The Geological Society of Australia Inc

Newsletter Number 166
March 2013

tag

Learning about volcanoes
see p33

Meeting Australia's dinosaurs
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3D structures beneath Australia revealed

Legacy of the Snowy

Finding the Ediacaran Golden Spike

The Australian Geologist

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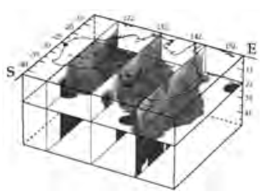

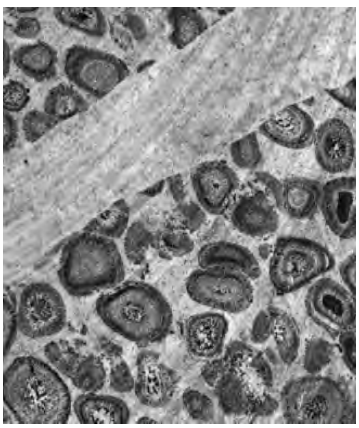

FRONT COVER

Orbicules enclosed in a granodiorite–tonalite matrix cut by a late-phase pegmatite vein. Image courtesy Mike Fetherston, Industrial minerals specialist, Geological Survey of Western Australia.

From the President

Welcome back from the Christmas – New Year break. I hope you all had a happy and fulfilling time and have come back with batteries recharged and ready for a new year filled with new challenges.

The Geological Society of Australia Federal Executive has a busy year ahead with finalising the new governance structure, which will be ready by the AGM in mid-year and in place for the new structure to be implemented by mid-2014. The new Constitution is now in good shape and almost ready to be voted on by members early in 2013. When the time comes I urge all of you to be aware of the changes and vote on their implementation. The changes are significant for the Society, particularly around election of office bearers and decision-makers. The greater the involvement of the membership of the Society, the greater chance the changes will have widespread support.

An initiative began by the previous Executive was for the Federal President to visit each of the branches to address the members. I support this practice and intend to continue this in the next 12 months. I think it is important for the Federal Executive to be accessible to the members and not be seen as a remote body. I will be contacting each Division over the next few weeks to lock in a schedule for the next year. When I visit your State Division, I would encourage as many members as possible to attend — and feel free to ask questions.

The State Divisions are the groups closest to the membership and are often aware of issues that we at the federal level are not. This is an opportunity for all members to meet and discuss issues with the president in a less formal environment.

Another initiative driven by the GSA is the National Rock Garden in Canberra. This initiative is entering an important phase. Much ground-work (excuse the pun) has been done, but much remains to be done before the garden is ready to be populated by rocks. While the presence of a rock garden in Canberra might seem remote for most of our members, it is important to raise the profile of geology within the general public and in government. The rock garden has been given a large tract of land (6.5 ha) in Canberra, and a committee of the Society is busy selecting iconic Australian rock samples. The concept has received widespread support, including recent financial support from the Australian National University (ANU). Government has also been supportive and the rock garden is seen by the ACT Government as being an important part of the Canberra Centenary celebrations later this year. The opportunity to raise the profile of our science and also show the contribution that geology has made to Australian history is priceless.

The committee is working very hard to get the rock samples in place for the centenary celebrations and all contributions are gratefully accepted. The committee also needs people to help with the organisation of the garden. If you can assist, please do. The garden will be a feature of which we can all be proud and will provide geology with a much-needed public boost. It will be open for all visitors to our capital once it is up and running.

LAURIE HUTTON
President

Society Update

Business Report

With the extremes of summer behind us, I expect we've all caught our breath and got on with the year. The GSA started the year with member renewals and a new online member access system for *AJES*. We have worked through governance documentation and responded to many member and general public queries.

Members put their holiday period to good use, as this issue of *TAG* is brimming with news and views, comments on previous letters and articles, as well interesting features and special reports. The variety of contributions reflects the diversity of member interests and fields of expertise. Robert Goldsmith writes on engineering geology and the development of the Snowy Mountains Hydro-Electric Scheme and Brian Kennett provides an update on the Australian Seismological Reference Model (AuSREM). The issue also includes educational information including a report on Earth Science Western Australia's 2012 activities and plans for 2013 and Greg McNamara's regular education column. We also have an update from the Teacher Earth Science Education Programme (TESEP). Bernie Joyce reports on the International Geological Conference (IGC) Geoheritage Symposium and implications for future geoheritage initiatives.

A number of members have sent in book reviews. We apologise if your review wasn't published in this issue — but stay tuned for the next issue.

In the 2012 March and September *TAG*s we published the names and photos of GSA Award recipients and members recognised for their contributions to the Earth Sciences and the GSA. If you missed these issues they are available online at **http://gsa.org.au/publications/tag.html.**

This issue of *TAG* includes an article recognising Simon Turner, who was recently made a GSA Fellow. Be sure to see who are our GSA Fellows and view the nomination process and criteria online at **http://gsa.org.au/recognition/ fellows.html**.

The GSA has set the dates for the 22nd biennial Australian Earth Sciences Convention as 7–11 July 2014. In a departure from capital cities, the convention will be held in Newcastle, NSW. Newcastle is a convenient location that is accessible by train, road and air and has interesting geology on its doorstep.

If you are new to the GSA, it is never too soon to consider participating in one of the committees. Whether it is a local division, specialist committee or one of the many subcommittees, the GSA provides an opportunity for you to contribute and network with your colleagues. It doesn't matter at what stage you are in your career, getting involved in the geoscience community as a volunteer is a rewarding experience. Want to know how to get involved? Contact the GSA at **info@gsa.org.au**.

SUE FLETCHER
Executive Director

New members

The GSA welcomes the following new members to the Society. May you all have a long and beneficial association with the GSA.

NSW
Member
Astrid Carlton
Kaydy Pinetown

QLD
Member
Melanie Fitzell
Gordon Southam

TAS
Student
Carlos Jimenet
Alexey Lygin

VIC
Affiliate
Seth Paddle

WA
Member
Stephen White

Lost members

Mail from the following members has been returned to the GSA, as all their contact details are out of date. If you know these members and have their contact details, please email **info@gsa.org.au** or call 02 9290 2194. Thanks in advance for your assistance.

Christian Bauchau	Mark Davies	Daniel Mantle	Bonnie Munchinsky	James Peterson	Courtney Taylor
Andre Caccioppoli	Stuart Ellar	Anna McAllister	Esther Nielson	Michael Setter	Rachel Wade
Paul Cummins	Peta Irwin	Geoffrey Muers	Stephen Parkes	Ahmad Tabassi	

Society Update

Governance changes

Comments on the proposed new Rules from Divisions and Specialist Groups were accepted up until 18 January 2013 with submissions received from three Divisions (Australian Capital Territory, Queensland and Western Australia) and two Specialist Groups (Coal Geology and Earth Sciences History). These responses are appreciated by the Governance Committee. They were either explicitly or implicitly supportive and included constructive suggestions, observations and queries that will improve the final version. Work on the accompanying procedures document is progressing according to schedule.

Jim Ross on behalf of the Governance Committee—
Ian Graham, Laurie Hutton, Jim Ross, Chris Yeats and Sue Fletcher

Climate Change Statement

A draft GSA Climate Change Statement was published in *TAG* 165 (December 2012), endorsed by the GSA Executive Committee, but inviting further comment from GSA members up to 31 January 2013. Indeed, that invitation has been taken up by a number of members, whose letters are published in this issue. Clearly, the Climate Change Statement remains a hot topic!

As outlined in *TAG* 165 (December 2012, p 6), the period of individual member feedback, to the end of January, is to be followed by consultation with Divisional and Branch committees during February 2013. After that, it is hoped that a final statement will be endorsed by the GSA Executive and placed on the GSA website.

Brad Pillans
Past President, GSA

GSA and facebook

For national news and events follow the GSA on facebook: Geological Society of Australia

Letters to the Editor

Response to Ian Crick — *TAG* 164, September 2012

Ian Crick (*TAG* 164, September 2012, p 8) asks whether Uluru and other central Australian monoliths may have been islands in a Cretaceous sea. I must be one of the few Aussie geologists who hasn't been to Uluru, but I have been to another place where I have posed the same question.

Ranges of Devonian sandstone in the Koonenberry Belt northeast of Broken Hill are flanked by remnants of Late Jurassic to Cretaceous sediment, in the Bancannia Trough to the west and outliers to the north, particularly the 'Three Hills' on the Wonnaminta 1:100 000 sheet. I studied the flat-topped 330-m elevation Turkaro Range and its surrounds over a few days in 1999 as part of the fieldwork for the Wonnaminta 1:100 000 regolith map. There are several low knolls 200 m distant from the northwest edge of Devonian outcrop at 220–230 m elevation, visible in Google Earth imagery (1/112007) at and around 54J 614300E 6584100N, which have outcrop of silcreted sandstone and conglomerate that contains rounded quartz pebbles as well as clasts of Devonian sandstone up to 3 m long. Transporting such large clasts is not a trivial matter, and I concluded that they represent boulders fallen from steep paleo slopes of the range, and incorporated into surrounding Mesozoic sediment which has been subsequently silica cemented to form silcrete. Mesozoic sediment (with leaf fossils) is preserved as a capping at the 19-km distant 'Three Hills' from about 220 m to the summit of the hill with the telecommunications tower at about 265 m. Therefore it is no great ask to have a paleo Turkaro Range at least partially, if not totally, buried by Mesozoic sediment, and then exhumed and subject to a few hundred metres of slope retreat. I also proposed that the nearby Koonenberry Mountain may have been exhumed from beneath a cover of Mesozoic sediment, but the evidence is not solid.

I've also heard 'pub talk' that the nearby Byngnano Range (Mutawintji National Park) is also an exhumed paleo landform, but I am not sure whether that is the Turkaro story slightly mashed, or whether there is more evidence at that location.

Finally, I am intrigued by comments from a water investigation report by TS Mount in 1992 that Mount Gunderbooka (440 m, 55J 375100 6614700, again Devonian sandstone) near Bourke is skirted by silcreted scree material at an elevation higher than the surrounding plain. Groundwater investigations suggest that the modern erosional feather edge of the GAB is about 15 km north of the mountain at about 110 m, and if there was ever a candidate for a paleo landform buried and then exhumed from beneath Cretaceous sediment, this is it. However, I have not visited this locality to test for field evidence.

DAVID GIBSON

Reply to Andrew Glikson — *TAG* 165, December 2012

Regarding my letter in *TAG* 164, September 2012

Dear Andrew,
Thank you for your thorough research. However, your Biochar–soil carbon policy is the same as the Coalition Policy, except on a smaller scale, meaning that [in] regards to my letter [*TAG* 165, September 2012, p 7], both are 'flawed', yours and the Coalition's. Regarding CO_2 levels causing global warming, I make the point, also in regards to ice ages and CO_2 levels, there is no simple link, for such a complicated global environment, regarding the 'exception' of the 'Ordovician', for CO_2 levels. Earth is not a 'Closed Model'; it is subject to the power of sun changes, extra-terrestrial dust and gases etc., and the climate could change direction at the 'Drop of a Hat'. Severe winters in Europe can suggest the start of a mini-ice-age. It cannot be ruled out.

Regarding CO_2 and plants and trees, in my previous letter I was trying to point out that excess CO_2 can be absorbed by corresponding extra plant/tree growth. The Earth has been a greenhouse for most of its existence. Man has lived for approximately 2 million years.

Remember, 'Open Models' can be notoriously incorrect, if misinterpreted.

PHILIP JOHN BROWN

GSA Climate Change Statement

I refer to the draft GSA Climate Change Statement published in *TAG* 165 (December 2012).

The original GSA climate statement, reported in *TAG* 152 (September 2009, p 31), reads "Human activities have increasing impact on Earth's environments. Of particular concern are the well-documented loading of carbon dioxide (CO_2) to the atmosphere, which has been linked unequivocally to burning of fossil fuels, and the corresponding increase in average global temperature".

The membership poll reported in *TAG* 158 (March 2011) shows 75.6% of members wish the GSA to have a position on climate. However, the poll did not include a question as to whether GSA members agree or otherwise with anthropogenic global warming. Notably, whereas the original GSA statement emphasises the role of CO_2 in global warming, nowhere in the draft statement published in *TAG* 152 are the effects of greenhouse gases (including H_2O, CO_2, CH_4, O_3, N_2O) mentioned.

The greenhouse effect, established since John Tyndall (1861) and Svante Arrhenius (1896) from observations in nature and the laboratory, and consistent with basic physical laws of blackbody radiation (the Planck, Stefan–Boltzmann and Kirchhoff laws), constitutes a basic tenet of paleo-climate science, as indicated by ice-core and proxy-based evidence from sediments. In this regard the atmospheric greenhouse effect is as fundamental to climate and paleoclimate sciences as are, for example, plate tectonic theory to Earth Science or Darwinian evolution to biological science.

The role of over 540 billion tons of carbon released into the atmosphere since 1750 from combustion and land-clearing (Global Carbon Project, 2011) is confirmed by: (1) the bulk of the peer-reviewed scientific literature; (2) the major climate research organisations (including NOAA, NASA, NSIDC, Hadley-Met, Tyndall, Potsdam, CSIRO, BoM); (3) the world's Academies of Science, including the Australian Academy of Science; (4) the world's Meteorological Organization; (5) the International Panel for Climate Change; and (6) other organisations.

Any climate statement by the Geological Society of Australia needs to take this evidence into account.

ANDREW GLIKSON

GSA Climate Change Statement

First day back at work after the Christmas – New Year break, rejuvenated and looking forward to the new year, opened the recent *TAG* issue [*TAG* 165, December 2012], read the Climate Change Statement of the Executive Committee of the GSA, and ... Massive Disappointment.

The only statement in the document that addresses the issue of the current climate change is a non-statement: "Regardless of whether climate change is from natural or anthropogenic causes, or a combination of both ...".

Talk about avoiding the issue! The only reason anyone would want to read a statement on climate change from a so-called 'learned' society would be to get some data-based view on the current climate change debate. This is not even mentioned!! The statement is a whitewash, a complete and total capitulation to the climate-change deniers and/or mining giants/political bosses, and is gutless, totally gutless. Worse, it is not even a document worthy of a scientific organisation — where is there any science in this statement? The document talks about variability and causes of past climate change, something about future climate change, but *nothing* about the current climate change.

Why? Is the backlash from the deniers so daunting that it has caused the executive committee to doubt the very scientific method it so blandly adds as a last paragraph to the statement?

At the very least, as a scientific organisation, we should present the debate (is the Earth warming, and if so, why?), state known facts on both sides of the issue (anthropogenic vs natural), and then apply the scientific method, using what we know from past climate-change studies to apply a learned view to the current change in the climate. This is why a learned society is looked to for professional opinion and guidance.

The last paragraph is a bad attempt to try to gain some credibility by rather grandly discussing the scientific method as if it is some holy grail that gives us credibility. The only way to gain credibility is to *apply* the scientific method and earn respect from the community by *being* scientific.

Andrew Glikson's short Letter to the Editor [*TAG* 165, December 2012, p 10–11] is a good example of using science as applied to the current climate change debate. He presents facts that speak loudly. We should not shy away from doing the same.

The GSA is a scientific body. Act like scientists. Present the science and then discuss the facts. Politics should be put aside and the data boldly stated. I have spoken with many laypersons who always say the same thing: "Why don't I hear anything about the science — only opinions?" The whole point of providing a Statement is to provide a service to the general public. The current Statement does not achieve this. Indeed, the current Statement is a disservice to the Earth Science community, the scientific community in general, and the general public.

I suggest this Statement be rejected.

MARTIN J VAN KRANENDONK

GSA Climate Change Statement

The issue of a GSA statement on climate change has become far more contentious than it needs to be. No geologist with an interest in the subject could possibly deny that in the past the climate has changed enormously, on a time scale of tens of thousands to billions of years. The controls on those changes are often not well understood and have been discussed, debated and researched for at least a century. My reading of the literature and some of my own contributions strongly suggest that one of the drivers of change on this scale is the concentration of greenhouse gases. I have followed this aspect of the debate for many decades, from long before it became a political issue.

TAG The Australian Geologist

SCHEDULE & DEADLINES

ISSUE	COPY	FINISHED ART	INSERTS
JUNE 2013	29 Apr	3 May	28 May
SEPTEMBER 2013	29 Jul	9 Aug	23 Aug
DECEMBER 2013	25 Oct	1 Nov	8 Nov
MARCH 2014	31 Jan	7 Feb	28 Feb

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GOT SOMETHING TO SAY?

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However, in a very real sense the geological record has limited relevance to the current controversy. In writing this I could be seen as acting against my own self-interest, and acting contrary to the conspiracy theory that climate scientists are just trying to maximise their chance of employment. I'm old enough that I don't care about my employment or research funding.

For me, the issue is the time scale. What we are concerned about now is decades, centuries and millennia, far too short a time for most of us who read *TAG* (I know there are exceptions). Of course there are longer term trends, but that is largely irrelevant. A hundred thousand years ago, a mere flash in the pan in geological history, there were no megalopolises on coastlines, and we were not dependent on climate-sensitive agriculture. In fact there is a debate as to whether *Homo sapiens* had yet evolved.

The issue is, what is causing short-term climate change? The evidence that the causes are anthropogenic is in my view quite overwhelming. A clear, objective statement has been published by the Australian Academy of Science. It is available at **http://www.science.org.au/policy/climatechange.html.**

The proposed statement by our Society is vacuous. We might as well say nothing. The statement does the GSA no credit and it is of no use to the broader Australian community who I think we all wish to inform and assist with difficult decisions, no matter what our personal views might be. So let's look at statements such as those from our own Academy of Science and craft a document that is actually of some use.

MALCOLM WALTER

REFERENCES IN LETTERS:
In the interests of space, Letters to the Editor will no longer include reference lists. *TAG* asks correspondents to use short weblinks or author's names and dates as sources for technical information in the body of the letter.

DISCLAIMER:
The Geological Society of Australia encourages letters from members. The letters do not necessarily represent the opinion of the Society.

GSA Climate Change Statement

The draft Climate Change Statement (dCCS) by the Executive Committee of the GSA, signed by Brad Pillans (*TAG* 165, December 2012, p 6–7), is a surrender to the climate change contrarians. It sets a record in discussing climate change without mentioning CO_2. Hamlet without Hamlet!

The *politics* of climate change is decidable by voters and politicians, but the *science* of climate change is uniquely understandable by climate scientists, as epidemics are uniquely understandable by epidemiologists.

I suggest that our Executive Committee themselves are not qualified to make a meaningful statement on climate change.

The dCCS is a cop out, unworthy of a Society that purports to be scientific. As it stands, it would make the GSA a laughing stock in scientific circles. Better to delegate the task to those climate scientists within the Society further informed by the statements of related learned societies such as:

(1) Australian Academy of Science (**http://www.science.org.au/reports/climatechange2010.pdf**),
and of our sister societies

(2) Geological Society of America (**http://www.geosociety.org/positions/position10.htm**)

(3) Geological Society of London (**http://www.geolsoc.org.uk/climatechange**)

(4) American Geophysical Union (**AGU_Climate_Statement.pdf**).

All learned societies, except ours, accept the reality of climate change and the need to mitigate its effects. With the existing dCCS we would be abrogating our responsibility by not contributing usefully to public debate and decision-making.

JOHN VEEVERS

Australian Journal of Earth Sciences

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From the *AJES* Hon Editor's desk

Reviewers for 2011 and 2012

I would like to acknowledge the efforts of our reviewers for 2011 and 2012. Each has contributed both their time and expertise to ensure the quality of papers published in *AJES*. You can see from the list opposite our reviewers are leaders in their fields and also some of our biggest contributors as authors.

Early/lower, late/upper

Authors (and this editor of *AJES*) sometimes suffer from confusion on the use of early vs lower, late vs upper, when to use capitals, and the use of Ma vs Myr. An author recently corrected my understanding of these usages and after some consultation with some local sages, it turns out we were both right and wrong. While for many instances it is quite straightforward that early/late refer to time and lower/upper refer to rock units, but there are many applications where it becomes more complex and in other areas there is still some controversy. *AJES* uses the International Chronostratigraphic Chart with a new edition released in August 2012, following the International Commission on Stratigraphy (ICS) meeting at the IGC in Brisbane (available at **http://www.stratigraphy.org**) but other journals use the North American nomenclature.

Not wanting to dig myself into a hole on this topic, I won't be outlining usage here. Rather, I recommend the North American Commission on Stratigraphy website (**http://www.agiweb.org/nacsn**). It includes several open-access papers that were published in the *Journal of Stratigraphy* in 2009 on aspects of this topic and in particular a paper by Donald E Owen that includes an outline of nomenclature for both the North American and the International codes and where they differ.

This editor is fallible and authors should feel free to disagree where they think I am wrong.

Scan for the latest GSA news.

Upcoming in *AJES*

AJES Vol 60/2

CJ Adams, RJ Korsch & WL Griffin: Provenance comparisons between the Nambucca Block, Eastern Australia and the Torlesse Composite Terrane, New Zealand: connections and implications from detrital zircon age patterns.

A Babaahmadi & G Rosenbaum: Kinematics of the Demon Fault: implications for Mesozoic dextral strike-slip faulting in eastern Australia.

JB Jago, CG Gatehouse, C McA Powell & T Casey: Implications of cross-bedding data from the upper part of the Cambrian succession, Arrowie Basin, South Australia.

AC Macken, MC McDowell, DN Bartholomeusz & EH Reed: Chronology and stratigraphy of the Wet Cave vertebrate fossil deposit, Naracoorte, and relationship to paleoclimatic conditions of the Last Glacial Cycle in south-eastern Australia.

AS Merdith, TCW Landgrebe, A Dutkiewicz & RD Müller: Towards a predictive model for opal exploration using a spatio-temporal data mining approach.

A Rajabi, E Rastad & C Canet: Metallogeny of Permian–Triassic carbonate-hosted Zn–Pb and F deposits of Iran: a review for future mineral exploration.

RH Sharma: Evaluating the effect of slope curvature on slope stability by a numerical analysis.

PN Southgate, NL Neumann & GM Gibson: Depositional systems in the Mt Isa Inlier from 1800 Ma to 1640 Ma: implications for Zn–Pb–Ag mineralisation.

Also on the way

RA Glen: Refining accretionary orogen models for the Tasmanides of eastern Australia.

CJ Carson: The Victoria and Birrindudu Basins, Victoria River region, Northern Territory, Australia: a SHRIMP U–Pb detrital zircon and Sm–Nd study.

PF Rey: Opalisation of the Great Artesian Basin (central Australia): An Australian story with a Martian twist.

ANITA ANDREW
Hon Editor *AJES*
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Horst Zwingman

Education&Outreach

In March 2012, the penultimate draft of a national Earth and Environmental Science (EES) course was circulated by the Australian Curriculum Assessment and Reporting Authority (ACARA) and a further round of feedback called for. The GSA and others commented, although I found the draft satisfactory and thought it best to comment only that no changes were needed and await its implementation. Implementation by the states will be another issue altogether.

Since the course is one that caters to both Environmental and Earth Science interests, it has generated some acrimony among educators wedded tightly to their pet disciplines. I fully expected to see some last-ditch efforts to change the content further one way or the other. Consequently, I expected to be disappointed with changes appearing in the final version, or to have to go through another round of comment and feedback as ACARA struggled to accommodate special interests that managed to get the final decision delayed.

ACARA closed off comments in June 2012 and indicated a final version would be announced in December 2012. My concerns seemed to be justified when December came and went and no announcement from ACARA was forthcoming. However, on contacting ACARA recently I have been told, and am pleased to report, that the final version was signed off in December and the EES material now available on the Australian Curriculum website is the final version. New information and extra examples will be added to the site in the coming weeks and months but the structure and content are final and no further amendments will be made. See **http://www.australiancurriculum.edu.au/SeniorSecondary/Science/Earth-and-Environmental-Science/RationaleAims** for the complete outline.

This is good news for education and outreach activities aimed at improving teacher education and student outcomes in the Earth Sciences. Not only has the new Australian Curriculum — Science F–10, with its explicit Earth Science content and expectation that all content will be taught — focused teachers' attention on the Earth Science content. Now there is a potential F–10 to Senior 11–12 pathway for students to follow and around which teachers can structure their delivery. All agencies interested in helping teachers and students understand Earth Science should seize the moment.

I fully expect some states to fiddle with the structure of the Australian Curriculum — Science in ways that ultimately undo the concept of a truly national approach, but only time will tell. In the meantime we should welcome the new EES senior subject, based on an Earth Systems approach, and encourage all State governments to adopt it and assist schools to equip themselves with the teachers and resources necessary to implement it sooner rather than later.

Finally, ACARA sees the EES course as a fourth senior subject, equivalent in weight and degree of difficulty to the other three: Biology, Chemistry and Physics. Examining the course there is no doubt in my mind that it is — but students will see it differently, especially when it comes to university entrance scores. EES should be ranked equivalent to Biology, Chemistry and Physics when it comes to calculating entrance scores. Hopefully that is the case in all jurisdictions but at the time of writing I am yet to confirm it. The time and effort required for good results in senior school demand a good return on the investment. Without the same return as other subjects it will always be seen by many good students as a second-class choice.

GREG McNAMARA
Geoscience Education and Outreach Services
Send all comments to Greg McNamara at
outreach@gsa.org.au

Quizine

BY TOR MENTOR

(Answers on page 49)

Many rocks, minerals and fossils are named after places, often by adding 'ite' to the place name — although I haven't found the 'gran' where granite came from (the name is actually derived from the Latin granum, for grain, referring to the coarse-grained texture). Where are the following named after?

1. Adamellite (quartz monzonite)
2. *Kalbarria* (the oldest euthycarcinoid arthropod)
3. Dunite (coarse-grained ultramafic rock)
4. Syenite (low-quartz or quartz-free granite)
5. Crinanite (analcite dolerite)
6. *Charnia* (an Ediacaran fossil)
7. Shoshonite (potassic trachyandesite)
8. *Uintacrinus* (a Cretaceous crinoid)
9. Dolomite (calcium magnesium carbonate)
10. Essexite (nepheline monzogabbro).

Heritage Matters

Australia is well known as being both the Earth's largest island and its smallest continent. However, while Australia is unique from this geographic perspective, it also is unique in that it has its own story to tell both geologically (ie, as Australia's geoheritage) and culturally. From a cultural perspective, since 1788, Australia's founding forefathers, prior to the minerals boom, established colonies where there was drinking water, soils suitable for agriculture and building materials. The focus of the Heritage Matters column in this issue of *TAG* is the formal recognition of 'heritage building stone' as a new aspect of geological heritage.

Heritage Stone Task Group

During the recent International Geological Congress in Brisbane, the International Union of Geological Sciences (IUGS) recognised a new aspect of geoheritage with the formal establishment of a Heritage Stone Task Group (HSTG). The HSTG is the first international grouping of geologists under the auspices of the IUGS to consider building stone and ornamental rocks, otherwise known as 'dimension stone'.

The initial purpose of the group is to provide a working framework that facilitates international designation of those natural stone products that have achieved widespread use over a significant historical period with due recognition in human culture, and hence its geoheritage aspect.

Global Heritage Stone Resource

From an Australian perspective, designated stones could include the 'Sydney Sandstone' or 'Victorian Bluestone'. Internationally, among many examples, there is the famous 'Carrara Marble' in Italy. The widely known 'Portland Limestone' from southern England was used for St Paul's Cathedral in London and the UN building in New York City.

Following formal approval of published research citations, designated dimension stone materials of international significance will be accorded status as a Global Heritage Stone Resource (GHSR). The term 'World Heritage Stone Resource' was first suggested but later rejected.

As part of the GHSR designation process, provision is made for associated formal recognition of specified features characterising natural stone resources such as:

- recognising a formal name for the designated stone
- defining the natural source of the stone
- tabulating the technical characteristics of the material.

Potential applications of this new designation have excited significant interest especially among European geologists. In Europe it has been suggested that the GHSR designation will assist safeguarding in-ground heritage stone resources and will facilitate prevention of inferior stone substitutes being used in the restoration of heritage constructions.

The newly appointed HSTG Board of Management has the role of:

- establishing a standing list of potential GHSR candidates
- soliciting draft citations for GHSR status and facilitating research papers discussing these citations
- approving citations for designated GHSR status or designating, as an alternative to GHSR status, a heritage stone that has national or regional significance.

Given that all rocks that are quarried as dimension stone have potential heritage status, a long-term objective of HSTG will likely be the preparation of an International Guide to Heritage Stone Designation. In the HSTG Terms of Reference, there has been advice that a GHSR may be recognised if the natural stone under consideration has most of the following attributes:

- historic use for at least 50 years
- wide-ranging geographic application
- use in significant public or industrial projects
- common recognition as a cultural icon, potentially including association with national identity or a significant individual contribution to architecture
- ongoing availability of material for quarrying
- potential benefits (cultural, scientific, architectural, environmental and/or commercial) arising from GHSR designation.

A GHSR may include natural stone that is currently being quarried, natural stone that is primarily of heritage significance, or natural stone of archaeological importance. Currently, the HSTG is still at a formative stage. However, a HSTG Board of Management was established at the 34th IGC and plans are being made to hold a second meeting in Vienna in April 2013 as part of the annual European Geological Union conference.

Portland Block Stone. Image courtesy Portland Stone Firms Limited, UK at ***http://www.stonefirms.com.***

A conference in 2014 is envisaged as a session of the XII IAEG conference to be held in Turin, Italy, 15–18 September 2014. A session entitled 'Building stones and ornamental rocks: resource evaluation, technical assessment, heritage designation' has been proposed.

A 2015 conference is being planned for North America (USA or Canada) by Joe Hannibal, Brian Pratt and Nelson Shaffer. A 2016 conference will likely be linked with the 35th IGC to be held in Cape Town, South Africa, 27 August–4 September 2016.

Details of HSTG work

As of September 2012, HSTG also has 154 Correspondents from 40 countries, including 19 from Australia. Correspondents are advised of HSTG activities by the Global Stone Circular that is distributed by email approximately every nine months. It is expected that Correspondents will assist greatly in the nomination and approval of Global Heritage Stone Resources.

Australia is represented on the inaugural HSTG Board of Management by its Secretary General, Barry Cooper (University of South Australia). More details about HSTG work are provided at **http://www.globalheritagestone.org**. Any GSA member who is interested in heritage stone research and who wishes to be added to the list of HSTG Correspondents should email Barry Cooper at **barry.cooper@unisa.edu.au**.

I would like to acknowledge and thank Barry for providing this informative account of the establishment of the HSTG.

MARGARET BROCX
Convenor
Standing Committee for Geological Heritage
geoheritage@iinet.net.au

Recognition

Congratulations Simon Turner

Simon Turner, long-standing GSA member and accomplished Earth Scientist, was recently made a GSA Fellow. Here we present Ron Vernon and John Foden's citation. Read Simon Turner's biography online at **http://gsa.org.au/recognition/fellows.html**.

Professor Simon Turner is a high-profile, world-renowned geochemist at the peak of his career. He is well known internationally and has worked with some of the leading international luminaries in his field. His research is concerned with mantle partial melting, magma formation and magma crystallisation, mainly involving analysis of chemical compositions and isotope ratios of rocks and minerals, include Rb–Sr, $^{40}Ar/^{39}Ar$, U–Th and Re–Os isotopic systems. His main specialty is the application of short-lived, U-series isotopes to investigate the time scales of formation, transport, storage and differentiation of magma in the upper mantle and lower crust, especially beneath arc volcanoes and flood basalts. In addition, he has extended this isotopic approach to the investigation of erosion rates. He had an early interest in the origin of granitoids, gabbros and tectonic relationship of the Delamerian of South Australia and western Victoria, and he has continued publishing on geological problems in this region. He has written on volcanism in an enormous range of places around the world, including the Sunda, Alaska–Aleutian, Tonga–Kermadec and Bicol arcs, the Lesser Antilles, the Betic–Alboran domain, the Aegean, New Zealand (White Island, Solander Island, Ngauruhoe, Ruapehu), Kamchatka, the Cascades, the Azores, Cotopaxi, the Lau basin, Manus basin, Vanuatu, Rabaul, Katmai, the Galapagos, Mount Cameroon, the Asal Rift, the Basin and Range and the Tibetan Plateau. He has had a close involvement with the problems of flood basalts, with special reference to the Deccan and Paraná provinces, and has advanced geochemical evidence for the production of associated rhyolites by crystallisation–differentiation of flood basaltic magma. He has also made several major contributions to the understanding of upper mantle processes, dynamics and magma extraction, including mantle plumes and the recycling of subducted material.

Professor Turner has an extremely strong publication record, with 147 articles in refereed academic journals. He edited, with A Dosseto and J Van Orman, a well-received book entitled *Timescales of Magmatic Processes: from core to atmosphere* (Wiley-Blackwell, 2010), which is evidence of his research versatility and international standing. One of his most outstanding educational contributions is supervision of PhD students, with seven completions and seven more under current supervision.

In view of his international research reputation, his numerous contributions to Australian geological research, and his contributions to postgraduate training, we have much pleasure in recommending Simon Turner for Fellowship of the Geological Society of Australia.

RON VERNON and JOHN FODEN

News from the Divisions





All students were presented their certificates by Ian Graham, Chair of the NSW Division and GSA Vice-President. Images courtesy Mira van der Ley and Ian Graham.
TOP LEFT: Emma Flannery receiving her certificate.
TOP CENTRE: Ryan Manton receiving his certificate.
TOP RIGHT: Timothy Chapman receiving his certificate.
ABOVE LEFT: Lydia Belford receiving her certificate.
ABOVE RIGHT: Amanda Hanani receiving her certificate.

NSW Division Honours

The NSW Division held its annual honours night on 15 November 2012, where the top-performing honours students gave talks.

Approximately 40 members enjoyed fascinating talks by Ryan Manton (University of Wollongong), Emma Flannery (Macquarie University), Lydia Belford (University of Newcastle), Timothy Chapman (University of Sydney) and Amanda Hanani (University of New South Wales). Their talks covered caves, calderas, hydrocarbons, hypersthene, and more hydrocarbons. Emma Flannery was awarded best talk of the night with her presentation on hydrocarbon signatures in core slices.

It was an extremely enjoyable night, with lots of tough questions for the students from members of the audience, generating lively discussion.

News from the Specialist Groups

SGGMP — Rocks, Reef and Rainforest

Mission Beach, Qld, 14–19 July 2013
Biennial conference of the Specialist Group in Geochemistry, Mineralogy and Petrology (SGGMP)

Following the format of the successful Kangaroo Island (2009) and Murramarang (2011) SGGMP conferences, this Gordon-style conference to be held in tropical North Queensland will combine oral and poster presentations, field trips and a packed social program. The conference will address three main themes:

1. Revealing the concealed Earth using novel techniques
2. Cooking the crust — high-grade metamorphism and melting
3. Evolution of the Australian Plate — ancient cratons and modern.

Field trips will include examination of the Paleozoic Barnard Metamorphic Complex at Mission Beach and on Dunk Island, and the Late Miocene to Holocene Atherton Basalt Province. Reef snorkelling and rainforest excursions are inclusive.

The conference will be limited to approximately 60 delegates, so register your interest early!

For more information, visit **http://sggmp2013.webs.com/.**

SGTSG — Biennial meeting

Thredbo, NSW, 2–8 February 2014

Meeting of the Special Group in Tectonics and Structural Geology (SGTSG) (held every second year).

There will be a welcome BBQ and cricket match on Sunday 2 February. The conference dinner will take place on the evening of Friday 7 February. Professor Mark Jessell (France) will deliver the mid-week after-dinner keynote address.

For more information, contact Gordon Lister at **gordon.lister@anu.edu.au**.

NEWS

In the news this issue

- NRG Rock of the Month
- National Rock Garden update
- International Geological Correlation Programme (IGCP)
- University honours geologist
- Case studies sought
- Ediacaran Golden Spike locality
- China, Australia and geoparks
- Fossil problematica from Moreton National Park

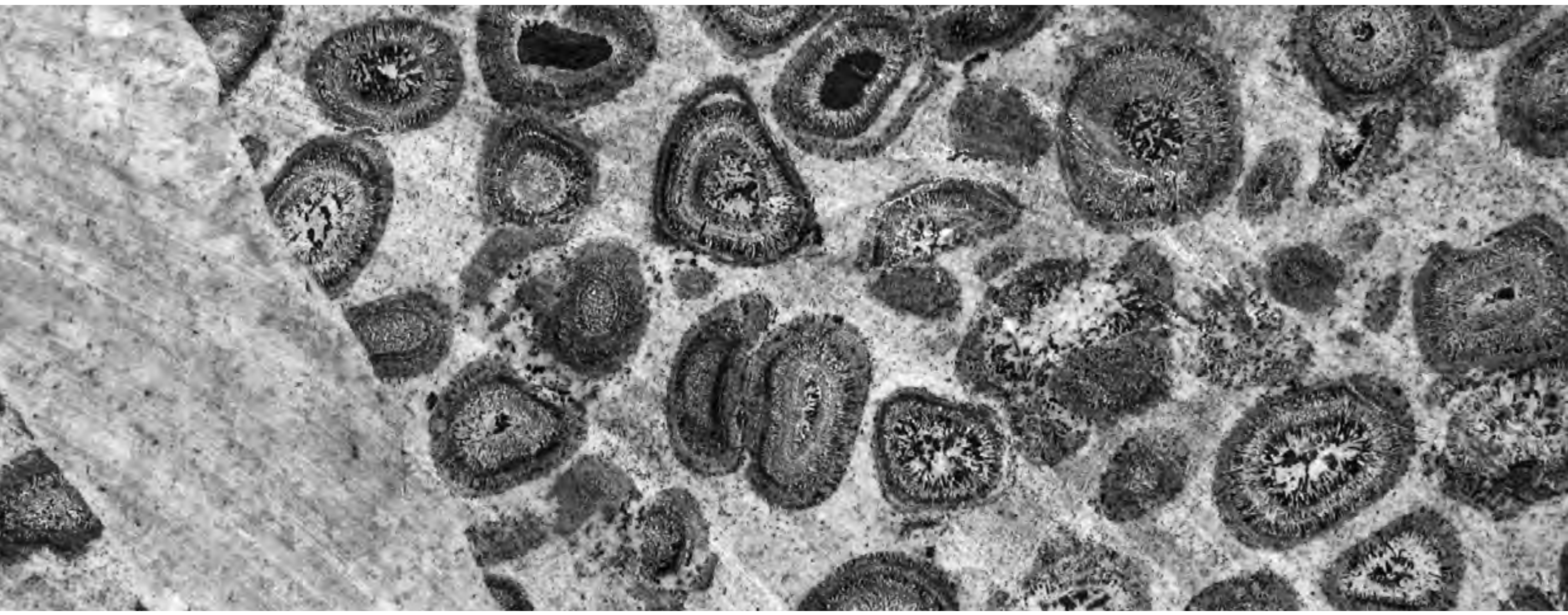
National Rock Garden — Boogardie orbicular granite

GSA Rock of the Month — March 2013

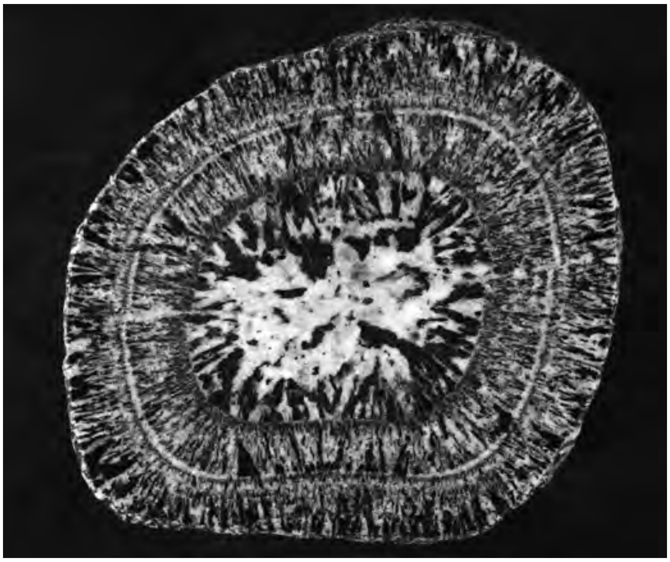
The Boogardie orbicular granite deposit is located 35 km west of Mount Magnet in Western Australia. This unusual granitic rock, located on Boogardie Station, is one of a few orbicular granite localities known worldwide. The orbicular granite is hosted by a pink, medium-grained, late Archean granitic rock, comprising myrmekitic biotite granodiorite that becomes tonalitic in places. Information from diamond drillholes indicates that orbicular granite bodies may have formed as saucer-shaped, sill-like structures within the host granodiorite–tonalite. Over the area of the Boogardie quarry, the orbicular granite appears as an oval-shaped body, about 40 m wide and at least 55 m long. Maximum thickness at the centre is 11.4 m, tapering off in all directions to relatively small thicknesses at the outer rims.

Within the sill-like structures, abundant granitic orbicules are contained in a leucogranitic body of variable tonalitic composition. The black and white, concentrically banded orbicules are of spectacular appearance. Orbicules are mostly ellipsoidal but also include lesser numbers of near-spherical, irregular and broken shapes. Orbicules have an average length of about 140 mm along their longest axis by 75 mm in width. Orbicule spacing varies from orbicular masses in tangential contact with one another to a maximum separation of about 100 mm, although overall orbicule distribution appears roughly uniform throughout the rock, as shown in the photograph of the matrix cut by a pegmatite vein below.

Individual orbicules are generally separated from the enclosing granitic matrix by a mid- to dark grey outer shell up to 10 mm thick, which is made of mainly fine- to medium-grained hornblende, biotite and plagioclase feldspar, with minor opaque oxide and titanite. Inside this protective shell, orbicules have a hornblende-diorite composition, largely composed of plagioclase feldspar and hornblende with lesser amounts of biotite, opaque oxide and titanite. Orbicules usually contain five to seven (or even more) major, well-defined concentric zones of variable width, structural complexity and mineralogy. Some major zones may be up to 15 mm wide and commonly contain large, irregular, elongate, radially aligned hornblende grains interspersed with white plagioclase. These hornblende grains may extend across the entire width of the zone and are commonly tapered internally to a point, as shown by the spectacular image of the individual orbicule opposite (Fetherston, 2010).



Orbicules enclosed in a granodiorite–tonalite matrix cut by a late-phase pegmatite vein. Image courtesy Mike Fetherston.



A spectacular hornblende-diorite orbicule about 150 mm wide. Image courtesy Mike Fetherston.

Bevan (2004) proposed that the orbicules were formed by crystallisation from a fluid-rich, supercooled dioritic magma. Variations in orbicule type and layer structure reflect a very dynamic history of crystallisation influenced by changes in magma composition and degree of cooling. The presence of broken fragments and variations in zone mineralogy indicate that proto-orbicules were very mobile in the magma chamber, probably propelled by convection currents within fluid-rich margins. Orbicules were eventually subject to gravity settling to form the deposit visible today. It is evident that, at the time of settling, orbicules were still in a plastic state as they are often deformed or moulded together. Some orbicules appear to have been dragged along by the current while others show evidence of mass movement after settling. Further recent information on the nature and origin of the orbicular granite is given in Bevan and Bevan (2009).

Because of its visually spectacular orbicular structure, relative rarity and ability to take a high polish, the orbicular granite has been quarried at different times, supplying blocks and slabs mainly to artisans and monumental masons. Prime examples of completed works include high-quality ornamental works such as contemporary sculptures, interior decorative panels and tables. Floating orbicular granite spheres measuring up to one metre in diameter are also popular.

MIKE FETHERSTON
Industrial minerals specialist
Geological Survey of Western Australia

REFERENCES

Bevan, J, 2004, Archaean orbicular granitoids from Boogardie, near Mt Magnet, *in* Western Australia: Dynamic Earth: Past, Present and Future: Geological Society of Australia, Abstracts 73, 17th Australian Geological Convention, Hobart, p. 252.

Bevan, JC and Bevan, AWR, 2009, Nature and origin of the orbicular granodiorite from Boogardie Station, Western Australia: an ornamental stone of monumental proportions: *The Australian Gemmologist* (2009), v. 23, p. 373–432.

Fetherston, JM, 2010, Dimension stone in Western Australia, Volume 2, Dimension stones of the southern, central western, and northern regions: Geological Survey of Western Australia, *Mineral Resources Bulletin* 24, p. 35–43.

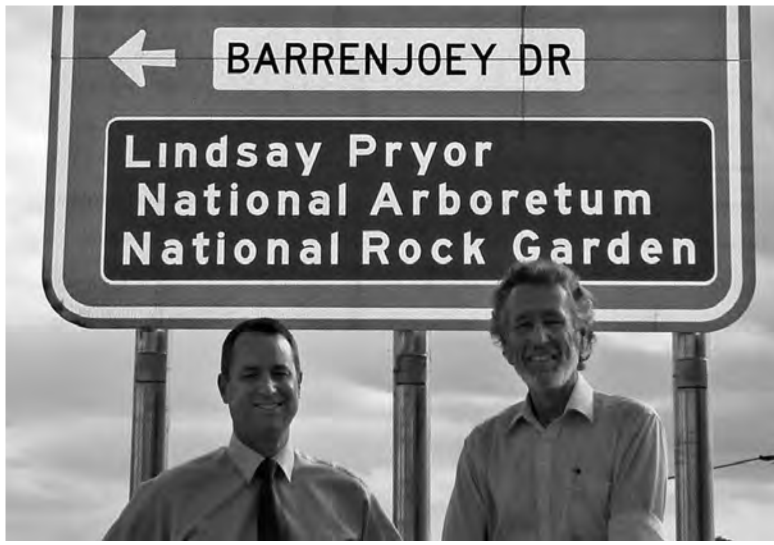
National Rock Garden update

Two recent developments have given the National Rock Garden (NRG) a major boost. First, the Australian National University (ANU) has agreed to become an Education Partner of the NRG. Second, the NRG has been made part of the Centenary of Canberra celebrations.

At a time when university budgets are stretched to the limit, the ANU has generously agreed to provide $100 000 in funding for the NRG. A draft Memorandum of Understanding has been drawn up and, once it is approved and signed, ANU will become an Education Partner with the NRG.

Dean of the ANU College of Physical and Mathematical Sciences (and GSA member), Professor Andrew Roberts, summed it up pretty well. "In Australia, we owe much of our national prosperity to our geological resources. The NRG is a great way to communicate to the general public about Australia's geological heritage. As one of the world's great Earth Science research establishments, it makes sense for ANU to partner with the Geological Society of Australia in the NRG."

On 13 October 2013, in Earth Science Week and during Centenary of Canberra celebrations, an inauguration ceremony will be held at the site of the NRG on the western side of Lake Burley Griffin. Not to be confused with an opening ceremony, which is still some years away, the NRG inauguration ceremony will mark the arrival of the first big rocks on-site — eight to be exact, if things go according to plan.



[L–R] Andrew Roberts and Brad Pillans at the NRG tourist sign — a sign of things to come! Image courtesy Brad Pillans.

The Canberra Foundation Stone, laid in 1913, and relocated to the lawns in front of New Parliament House in 1988. Image courtesy Brad Pillans.

It is proposed that an important element of the NRG will be eight large rocks representing each of the states and territories of Australia and commemorating Federation — the *raison d'être* for Canberra. They will be displayed permanently and prominently near the NRG entrance and will form a centenary link to the six-sided Canberra Foundation Stone, laid in March 1913, in front of Parliament House. The Foundation Stone was intended to be the base for an obelisk made of rocks from around the British Empire, but it was never completed. The base is made of 'Bowral trachyte', also known as Mt Gibraltar microsyenite, once a popular building stone that we may also choose to display in the NRG.

Each of the eight rocks, to be known collectively as the 'Federation Rocks', will be selected for its special significance to the state or territory from which it comes. The NRG is liaising with the ACT Government to encourage all states and territories to fund the Federation Rocks.

BRAD PILLANS
Chair, National Rock Garden

International Geological Correlation Programme (IGCP)

Annual report 2011–2012

The Australian committee's annual report to the IGCP for 2011–2012 is summarised here. This report highlights the committee's work in ensuring Australian scientists and students can engage with this international program.

Committee members 2011–2012

Members of the committee during 2011–2012, and their main areas of interest were:

Professor Patricia Vickers-Rich (Chair for 2010 onwards) — Paleobiology and Science Communication
School of Geosciences, Monash University, Monash Vic 3800
pat.rich@monash.edu.au

Professor Peter Cawood — Tectonics, Assembly and Dispersal of Continents
School of Earth and Environment, The University of Western Australia, Crawley WA 6009
peter.cawood@st-andrews.ac.uk

Professor Tony Crawford — Petrology and Geochemistry
ARC Centre of Excellence in Ore Deposits, University of Tasmania, Private Bag 126, Hobart TAS 7001
tony.crawford@utas.edu.au

Dr Brenda Franklin — Mineralogy and Industrial Minerals
Consulting Mineralogist/Petrologist
141 Oaks Ave, Dee Why NSW 2099
brendafranklin@bigpond.com

Professor Steven Reddy — Structural Geology and Tectonics
Department of Applied Geology
Curtin University, GPO Box U1987, Perth WA 6845
s.reddy@curtin.edu.au

Dr Elizabeth Truswell — Environmental Geoscience and Paleontology
Visiting Fellow, Research School of Earth Sciences, ANU, Canberra ACT 0200
etruswell@aapt.net.au

Dr Sue Turner — Vertebrate Paleontology and Biostratigraphy
Queensland Museum Ancient Environments
122 Gerler Road, Hendra, Qld 4011
sue.turner@qm.qld.gov.au

Professor Allan Chivas — Geochemistry and Geochronology
School of Earth & Environmental Sciences, University of Wollongong, Wollongong, NSW 2522
toschi@uow.edu.au

Dr Alfons (Fons) VandenBerg — Biostratigraphy, Graptolites, Regional Geology, Volcanology, Structural Geology and Geological Mapping
Museum Victoria, GPO Box 666, Melbourne 3001
avandenberg@museum.vic.gov.au

IGCP projects

The IGCP is a joint initiative of the United Nations Educational, Scientific and Cultural Organization (UNESCO), through its Division of Earth Sciences, and the International Union of Geological Sciences (IUGS). Australia has been involved with the IGCP since its inception in 1972.

In 2011–2012, 27 IGCP projects were active and funded. Australian geoscientists at the beginning of 2011 were either leaders or co-leaders of seven projects, and active participants in 11 others, indicating the on-going high level of interest and the benefits to be gained from cooperation in international projects. Professor Patricia Vickers-Rich continues in a position on the expanded IGCP Scientific Board and was elected as the Theme Leader for Global Change and the Evolution of Life on the International Geoscience Programme Board based in Paris for 2011–2014.

Two new IGCP project proposals have been submitted to UNESCO for 2012. There are Australian leaders for 17 of the internationally submitted projects. And of those 17, several include Australian participants beyond the two led by Australian researchers.

Bursaries for Australian researchers

The Australian National IGCP Committee functioned as usual. Its main business is to disburse much of the $20 000 ($22 000 less tax) Grants-in-Aid provided annually by Geoscience Australia to assist Australian geoscientists, in particular students and early career researchers, to participate in IGCP activities. The ongoing contribution made by Geoscience Australia and the GSA to IGCP activities is gratefully acknowledged.

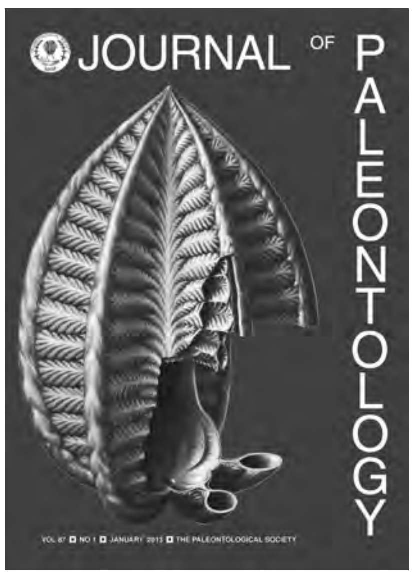
The following grants were provided to assist Australian scientists to attend IGCP sponsored meetings and workshops. This included assistance towards attending international workshops and conferences as well organisation of the 40th anniversary meeting of IGCP in Paris in 2012. There were also two field conferences in Newfoundland and Saudi Arabia and a conference on science communication in Iran.

Recipient	GRANT $	Project and purpose
Mr Mao Luo, School of Earth and Environment, The University of Western Australia, Crawley, WA (graduate student)	1800	572 – Field conference on Restoration of Marine Ecosystems, following the Permian–Triassic extinction even, Guizhou Province, China, March 2012
Mr Jeffrey Smith, Monash University, School of Geosciences, Melbourne	1500	587 – Field Conference with the Saudi Geological Survey and Winter Enhancement Programme at King Abudulla University of Science and Technology, Jeddah, Jan 2012
Dr Thomas H Rich, Museum Victoria, Melbourne	1500	587 – Field Conference with the Saudi Geological Survey and Winter Enhancement Programme at King Abudulla University of Science and Technology, Jeddah, Jan 2012
UNESCO IGCP, Paris	3532	IGCP 40th Anniversary Program, Paris, February 2012
Ms Sandra Thong, Education Specialist, Monash Science Centre, Monash University, Melbourne Dr Corrie Williams, Exhibition, Manager, Monash Science Centre, Monash University, Melbourne (2500 each)	5000	587 – Nama Field Conference, Namibia, and attendance at the 6th International Science Centre Conference, Johannesburg Presentation at Science Festival in Johannesburg, Aug–Sep 2011
Organisation of Nama Field Conference and attendance of the following attendees: Graduate students David Elliott, Peter Trusler and academics Prof Mike Hall, Prof Patricia Vickers-Rich and support at the conference of attendees from Taiwan, Canada, Namibia, Russia and Australia	10 000	587 – Nama Field Conference, Namibia, and attendance at the 6th International Science Centre Conference, Johannesburg Presentation at Science Festival in Johannesburg, Aug–Sep 2011
P Vickers-Rich also took part in and was on the organising committee for the IGCP512/587 conference and field conference in Siberia Aug 2011 Each recipient $2500		512/587 – Siberia Conference on Neoproterozoic Sedimentary Basins: Stratigraphy, Geodynamics and Petroleum Potential. Novosibirsk and East Sayan, Foothills, 30 Jul–14 Aug 2011
David Elliott presented at the Hans Hofmann Memorial Conference	2500	587 – Hans Hofmann Memorial Conference and Ediacaran Field Conference, St John's, Newfoundland, May 2012
Prof Katherine Trinajstic	2500	586 – Presentation of paper 'Late Devonian carbonate magnetostratigraphy from the South Oscar Range, Lennard Shelf, WA' at IGC conference, Brisbane, 2012
Dr Tanya Fomin	2000	559 – Attendance of the 15th International Symposium 'Deep profiling of the Continents and their Margins' SEISMIX 2012, Beijing, China, 16–25 Sep 2012
Prof Patricia Vickers-Rich	2000	587 – Attendance at IGC, Brisbane in 2012 Presentation of 16 lectures for the Iranian Science and Technology Museums in Tehran, May 2012 on science communication for youth and construction of Science Centres
Dr Alexey Goncharov	2000	559 – Attendance of the SEISMIX 2012 conference in Beijing, visit to SINOPROBE and present at a workshop in Perth for industry and academia at the National pool of ocean-bottom seismographs (an AGOS initiative funded by the Australian Government)
Prof Zheng-Xiang Li	2000	581 – Presented a keynote talk on 'The opening of the South China Sea: Driven by Pacific Subduction, or by India–Eurasia Collision?' at the IGCP 581 Conference in Hyderabad, India Field excursion in western Nepal Nov 2012
Mr Uri Shaanan	500	592 – Presented an oral paper 'Possible mechanisms for the formation of the New England Orocline' at the Gondwana to Asia 2012 conference, Adelaide, 2012
Mr Pengfei Li	1500	592 – Presented an oral paper at the Gondwana to Asia 2012 conference in Adelaide 'Continental construction in Central Asia'

The total amount allocated was $18 532 to recipients to assist their involvement in six different IGCP projects. In addition, $2000 of GST was paid to the Australian Taxation Office for 2012.

Bursaries for Australian students

Applications from graduate and undergraduate students were supported. Although some support allowed papers to be presented at two conferences dealing with pre-Tertiary geosciences education (Iran and Australia), efforts still need to be made to increase the awareness of the geoscience community, particularly younger geoscientists, about the advantages that the IGCP program offers in establishing international research contacts. It should be noted that funds granted to academics were shared with their students or supported students in the countries where meetings occurred.



Rangea revealed. Recent discoveries by team members of IGCP587 'Identity, Facies and Time – the Ediacaran (Vendian) Puzzle' and IGCP493 'The Rise and Fall of the Vendian Biota' have revealed detailed morphology of the longest lived Ediacaran group, the rangeomorphs. This cover article explores the latest discoveries of one genus in the group, Rangea, from rocks representing nearshore marine paleoenvironments cropping out in Southern Namibia. These rocks represent a time near the end of this successful radiation of the first animals. Art by Peter Trusler. Image courtesy Journal of Paleontology.

IGCP projects with Australian leaders

526	Risks Resources and Record of the 2000 Past on the Continental Shelf 2007-2011	FL Chiocci (Italy) L Collins (Australia), MM de Mahiques (Brazil) R Hetherington (Canada)	L Collins Dept of Applied Geology Curtin University GPO Box U19876845G Perth WA
559	Crustal Architecture and Landscape Evolution 2008-2012	Bruce R Goleby (Australia) and 14 members (USA, Canada, China, Finland, Netherlands, New Zealand, Russia)	B Goleby Geoscience Australia GPO Box 378 Canberra ACT 2601
565	Geodetic Monitoring of the Global Water Cycle 2012	Hans-Peter Plag (USA) Richard S Gross (USA) Markus Rothacher (Germany) Norman L Miller (USA) Susanna Zerbini (Italy) Chris Rizos (Australia)	C Rizos University of New South Wales Sydney 2062
572	Permian–Triassic ecosystems 2008-2012	Zhong Qiang Chen (Australia) Richard J Twitchett (UK) Jinnan Tong (China) Margret L Fraiser (USA) Sylvie Crasquin (France) Steve Kershaw (UK) Thomas J Algeo (USA) Kliti Grice (Australia)	Z Qiang Chen University of Western Australia Perth WA 6009
581	Evolution of Asian River Systems 2009-2013	Hongbo Zheng (China) Ryuji Tada (Japan) Peter Clift (UK) Masood Ahmad (India) Zheng Xiang Li (Australia)	Zheng-Xiang Li Curtin University Perth, WA 6009
587	Of Identity, Facies and Time: The Ediacaran (Vendian) Puzzle 2010–2015	P Vickers-Rich (Australia) MA Fedonkin MA (Russia J Gehling (Australia) G Narbonne (Canada)	P Vickers-Rich Monash University Wellington Road Monash VIC 3800
588	E-MARSHAL. Earth's Continental MARgins: ASsessing the geoHAzards from submarine Landslides 2011-2014	Adam D Switzer (Malaysia) Craig Sloss (Australia) Benjamin Horton (USA) Imasiku Nyambe (Zambia)	Craig Sloss School of Natural Resources Queensland University of Technology Brisbane, QLD 4001
597	Amalgamation and Breakup Pangaea: The Type Example of the Supercontinent Cycle 2011–2015	J Brendan Murphy (Canada) J Duncan Keppie (Mexico) Cecilio Qüesada (Spain) Bill Collins (Australia)	Bill Collins School of Environment and Life Sciences University of Newcastle Newcastle, NSW 2308
599	The Changing Early Earth 2011-2014	Jaana Halla (Finland) Kent C Condie (USA) Roberto Dalt (Brazil) Mudlappa Jayanada (India) Martin J Van Kranendonk (Australia) Hugh Rollison (UK) Gary Stevens (South Africa) Jin-Hui Yang (China)	Martin J Van Kranendonk Australian Centre for Astrobiology University of New South Wales Sydney, NSW

IGCP projects with participation by Australian geoscientists

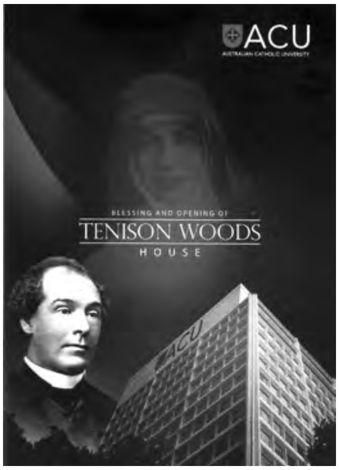
Projects with leaders or participants from Australia include 512, 526, 540, 546, 557, 559, 565, 572, 580, 581, 582, 585, 587, 588, 597, 599 and 609. Information concerning their participants and their annual reports can be accessed on the UNESCO IGCP website, recently updated at **http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/international-geoscience-programme/igcp-projects/**.

Reports from Australian participants in IGCP projects

In previous years a full documentation of annual reports of projects with Australian participants or leaders has been included in the annual report, but for the recently updated and most accessible UNESCO IGCP website this is no longer necessary. Simply reference to the website noted above will provide the details of each of these projects and will certainly be updated as new projects are approved.

PATRICIA VICKERS-RICH

A late report — another university honours a geologist



For various reasons this piece of news, of minor historical significance, has escaped the notice of most Australian geologists. It happened about a year ago on 3 February 2012.

Australian universities have been slow to commemorate geologists who have taught at or attended particular establishments. The University of Sydney erected a 'custom-built' Geology School in 1960, named for Edgeworth David, and proceeded to demolish it in 2005 to make way for a new Law School. Fortunately, on this second occasion it took the desires of David's then living grand-daughter to rename 'Old Geology' the 'Edgeworth David Building'. This was an appropriate enough move, seeing that David had been instrumental in its planning and construction in 1895. An earlier distinguished former Professor of Geology, Archibald Liversidge, continues to get the cold shoulder at the university.

I'm not sure if the building at the University of New England named for Leo Cotton by the first Professor of Geology, Alan Voisey, at the time UNE cut its ties with Sydney, still exists. Dorothy Hill at least has a library in her name at Queensland, and of course, Douglas Mawson is honoured at Adelaide. I think McCoy gets a mention at Melbourne, and Woolnough likewise at WA.

However the 2012 naming was quite different for it took place at a university that teaches little or no science, let alone geology. So what is the link?

The name is the Tenison Woods House of the Australian Catholic University, at its North Sydney (MacKillop) Campus. The link is, of course simple. Julian Edmund Tenison Woods (1832–1889), a Catholic priest, when in South Australia was the mentor of the young Mary MacKillop in her early years founding the Sisters of St Joseph (1866), an order designed to ensure education of the underprivileged.

Woods needs little introduction to those familiar with his Australian geology work, which notably included karst, volcanic and metamorphic studies in South Australia, and mineral studies in the Northern Territory, Malaya (as it then was) and Japan.

The fine, renovated numerous-storey building was given a good opening, thanks to the local member, Joe Hockey, and also received a religious blessing at the hand of Cardinal Pell. There was a certain irony in the latter event, as Woods was somewhat on the outer with the church hierarchy at the time of his death in 1889, although Cardinal Moran did preside at his funeral Mass at St Marys Cathedral. However time has seen him well and truly rehabilitated!

Descendants of Woods's brother and several of his biographers attended the 2012 renaming ceremony.

DAVID BRANAGAN

Case studies sought for text book supplement

Dear Geoscience Colleagues,

The highly successful Teacher Earth Science Education Programme (TESEP) is seeking your assistance.

We are collaborating with Earth Science Western Australia (ESWA) to produce case studies that complement their fantastic Earth and Environmental Science (EES) text book.

By updating with Australia-wide examples, the book will more effectively help all Australian teachers when the new Australian Curriculum EES course for Years 11–12 is rolled out in a few years. TESEP is encouraging nationwide adoption of this text. By providing additional complementary case studies we are helping to ensure it is of maximum use across the country.

The book has 19 chapters and we are looking for excellent Australian examples for many areas of text. Each case study will consist of two to six pages including research, diagrams, maps and activities. The chapters address minerals, fossils, geological time, plate tectonics, geohazards, energy, resources and the three rock types. Chapters also embrace soils, water, weather, climate change, human activity, ecosystems and bio-diversity. A complete overview is available on the TESEP website at **http://www.tesep.org.au/casestudies.html**.

However, we are not seeking to rewrite the curriculum! You may think there are sections of the book missing but it is written to meet the WA EES curriculum requirements. It will also be revised to meet the national EES curriculum even better in due course, but either way it will not cover all possible content. Consequently, if you think you have material that does not fit the chapter headings do not be discouraged. The content touched on under those headings is wide-ranging and many less-obvious connections can be made as a result.

I will be personally contacting those in the geoscience community I know may be able to provide or easily develop some of the material required — but I encourage one and all to help.

If you have anything of your own or are aware of materials that might suit our needs please contact me as soon as possible. Obviously, we need to be sure that there are no copyright restrictions on the materials you provide. However, even if you contribute just one classic photo of a particular geological phenomenon, the Australian teaching fraternity and all future students will be very grateful and your contribution will be acknowledged.

Needless to say, in order to ensure national appeal the case studies will need to have national geographic spread. This means we may have the unenviable task of choosing some over others for the first batch of case studies that we hope to have finalised by October 2013. However, since the case studies are likely to be delivered online we should be able to continually add them to the ESWA and TESEP websites as they are written up and inform teachers by email and newsletters.

GREG MCNAMARA
Executive Officer of the Teacher Earth Science Education Programme
Email **eo@tesep.org.au**
Mobile 0412 211 797

Ediacaran Golden Spike locality

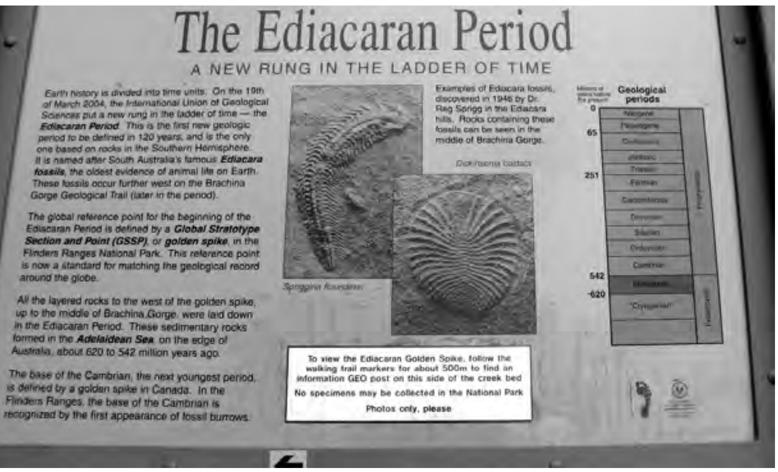
Visitors to South Australia's Flinders Ranges wishing to view the Ediacaran Global Stratotype Section and Point (GSSP), also known as 'Golden Spike', may benefit from an explanation to assist them find its location.

Approach the site by turning left at the well-signposted, gravel Brachina Gorge Geological Trail intersection with the bitumen Hawker to Blinman Road. Time spent at the excellent information station, close to the beginning of the trail, provides the visitor with comprehensive knowledge of the geology of the trail that they are about to drive along.

Back on the trail, regular signage directs the traveller to self-guided localities to view exposures of geological interest and to camping localities. Take the signposted Trezona Campsite turnoff, approximately 6 km from the eastern end of the trail. Within the campsite on Enorama Creek (not at the trail turnoff) is an information panel shown in a photograph accompanying this article. This panel gives both the background to the Ediacaran time-slice and broad directions as to where the Ediacaran golden spike may be found by walking along the creek.

Follow the yellow marker posts for about 500 m in an easterly direction along the southern bank of Enorama Creek. The final marker, several metres from the golden spike, states:

Golden Spike — Global Stratotype Section and Point. Geo site marks the start of the Ediacaran Period of geological time, as Earth warmed following glaciation. Multi-celled organisms became widespread in maritime environments. The brass disc indicates its location, where pink Elatina Formation glacial tillite is overlain by buff Nuccaleena Formation dolomite.



The Ediacaran Period information panel in Trezona Campsite, Enorama Creek, Flinders Ranges. Image courtesy Roger Pierson.

Pink Elatina Formation, 620 Ma glacial tillite with erratics, which underlies Ediacaran Nuccaleena Formation dolomite. Images courtesy Roger Pierson.

Ediacaran GSSP in the Nuccaleena Formation dolomite exposure on the southern bank of Enorama Creek at Lat 31.331°S, Long 138.633°E. Scale in centimetres.

The tillite, with prominent erratic pebbles, is shown below. A photograph of the golden spike Lat 31.331°S, Long 138.633°E is shown above.

On 19 March 2004 the IUGS approved the reference point indicating the beginning of the Ediacaran Period (about 620 Ma) in the Flinders Ranges. The Ediacaran Period golden spike marks the first new geological period to be defined in 120 years and it is the only time-slice demarcated by rocks in the Southern Hemisphere. On 16 April 2005, the then-premier of South Australia, Mike Rann, completed the formal defining of this especially significant Australian geological site by driving in the brass 'Golden Spike'. No fossils are present in the dolomite near the golden spike. Ediacaran fossils are found further west along the geological trail in younger sections of the Nuccaleena Formation.

Useful resources

Useful information resources for geological travellers in the Flinders Ranges include:

Commonwealth of Australia (1999) *Parachilna South Australia*, Topographical Map 1:250 000 scale, SH54-13 Edition 2.

Hema Maps Australia, Regional Map, *Flinders Ranges Regional Map*, 4th Edition.

Minerals and Energy, Primary Industries and Resources SA, *Brachina Gorge Geological Trail.*

Primary Industries and Resources SA (1999) *Parachilna South Australia*, 1:250 000 scale Geological Series, Sheet SH54-13 with explanatory notes.

Primary Industries and Resources SA, *Geology of the Flinders Ranges National Park.*

South Australian Department of Lands (1994) *Corridors Through Time — the Geology of the Flinders Ranges National Park.*

ROGER PIERSON
School of Life and Environmental Sciences
Deakin University

China's latest global geopark – Tianzhushan in Anhui Province. Image courtesy Xu Dian.

China, Australia and geoparks

Late last year, I had the privilege to visit China's latest global geopark – Tianzhushan (Tianzhu Mountain) in Anhui Province, west of Shanghai.

Tianzhushan is a truly amazing natural heritage icon of world-class standing. With spectacular and breathtaking scenery underpinned by a complex granite and metamorphic landscape, this geopark is unique in the world. An outstanding feature of the geopark is the design and construction of an extensive network of walkways and other essential infrastructure that immerse the visitor into the landscape and geology of Tianzhushan, the centrepiece of the geopark, but without detracting in any way from the visual amenity of the visitor experience. This feature is worthy of a global park design award, but significantly it is also a lasting tribute to the vast amount of human effort that was required to construct these works and the absolute dedication of the local community to put in place access to the landscape for the world community.

Also visited was the Valley Stream cultural park, which featured well-protected carved stone relics, with the constructed tourist facilities totally harmonious with the natural environment. On display in nearby Qianshan County Museum were unearthed stone tools, pottery, bronze and fossils.

A 'global geopark', as defined by UNESCO, is a unified area with geological heritage of international significance. It is a concept that enhances 'branding' of natural areas for tourism purposes. A geopark is not part of a designated land system that creates public reserves aimed at protecting or preserving natural heritage.

Currently there are 90 global geoparks – a large number of which are in China – spread across 27 countries forming part of the Global Geopark Network (GGN). The GGN is a growing movement that is perceived by host countries as a key driver of global 'geotourism'.

In 2011, the GSA established a Geotourism Subcommittee of the Standing Committee for Geological Heritage to advance and promote geotourism development in Australia, and to raise public awareness and appreciation of geodiversity. Although the issue of the future of geoparks has not been formally included within the Subcommittee's charter, it is recognised that some members of the Geotourism Subcommittee are able to provide advice about 'geopark' development in Australia.

The Subcommittee is very mindful that a November 2009 resolution of Australian Government Ministers for the Environment (EPHC) has determined that existing mechanisms are considered sufficient to protect geoheritage in Australia. After consultation with Resource Management Ministers, EPHC has expressed significant concerns with the application of the UNESCO geoparks concept in Australia, especially without government endorsement. Australia's only attempt to establish a global geopark, which embraces parts of Victoria and South Australia (Kanawinka), has not been approved by the Australian Government. Kanawinka Geopark has recently been delisted from the GGN.

Nevertheless, the Geotourism Subcommittee has also recognised that there is an opportunity to foster and promote geotourism initiatives within Australia's 16 designated National Landscapes with geological and geomorphological significance, as a model for advancing geotourism and geoheritage considerations in other regions.

ANGUS M ROBINSON
Chair, Geotourism
Subcommittee

Fossil problematica from Moreton National Park, NSW

I'm seeking assistance with a tricky fossil found in Moreton National Park, NSW.

Some time ago I was shown some unusual structures on the surface of steeply dipping arenaceous rocks in Moreton National Park. These tightly folded metasediments are Late Ordovician in age and locally form the basement to Permian sandstones of the Sydney Basin.

The patterns on the rock surface (see photographs below) suggested to me that they might be of organic origin.

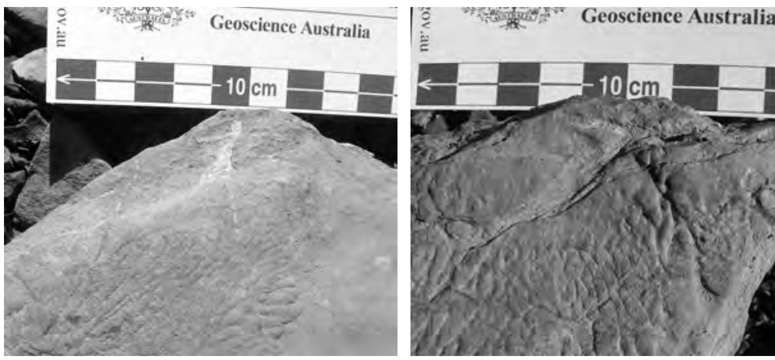
I am also aware that they may simply represent some kind of sole markings on the sedimentary bed.

If they are organic in origin, could they be imprints left by some form of sedentary sponge-like animal living in a deep-sea environment?

Graptolites are found in the Upper Ordovician rock sequence in this southeast region of NSW but they are confined to black slate horizons. They provide the only other fossil evidence in the Upper Ordovician metasediments.

If you think you can assist, please contact me.

PHIL SMART
Retired Member GSA, Volunteer Fossil Walk Leader
and Discovery Ranger with National Parks NSW
info@145ontheparade.com.au. Telephone 0408 588 166



Structures found in sediments in Moreton National Park, NSW.

Negative image of structures found in sediments in Moreton National Park, NSW. Images courtesy Phil Smart.

Feature 1

Snowy Mountains Hydroelectric Scheme

At the 34th International Geological Conference (IGC) in Brisbane last August, I presented a lecture on the Snowy Mountains Scheme. This fostered some interest among my engineering geology colleagues and I plan to publish a paper on it in due course. This article provides a brief summary of the project and the huge legacy it has provided the geotechnical profession.

The Snowy's contribution to engineering geology

Throughout the 1950s and 1960s I was aware of this great scheme while growing up in Canberra. With my family I would visit the Snowy Mountains for skiing and bushwalking and for trips to see the large dams. While a student at ANU I was also privileged to attend a field trip led by David Stapledon, one of the first engineering geologists to work on the construction. It was probably this trip that inspired me to follow a career in this field.

The Snowy Mountains Scheme, often known simply as the 'Snowy', was constructed from 1949 to 1974 and is located in southeast New South Wales, about 100 km from Canberra. The high country forms a divide between three main catchment areas for the Snowy, Murray and Murrumbidgee Rivers. Broadly, the scheme was devised to transfer waters from the Snowy River to the inland for irrigation purposes, with the combined benefit of generating hydroelectricity.

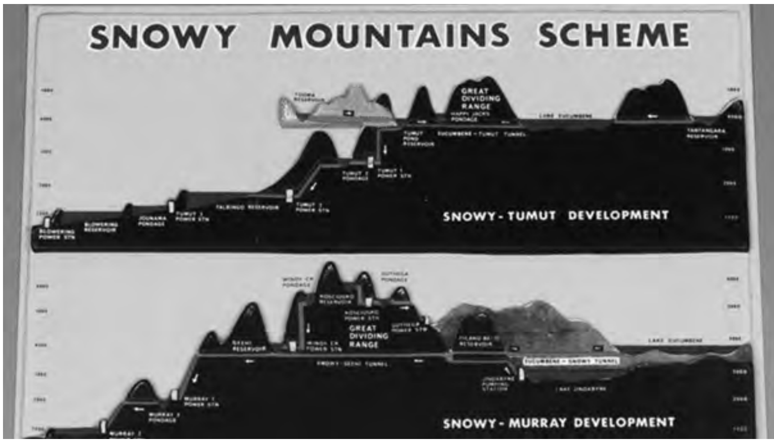
The project is in two sections:

- northern – Snowy–Tumut development
- southern – Snowy–Murray development.

Both developments are connected by tunnels to a main regulating storage on the Eucumbene River. The completed scheme comprises 16 large dams, over 145 km of tunnels and seven power stations with an installed generating capacity of 3756 MW.

The area was first surveyed in the mid-19th Century and the concept of diverting water inland can be traced back to the 1880s. However, it was not until 1949 that the *Snowy Mountains Hydro-electric Power Act 1949* was enacted, after much deliberation between the bordering states of Victoria and New South Wales. This was a large 'Plan for the Nation' and the Snowy Mountains Hydro-Electric Authority (SMHEA) was set-up under the leadership of the indefatigable Sir William Hudson. He brought together a team of world specialists to undertake this challenge. After World War II there were many displaced people, including skilled professional and trades people who also made the move to Australia to start a new life and take up the challenge in the remote Snowy Mountains. The construction period was from 1949 to 1974, starting with the Guthega Dam in 1951, well above the snow line.

The engineering challenges were immense in the remote and rugged mountains, with steeply incised river valleys and extensive snow cover in winter. The decision to construct underground powerhouses was partly due to the tough climatic conditions and partly to reasons of national defence. The Snowy Mountains Scheme is clearly the largest hydro-electric development in Australia and at the time of construction was one of the largest development projects in the world.



An information sign at one of the key locations for the Scheme – a familiar site for visitors to the area up to the 1970s. Image courtesy SMEC collection.

Inspection of the Jindabyne Dam site in 1951. The chief of the Snowy Mountains Commission, Sir William Hudson, in the grey coat, is with Daniel Moye on his left. From Dan Moye collection at **http://www.daniel-moye.org**.

Geology of the area

The Snowy Mountains are a set of high plateaus dominated by granites and metamorphics of the Lachlan Foldbelt. Generally the area has Ordovician metamorphosed sedimentary rocks that have been intruded by Silurian to Devonian granites with some development of gneisses. On the northern flanks are Devonian volcanic and sedimentary rocks, then a capping of remnants of Cenozoic basalt lava flows. Also of significance are the Quaternary to Holocene lacustrine and alluvial deposits, in addition to one of the few areas of glacial formations in the main range.

The geological structure comprises prominent north–south foliation, with extensive normal and strike-slip faulting that developed prior to and during uplift in the Cenozoic.

The geomorphological history is complex and has been inherited from one of fault-scarp development, crustal uplift and warping. This has resulted in stream capture, such as where the upper Murrumbidgee used to flow south to the Snowy River catchment, and now forms a significant about-turn to the north and then west.

Engineering geology advances

The investigation years by the SMHEA commenced in about 1949 and a team of geologists was set-up under leadership of Dan Moye as Chief Engineering Geologist, from 1949 to 1967. He built a team that pioneered many of the now-accepted practices in the discipline of engineering geology, including drilling methods, rock-mass classification, rock mechanics applications, tunnel logging methods and water permeability testing.

Dan Moye (1955) stated in his landmark paper:

Engineering geology in practice is a service to civil engineering (including the civil aspects of mining engineering). The engineering geologist should be, first and foremost, a well-trained geologist.

This statement still holds true today.

During the Snowy Mountains Scheme's site investigations, civil designs, construction supervision and monitoring, the following fundamental issues were addressed:

- classification of weathering of granitic rocks and strength estimation
- diamond drilling — triple-tube core barrels to improve core recovery, core logging and boxing methods standardised, careful recording of rock defects
- improvement of the water pressure test (Lugeon) method.

During celebrations of 'The Spirit of the Snowy Fifty Years On', Professor ET Brown stated, "... the Snowy's geological and engineering staff were ahead of their time".

The rocks encountered in the various project areas were commonly granitic — granites, granulite and gneiss — with variable degrees of weathering, often to 100 m depth. It was clear that a system for assessment of the performance of rocks and soils in slopes, foundations and underground openings was needed. This was when a classification of weathering was introduced by the engineering geologists, starting from 'fresh' (unweathered) through to 'completely weathered'. This and similar systems, defined internationally by various institutions such as the International Society for Rock Mechanics, form a basis for engineering description of rocks today.

In addition to weathering, the definitions of engineering properties of soil and rock materials were expanded to cover substance strength, geological structures, groundwater permeability and state of stress so that predictions could be made about excavatability, foundation suitability and stability of slopes. As the work proceeded underground, a new set of guidelines became critical for ground support (this is discussed later in this article).

The engineering geologists also became part of the design team, with contributions to design and tendering, and then to methods of construction and site supervision. During the development, contracts were awarded on a lump-sum basis, as the old government-supervised day works contracts on large civil projects were being phased out. Thus, the tender packages required a high standard with consistent and high-quality data. The need to provide geological information was aided by the discipline of obtaining quality data and standardising the presentation and rock quality classifications.

Above: The bucket test — bucket filled with crushed rock and model rock bolts used to demonstrate the principle to tunnel workmen. Image courtesy SMEC collection.

Right: Eucumbene–Tumut tunnel, indicating construction activity in 1954. Image courtesy SMEC collection.

Advances in rock-bolting technology

At this time in the 1950s to 1960s, rock mechanics was an emerging discipline and development of underground rock engineering was advanced during construction of the Tumut 1 and 2 underground power stations. Early stress analyses were typically done as a two-dimensional photoelastic modelling process. It was only after Tumut 1 was excavated did *in situ* stress testing start — by the flat jack method.

These studies and practical underground excavation work led to huge advances in rock-bolting technology:

- The technique of rock bolting was one of the many innovative engineering achievements used on the scheme to prevent rock instability.
- The properties and behaviour of rock played a major role in determining the design and construction programs adopted.
- Steel bolts of differing lengths and spacing were inserted, where they were found to be an excellent anchorage rock in tunnels.
- Grouting of bolts into the rock became the normal practice.

In the words of engineer Aubrey Hosking:

Previous to the Snowy, rock bolts were put up individually — this is, you put up a rock bolt because there was a bit of rock that was going to fall down, so you put a bolt up and pinned it to the rock behind. You've got to have an anchoring inside, and then you tension the bolt. If you're compressing it in the direction of the bolt, there is also a lateral force generated. What the Snowy did was to realize [sic.] that this lateral force could make the bolt self supporting — that is [if] you had rock bolts in a pattern, instead of individually, they could reinforce one another and create a structural entity, which would support a power station or a tunnel roof.

At one stage the underground miners expressed concern about working under a free span of rock with no steel rib support or other conventional support systems. All they could see were many face plates of the supporting bolts. So a demonstration was made by the geotechnical team by placing aggregate in a large steel bucket, then small model bolts were embedded and tensioned against inch-size face plates. The bucket was then upturned and nothing fell out. Whether this convinced all miners to get back underground was not recorded but for many years there was a large mine skiff with full-sized bolts hanging upturned near the Snowy Mountains Engineering Corporation (SMEC) laboratories in Cooma.

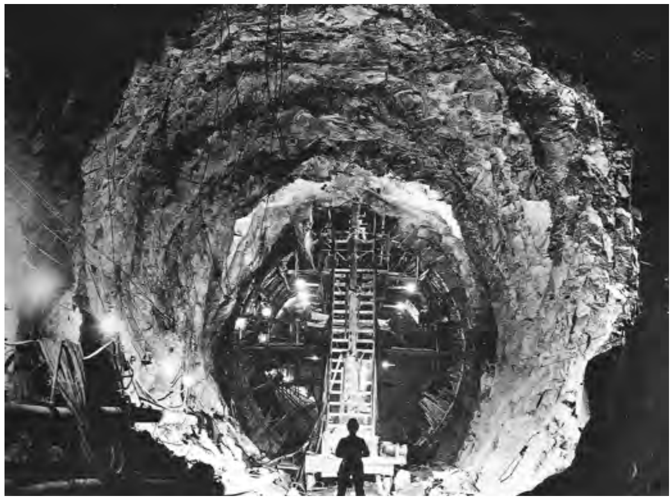
Tumut 2 power station cavern under construction. Image courtesy SMEC collection.

Field tests to assess the rock bolting were conducted at Lambie Gorge near Cooma and detailed design and analyses were carried from 1956 to 1962.

By 1959 over 40 000 bolts had been installed. This reduced the steel required for support to one-eighth of that for conventional methods. The resulting cost savings were about 45%, with additional benefits for safety and rates of tunnelling.

Professor Brown has also stated the development of rock bolting was "… probably the most significant engineering development made on the Snowy Scheme".

Guthega Dam under construction — image taken in 1954. Image courtesy SMEC collection.



Tumut 2 tailwater tunnel during construction. Image courtesy SMEC collection.

The rock bolting during driving of tunnels allowed for a huge improvement in efficiency and some records in tunnelling rates over subsequent years. The construction of major tunnels through the Snowy Mountains range reached a total of 145 km with excavated dimension all less than 7 m. They were driven mainly through granite, with some quartzite, siltstone, slate and hornfels.

The longest was the Eucumbene–Snowy Tunnel at 23.5 km. It was horseshoe-shaped and had a diameter of 6.9 m. The best tunnelling rate was in the Tooma–Tumut tunnel, where a 160-m drive was achieved in a 6-day week.

Legacy of the Snowy

The legacy of the Snowy for engineering geologists has included disciplined rock description and classification, improved quality of diamond drilling and in *situ* testing and pioneering of methods information for tenderers.

In rock-bolt research, the legacy has been pioneering of pattern bolting, instigating bolt grouting and improving installation procedures.

The discipline of rock mechanics has benefited from development of in-stress measurements and rock-support analysis methods.

As well as the testimony of the successful completion of the major dams, tunnels and power stations, Daniel Moye published graphic accounts of the way geology was applied during their planning and construction. Most of the principles and techniques of engineering geology described in these accounts are still accepted and indeed are standard practice worldwide today.

ROBERT GOLDSMITH

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AuSREM: Australian Seismological Reference Model

The recently completed Australian Seismological Reference Model (AuSREM) is designed to capture the wide range of seismological information on the Australian continent, and provide a synthesis in the form of a 3-D model that can provide the basis for future refinement from more detailed studies. AuSREM provides a representation of the 3-D structure beneath Australia and its environs (Kennett & Salmon, 2012) on a 0.5x0.5 degree grid in both latitude and longitude. The representations of the various model parameters in AuSREM are designed to be fully interpolable, so that properties can be extracted at any point. The reference model has been built using Australian specific information of varying vintage and quality. The aim is not to attempt to produce a definitive model, but rather to capture the major features of the structure beneath the continent and the surrounding region in a way that will allow testing against future results.

The AuSREM model provides a delineation of major structural features in the crust and mantle in the Australian region. It also provides information to support a wide range of studies, such as the calculation of earthquake source parameters, regional hazard modelling and imaging of lithospheric dynamic processes. The model is already being used in Australia for geothermal research, basin analysis, detailed tomographic studies and earthquake location analysis. The crustal and mantle models are also being used internationally for gravity and magnetic studies.

The AuSREM model consists of two parts: a crustal component specified at 5 km intervals in depth, and a mantle component at 25 km intervals from 50-300 km.

The two components are linked through the slice at 50 km. AuSREM builds on a recent map of depth to Moho data from refraction, reflection, tomography and receiver functions (Kennett *et al*, 2011 with updates from recent reflection profiling). The AuSREM model is available for download at the web site: **http://rses.anu.edu.au/seismology/AUSREM**, where tools for visualisation and access to information sources are available.

The crustal component of AuSREM makes use of prior compilations of sediment thicknesses, with cross checks against recent reflection profiling. P and S wavespeed distributions are provided through the crust, as well as density. The primary crustal model is for P wavespeed, and the other parameters are derived from this distribution. Direct information on P velocities comes from refraction profiles, and from analysis of receiver functions from distant earthquakes. Such information provides wavespeed profiles at about 200 points across the continent. The results of ambient noise tomography for 3-D structure in the crust (Saygin & Kennett, 2012) are then employed to link the point observations into national coverage. Useful structural controls are also provided by the extensive national coverage of full crustal reflection profiles. Details of the construction procedure for the crustal component of AuSREM, and further illustrations of the crustal model are given in Salmon *et al* (2013).

The nature of crustal model for P wavespeed is illustrated in Figure 1, with multiple cuts through the 2-D volume keyed to a depth slice at 20 km. In Figure 2 we show a snapshot from the visualisation pages at the AuSREM web site that exploit the display procedures of Google earth, to provide a representation of the P wavespeed field at 15 km depth with the locations of the refraction and receiver function sites superimposed. A summary of the P velocity profile at each point can be extracted by clicking on the point as illustrated in Figure 2.

For the mantle component (Kennett *et al*, 2013) the primary source of information on the upper mantle comes from seismic surface wave tomography, and the model draws on a range of recent studies with different path coverage and analysis procedures. Body wave studies and regional tomography provide useful additional constraints, particularly on the relation between P and S wavespeeds. Representative S wavespeed models have been developed to summarise the available information. The practical horizontal resolution is about 200 km, but as before the model is represented on a 0.5 degree grid in latitude and longitude. There is good evidence for polarisation anisotropy for S waves in the lithosphere and so separate models are provided for vertically polarised (SV) and horizontally polarised (SH) waves. The SV wavespeed distribution is issued to generate the other parameters including P wavespeed, density and S wave attenuation. The density conversion includes a compositional component to allow for the light roots of the cratonic regions.

The mantle model extends beyond the continent and so covers a larger area than for the crust. Below 350 km and in the surrounding area AuSREM is linked to the S40RTS model (Ritsema *et al*, 2011). Figure 3 shows a 3-D representation of the mantle structure keyed to a map view at 150 km, illustrating the strong contrasts in wavespeed across the region. Further illustrations of the mantle models and details of the construction of the mantle component are given in Kennett *et al* (2013).

The construction of the AuSREM model with open availability through the website marks just the first stage in making this summary of the structure of the continent widely available. Work is in progress on accessible 3-D visualization of the model in its various aspects. Tools are also under active development for location of earthquakes in the full 3-D model, and for earthquake source characterisation.

Acknowledgments

The AuSREM project has been supported by AuScope and the Australian National University. We are grateful to the many people who have contributed to the project through the provision of data and published work on Australian structure.

BLN Kennett & M Salmon
Research School of Earth Sciences
The Australian National University

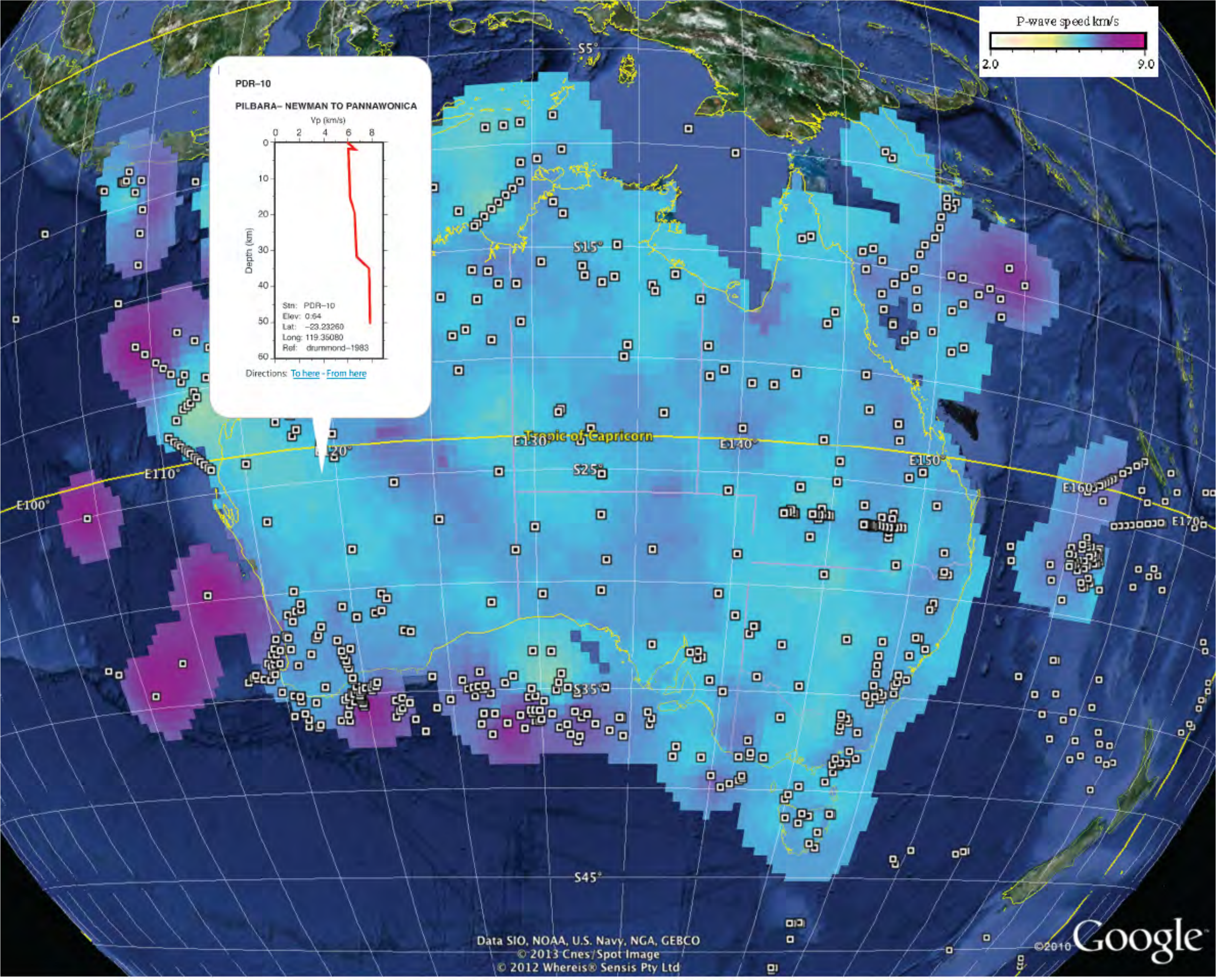
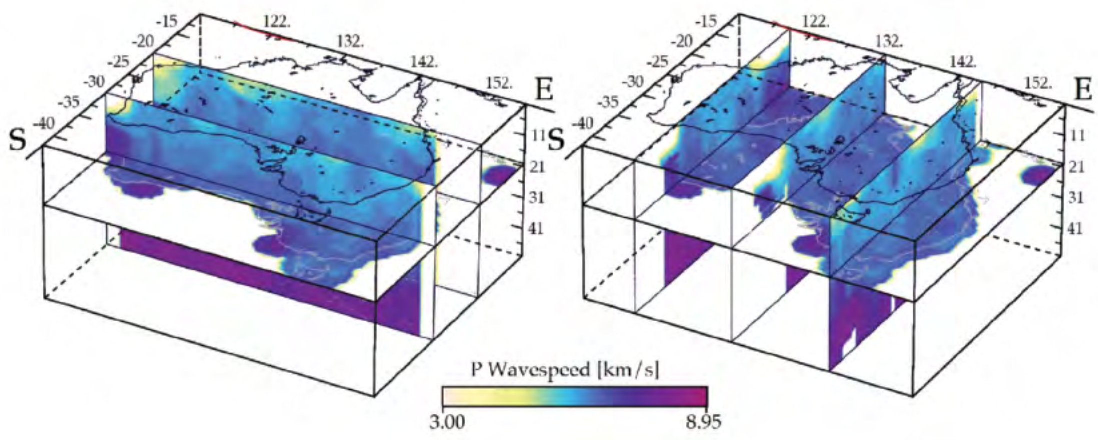


FIGURE 2: Snapshot of Google Earth Plug-in on the AuSREM website showing visualisation of the crustal model for P wavespeed at 15 km depth, and access to information on crustal models employed in the construction. Image courtesy Michelle Salmon.

FIGURE 1: 3-D view of the AuSREM crustal model for P wavespeed with cross-sections at constant latitude and longitude and a map view at 20 km depth. Image courtesy Brian Kennett.



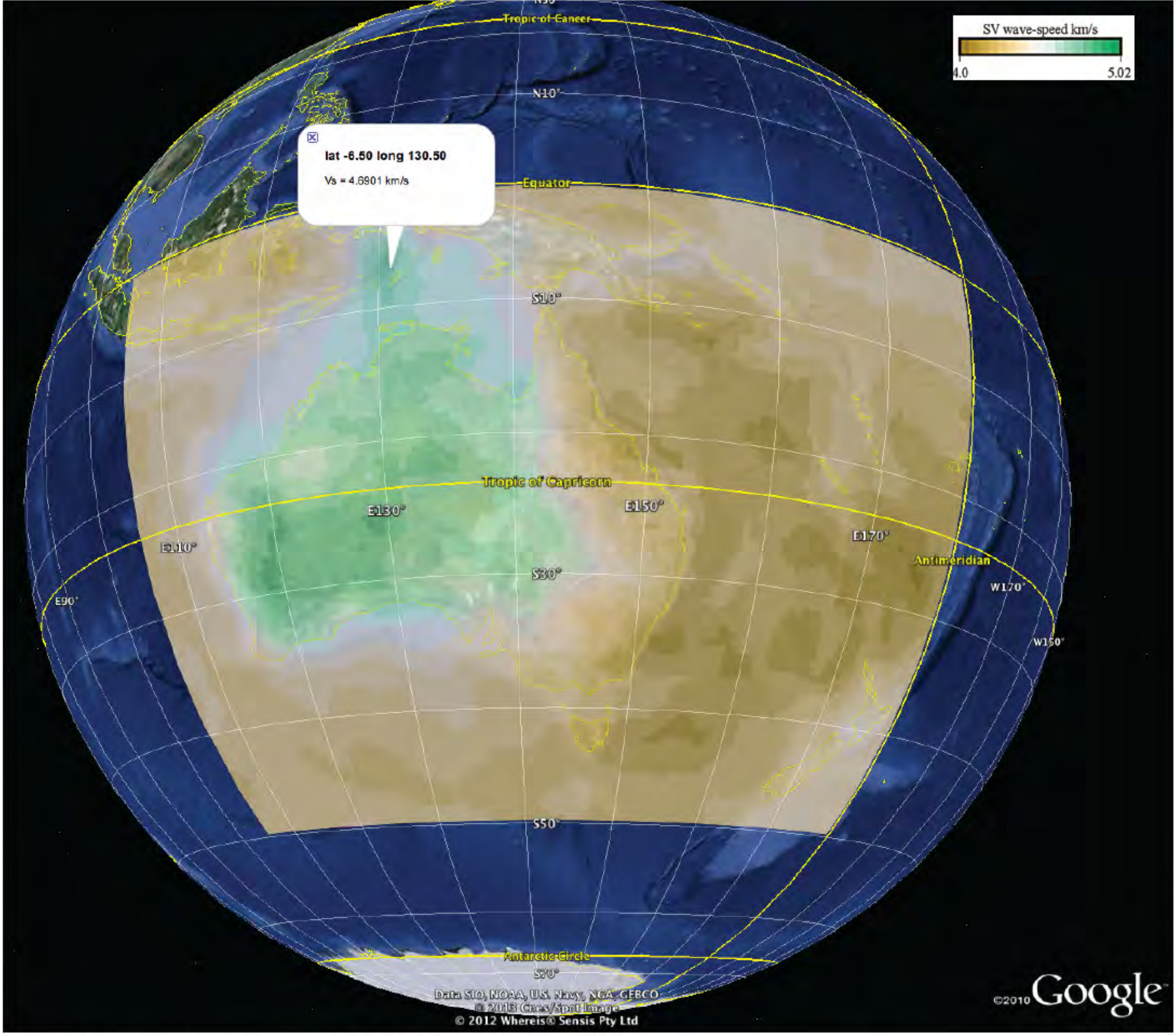


FIGURE 4: Snapshot of Google Earth Plug-in on the AuSREM website showing visualisation of the mantle model for SV wavespeed at 200 km depth, with access to wavespeed information at each grid point. Image courtesy Michelle Salmon.

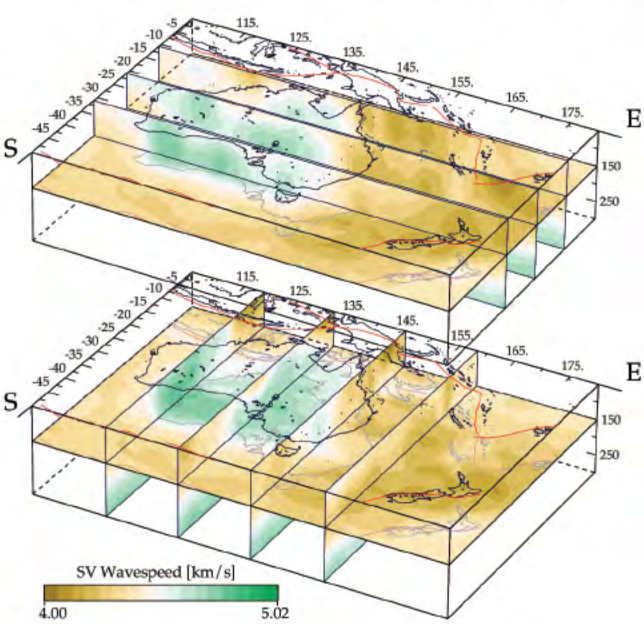


FIGURE 3: 3-D view of the AuSREM mantle model for SV wavespeed with cross-sections at constant latitude and longitude, and a map view at 150 km depth. Image courtesy Brian Kennett.

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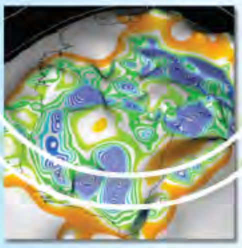
AuScope

Australian Geophysical Observing System - AGOS



The Commonwealth government EIF investment in establishing the Australian Geophysical Observing System (AGOS) is on track to deliver an important piece of Earth Science and Geospatial infrastructure for Australia. The first 18 months of activities has seen excellent progress on establishment of the capability for earth obseration and monitoring at 7 nodes across Australia.

Geohistory Laboratory

Progress at the Geohistory Laboratory has been on track with all major infrastructure components at the AGOS Melbourne node installed and commissioned. Specifically, the Confocal Laser Scanning Microscopy Facility and the Agilent ICP-Mass Spectrometer have been installed. Similarly at the Curtin University node the ICP-Mass Spectrometer has been installed together with the Excimer Laser Ablation System. Both nodes are now fine-tuning operations of new infrastructure and this will include a series of inter-laboratory calibration experiments.

Geospatial Observatory

The deployable GNSS equipment pool was purchased and the Equipment Access Committee created and activated with the first major surveys undertaken across the Gippsland and Otway basins in Victoria. The robotic antenna calibration unit has been installed at Geoscience Australia (GA). Work on the remote sensing portal continued with refinement of the Earth Observation Data Store at GA allowing for InSAR and design and orientation of the InSAR retro reflectors.

Inversion Laboratory

At ANU, the initial program suite of four Bayesian inference codes were delivered on time in beta form and shipped to beta testers at the University of Tasmania and University of Rennes, France who reported on installation and running issues in relation to the development process. The TerraWulf computer upgrade design phase was completed in February 2012. At the University of Queensland (UQ) node, software development continues with computer algebra techniques integrated into Escript providing a powerful tool for automatic generation of inversion software.

Earth Sounding Network

ANU completed the acquisition of 25 new Earth Data recorders. Prototypes of the new generation ANU recorder have been completed and tested with construction under way. Construction of a pool of 20 Ocean Bottom Seismometers has commenced. The University of Adelaide has constructed 100 new electric field data loggers for rapid field deployment for MT experiments and surveys.

Geophysical Education Observatory

AuScope Seismometers in Schools (AuSIS) project ran a successful pilot program at Melrose High School, ACT and Daralmarlan College. The AuSIS website was developed in collaboration with Macquarie University. The AuSIS Network was officially launched on the 31st of May 2012 by Minister the Honourable Kate Lundy. This launch marked the transition from the pilot program to a national level program. Since the launch applications to participate have been received from 55 schools across Australia.

Subsurface Observatory

The first instrument deployment of Subsurface Observatory program has been undertaken and collaborative projects have been established for use of the Petrophysics Laboratory by government organisations in Victoria and South Australia. The first subsurface access to a drill hole for application of the AGOS infrastructure was negotiated in Victoria and involved a new partnership with Granite Power Ltd who is investigating the subsurface character of the Tynong Granite for geothermal energy production.

The outlook for the scheduled completion of the AGOS infrarsucture program is positive and it has progressed to the stage where the infrastructure is being accessed for research in areas that were previously poorly served.

www.auscope.org.au

Special Report 1

Outback Outreach — Australia's dinosaur trail

Educators tell us that children respond positively to dinosaurs and volcanoes and Hollywood has long exploited emotive reactions to both. Consider the films *Dante's Peak*, *Volcano* and *Jurassic Park* or stories and mythology surrounding the Tyrant Lizard King (*Tyrannosaurus rex*). *Tyrannosaurus rex* elicits fear in the minds of children, as Hollywood made humans an enticing snack for the 'flesh-eating' dinosaur (even though we existed in different time periods). The first partial skeleton was found by Barnum Brown in 1902 — at the time *T. rex* was considered the biggest known meat-eating dinosaur. Has Hollywood just had more time to develop story lines that pervade most western media or is it a northern hemisphere-centric influence?

My own search for dinosaurs introduced me to other large reptiles from the Mesozoic and led me to ask why has *T. rex* become the most famous of these. What about a marine plesiosaur such as *Kronosaurus* or a local theropod dinosaur, possibly the frightening *Australovenator wintonensis*, affectionately named 'Banjo'?

As most paleontologists know, Australia has a diversity of fossils from the Age of Dinosaurs. Can we instil a familiarity with Australian dinosaurs that equals *T. rex* or do we need scarier names and stories that chill?

Recently, while visiting the Dinosaur Trail in Northern Queensland, I was reminded of the rich dinosaur history in our own backyard and was excited by the story-telling the curators there have developed. I wonder how we can use our local environments for outreach or educational opportunities. Dinosaurs are a way in, and the Dinosaur Trail in Northern Queensland is an impressive example we can learn from. The trail encompasses Richmond, Hughendon and Winton.

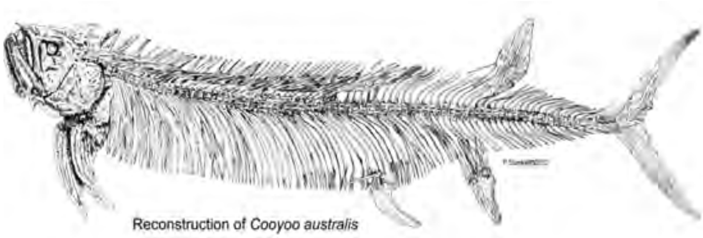
Roads paved in geological history

My exploration started at Richmond, not with a dinosaur but with a plesiosaur. Richmond and the immediate area were once part of an inland sea. One hundred million years later, the region has low horizons with big blue skies, an abundance of marine fossils and 'Kronosaurus Korner', a world-class museum that is home to more than 500 of these fossils.

The museum's name is no accident, as it is home to the pliosaur *Kronosaurus queenslandicus*, colloquially known as 'Kronos'. Kronos lived 125–100 million years ago and was a skilled, vicious predator of the inland seas. It was the biggest predator to live in the ancient Eromanga Sea. The museum holds a complete skeleton of Kronos. The neck was 5 m long — this marine reptile is *huge* and it is awesome to imagine it swimming and hunting. Scans of Kronos have shown turtle bones in the abdomen. The museum presents information on what these creatures from the past ate and how they lived, creating stories that the public can engage with. It is challenging for non-geoscientists to comprehend the time periods geologists are familiar with, but the museum also makes the time-frames more accessible to all. Kronos is twice the size of *T. rex* — imagine what Spielberg could do with that story!

Madonna Rogerson and Paul Stumkat put the finishing touches to the Kronosaurus Korner (fossil capital of Australia) signage on the way to Richmond, Queensland.

Dorree, a complete teleost fish from the Cretaceous of Richmond.



Reconstruction of Cooyoo australis, *Wandah the big fish. Above images courtesy Paul Stumkat.*

Fossil hunting organised by Kronosaurus Korner in Richmond. Gary Flewelling, Paul Stumkat (kneeling), Niel Hammond and Barb Flewelling. Image courtesy Paul Stumkat.

The Richmond region demonstrates high-quality Cretaceous fossils that are well preserved. Numerous invertebrates, dinosaurs, marine reptiles and fish skeletons are found in muddy limestones or in limestone concretions. Unlike many places in Australia where fossils are abundant, at Richmond the general public can dig for fossils unsupervised. The Council has two quarries where they source road-base, but the quarries contain fossils just slightly below the surface. Kronosaurus Korner encourages the public to explore the quarries and bring samples back to the museum for review. Quite a number of unique finds have occurred this way. While visiting the Council quarry, I found part of an ichthyosaur eye bone (sclerotic plate) just sitting on the surface — it now sits on my desk.

I wondered if this created issues for preservation and/or vandalism, and Kronosaurus Korner Curator, Paul Stumkat explained. "To engage the public in a positive way reinforces many positive outcomes for Kronosaurus Korner and the science of paleontology. Visitors to Richmond's public fossil hunting sites are encouraged to have a go to find their own piece of Cretaceous Queensland. Nine times out of ten they will discover specimens that are well represented in the museum's scientific collections. If they do discover something significant, they will often bring it into the museum for identification. Or, if it is a large specimen, they will not be able to withhold their excitement and ask the curator of paleontology to visit them in the field for a positive identification. Many fantastic specimens found by visitors are on display or in preparation with documentation identifying the discoveries. I always tell recalcitrant donors that it's better to have your name associated with a specimen in a public place than to have that specimen on your shelf at home where no one can see it."

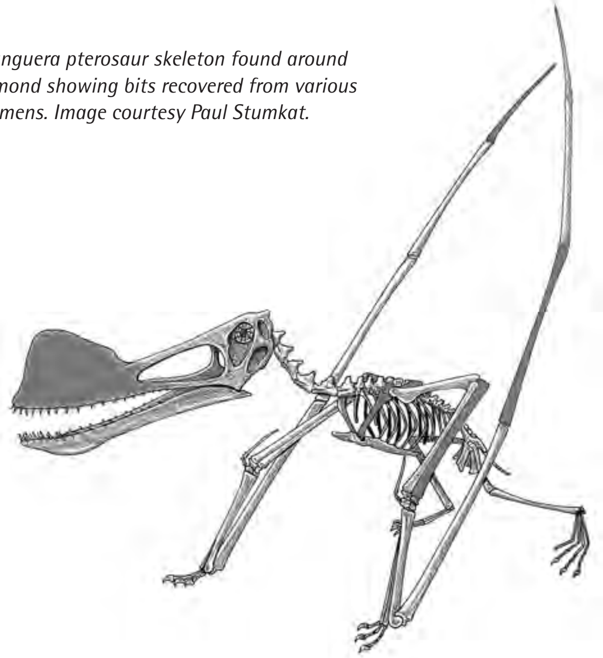
The holotype specimen of *K. queenslandicus* was described by Longman in 1924, and is currently in the Queensland Museum. Kronosaurus Korner tells stories of how graziers discovered a recent find of *Kronosaurus* in 1979. While mustering, cattle farmers noticed a few bones sticking out of the ground, contacted the Queensland Museum, and the rest is history.

Showing the science behind the bones

Kronosaurus Korner has some of the most complete marine reptile fossils in the world. While many geoscientists may know *K. queenslandicus* belongs to the short-necked plesiosaurs called pliosaurs, the general public often doesn't. The museum excels at making the science behind the bones come to life. An introductory film about Gondwana sets the scene for the period, explaining how the Eromanga Sea developed and why marine reptiles could have been in outback Queensland. A behavioural picture is built of *Kronosaurus* through details about teeth that evolved for tearing huge chunks of flesh from prey rather than chewing, and information about lungs and breathing, which explains why *Kronosaurus* continually returned to the surface. This picture enables us to visualise this creature from another time.

Facts about the marine reptiles are introduced through a mixture of film and signage with 'bones in sand pits' and a number behind glass. The museum boasts an example of *Minmi paravertebra* — an ankylosaur, or quadrupedal dinosaur covered in bony armour. It was first discovered in 1964 near Minmi Crossing, Queensland, and at the time was the first ankylosaur known from the Southern Hemisphere.

Dating the rock formations *Minmi* was preserved in indicate *Minmi* lived about 100 million years ago. Scientists have hypothesised how *Minmi* may have lived and ate, and importantly, the last days of *Minmi's* life and why it is in such great condition — this individual was not eaten by scavengers. The science is accessible through the story-telling that describes behaviour the public is familiar with — eating, hunting, reproducing and dying.



Anhanguera pterosaur skeleton found around Richmond showing bits recovered from various specimens. Image courtesy Paul Stumkat.

Scientific study

As well as being an educational facility, Kronosaurus Korner undertakes scientific study. For example, the Richmond Pliosaur is being studied on-site and is almost 100% complete. It could be the best preserved marine vertebrate skeleton in Australia. The laboratory window in the gallery provides direct viewing for museum visitors. A recent find of an adult ichthyosaur has a completely preserved body section (a first for Australia). A specimen of ichthyosaur *Platypterygius longmani* exhibits a number of young still in the abdominal cavity. Exciting stuff!

Asked about the attraction of the Dinosaur Trail and why there are regular digs, Paul Stumkat says, "Organised digs are one of the only opportunities where university graduates and the general public can not only experience the process of uncovering a significant specimen but also have their questions and curiosity satisfied by a curator of paleontology.

"Engagement with the visitor is high priority for Kronosaurus Korner. Not only do we want a budding paleontologist to learn about Australia's fabulous geological past but we also want them to have the opportunity to discover their own piece of Australian prehistory. Richmond is fortunate that it is strategically placed among the richest Cretaceous fossil beds in Australia. It is not unusual for amateur fossil hunters to pick up fragments from Richmond public fossil hunting sites of marine reptiles ranging from a giant *Kronosaurus* tooth to 110-million-year-old marine turtle shell or even an ichthyosaur vertebra. Often tourists will bring in a sample of a specimen that turns into a spectacular specimen. Some of these fantastic finds can be seen on display in Kronosaurus Korner museum with many finds turning into week-long field excavations. We encourage visitors to have their photo taken with their spectacular discoveries so they can tell their family or friends to go online [to **http://www.kronosauruskorner.com.au/new-finds**]".

Paul says, "Unravelling the paleontological past can be like trying to read a book that has been left out in the weather for 100 million years. This is why it is so difficult for scientists to discover the biological diversity of past environments. Often only a fragment of a highly specialised animal may remain to be interpreted by a paleontologist. Sometimes not so successfully."

Details	*Kronosaurus queenslandicus*	*Australovenator wintonensis*	*Minmi paravertebra*	*Diamantinasaurus matildae*	*Tyrannosaurus rex*
	Kronosaurus	Banjo	*Minmi*	Matilda	*T.Rex*
Where	Richmond, Qld	Winton, Qld	Minmi Crossing, Qld (near Roma) and Marathon Station near Hughenden	Winton, Qld	USA, (Montana Texas, Utah and Wyoming), Canada (Alberta) and Saskatchewan) and Mongolia
Period Time	Early Cretaceous (Aptian–Albian) about 125–100 Ma	Early Cretaceous (Latest Albian) 105–100 Ma	Early Cretaceous (Aptian) about 125–113 Ma	Early Cretaceous (Latest Albian) 105–100 Ma	Late Cretaceous, about 85–65 Ma
Diet	Apex marine carnivore – ate large fish, squid ichthyosaurs, turtles, ammonoids, elasmosaurus and smaller *Kronosaurus*	Carnivore	Herbivore	Herbivore	Carnivore – ate large dinosaurs like *Triceratops*
Length	12 m (approx)	5 m (approx)	3 m (approx)	15–16 m long (approx)	12.4 m
Height	2 m	1.5 m high at the hip (approx)	1 m (approx)	2.5 m high at at the hip (approx)	4.6–6 m
Weight	15–20 tonnes	500 kg (approx)	500 kg (approx)	15–20 tonnes (approx)	5–7 tonnes
Discovered	Longman 1924 first discovered by Crombie 1899	June 2006	1964	June 2005	Golden Colorado, 1874 (teeth only) Wyoming, 1890s (postcranial elements)
Interesting facts	Krono's head was over 2 m long–twice as large as the skull of *T.Rex*. Four massive flippers, up to 2 m long, powered it through the water. *Kronosaurus* breathed air.	Banjo had two massive claws – one a 15 cm hook, which helped Banjo kill. Banjo held its prey in a vice-like grip. It was light, agile and fast.	The Richmond *Minmi* is 95% complete. This specimen has interlocking bony scutes and ossicles covering even the belly region.	Most complete known Australian sauropod.	T.*Rex*'s arms were only about 1 m long, with two fingered hands. It had cone-shaped, serrated teeth that were continually replaced.

Fortunately for Paul Stumkat, he is able to work within lithographic units that exhibit exceptional fossil preservation. "Some fish specimens on display show 100% body preservation with details of gut and scales intact. This kind of preservation excites paleontologists from around the world who often visit Kronosaurus Korner to undertake comparative work on the museum collections. The museum collection policy is to curate any material that is new to science with a view to keeping these collections on display where visitors can enjoy them."

Banjo, Clancy and Matilda

A few hundred kilometres away, Winton is home to the Australian Age of Dinosaurs Museum of Natural History. While the dinosaur bones being excavated in western Queensland and on display at Winton are fragmented, the museum is home to the largest collection of Australian dinosaurs. With a highly productive fossil preparation laboratory, the museum attracts eminent paleontologists and provides opportunities for the general public to learn more about fossils and preparatory work. The Age of Dinosaurs conducts three week-long digs per year — great opportunities for outreach. The museum guides bring the dinosaurs to life by providing comparisons to animals the public are familiar with and again informing the public about behaviour that they can understand.

The Australian Age of Dinosaurs Museum is home to recent finds including *Australovenator wintonensis*, *Wintonotitan wattsi* and *Diamantinasaurus matildae*, known affectionately as Banjo, Clancy and Matilda, respectively. The enthusiastic story-telling makes a visit well worth the trip.

Stampeding dinosaurs

Another 100-km drive down the road is a step back in time at the Lark Quarry Dinosaur Trackways. This site is the world's only recorded evidence of a dinosaur stampede. Around 95 million years ago, a large herd of small two-legged dinosaurs gathered on the edge of the lake to drink. The herd included carnivorous chicken-sized coelurosaurs and slightly larger plant-eating ornithopods — some of these were the size of an emu. A large hunting theropod stalked the herd and when it charged, the herd panicked and the stampede created more than 3300 fossilised footprints on the muddy flats.

To stand where dinosaurs stampeded and to see the evidence is awesome and cannot help but excite the imagination of most people (including scientists).

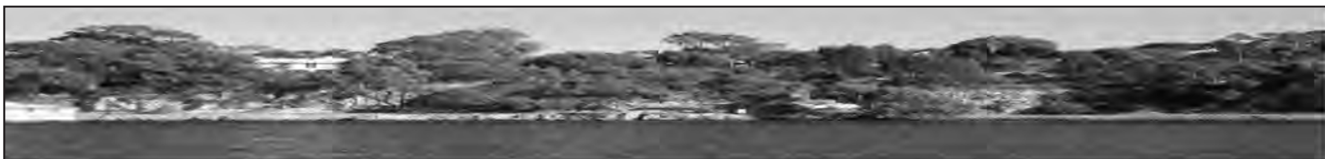
Battle of the dinosaurs

The 'Tyrant Lizard King' undoubtedly is a great name. A name that instils fear. But was it so scary because of its name or Hollywood's story-telling and mythology? Was *Australovenator,* meaning 'Southern Hunter' (and also known as Banjo), a meat-eater with razor-sharp claws and lightning speed, possibly a more fearsome hunting dinosaur than *T. rex*? Could the Southern Hunter become more familiar through a major part in a film or possibly a legendary cartoon character? Will an Australian dinosaur or marine reptile be immortalised by eating *T. rex* for breakfast if Hollywood stretched the locations and time periods?

Museums create access opportunities for science through play, stories, fun and engagement, while at the same time communicating the science. It is a challenge, but the Queensland Dinosaur Trail demonstrates it is entirely possible and entertaining. What is happening in your backyard that could develop story-telling for the general public or be the start of amazing mythology?

Special thanks to Paul Stumkat, Curator, Kronosaurus Korner, Richmond, Queensland.

SUE FLETCHER



A Field Guide to Perth and Surrounds
John A. Bunting and ESWA

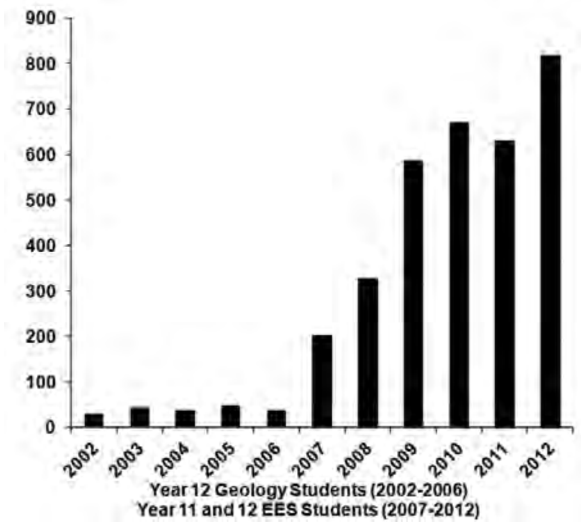
This A5, 110 page, spiral bound volume covers six geologically significant locations in detail and in full colour. Featuring an overview of the geology of Perth, detailed descriptions at each locality and a comprehensive glossary, this guide is designed to make your geological excursions easy and enjoyable.

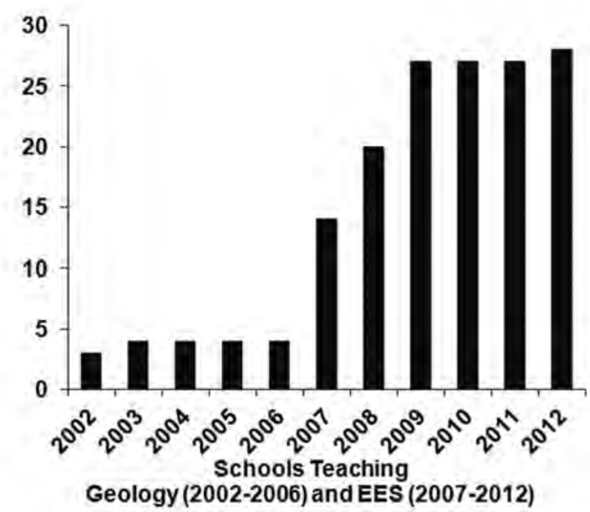
Further resources can be downloaded free from www.earthsciencewa.com.au
Available from the GSA for $34.00
http://gsa.org.au/publications/index.html or phone: (02) 9290 2194

Special Report 2

Earth Science Western Australia

Earth Science Western Australia (ESWA) has four main areas of operation: outreach to schools, development and provision of classroom resources, professional development of teachers, and publications. Thanks to the skills, energy and enthusiasm of our staff and Board, ESWA achieved very significant advances in the 2012 year for Earth Science education in WA schools. In addition, the broadening of our supporter base, and finalisation of new initiatives funded by Woodside Energy Ltd and BHP Billiton, give us cause to look forward to more progress in 2013.





The year began with an almost 30% increase in the enrolments of Year 11 and 12 students in Earth and Environmental Science EES), to more than 800 students at 28 schools (see graphs at left). This encouraging increase raised the demand for teacher and student support, both in the classroom and in the field, but did not impede a vigorous outreach program in WA primary and secondary schools. ESWA outreach has two objectives:

1. Continue to build on the increasing interest in Earth Science in WA schools.
2. Assess the needs in Years K–10 that follow from inclusion of EES as the fourth science subject in Years 11 and 12 of the Australian Curriculum. This development has led to an Earth and Space Science component in the new K–10 curriculum, a requirement that is challenging for many primary school teachers. The development is also an opportunity to embed Earth Science deeper into the education system.

Outreach highlights

Joanne Watkins (Executive Officer) and Julia Ferguson (Project Officer) travelled throughout WA presenting to over 6000 students from Kindergarten to Year 12. They provided professional development to more than 900 teachers (including repeat visits on request).

Students at the Jigalong Remote Community School learn about fossils with Julia Ferguson.

Year 12 EES students from across WA attend one of the free revision seminars provided by ESWA.

In June, for example, Julia and Jo visited 11 schools in the Pilbara region, introducing Earth Science to nearly 800 students and more than 30 educators. Primary and secondary students were able to create their own fossil replicas, take part in hands-on experiments to demonstrate volcanism and tested their powers of investigation with UV beads. Along the way Julia and Jo dropped off kits of fossils and minerals, which were full of hands-on materials and books of activities thanks to Atlas Iron Limited.

Numerous EES schools were supported to take Year 12 student field trips to Kalgoorlie for course enrichment and to see the industry in action. Students were hosted by the West Australian School of Mines, Paddington Gold Mine, KCGM (The Superpit), Daisy Milano Gold Mine (Silverlake Resources) and the Joe Lord Core Library, with assistance from Geological Survey of Western Australia (GSWA) geologists. Students also undertook fieldwork in the Kanowna area.

In October, we ran four free revision seminars for Year 12 EES students, hosted by Curtin University.

Our Geoscientists in Schools program was strengthened, with 11 volunteer speakers from across the industry now participating.

We also assisted with design and staffing of the inaugural Resources Pavilion at the Perth Royal Show in September, which showcased the gold, iron ore and oil and gas resources of WA. Showgoers were treated to 'gold' panning, hands-on 'mining' and the chance to see the 'Immerse' exhibit (on loan from the WA Museum, showcasing underwater technology). Visitors could also view equipment, videos and photos and interact with industry professionals.

School resources

We prepared boxes of fossils, crystals and minerals for loan to schools. These kits contain a teacher guide, a student booklet for photocopying and all of the hands-on resources needed to run many engaging lessons. The sets have been a huge hit, and they are now hosted in seven regional and two metropolitan locations thanks to generous support from BHP Billiton, the Petroleum Exploration Society of Australia, Scitech and Atlas Iron Limited. New funding from BHP Billiton will enable us to increase loan pools across WA in 2013, as well as to continue the student and teacher support for Years K–10.

The Woodside Australian Science Project (WASP) was initiated as a joint venture between ESWA and Woodside Energy Limited. Its aim is to provide a substantial suite of teaching resources in support of the Earth and Space Science component of the Australian Curriculum for Years 6–10. Included in these packages are hands-on learning experiences for students, together with support materials for teachers. The packages will be launched with accompanying professional development. Loan kits of resources and guest classroom presentations are also incorporated into this project and the resulting web-based resources will be available Australia-wide. Importantly, these resources will also highlight their relevance to other science subjects, where appropriate. The Year 7 package is already in use with resources for Years 8 and 9 to be released through 2013, and Years 6 and 10 in 2014. For more information visit **http://www.wasp.edu.au**.

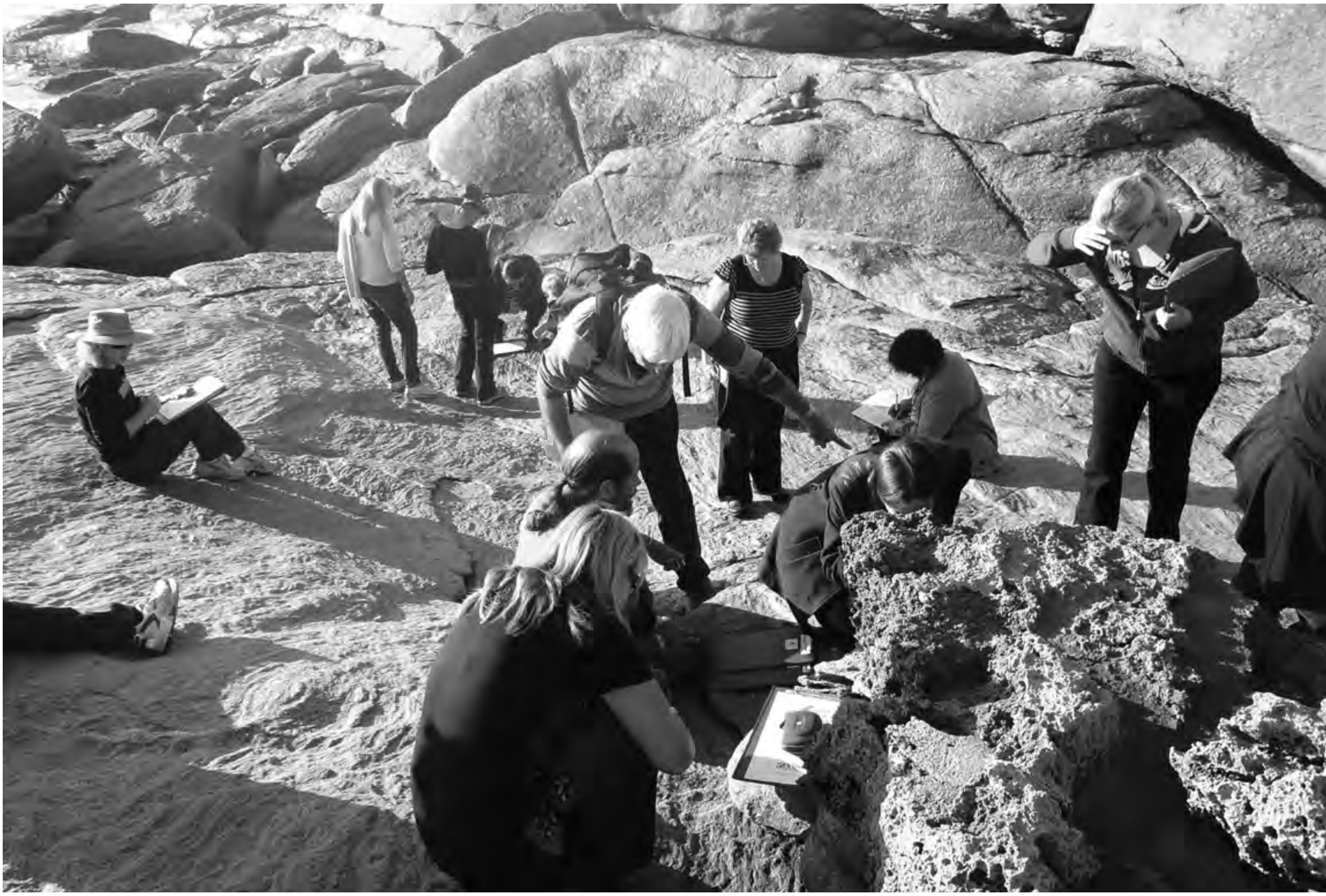
Professional development for teachers

Teacher professional development, together with ongoing support to teachers, is a large component of our work. Highlights in 2012 included the following projects.

We ran three sessions at the annual weekend conference hosted by the Science Teachers' Association of WA (STAWA). These were a hands-on experience to support the teaching of rocks and minerals; a suite of experiments to enrich the teaching of plate tectonics, plus a take home kit of resources for each participant; and a field excursion to Redgate Beach, one of the locations for our upcoming southwest field guide, led by John Bunting.

We assisted numerous professional development sessions designed to upskill primary science leaders in preparation for the Australian Curriculum.

We assisted a tour of New Zealand for EES teachers, run by Group Events. The tour included earthquake-devastated Christchurch, the Tasman Glacier, Queenstown, volcanic and cultural sites around Auckland and the volcanically active White Island.



Teachers investigate the geology of Redgate Beach with John Bunting. All images courtesy of Joanne Watkins and Julia Ferguson.

Focused professional development sessions for Year 11 and 12 EES teachers throughout the year included experts from industry and research institutions contributing expertise and resources and teachers sharing resources, expertise and experiences with one another.

Publications

Our popular textbook *Exploring Earth and Environmental Science* was amended and updated in preparation for its second print run. Planning has commenced for conversion to an eBook format in 2013.

Our first published field guide *A Field Guide to Perth and Surrounds* was launched in May and has received high praise from teachers and Earth Science professionals. It is accompanied by student booklets and has already assisted numerous schools to conduct excursions. The support of the WA Division and National body of the GSA in financing production of this guide is gratefully acknowledged.

Work has already commenced on ESWA's second field guide, covering the southwest of WA. We aim to complete it in 2013, again under the accomplished authorship of John Bunting.

ESWA's outreach

None of this work would be possible without our volunteer Executive and Board and a growing list of supporters, particularly CSIRO, Scitech, Woodside Energy Ltd and BHP Billiton. More details of ESWA's activities and supporters are available at **http://www.earthsciencewa.com.au.**

If you are looking to support Earth Science outreach in your State, and capitalise on the unique opportunity provided by the new Australian Curriculum, ESWA would be more than happy to assist with information and advice.

ESWA's contacts are Joanne Watkins (Executive Officer), Julia Ferguson (Project Officer) and Jim Ross (Chair).

JIM ROSS and JO WHELAN

[At the GSA 2010 Council Meeting, Council approved dollar-for-dollar subsidies for any Division wishing to undertake initiatives aimed at supporting introduction of the new Australian Curriculum, up to a limit of $5000. To date the only call on this support has been from the WA Division in 2011, for $2500 to support the printing of ESWA's first Field Guide.]

Special Report 3

Global warming and geoengineering – an Earth Science perspective

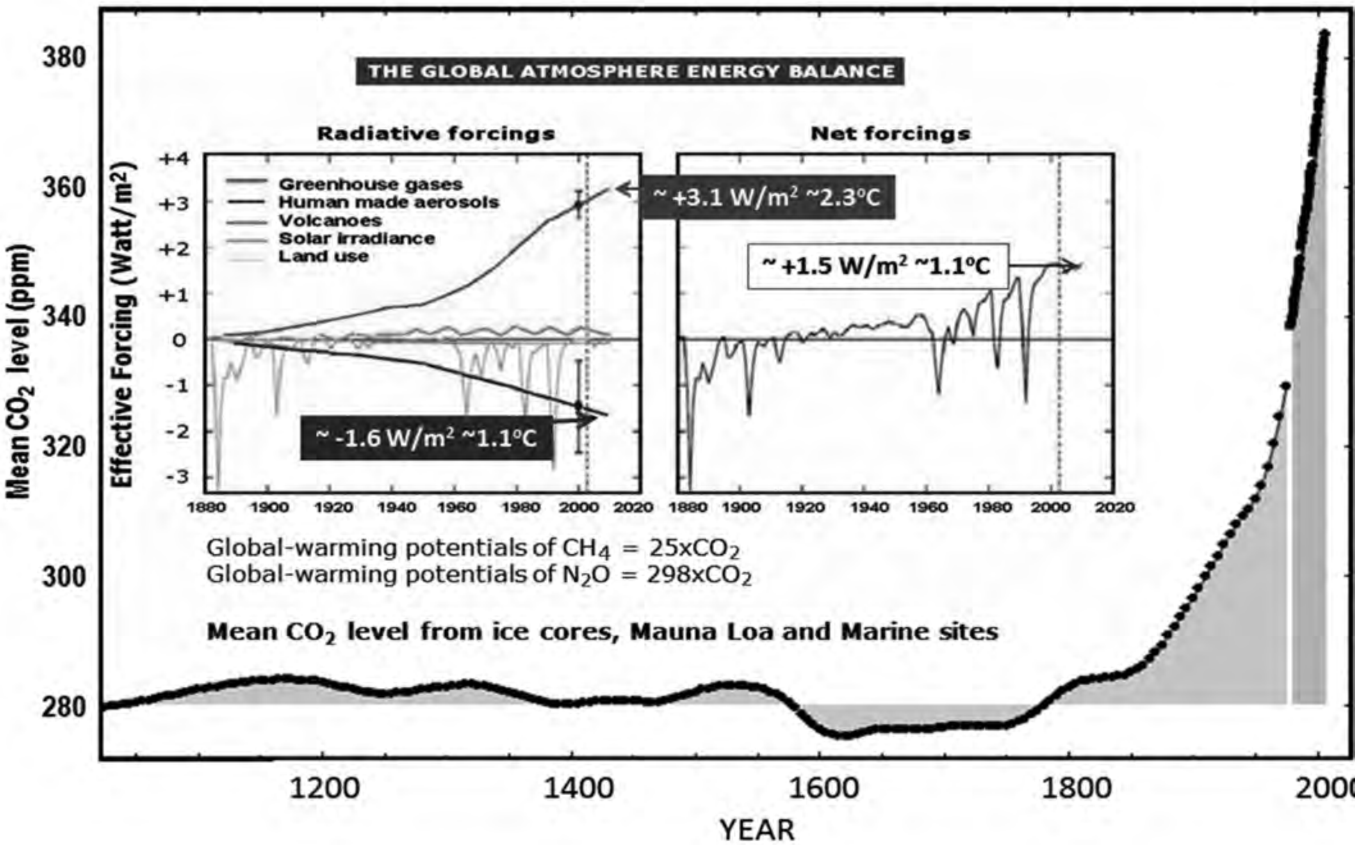
The scale and rate of modern global warming have been underestimated. The release to date of a total of over 500 billion tonnes (GtC) of carbon through emissions, land clearing and fires has raised CO_2 levels to 397–400 ppm and near 470 ppm CO_2-e (a value including methane) at a rate of about 2 ppm CO_2 per year (IPCC AR4; Global Carbon Project; State of the Planet Declaration; undated).

This is shown in the two figures accompanying this article. These developments are shifting the Earth's climate toward Pliocene-like (5.2–2.6 Ma, +2–3°C) conditions and possibly mid-Miocene-like (*ca* 16 Ma; +4°C) conditions (Zachos, 2001; Beerling & Royer, 2011; PRISM USGS Pliocene Project, undated), within a couple of centuries — a geological blink of an eye.

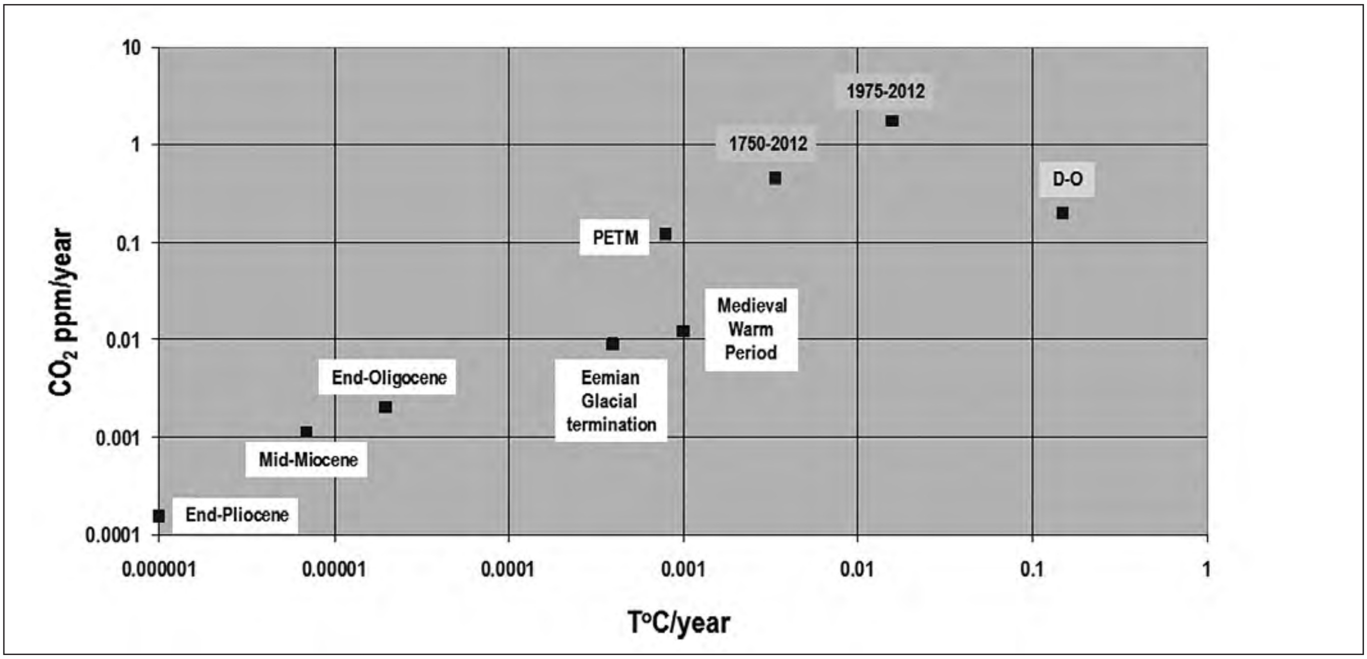
The current CO_2 level generates amplifying feedbacks from the ice–water transformation and albedo loss; from methane release from permafrost, methane clathrates and bogs; from droughts and loss of vegetation cover; from fires; and from reduced CO_2 sequestration by warming water.

With CO_2 atmospheric residence times in the order of thousands to tens of thousands years (Eby *et al*, 2008), protracted reduction in emissions, either flowing from human decision or due to reduced economic activity in an environmentally stressed world, may no longer be sufficient to arrest the feedbacks.

Four of the large mass extinction events in the history of Earth (end-Ordovician, end-Devonian, Permian–Triassic, end-Triassic, K–T boundary) have been associated with rapid perturbations of the carbon, oxygen and sulfur cycles on which the biosphere depends, at rates to which species could not adapt (Keller, 2005; Glikson, 2005; Ward, 2007).



Mean CO_2 level from ice cores, Mauna Loa observatory and marine sites. Inset — Climate forcing 1880–2003 (Hansen et al, *2011). Aerosol forcing includes all aerosol effects, including indirect effects on clouds and snow albedo. Greenhouse gases (GHGs) include O_3 and stratospheric H_2O in addition to well-mixed GHGs.*



Relations between CO_2 rise rates and mean global temperature rise rates during warming periods including the Paleocene–Eocene Thermal Maximum (PETM), Oligocene, Miocene, glacial terminations, Dansgaard–Oeschger (D–O) cycles and the post-1750 period (after Glikson, 2012).

Since the 18th century, and in particular since about 1975, the Earth system has been shifting away from Holocene (10 000 years ago to the present) conditions that allowed agriculture, previously not possible due to instabilities in the climate and extreme weather events. The shift is most clearly manifested by the loss of polar ice (Loss of polar ice article, 2001). Sea-level rises have been accelerating, with a total of more than 20 cm since 1880 and about 6 cm since 1990 (CLIM 012, 2012; Rahmstorf *et al*, 2012).

For a temperature rise of 2–3°C, to which the climate is committed if sulfur aerosol emission discontinues (see accompanying figure on mean CO_2 from ice cores), sea levels would reach Pliocene-like levels of 25 ± 12 m, with lag effects due to ice sheet hysteresis. With global CO_2-e levels at about 470 ppm, just under the upper stability limit of the Antarctic ice sheet, and with the current rate of CO_2 emissions from fossil-fuel combustion, cement production, land-clearing and fires of about 9.7 GtC in 2010 (Raupach, 2011), it is clear that global civilisation is at a tipping point, facing the following alternatives:

- With carbon reserves sufficient to raise atmospheric CO_2 levels to above 1000 ppm, continuing business-as-usual emissions can only result in advanced melting of the polar ice sheets, a corresponding rise of sea level on the scale of metres to tens of metres and continental temperatures rendering agriculture, in its present distribution and extent, unlikely.
- With atmospheric CO_2 at about 400 ppm, abrupt decrease in carbon emissions may no longer be sufficient to prevent current feedbacks (melting of ice, methane release from permafrost, fires). Attempts to stabilise the climate would require global efforts at CO_2 drawdown, using a range of methods including global reforestation, extensive biochar application, chemical CO_2 sequestration (using sodium hydroxide, serpentine and new innovations) and burial of CO_2.

SO_2 injections	Cheap and rapid application	Short multi-year atmospheric residence time; ocean acidification; retardation of precipitation and of monsoons
Space sunshades/mirrors	Rapid application. No direct effect on ocean chemistry	Limited space residence time. Uncertain positioning in space. Does not mitigate ongoing ocean acidification by carbon emissions
Ocean iron filing fertilisation enhancing phytplankton	CO_2 sequestration	No evidence that dead phytoplankton would not release CO_2 back to the ocean surface
Ocean pipe system for vertical circulation of cold water to enhance CO_2 sequestration	CO_2 sequestration	No evidence of cold water would circulate back to ocean depths where CO_2 is prevented from returning to the surface
'Sodium trees'–NaOH liquid in pipe system sequestering CO_2 to Na2CO3, separation and burial of CO_2	CO_2 sequestration estimated by Handsen *et al.* (2008) at $300 per ton CO_2	Unproven efficiency; need for CO_2 burial; $trillions expense (though no more than current military expenses)
Soil carbon burial/biochar	Effective means of controlling the carbon cycle (plants+soil exchange more than 100 GtC/year with the atmosphere)	Requires a huge international effort by a workforce of millions of farmers
Serpentine CO_2 sequestration	CO_2 sequestration	Possible scale unknown

Main proposed solar mitigation and atmospheric carbon sequestration methods.

As indicated in the table accompanying this article, the use of short-term solar radiation shields such as sulfur aerosols cannot be regarded as more than a band-aid, with severe deleterious consequences in terms of ocean acidification and retardation of the monsoon and of precipitation over large parts of the Earth. Retardation of solar radiation through space sunshades is of limited residence time and would not prevent further acidification from ongoing CO_2 emission.

Methods such as dissemination of iron filings in oceans aimed at increasing fertilisation by plankton and algal blooms, or vertical ocean pipe systems to bring about temperature exchange, are unlikely to be effective in transporting CO_2 to relatively safe water depths.

In contrast to these methods, CO_2 sequestration through fast-track reforestation, soil carbon, biochar and possible chemical methods such as 'sodium trees' and serpentine (combining Ca and Mg with CO_2) may be effective, provided these are applied on a global scale, requiring budgets on a scale of military spending (>$20 trillion since World War II).

Urgent efforts at innovation using new CO_2 drawdown methods are essential. One would think that a species that decoded the basic laws of nature, split the atom, placed a man on the Moon and ventured into outer space should also be able to develop the methodology for fast sequestration of atmospheric CO_2. The alternative, in terms of global heating, sea-level rise, extreme weather events and the destruction of the world's food sources, is unthinkable.

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Hansen *et al*, 2011. **http://pubs.giss.nasa.gov/abs/ha06510a.html.**
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Global Carbon Project
http://www.globalcarbonproject.org/;
State of The Planet Declaration
http://www.planetunderpressure2012.net/
Keller, 2005; Glikson, 2005; Ward, 2007. **http://www.amazon.com/Under-Green-Sky-Warming-Extinctions/dp/B002ECEGFC#reader_B002ECEGFC**
Loss of polar ice **http://www.agu.org/pubs/crossref/2011/2011GL046583.shtml.**
Rahmstorf *et al*, 2012.
http://iopscience.iop.org/1748-9326/7/4/044035/article.
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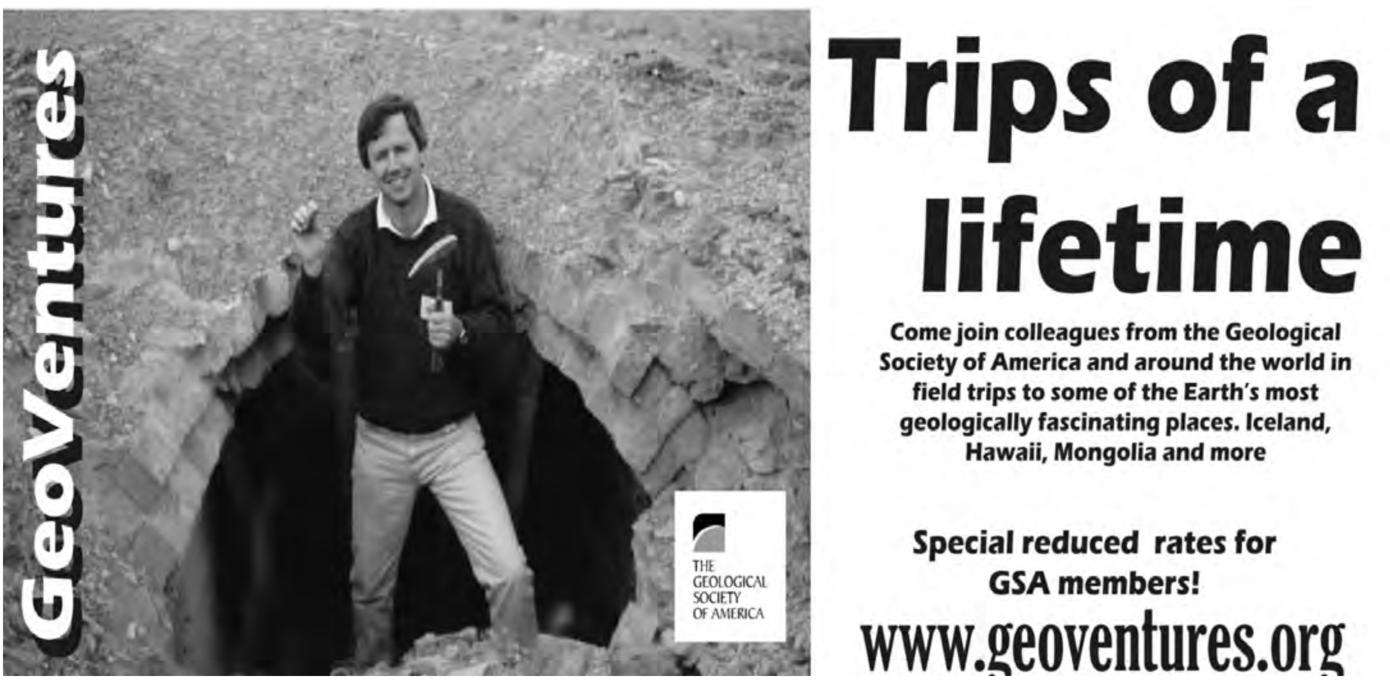
Zachos, 2001.
cmbc.ucsd.edu/content/1/docs/zachos-2001.pdf;



Special Report 4

IGC Geoheritage symposia

Report on the Symposium on *Geoheritage, Geoparks and Geotourism* at the 34th International Geological Congress, Brisbane, August 2012

At the IGC in August 2012 in Brisbane, Symposium 1.1 — *Geoheritage, Geoparks and Geotourism* had a strong presence from Europe of ProGEO members. There were also presentations from many other countries. Sessions ran over three full days, making this the biggest international geoheritage gathering in Australia. The geoheritage sessions were also much larger than those at the IGC in Oslo in 2008 and Florence in 2004.

Local presentations included the history of work in Australia by the GSA, by State governments in Tasmania and NSW, and the Australian Government through World and National Heritage listings. Other topics included fossil heritage, desert landscapes, the Pilbara region of WA, Wolfe Creek Meteorite Crater and the Kanawinka volcanic geopark of southeastern Australia. Many overseas presenters also took part in the symposium. Following two days about geoheritage, the third day was devoted to geoparks and geotourism, again with both local and overseas presenters.

At the conclusion of the meeting, participants left feeling highly motivated for the future of geoheritage, geoparks and geotourism, both internationally and within Australia.

Planning the meeting

Work on developing the symposium began in April 2010 when the author contacted Colin Simpson with an offer to help with the IGC Brisbane, noting also that José Brilha was planning to come to Brisbane for the meeting.

Having been asked to take over the planning of the Geoheritage sessions, the author and Colin worked together through 2010 and 2011 publicising the IGC and soliciting presentations from local and overseas geoheritage workers. Ross Dowling also became involved with the geotourism sessions, and Patrick McKeever with the geoparks sessions.

The geoheritage sessions at the IGC in Brisbane can be said to have had their origin in a ProGEO meeting at Braga, Portugal in 2005, when just a few participants were attending from beyond Europe and the Northern Hemisphere. At that meeting the author suggested it was time that ProGEO extended its interest and expertise beyond Europe. Francesco Zarlenga, the President of ProGEO, supported this idea at the closing ceremony in Braga. For the IGC meeting in Brisbane in 2012, Margaret Brocx and the author were appointed as ProGEO representatives in Australia. José Brilha came from Braga, Portugal, with other European colleagues to take part in this joint European–Australian exercise in working together on geoheritage.

In January 2012, the first of a numbered series of widely distributed emails was sent out to provide information about the Symposium 1.1 — *Geoheritage, Geoparks and Geotourism* at the 34th IGC. In subsequent emails abstracts were invited, and attention drawn to various articles published in *The Australian Geologist* and newsletters overseas. Details were also promoted sessions for the 'State of the art in the discipline of geoheritage' set-up by Margaret Brocx for the GSA and held outside the main conference at Queensland University of Technology (QUT). A summary program for geoheritage was made available on the website.

A website was set-up to include details about the conference symposium, relevant IGC field trips, published field guides, geoheritage guides to Australia, and links to the UNESCO Kanawinka Global Geopark in Victoria and South Australia.

Summary of the Geoheritage Symposium programs

The symposium was held in the Boulevard Auditorium. For program details see the *IGC Geoheritage Symposium 2012* website shown below under 'Further information'.

Wednesday 8 August 2012 — the opening session began at 3.30pm, with the author and José Brilha welcoming participants and introducing the geoheritage program to be held over the following days. Kevin Page presented his keynote address, taking the place of Bill Wimbledon who was unable to attend. (Our best wishes to Bill for his rapid recovery). Four presentations followed, with three by Australians. After a discussion session including details of the posters, we then went to the Mezzanine Level for our first poster session.

Thursday 9 August — a full day of sessions began with a morning session mainly on Australia. Sessions continued after lunch, with sessions 3 and 4, to conclude with our second poster session.

Session 2. Geoheritage in Australia and the Southern Hemisphere

Bernie Joyce opened the session with a tour of a range of sites of geoheritage significance in Australia, and discussed the role of members of the GSA operating within the framework of the governments of the day between 1960 and 2004. Susan White discussed the current position in Australia where there is a contrast between the objectives of the GSA in identifying and protecting sites of geoheritage significance for science and education, and the Australian Government's focus on thematic and iconic sites.

Michael Comfort spoke on the Tasmanian Geoconservation Database (TGD), which bears in mind that Tasmania is Australia's smallest State, but has 1084 sites listed, ranging in scale from individual rock outcrops to landscape-scale features. Under Tasmania's three major environmental codes of practice, the TGD must be consulted during the planning stage for some activities. A limitation of the database is that it only lists sites of known significance, and is not based on a comprehensive State-wide inventory.

Jane Ambrose's paper highlighted the importance of recognising and protecting sites with significant geoheritage values in Australia through World Heritage and National Heritage listings, a key way that the geoheritage values of places in Australia can be recognised, protected and appreciated.

Ian Percival spoke on protecting and preserving Australia's fossil heritage. Australia has a rich and diverse fossil heritage of critical importance to paleontology — some sites remain under threat from vandalism, theft and over-collecting. Federal law only protects fossil specimens, rather than the localities in which they occur. (Victoria currently has no legislation that specifically mentions fossils or the protection of paleontological sites.)

Gresley Wakelin-King spoke on the National Heritage potential in Australian desert landscapes. A study has been undertaken to assess the heritage values of desert landforms through literature review and specialist consultation, and using the Earth Sciences Comparative Matrix (ESCoM). The drivers of Australian landform evolution were seen to include inheritance, previous climates and the development of modern aridity — 29 sites spread across nice geomorphic themes have been identified with high potential to pass government heritage criteria.

Kathy Meney demonstrated the principle that geodiversity underpins vegetation biodiversity at all scales. She used a case study from the Pilbara region of Western Australia, where vegetation suites largely mirror the major geological units, as the landforms, habitats and geochemistry of the rocks and soils are distinctive and diagnostic of a geological setting.

José Brilha spoke on geoconservation in Brazil, a country that parallels Australia in its size and heritage values. Brazil has a small number of geologists and there is a focus on mining. José outlined the increased interest in geoconservation, with universities offering geosciences, multiple opportunities and ongoing projects to develop geoparks.

From the presentations above, it is apparent that conservation of sites of geoheritage is very much on the agenda of geological societies, government institutions and research institutions and that geoheritage has become a scientific discipline in its own right. However, while there has been a groundswell of interest in geoheritage, the institutional and multidisciplinary framework to deliver the benefits deriving from the research, and identification and protection of sites of geoheritage significance lags behind.

Margaret Brocx, session chair, provided the above summary for the Australia session.

[GSA sponsored the National Convenor for Geoheritage and two international delegates to attend the IGC upon special request – Ed].

Extra presentations

The afternoon concluded with two extra presentations, which had been inserted into the original program.

Ian Lewis, newly appointed Director of the Kanawinka Geopark in Western Victoria and South Australia, discussed his experience in Australia's first and so far only geopark.

Jonathan Tourtellot of *National Geographic Traveller,* as an Invited Keynote Speaker, explored the definition of the term 'geotourism'.

Geotourism and conclusion

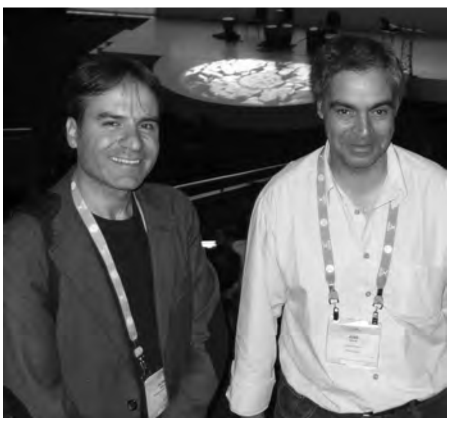
Friday 10 August — our third and last day, was devoted to geoparks and geotourism. Patrick McKeever opened the geoparks sessions with his keynote address 'The UNESCO Global Geoparks Network'. Angus Robinson then presented some new ideas for exploring new pathways for geopark development in Australia. In the early afternoon Ross Dowling began the geotourism sessions with his keynote address 'Geotourism — advancing geological appreciation through tourism'.

Friday afternoon concluded with a general discussion led by José Brilha on our plans for the future of geoheritage, and possible activities at other conferences — see 'Final discussion and plans for the future below'.

Newspaper publicity in Australia

The Sydney Morning Herald and its related Melbourne newspaper *The Age* published an article in the 'Traveller' section on Saturday 11 August 2012, quoting Patrick McKeever and Ross Dowling. It discussed geoparks, geotourism and the Kanawinka Geopark of southeastern Australia.

On Saturday 25 August, in the same newspapers, a letter from David Branagan of The University of Sydney welcomed the earlier story, but pointed also to the geoheritage discussions in Brisbane at the 34th IGC, with presentations and posters from across the world.



[L–R] Alireza Amrikazemi, Geotourism & Geopark Management at the Geological Survey of Iran and José Brilha, University of Minho, Portugal, Editor-in-Chief of Geoheritage *and Co-Convener of the IGC sessions on geoheritage, geoparks and geotourism. Image courtesy Patricia Erfurt.*

[L–R] Ross Dowling, Foundation Professor of Tourism at Edith Cowan University, Western Australia and keynote speaker on Geotourism, and Patrick McKeever, new Chief of Section at the Global Earth Observation Section and Secretary of the International Geoscience Programme, UNESCO, Paris, and keynote speaker on geoparks. Image courtesy Ross Dowling.

Patricia Erfurt, James Cook University, Australia, who spoke on 'Volcanoes and geotourism'. Image courtesy Alireza Amrikazemi.

Extra-conference GSA-sponsored session

On 8 August, during the IGC week at QUT, the GSA facilitated an international information session entitled 'State of the art in the discipline of geoheritage', which attracted 22 geoscientists from around the world who practice in the arena of geoheritage. Countries represented at the session included Australia, New Zealand, the UK, the USA, Hong King, China, Iran, Portugal, South Africa, Uganda and Romania, with apologies from Prof Shrikant Limaye from India. The event was sponsored by GSA, GSA (Qld Division) and QUT (see 'Further Information', below).

Symposium overview

A strong ProGEO presence from Europe and many presentations from other countries across the globe, with sessions running over three full days, made this the biggest international gathering to meet in Australia to discuss the three aspects of geoheritage, geoparks and geotourism. Total attendance at sessions, with numbers up to 80 at a time, can only be described as excellent.

In the geoheritage, geoparks, and geotourism sessions, convened by Bernie Joyce and José Brilha, there were 44 oral presentations, including keynote presentations by Kevin Page (Plymouth University, UK), Patrick McKeever (UNESCO), Ross Dowling (Edith Cowan University, WA) and Jonathan Tourtellot (*National Geographic*). There were also 15 poster presentations.

Sessional Chairs were José Brilha, Margaret Brocx, Bernie Joyce, Lars Erikstad, Kevin Page, Patrick McKeever, Changxing Long, Ross Dowling and Angus M Robinson.

Future of geoheritage in Australia and internationally

The last day concluded with a session entitled 'Final discussion and plans for the future' led by José Brilha.

The organisation at the 2012 Brisbane IGC of a symposium including the trilogy of geoheritage, geoparks and geotourism can be considered a successful model that should be implemented at the next IGC.

Geoconservation is an emergent geoscience. Funding agencies should increase support for research projects on geoconservation and academic institutions should consider this research as important as the research done in any other geosciences.

Although geoheritage is a recent geoscience, there is already a vast amount of scientific knowledge published during the last few decades. All of this knowledge should be used to support new studies on geoconservation with no need to 'reinvent the wheel', which sometimes happens, particularly in countries with no tradition of geoconservation.

Any geotourism and geopark project should be founded on a strong knowledge of geoheritage, including a proper inventorying and assessment of geosites.

Geotourism and geoparks can in turn provide geoheritage workers with responses from the public, and also greater security of individual geosites and the landscape.

Geoparks are an excellent tool to develop geoconservation, geoeducation and geotourism, at the same time promoting sustainable local development. In spite of the rapid expansion of geoparks all over the world there are still continents where efforts should be made to promote the geopark concept and the growth of the Global Geoparks Network, assisted by UNESCO.

We should all now plan how best to work towards the next IGC in Cape Town, South Africa, in 2016.

And we must continue to support our international journal *Geoheritage*.

Locally, some points Australian geoheritage workers can consider for the future are:

- cooperating with geotourism groups through the GSA's Geotourism Subcommittee
- reviving Divisional Subcommittees for Geological Heritage across Australia
- taking part in upcoming international conferences on geoheritage
- working with State governments
- working with the Australian Heritage Council
- working with the Kanawinka Geopark and the Australian Geopark Network Committee.

Conclusion

The last day concluded with a session entitled 'Final discussion and plans for the future' led by José Brilha.

Congratulations to all participants, from Australia and overseas, on an outstanding Symposium 1.1 — *Geoheritage, Geoparks and Geotourism*. The sessions at the IGC have provided a major boost to future geoheritage work in Australia.

Thanks also to those who planned the sessions over several years, reviewed oral and poster presentations, gave keynote addresses and chaired sessions. Thanks to Ross Dowling with the geotourism sessions and Patrick McKeever with the geoparks sessions, Lars Erikstad (NINA and the Natural History Museum, Oslo, Norway), Changxing Long (Global Geoparks Bureau, China) and Angus M Robinson (GSA Geotourism Subcommittee Chair, Australia). And special thanks to Margaret Brocx (National Convenor for Geoheritage, GSA) for the major contribution she made to the planning and smooth running of the symposium.

A full conference report is being prepared by Ian Lewis and will be published in the journal *Geoheritage*.

Manuscripts are being solicited for a special volume of *Geoheritage* and should be uploaded now to **http://www.springer.com/earth+sciences+and+geography/geology/ journal/12371**.

Further information

IGC Geoheritage Symposium 2012 website at **http://web.earthsci.unimelb.edu.au/Joyce/heritage/IGCGeoheritageSymposia2012.html**.

A link to the Final Program Geoheritage Symposium is available at **http://web.earthsci.unimelb.edu.au/Joyce/heritage/Geoheritage%20Symposia%2027.09.12.pdf**.

The main geoheritage site also includes photographs from the conference (to be updated as further material becomes available), newspaper reports, links to information about the GSA-sponsored sessions at QUT, conference field trips and other IGC-related material, publications of interest on geoheritage in Australia, some of the email news sent out before the meeting, and websites on geoheritage work in Australia.

Articles in *The Australian Geologist* are:
TAG 160 (September 2011, p 14)
TAG 163 (June 2012, p 21–22, 37–40)
TAG 164 (September 2012, p 18–19)
TAG 165 (December 2012, p 16–17, 40)

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Books for review

Please contact the Geological Society of Australia Business Office (**info@gsa.org.au**) if you would like to review any of the following publications.

SP367 Faulting, Fracturing and Igneous Intrusion in the Earth's Crust
D Healy, RWH Butler, ZK Shipton & RH Sibson

Gemstones of Western Australia
JM Fetherston, SM Stocklmayer and VC Stocklmayer

Destiny or Chance Revisited
SR Taylor

From Geomechanics to Geoid Tectonics: the analysis of major geological processes
PM James

Re-advertised

Geomechanics Applied to the Petroleum Industry
Jean-Francis Nauroy
www.editionstechnip.com

Essays in Honour of Frederico Waldemar Lange, Pioneer of Brazilian Micropaleontology Continent
EP Bosetti, Y Grahn, JHG Melo
www.editorainterciencia.com.br

A Colour Guide: geomaterials under the microscope
JP Ingham
www.mansonpublishing.com

Minerals, Metals and Sustainability: meeting future material needs
WJ Rankin
www.publish.csiro.au

Clean Energy, Climate and Carbon
Peter J Cook
www.publish.csiro.au

From the Geological Society of London

The following books are published by the Geological Society of London, **www.geolsoc.org.uk/bookshop** but are available from the GSA for review. Contact **info@gsa.org.au**.

SP293 Metasomatism in Oceanic and Continental Lithospheric Mantle
M Coltorti and M Gregoire

SP313 Underground Gas Storage
DJ Evans and RA Chadwick

SP337 Petrological Evolution of the European Lithospheric Mantle
M Coltori, H Downes, M Gregorie & SY O'Reilly

SP343 Dinosaurs and Other Extinct Saurians: an historical perspective
RTJ Moody, E Buffetaut, D Naish & DM Martill

SP358 Comparing the Geological and Fossil Records
AJ McGowan & AB Smith

SP361 Natural Hazards in the Asia-Pacific Region: recent advances and emerging concepts
JP Terry & J Goff

SP362 Military Aspects of Hydrogeology
EPF Rose & JD Mather

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Book Reviews

Geology of the Earthquake Source

A volume in Honour of Rick Sibson

Å Fagereng, VJ Toy and JV Rowland (Eds)
Geological Society of London, Special Publication 359, London 2011, 341 pages.
ISBN 978-1-86239-337-0

This Special Publication of the Geological Society is a well-presented compilation of papers, some of which were given at a special symposium *Geological and Geophysical Signatures of Earth Deformation and Fluid Flow* held at Oamaru, New Zealand in November 2009.

It surprised me to see that of the 18 papers, Sibson was the author of one paper and joint author of another in a volume dedicated to honouring him, his research-inspired teaching role and his efforts to integrate structural geology and seismology. The editors have grouped the papers into broad headings: Observations in active fault zones; Fault rocks and fault-slip styles; The base of the seismogenic zone; Effects of fluids on faulting; and Fault reactivation vs initiation. The sections are book-ended with a very useful introduction by the first two named editors, and Future directions, 'The scope of earthquake geology', from Sibson himself. Thankfully the editors included an index.

The earthquake source zones sampled include Italy, Japan, the Middle East, New Zealand, Norway, Turkey, Taiwan, the USA and surprisingly Australia — one of them just down the road from my office and over the border at Taemus, NSW.

It is a pity there are such lean pickings for seismologists in the book although it still should be on every Earth Scientist's reading list, seismologists included, thanks to Sibson's last chapter. Mostly the authors have focused on interpreting ancient rock deformation structures without the benefit of comparing them with the deformation observable in recent earthquakes where the fault skylights or ruptures deep mine leads. The educational process should work both ways. Toy, Ritchie and Sibson discuss the brittle–ductile transition zone at the central Alpine Fault in New Zealand without discussing why the earthquakes occur within the hangingwall and not on the fault itself. Neither do they discuss why the transition zone is so shallow at 8.5 km, whereas earthquakes occur to double that depth in Eastern Australia where the basement rocks are of similar age. This observation of current small earthquakes being restricted within the hangingwall and not on the fault has been made on the Lapstone Fault in eastern NSW (Gary Gibson, pers. comm., 2005).

Whether earthquakes create new faults or re-rupture existing faults has often been a matter of dispute between seismologists (see Sibson's last chapter). However, Nortje and others in their analysis present tangible evidence for both mechanisms in their study of copper mineralisation at Mount Isa. Scholz also addresses this issue briefly, explaining why splay faults can be so important in the process of reactivation of seemingly unfavourably oriented faults.

The final chapter by Sibson is a good read, covering the 40-odd-year history of earth-quake geology. He points to the need for better definition of fault zone models: the Christchurch earthquakes and large intraplate areas such as Australia are good examples of such a need. He points out that earthquakes do occur in what would normally be regarded as the ductile zone right down to the mantle. In passing, he states that the recurrence intervals on 'active' faults within intraplate areas may approach 10 000 years or more.

Sibson also suggests that research relating geological (ie, paleoseismological) observations to the physics of earthquake rupturing would be fruitful (are earthquakes fluid-driven or stress-driven?), that dynamic triggering of small earthquakes by distant great earthquakes is a reality (pooh-poohed by some Australian seismologists), and there is a need to develop sampling and statistical techniques to positively identify major earthquakes in the geological record.

I seem to remember John Tchalenko encouraging the Imperial College earthquake engineering students to attend one of Rick's talks in the very early 1970s and I wish I had had the time to listen to more of them. Undoubtedly seismologists need to learn more from geologists to refine their models and vice versa. Both need to learn more about the physics of the earthquake source.

The more I read this book, the more I warmed to it. Good thoughtful source material for all earthquake geologists and seismologists.

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Palaeoproterozoic of India

R Mazumder and D Saha (Eds)
Geological Society of London, Special Publication 365, London 2012, 290 pages.
ISBN 978-1-86239-345-5

The editors have pulled together 13 papers to produce another quality Geological Society Special Publication. The book emanates from a conference and post-conference field workshop related to the UNESCO-IGP 509 project on *Palaeoproterozoic Supercontinents and Global Evolution*.

The Indian shield comprises a number of major and minor Paleoproterozoic sedimentary basins and supracrustal sequences developed on four large Archean nuclei. The papers in this volume cover aspects of regional geology and have allowed the various authors to put portions of the Indian subcontinent into a global context. This is a particularly important outcome given the size of India. Furthermore it adds a sub-strate to country-scale evaluation for mineral exploration in a country that undoubtedly hosts major undiscovered mineral deposits.

The Paleozoic era spans the period of *ca* 2500–1600 Ma and has been interpreted by some authors as the first supercontinent cycle. Importantly, it encompasses one or more global tectonic events and implicates processes associated with the core, mantle, lithosphere, hydrosphere, atmosphere and biosphere. As such, the volume is a welcome contribution to the overall understanding of this period.

An introductory paper to the volume provides an overview of key stratigraphic and tectonic issues for the Paleoproterozoic. Although relatively short, the paper is important in that it brings out salient features for global comparison. Clear figures, often in colour, plus tectono-stratigraphic correlation tables make this a quality contribution. However, some of the correlations need to be viewed with caution as other contributors to the volume point out problematic and controversial regional stratigraphic issues that require further study.

The theme that pervades the book is the attempt to place Indian Paleoproterozoic tectono-stratigraphic events in a global context and to assess the validity of global-scale correlations. The authors are to be commended because areas lacking in information are identified and discussed rather than dismissed. If there is a criticism it is that some of the figures do not have grid coordinates. Many of these figures in more than one paper show key relationships but they cannot be assessed fully by the reader.

If anything, the papers highlight the elements of Paleoproterozoic geology in India that require considerable future study. In this sense it is refreshing as it doesn't offer a panacea to geological understanding of this period, but rather identifies many avenues of exciting ongoing study and discovery. Geological Society Special Publications provide collections of papers with up-to-date references, which are commonly as important as the papers themselves.

Having worked in India I am aware of the potential of the country for discovery of new mineral deposits and for the ongoing contribution to geological science in general. However, the volume is probably limited in scope for people who are not specifically interested in Indian geology, and its value will be restricted to those researchers working on specific global Paleoproterozoic puzzles. Overall, though, a welcome contribution.

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Orefind Pty Ltd

Geological Field Techniques

AL Coe (Ed)
Wiley-Blackwell, 2010, 336 pages
ISBN 978-1-4443-3062-5 (paperback)

As geologists, we learn the most while we are in the field looking at and discussing the rocks exposed before us. The old adage 'the best geologist has seen the most rocks' has been a central tenet to my professional life. However, as an undergraduate I added a qualifier '... but it helps if your field guide knows what they are looking at'. For many students, learning 'how' to think and 'what' to consider while working in the field comes primarily from our academic mentors (who may be a fellow student in the year above!) and the depth and quality of their experiences and practical field skills that can be varied and at times, incomplete.

Geological Field Techniques edited by Angela L Coe could be best described as a portable field demonstrator — a knowledgeable source of fundamental facts, techniques and examples readily available to teach us the 'how' of fieldwork, while offering practical advice on 'why' that only comes from time and effort spent getting it right in the field. Written for students of geology, the book assumes a basic understanding of fundamental concepts and theory in geology and maintains a broad overview across the geology spectrum of fieldwork.

Right from the start the detailed contents page outlines the logical and comprehensive approach taken by the text. The headings are simple and concise with each chapter organised to introduce the steps and considerations needed when preparing for and conducting fieldwork. The book consists of 14 main chapters (each colour-coded for easy reference), several pages of references, seven appendices and an index. Initial chapters introduce the reader to the safety aspects and equipment required for work in the field, the art of field observation at various scales, the importance of a notebook and techniques for recording observations and measurements. These provide an invaluable grounding for the inexperienced student as the authors adeptly instil the philosophy of why we do fieldwork by linking the equipment and procedures to the problem under investigation and the tasks ahead. Subsequent chapters outline methods for observing, describing and recording field information on fossils, brittle and ductile structures, and sedimentary, metamorphic and igneous rock types. The book concludes with shorter chapters on recording numerical and geophysical field data, field photography and sample collection.

The colour photographs, figures and illustrations are generous and clear. Often sequences of photographs and/or figures illustrate individual steps in an important technique accompanied by a detailed description in the text (eg, using a compass to measure the attitude of strata, constructing a cross-section). Flow charts and tables are well-structured visual aids that are used to good effect to illustrate processes and summarise important notes discuss in the text. Use of actual field maps produced by the authors, many while students themselves, gives a realistic perception of intended standards that the student should aim to achieve, and how important it is to clearly and logically collect relevant data for later reconstruction. Importantly, figures and related text are generally juxtaposed on the same page opening, making reference and visualisation effective. A highlight of the book is the inclusion throughout of coloured inset boxes placed at page margins that contain practical advice of the type typically dispensed by the experienced field demonstrator standing next to you. Each chapter ends with a section of further reading, with each reference complemented by a useful description of its focus and strengths. The appendices augment the main chapters well, containing commonly needed tables and figures for field identification of minerals, fossils and sedimentary features, interpretation of structural elements relating to folding and faulting, metamorphic facies and index minerals and mapping conventions. The paperback edition is made for the outdoor environment with good-quality coated paper bound in a weatherproof cover. While slightly heavy for easy scrabbling across the exposure book-in-hand, it opens easily in the palm and fits in a field pack.

Designed as a broad reference, this book is an ideal text for practical undergraduate fieldwork. There does appear to be a slight bias towards working in sedimentary rocks, with a greater level of detail included in these chapters than other chapters. However, this is addressed in the further reading suggestions. The companion website hosted by publisher Wiley-Blackwell is a useful resource containing figures, tables and photographs from the book and appendices, plus worked exercises with answers.

MARK N BURDETT

Slope Engineering for Mountain Roads

GJ Hearn (Ed)
Geological Society of London, Engineering Geology Special Publication 24, London, 2011, 316 pages
ISBN 978-1-86239-331-8

I am highly envious of the authors of this excellent book. In their well-thought-out, well-structured and wonderfully illustrated tome they have published a most useful book on engineering geology applied to the design, maintenance and assessment of mountain roads. It is one that I would have liked to have authored had I the time, patience and access to one of the best collections of landslide photographs and engineering geology illustrations I have seen in one place.

Past the foreword by the eminent Professor PG Fookes and an introduction outlining how to use it, the book is divided into four main parts. As explained in the introduction the book is not intended to be read from cover to cover (though it works well that way) but instead to be used by experienced professionals on an as-needs basis depending on the specific requirements of the job at hand. This might be preliminary geological/geotechnical investigations for route selection or slope risk assessment of existing roads to help plan maintenance and monitoring needs. The chart on p xii provides a handy road map of where in the book to go to find the required information. There is a glossary of terms and a handy index.

Part A covers the basics about landslides on mountain roads. Included here is concise information on the intended geographic coverage and climate conditions. While intended for the tropics the book also has wide application in subtropical and temperate regions and would be of great use to practitioners in mountainous terrain in eastern Australia and New Zealand for instance. Part A3 on slope materials, landslide causes and landslide mechanisms provides an excellent run-down of different soil and rock classes. The terminology used is a little different from the current Australian Standard for Geotechnical Site Investigations (AS 1726) but is applicable to some Australian conditions.

Part B covers site investigation ranging from scope and programming (B1), and desk studies (B2), which includes a good run-down on terrain analysis and development of landslide susceptibility and hazard and risk maps.

I was pleased to see field mapping given some prominence in section B3. This remains one of the best and most economical methods of developing local and regional geological/geomorphological understanding of a site or route from which to derive a geotechnical model that might assist in planning for road construction and maintenance in steep country. B4 deals with ground investigation and B5 briefly deals with monitoring slope movements.

Part C on design and construction deals with route selection (C1), earthworks (C2) soil and rock stabilisation methods (C3 and C4), retaining structures (C5), drainage (C6) and erosion control (C7). All these are well supported with case studies and excellent photos. All parts are quite up-to-date in terms of methods and materials.

Part D is about slope management and includes a section on slope risk assessment. The risk assessment procedure outlined appears to have some flaws with many slopes rating as high risk, leading perhaps to some difficulty in assigning remediation priorities by nervous asset managers. How do you decide which slope to start with if they are all equally high risk? This section cops my only criticism in that it omits the excellent guide to slope risk analysis developed by the NSW RTA (now Roads and Maritime Services (RMS); see Stewart *et al*, 2002), although this document is not widely available outside Australia. I have been assisting RMS with the further development of the guide for a number of years. I am also assisting in training, so admit a vested interest in it. I have forwarded the authors a copy of the RMS guide in the view that it might be referenced in future editions.

The text is supported throughout by an excellent collection of photographs, figures and tables. The authors are to be commended for the variety and sheer volume of photos and illustrations. Some photos are really quite stunning and they are well produced in colour. More to the point they are all relevant to the text and help expand on the excellent commentary.

Case studies are referenced throughout. These emphasise the practical nature of the text in seeking to provide users with practical guidance on the selection of remedial options, for instance. They are brief and to the point and again are supported by well-chosen photos often annotated to clearly show the features mentioned in the text.

One of the others things I enjoyed about the book was the practical no-nonsense approach to remediation and design. Many of the case studies have been collected from developing nations where funds for remedial works or for upfront design and construction of new roads are limited and practitioners need to make common-sense decisions that weigh practical factors of safety against the cost involved to implement them. It makes no sense to upgrade very short sections of road to high factors of safety when adjacent slopes remain vulnerable to failure from frequent rain events. The lessons are equally relevant to developed nations with old road networks designed to standards long since superseded, but with budgets that will not sustain a gold-plated solution to every minor road slip or rockfall.

I have run out of superlatives! This book will be of great practical use to those responsible for maintaining and managing fragile slopes next to roads in misty mountains in all countries, not just those found in the tropics. Congratulations again to the authors and editors.

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REFERENCE

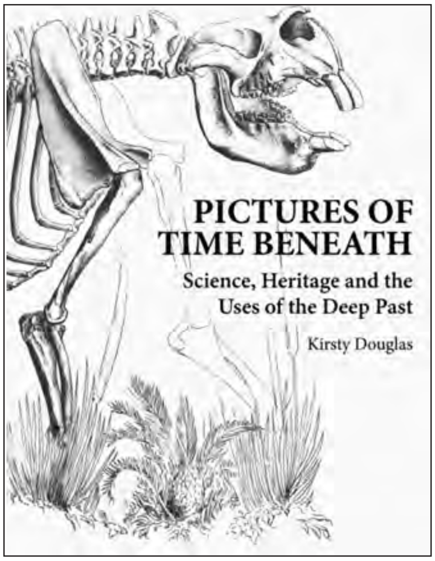
Stewart, IE, Baynes, FJ & Lee, IK, 2002. The RTA Guide to Slope Risk Analysis Version 3.1. *Australian Geomechanics* vol. 37(2) pp. 115–147.

Pictures of Time Beneath: science, heritage and the uses of the deep past

K Douglas
CSIRO Publishing, Melbourne, 2010, 224 pages, $89.95
ISBN 9780643097049

Kirsty Douglas works with the Natural and Indigenous Heritage Branch of the Department of the Environment, Water, Heritage and the Arts in Canberra. This book is based on a PhD at ANU, completed in 2004.

The book marks a period when we are hoping for a change in geoheritage work in Australia, making better contact with ordinary Australians and with the first inhabitants of



this land, and showing the richness of the last 50 to 100 000 years of our landscapes, landforms and recent life forms. The author here invites us to take our geoheritage work back into the 'deep past' of Australia.

Her colleague Tom Griffiths at ANU says (in one of several reviews available on the CSIRO Publishing website), "Her book is remarkable, and her vision highly original. She brings together geology, glaciology, biology, paleontology, climatology, archaeology, anthropology, geography, cultural history, heritage studies, politics, museology, environmental history, local history, national history, world history, philosophy, literature, poetry and, and … I could go on! It is an astonishing synthesis."

Douglas (2006) first published a paper on a theory of geological heritage, which concentrated on three landscapes in Australia. This book continues to use as examples Adelaide's Hallett Cove, inland South Australia's Lake Callabonna Fossil Reserve and the World Heritage listed Willandra Lakes of western New South Wales. Once thought of as 'wasteland, desert, forsaken, degraded, unproductive and isolated', such features are now being referred to as of 'world renown' or 'classic ground'. Douglas points to an evolving methodology of geological heritage in Australia, citing the work of the GSA and the former Australian Heritage Commission (now Australian Heritage Council). She includes a bibliography of 22 pages on heritage and geology in Australia, divided into published and unpublished material.

What the author is doing in her book is 'telling stories' — and she has three stories in all. This approach is now often suggested as the way to interest the public in heritage, in this case specifically geological heritage. (Today we mostly use the term 'geoheritage', while increasingly we also feel the need to emphasise the landforms and landscape — aspects covered by the term 'geomorphology'.)

The iconic Lake Mungo in the Willandra Lakes World Heritage Area/Place is one such place. Part three in the book examines Lake Mungo, discussing, "human antiquity and the watered inland: reading the scripture of the landscape" and the iconic geomorphological work of Jim Bowler which goes over 40 000 years into the past.

This is all part of a new and hopeful approach, where we can incorporate Aboriginal stories, young landscape stories (megafauna in South Australia, Queensland and Victoria), young volcanic landscapes of southeastern and northern Australia — and not just dinosaurs, which are more remote in time from us!

Part one of the book discusses Hallett Cove, with geological heritage extending well back in time, and including remnants of a Permian glacial landscape. The book relates the battle to save Hallett Cove led by local GSA heritage worker Maud McBriar — another iconic worker in Australian geoheritage.

Part two is entitled 'Dirt, bones and the diprotodons of Lake Callabonna: discovering the lost worlds of vertebrate palaeontology'. It tells the story of Australia's first fossil reserve using striking images of dying megafauna 40 000+ years ago.

Although a rather low-key presentation for CSIRO Publishing, this book belies its appearance. 'Iconic' is nowadays a rather overused word, but we might use it yet again and apply it to Kirsty Douglas's important book. I urge you to read it if you are concerned about the future of our geoheritage.

EB JOYCE

Evolution of the Levant Margin and Western Arabia Platform since the Mesozoic

C Homberg & M Bachmann (Eds)
Geological Society of London, Special Publication 341, London, 2010, 338 pages
ISBN 978-1862393066

This publication is a review of the disciplines employed in the study of the development and deformation processes of the Levant Basin. The data are derived from the Middle East Basin Evolution Program and the 'Levant Group' meeting led by C Homberg of the Université Pierre et Marie Curie, Paris, in 2006. The papers are in three sections relating to the offshore deep basin, and the southern and northern platform areas of the Levant. There are 15 papers of which six refer to tectonic evolution and a further six to basin correlations, facies patterns, carbon isotopes, biostratigraphy, paleontology and paleoenvironment studies. The remaining papers cover seismic stratigraphy and well data, development of syndepositional structures and the structural interpretation of exposed surface features from satellite views.

The value in the compilation is the release of multidisciplinary data and interpretations from a region with a key tectonic setting, which is readily visualised in a plate tectonic context that can thus be applied to other areas and geological ages. Notable figures include the Tethyan rift system of the Levant region, a seismic 'depth to top crystalline basement' map and generalised colour cross-sections illustrating the stratigraphic succession of the Levant Basin. There are a number of large-scale interpreted seismic profiles illustrating growth faulting (both marine and on the platform) and simplified geological and structural maps of Sinai and the Naqb Desert. There are also annotated colour satellite images of significant structures and folds of the North Sinai.
The publication is relevant to postgraduate students as the concepts developed might be applied to parallel studies. The work should be available to students and on-hand in petroleum company libraries for general reading and training.

A few editorials creep in with 'epiorogenical' and detachment of Gondwanan 'terrains' (p 12) but the summaries of structure and tectonics are very readable. There is however only limited reference to thin-skinned tectonics in the deep Egyptian margin or to the influence of the Messinian salt on structuring. Surprisingly there is a recent paper in Geological Society of London Special Publication 363 devoted to strain in the Levant Basin associated with four major halite detachments, which are interpreted from 3D seismic data.

Geology discussed in the volume covers the offshore Levant Basin (eastern corner of the Mediterranean) and the adjacent platform on the Arabian and African Plates, and it deals with late Paleozoic and early Mesozoic basin development and late Cretaceous–Cenozoic deformation associated with the closure of Tethys. The Mesozoic eastern margin of the basin and its shelf edge are identified near the present-day Israeli coastline as a narrow transition zone extending from northern Egypt to western Lebanon. Late Cretaceous convergence of Afro-Arabia with Asia resulted in the north-dipping subduction zone at present-day Cyprus and southern Turkey. This event is marked in the Levant Basin by inversion of existing normal faults and local deformation with pronounced paleorelief, also the development of syndepositional basins and swells resulting from growth faulting. There is thus a wide range of sedimentary environments ranging from outer shelf to deltaic–fluviatile deposits. The last major tectonic event is recorded as the breakup of the African and Arabian cratons with the development of the Dead Sea transform. Sinistral movement on this boundary amounts to about 100 km. In brief, the Levant Basin is a structure of considerable interest due to its tectonic setting and the influence of major plate interactions since the breakup of Gondwana.

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Shaping a Nation: a geology of Australia

R Blewett (Chief Ed)
Geoscience Australia & ANU Press, 2012,
571 pages, $70.00
ISBN 9781922103437

If the 34th IGC in Brisbane (August 2012) achieved nothing except the related writing of this book, we should be grateful. The unusual structure of the book probably owes its form to the Editorial Board and Chief Editor, Richard Blewett. The 11 chapters were written by 57 authors, some making multiple contributions.

This large tome (hard cover printed on art paper, weighing almost 8 kg) is, at the same time, both fascinating and annoying. The landscape format is well adapted to its many fine maps, photos and figures, although the localities of some photos are not identified.

The editors state, "this book is not another geology of Australia with the rocks, minerals and fossils catalogued through time". Rather it deals with "Australian geology: the foundation that shapes the people". This concept is imaginatively brought out in Figure 1.1, and is presented again in a different form, encircled by 'Earth System Science', in Figure 11.1.

The titles of the 11 chapters, too, give an idea of the book's 'philosophy': Australia and the Australian people; Australia in space and time; Living Australia; Out of Gondwana; Old, flat and red — Australia's distinctive landscape; Living on the edge — waterfront views; Groundwater — lifeblood of the continent (perhaps the most accessible technical chapter); Foundations of wealth — Australia's major mineral provinces; Sustaining Australia's wealth — economic growth from a stable base; the interesting 'speculative' Deep heat — Australia's energy future?; and Advance Australia Fair.

The relationship to the Australian people is strongly maintained, most notably through mentions in chapters one, two, seven and eleven. Recognition is given in places to the contribution of the Aboriginal people, notably in their respect for country.

An important topic discussed is the question of the age of Australian landscapes. While there seems to be agreement that many Australian landscapes presently visible are old, opinions differ, even within a single chapter as to: (1) whether they have remained exposed since formation, weathering slowly and eroding even slower; or (2) they have been protected by thick cover and owe their appearance today largely to uplift and exhumation. In chapter 6 (p 289) there is mention of "minimal landform erosion, ... a strong feature of the dry, flat regions of southern Australia". What does one make then of the discussion of apatite fission (p 260 and Box 5.5), which is said to provide "estimates of denudation over large areas"? Figure 5.23 presents the results of such calculations, Australia-wide. This figure seems to call for almost catastrophic activity to remove 4 km of rock adjacent to areas from where only 2 km has gone. South Australia, as depicted, is one such region. The localities in all states and territories (notably Queensland) showing nearly zero removal, often sit somewhat uncomfortably close to regions of claimed extreme denudation. Figure B5.5b by Scott and Pain (2008) seems to absolutely contradict Figure 5.23. For the present I will stick with S & P!

Editing and proof-reading have been very well done, but in a volume of this size and complexity, a few errors have escaped notice. Box 2.2, p 67 incorrectly credits Edgeworth David and his party with reaching the South Magnetic Pole. Box 4.3 (p 196) uses 'palaeography' for 'palaeogeography'. Figure 5.10a (p 240) suggests that Pain (1985) 'defined' the 'Great Escarpment', but it is surely Ollier (1982), as referred to on several figures. Box 5.2 (p 246) puts the Murray–Darling headwaters all in Central Queensland, but they are not.

A new matter for me was the appearance of caveats accompanying some illustrations. The small print accompanying the data on Figure 4.11 (similar for other figures) puts the onus on the reader to check the information before using it, presumably for economic purposes. Has the legal world gone over the top?

In terms of grammatical use, the volume proves that the 'infinitive is well and truly split'!

Geologists of all levels will gain much from the book, although perseverance will often be needed. Local terminology will appeal to Australian readers, but overseas readers might well be puzzled by some material, including occasional typical Australian self-deprecating remarks.

The book is a fine, if demanding volume, showing how important geology has been, and continues to be, for the Australian population. Although somewhat too proselytising at times, it deserves wide circulation. Martin Ferguson, the present Minister for Resources, Energy and Tourism, endorses the volume enthusiastically, writing, "This exciting book demonstrates the fundamental importance of the study of Earth Sciences to our society." Well said, sir!

DAVID BRANAGAN

REFERENCE

Scott K & Pain CF (eds) 2008. *Regolith Science*, CSIRO Publishing, Melbourne.

Geology of Queensland

P Jell (Ed)
Department of Natural Resources and Mines (DNRM) and Geological Survey of Queensland, 970 pages

This brilliant book has been written by teams of geoscientists from the Geological Survey of Queensland, universities and industry. It is exceedingly well edited by Peter Jell.

There are two parts to the volume. The first and larger part describes the hard-rock geology that underlies younger basins and recent cover. These provinces range in age from the Precambrian rocks of the North Australian craton (chapter 2) through the Neoproterozoic to Paleozoic Thomson Orogen (chapter 3), which is largely obscured by the Eromanga Basin, the newly named Paleozoic Mossman Orogen (chapter 4) and the Paleozoic to Mesozoic New England Orogen (chapter 5) and related Carboniferous-Permian granites of the Kennedy Igneous Association (chapter 6).

The second part of the volume brings us up to the present day by describing younger rocks (post orogenic Mesozoic basins and magmatism, chapter 7), Paleogene and Neogene (chapter 8) and Quaternary (chapter 9). It even includes impact structures and meteorites (chapter 14). But more significantly, it describes what one does with these rocks and why they underpin the economic development of Queensland. Mineral and energy resources are discussed in chapter 10, engineering geology in chapter 12 and groundwater resources in chapter 13. Chapter 15 briefly introduces the reader to the geological heritage of Queensland and discusses preservation as well as geotourism and understanding landscape evolution. Seismicity is discussed in chapter 11. This focuses on databases and spatial distribution. To my mind it would have been enhanced by placing it in a structural context. All this is underpinned by an exhaustive reference list of 117 pages!

This book is the most up-to-date summary of the geological development of Queensland over the last 1870 million years. This story of Queensland's evolution is told mainly in terms of the logical development of different stratigraphic units on top of one another, although the description of the Mt Isa Province is clearly told in terms of tectonic events based on a sequence of events encompassing (super)basin formation, crustal extension and crustal contraction. Clear maps and time–space plots help clarify the geology. All figures are in colour and this is a tremendous help. The last parts of the 'hard-rock' chapters discuss different tectonic hypotheses, so that there is a welcome clear subdivision between 'facts' and 'arm-waving'.

This is a fantastic book: it's the one I've been waiting for because, to be honest, I've always had trouble visualising the subdivision into different tectonic elements and how the Neoproterozoic to Mesozoic elements of Queensland geology fit into the coeval rocks of more southern parts of the Tasmanides of eastern Australia. So now we have an internally consistent set of tectonic elements that underlie Queensland, as well as defined boundaries between different provinces and subprovinces. All this is shown in Figure 1.3, which is a superb structural framework map showing older provinces and younger (overlapping) basins interpreted beneath the blanketing Jurassic–Cretaceous Eromanga and Surat Basins. I've stuck the map up above my desk.

On the map, the hierarchy is cratonic Australia or orogens, then provinces, then subprovinces. Basins are treated differently. Devonian–Carboniferous basins west of the New England Orogen are given their own names, whereas those in the New England Orogen are included in the Yarrol Province. From chapter 1, I'm not sure whether the Devonian–Carboniferous Burdekin Basin west of Townsville is part of the Charters Tower Province of the Thomson Orogen, or lies above it. And I didn't really know that there was an Iron Range Province in eastern York peninsular that may be part of the Thomson Orogen or that there is a Cape York–Oriomo Province.

Chapter 1 provides the background to the State's geology, summarising the key provinces and looks forward to chapter 10, which discuses the mineral endowment. It also discusses the history of geological activity and mapping in the State.

Given that Queensland is home to some people of fundamentalist persuasion, who commonly wear maroon jerseys, as well as some of Australia's most exciting dinosaurs finds, it is apposite that chapter 1 also contains significant data on the time scale and how time is measured, with summaries of different dating techniques. Feature boxes, which are used in chapters 3, 4 and 8 to present new data and interpretations, are maroon in colour so perhaps all is well!

I was most interested in the hard-rock chapters of the Tasmanides and some comments on these chapters follow. Chapter 3 describes the Thomson Orogen. Most of this lies beneath the Eromanga Basin, so this orogen is described in two parts: an excellent synthesis of outcropping parts, such as in the Anakie and Charters Towers Provinces, together with synthesis maps of drillcores into the subsurface parts (based largely on Cec Murray's 1994 paper). Interestingly, Devonian basins such as the Adavale in central Queensland are not regarded as part of the Thomson Orogen, but as overlying it. This differs from the terminology used in NSW where the Thomson Orogen incorporates elements from the ?Neoproterozoic through to the Late Devonian. Chris Fergusson and Bob Henderson provide a valuable synthesis at the end of the chapter. Related to this, I note that the dynamic significance of the shallow-dipping S2 foliation in the Anakie area is once again thought of as contractional rather than extensional, based on a feature article by Robin Offler and others.

Chapter 4 describes the Mossman Orogen. This I read with great attention since I've been perplexed in the past by terminology, as well as boundary relationships to the south and internally. Interestingly, the orogen is restricted in age to Silurian and Devonian and presumably in area by their outcrop/subcrop areas. This means that in places it overlies small outcrops of Thomson Orogen. The Mossman Orogen is inferred to lie west of the partly coeval New England Orogen, although locally the eastern boundary is faulted against the Barnard Province of the Thomson Orogen. Silurian Devonian granites that largely intrude the craton to the west are also included in the Mossman Orogen. This chapter contains great detailed descriptions, together with tectonic interpretations and syntheses of the classic arguments about the tectonic setting of the Chillagoe Formation and Hodgkinson Group. Both arguments are clearly presented here — the back-arc argument by Paul Donchak and the accretionary margin model of Bob Henderson. It's a tribute to the editor that both sides of such controversial and important topics get airplay.

Chapter 5, by Paul Donchak and others, describes the New England Orogen in terms of provinces and subprovinces. Provinces comprise the Calliope (late Silurian – middle Devonian fault blocks) within the fore-arc basin (late Devonian–Permian arc–fore-arc basin that constitutes the Yarrol Province) and the Wandilla Province (Devonian–Carboniferous accretionary complexes). Clear maps and time–space plots facilitate understanding of this convergent margin orogen. Granites are an important part of this chapter and this is the place to come to gain an understanding of these important elements of the New England Orogen. Controversially, the Bowen Basin (and other, smaller basins) is also included in this orogen, but the logic is impeccable. The New England Orogen is one of the world's great convergent margin orogenic systems and the wealth of data gathered in the one place will help refine our models and better our understanding of this important province. Now if only the NSW part carried major mineral deposits!

Chapter 6 describes granites of the Kennedy Igneous Association, which were emplaced in northern Queensland largely behind the continental margin arc in the New England Orogen. These chapters contain great maps and geochemical separation diagrams. Granites are clearly divided into suites and supersuites and S-, I- and A-type bodies supported by geochemical, isotopic and age data.

This is a must-have book if you are interested in any of the diverse aspects of Queensland geology captured in the 15 chapters.

DICK GLEN

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Calendar

2013

23 April

Interpretation of Geochemical Data for Environmental Applications Workshop

Novotel Perth Langley Hotel, Perth, Western Australia
Presenter — Associate Prof Ron Watkins, Director, Environmental Inorganic Geochemistry Group, Curtin University

2–5 June

2013 EGRU conference, Future and Understanding of Tectonics, Resources, Environment and Sustainability (FUTORES)

Townsville, Queensland

http://www.jcu.edu.au/futores/

14–19 July

Specialist Group in Geochemistry, Mineralogy & Petrology (SGGMP) — Rocks, Reef and Rainforest

Mission Beach, Qld

http://sggmp2013.webs.com/

11–14 September

Mines & Wines 2013

Orange Ex-Services Club, NSW

http://www.aig.org.au/images/stories/eventfiles/MW_2013_Flyer.pdf

18–21 November

26th International Applied Geochemistry Symposium, incorporating the New Zealand Geothermal Workshop

Rotorua, New Zealand

http://www.gns.cri.nz/iags

25–28 November

Geosciences 2012

University of Waikato, Hamilton, New Zealand

http://www.geosciences2012.org.nz

2014

2–8 February

Meeting of the Special Group in Tectonics and Structural Geology

Thredbo, NSW
Welcome BBQ and cricket match Sunday 2 February

Email Gordon Lister
gordon.lister@anu.edu.au

7–11 July

Australian Earth Sciences Convention — AESC 2014

Geological Society of Australia biennial conference
Newcastle, NSW

Quizine ANSWERS

(From page 10.)

1 Monte Adamello in Italy
2 Kalbarri in Western Australia
3 Dun Mountain in New Zealand
4 Syene in Egypt
5 Loch Crinan in Scotland
6 Charnwood Forest in England
7 Shoshon River in Wyoming, USA
8 Uinta Mountains in Utah, USA
9 Named for the French geologist Déodat Gratet de Dolomieu; the Dolomites are named after the mineral
10 Essex County in Massachusetts, USA.

Sylvia Whitehead

1921–2012

Image courtesy Silva Whitehead's family.

Silvia Whitehead, well known petrologist, mineralogist and economic geologist, as well as a GSA Foundation Member, died on 12 November 2012 at the age of 91.

Silvia Gladys Bosselmann was born in Kerang in rural northwest Victoria and her father explicitly discouraged her from tertiary education. Nevertheless Silvia entered the University of Melbourne and graduated BSc with a major in Geology and Chemistry in 1942. She then continued studies in geology with an MSc in 1943. Her thesis on the genesis of sand dunes on Victoria's Mornington Peninsula was supervised by ES Hills. Most of her necessary fieldwork was done by bicycle. In 1943, Silvia married a fellow geology student, Reg Whincup, who was tragically killed in action the following year when Silvia was expecting her first child. As a single mother with a son, Silvia then entered the workforce as Curator of Minerals at the National Museum of Victoria and was the first full-time appointee to that post. During this period, she also lectured in gemmology.

In 1950, Silvia married another geologist, Bob Whitehead. With Bob's posting with BHP in Whyalla, South Australia, Silvia left Victoria and spent the period 1950–1958 as a mother raising three sons. During the same period she joined GSA. In 1958, she rejoined the workforce with BHP in Whyalla as a petrologist, moving between Whyalla and Melbourne until 1965. Her work at this time centred on banded iron formations sourced by BHP primarily from Iron Monarch in South Australia's Middleback Ranges. The geological staff in Whyalla also gave attention to the assessment of carbonate rocks to meet blast furnace specifications: limestone from Rapid Bay, dolomite from Ardrossan and magnesite from Balcanoona. High-grade calcareous sand was also identified near Coffin Bay on southern Eyre Peninsula as being ideal for use as flux in the smelting of fine-grained iron ore.

In response to an upsurge in mineral exploration by the private sector in 1965, the Whiteheads were induced to join Anaconda Australia Inc. The company acquired an exploration tenement in the Puttapa area in the Flinders Ranges. Bob Dalgarno, also employed by Anaconda at this time, has the following recollection.

At the end of June 1965, I was asked by new employer, Anaconda, to choose an area of about 20 square miles where I thought diapirs may result in mineralisation worth focusing on. I defined a block on the crown of the Puttapa diapir because of similarities to the Wirrealpa diapir where Cambrian limestones host base metal occurrences. The boss was Bob Whitehead who directed me to go with his geologist wife, Sylvia, to Puttapa for one day to demonstrate the area to her. This was my first day with the company and I met Sylvia, for the first time, at Beltana on 5 July and proceeded to 'show' her what I knew of the area. At end of day we boiled a brew on the subsequent site of the zinc opencut and Sylvia queried me on a block of stained white mineral beside the billy. 'Barytes' I offered with confidence, being used to the veins around Oraparinna. I then drove off to the Willouran Ranges. Sylvia had not commented, but a few weeks later I received an assay registering 38% Zn. I doubt Sylvia and I ever spoke afterwards of her discovery as it turned out one of the most tumultuous and disastrous years for her privately. Anaconda broke up its Adelaide office in September.

At Puttapa, stream sediment sampling undertaken by Silvia confirmed anomalous lead and zinc. Follow-up rock sampling and detailed mapping then disclosed outcrops of what would prove to be the world's largest willemite deposit, a rare zinc silicate lacking sulfides. Silvia's report and maps were lodged with the SA Department of Mines in 1967.

In 1968, Silvia's second husband, Bob, died, and with two children remaining at home Silvia joined the Australian Mineral Development Laboratories (AMDEL) as a petrologist, based in Adelaide where she remained until retirement in 1981. This period signalled a return to her earlier interests, the study of rocks and minerals under the microscope, reporting on samples that were mostly referred to her from SA Department of Mines.

During her long career, Silvia demonstrated great talents in the laboratory and in the field. She was especially a great believer in seeing and feeling the rocks in the field, despite having many home-bound obligations. Silvia was also held in high esteem by her peers for integrity, knowledge, ability and interest. She was quietly unassuming, friendly, a gracious hostess at home; she also displayed great fortitude in adversity and dogged persistence in meeting many personal challenges. She is survived by sons Peter Whincup and Richard Whitehead, four granddaughters and a grandson. Her youngest son, Brian, now deceased, was also a geologist.

RK JOHNS and CR DALGARNO with final compilation by BJ COOPER and additional information from P WHINCUP

Condolence – Guy Thulborn

On behalf of all their colleagues in the Geological Society of Australia, condolences are expressed to Sue Turner and Tony Thulborn on the loss of their son, Guy (1986–2012), in November 2012. The extensive paleontological fieldwork undertaken by Sue and Tony over many years in many parts of the world often included Guy, and with his keen eye he made numerous significant discoveries.

Geological Society of Australia Inc. Office Bearers 2012–2014

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The Australian Geologist

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The Australian Geologist (TAG) is a quarterly member magazine which includes society news, conference details, special reports, feature articles, book reviews and other items of interest to Earth Scientists. Each issue has a long shelf-life and is read by more than 3000 geologists, geophysicists, palaeontologists, hydrologists, geochemists, cartographers and geoscience educators from Australia and around the world.

Schedule and deadlines for 2013–2014

Issue	Copy	Finished Art	Inserts
June 2013	29 April	3 May	28 May
September 2013	29 July	9 August	23 August
December 2013	25 October	1 November	8 November
March 2014	31 January	7 February	28 February

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