetic. They produce energy from sunlight and release oxygen.

'We now know that 2.7 billion years ago we had oxygen production in a world with an oxygen-starved atmosphere', says Mr Brocks.

The bacterial production of oxygen would be essential for the later development of higher life forms.


The discovery of a wide variety of different steranes in the Pilbara molecular fossils indicates that eucaryotes existed in the Archaeal. Eucaryotes require oxygen for their enzymes to produce sterol. It was thought the atmosphere had very little oxygen at this time, but these results indicate that low levels of free oxygen must have been available in the upper water column.

There was no geochemical evidence of higher order plants (540 million years old or younger) in the Pilbara shales, confirming that the eucaryote molecular fossils had to be at least Precambrian.

'Our data give two new dates for the fundamental tree of life', says Mr Brocks.

'The eucaryotic branch and the cyanobacterial branch are both at least 2.7 billion years old.'

This research has extended the evidence of the evolution of eucaryotes or plant and animal life, by 500 million to a billion years.

For further information phone Graham Logan on +61 2 6249 9460 or e-mail graham.logan@agso.gov.au. Jochen Brocks can be contacted at Harvard University after October when he settles into post-doctoral research as a Junior Fellow in the Society of Fellows. 

Geoscience Australia, A MAJOR PLAYER in marine planning process

Australia has one of the largest marine jurisdictions in the world. In a recent initiative to improve understanding of Australia's marine jurisdiction, the Commonwealth Government, through the National Oceans Office (NOO), has embarked on a program of ecosystem-based management.

Government policy on management of Australia's marine jurisdiction will be implemented through a series of Regional Marine Plans (RMP). The first of these plans covers the south-east Australian margin. AGSO – Geoscience Australia is helping NOO unlock the secrets associated with the bathymetry, sediment transport processes and seabed character for the south-east region.

Geoscience Australia scientists in Hobart and Canberra will be investigating the relationships between the geology of the seabed and benthic habitats. They will build a database for the south-east region that will contain geophysical, geological, oceanographic and biological data. It will be web accessible in 2002.

1. Bathymetry model

The first component of work focuses on developing a high-resolution bathymetry model. This work will add depth data to Geoscience Australia's bathymetry database for approximately 400 000 new points in the south-east region. These additional data points are located mainly on the continental shelf. They will supplement detailed data already available for the outer shelf, slope and rise.

The outcome of this work will be a consistent, reliable, high-quality bathymetric GIS-based model for the south-east marine region. The improved bathymetry model will provide an unparalleled view of the sea floor, including the location and abundance of sea-floor features such as sea mounts (which are important for fisheries conservation). It will be integrated into Geoscience Australia's computer-based sediment transport model, GEOMAT.

2. Sediment transport

The second component is to further develop GEOMAT, and apply it to the south-east region. GEOMAT uses tidal and ocean swell-wave models to predict sediment mobilisation on the shelf (i.e. <500 m).

Habitat types can be differentiated on the basis of the mobility of the substrate in response to oceanographic processes. The goal of GEOMAT is to calculate on an annual basis, the percentage of time that sediment on the shelf is mobilised by swell waves and tidal currents. Three years of wave data and two weeks (i.e. one neap-spring cycle) of tidal current data will be used to generate a series of ARCInfo coverages gridded at one-kilometre resolution showing the percentage of time that the observed sediment grain size on the bed is mobilised. The ratio of wave and tide mobilisation will also be calculated to provide a spatial assessment of the relative importance of swell waves to tides.

The main outcome will be numerical estimates of seabed processes that can be integrated with biological data to identify and map bio-regions and benthic habitats for the south-east region. The work builds upon the collaborations over the past three years of Geoscience Australia, University of Tasmania, Australian Bureau of Meteorology and Kort & Matrikelstyrelsen, Geodetic Division in Denmark.

3. Seabed character

The third component focuses on characterising the seabed to produce geological proxies for the occurrence and distribution of benthic habitats. The work involves examining and characterising archived 3.5 kHz and other echo-sounding data held at Geoscience Australia. Sediment data and samples held by various geoscience agencies, universities, companies, and the Royal Australian Navy also will be collated.

A series of ARCInfo grids, based on interpretation of acoustic data sets and physical seabed sediment data, will be produced to show seabed character. The emphasis will be on producing ARCInfo coverages of seabed types of primary interest to biological habitats. These include bedrock outcrop, sediment cover, thickness of unconsolidated sediment, location of geomorphic features and seabed roughness. GIS-based maps also will be produced showing the distribution of basic parameters such as grain size (mean and sorting), and per cent clay, silt, sand, gravel, and carbonate content.


The seabed sediment data will be integrated into GEOMAT to provide more precise and reliable estimates of sediment mobility for the south-east region.

4. Bio-regionalisation

Geoscience Australia and CSIRO Marine Research are jointly working on the fourth component to produce a bio-regionalisation for the south-east region. This work will be completed by November 30.

Geophysical, geological, oceanographic and biological data will be used to delineate bio-regions for the shelf, slope and rise. A range of statistical and mathematical approaches will be applied to derive spatial maps of inferred bio-regions at various levels of spatial resolution. Where possible, the bio-regionalisation will complement existing meso-scale IMCRA bio-regions.

When complete, the bio-regionalisation should provide support for baseline and strategic surveys within Australia's marine jurisdiction, and improve current levels of bio-diversity information (at scales required for description, planning and management).

For more information about Geoscience Australia's involvement in Regional Marine Planning phone Peter Harris on +61 3 6226 2504 or e-mail P.Harris@utas.edu.au 

International magnetic network accepts *classy* Aussie observatories

AGSO – Geoscience Australia magnetic observatories at Kakadu in the Northern Territory and Charters Towers in Queensland have been added to the INTERMAGNET Magnetic Observatories (IMOs) list that already includes Australian observatories at Canberra, Gngangara and Alice Springs.

INTERMAGNET (the International Real-time Magnetic Observatory Network) promotes the exchange of real-time magnetic data around the world. The network was set up more than 10 years ago by a consortium of countries on the north Atlantic coast that wanted real-time geomagnetic data for monitoring and forecasting space-weather. This information is important for navigation, geophysical exploration, radio communications and satellite systems. Seventy magnetic observatories in 27 countries were part of the network in 1998, and the number is steadily growing.

Magnetic observatories must demonstrate their data are of suitable accuracy and stability to be accepted as an IMO. Once accepted, the observatory is obliged to maintain good quality data and provide the data within an agreed time frame. As well, at the end of every calendar year IMOs must contribute to the annual INTERMAGNET CD-ROM of Definite Data. This means supplying fully calibrated data for the full year, with all appropriate corrections applied.

Near real-time data from participating magnetic observatories are transmitted to any one of a number of Geomagnetic Information Nodes (GINs) via satellite or other electronic means, typically e-mail, within 72 hours of acquisition. GINs have been established at Golden, USA; Ottawa, Canada; Edinburgh, UK; Paris, France; and Kyoto, Japan. Data sent to one GIN is distributed to all the others.

Data contributed to INTERMAGNET are immediately available to the scientific community. The latest geomagnetic data from around the globe may be viewed at

www.gsrg.nmh.ac.uk/intermagnet/

This site is worth checking because Earth is experiencing the first solar maximum since the network was set up. Close to real-time geomagnetic data showing the effects of this phenomenon are available online.

Canberra magnetic observatory became a bona fide IMO in 1994, followed by Gngangara (near Perth) in 1995 and Alice Springs in 1999. It is expected that Geoscience Australia's remaining observatories at Learmonth (WA), Macquarie Island and Mawson (Antarctica) will soon join INTERMAGNET.


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ALL
TOGETHER
NOW...
jump!

Kaleen Primary School students jumped at a chance to launch Earth Science Week in Canberra by simulating an earth tremor.

Their jump was measured by an AGSO – Geoscience Australia seismograph in the school assembly hall. The pounding feet created squiggles on the seismograph drum equivalent to the official Canberra seismometer recording of a 6.9 earthquake in New Zealand earlier this year.

Earth Science Week, an international event celebrated from October 7–13, aims to increase community understanding of the importance of earth sciences in everyday life. It focuses on being responsible for the use and protection of Earth's natural resources and the environment.

Geoscience Australia begins Earth Science Week with an Open Day at its Canberra headquarters on October 7. 



SPATIAL MAPPING giants merge



The merger of spatial mapping giants, AGSO – Geoscience Australia and AUSLIG was announced by Minister for Industry Science and Resources Senator Nick Minchin on September 25.

Senator Minchin also stated that access to many of the amalgamated organisation's online spatial data sets would be free.

The new organisation, AGSO – Geoscience Australia, has a staff of more than 530 and a budget approaching \$100 million. With the merger, AUSLIG becomes a division of Geoscience Australia but its brand names (ACRES, NATMAP and GEODATA) will not change. The merger will take six months to implement.

Senator Minchin says the merger is part of a package of initiatives designed to develop Australia's spatial information industry, and capture a greater share of a growing global market estimated at \$34 billion with a growth rate of 20 per cent.

Geoscience Australia and AUSLIG are two of the biggest Commonwealth producers and maintainers of spatial information available to industry and the public. The merger formalises a long-standing working relationship between them.

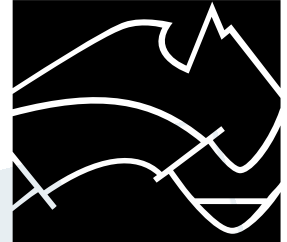
'The merger will benefit clients common to both organisations in such fields as mineral exploration, maritime boundaries and emergency services', says Senator Minchin.

There will be free online access to satellite mapping and topographical data covering the whole of Australia, as well as Australian data on such themes as geology, land use, salinity, gravity and seismic activity.

'Free spatial data is particularly good news for the resources industry, which has been going through tough times', says Senator Minchin.

To see what is available check the Geoscience Australia and AUSLIG web sites (www.agso.gov.au or www.auslig.gov.au). Data sets are continually updated and new material regularly added.

AGSO



GEOSCIENCE AUSTRALIA

For more information about the merger phone AUSLIG General Manager, Peter Holland on +61 2 6201 4262 or AGSO – Geoscience Australia General Manager Tony Robinson on +61 2 6249 9411. ☒

PETROLEUM

*activity
details
released*

www.agso.gov.au

Nine offshore and 12 on-shore petroleum discoveries in Australian territory were made in the first half of 2001, according to figures released by AGSO – Geoscience Australia's Petroleum and Marine Division at the end of August. Fifteen of the discoveries are gas.

On shore for the second quarter (April to June) there were five gas discoveries: two in the Queensland sector of the Cooper/Eromanga Basin and three in the Victorian part of the Otway Basin. Offshore for the same period, there were gas discoveries in the Browse and Otway basins and oil was discovered in the Carnarvon Basin.

Otway Basin discoveries at Thylacine and Geographe in Victorian and Tasmanian waters are in an area of previous smaller discoveries, which is encouraging news. Combined, there is speculation about whether they have the potential (if commercially developed) to affect the gas-supply market in south-east Australia.

Details of Australia's petroleum discoveries in the first half of 2001 and information about offshore and on-shore exploration drilling are published in Geoscience Australia's 'Petroleum Exploration and Development Activity' report. Copies are available free of charge from the Geoscience Australia Sales Centre or can be downloaded from the web (www.agso.gov.au).

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Direct entry to Geoscience Australia databases under way

Non-staff geoscientists can enter and retrieve data directly from AGSO – Geoscience Australia's corporate databases with the introduction of new Oracle database technology. At this stage, access is restricted to State/Territory geological surveys. Other collaborating organisations such as CSIRO and universities will be given access in the future.

Organisations save the expense of developing and maintaining their own database systems by using Geoscience Australia's facilities. These facilities are particularly attractive when data structures are complex and an organisation does not have in-house expertise in a specific scientific discipline.

There are other benefits as well. Data are stored in a standardised format within a single environment. This arrangement simplifies subsequent retrievals and integration with other data sets. As well, Australia's knowledge base of national-scale geoscience data is being built.

Geoscience Australia is not seeking to be the sole custodian of all geoscientific data sets. It is interested in those data sets where, in line with the ANZLIC custodianship guidelines (www.anzlic.org.au/asdi/anzdiscu.htm), it has a recognised role.

Online access

Until now it has been impractical for geological surveys to contribute directly to OZCHRON and freely access the data. Data exchange relied on digital files, which created a considerable overhead in extracting, formatting and importing data into and from databases.

The Internet solved access issues. Online GIS provides the mechanism for retrieving data, and the new Oracle technology has solved the data entry issue.

Geoscience Australia uses Oracle 8i RDBMS and Oracle Developer 6i applications to access the data. Oracle 6i forms and reports are used to enter and query data. These forms run on any Java-enabled web browser, provided the correct Java classes are installed. The forms that run on Geoscience Australia's intranet can be deployed on the internet. This capability allows external users to enter data into Geoscience Australia corporate databases, if they have access privileges.

External users have control over the data they enter. Data quality will be assured by validation procedures, which are built into the data entry forms. A quality assurance process checks data before they are made publicly available.

External data entry is being piloted with the OZCHRON and the associated OZROX databases. The pilot program eventually will be expanded to include the following databases that receive significant contributions from external sources:

- RTMAP – data from State/Territory surveys, CRC LEME partners and out-posted Geoscience Australia staff;
- OZESTUARIES – data from CRC for Coastal Zone Estuaries and Water Management;
- STRATDAT – biostratigraphic data;
- GEODX – database of Australian stratigraphic names; and
- Orgchem – organic chemistry.

OZCHRON trial

The new database technology is being trialed on the national geochronology database, OZCHRON. Earlier this year, the Chief Government Geologists Conference in New Zealand endorsed Geoscience Australia's role as custodian of OZCHRON, and agreed that it should be used to store geochronology data for the States/Territory. Under this agreement, Geoscience Australia must manage the State/Territory data and provide access to it as well as any data it generates. This role was seen as a natural responsibility for Geoscience Australia due to its in-house expertise in geochronology and corporate databases.

The OZCHRON database has been operational since 1993 storing SHRIMP U-Pb and Sm-Nd age determinations processed by staff geochronologists, plus a range of mainly literature-derived Rb-Sr, Ar-Ar, K-Ar and U-Pb conventional data. All OZCHRON data are spatially referenced and are released to State/Territory surveys and exploration companies as digital files. In the past, data releases usually occurred biannually.



FORBES MAP WINS PEOPLE'S PRIZE

The Forbes 1:250 000 Regolith Landforms map won the people's award for Excellence in Cartography at the recent 20th biennial International Cartographic Conference in Beijing, China.

Nominations were displayed at the International Map Exhibition held in conjunction with the conference so that delegates and members of the public could vote for a winner of the prestigious international award.

The map depicts regolith landforms, palaeo-drainage and mineral occurrences in the Forbes district, central New South Wales. It includes pictures of the regolith and local landforms, as well as some small-scale images derived from digital spectrometry, airborne elevation, depth to bedrock, and simplified landform polygon data.

AGSO – Geoscience Australia cartographers produced the Forbes map for CRC LEME (Cooperative Research Centre for Landscape Evolution & Mineral Exploration). Data for the map was supplied by CRC LEME, Geoscience Australia, the Geological Survey of New South Wales, Department of Water Conservation (NSW), and AUSLIG.

Since the early 90s, Geoscience Australia has won more than 20 national and international cartography, mapping science and computer art awards, as well as numerous printing and design awards for its colour maps.

The first edition Forbes 1:250 000 Regolith Landforms map is a print-on-demand product available from Geoscience Australia's Sales Centre for \$54 (plus postage and handling).

For more details phone Jon Storzaker on +61 2 6249 9135 or e-mail jon.storzaker@agso.gov.au

China EXPLORES HOW GOVERNMENTS MANAGE MINERAL RESOURCES

Two government delegations from the People's Republic of China interested in the management of land and mineral resources in Australia, particularly the roles of state and federal governments, visited AGSO – Geoscience Australia at the end of July.

The Hebei delegation led by Mr Guochang Zhao, Deputy Secretary General of Hebei Provincial People's Government included senior officials from the province's Land Resources Department and the Geology and Mineral Resources Bureau.

Delegates listened to presentations by Geoscience Australia's Minerals Division that outlined the responsibilities of different levels of government in Australia, particularly their roles in the administration and taxation of mining activities. There was also a presentation using recent case studies to show different ways governments use geoscience data to make major land-use decisions.

The Ministry of Land Resources delegation was interested in the reporting requirements for companies holding mining leases, and government provision of geoscience information to prospective mining lease holders. The Ministry is part of China's national government and is responsible for the planning, administration, protection and rational use of land, mineral and marine resources. It includes such institutions such the China Geological Survey.

The delegation was led by Ms Zhang Wanli, Deputy Director of the Policy and Legislation Department, and included four staff of the department, a legal officer, and the Director of the Geological Materials Research Laboratory.

The Ministry delegation visit included a tour of Geoscience Australia's data repository. Some delegation members are currently designing a major national repository for mineral specimens from across China. They were most interested in how specimens and reports are registered and recorded, as well as the design and layout of the storage facilities.

For further information about the visits phone Steve Ross on +61 2 6249 9263 or e-mail steve.ross@agso.gov.au

■ Mining 2001 International Convention & Trade Exhibition

Mining 2001

7 to 9 November

Royal Exhibition Building, Melbourne

Contact: Mining 2001, PO Box 607, West Perth, WA 6872

phone +61 8 9485 1166

fax +61 8 9481 8023

e-mail info@mining2001.com.au

■ Eastern Australasian Basins Symposium 2001

Petroleum Exploration Society of Australia

25 to 28 November

Hilton on the Park, Melbourne

Contact: Miriam Way, EAB Symposium, PO Box 660, Carlton South Vic 3053

phone +61 3 9662 3166

fax +61 3 9662 3662

e-mail miriamw@ausimm.com.au

■ NewGenGold 2001 Conference & Exhibition

Australian Mineral Foundation, Keith Yates & Associates

26 & 27 November

Burswood Convention Centre, Perth

Contact: Conference Secretary, Australian Mineral Foundation, 63 Conyngham Street, Glenside SA 5065

phone +61 8 8379 0444

fax +61 8 8379 4634

e-mail newgengold@amf.com.au

■ PDAC 2002 Convention & International Trade Show

Prospectors & Developers Association of Canada

10 to 13 March

Toronto, Canada

Contact: Prospectors & Developers Association of Canada, 34 King Street East, Floor 9, Toronto, Ontario M5C 2X8

phone +1 416 362 1969

fax +1 416 362 0101

e-mail info@pdac.ca

■ AAPG 2002 Annual Meeting & Exhibition

American Association of Petroleum Geologists

10 to 13 March

Houston, Texas

Contact: American Association of Petroleum Geologists, PO Box 979, Tulsa Oklahoma 74101-0979 USA

phone +1 918 560 2679

fax +1 918 560 2684

e-mail convene@aapg.org

GEOSCIENCE HEADQUARTERS venue for environment legislation workshop

AGSO – Geoscience Australia welcomed to its Canberra headquarters on August 30, registrants and speakers for a workshop on the new Commonwealth environment legislation.

The workshop was organised by the Environment Institute of Australia (ACT Division) to mark the first anniversary of the *Environment Protection and Biodiversity Conservation Act 1999*, which was implemented in mid-2000.

A full day of presentations and a panel discussion focused on the experiences of various portfolio areas of government, industry and consulting practice under the first year of the new legislation.

Representatives from a wide range of government and industry heard a detailed review of the implementation and operation of the new Act from Gerard Early, First Assistant Secretary of the Legislation and Approvals Division of Environment Australia.

Other presentations in the morning were made by the Department of Transport and Regional Services (Airports) and Invest Australia (Major Projects Facilitation). Geoscience Australia's Dr Ian Lavering also gave an overview of the use of geoscientific data for environmental assessment and evaluation.

An outline of experiences of the Department of Defence and the Australian Fisheries Management Authority followed the midday break. The late afternoon program included a panel discussion of hypothetical cases, chaired by barrister David Mossop.

The workshop was an opportunity to increase contact between environmental practitioners and Geoscience Australia staff. Members of the Environment Institute were able to learn more about the diverse work undertaken by Geoscience Australia.

For more information about the Environment Institute of Australia or the workshop phone Ian Lavering on +61 2 6249 9450 or e-mail ian.lavering@agso.gov.au



▲ Panelists for the workshop's afternoon discussion session were (left to right): Peter Wright (URS Australia), David Mossop (barrister and panel leader), Gerard Early (Environment Australia), Graham Kelleher (former head of the Great Barrier Reef Marine Park Authority) and Dr Don McMichael, Executive Member and Treasurer of the Environment Institute of Australia (ACT Division).

Geoscience
Australia
*plans for
decennial
Archaean
meeting*



▶
ORAL &
POSTER
PAPERS

The International Archaean Symposium occurs once a decade. The fourth takes place in September this year in Perth, Western Australia. Geoscientists from around the world working in Earth's oldest terranes will converge on Perth from September 24–28 to discuss important developments in Early Precambrian geology since the last symposium in 1990.

On the agenda will be technological advances in remote sensing, and isotopic techniques and their interpretation; as will the regional and detailed studies that have advanced the understanding of tectonics, metallogeny, magmatic, and sedimentary systems. The symposium also will promote the importance of an integrated, multidisciplinary approach to studying the Early Precambrian Earth.

Major contributor

AGSO – Geoscience Australia currently has two projects in Archaean terranes—the Norseman–Wiluna Synthesis Project and the Gawler Project—and it recently completed two others: the Eastern Goldfields Project and the North Pilbara Project.

The multidisciplinary approach used by Geoscience Australia projects fits well with symposium themes. Geoscience Australia staff will present project results via field excursions, a conference booth, and oral and poster papers.

Field excursion guides are available on the web (see www.dme.wa.gov.au) and the extended abstracts will be published as AGSO record 2001/37, which will be available from the Sales Centre.

Pre-meeting field trip

The Pilbara Metallogeny excursion (led by Huston, Blewett and university/industry coworkers) will examine mineral deposits within the context of the regional stratigraphic and structural setting of the north Pilbara Craton. The excursion will visit a number of orogenic gold deposits in the Pilbara, volcanic-hosted massive sulfide deposits, pegmatite Ta-Sn deposits, epithermal deposits, and ultramafic-hosted Cu-Ni deposits.

An excursion highlight will be the Panorama district. It contains the oldest substantial base metal deposits (circa 3.24 Ga at Sulphur Springs), and is perhaps the best exposed and best preserved Archaean VHMS district in the world. There are few places anywhere with such a variety of mineral deposits, and many are significantly different from 'typical' Archaean deposits of their type.

The Early to Middle Archaean (3500–2750 Ma) north Pilbara granite-greenstone terrain is one of the best-preserved early Archaean regions in the world. Recent studies indicate that its metallogeny differs in a number of fundamental ways to that of the Late Archaean (i.e. 2500–2750 Ma). Examples of these differences will be highlighted during the excursion.

Post-meeting field trip

The Eastern Goldfields: Volcanic and Sedimentary Environments excursion (led by Champion, Cassidy and university coworkers) will examine Archaean volcanic and sedimentary rocks in the Yilgarn Craton, with a particular emphasis on the environments of deposition, and the geochemistry and timing of felsic magmatism.

The excursion starts with a review of the volcanology of submarine basalts and komatiites of the Kambalda group (2705–2690 Ma), followed by traverses through sections of the overlying felsic volcanoclastic successions (Black Flag Beds; 2690–2670 Ma), interpreted as mostly arc-derived submarine fan deposits. These successions will be contrasted with the coarse-grained clastic fluvial and submarine fan deposits of the Merougil and Kurrawang Formations that unconformably overlie the Black Flag Beds in the Kalgoorlie Terrane.

Travelling north to the Melita volcanic complex (2690–2680 Ma), the excursion will visit spectacular exposures of bimodal basalt-rhyolite (HFSE-enriched) volcano-sedimentary successions, similar to those that host economic VMS base-metal mineralisation at Teutonic Bore. Aspects of arc-related calc-alkaline volcanism and sedimentation will be examined with a visit to the Welcome Well volcanic complex (circa 2710 Ma).

Further north, in the Yandal greenstone belt, proximal calc-alkaline intermediate-acid volcanism represented by the Spring Well complex (circa 2690 Ma) will be examined. Key granite exposures will be visited; the geochemistry and timing of granite magmatism and felsic volcanism will be discussed in relation to the tectonic evolution of Late Archaean greenstones of the Eastern Goldfields Province.

For more information about the symposium and the pre- and post-meeting field trips phone Richard Blewett on +61 2 6249 9713 or e-mail richard.blewett@agso.gov.au. See also www.geol.uwa.edu.au/~ias/

Geoscience Australia staff are presenting the following oral and poster papers to the symposium's international audience:

- Blewett RS. The tectonic framework and geological evolution of the Archaean Pilbara Craton granite-greenstone terrane: Integration of geology and geophysics
- Cassidy KF & Hagemann S. Archaean orogenic gold mineral systems: Diversity in the Yilgarn Craton
- Champion DC & Smithies RH. Secular trends in Archaean granites: Examples from the Yilgarn & Pilbara cratons, Western Australia
- Goncharov A, Lizinsky M & Tripolsky A. Archaean crust in Australia, Fennoscandia and Ukraine: From seismic velocity models to composition
- Huston DL, Blewett RS & Sun S-S. Metallogenesis and tectonic evolution of the North Pilbara, Western Australia
- Korsch RJ, Goleby BR, Fomin T & Bell B. Imaging the Kalgoorlie region using seismic and gravity techniques
- Lyons P, Tomkins AG, Fraser GL, Direen NG, Daly SG & Frances DJ. The geology and mineral potential of the Mulgathing Complex, north-west Gawler Craton
- Whitaker A. Components and structure of the Yilgarn Craton, as interpreted from aeromagnetic data

MUD DWELLERS:

bystanders or agents
for **GIANT** DEPOSITS

A billion years before significant multi-cellular life on Earth, unusual bacteria thrived in low oxygen levels on muddy sediments that nowadays are buried deep in the Australian continent.

Life was precarious for these ancient bacteria because their environment could change very rapidly. Too much or too little oxygen killed them off.

Into their muddy domain, from deep in the Earth, flowed metal-rich brine. This brine was the source of metals that formed giant lead-zinc deposits like McArthur River in Australia's Northern Territory.

Could these bacteria have played a role in the formation of the giant ore deposits or were they simply bystanders?

**For more information
phone Graham Logan
on +61 2 6249 9460
or e-mail
graham.logan@agso.gov.au**

Unconventional

Organic geochemist, Dr Graham Logan has been applying petroleum industry techniques for identifying oil sources and differences between oils, in unconventional settings. He has been studying organic matter in ores and sediments from McArthur River, to see if anything unusual happened to the organic matter 1.6 billion years ago.

'We wanted to see whether the organic matter reacted with the ore fluid', says Dr Logan.

'And we were particularly interested in the process of sulphate reduction—whether it was bacterial mediated.'

McArthur River, one of the largest and best preserved lead-zinc-silver deposits in the world, was ideal for study because the ore is sediment-hosted and believed to have been formed by a sulfate- and metal-rich brine.

Dr Logan's work concentrated on fossil molecules extracted from two high-grade deposits in the area.

Fossil molecules

The molecules that Dr Logan and others are interested in usually occur in cell walls (figure 1). They form part of the membrane of the cell and are diagnostic of particular plants, algae and bacteria.

The molecules are built from carbon atoms of various sizes (from 10 to 40 carbon atoms). When fossilisation occurs, a hydrocarbon forms. Crude oil is a collection of fossilised molecules.

When the molecules are heated by the Earth (geothermal heating), the structure of the molecule changes. By examining the structure of a range of molecules, the sorts of life that existed and their environment can be studied.

Such work requires many months in AGSO – Geoscience Australia's geochemical laboratories.

'We took a complex mixture of hydrocarbons from a rock, then separated this mixture in the laboratory by various chemical techniques', says Dr Logan.

A 'gas chromatography mass spectrometer', which to the lay person looks like six large photocopiers placed end to end, is then used to help identify the molecular structure of the separated molecules.



▲ Dr Graham Logan in one of Geoscience Australia's geochemical laboratories

Biological signal

Samples were taken from different points in the ore deposit and the surrounding host sediments to compare molecular fossil composition. Groups of molecules called hopanes were found; 2 α -methylhopane being diagnostic of cyanobacteria.

In some samples there was a highly unusual distribution of hydrocarbon molecules. These had predominantly even numbers of carbon atoms, with some molecules comprising 28 or 30 such atoms. As well, some of the carbon atoms had an unusual structure, one that had been observed in the ore of Mt Isa.

'When I first saw this signal I hoped it related to how the ore formed', says Dr Logan.

Further research proved otherwise.

Bystanders

Dr Logan sliced apart layers of mudstone, ore layers, and took several inter-layer examples.

'When I looked at the molecular fossils in the ore, I didn't see the signal. But when I looked at the mudstone alone, the signal was strong', says Dr Logan.

'I was looking at an unusual population of bacteria that lived 1.6 billion years ago on the mud, which formed the ancient seabed.'

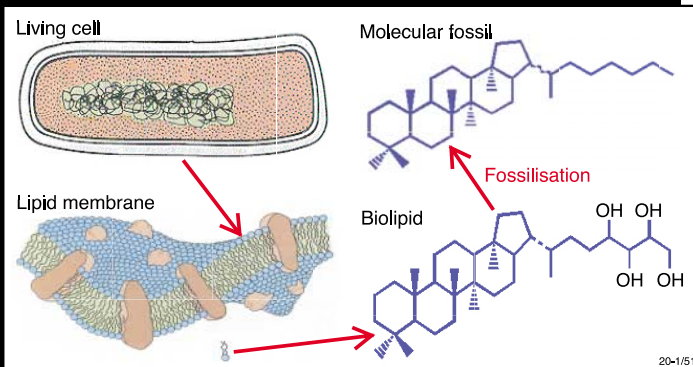
The electron microscope revealed that the bodies of these bacteria were comprised of very large filaments. Organisms like these are found matted together around vents in the deep ocean today.

'At the sediment-water interface, where there were low concentrations of oxygen and hydrogen sulphide, these bacterial mats proliferated', says Dr Logan.

But their existence on the seabed was precarious. Their tolerance of oxygen and hydrogen sulfide was very limited. They died out when sulphide levels increased, and when the oxygen in the water ran out or the oxygen concentration was too high (figure 2).

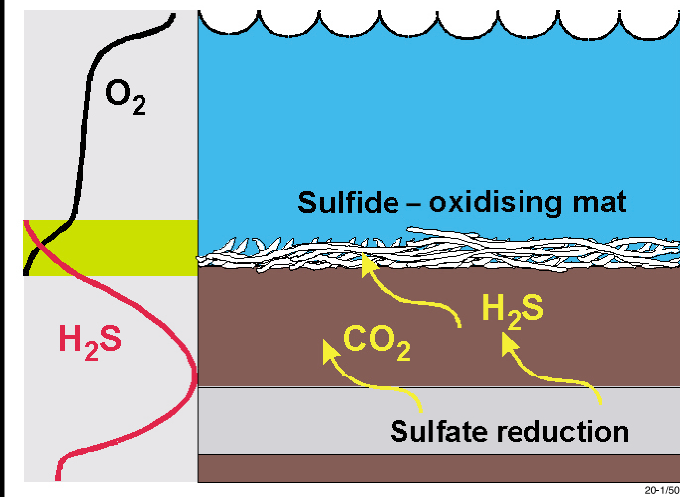
'Since the signal for the bacteria is limited to mudstones and not found in the ores, it would appear that these organisms were mere bystanders and did not have a significant role in ore formation', says Dr Logan.

These bystanders belong to a group called 'sulfide-oxidising bacteria', thought to have evolved 800 million years ago. Dr Logan's research indicates that these bacteria existed much earlier—approximately 1.6 billion years ago. ■



▲ **Figure 1.** The cell wall of bacteria is composed of a lipid membrane. This membrane consists of some molecules with very characteristic structures. Even after the bacterium's death and many million years of burial, these structures can be recognised in the fossil molecule.

Ecology of sulfide - oxidising bacteria



▲ **Figure 2.** The mat-forming, sulfide-oxidising bacteria live in a very restricted chemical environment where oxygen and hydrogen sulfide co-exist in low concentrations. These bacteria are found matted together around vents in the deep ocean today.



Flood, thunderstorms dampen 'perfect' claim: *Natural hazards report*

South-east Queensland: beautiful one day, perfect the next—so say the tourist campaigns. This claim is plausible due to the region's mild winters, long summers, white beaches and lack of serious natural disasters for 27 years.

South-east Queensland is one of Australia's fastest growing urban regions. It has 53 per cent of Queensland's population and most of the state's major infrastructure. A repeat of a serious natural disaster like Brisbane's 1974 floods would halt much of the state's commerce and cause billion-dollar damage.

How vulnerable is this corner of Queensland and its population?

The natural hazard risks facing South-east Queenslanders are spelt out in a report by AGSO – Geoscience Australia that was released by Urban Geoscience Division chief, Dr Wally Johnson on August 8 in the state's capital, Brisbane.

The report looks at the disaster history of South-east Queensland and assesses the community's risk of tropical cyclones, east-coast lows (winter cyclones), floods, landslides, severe thunderstorms, heat waves, bushfires and earthquakes.

It is the third in a series assessing the vulnerability of Queensland communities to natural hazards (Cairns and Mackay being the first two studies). The information in the report is a valuable planning tool for local authorities.

Risk analysis

Risk analysis involves assessing the levels and frequency of hazards in the region, determining which elements of the community are at risk, and working on a range of hazard scenarios. A comprehensive database of building types and locations is then used to generate damage assessments for the various scenarios.

'History points to what can happen in the future', says Dr Wally Johnson.

'People in South-east Queensland are vulnerable to such hazards as cyclones, heavy rainfalls and floods, so no-one should be complacent.'

Dr Johnson says that nothing can prevent these hazards, but the State Government and local authorities can reduce the impact by identifying potential risks and vulnerable areas, and ensuring disaster-mitigation measures are in place.

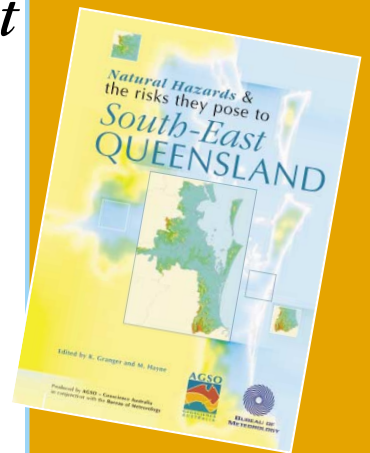


Photo insert. Dr Wally Johnson (second from right) presents the South-east Queensland hazard assessment booklet and CD to (from left) Logan City Council Mayor, John Freeman, Bureau of Meteorology Regional Director (Queensland), Gary Foley, and Department of Emergency Services Director-General, Michael Kinnane.

Potential hazards

Because of its idyllic setting beside rivers and Moreton Bay, South-east Queensland is prone to certain natural hazards. Along the coast, for example, wind and water have moved the Nerang River mouth north by about five kilometres over the past 100 years, and the Spit on which Seaworld stands was not present until the 1920s.

Sixteen tropical cyclones have come within 500 kilometres of Brisbane since January 1974 when cyclone Wanda prompted Brisbane flooding.

A single rainfall event from a cyclone like Wanda can cause all rivers in the region to flood. The potential losses across the study area from river flooding (at a 100-year average recurrence interval) is the highest urban flood risk in Australia with as many as 25 650 developed properties likely to experience over-floor inundation.

Intense rainfall associated with cyclone Wanda produced 1000 millimetres of rain over three days, triggering more than 1800 landslides.

Over the past 45 years the region has experienced on average two damaging thunderstorms each year (although in each of the years 1995 and 1999 there were eight storms). These thunderstorms bring destructive winds, but severe damage tends to be localised to a few suburbs. Approximately 30 per cent of all severe thunderstorms produce damaging hail and flash flooding.

Tornadoes sometimes accompany the severe thunderstorms. There have been 15 tornadoes in the region over the past 45 years. In November 1973, one small tornado cut a 51-kilometre path of damage from Brookfield to Nathan and across Redland Bay, unroofing 500 and damaging 1400 houses.

Low-pressure systems along the coast in winter can develop quickly and become quite intense, causing wind damage, storm surge, beach erosion, and marine accidents. If winter months are dry and the summer hot, human carelessness starts bushfires in vegetated areas.

Particularly hot summers bring heat waves, making the elderly susceptible. In January last year, a heat wave was blamed for the death of 22 people in the region—most of the victims elderly women shutting themselves in closed-up homes for 'security'.

There are few reports of earthquakes in South-east Queensland. The last moderate magnitude earthquake felt across the region was in 1935.

Risk reduction

Geoscience Australia worked closely with the Bureau of Meteorology, the Queensland Department of Emergency Services and local councils of the study area to assess hazard risk.

'Armed with an understanding of what hazards can affect the community and information on how to cope with their impact, the State Government and local councils can work together on mitigation measures and develop disaster plans', says Dr Johnson.

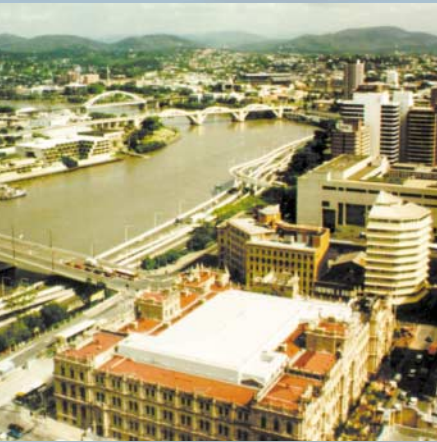
In South-east Queensland, the Bureau of Meteorology provides community alerts for hazards that have an atmospheric component (e.g. cyclones, floods and storms). Since 1974, local councils control development in low-lying and flood-prone areas, and engineering defences such as the Wivenhoe and the Hinze dams have been built or raised to reduce flood risk.

The Queensland Building Act provides engineering standards for constructing buildings in areas subject to high winds and earthquake ground shaking. Buildings constructed prior to the Act don't necessarily meet the standards.

The area studied is roughly 5230 square kilometres. It includes parts of Caboolture and Pine Rivers Shires and Ipswich City, all of Redland Shire, and the cities of Redcliffe, Brisbane, Logan and Gold Coast.

The full report is set out in a booklet and CD titled *Natural hazards and the risks they pose to South-East Queensland*. The set costs \$45.10; individually, the booklet costs \$22 and the CD \$33. Prices include GST but not postage and handling. They are available from the AGSO – Geoscience Australia Sales Centre.

For more details phone Matt Hayne on +61 2 6249 9536 or e-mail matt.hayne@agso.gov.au



NEW GLOSSARY, A HANDY REFERENCE FOR REGOLITH TERMS

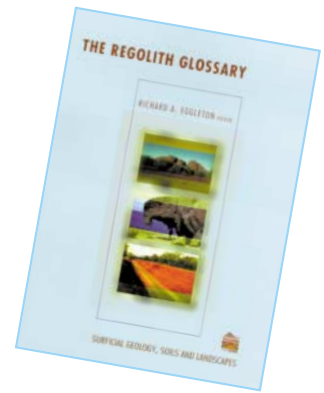
From abrasion to zone... The 'a' to 'z' of regolith terms is covered in a very handy book aptly titled 'The regolith glossary'.

This 150-page glossary has more than a thousand entries and 100 photographs and diagrams. It is a CRC LEME publication (Cooperative Research Centre for Landscape Evolution and Mineral Exploration) compiled with the help of regolith groups at AGSO – Geoscience Australia, the Australian National University, the University of Canberra and CSIRO Division of Exploration and Mining.

Regolith science evolved from several older disciplines, particularly geology, soil science, geography and geomorphology. Many regolith terms come from these sources, but they have not always been used accurately.

The glossary brings consistency and uniformity to the use of regolith terms. In some cases, the terms printed in the glossary are simplified definitions from, for example, soil and landscape science. The intention is not to redefine these terms for their disciplines, but rather to offer non-specialists a ready meaning. For many entries, there is a reference to a fuller definition.

The glossary is highly recommended for geologists, geographers and mineral explorers. It will be valuable also to those working in the environmental, soil and agricultural sciences, as well as earth science teachers.



The regolith glossary: Surficial geology, soils and landscapes edited by RA Eggleton can be purchased from the AGSO – Geoscience Australia Sales Centre for \$25 (includes GST) plus postage and handling.

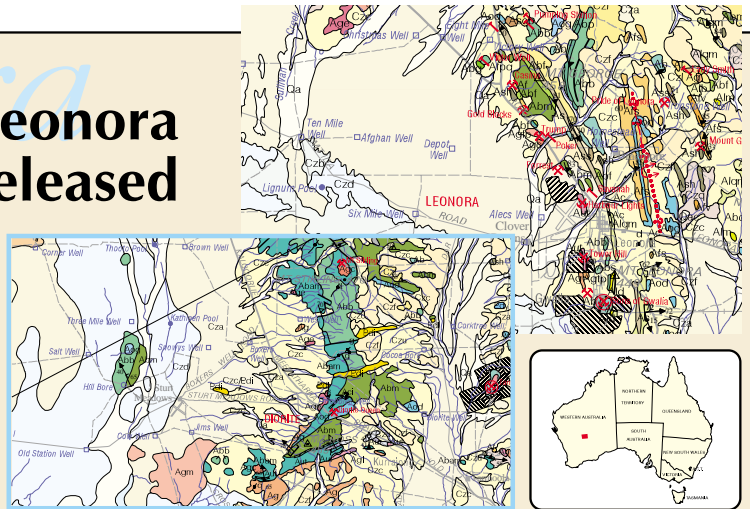
For more information phone Colin Pain on +61 2 6249 9469 or e-mail colin.pain@agso.gov.au

NEW edition Leonora geology map released

The second edition Leonora 1:250 000 geology sheet is a generalisation of outcrop mapping by AGSO – Geoscience Australia in the Eastern Goldfields during the National Geoscience Mapping Accord. The mapping was previously released as 1:100 000 sheets.

The sheet area covers parts of four greenstone belts: (from north-east to south-west) Yandal–Murrin, Agnew, Mount Clifford–Malcolm, and Mount Ida. Most greenstones were deposited 2700–2665 million years ago as mafic to ultramafic volcanic rocks with subordinate intrusive equivalents, felsic volcanic rocks, and fine-grained to conglomeratic sedimentary rocks. Large areas of granite and granitic gneiss separate the greenstone belts.

The Leonora sheet area has some 550 known mineral deposits, most of them gold. They range from the world-class Sons of Gwalia (160 t), Emu (127 t), and Tarmoola (110 t) gold deposits to gold, nickel, base-metal and uranium prospects.



Most large gold deposits discovered to date are in greenstone, but there are significant deposits (e.g. Tarmoola) in granitic rocks.

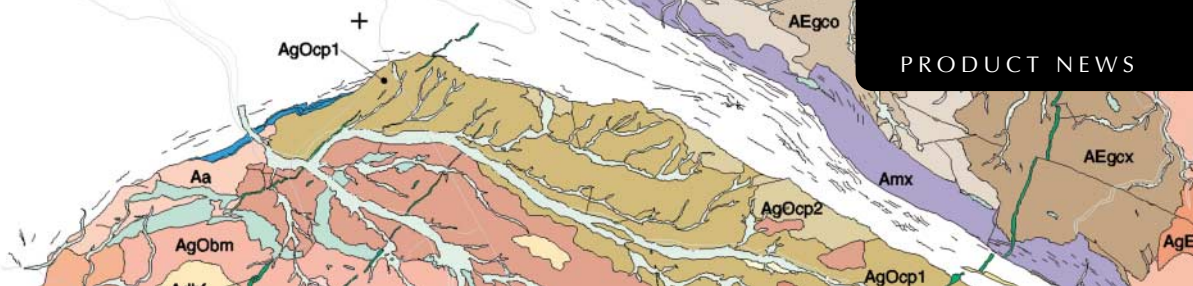
The new map also includes:

- a 1:1 million scale solid-geology map as an inset, compiled from interpretation of Geoscience Australia's 400-metre line-spacing aeromagnetic data controlled by outcrop mapping; and
- a cross-section controlled by outcrop mapping and by modelling of the gravity field along the cross-section.

Because the map shows the extent of greenstones and their structure throughout the sheet area, it will prove valuable for mineral exploration in areas covered by regolith.

Paper copies of the Leonora map cost \$53.96 each (including GST) plus postage and handling. Digital data costs \$165 (includes GST). To purchase these products please fill out the enclosed order form and fax or mail it to the AGSO – Geoscience Australia Sales Centre.

For more information about the Leonora sheet, telephone Alan Whitaker on +61 6249 9702 or e-mail alan.whitaker@agso.gov.au



NEW PILBARA products so cheap... some are even *free!*

FOR THE PILBARA AFICIONADO, HERE ARE A FEW MORE EXCELLENT PRODUCTS TO ADD TO YOUR EXPLORATION CACHE.

New maps

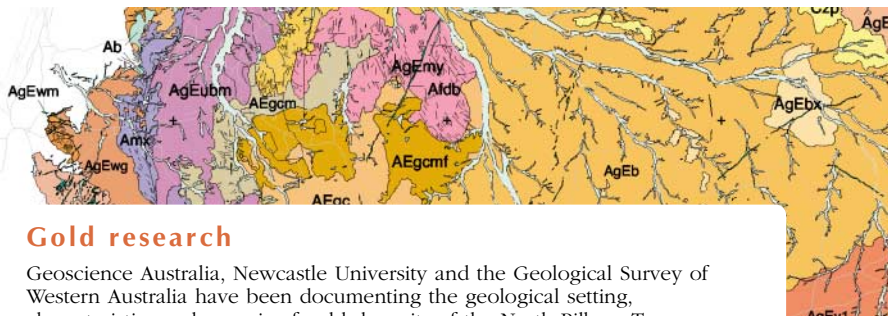
A comprehensive set of thematic maps of the entire North Pilbara region is now available. The set complements previously released Landsat 5-TM, radiometric and aeromagnetic maps.

These new maps at 1:500 000 scale, cover the area between 116°E and 121°E and 20°S and 22°30'S. They link the geology of the East Pilbara and West Pilbara, and include the northern part of the Hamersley Province. Map themes include:

- a solid geology interpretation of the granite-greenstone terrane (Hamersley removed);
- a variety of presentations of the aeromagnetics, gravity, radiometrics, mineral deposits, and three-dimensional shape; and
- a 'chemical map' derived from the radiometrics.

These additional presentations of the data provide further insights into the complexity of the Pilbara's geology that are not readily appreciated from standard image processing presentations.

The maps are available (as print-on-demand) from the AGSO – Geoscience Australia Sales Centre for \$50 each. To order copies, please complete the enclosed order form and return it to the Sales Centre.



Gold research

Geoscience Australia, Newcastle University and the Geological Survey of Western Australia have been documenting the geological setting, characteristics and genesis of gold deposits of the North Pilbara Terrane as part of the North Pilbara NGMA Project. The results of this research are summarised in record 2001/10 titled *Gold deposits of the Pilbara Craton: Results of AGSO research 1995–2000* by Huston et al.

The research program concentrated on turbidite-hosted lode Au deposits in the Indee and Nullagine areas, as well as basalt- and ultramafic-hosted deposits in the Mt York–Lynas Find area. Geoscience Australia's research also included epithermal deposits in the Indee area and (in less detail) lode Au deposits at Gold Show Hill and Klondyke. The research program was designed to complement recent university work on the Mt York, Lynas Find, and Bamboo Creek deposits. Record 2001/10 is available free online at www.agso.gov.au/pdf/pilbara_gold.pdf

Granite mapping

Also free online is a report and two A4-sized maps of the geology of the Mount Edgar and Corunna Downs Igneous Complexes—two classic 'domal' batholiths in the East Pilbara. The report by Sims and Carson summarises results of contract mapping of these batholiths by Geoverde Pty Ltd.

The Mount Edgar and Corunna Downs Igneous Complexes are located near the eastern margin of the Pilbara Craton in north-west Western Australia. The Mount Edgar Igneous Complex occurs on parts of the 1:250 000 geological sheets: Yarrie, Port Hedland, Marble Bar and Nullagine. The Corunna Downs Igneous Complex occurs on parts of the 1:250 000 geological sheets: Marble Bar and Nullagine.

The online report is based on a reconnaissance-level field survey and detailed air-photo interpretation, in conjunction with analysis and interpretation of airborne gamma-ray spectrometric and magnetic surveys.

Detailed interpretation of aerial photography and geophysical imagery over the Mount Edgar and Corunna Downs Igneous Complexes suggests the presence of numerous discrete units. Where these units fall geographically within defined suites and have similar rock properties to these suites, they are included as a sub-unit even though they have not been formally named. Where the units fall geographically outside obvious suites, they have been organised on the basis of geographic distribution and/or common rock properties and are labelled as ungrouped.

The report (record 2001/35 titled *The Geology of the Mount Edgar and Corunna Downs Igneous Complexes, East Pilbara Craton, Western Australia*) and two maps are available at www.agso.gov.au/pdf/edgar_corunna.pdf

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SUMMER PLAYGROUND, SUBJECT OF NEW EDUCATION RESOURCE

The weather is warming up Down Under and thousands of Australians are already planning their summer holidays at the coast. And they have plenty from which to choose.

Australia has almost 36 thousand kilometres of coastline (excluding its external territories), thousands of beaches and more than 960 estuaries on which to play. The Australian coastline is a Mecca for holiday makers, retirees, tourists and those who want a 'laid-back' lifestyle.

It is very timely for AGSO – Geoscience Australia to release a product called 'Coasts' aimed at helping secondary students and teachers better understand the unique and fragile coastal environments in which they frolic over the summer months.

'Coasts' is a 50-page booklet and CD-ROM. The booklet is divided into six topics with nine accompanying activities, namely:

1. Beach morphology and longshore drift
2. Rocky shorelines, differential weathering and erosion
3. Estuaries
4. Sea-level changes
5. Impact of human activity on coasts
6. Evolution of a coastal area: Gold Coast case study

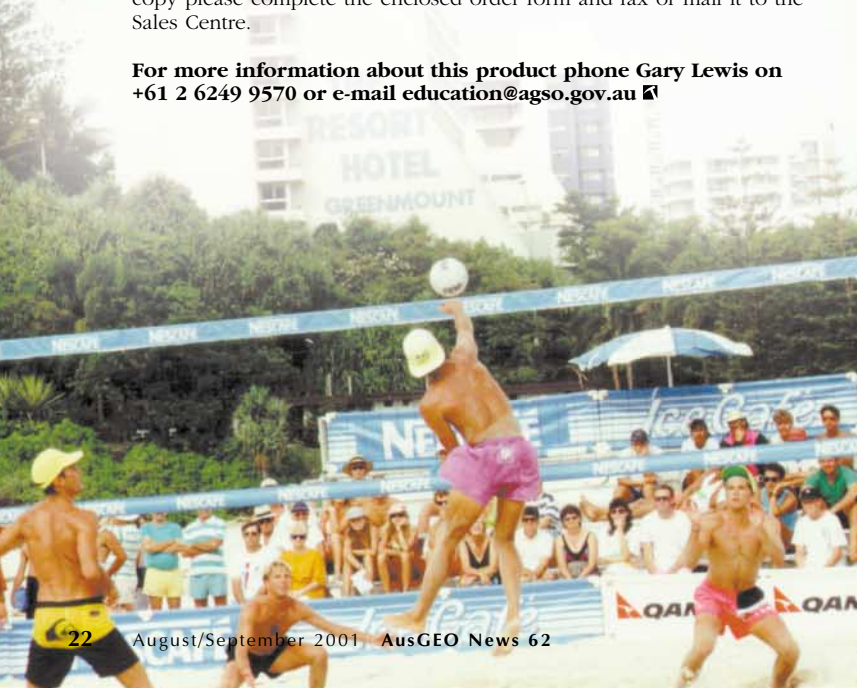
The activities designed by Geoscience Australia's education team are quite challenging. They take some time to complete as they require students to observe and in some cases make judgements and forecasts for coastal communities.

The CD-ROM has a mini photo library of coastal formation images. There are photos of Port Kembla, Myall Lakes, and the sand-mining area of Bridge Hill Ridge; rocky coastlines, sediment coasts, beaches, estuaries, coasts in parts of Hawaii, and Tweed Heads and the Gold Coast. Some activities are based on the images. Other images can be used to aid discussion and thinking. The CD images will prove useful to those who don't live along the coast and rarely see a beach.

Also included in the booklet are a very handy glossary and a resources list and, for the teacher, a 'cheat sheet' with possible answers for the student activities.

Coasts: Activities, images and an Australian case study, or AGSO record 2001/05, by Tuhan and Lewis can be purchased from the Sales Centre for \$16.50 (includes GST) plus postage and handling. To obtain a copy please complete the enclosed order form and fax or mail it to the Sales Centre.

For more information about this product phone Gary Lewis on +61 2 6249 9570 or e-mail education@agso.gov.au





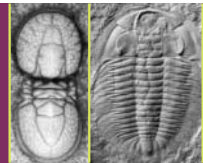
Fossil record suggests snail tastes reflect Earth's changes

Spare a thought for the humble mollusc as you crunch them underfoot on the beach or among the garden foliage. Theirs is a long history of more than 500 million years, according to a new booklet (*Fossils*) released by AGSO – Geoscience Australia. Their fossilised shells tell us about changes to Earth's oceans, climate and vegetation, and about human activity.

Fossils written particularly for teachers and students proves interesting reading. The booklet comprises 24 fact sheets about different groups of fossils including molluscs, six activity sheets which middle and upper primary school students will enjoy, and a few pages of general information that explain geological time and what is meant by 'fossilisation'.

Fossils of the garden-variety snail, we're told, show they were very fussy about climate, rainfall and vegetation. Their distribution and abundance provide an insight into human impact on vegetation.

Of course not all fossils are formed from shells. Bones and other remains, animal tracks and footprints, burrows and faeces of a great variety of organisms have been preserved as fossils. These fossils indicate what the environment was like when the plant or animal lived.



When the fossils of marine molluscs that only live in ocean depths are found in rocks in the interior of a continent, we know that the land was once ocean floor and that sea levels have changed markedly. Major climate changes can also be traced through fossils. When rocks that contain fossils of corals (organisms that live in shallow, warm waters) are found in today's cold climates, we know the region was much warmer millions of years ago when the rock formed.

Fossils can also record a moment in time. Near Winton in outback Queensland, there is a fossil record of a dinosaur stampede. Roughly 3300 individual fossilised footprints show a herd of small dinosaurs (about 150 animals) was fleeing from danger.

The booklet tells us that fossils range in size from the skeletons of whales and dinosaurs to the remains of microscopic algae and bacteria, and that most fossils are younger than 540 million years. Older fossils are rare because most organisms before this time had soft bodies. They did not have shells, bones, stems or seed pods that could be fossilised.

Even if you have a box of real fossils, you can learn a lot from this booklet written by Geoscience Australia's education team. *Fossils*, or AGSO record 2001/32, is available from the AGSO – Geoscience Australia Sales Centre for \$11 (includes GST) plus postage and handling. To buy a copy please complete the enclosed order form and fax or mail it to the Sales Centre.

For more details about the booklet phone Cindy Trewin on + 61 2 6249 9800 or e-mail education@agso.gov.au



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