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COVER and INSIDE FRONT COVER: Luoichuan loess section, Shaanxi Province loess plateau, China. A valley is incised into loess which has accumulated downwind from the Chinese deserts over at least the last 1 million years. Stratigraphy preserved within the loess provides an unparalleled record of Quaternary palaeoclimatic change in response to the east Asian monsoon. The site formed a major highlight of the field trip for the Luminescence and Electron Spin Resonance Dating Conference held in Beijing, China, in September 2008. Photos: Kathryn Fitzsimmons.



Dear Fellow Quaternarists,

This will be my final issue as sole Editor for Quaternary Australasia. Owing to my impending move overseas, we have co-opted an assistant editor,

Jess Reeves, who will share the responsibility with me, including taking care of the printing and distribution in this part of the world. I very much look forward to working as part of an editorial team!

This issue, as others before it, demonstrates the active nature of the Australasian Quaternary community, and particularly of its early career researchers and students. Several early career scientists were sponsored by AQUA to attend the recent PAGES meetings in the USA mid-year, and their insights into these events on the other side of the Pacific are reported here. In addition, I report on a workshop into the status of women in science in Australia, commissioned by the Federation of Scientific and Technological Societies (FASTS) and held at Parliament House in Canberra. It was great to be part of the process bridging politics and science, and I fervently hope that our voices as advocates for improving the status quo will be heard by decision-makers. We also publish reports on recent workshops for (and by) early career researchers and students on geochronological and archaeological methods – important for building skillsets for young scientists.

Australia this year played host to the International Association of Geomorphologists Conference, held in Melbourne in July. With over 1000 delegates, this was a major meeting, and one which provided Australian researchers with an excellent opportunity to show off their unique landscape. In this issue we publish reports on excursions to central Australia, western Victoria and the suburbs of Melbourne – the latter revealing some interesting geomorphic surprises in a human-altered landscape.

We also publish a research report by Romina Belli, who was awarded for her presentation at the AQUA meeting in Victor Harbour, on multi-disciplinary proxy reconstructions of climate at an important archaeological site in Europe. The interaction between Quaternary science and archaeology is a fascinating exercise, with tremendous scope for fruitful collaboration.

We also include a review of the recently published book “Climate change: the science, impacts and solutions” by Barrie Pittock, and a report on the award given to Ian Graham’s publication on New Zealand geology.

Best wishes

Kathryn Fitzsimmons
(soon to be Editor-at-large)



Greetings from sunny Queensland,

Climate change has been a ‘hot’ (pardon the pun) issue over the last several months, both within Australasia, particularly with ETS legislation, and internationally with the upcoming Copenhagen conference. I am reminded of the fact that Quaternary science and scientists play a key role in understanding climate and human impacts on the environment. With this in mind, AQUA has been (and will be) actively involved in the climate change debate through engagement with government and key stakeholders, through submissions to parliamentary enquiries, participation in the Science Meets Parliament events, and the support of students to attend the recent PAGES Young Science and Open Science meetings. However, I feel that this engagement has predominantly been focused on the Australian component of our organisation. We need to broaden our efforts to more effectively include our New Zealand and Pacific members. Therefore, I encourage AQUA members to make some suggestions as to how we can more effectively involve our non-Australian members, particularly in the area of engagement with their respective governments and/or key stakeholders. Any suggestions would be gratefully received by me or the other executive members.

There has been a change to the AQUA executive with the appointment of an assistant editor to work with Kathryn Fitzsimmons with the production of QA. This is due to Kat moving to Germany to undertake a postdoc at the Max Planck Institute for Evolutionary Anthropology. All the best Kat and thanks for all your tireless work in the production (including the timely reminders for a certain column from the President) of QA. It is gratifying to know that you will still be involved in the editorship of QA in the new joint role.

Finally, I just want to highlight the upcoming AQUA biennial conference on North Stradbroke Island, which is scheduled for July 11th to 17th at UQ’s Moreton Bay Research Station. More details will be provided shortly. Having been a regular visitor (as researcher, teacher and holiday maker) to ‘Straddy’ over the last 5+ years, I strongly recommend attending the conference.

Best Wishes
Patrick

A Multidisciplinary Approach To The Study Of An Archaeological Site

The Case Of Riparo Dalmeri (Trentino, Italy)

Romina Belli, Silvia Frisia, Russell Drysdale, Andrea Borsato

Romina Belli (corresponding author), Silvia Frisia, Russell Drysdale:
School of Environmental and Life Science, University of Newcastle NSW 2308, Australia
Email: Romina.Belli@studentmail.newcastle.edu.au, Fax +61 2 4921 5877
Andrea Borsato:
Museo Tridentino di Scienze Naturali, Italy

Introduction

Climate changes during the Quaternary, in particular between the end of the Last Glacial Maximum and the beginning of the Holocene, exerted great influence on the activities of prehistoric people (Burroughs, 2005). In the Alps of NE Italy, an unusual rockshelter located at an elevation of ~1200 m (Figure 1) was frequented for ~500 yr by humans during the Bølling-Allerød period. Interesting features of the shelter include its relatively high altitude, the northern (and cooler) exposure and the presence of over 200 painted stones of possible ritualistic significance (Dalmeri et al., 2005). Pre-historic painted rocks provide insight not only on the spiritual world of our ancestors, but also on the evolution of technology and paleoenvironmental change through the depiction of flora and fauna. The aims of this paper are twofold: 1) to further investigate the climate and environmental conditions that created a “sanctuary” at high elevation in the Alps of NE Italy, which must have coincided with complete deglaciation of the region, and 2) to gain insight into the reasons why the sanctuary was abandoned.

We use a combined approach, incorporating techniques used in palaeoclimate and paleoenvironmental

investigation, as well as those more specifically related to material sciences, to address this archaeological “problem”. Italian archaeologists were intrigued by the unusual location of the Riparo Dalmeri rockshelter because it opens on a steep, north facing slope, which in the northern hemisphere receives the least amount of sunlight. Today, the shelter is further shaded by a thick mixed conifer and deciduous tree forest. The mean annual temperature at the site is ~6°C, with maximum summer temperatures of ~17°C, in contrast with the surrounding areas where summer temperatures reach 28°C (Eccel and Saibanti, 2005). At the time of human occupation, however, the area might have been open grassland, and thus received more light (Dalmeri and Lanzinger, 2002). Unfortunately, there are no continuous climate archives at the archaeological site to reconstruct environmental change during the occupation of the shelter. In some rockshelters, speleothems are found within stratigraphic sections which provide chronologic and palaeoclimatic information (e.g. Ramos et al., 2008). At Riparo Dalmeri the archaeological campaign concentrated on the recovery of artefacts. Calcium carbonate deposits overlying a massive collapsed breccia, which buried the archaeological layers, were completely removed and disposed of in the 1990s (M. Bassetti, pers. comm., 2008). Therefore, we had to rely on archives from the broader region, including Grotta Savi cave speleothems and Lago di Lavarone lake sediments.

The archaeological site

Following deglaciation of the valleys of the European Alps, hunter-gatherers migrated to the ice-free areas. In the Trento region, the most recent radiocarbon dates indicate that by about 15,000 ¹⁴C BP most of the major and peripheral valleys were completely deglaciated (Bassetti and Borsato, 2005). The Riparo Dalmeri shelter is a high-altitude site, located at 1200 m above sea level (Figure 1). Nearby lake sediments suggest that the area was already deglaciated by approximately 17,000 years ago (Filippi et al., 2005). Radiocarbon dates on charcoal samples associated with fireplaces constrain the period of occupation to between ~13,400 and 12,900 cal. yr BP (EDF stratigraphic units, Figure 2) (Dalmeri et al, 2006), when the valleys were completely deglaciated, and in an interval of time framed within the Bølling-Allerød



Figure 1. Location of the Riparo Dalmeri rockshelter (D), Grotta Savi (S) and Lago di Lavarone (L).

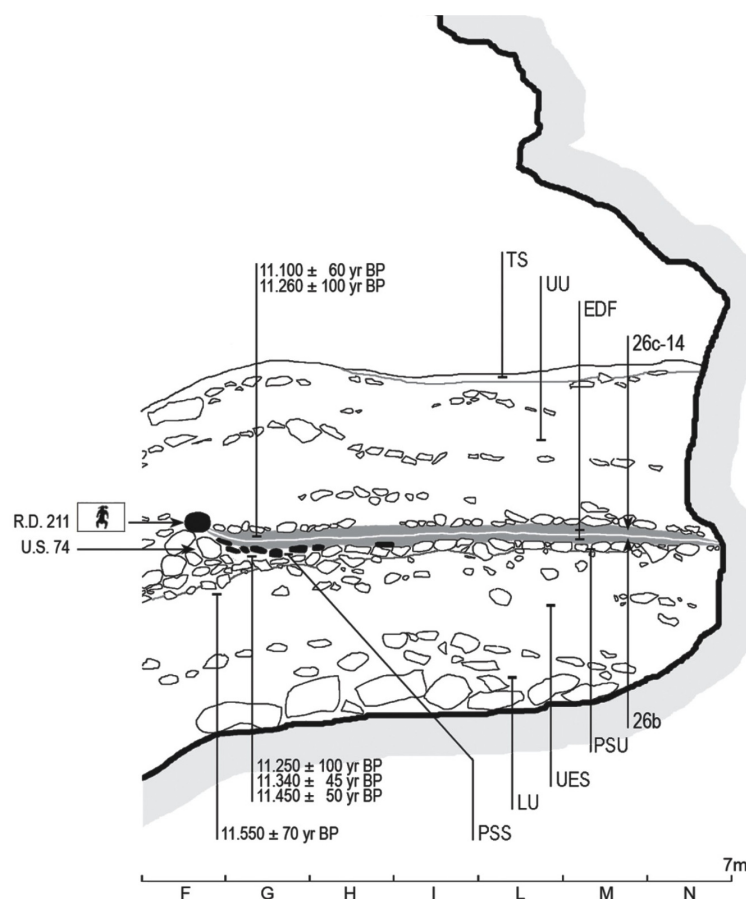


Figure 2. Stratigraphic section showing radiocarbon dates and layer relations of the Riparo Dalmeri rockshelter (LU = lowermost units, UES = units with aeolian sediment, PSU = pre-settlement units, PSS = painted stone structures, EDF = Epigravettian dwelling floor, UU = upper units, TS = top soil, R.D.211 = the biggest anthropomorphic figure; U.S.74 = handmade stone heap) (modified by permission of G. Dalmeri, from Dalmeri et al. 2005).

pollen zone of northern Europe (Mangerud et al., 1974). This period corresponds to the final cultural phase of the Recent Epigravettian (Dalmeri et al., 2006). The human occupation of the rockshelter ended at the onset of the Younger Dryas cold event which terminated circa 11,500 yr ago, and became established between 12,900 yr (Bakke et al., 2009; Alley, 2000) and 12,500 yr ago (Lowe et al., 2001).

Previous archaeological investigations revealed that the Riparo Dalmeri rockshelter was last used as a seasonal hunting camp (Dalmeri et al., 2006). However, the discovery of over 200 painted stones in the oldest anthropic layers (PPS unit and R.D.211, Figure 2) reveal another use of this north-facing shelter, at least in some stages of its history (Dalmeri et al., 2005). Since this discovery, the rockshelter has been interpreted more in terms of an artistic-sacred site (Dalmeri et al., 2005, 2006). Dalmeri et al. (2005) based their hypothesis on the fact that most of the rocks were placed with the painted surface facing downward. The pictures had, therefore, been deliberately made invisible to people who visited the shelter. The red-painted stones depict animal images as well as geometric and anthropomorphic figures (Dalmeri et al. 2005).

Animals represented on the stones include wild oxen, boar, mountain goat and deer, suggesting the hunter-gatherers were familiar with game living in both the valley floors, where abundant grass was available, and the rugged mountain areas (Dalmeri et al., 2006). The variety of animals reproduced on the rocks is regarded as further proof of a nomadic way of life for the prehistoric artists, who seasonally visited the Riparo Dalmeri rockshelter.

Materials and Methods

Our reconstruction of climate changes during, and after, the occupation of the Dalmeri rockshelter is based mainly on the variability through time of stable isotope ratios ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) preserved in a uranium-thorium dated stalagmite (SV1 in Frisia et al., 2005; and new data of NSV1), and on pollen associations and chironomids found in nearby lake sediments (Filippi et al., 2005; Heiri et al., 2005). Stalagmite SV1 was recovered from Grotta Savi (Trieste, NE Italy), which, although located 250 km east of the shelter (Figure 1), at an altitude of 450 m a.s.l., provides the first continuous climate record from the region spanning the last ~17,000 years (Frisia et al., 2005). It is the only existing continuous archive of the last deglaciation for the region. A new section of SV1 (NSV1) is, therefore, currently being investigated at higher temporal resolution. Here we focus on the time between the end of the Late Glacial and the early Holocene, the period framing human occupation of the Dalmeri rockshelter. NSV1 was sampled for carbon isotopic composition along the central axis of the speleothem at fixed 150 μm increments using a micro-milling system at the University of Newcastle (Australia). The isotope ratios of the powders were measured on CO_2 gas released by reaction with 105% phosphoric acid at 70°C using a continuous-flow GV2003 gas-source isotope ratio mass spectrometer at the University of Newcastle. Carbon isotopic ratios are reported using the δ denotation in per mil (‰). Samples were measured against a house standard (NEW1) which has been calibrated to the Vienna Pee Dee Belemnite (VPDB) scale using the international standard NBS19. Mean analytical reproducibility (1σ) of $\delta^{13}\text{C}$ was less than 0.1‰. Isotope values for NSV1 are here reported against distance from the top, rather than age, because the age model has not yet been finalised (U/Th dating is being carried out at the University of Melbourne). The chronology has been reconstructed using wiggle-matching.

Preliminary Results

The NSV1 stable isotope profile obtained at 0.15 mm resolution show $\delta^{13}\text{C}$ values between -9.7 and -11.5 ‰ with a mean of -10.8 ‰ (Figure 3b). The range and the mean value of NSV1 $\delta^{13}\text{C}$ are close to those at the low resolution already published (Frisia et al. 2005, Figure 3a). Between ~223 and 218 mm from the top, NSV1 records a pronounced $\delta^{13}\text{C}$ positive peak (enrichment in ^{13}C , values from -10.75 to -9.75 ‰) with the same pattern as observed in SV1 between 12,500 to 11,500 yr ago (the Younger Dryas event, Frisia et al. 2005). The main feature of the new, high resolution NSV1 series is that the $\delta^{13}\text{C}$ trend shows higher complexity (Figure 3b). The positive peak, which possibly spans about

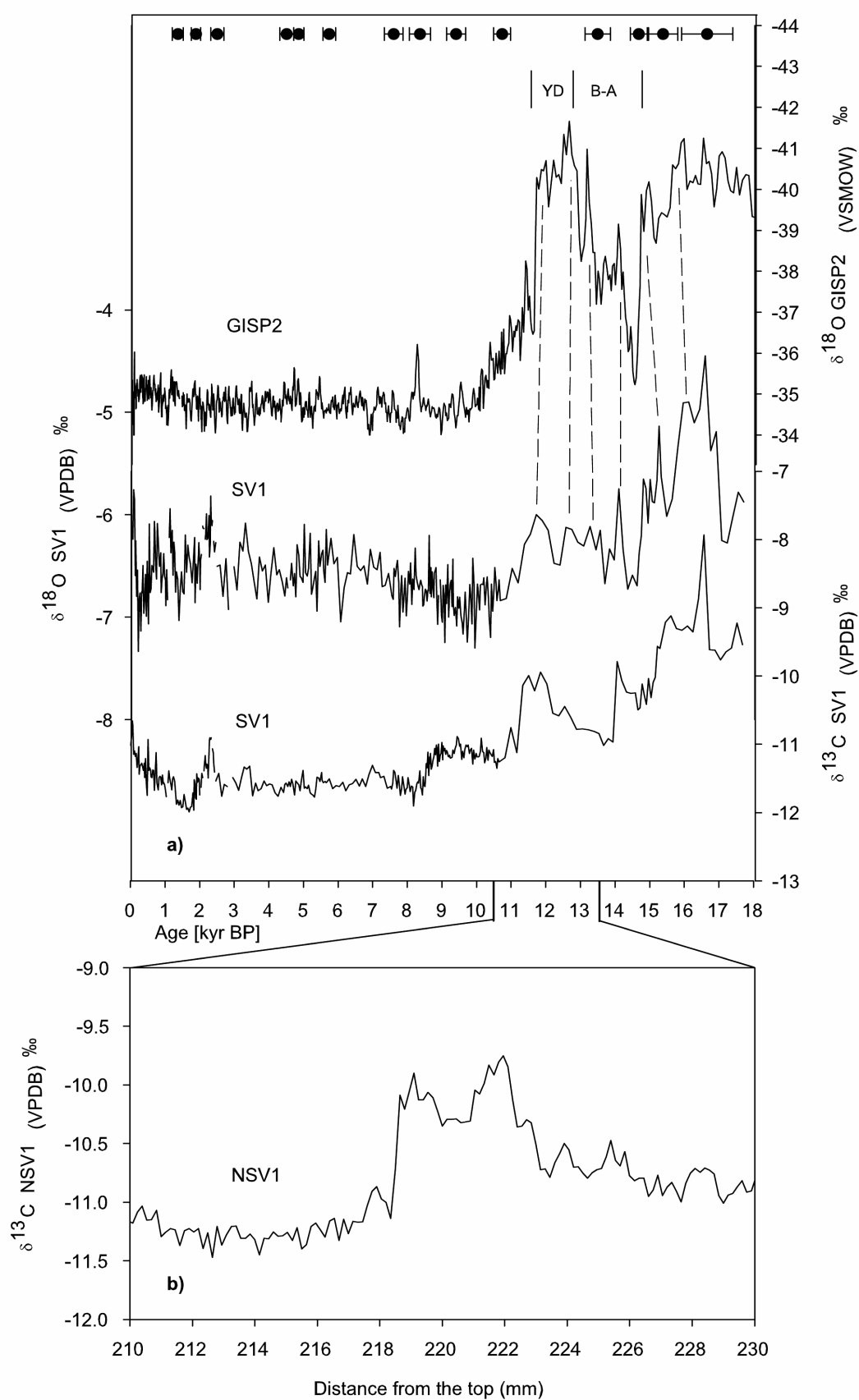


Figure 3: A comparison between a) the Greenland GISP2 ice core $\delta^{18}\text{O}$ (note the inverted scale – Grootes et al, 1993) and b) the SV1 $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$. The position of U/Th ages shown with the 2σ error bar are plotted (modified from Frisia et al. 2005) and b) the axial profile of the high-resolution NSV1 $\delta^{13}\text{C}$ record (plotted versus distance, U/Th dating in progress). YD = Younger Dryas, B-A = Bølling-Allerød (Lowe et al, 2001).

1000 years, is interrupted by a shift to more negative values (-9.75 to -10.25 ‰) that persist for about 4 mm. Comparison with SV1 age model suggest that 4 mm vertical extension in SV1 should correspond to about 100 years

Discussion

The $\delta^{13}\text{C}$ variability in speleothems has been commonly interpreted in terms of duration of active root respiration and microbial degradation of organic matter in the soil, which produces ^{13}C -depleted CO_2 if the vegetation was of the C_3 type (McDermott, 2004). The fundamental assumption that Savi speleothem calcite was deposited in equilibrium with CO_2 respired by C_3 plants both in the Late Glacial and in the Holocene is supported by pollen and plant macroscopic remains data from the region (Pini, 2000). A shift to more positive $\delta^{13}\text{C}$ values should, therefore, indicate reduced soil CO_2 production, which commonly coincides with dry/cold climatic conditions in Central and Southern Europe (see Genty et al., 2003). By contrast, warm and humid conditions result in prolonged periods of active root respiration and microbial degradation in the soil, which together yield higher concentrations of ^{13}C -depleted soil CO_2 and, consequently, more negative $\delta^{13}\text{C}$ values (McDermott, 2004).

Carbon isotope ratios appear to be sensitive to hydrological variations in a Mediterranean setting (Genty et al., 2003). The $\delta^{13}\text{C}$ shift to more positive values recorded in NSV1 (Figure 3b) could be interpreted as due to overall cold and/or dry climate. The short-lived shift to more negative values suggests a return to relatively more humid conditions. The complex structure of the Younger Dryas revealed by the NSV1 $\delta^{13}\text{C}$ data is similar to that observed in Lake Ammersee (von Grafenstein et al., 1999) and at Chauvet Cave (Genty et al., 2006). NSV1 record, thus, suggests that the Younger Dryas climate deterioration was punctuated by a warmer/wetter phase. The NSV1 record, however, exhibits much longer (secular?) climate amelioration, with respect to the Ammersee and Chauvet records. The climate deterioration recorded by NSV1 interrupted a general trend toward warming, which has been reconstructed from $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ records of the SV1 stalagmite (Figure 3). The stable isotope ratios values show trends toward more negative values, which have been interpreted as indicative of humid conditions during the Bølling-Allerød, with well developed vegetation (Frisia et al., 2005). Pollen assemblages from Lago di Lavarone (Italy, 30 km east of the Riparo Dalmeri, Figure 1) sediment record also suggest that during the Bølling-Allerød a conifer forest surrounded the shelter (Filippi et al., 2005) (Figure 4). The chironomid-temperature transfer function developed for central Europe (Lotter, 1997; Heiri and Lotter, 2005; and Bigler et al., 2006) applied to chironomid associations preserved in Lago di Lavarone sediments indicates mean July temperatures of $\sim 14^\circ\text{C}$ during the Bølling-Allerød, reaching up to 15°C just before the Younger Dryas (Heiri et al., 2005). Today, the mean July temperature at Lavarone is 17.4°C (Eccel and Saibanti, 2005), a few degrees higher than summer temperatures experienced by prehistoric people in the Bølling-Allerød. During the Bølling-Allerød, pleasant warm and

humid climate conditions, perhaps resulting also in the availability of water resources in what is now a dry karst plateau, would have favoured seasonal migration to Riparo Dalmeri rockshelter. Findings of painted stones, tools, animal bones, milk teeth and a hut suggest that during the Bølling-Allerød entire families may have temporarily dwelled at the site (Dalmeri et al., 2006). However, some dramatic events must have happened to change their lifestyle, since there is no evidence of occupation after 12,900 cal yr B.P., even though the painted stones suggest that it may have been a sacred and significant site. On the basis of the NSV1 isotope record, we infer that abrupt climate deterioration is one of the causes of the abandonment of the shelter. Furthermore, the stable isotope record from SV1 stalagmite (Frisia et al. 2005) shows a rapid, positive co-variation of both $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ at about 12,500 years ago (Figure 3a), which sets the onset of dry/cool conditions at roughly the beginning of the Younger Dryas (Frisia et al., 2005). Chironomids in the Lago di Lavarone sediments indicate a decline in mean July temperatures down to circa 13.3°C for the Younger Dryas (Heiri et al., 2005), which is significantly below the peak reached during the Bølling-Allerød. Pollen associations indicate an increase in cool climate grasses and a decline in conifers. This strongly supports cooling associated with a decrease in rainfall, as suggested by the speleothem data (Filippi et al. 2005).

The NSV1 record provides more information on the Younger Dryas and suggests that this “cold/dry” period was punctuated by a return to milder conditions. However, no evidence of re-occupation within the Younger Dryas has been found at the Dalmeri rockshelter. It appears, therefore, that the geographic position of the shelter played a fundamental role in its complete abandonment.

Following the Younger Dryas, the onset of the Holocene was marked in the region by an increase in summer air temperatures up to 16°C (Heiri et al., 2005). Pollen data suggest the recovery of the conifer forest (Filippi et al. 2005, Frisia et al. 2005a) and the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ records of SV1 (Figure 3a) indicate a return to humid and relatively warm conditions (Frisia et al. 2005). Despite the climate amelioration in the Early Holocene, there is no evidence for the return of the hunter-gatherers to the Riparo Dalmeri rockshelter. Thus, the Younger Dryas climate deterioration seems to have had a major role in the abandonment of the rockshelter. By contrast, the amelioration in the Early Holocene apparently had no role on the subsequent behaviour of the hunter-gatherers. Climate, therefore, is not the only explanation for our ancestors’ behavioural changes. Climate almost certainly had another important role at Riparo Dalmeri rockshelter, and in particular on the preservation of the art. The onset of the Holocene in the southern Eastern Alps marked the appearance of a peculiar speleothem, calcite moonmilk (Borsato et al., 2000). Alpine calcite moonmilk is a whitish biomediated cave deposit (Blyth and Frisia, 2008) mostly consisting of water and elongate fibre calcite crystals (CaCO_3). In the Eastern Italian Alps, calcite moonmilk grows under a narrow set of environmental and climate parameters, such as the presence of a continuous water film, cave air temperature above

3.5 °C, and presence of conifer forests above the cave (Borsato et al., 2000). Calcite moonmilk deposits have been observed associated with the red paint on the stones (Belli et al. 2006). Belli et al. (2006) proposed the formation of moonmilk soon after the deposition of the stones on the ground. This timeframe is suggested by the textural mixing between paint and moonmilk, and the absence of a clear interface between the pigment and the cave deposit. Since the environmental conditions of calcite moonmilk formation in the Italian Alps are known (Borsato et al. 2000), the timing of moonmilk precipitation potentially provides additional information on climate and environment at the time

of human occupation at Riparo Dalmeri rockshelter. It supports the reconstructed scenario of a relatively warm shelter, surrounded by conifer forest where drinking water must have been available.

Conclusion

The present work reveals that archaeological problems are best addressed using a multi-disciplinary approach. Various archives should be used to reconstruct a more robust record of the climate and environmental evolution of archaeological sites. For the Dalmeri rockshelter of the Italian Alps, multi-proxy data suggest

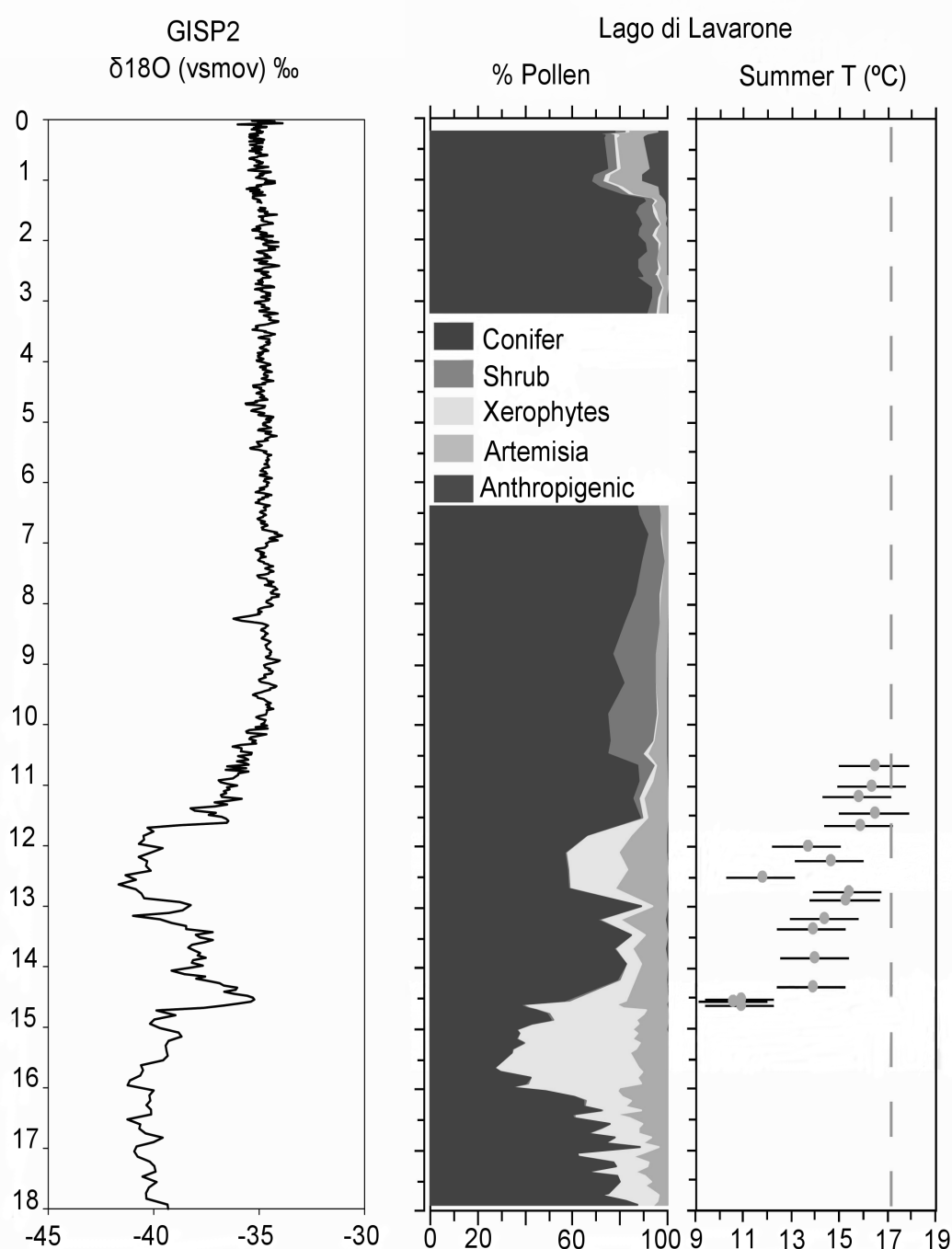


Figure 4. Pollen and summer temperature changes from Lago di Lavarone sediments compared to the GISP2 ice core $\delta^{18}O$ record (modified by permission of Filippi M., Museo Tridentino Archive).

that relatively humid and warm climate conditions in the Bølling-Allerød favoured migration to shelters located at high elevation. In the specific case of Riparo Dalmeri, the shelter was also an important artistic and possibly sacred site. Consequently, its abandonment is particularly puzzling. In this paper we infer that it was related to the rapid climate deterioration of the Younger Dryas, which lasted about 1000 years. During a warmer spell within the Younger Dryas, and in the following warm Early Holocene, however, the hunter-gatherers did not return to the archaeological site. This suggests that climate influences, but does not determine, human behaviour.

Although the present study deals with events in Italy, a similar approach which links archaeometric and palaeoclimate investigation could be used to unravel the complex relationships between climate and cultural evolution in Australia. In particular, speleothems are not only powerful palaeoclimate tools, but may also grow in association with pigments, providing useful data for palaeoclimate reconstruction in the absence of other *in situ* archives.

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PAGES 1st Young Scientists Meeting and 3rd Open Science Meeting

Corvallis, Oregon, USA, 6-11 July 2009

Steven J. Phipps, Joelle Gergis and Lynda Petherick

Steven J. Phipps: Climate Change Research Centre, University of New South Wales

Joelle Gergis: School of Earth Sciences, University of Melbourne

Lynda Petherick: School of Geography, Planning and Environmental Management, University of Queensland

The PAGES 3rd Open Science Meeting (OSM) and 1st Young Scientists Meeting (YSM) were held at Oregon State University, in the pleasant college town of Corvallis. Located in the heart of the Willamette Valley, Corvallis is about two hours south of Portland and within day-trip range of the rugged Oregon coastline, Mount Hood and the scenic Columbia River Gorge. A little further away is Mount St Helens, Washington, which is still impressively barren almost 30 years after the eruption.

The theme of the meetings was “Retrospective Views on Our Planet’s Future”, recognising the role that palaeoclimate research plays in the science of global climate change. There was a strong Australian presence, including five young scientists whose attendance had been subsidised by AQUA and ARCNESS (Joelle Gergis, Michael Griffiths, Sophie Lewis, Lynda Petherick and Steven Phipps).

The Young Scientists Meeting took place over the first two days. This was the first such meeting held by PAGES, and recognised the need to nurture young scientists if palaeoclimate research is to thrive in future. There were more than 90 participants from 21 different nations; for many of those present, it was their first international meeting. The aim was to allow the young scientists to share and discuss their knowledge, and to enable them to make contacts across both geographical and disciplinary borders.

After a warm welcome from the hosts, the first one-and-a-half days were devoted to oral and poster sessions. These spanned a wide range of topics, and the quality of the presentations was very high. The first day also included breakout groups, which discussed key topics such as public awareness of palaeoclimate research, the involvement of young scientists in the palaeoclimate community, and access to published data. Each group reported back the following day, giving the participants the opportunity to provide feedback and to make suggestions and recommendations. The final afternoon was devoted to career development, with presentations by senior scientists and journal editors on grant-writing, getting work published, data management and communication of scientific results.

Running parallel to the YSM was a special one-day workshop on the new PAGES 2K regional network. This

brought together key representatives from the North American, European, Arctic, Antarctic, Australasian and African research communities, to present recent advances in regional multiproxy data syntheses covering the past 2,000 years. While the priority is on combining annually-resolved palaeoclimate records, the importance of developing low-frequency baseline climates using decadal–multidecadal resolution records in data-sparse regions like Australasia was discussed. The aim of the initiative is to publish a 2K book detailing each region’s reconstructions and palaeomodelling efforts in time to contribute a state-of-the-art review towards the Intergovernmental Panel on Climate Change (IPCC’s) fifth assessment report, which is due out in 2014.

Following the YSM, the young scientists were joined by senior scientists for the Open Science Meeting (or Old Scientists’ Meeting, as it was cheekily dubbed). Three hundred scientists from six continents and 30 countries attended, with interests falling under the umbrella of PAGES’ four foci:

- ☐ Climate forcings
- ☐ Regional climate dynamics
- ☐ Global earth-system dynamics
- ☐ Human-climate-ecosystem interactions

The four-day meeting consisted of a mix of oral/poster sessions and a selection of “Hot Topic” talks. These included an entertaining and informative presentation by Richard Alley (Pennsylvania State University) on “How abruptly can sea level rise?”, which discussed the current lack of knowledge of ice sheet dynamics and the likely response of the Greenland and Antarctic ice shelves to global warming. Jonathan Overpeck (University of Arizona) gave everyone a timely reminder that we should be aiming to publish our best, high-impact papers within the next two to three years, so that they are peer-reviewed in time to form part of our community’s contribution towards the next IPCC assessment report. He also emphasised the urgent need for us to develop the ‘policy relevant’ science needed by regional-scale decision makers, thus ensuring that palaeoscience remains an evolving discipline capable of meeting the current challenges of anthropogenic climate change. Webcasts of the keynote talks are now freely available online (<http://www.pages-osm.org/osm/videos.html>).

Evening sessions included a public lecture by Jim Hansen (NASA Goddard Institute for Space Studies), who spoke to a packed auditorium on the “Global warming time bomb: The path from science to action”. Avid scientific discussions were held at the local pubs, enhanced by the superb range of local microbrewery stouts and ales (including a particularly tasty raspberry beer). These conversations continued over the conference dinner, which was held at a local winery. The meeting was also the setting for the inaugural PAGES Soccer Cup, which saw the Modellers score a 2-1 victory over the Proxy People!

Throughout both meetings, one of the continuing themes was the great importance of communicating scientific results to the public. Several keynote speakers noted the significance of being able to clearly report scientific findings to the media, while avoiding misinterpretation or sensationalism. This is especially true when discussing projections of future climate change.

Overall, the six days were remarkably informative and inspirational. In particular, the presentations demonstrated a consistently high degree of integration, both between different proxies and between the data and modelling communities. This sets a standard towards which we should all aspire.

The authors made many invaluable new contacts, and the meetings have given rise to many new collaborations. We also learnt a lot more about PAGES, which aims to act as an integrator between communities and disciplines. PAGES has a lot to offer the Australasian palaeoclimate community, and there is a lot of potential for PAGES and the local community to work much more closely together in future. In the short term, a regional workshop for the Australasian 2K working group is being planned for mid-2010. Please contact us if you are working in this time period and are interested in being involved.

We wish to thank PAGES and the hosts for organising such excellent and enjoyable meetings, and also wish to thank AQUA and ARCNESS for offering financial support.



Women in Science in Australia:

A workshop to discuss a new report commissioned by the Federation of Australian Scientific and Technological Societies (FASTS)

Parliament House, Canberra, 17 September 2009

Kathryn E. Fitzsimmons

Research School of Earth Sciences
Australian National University
Canberra ACT 0200
Telephone: +61 (0)2 6125 4035
Email: kathryn.fitzsimmons@anu.edu.au

As a young, female, early-career researcher in science, there can be times when I become aware of being in somewhat of a minority group, particularly when seeking a role model on which to base one's career path. It becomes readily apparent that among the many distinguished senior scientists in our field, a disproportionately small number of those people seem to be women. Being a scientist my natural reaction is to seek statistics to support my (possibly gender-biased) observations before making sweeping generalisations about the state of things.

In this respect the Federation of Australian Scientific and Technological Societies (FASTS), of which AQUA is a member, was one step ahead of me when it recently

commissioned a report into the status of women in science in Australia. The report was prepared by Professor Sharon Bell (previously Deputy Vice-Chancellor of the University of Canberra) with input from FASTS, the Office of the Chief Scientist (including Chief Scientist Professor Penny Sackett) and the federal Department of Education, Employment and Workplace Relations. The aim of the report is to highlight the present status of female scientists to Australian government, policy advisors and leaders of research institutes, in an accessible and inclusive format. The report examines the data available on the participation, retention and success of women in the science and technology field, and identifies emerging themes and issues, as well as existing initiatives to improve the



Photo: Participants at the workshop to discuss the FASTS report on the status of women in science (note trusted Editor of *Quaternary Australasia* third from left in front row). Although women outnumbered men in this instance, it was reassuring to see a number of men present at the workshop, all of whom were just as passionate about the issue as the women!

gender balance problem. It is important to note that the gender imbalance issue, as Professor Bell points out, is not simply a problem of achieving equality in numbers, but is one affecting productivity, expertise and innovation in Australia as a whole.

This report is the successor to an earlier document presented to the Australian government in 1995. The main conclusion of both reports is that women are substantially under-represented in most scientific disciplines, and that they are particularly poorly represented at the most senior levels of all science fields. That the report outcome in 2009 should be effectively the same as in 1995 is disheartening to say the least. Probing deeper, it becomes apparent that the issue is not simply one of increasing numbers of women in the sciences. It is a complicated issue requiring an understanding of the reasons behind attrition rates of women beyond PhD completion and Level A appointments (at which levels the proportion of women is almost equal to that of their male colleagues), the typically more circuitous career paths taken by women compared with their male counterparts, the nature of scientific work itself, and even political change which has affected (and hindered) initiatives which may have seen positive steps to improve the situation.

Although the report was prepared by a small team, FASTS had the fine idea of holding a workshop to obtain feedback on the report, and to brainstorm potential initiatives to boost the status of women in science, prior to its release to the Australian Government. I had the privilege of representing AQUA at this workshop, which was held at Parliament House in Canberra and involved approximately 100 men and women, junior through to senior, from science researchers to public servants, industry folk and lobbyists. We shared the common interest of wishing to understand why women are so disproportionately under-represented in science in general (and have remained so for at least the last 14 years), and to ponder solutions to the issue of gender imbalance and the problems for work environments, and loss of productivity, innovation and expertise, that this situation entails.

The workshop began with a breakfast which provided an opportunity to “break the ice” and to appreciate the diverse backgrounds of the participants. Professor Sharon Bell presented us with an excellent synopsis of the main findings of her report. Among these, she noted that when the 1995 study was commissioned, the status of women in science in Australia, while under-represented, was nevertheless ahead of the field internationally. Fast forward to 2009 and the situation for women in Australia has effectively stagnated, compared with initiatives which have been undertaken in places such as the UK, USA and Europe to bolster both the numbers and seniority of women in science. She questioned why women have fallen off the equity agenda in Australian policy. She suggested that while it is tempting to perceive women as the most successful equity group, this perspective does not take into account women’s proportion of the population relative to other equity groups. She completed her oration

by recommending the inclusion of men, particularly those who frame the organisational culture of research institutions, in decision-making and advocacy to challenge the status quo. Professor Bell’s presentation was followed by Professor Doug Hilton, Director of the Walter and Eliza Hall Institute (WEHI) for medical research. His was a refreshing take on the various initiatives which could be implemented to improve the status of women in scientific research, and a prime example of how men in positions of leadership can use their influence to advocate for change. Professor Hilton commented on the “fossilisation” of science, whereby increasing numbers of older male academics take up proportionally larger amounts of the available research funding, leading to the disenfranchisement of early career researchers, and especially of women. At WEHI various positive steps have been taken to overcome this challenge. These include the extension of contracts by an additional year for each child a female staff member has, the provision of technical support for women on maternity leave, the appointment of tenured staff earlier in their careers, and the implementation of female-only fellowships. Professor Hilton’s aim is to have women in science perceived as heroic not because they survived in scientific careers, but because they excelled in scientific discovery. Breakfast concluded with a short presentation from Chief Scientist Professor Penny Sackett, who provided us with some of her personal experiences as a woman in science.

The workshop then began in earnest. We divided into tables of eight and commenced intense discussion of the five big issues for women in science in Australia:

- How to generate a positive organisational structure in the workplace;
- How to encourage our leaders to address the issue of gender imbalance;
- Building the base of evidence illustrating the status of women in science;
- How to improve the level of influence available to women by appointing them to policy areas, funding bodies and company boards;
- Identifying new ways of getting the issue onto the political agenda.

The main criteria for strategies to address these issues were impact and deliverability. Popular suggestions included providing incentives for change, working towards providing flexible working hours, and changing the prevailing attitude that achievement is judged on hours worked rather than research outcomes. The overwhelming concern seemed to be that we need to change the existing attitudes, present in both women and men, whereby the under-representation of women is perceived as a “numbers game” and a female-only problem. The most suitable strategies for this were agreed to be engaging men and actively seeking their support, and by framing the issue as one of loss of productivity and innovation, not just of achieving equity for equity’s sake. A vote was then cast to identify the most important of these issues. Generating a positive organisational structure and getting the status of women back onto the political agenda were overwhelmingly seen as the most critical topics.

At the conclusion of the various brainstorming, discussion and distillation exercises, Professor Sharon Bell pulled the threads together in a concise summary of our contributions. She added that we need to understand the profile of the people we are losing, as well as identifying what is attractive about the alternative places to which these people are moving, if we are to truly address the issue of female attrition from the science sector. Her principle concern with the report was that it provides an explanation of the “what” and “how” of the issue, but not the “why”, and she thanked us for our discussions which had elucidated, at least in part, that last critical question. Our critical feedback on the report would be combined with the main conclusions from the various (sometimes heated) debates on the critical issues into a final version of the report. This final version of the report was launched by the Australian Minister for Innovation, Industry, Science and Research, Kim Carr, in October.

Although there is clearly no simple solution to the issues surrounding the under-representation of women in science in Australia, the report certainly provides us – and politicians and policy-makers - with more robust and accessible data showing that the issue is real and persistent. Although I may have been vindicated in my perception that, as a woman, I am part of a minority in my field, I would prefer not to be. I would very much like to see future generations of young female researchers take their place in an equitable working environment, where they will be judged on merit rather than tenacity. Thanks to my participation in the workshop, I can appreciate that we all, men and women, junior and senior, have a responsibility to change attitudes and perceptions in the scientific workplace in order to make it a place to discover, not just to survive – which is, after all, what science is about.

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ECR Training Workshop Report: Geochronological dating methods and their applications in Australasian palaeoenvironmental and archaeological research

Morgan Disspain and Ben Keys

Department of Archaeology, Flinders University
GPO Box 2100, Adelaide SA 5001

In early 2009, a group of graduate students, staff and industry professionals participated in a geochronology workshop at the Department of Archaeology at Flinders University, Adelaide. The workshop was run over five consecutive days from the 2nd to the 7th February and was offered through the Early Career Researcher Support Program (ECR) of the ARC-funded Environmental Futures Network (EFN). Program coordination was collaboratively undertaken by Renaud Joannes-Boyau and Sarah Rittner, PhD candidates from the Research School of Earth Sciences at The Australian National University and the Geography Department at the University of Cologne, respectively, with support provided by Dr Lynley Wallis, Senior Lecturer in the Department of Archaeology at Flinders University. The workshop drew participants from numerous Australian universities, along with industry professionals involved in different aspects of Quaternary research.

With Quaternary science's strong emphasis on chronology, the workshop was designed to provide participants with a solid understanding of the basic theories and methodologies for a range of dating techniques applicable to Quaternary timescales, including optically stimulated luminescence (OSL), thermoluminescence (TL), electron spin resonance (ESR), radiocarbon and U-series dating. The workshop highlighted the necessity to place events within the context of the geological timescale, so as to provide a

robust framework where understanding the chronology of palaeoenvironmental change and the interpretation of archaeological sites can be drawn together. This interdisciplinary approach of the program was acknowledged by participants and presenters as being well overdue in Quaternary sciences, and particularly in South Australia where the value of maintaining linkages between the earth sciences and archaeology have been somewhat overlooked. Importantly this workshop also provided ECRs Jonannes-Boyau and Rittner the opportunity to further develop their practical skills in instructing and coordinating symposia within an interdisciplinary context.

The workshop drew together specialists from a wide range of disciplines including dating, archaeology, geomorphology, environmental sciences, geology, vertebrate palaeontology and physics. These specialists presented a diverse series of lectures, applied case studies, practical laboratory demonstrations and a field visit to learn sampling techniques. Presenters included Dr Fiona Petchey from the Waikato Radiocarbon Laboratory in New Zealand, who discussed methods, applications and future developments of radiocarbon dating, along with issues concerning sample preparation and contamination. She also conducted a hands-on session in the use of the University of Oxford calibration software, OxCal (v4.1), as well as a demonstration on sample pre-treatment. Dr Frances



Figure 1: Dr Fiona Petchey running the interactive Oxcal session (Photo M.Disspain).



Figure 2. Dr Fiona Petchey and Dr Frances Williams in the Adelaide University OSL/TL dating laboratory (Photo M.Disspain).



Figure 3. Dr Fiona Petchey demonstrating preparation of C14 samples (Photo M.Disspain).

Williams from the School of Chemistry and Physics at the University of Adelaide introduced participants to the principles of luminescence dating, which was complemented by Sarah Rittner's session on the application of and issues in OSL. Renaud Joannes-Boyou introduced the principles of uranium-thorium dating, and both Rittner and Joannes-Boyou discussed ESR dating methods and applications. A range of specialists presented highly informative case studies for various geochronological dating techniques. These included Dr Eric Bestland, Dr Lynley Wallis, Dr Gavin Prideaux, Dr Liz Reed and Prof Rod Wells from Flinders University, Prof John Prescott and Dr John Tibby from the University of Adelaide, Prof Rainer Grün from the Australian National University, and Dr Nigel Spooner from the Defence Science and Technology Organisation.

The workshop included a tour of the Adelaide University OSL/TL dating laboratory. This incorporated a demonstration of OSL and TL sample collection in the field and laboratory preparation, as well as an explanation of single grain dating procedures using Risø equipment. On the final day of the workshop Rittner coordinated a field trip to Port Willunga, where participants had the opportunity to collect samples for OSL dating from the cliffs surrounding the beach.

Outcomes of the workshop included a broadening of skills and knowledge for participants in terms of the theory behind different geochronological techniques, their applications and limitations. It also provided a valuable forum for Quaternary specialists to meet and discuss ideas, innovations, and future collaborative projects.



Figure 4. Sarah Rittner and Clare VonMaltzhan taking OSL samples at Port Willunga (Photo Louise Holt)

Archaeological Field Methods Field School Report

Albany and Esperance, Western Australia

Hayley Heffernan

Department of Archaeology, Flinders University
heff0019@flinders.edu.au

Editors: Dr Lynley Wallis
Lynley.Wallis@flinders.edu.au

Ian Moffat
Ian.Moffat@flinders.edu.au

In April 2009 Flinders University's Archaeology Department ran a field school in collaboration with various other industries and organizations. Located at Albany, Esperance and surrounding areas in Western Australia, students came from universities and industries around Australia in order to participate. Students were exposed to field methods and practices forming an essential part of archaeology. The field school was designed to help students improve and expand their ability to record, excavate and analyse archaeological material in a field setting. Other methods such as Ground Penetrating Radar (GPR) were applied at Albany Historical Cemetery in order to locate historical unmarked graves. Traditional Owners from the Nyoongar community were onsite throughout the entire field school providing students with the opportunity to work closely with them. This gave students the opportunity to develop a greater understanding of ethics and cultural considerations when working with Indigenous communities and on their land.

From April 12th to 25th a group of students from universities and various industry partners, including Ergon Energy Queensland, BHP Billiton and Aboriginal Affairs Victoria took part in an archaeological field school based in Albany and Esperance, Western Australia. The field school was run collaboratively by staff from the Flinders University Archaeology Department, the Western Australia Museum, Applied Archaeology and local Nyoongar communities. It was supported by South Coast Natural Resource Management, the Western Australian Department of Indigenous Affairs and the Gabbi Kylie Foundation, through the National Trust of Australia (WA).

The field school was designed to help students improve and expand their ability to record, excavate and analyse archaeological material in a field setting. It also provided students with an opportunity to consider how to develop research questions for archaeological problems and develop a further understanding of ethics and cultural considerations associated with the practice of Indigenous archaeology, and cultural heritage management.

Over the two week period students participated in various activities including recording of Indigenous



Figure 1. Students collecting data with the GPR at Albany Historical Cemetery. Photographer: Hayley Heffernan

sites and artefacts, mapping, environmental surveying, significance assessments, and the recording of oral histories. In particular, students developed skills in the use of GPS units, topographic maps, Munsell colour and pH charts, dumpy levels, and surveying equipment. Students were taught how to describe stratigraphy, set out excavation squares, complete excavation recording forms, undertake baseline-offset surveying, conduct excavations, sieve, sort and analyse recovered artefacts, and take archaeological photographs. Various Indigenous sites were investigated and visited. These included a rock shelter site at Lake Pleasant View, an open site at Munglinup and a large stone arrangement near Esperance.

Students also had the opportunity to work with geophysicist Ian Moffat, who instructed groups of

students over several days in the application of Ground Penetrating Radar (GPR). Moffat and the students applied this subsurface surveying technique to the Albany Historical Cemetery with the intention of locating historical unmarked graves of local Indigenous and Chinese people. This work also provided an opportunity for local community involvement and interaction. Several Nyoongar community members have ancestors buried in the cemetery and were on-site to assist not only in the collection of data and mapping of the cemetery, but also to provide a historical understanding of the segregation of burials on the site.

Having members of the local Nyoongar community on site throughout the field school provided students with the opportunity to communicate with Traditional Owners and establish relationships based on a common interest and the exchange of knowledge about specific places and sites. The establishment of relationships with Traditional Owners is an important part of Indigenous archaeology, especially in Australia. The opportunity to interact with community members enabled students to understand and make sense of the issues affecting Traditional Owners today and into the future. I personally gained a greater understanding of the importance for the involvement of Traditional Owners in archaeological investigations. It was interesting to note how Indigenous community members can help us understand the past through oral histories, and in exchange, how we archaeologists can help communities understand their past through archaeology.

‘I learned that ethical and cultural sensitivity is a major part of Indigenous archaeology. Also there is a huge emphasis on the heritage management of the land which is sensitive’, stated Emma Young, a Flinders archaeology postgraduate student, who added ‘the field school provided me with a range of archaeological field methods such as site recording, mapping, surveying,



Figure 2. Students excavating a test pit at the Lake Pleasant View open site. Photographer: Hayley Heffernan



Figure 3. The Stone Arrangement, near Esperance, WA. Photographer: Jo Thredgold

site location, how to excavate and then sort as well as artefact analysis’. Georgina Ashley, another Flinders archaeology postgraduate student further commented on the community involvement: ‘One of the best things about the field school was the continual active involvement of the Aboriginal people in our learning and practical components. It was also good to be involved in real projects which worked to benefit the Aboriginal as well as the archaeological community’. ‘As a ‘beginner’ and not knowing anything about field techniques I definitely learnt loads on this trip, not just about archaeology but about cultural understanding and the need for community involvement’, stated Julia Garnaut, Flinders cultural heritage management postgraduate student.

This field school has refreshed old and taught me new skills, all of which will certainly be beneficial to my future career. It made me realise that even though practical components and skills are essential in the field, the social aspect of archaeology is just as important. It is the relationships archaeologists build with communities which not only benefit individual projects but support archaeology as a discipline.

I would like to thank everyone who helped with the organisation and running of this field school. Firstly, to members of the Nyoongar community for generously sharing your knowledge and allowing us work on your country; thank you to Lynley Wallis, Heather Burke, Moya Smith, David Guilfoyle and Myles Mitchell for the organisation and logistics associated with the running of this field school; thank you to Ian Moffat for imparting your GPR wisdom to us; and last but not least, to Louise Holt and Alice Beale for your technical skills and patience.

Rivers, Lakes, Dunes and Soils

A post-IAG conference field trip to the arid interior of Australia

12-19 July, 2009

Peter Almond

Division of Soil, Plant and Ecological Sciences
Lincoln University, Canterbury, New Zealand

This was going to be the longest conference field trip I had ever been on, and I was looking forward to it. Months of winter drizzle in New Zealand, the grind of teaching and exam marking, and I was ready for some cerebral stimulation and adventure in a foreign environment amongst a group of mostly unfamiliar people. We gathered in Mildura, on the Victoria/NSW border on Sunday 12th July; some familiar with the outback, many not, but all with a strong sense of anticipation. We were about to embark on an intense course of Australian arid land geomorphology with the experienced old hand, Gerald Nanson, from University of Wollongong, and a cohort of young guns including Kat Fitzsimmons (ANU), Tim Cohen (Macquarie University), Gresley Wakelin-King (Wakelin-King associates) and John Jansen (University of Glasgow).

Gathering around the buses in the early afternoon at Mildura airport we were given a safety briefing, the two-volume field trip guide and warned of the long days of outback travel. Our transport, gleaming white on the curb side, hadn't lived up to my expectations of rugged outback travel – two Kanga Tours buses, which looked like they would be more at home on the streets of Melbourne than in the outback, each with a trailer attached. But hell, if these guys didn't know what they were doing, who did? Our tour formed a clockwise

loop once we got to Broken Hill (NSW), going by Lake Callabonna, the Flinders Ranges, Innamincka/Coopers Creek, Noccundra, Fowlers Gap and returning to Broken Hill.

The first afternoon was the chance to get an overview of the Cenozoic history of aridity in Australia, which coincided with the continent's migration from the high to low latitudes. This was also the time to adjust to covering dirt road miles at speeds most of us were only accustomed to when travelling on sealed highways. Pooncarie was the destination with one major stop planned for Lake Mungo. An unplanned stop was needed. As we careened along the dirt roads NW of Mildura on our way to Lake Mungo a radio message from Tim Cohen's trailing bus advised us in Gerald's leading bus that our trailer was haemorrhaging luggage. Tim likened the recovery of it to a garage sale.

We arrived at the source bordering dune at Palaeolake Mungo in the late afternoon and were treated to the rich reds, yellows and golds of the desert in the setting sun. Here we had a taster of the late Pleistocene history of aridity in Australia, but more than anything, the stop allowed us to do a pilgrimage to the site which had revealed the antiquity of Aboriginal settlement of Australia, and to discuss the coincidence of that

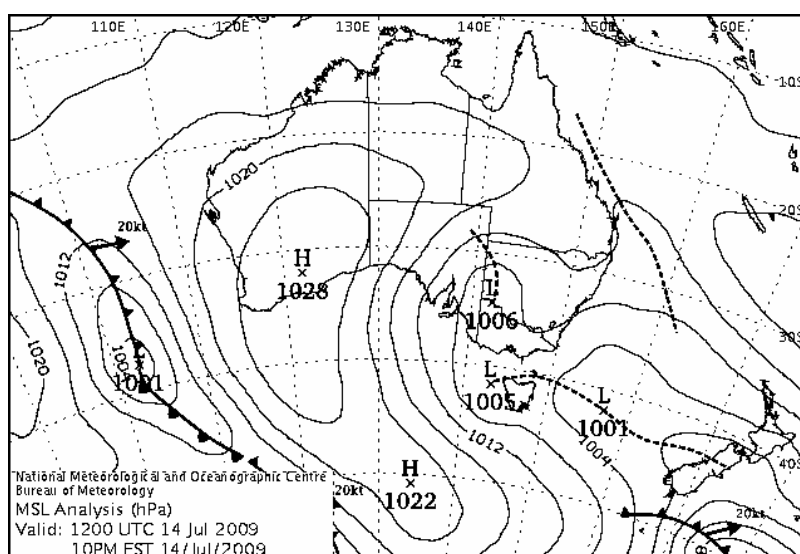


Figure 1. The system that brought Southern Ocean rain to the central Australian desert.



Figure 2. The Slippery Dip section in Brachina Gorge showing finely laminated slackwater deposits.
Photograph: Konah Zebert.

arrival with megafauna extinction. We left in failing light and arrived at the Telegraph Hotel in Pooncarie in the dark. Here the great unwashed were sent off to the campground to set up their tents, while the better resourced stayed at the hotel. In the dark we came to grips with tents that had been repacked by campers fleeing a tsunami: some had flies and no poles, some had no poles, no pegs and only a fly and so on. Somehow we all set up some form of protection from the elements and went to the hotel for a well-deserved cold beer and to share stories with the locals about fishing, farming and the culinary value of echidnas over dinner.

Monday started on the banks of the meandering Darling River in Pooncarie. After a discussion of channel dynamics and river water politics we set off for Erudina Woolshed in the heart of the desert. The day was long and it was over this section we got a taste of the corrugations that were going to rattle us for the next 7 days. It was over this stretch too that many of us began to wonder how well secured all the bits on the buses were. We arrived late in the day again and were greeted by our host at Erudina, John McEntee. The accommodation options were bunks and, for the campers, tents or the woolshed. A recent dust storm had lined the woolshed in a fine choking redness that was too much for me.

John McEntee does not fit the mould of the outback sheep farmer to any extent other than in appearance. After dinner, John regaled us with the finer points of the local Aboriginal languages and stories. The complexity of sounds was overwhelming – four different R-sounds and five different L-sounds in the local language. The other sobering insight he gave us was the perspective the Indigenous people had of the land. As geomorphologists we think we might understand a

landscape; they knew the landscape. In the NE corner of South Australia, the Aboriginal people had 5600 different place names, a fact we know only because of the assiduousness of Lutheran missionaries. The culture and language are being revitalised on the basis of their records. The density of “place” and the dreamtime stories reflect an intimate association with the land that is opaque to people who move at 100 km/h in a steel box. The spatial perspective of these people, who had an appreciation of the shape of landforms obvious to us only from satellite imagery, is beyond wonder. John told us the dreamtime story of how Lake Eyre was made from the stretched (other than a back leg) hide of a kangaroo. Some of the farming statistics were of interest to a New Zealander: 20,000 sheep maximum stock numbers, 16 sheep per square mile on the ‘good’ land, 6 sheep per square mile on the poorer land.

The next day dawned clear, but by mid-morning a trough from the Southern Ocean was demonstrating a source of moisture (and cold air) for the arid interior. Very soon the gleaming white buses were being spray painted haematite red and the roads took on a very different character.

The route this day first took us through the Neoproterozoic to Cambrian rocks of the Adelaide Fold Belt in the Flinders Ranges. As we drove through the contorted rocks we went back in geological time through Cambrian Trezona limestone with stromatolites and then the Rawnsley Quartzite with the enigmatic Ediacaran fauna at its base. These strange life forms initially defied understanding and have been popularised in Stephen Jay Gould’s book *This Wonderful Life*, which describes the explosion of life forms evident in the Cambrian Burgess shale. At Brachina Gorge

we jumped almost the whole of the Phanerozoic to the finely laminated Pleistocene slackwater deposits David Haberlah (Adelaide University) has recently been studying. These deposits, he argues, tell the story of climatically-controlled erosion of loess from local hillslopes during phases when forest and scrubland was replaced by grassland. Erosional phases are consistent with the early-onset (30 ka), two phase Southern Hemisphere LGM emerging in other records.

We were promised quandong pie for lunch at Copley and I was getting excited about some kind of meat pie featuring a local monotreme. To my surprise, though not my disappointment, the pie was filled with a local sweet and tangy delicacy, which, I learnt, was a peach-like fruit from a parasitic tree. From Copley the road rapidly degenerated into a muddy, corrugated strip that shook the bus and our bones for the next five hours through to Moolawatana. We arrived after dark again, to a wonderful barbeque put on by our hosts Karina and Gerard at Moolawatana Station. The night was cold with a gusty wind but a fire in a 44-gallon drum kept the worst of it out. This night everyone was camping; most dosed down in the garage, though some chose to escape the snoring outside in the lee of the garage.

Wednesday morning was scheduled for complex, organisationally challenging movements of people between the station, the airstrip and pits excavated the day before by Tim, Josh and Solomon on paleoshorelines of Lake Callabonna. The plan was for everyone to both see the pits to discuss the timing of lake filling and to go for a flight. It could have worked, but a bus that wouldn't start (and had to be crash started) and a pilot running on outback time meant only one group got in the air. The pits, sampled for luminescence dating the day before, will be

contributing to the story of the recent (last glacial cycle) changes in hydrology of the Mega-Frome paleolake system. We learnt of the correspondence of high lake levels with speleothem growth phases in Narracoorte Cave in coastal South Australia, the inference being that the Southern Ocean must be considered alongside the tropical north when trying to understand the fluvial activity of central Australia (no problem for us based on our previous day's experience).

The lead bus left at about 2.00 pm heading north for Innamincka on Cooper Creek while the other headed to the pits. We were enjoying the last of dinner at Innamincka at 10 pm when we heard the second bus had broken down 45 km south. After a rescue mission, everyone was at Innamincka by midnight and the bus was parked alongside the lead bus at the local garage by morning. Both buses had suffered 'terminal' battery failures.

The enforced break in the morning was used profitably, poring over satellite images and placing in context the fluvial and aeolian geomorphology. The contrasting behaviour of the sediment supply-controlled dunes on the margins of Cooper Creek paleochannels (source bordering lunettes and associated transverse and linear dunes) and the aridity-controlled distal linear dunes was illuminated. Visits to both, on this and the next day, were a highlight for me. Dunes of both kinds record, in one region, aspects of wetness and aridity, although it was apparent from the discussion that the spatial and temporal interplay of the drivers is obviously not simple. The field trip was a great opportunity for Tim Cohen and Kat Fitzsimmons to debate the interpretations.

Up until this point the transportation problems had been in the 'minor and inconvenient' class; they were



Figure 3. Discussing the soil stratigraphy of Hesse Dune, Strzelecki Desert. Photograph: Konah Zebert.



Figure 4. You picked a fine time to leave us, Loose Wheels. Photograph: Konah Zebert.

about to migrate into the ‘catastrophic’. Leaving Innamincka the lead bus started to lurch and shudder, to which Gerald’s response was “We’re losing power. I’ll check the battery terminal”! This was another example of Gerald’s ‘glass is half full’ attitude because it was obvious that the bus’s reluctance could not be attributed to a loose battery terminal, no matter how positively one might wish to think of it. On exiting the bus the problem was clear: the trailer had become a very effective bus anchor by shedding both wheels. Not to waste an opportunity, we had lunch while luggage was stacked into the rear of the bus and a fair-dinkum good Samaritan in a 4WD dragged our trailer to its final resting place in the desert.

The next two days were a long haul to Fowlers Gap via Noccundra. The locals were celebrating a birthday in Noccundra and not much sleep was had by the campers, who, in the local hall, had to sleep through the intermingled sounds of AC/DC, and a 300 hp diesel generator (hard to distinguish at times), blazing lights and the attentions of nocturnal face-licking, shoe-shredding dogs.

Fowlers Gap was reached the next day after running the evening gauntlet of suicidal kangaroos from Tibbooburra. The research station provided great facilities and very interesting geomorphology. In the morning, Gresley Wakelin-King took us through the historical geomorphology of Homestead Creek, a tributary of Fowlers Creek, enlivening vigorous debate about river dynamics and the significance of European grazing. John Jansen took us to another tributary, Sandy Creek, to discuss bedrock incision rates in alluviated streams of post-orogenic mountains. For a New Zealander, discussion of Eocene River terraces as young features involved yet another paradigm shift on my behalf. The anabranching nature of Fowlers Creek

was the last topic of the day. Gerald gave a wonderful distillation of years of pondering the causes of anabranching behaviour. Highly anthropomorphised, it comes down to Australian rivers doing a deal with river red gums so that together, and with precious little help from gravity, they can prevent a clapped out continent getting buried in its own detritus. Obviously it’s only partially working.

Broken Hill and the official end of the field trip was reached that evening. Frantic damage control was put in place down at the local car detailers with a large contingent on the brushes, hoses, brooms and vacuum cleaners. The buses needed to be ready for an early morning return to Adelaide and confrontation with the rental company. We all had faith that Gerald would be able to sweet talk his way through it. “Look... we won’t charge you for those coach bolts holding the bumper on if you’ll forget about the ... now what was it?...forgotten about it already... oh yes, the trailer”.

This was a fantastic trip with a great bunch of people and some wonderful science, which my report has not done justice to. We all felt very privileged to have spent time with Gerald and the crop of young, gifted and vigorous scientists who guided us. The legacy of arid lands research in Australia is in good hands. Special thanks to Gerald (for being Gerald), Kat Fitzsimmons for all her hard work on the organisational front, and Tim Cohen for his driving, and all for sharing their expertise.



Figure 5. Participants of the post-ANZIAG Conference Rivers, Lakes and Dunes field tour. Photograph: Konah Zebert.

Urban Geology and Geomorphology of the City and Suburbs of Melbourne

A mid-IAG Conference field trip

Dr Mel Mitchell

Victorian Environmental Assessment Council
Melbourne, Australia

On the 9th July, around 40 ICG conference participants toured a selection of greater Melbourne's geological and geomorphological sites. Organised by Bernie Joyce (University of Melbourne), Susan White (La Trobe University) and Neville Rosengren (La Trobe University), the field trip included a range of important teaching and research sites across urban Melbourne and provided an introduction to the geology and geomorphology of the region for visitors. Melbourne has a wide range of geological and geomorphological features. Within a short journey from the city centre, rocks spanning Cambrian to Holocene age can be readily examined. Geomorphological processes, both active and relict, are evident on volcanic, sedimentary and granitic landscapes. The low relief landscape was unexpected for visitors from mountainous countries. The influence of urbanisation and coastal engineering are clearly evident. Good exposures in this urbanised environment focus on incised rivers, coastal cliffs and man-made exposures such as road or railway cuttings. The first site visited was Organ Pipes National Park where a range of important volcanic features are displayed in Quaternary Newer Volcanics basalt. Declared in 1972, this national park located about 25 km west of the city was named after the near vertical 30 metre columns of basalt that are said to resemble "organ pipes". These features and others formed when lava pooled and cooled relatively slowly in the palaeo-channel of Jacksons Creek. Dating of basaltic flows in this region indicate that eruptions occurred from approximately 2.8 to 2.5 Ma (Rosengren 1986; Price et al. 1988; Mitchell et al. 2000). Subsequently, Jacksons Creek has re-excavated a valley to a depth of up to 70 metres below the volcanic plain. The valley exposes not only the internal features of basaltic flows, but also sub-volcanic gravels, and Silurian marine mudstones and sandstones which form the basement rocks below much of metropolitan Melbourne. The walk to the 'Organ Pipes' feature takes about 15 minutes down a steep slope (generally longer on the return journey), and the feature is not visible from the visitor centre or the upper areas on the plain. With limited time for each site in an action packed day, a walk to the main viewing area was not on the agenda. Bernie Joyce described the loss of visibility of the organ pipes through inappropriate planting of trees and tall shrubs along the valley floor which now obscure the geological features as inconsistent with the original grassy plains flora of this area.

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View south along Jacksons Creek valley at Organ Pipes National Park, showing river incision below the largely flat lying Newer Volcanics plain.

Leaving this location we travelled across the Werribee Plains, observing a range of features such as volcanic cones and dry stone walls constructed from the readily available volcanic rocks. As we descended into Deep Creek at Sunbury, river terraces, granitic tors, and the relationships between indigenous vegetation and landscape were highlighted. Returning to inner Melbourne, the tour examined three exposures at Royal Park, near Melbourne University. Cuttings along the discontinued inner railway line, now a bike and walking path, and the operating Upfield railway line, expose folded and faulted Silurian sediments, highly weathered Miocene Older Volcanics, and Brighton Group shallow marine sediments (Webb 1988). Dr Susan White, chair of the Geological Society of Australia (GSA) (Vic) Heritage subcommittee, led the tour through this series of exposures. At the southern cutting, GSA (Vic) Heritage has worked closely with the land manager to retain good visual access to the geological section, by encouraging the planting of native grasses rather than tall shrubs or trees along this section of the bike path. Here the group spent some time examining the Brighton Group sediments and the weathering and erosion features on the surface of these



Dr Susan White describing geological features at Royal Park south railway cutting to the field trip participants.

and the underlying Older Volcanics (Mitchell et al. 2000; White et al. 2003).

Coastal sites occupied the afternoon schedule. We travelled along the foreshore of northern Port Phillip Bay starting at Port Melbourne, east to St Kilda and then southeast stopping for lunch at Green Point, Brighton. From this location, there is an excellent view of the city, the historic Brighton bathing boxes, and the popular sandy beaches. Neville Rosengren detailed investigations of coastal beach and cliff relationships, the effects of engineering, infrastructure and land management that have been conducted here for a number of years (Baker 1963; Bird 1990; Rosengren 1988; King et al. 1987). In this region there are a series of bays separated by rocky promontories. These coastal features have formed by gentle undulations or minor anticlines and synclines in the Brighton Group sediments consisting of the Black Rock Sandstones overlain by softer clay dominated Red Bluff sands. Where the more resistant formation of Black Rock

Sandstone has been raised on anticlines, a rocky promontory has formed, and the Red Bluff Sands have eroded to form sandy embayments corresponding to synclinal formations.

The seasonal drift of sandy beach deposits has been documented in sedimentological studies and detailed coastal cliff observations have been conducted in this region (e.g. Baker 1963; Bird 1990). In summer months, the weather pattern is dominated by south and south-westerly wind, driving waves and sand movement to the north. Northerly and westerly wind during winter months drives the sand movement to the south. Seasonal migration of sandy beach deposits at Sandringham harbor south of Brighton was readily compared with those observed on-route in the St Kilda area. The shallowing of the Sandringham harbor occurs because of the capture of sediments behind the impermeable groynes, compared to the relatively free sand movement at the St Kilda piers.

The tour group walked from Sandringham harbour to nearby Picnic Point and then travelled southeast to view the 34 metre high Red Bluff Cliffs, where the Red Bluff sands are spectacularly exposed. Offshore the wreck of HMVS Cerberus tells an interesting story of Australia's maritime history. Commissioned in the 1870s, the Cerberus was one of the first naval ships to serve the colony of Victoria, at a time when there was fear of Russian invasion. It was sunk as a breakwater for Black Rock (Half Moon Bay) harbour in 1926 after being decommissioned. The Cerberus never fired a shot in anger and is listed on the Australian Heritage Register. Travelling a few hundred metres along the coast to Black Rock Point the tour was joined by Professor Eric Bird who described coastal management and geomorphology in the area, including threats to infrastructure from erosion. His long-term research on coastal cliff retreat demonstrated that erosion from run-off and seepage after heavy rain is greater than that caused by wave erosion (Bird et al. 1973; Rosengren 1988; Bird 1993). This research is important for



At Sandringham harbour the prevailing winds move sandy sediments along the coastline either northwest or southeast depending upon the season. Changes to coastal engineering have affected this geomorphic process. Sand is trapped behind the groyne causing the harbour to shallow over time.



At Black Rock Point, Professor Eric Bird and Bernie Joyce described coastal erosion processes and land management.

understanding the impacts of engineering works such as landscaping of the sea cliffs.

Beach renourishment is now undertaken to restore sandy deposits to the popular shores. By reducing cliff erosion through engineering and landscaping, and constructing sediment traps such as the groynes and harbours, the input of sandy material to the beach has been substantially changed. Restoration of the beaches through engineering is a very expensive solution. Ricketts Point teahouse in Beaumaris southeast of Black Rock hosted our afternoon tea and many of the group enjoyed a stroll through the Banksia woodland at the picnic area. The wide shore platform at this location was contrasted with the coastal cliffs and bays we had seen between Brighton and Black Rock. Here the sea cliffs lie inland of the foreshore. Nearby at Table Rock, the coast orientation abruptly changes from NW-SE to NE-SW, influenced by the Beaumaris Monocline (e.g. King et al. 1987; Rosengren 1988; Bird 1993). At the final locality we viewed the Brighton Group sediments exposed in the Beaumaris sea cliffs, which provides the type section of the Late Miocene Cheltenhamian stage. This is also one of very few Australian localities of this age that contains fossils of both terrestrial and marine vertebrates. The coast again changes orientation at Mentone. This section of the coastline has been entirely modified by landscaping and bevelled to a low angle, and the original white sea cliffs can now only be seen in early 20th century art from the impressionist Heidelberg School.

As the light began to fade, the tour ended with a vote of thanks for the organisers, and a lovely view of the sun

setting across the bay on the return journey to the city.

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Volcanoes, Apostles, Eels, Caves and Homesteads

A pre-IAG Conference field trip to western Victoria

3-6 July 2009

Chris Pavich

Department of Environment, Climate Change and Water, New South Wales
Email: chrispav@winsoft.net.au



Figure 1. Appreciating the erosive power of the western Victorian waves. Photograph: Chris Pavich.

Geological, biological, and cultural diversity were memorable features of the Geomorphology 2009 pre-conference field trip to the western district of Victoria from 3-6 July 2009. Twenty-five geomorphologists from Japan to Croatia inspected coastal sea-stacks, Quaternary volcanics, prehistoric eel traps and permanent structures, megafauna footprints, colonial homesteads, and modern land management issues, all in the space of four days.

Bernie Joyce (University of Melbourne) enthusiastically welcomed and led the multicultural group to discover the hotspots of the region's surprisingly varied scientific attractions, all located within the eastern three precincts of the Kanawinka Global Geopark – the first geological park in Australia. He collaborated with local indigenous people, prehistorians, speleologists, local government notables, palaeontologists, and Geopark / National Parks managers to give participants



Figure 2. Eroded coastline near Port Campbell. Photograph: Chris Pavich.



Figure 3. Community engagement is important for establishing geological parks. Photograph: Chris Pavich.



Figure 4. Megafauna tracks through lunette-fringed wetland. Photograph: Chris Pavich.

wide-ranging views and understanding of the region's scientific, natural, cultural and economic values. At one of the trip's earliest stops our international guests particularly appreciated the "Welcome to Country" given by Richard Collopy of the Otway people. Hot on the heels of the recent collapse of the Island Archway just off the coast at Port Campbell National Park, we observed the erosive powers of storm waves rolling in off the Great Southern Ocean. To the chagrin of would-be Port Campbell developers, geotechnical advice presented to us warned that the continuing rapid wave shaping of the narrow inlets and sea caves was likely to destabilise the town's headland, potentially

destroying the controversial structures they proposed to build there.

With the smell of salt in the air (and in our hair) the group walked to the ocean edge both on open beaches and in narrow defiles. Exposures of Miocene limestone revealed seepage lines and speleothems, leading to discussion about the geochemical processes which promote collapse. Chillingly evident was the hopeless situation faced by shipwrecked nineteenth century mariners and their rescuers faced with the prospect of scaling the deeply incised coastline.

Lower sea levels during glacial periods facilitated the



Figure 5. Speleothem growth along the perilous western Victorian coastline. Photograph: Chris Pavich.

(now offshore) flow of lavas originating at Mt Eccles to around 12km seaward of the current coastline. The Tyrendarra lava flow dammed creeklines, creating eel nursery habitats utilised by Aboriginal harvesters. The productivity of the site and availability of appropriately shaped, durable building materials led to the development of permanent stone shelters, an Indigenous technology apparently unique in Australia. The constructed stone eel and fish traps also present are not dissimilar to stone fish traps built by Aboriginals elsewhere in Australia. Local Aboriginal elder Darryl Rose and prehistorian Dr Heather Bulth gave insights into the development of this technology.

Koalas, kangaroos and emus provided highlights on the excursion's second day at the Tower Hill maar volcano. This was the first opportunity for most of our overseas colleagues to observe native Australian fauna in the wild. Management of this site was described by

a local Aboriginal co-operative elder, John Sutherland, which Bernie complemented with a comprehensive interpretation of the volcanic events here.

Speleologist / Geologist Ken Grimes joined us for the rest of this day, at the Mt Eccles volcanic complex and Byaduk lava caves. Ken led us both over and underground to examine the finer details of the internationally significant lava tubes. He and Bernie subsequently helped all participants assess the relative ages of volcanic events, from observations of the weathering profiles to morphology of the regolith.

Recently discovered megafauna tracks across volcanic ash deposits raised a high level of interest amongst participants. Steve Carey showed us the results of his fieldwork in the area of a lunette fringed wetland, where the movements of several vertebrate species could be observed and their purpose speculated on!



Figure 6. Bernie Joyce discussing western Victorian volcanic activity. Photograph: Chris Pavich.

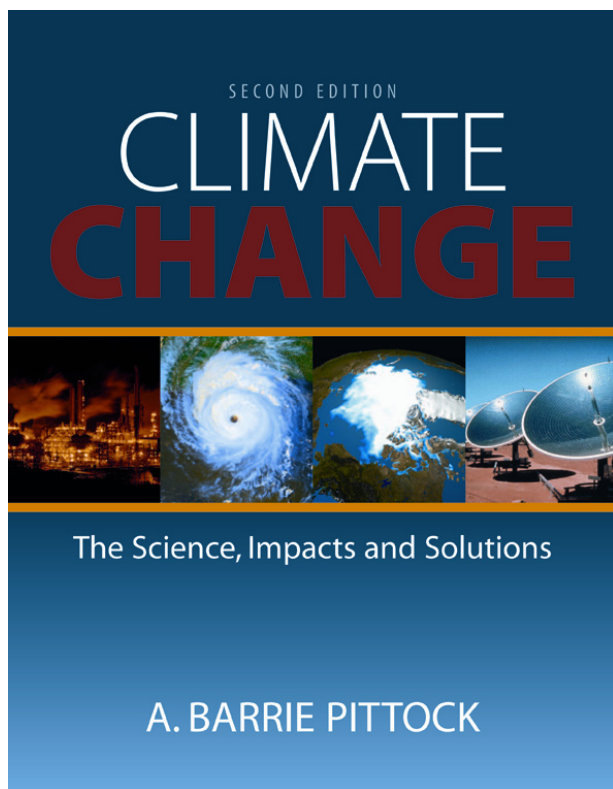
Significant cultural features including historic stone walls, quarries, and homesteads were also appreciated. Conflicts such as inappropriate housing developments, towers, and roads that degraded volcanic feature sightlines and viewpoints were observed and analysed.

Kanawinka Geopark features were expertly promoted at the Penshurst museum. We were warmly welcomed here by the UNESCO Kanawinka Global Geopark Director, Joane M^cKnight, and her staff. This was followed by discussions regarding the park's scientific values and their interpretation to the public.

The ease of establishing the Geopark was partly based on the lack of any associated formal regulations inhibiting development within Park precincts. Patient diplomacy was considered a more effective long term planning and management tool than having no Geopark status at all. We met with local community groups or their representatives several times and were generally impressed by their hospitality, commitment and results.

All fieldtrip participants were guests of the Corangamite Shire at a reception held in our honour. The Mayor, councillors, concerned staff, and local dignitaries gave presentations concerning the Geopark's local significance. Everyone then listened to several fieldtrip participants describe their overseas geomorphological research interests and local community involvement.

This fieldtrip was an excellent overview of the geomorphology of the Western District of Victoria, together with analysis of the inevitable conflicts that arise when protecting or conserving the inherent scientific, cultural and economic values. The Kanawinka Global Geopark concept appears to be a valuable contribution to resolving these conflicts.



Climate Change: The Science, Impacts and Solutions

A. Barrie Pittock

Published by the Geological Society of New Zealand in association with GNS Science

One of the courses I taught every year in Hong Kong was a broad climate change course delivered to a diverse body of 120+ students from all faculties. One of the key challenges I faced was finding an unbiased, concise, readable text for students with little scientific background. Thanks to A. Barrie Pittock that search is now over. *Climate Change: the Science, Impacts and Solutions* is the second edition to Pittock's 2005 book *Climate change: Turning up the heat*.

Barrie Pittock's contribution to science and science leadership in Australia is well recognised at all levels. His broad knowledge of the climate change debate, its science, policy implications and internal politics are second to none in the region. This depth and the breadth of his knowledge are truly evident throughout this book. Despite the wordy and sometimes jargon-filled nature of certain portions, the text is generally written in a relaxed readable style that reflects his years of experience. It delivers what I think is one of the most balanced commentaries of the ever-evolving scientific research now available on the world's most topical debate.

For the most part the author makes a point of presenting all sides of the arguments about the science, and possible remedies for dealing with climate change. I particularly enjoyed the way Pittock went after some of the main lines of evidence used by climate change skeptics, including a detailed commentary on the

'hockey stick' debate and a discussion of why even 1°C of warming could still have dire consequences. Pittock also reserves a well worded kicking for geologists that some QA readers may find a little rattling.

Pittock covers many, if not most, aspects of the debate, including a concise review and examination of recent climate change analyses. He touches on Arctic and Antarctic sea ice, the IPCC Fourth Assessment Report, and the policies of the then Australian Government. The book also contains discussions on large-scale renewables, citing California as an example, as well as tips for smaller-scale personal choices in individual homes and businesses. The book includes extensive links in footnotes, providing site links with ongoing and updated information (although some are no longer valid) that would be of much help to senior undergraduate students. For the most part the arguments for change and the methods proposed are outlined and described well. That said, the author does tend to gloss over the negatives involved in some changes. Although the depth of coverage is excellent, one gets the sense that Pittock is often holding back on criticism of some mitigation measures and recent policy decisions, for example the rejection of the previous Australian government of the Kyoto Protocol.

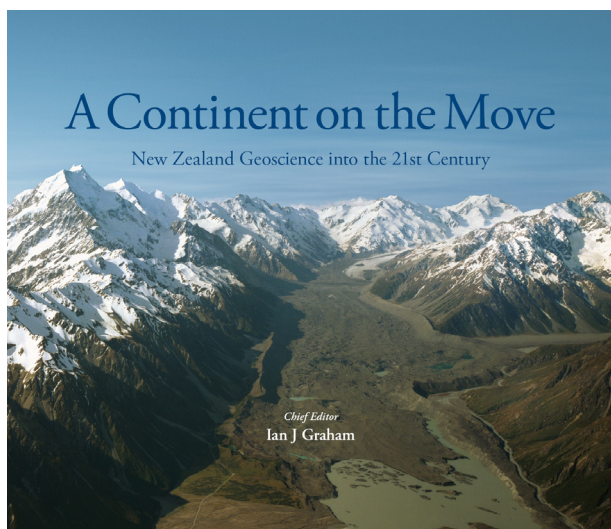
While the book's message is clear that climate change is here to stay, Pittock sees some hope for the future and gives us excellent insights into how we can go about changing our ways. Although the text can be a bit dry in places, I feel that *Climate Change: The Science, Impacts and Solutions* is a good and very necessary read for students in earth, environmental or social sciences, policy makers, and people who are genuinely concerned about the future of the planet.

Review by Adam D Switzer

Earth Observatory of Singapore

Nanyang Technological University

Singapore



A Continent on the Move
Edited by Ian J. Graham

New Zealand geosciences book wins national award

On Monday 27th July at the awards ceremony in Auckland for the Montana New Zealand Book Awards for 2009, a new geosciences book “A Continent on the Move: New Zealand Geoscience into the 21st Century”, edited by Dr Ian Graham and published by the Geological Society of New Zealand (GSNZ) in association with GNS Science, was awarded first prize in the ‘Environment’ category. The judges commented that the book “...is hugely successful in the terms it sets and will make a wide range of New Zealand readers, from the general reader to the specialised reader, enthused about a subject so close to us ... The presentation is superb. The landscape pictures, besides their relevance, are often beautiful and the diagrams consistently clear... (Dr Ian) Graham has brought together the work of more than 100 specialist writers and created a scientifically exacting yet accessible book, one that is cohesive in tone

and style.” Category advisor Geoff Chapple predicts it will become ‘a benchmark publication for popularising the Earth sciences in New Zealand’.

Originally conceived as a project to celebrate the society’s 50th anniversary in 2005, the resulting book after four years in preparation is destined to become a ‘classic’ both as an authoritative text and as a ‘coffee table’ documentation of New Zealand’s stunning geology and active landscapes. Chief editor and central driving force in the project was Dr Ian Graham (GNS Science, Lower Hutt). He was assisted by 13 sub-editors and three scientific/technical editors (Mike Isaac, Eileen McSaveney, and David Lowe). More than 120 authors, all active geoscience researchers, wrote the articles. The book stretches to nearly 400 pages and contains hundreds of illustrations in colour including numerous photographs by superb landscape photographer Lloyd Homer as well as specially prepared diagrams and maps, all in colour. A feature of the book, divided into 13 thematic chapters, is that contributing articles are either two or four pages long and so a very wide range of topics has been covered, each in easily digestible sections. The book is fully indexed and contains a glossary and suggestions for further reading as well. Free copies of the book have been distributed to every secondary school in New Zealand. The hard-bound book, launched in the New Zealand Parliament in September 2008, has sold very well and a second printing has been required within 12 months of publication.

“A Continent on the Move” can be purchased in New Zealand from Whitcoulls, Dymocks and Bennetts or ordered from Craig Potton Publishing on the internet (<http://www.craigpotton.co.nz/Products/published/Books/>). The cost in New Zealand is around \$50 (post free via Craig Potton website).

David J. Lowe
Department of Earth and Ocean Sciences, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand



Photo (From left) Ian Graham (GNS Science), Mike Isaac (GNS Science), Jan Lindsay (Auckland University, Vice-president GSNZ), and David Lowe (Waikato University) celebrate the success of the “Continent” book at the Montana NZ Book Awards for 2009. Photo: Seb Lowe

An enhanced ~1800-year record of recent volcanic ash-fall events for northern New Zealand from the analysis of cryptotephra

Maria J. Gehrels (PhD)
School of Geography, Earth and
Environmental Science
University of Plymouth and
Department of Earth and Ocean Sciences
University of Waikato

The history of volcanic eruptions in North Island, New Zealand, based on the visible stratigraphic record of tephra is not fully representative of the type, frequency and magnitude of eruptions that have occurred in the past or that are likely to occur in the future. Relatively small-scale eruptions from the region's andesitic volcanoes can produce widespread fine tephra falls with considerable impact, such as during recent eruptions of Mt Ruapehu (1995-1996) and Mt Ngauruhoe (1974-1975), and their threat is therefore likely to be underestimated. The aim of this study was to develop an enhanced stratigraphic record of recent ash-fall events in the Auckland and Waikato regions through the application of cryptotephrostratigraphic techniques. Cryptotephra in sediment cores from two peat bogs and two lakes were quantified and characterised for the period since deposition of the AD 233 ± 13 Taupo Tephra. A complex record of primary and reworked rhyolitic and andesitic tephra-fall is revealed. A stratigraphic and geochemical protocol for distinguishing primary from likely reworked tephra was developed and enabled the identification of ten post-Taupo cryptotephra-fall events. The rhyolitic Okataina Volcanic Centre-derived Kaharoa Tephra (AD 1314 ± 12), a key chronostratigraphic marker for human settlement in New Zealand, was found in all sites together with four pre-historic Mt Ruapehu-derived tephra of the Tufa Trig Formation (Tf4, Tf5, Tf6, and Tf14). In the Waikato Region, an additional Tufa Trig tephra (Tf8) was detected, as well as ash fallout from historical eruptions of Mt Ruapehu (1861, 1945 and 1996) and Mt Ngauruhoe (1975). These findings represent a considerable extension to the known geographical ranges of tephra-fall events and demonstrate that cryptotephrostratigraphic techniques can enhance the historical and geological record of ash-fall events

as a guide to future volcanic hazard assessment for countries such as New Zealand.

High-Resolution Holocene Palaeoenvironmental and Palaeoclimatic Changes recorded in Southern Australian Lakes Based on Ostracods and their Chemical Composition

Chris Gouramanis (PhD)
Research School of Earth Sciences
The Australian National University

This thesis presents the first high-resolution Holocene (palaeo) climate reconstruction from both southeastern and southwestern Australia that is developed from sediment cores obtained from four lakes. This thesis is also the first attempt to integrate high-resolution climate variability across the southern margin of the Australian continent using a consistent methodology.

Four sediment cores, one from each of Lake Keilambete, Lake Gnotuk and Blue Lake (Mt Gambier) from southeastern Australia, and one from Barker Swamp from southern Western Australia were collected, and especially studied for the ostracod faunal assemblages. Selected ostracods were carefully chosen for trace metal (Mg/Ca, Sr/Ca, Na/Ca and Ba/Ca) and stable isotope (^{18}O and ^{13}C) analysis to identify the geochemical variations from sequential horizons from each core. Trace metals of ostracod valves were analysed on the Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) and stable isotopes were analysed on a Mat-Finnigan 251 mass spectrometer.

Age models for each core were provided through the analysis of ^{14}C by Accelerated Mass Spectrometry of biogenic carbonate and plant microfibrils. Quartz grains were also examined using Optically Stimulated Luminescence techniques to develop an age models for comparison with radiocarbon dates. This work was conducted by Wilkins (2008) and only the results and their application to the palaeoenvironmental and palaeoclimatic reconstructions are provided here.

Field sampling of ostracods and lake water physical and chemical

parameters from both southeastern and southwestern Australian sites and trace metal analysis of cleaned ostracod valves (from live specimens at the time of collection) combined with results published elsewhere allowed the development of partition coefficients (K_d) between the trace metal concentration of ostracod calcite to lake water. Lake waters were analysed at the Western Australian Chemistry Centre and cations were also analysed on the ICP-AES at ANU to calibrate the results from the two laboratories. Ostracod valves were analysed for trace metals on the ICP-AES and the inter-laboratory calibrations applied. It is shown that $K_d(\text{Mg})$ varies as a function of the $\text{Mg}/\text{Ca}_{\text{water}}$ and temperature and that $K_d(\text{Sr})$ varies as a function of the HCO_3^- of the water. It is also shown that the Na/Ca of ostracod valves can be used as an indicator of hydrochemical change.

The field collections, supplemented by other published records from many sites around Australia, were used to examine the relationship between ostracod species and the physical and chemical environment of the host lake water. Non-metric Multidimensional Scaling was used to determine the primary environmental gradients that define individual ostracod species distributions from both a continent-scale and regional perspective. Salinity and $\text{Mg}/\text{Ca}_{\text{water}}$ were significant environmental gradients in all analyses and statistical comparison of individual species shared between regions indicated, that for salinity and $\text{Mg}/\text{Ca}_{\text{water}}$ regional differences occurred. The Modern Analogue Technique was employed to develop salinity and $\text{Mg}/\text{Ca}_{\text{water}}$ transfer functions from datasets from the southeastern and southwestern Australian ostracod and water field collections and these transfer functions are applied to the fossil ostracod assemblages identified from each lacustrine core. The salinity transfer functions are applied to all four lake cores whereas the $\text{Mg}/\text{Ca}_{\text{water}}$ transfer function is only applied to the Lake Keilambete and Lake Gnotuk ostracod assemblages. The $\text{Mg}/\text{Ca}_{\text{water}}$ transfer function was developed in order to constrain the effects elevated $\text{Mg}/\text{Ca}_{\text{water}}$ has on the Mg uptake during ostracod valve calcification and allow inferences on temperature variation to be developed.

The palaeoenvironmental and palaeoclimatic history of the four lake cores shows that there was a progressive warming and increase in precipitation through the early Holocene as suggested by an expansion of the Australian monsoon into more southerly latitudes. This expansion, however, was not a linear feature through time with sudden but short lived contractions punctuating the overall expansion. This period of elevated humidity and rainfall resulted in the filling of Lake Keilambete and Lake Gnotuk and significant hydrological recharge of the aquifers surrounding Blue Lake in southeastern Australia. In southwestern Australia increased precipitation caused weathering of the aeolianite and initiation of a very wet phase resulting in high water levels in Barker Swamp.

The middle Holocene is characterised by higher temperatures than today and very little precipitation resulting in rapid and significant lake level lowering both Lakes Keilambete and Gnotuk. Due to volumetric differences between Lakes Keilambete and Gnotuk, Lake Gnotuk's response to this climate shift lags that of Lake Keilambete. Paradoxically, as these lake levels decline, the nearby Blue Lake water levels rose. This is attributed to increased groundwater flow into the lake basin from the surrounding recharged aquifers. Similarly, southwestern Australia, recorded much drier conditions, although subtle variations in temperature and precipitation are recorded during this phase.

The middle to late Holocene records highly variable climate shifts with hot arid periods and cool wet periods resulting in decreased and increased lake levels across southern Australia. This indicates that the region was influenced by similar large-scale circulation features with latitudinal shifts in the mean position of the mid-latitude frontal systems. From about 3.5 ka, the southeastern and southwestern Australian records diverge, which is due to the increased influence of El Niño Southern Oscillation along the eastern margin of Australia. There is also evidence of a 200 year periodicity in the south eastern Australian lake levels that may be related to solar cyclicity. The last 1000 years records significant variation in the lake levels from

southeastern Australia culminating in the current rapid decline in lake levels.

Comparison with other climate proxies from a high-resolution core offshore of the Murray River mouth in South Australia and the alpine Blue Lake in the Snowy Mountains shows similar trends to those found in the four cores studied here.

The palaeoecology of the Midlands, Tasmania

Penny Jones (Honours)
School of Land and Environment
University of Melbourne

Pollen and charcoal analysis has provided vegetation and fire histories from two contrasting sites in the Midlands of Tasmania. The Midlands are a belt of plains occupying the driest part of Tasmania supporting grassland, grassy woodland and open forest. The vegetation has been heavily modified since European settlement and many communities are now threatened. Knowledge of past vegetation patterns is sparse, with just one reliable pollen sequence previously available for the region.

Sediments from Stoney Lagoon in the eastern Midlands provide a record of environmental change over the past 13 000 years. The area supported sparse grassy woodland in the terminal Pleistocene, with Eucalyptus forest expanding ca 11 000 14C years BP. Eucalyptus forest persisted at the site throughout the Holocene but there have been significant changes in understorey composition. Asteraceae dominated around 11 000 14C years BP before a grassy understorey developed in the early Holocene. A gradual transition to a heathy understorey began ca 8000 14C years BP and the local vegetation has been relatively stable for the past 6000-7000 years. However, wetland dynamics reveal mid-late Holocene shifts in the water balance and a brief pteridophyte expansion ca 3000 14C years BP suggests a short-term cooling episode. Burning appears to have increased in the late Holocene but vegetation dynamics do not appear related to trends in the charcoal record.

Township Lagoon provides a record of change in the central Midlands over the past 400 years. Significant changes are evident post-European

settlement, and the major trends include tree loss, exotic invasion and accelerated erosion. Allocasuarina exhibits a rapid and early decline, suggesting preferential clearing for timber and firewood in the early years of settlement. Most other changes have accelerated in the twentieth century, reflecting increased land clearance and the spread of exotic pastures.

Engrained in the Past: Using Geoarchaeology to Understand Site Formation Processes at the Gledswood Shelter 1 Site, Northwest Queensland

Ben Keys (Honours)
Department of Archaeology
School of Humanities
Flinders University

This thesis explores the relationship between the preserved material record and site formation processes at the Pleistocene aged Gledswood Shelter 1 in northwest Queensland. Multi-technique investigations were conducted to determine the source of the sedimentary matrix, to better define the chronology and to help elucidate the environmental conditions during occupation phases. The results suggest that there is limited post-depositional movement of artefacts through the stratigraphic sequence, which allows confident interpretation that excavation units containing material culture are representative of periods of occupation. Additionally, the sediment in the site derives principally from the adjacent bedrock through *in-situ* decomposition however has been subject to varying amounts of anthropogenic and pedogenic post-depositional alteration depending on age. These findings will assist in the interpretation of the archaeological record of the site and so help develop our understanding of the archaeological record of northwest Queensland and refine occupation models for Pleistocene Sahul.

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School of Geography, Planning and Architecture
The University of Queensland
Brisbane QLD 4072
Australia
PH: +61 (0)7 3365 6418 FAX: +61 (0)7 3365 6899
President@aquaa.org.au

Vice President

Dr Peter Almond
Division of Soil, Plant and Ecological Sciences
Lincoln University, PO Box 84, Canterbury, New Zealand
PH: +64 3 3252 811 FAX: +64 3 3253 607
VicePresident@aquaa.org.au

Treasurer

Dr Samuel Marx
School of Geography, Planning and Architecture
The University of Queensland
Brisbane QLD 4072
Australia
PH: +61 (0)7 3365 3995 FAX: +61 (0)7 3365 6899
Treasurer@aquaa.org.au

Secretary

Dr Craig Sloss
School of Natural Resource Sciences
Queensland University of Technology
GPO Box 2434
Brisbane QLD 4001
Australia
PH: +61 (0)7 3138 2610 FAX: +61 (0)7 3138 1535
Secretary@aquaa.org.au

Information Technology Editor

Dr Timothy T. Barrows
School of Geography
University of Exeter
The Queen's Drive, Exeter, Devon, EX4 4QJ
United Kingdom
PH: +44 (0)1392 262494 ITeditor@aquaa.org.au

Quaternary Australasia Editor

Dr Kathryn Fitzsimmons
Research School of Earth Sciences
The Australian National University Canberra ACT 0200 Australia
PH: +61 (0)2 6125 4035 FAX: +61 (0)2 6125 0738
Editor@aquaa.org.au

Public Officer

Dr Matt Cupper
School of Earth Sciences
The University of Melbourne Melbourne, Victoria 3010 Australia
PH: +61 (0)3 8344 6521 FAX: +61 (0)3 8344 7761
cupper@unimelb.edu.au

