Australasian Quaternary Association Inc.
ABN 78 458 664 047
www.aqua.org.au
AQUA

Photo: Mungo lunette; Kathryn Fitzsimmons

AQUA Biennial Meeting

The Grand Hotel, Mildura

29th June – 4th July, 2014

Program and Abstracts

PROGRAM

	Sunday 29th	Monday 30th	Tuesday 1st	Wednesday 2nd	Thursday 3rd	Friday 4th
8:30-10:30		**Lakes, Dunes, etc.**	**SHAPE**	**Management**	**Oceans and Ice**	
10:30-11:00		*Morning tea*	*Morning tea*	*Morning tea*	*Morning tea*	
11:00-1:00		**Lakes, Dunes, etc.**	**SHAPE**	**Willandra**	**LGM**	*Mungo Fieldtrip* *Departing 7:30 am*
1:00-1:45		*Lunch*	*Lunch*	*Lunch*	*Lunch*	
1:45-3:45		**Human Impact**	**Open Session**	*Mildura Wetlands Fieldtrip* *2-5 pm*	**Rivers**	
3:45-4:00	*Ice-breaker Registration* *The Mildura Club (5-7 pm)*	*Afternoon tea*	*Afternoon tea*		*Afternoon tea*	
4:00-6:00		**Human Impact** *Beer O'clock* *Pizza Club* *5:30-7:00 pm*	**Poster session**		AQUA Business Meeting	
		Public Lecture Grand Hotel 7:30 – 9:00 pm	*Conference Dinner* – Mundoo 6:30-10 pm		*Trivia Night* Mildura Tennis Club 6:30-10 pm	

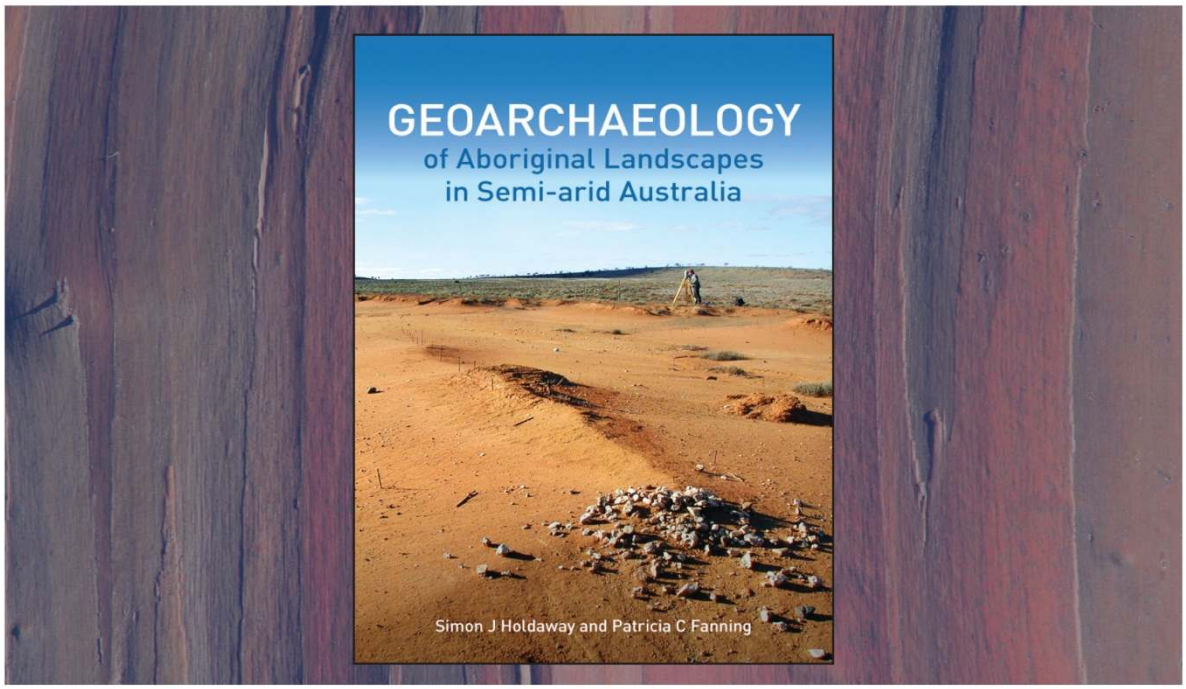
Thank you to our sponsors…

AINSE

ANSTO

BETA ANALYTIC Radiocarbon Dating

Federation UNIVERSITY • AUSTRALIA



CSIRO PUBLISHING
www.publish.csiro.au

Monday 30th June 2014

Lakes, dunes, dust and soils

8:30am - 10:30am

Chairs: Peter Almond & Paul Hesse

Australia is the world's driest inhabited continent. Approximately half of the land mass is either arid or semi-arid. In recent years substantial developments have been made in our understanding of environmental change in the arid interior, through further investigation of geomorphic records such as lakes, dunes, dusts and soils, the nature and timing of their formation, and their preservation. This session focuses on inland terrestrial archives in Australia and beyond, and the nature and limitations of palaeoenvironmental information derived from these records. We invite to this session contributions presenting new datasets, the development of new proxies, and new perspectives on the kind of palaeoenvironmental and palaeoclimatic information which can be derived from inland terrestrial archives.

8:30 AM **Marcus Vandergoes**
Developing a high-resolution record of hydroclimatic variaibility from laminated sediments in Lake Ohau, South Island, New Zealand. *abs# 1*

8:50 AM **Paul Augustinus**
Holocene Environmental Change in Northern New Zealand: the view through the lens of Lake Spectacle *abs# 2*

9:10 AM **Allan Chivas**
The use of charophytes for palaeoenvironmental studies *abs# 3*

9:30 AM **Craig Woodward**
The hydrological legacy of deforestation on global wetlands *abs# 4*

9:50 AM **Matt Cupper**
Terminal Pleistocene to Holocene hydrologic change at Lake Victoria, southwestern NSW *abs# 5*

10:10 AM **Will Farebrother**
Dry lake beds as sources of dust in Australia: a volumetric approach based on lake basin and deflated dune volumes *abs# 6*

Morning Tea 10:30-11:00am

Lakes, dunes, dust and soils

11:00am - 1:00pm

Chairs: Peter Almond & Paul Hesse

11:00 AM **Peter Almond**
A last glacial cycle palaeoclimate record from the Mt Cass loess section, North Canterbury, New Zealand *abs# 7*

11:20 AM **Deirdre Ryan**
Dunes as archives of climatic changes and tectonic processes on Hindmarsh Island, South Australia *abs# 8*

11:40 AM **Paul Hesse**
How do longitudinal dunes respond to climate forcing? A new approach to analysis of luminescence ages from Australia's dunefields *abs# 9*

12:00 PM **Adrian Fisher**
Climate, vegetation and the stability of longitudinal dunes: insights from Landsat TM/ETM+ derived fractional cover *abs# 10*

12:20 PM **Dorcas Vannieuwenhuyse**
Using micromorphology to investigate the relationship between environmental changes and human behaviour in prehistoric Australia: contributions to the understanding of the LGM discontinuities in north western Australian archaeological sequences. *abs# 11*

12:40 PM **Jeannette Hope**
The Demon Duck of Doom: Quaternary mysteries of western New South Wales. *abs# 12*

Lunch 1:00-2:00pm

Prehistoric human impact in Australia

2:00pm - 3:20pm

Chair: Scott Mooney

Consensus about the causes of late Quaternary environmental change, and what role or to what degree humans played a role, remains elusive. It is not only timely but particularly apt to include this session at the 30th AQUA meeting, as it will occur in a region that contributed to our understanding of the antiquity and significance of our first people. This session aims to bring together people from both sides of the debate, to air divergent views and to seek common areas in the debate. We also welcome the inclusion of any paper describing research within the theme encompassed by the title of the session.

2:00 PM **Kira Westaway**
Establishing a chronology for first arrival in Australia; OSL dating of Kimberley occupation and rock art *abs# 13*

2:20 PM **Richard Cosgrove**
Fire histories of the Australian Wet Tropics - natural and human patterns *abs# 14*

2:40 PM **Patricia Fanning**
Human-environment interactions in Australia's tropical north during the Holocene: early results from the Weipa Archaeological Research Program (WARP) *abs# 15*

3:00 PM **Lydia Mackenzie**
Occupation and abandonment of the South Wellesley Islands: Fire regimes during the late Holocene *abs# 16*

Afternoon Tea 3:20-3:50pm

Prehistoric human impact in Australia

3:50pm - 5:00pm

Chair: Scott Mooney

3:50 PM **Alan Williams - *Plenary***
Population and mobility of prehistoric Australia – Developing a regional framework for archaeological and palaeoclimatic correlations. *abs# 17*

4:20 PM **Scott Mooney**
Human-fire interactions in Australia: The statistical comparison of charcoal and archaeological records from multiples spatial scales within Australia. *abs# 18*

4:40 PM **Judith Field**
Megafaunal Extinctions in Late Quaternary Sahul *abs# 19*

Tuesday 1st July 2014

SHAPE - Interhemispheric comparisons

8:30am - 10:30am

Chairs: Andrew Lorrey & Steven Phipps

This session will showcase the diverse research being conducted across the terrestrial, marine and glaciated environments of the Southern Hemisphere as part of the SHAPE initiative. Presentations on palaeoclimate reconstruction, geochronology, palaeoecology, and climate modelling covering any of the last 60ka are welcome. A particular focus of the session will be on the reconstruction of key time slices of the late Quaternary, multi-proxy integration approaches, terrestrial-marine-cryosphere connections and model-proxy linkages.

8:30 AM **Katherine Holt**
Developing a New Zealand tephrochronological framework for the SHAPE timeframe *abs# 20*

8:50 AM **Ignacio Jara**
New palynological investigations from New Zealand provide insights into regional and hemispheric climate variations during the last glacial-interglacial cycle *abs# 21*

9:10 AM **Andrew Rees**
A chironomid temperature reconstruction characterising change through the Antarctic Cold Reversal from Lake Rangatauanui, North Island, New Zealand *abs# 22*

9:30 AM **Shaun Eaves**
Uniform summertime cooling drove glacier re-advance across New Zealand during the late-glacial (15-11 ka). *abs# 23*

9:50 AM **Haidee Cadd**
Life on the edge: fire and the fate of Tasmania's montane rainforests *abs# 86*

10:10 AM **Andrew Lorrey**
Assessment of Mid Holocene atmospheric circulation and synoptic forcing of regional climate using New Zealand speleothems and terrestrial proxy data: application of the Past Interpretation of Climate Tool (PICT). *abs# 25*

Morning Tea 10:30-11:00

SHAPE - interhemispheric comparisons

11:00am - 1:00pm

Chairs: Andrew Lorrey & Steven Phipps

11:00 AM **Claire Krause**
New insights on tropical vegetation productivity and atmospheric methane over the last 40,000 years from speleothems in Sulawesi, Indonesia *abs# 26*

11:20 AM **Jennifer Wurtzel**
Holocene rainfall variability recorded in an aragonite speleothem from Sumatra and the role of the Indian Ocean Dipole *abs# 27*

11:40 AM **Katrin Meissner**
What can isotope-enabled climate models tell us about Heinrich Events? *abs# 28*

12:00 PM **Andrew Mackintosh**
Progress in inferring past climate from glacier modelling *abs# 29*

12:20 PM **Helen Bostock**
The Antarctic Cold Reversal: A Data-Model Synthesis *abs# 30*

12:40 PM **Steven Phipps**
Southern Hemisphere climate variability over the past 8,000 years: an integrated data-model perspective *abs# 31*

Lunch 1:00 - 1:45pm

Open session

1:45pm - 3:45pm

Chair: Jessica Reeves

1:45 PM **Lynley Wallis**
Ochre through the late Quaternary at Gledswood Shelter 1, northwest Queensland *abs# 32*

2:05 PM **Jessica Reeves**
Further stories from the ‘rain gauge’ of Western Victoria *abs# 33*

2:25 PM **Lennard Martin**
Sedimentation rates in eastern Australia: evidence for rapid change from 12 - 6 Ka (mid- to early-Holocene) *abs# 34*

2:45 PM **Naomi Riggs**
Microtextural characteristics of quartz grains from large scale marine inundations: case studies from the eastern coastline of Australia *abs# 35*

3:05 PM **Monika Markowska**
Drip hydrology monitoring in caves to inform stalagmite paleoclimate records, Yarrangobilly, NSW. *abs# 36*

3:25 PM **Philip Marren**
Debris flow dominated alluvial fans in the Victorian high country indicate that landscape denudation through the Holocene has been dominated by post-bushfire runoff events *abs# 37*

Afternoon Tea 3:45 – 4:00pm

Poster Session

4:00pm - 6:00pm

Chair: Jessica Reeves

Lani Barnes
Human arrival and impact on the environment enroute to Australia *abs# 38*

Amy Blakemore
First recorded evidence of subaqueously-deposited late Pleistocene interstadial coastal strata above present sea level in Australia *abs# 39*

Helen Bostock
Paleoceanography of the Southern Hemisphere oceans from 60-30 ka *abs# 40*

Bronwyn Dixon
A multi-archive synthesis of decadally resolved Australian palaeoclimate records over the past 2000 years *abs# 41*

Shaun Eaves
Surface exposure dating in igneous domains: development and application of cosmogenic ^{3}He as a geochronological tool in the southwest Pacific region. *abs# 42*

Patricia Gadd
The potential of ITRAX core scanning: Applications in Quaternary science *abs# 43*

Jillian Garvey
Identifying Aboriginal hearths in Late Quaternary northwest Victoria: an experimental study to replicate the production of ‘clay ball’ and carbonate nodule heat retainers *abs# 44*

Allen Gontz
In search of relationships between forms of and processes that created and modified the sandy southeastern Queensland coast *abs# 45*

Cara Hull
Environmental changes at Australia's roundest lake - preliminary results *abs# 46*

Hannah James
Slavery in the Caribbean: Isotopic evidence of forced migration *abs# 47*

Justine Kemp
Vegetation and environments since the Last Glacial Maximum in the Southern Tablelands, New South Wales *abs# 49*

Justine Kemp
Digging your own grave: OSL signatures in experimental grave plots *abs# 50*

Stephanie Kermode
Alluvial terraces of the upper Shoalhaven River, New South Wales: the influence of climate change in a temperature, highland setting. *abs# 51*

Stephanie Kermode
'Age', recharge rates and connectivity of groundwater in deeper aquifers of the Sydney Basin. *abs# 52*

Zacchary Larkin
Trunk stream evolution from lateral to vertical accretion and channel breakdown in the Holocene Macquarie River, eastern Australia *abs# 53*

Andrew Lorrey
An overview of palaeoclimate and palaeoenvironmental change records for New Zealand covering 60ka-Present as a contribution to the Southern Hemisphere Assessment of PalaeoEnvironments (SHAPE) project *abs# 54*

Lynda Petherick
Millennial-scale variability in precipitation during the Last Glacial Maximum: A record from Tortoise Lagoon, subtropical Queensland, Australia *abs# 56*

Steven Phipps
Climate model simulations from the Last Glacial Maximum to today *abs# 57*

Jessica Reeves
SHAPE – Australia: 60-30 ka *abs# 58*

Deirdre Ryan
Dunes as archives of climatic changes and tectonic processes on Hindmarsh Island, South Australia *abs# 59*

Safana Sellman
A reconstruction of Pliocene climate using speleothems from the Nullarbor Plain, southwest Australia *abs# 60*

Asadusjjaman Suman
Late Holocene temperature variability in Tasmania inferred from borehole temperature data *abs# 61*

Adam Trewarn
Industrial Past, Urban Future; assessing risks of metal mobilisation in a historically contaminated wetland *abs# 62*

Duanne White
A compilation of climate records from the Antarctic region spanning 0 to 60ka *abs# 63*

Alan Williams
A Glacial cryptic refuge in southeast Australia: Human occupation and mobility from 36,000 years ago in the Sydney Basin, New South Wales *abs# 64*

Rachel Wood
Radiocarbon dating bone in warm, arid environments using ninhydrin: a case study at Cloggs Cave, Victoria. *abs# 65*

Wednesday 2nd July 2014

The role of the Quaternary to inform management

8:30am - 10:30am

Chair: Stuart Pearson

"Actionable knowledge" about the distant/deep past for informing management is often difficult to find or acquire. This session seeks to provide evidence that it should be done, find out how it is being done and to gather what we need to know. The session appeals to people who want to share environmental history, inform people about the past and achieve change in the way people think or behave. Through insights from researchers and managers this session aims to increase the use of palaeo-information.

8:30 AM **Roger Jones**
Shifts, shocks and thresholds – what does palaeoclimate have to say to decision makers about managing climate change? *abs# 66*

8:50 AM **Andrew Wooldridge**
Salinity management in Central West NSW: informing land management decisions through use of quaternary fluvial models. *abs# 67*

9:10 AM **Anna Lintern**
Identifying historical flood deposits in a sediment core from an oxbow lake *abs# 68*

9:30 AM **Matthew McDowell**
Using Holocene vertebrate fossils to facilitate the management and restoration of Australian ecosystems *abs# 55*

9:50 AM **Stuart Pearson**
Managing the future is a thing of the past. *abs# 70*

10:10 AM **Giri Kattel**
Potential of multi-proxy approach to detect human-induced disturbances on floodplain wetland ecosystems: A case of Kings Billabong, River Murray System (Australia) *abs# 71*

Morning Tea 10:30 – 11:00am

New research in Willandra

11:00am - 1:00pm

Chairs: Jacqui Tumney & Nikki Stern

It is now over 40 years since Jim Bowler's discovery of human burials, hearths and middens in the Willandra Lakes brought this region to the attention of the world's scientists. In the decades that followed these discoveries, an outstanding record of late Quaternary climate and landscape change and human activity was unearthed, and its global significance was recognised with its inclusion on the World Heritage List. In the last decade, a number of new research projects have commenced in the region. We invite papers from researchers and students who have been involved in recent research in the Willandra Lakes region.

11:00 AM **Timothy Barrows**
Late Pleistocene lake level history of Lake Mungo, Australia *abs# 72*

11:15 AM **Jim Bowler**
Joulni as key data centre with basin overflow data from the Amphitheatre Basin west of Lake Leaghur *abs# 73*

11:30 AM **Kelsie Long**
Fish otolith geochemistry, environmental conditions and human occupation at Lake Mungo *abs# 74*

11:45 AM **Emily Dillon**
A question of scale: Investigations of localised archaeostratigraphy on the Mungo Lunette *abs# 75*

12:00 PM **Nicola Stern**
Insights into life at Lake Mungo during the Last Glacial Maximum *abs# 76*

12:15 PM **Marnie Baklis**
New faunal analyses from the late Quaternary of Lake Mungo *abs# 77*

12:30 PM **Michael Westaway**
Researching the people of Ice Age Willandra *abs# 78*

Lunch 1:00 – 2:00pm

Thursday 3rd July 2014

Role of the oceans and ice

8:30am - 10:30am

Chairs: Helen Bostock & Duanne White

Antarctica and the Southern Ocean have a major role in the global climate over glacial/interglacial timescales. They also affect the local climates of the coastal regions of the Southern Hemisphere. During the glacial ice sheets and glaciers were extensive, and locked up vast quantities of water resulting in a lower sea level, while the extent of winter sea ice expanded considerably and influenced productivity and ocean circulation. The reorganisation and shifting of ocean currents and fronts also affected adjacent terrestrial climates. This session will focus on ice and marine records from the Southern Hemisphere.

8:30 AM **Stacy Oon**
Holocene Coastal Landscape Change in Albatross Bay near Weipa, North Queensland, Australia *abs# 79*

8:50 AM **Duanne White**
East Antarctic ice volume during the last glacial cycle *abs# 80*

9:10 AM **Esmee Webb**
To and Fro across the North Sea: analysis of the pattern of thermophilous non-volant mammalian immigration into the British Isles during successive interglacials from MIS 17 to MIS 1 as an indication of the position and duration of the landbridge connecting Britain to northwest Europe *abs# 81*

9:30 AM **Peter Kershaw**
Nature, causes and impacts of the Mid-Pleistocene Transition in southeastern Australia *abs# 82*

9:50 AM **Helen Bostock**
Changes in the position of the Subtropical Front around New Zealand over the last 30 kyr from sea surface temperature estimates: potential implications for the strength and position of the Southern Hemisphere Westerly Winds *abs# 83*

10:10 AM **Patrick De Deckker**
Land-sea correlations in the Australian region: post-glacial onset of the monsoon in northwestern Western Australia *abs# 84*

Morning Tea 10:30 – 11:00am

The Last Glacial Maximum in Australia

11:00am - 12:40pm

Chairs: James Shulmeister & Justine Kemp

The last glaciation maximum (LGM) in Australasia is an event that is both complex and of longer duration than the true 'global' LGM. Recent work through the INTIMATE and SHAPE projects have focussed considerable attention on this key interval and exciting new results are available that will allow us to start to resolve both events within the LGM and regional variations in climate and environment. This session welcomes submissions that provide new proxy data on LGM climates or environments as well as climatic reconstructions and modelling results for the Australasian LGM and for surrounding regions.

11:00 AM **Jie Chang**
Development and application of a chironomid based transfer function for reconstructing summer temperatures in south eastern Australia *abs# 85*

11:20 AM **Daniela Mueller**
Murrumbidgee Gum Creek phase - revisited *abs# 87*

11:40 AM **Daniel Ellerton**
A Palaeoclimate Interpretation of Little Llangothlin Lagoon, Eastern Australia *abs# 88*

12:00 PM **Adrian Slee**
Geomorphic evidence for periodic easterly rainfall on the Australian east coast during the last glaciation *abs# 89*

12:20 PM **James Shulmeister**
The LGM in eastern Australia - an overview *abs# 90*

Lunch 12:40 – 1:30pm

Lessons from Rivers

1:30pm - 4:00pm

Chairs: Stephanie Kermode & Tim Ralph

River systems provide a unique combination of short and long term records as a consequence of their processes and dynamic nature. Quaternary records from such systems throughout Australasia have informed wide-ranging topics, from fluvial sedimentary theory to practical management of river systems and everything in between. This session invites submissions from all aspects of fluvial research. Submissions may address issues such as quantification of erosion and sedimentation rates; understanding of palaeo-environmental settings; archives of fluvial events and activity in response to climate fluctuation; impacts of human populations; impacts on human populations or/and how records can advise management.

1:30 PM **John Magee - *Plenary***
Quaternary fluvial history and neotectonics in the Lower Darling Valley, Western NSW *abs# 91*

2:00 PM **Éva Papp**
Geophysics, palaeochannels and groundwater resources in alluvial plains: Lower Murrumbidgee catchment, NSW *abs# 92*

2:20 PM **Anthony Dosseto**
Novel isotopic proxy for studying Quaternary pedogenic processes: insights from the Murrumbidgee palaeo-channels *abs# 93*

2:40 PM **Paul Hesse**
Late Quaternary Palaeohydrology of the Macquarie River and the Murray-Darling Basin *abs# 94*

3:00 PM **Timothy Ralph**
How can knowledge of mechanisms and timescales of avulsion and floodout formation in floodplain wetlands inform interpretation of Quaternary fluvial sedimentary records? *abs# 95*

3:20 PM **Sandra Mann**
Investigating controls on dryland fluvial geomorphology and sedimentology: Case studies from the Neales River, Peake Creek and Lake Yamma Yamma, Lake Eyre Catchment *abs# 96*

3:40 PM **Jillian Garvey**
Late Quaternary human occupation and subsistence along the Central Murray River corridor, semi-arid northwest Victoria *abs# 97*

Abstracts

1

Developing a high-resolution record of hydroclimatic variability from laminated sediments in Lake Ohau, South Island, New Zealand.

Marcus Vandergoes[1] , Richard Levy[1] , Gavin Dunbar[2] , Heidi Roop[2] , Sean Fitzsimons[3] , Gary Wilson[4] , Fabio Florindo[5] , Jamie Howarth[1] , Chris Moy[6] , Steven Phipps[7] , Abha Sood[8] , Jeff Stone[9] , Darrell Kaufman[10] , Bob Ditchburn[1] , Xun Li[1] , Andrew Gorman[6] , Phaedra Upton[1] , Alex Pyne[2] , Darcy Mandeno[2] , Sharon Walker[11] , Jennifer Purdie[12]

1. *GNS Science, Lower Hutt, New Zealand*
2. *Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand*
3. *Department of Geography, University of Otago, Dunedin, New Zealand*
4. *Depoartment of Marine Sciecne, University of Otago, Dunedin, New Zealand*
5. *Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy*
6. *Department of Geology, University of Otago, Dunedin, New Zealand*
7. *Climate Change Research Center, University of New South Wales, Sydney, NSW, Australia*
8. *NIWA, Wellington, New Zealand*
9. *Department of Earth and Environmental Systems, Indiana State University, Terre Haute, USA*
10. *School of Earth Sciences & Environmental Sustainability, Northern Arizona University, Flagstaff, USA*
11. *NOAA, Seattle, USA*
12. *Meridian Energy, Twizel, New Zealand*

A ~100+ metre-thick laminated sedimentary sequence exists beneath Lake Ohau (44°10'S, 169°49'E; 500 masl) that we believe contains a 17,000 year record of regional hydroclimatic variability. In turn, instrumental data and modelling suggest that precipitation at these latitudes varies primarily with changes in westerly wind flow over New Zealand. On millennial and shorter timescales these changes appear to reflect the relative influence of the Southern Annular Mode (SAM), El Niño-Southern Oscillation (ENSO), and Interdecadal Pacific Oscillation (IPO).

A study of modern lake sediment processes, including short cores, sediment traps and hydrological data (lake inflow, velocity, temperature, turbidity) demonstrate that changes in stratigraphy and mass accumulation are largely a consequence of seasonal sediment influx and lake hydrology. Short (< 6 m) sediment cores from the lake contain mm – cm scale sedimentary couplets defined by colour and grain size changes. Dating of these cores indicate a sedimentation rate of ~5mm/yr and thus cover ~1200 years. We present an update from the Lake Ohau project including an assessment of climate-varve relationships based on layer classification and ITRAX data; storm back-trajectory analysis and sedimentology relationships; and preliminary palaeoclimate data/model comparisons. Initial results suggest on century and longer timescales, changes in sediment composition as measured by colour reflectance show similar patterns to those modelled for the SAM for the past 1200 years and that changes in lake sediment provenance may provide a means to identify storm trajectory. These findings suggest that Lake Ohau sediments preserve synoptic and hemispheric scale palaeoclimatic information.

We also outline the planned recovery of the complete ~17,000 year sedimentary sequence in 2015 with the aim to reconstruct hydroclimatology since the late glacial at decadal to annual timescales. This new core will offer a record to strengthen our understanding of the role of synoptic and latitudinal climate drivers across the Southern Hemisphere.

2

Holocene Environmental Change in Northern New Zealand: the view through the lens of Lake Spectacle

Paul Augustinus[1] , Mark Horrocks[1] , Helen Munro[1] , Patricia Gadd[2] , Tamzin Linnell[1]

1. *University of Auckland, Auckland, New Zealand*
2. *Institute For Environmental Research, Australian Nuclear Science and Technology Organisation, Lucas Heights, NSW 2234, Australia*

Lake sediments often reflect both natural and human-induced changes within the lake and surrounding catchment and the Auckland region dune-impounded lake records are no exception. We undertook a program of coring of the sediment records contained in Lake Spectacle to undertake a multi-proxy investigation of selected proxies for environmental change. The sediments were analysed for pollen, grain size, magnetic susceptibility, loss-on-ignition, total organic carbon (TOC), nitrogen (TN), sulphur (TS), TOC/TN ratios, as well as bulk organic matter $\delta^{13}C$ and $\delta^{15}N$ as indicators of change in the lake and catchment. These proxies were supported by an examination of diatoms as indicators of lake trophic status and changes therein. The timing of major changes in the lake and catchment associated with Polynesian impacts coincides closely with the Kaharoa tephra (636 ± 12 cal. years BP) in the core. The ecological changes identified are complex but demonstrate that the pre-human catchment was dominated by Kauri-podocarp forest and with reduction in forest and expansion of grass and bracken closely coincident with the Kaharoa tephra. Associated changes in sediment influx to the lake due to catchment erosion and increased windiness occurred throughout the period of sediment accumulation, with the most significant changes in the lakes and their catchments after ca 636 years BP interpreted as dominated by anthropogenic burning with associated increase in erosion induced sediment and organic matter influx into the lake.

3

The use of charophytes for palaeoenvironmental studies

Allan Chivas[1] , Adriana Garcia[1] , Florian Dux[1] , Beleed Saleh[1]

1. *School of Earth & Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia*

Charophytes are useful indicators for past lacustrine and fluvial environments by virtue of particular species being indicative of water salinity and depth, particularly in Australia which has several saline-tolerant species. Here, we expand upon this by adding trace-element, stable-isotope and organic markers via a series of experimental cultures. The first set of cultures was designed to understand the partitioning of Mg/Ca and Sr/Ca and oxygen isotopes between calcareous gyrogonites (fruiting bodies) and host water. The euryhaline charophyte, *Lamprothamnium* cf. *succinctum* was grown at 15, 20, 25 and 30 °C and at salinities of 20, 25, and 35 PSU (g/L, total dissolved solids). Among this matrix of conditions, thallus extension rates demonstrate optimal growth at 25 deg C and 35 PSU. The carbonate phase in the gyrogonites is high-magnesium calcite with up to 15 mole percent Mg. The Mg/Ca ratios of the gyrogonites are related to growth temperature, whereas Sr/Ca has no correlation to temperature. Variations in salinity, at conservative chemistry, do not affect the minor-element chemistry of the gyrogonites. The $\delta^{18}O$ values of gyrogonites show complex but linear relationships as a function of both temperature (-0.10 per mil/ °C) of the host water and of salinity. This dual control on gyrogonite $\delta^{18}O$ values will complicate applications to the fossil record. A combination of Mg/Ca, Sr/Ca and $\delta^{18}O$ will assist, although additional ratios such as Ba/Ca and Na/Ca may be required.

In a separate study, the organic (geo)chemistry of extant *Lamprothamnium* cf. *succinctum* and *Chara australis* and their degradation products was investigated for useful biomarkers that might persist in the Quaternary record. The n-alkanes detected by GC-FID and GC-MS of both the thallus and oospore illustrate a high abundance of mid-carbon-number alkanes that accordingly differ from both terrestrial plants and simple algae. Some other quite complicated biomolecules are also present.

The hydrological legacy of deforestation on global wetlands

Craig Woodward[1] , James Shulmeister[1] , Josh Larsen[1] , Geraldine Jacobsen[2] , Atun Zawadzki[2]

1. *The University of Queensland, St Lucia, QLD, Australia*
2. *Institute for Environmental Research, Australian Nuclear Science and Technology Organisation, Lucas Heights, NSW, Australia*

Catchment erosion and increased nutrient loading are commonly recognised impacts of deforestation on global wetlands. Forest clearance can increase water availability in wetland catchments, but globally, the hydrological effect of deforestation has received little attention. We provide the first unequivocal evidence that historic and prehistoric forest clearance in dryland areas in Australasia increased catchment water yield; creating new wetlands and converting existing wetlands into shallow lakes. We developed a hydrological model to predict the location of global wetland catchments that are susceptible to this effect and demonstrate that hydrological alteration of wetland catchments is a previously overlooked dimension of the cultural landscape. We used a meta-analysis of published papers to demonstrate that the effect is widespread but under-appreciated in the literature. We conclude that artificially enhanced wetlands may be common even in regions with short histories of human settlement. Restoring them to their pre-human impact state may be difficult or even undesirable if we want to protect biodiversity and wetland ecosystem services.

Terminal Pleistocene to Holocene hydrologic change at Lake Victoria, southwestern NSW

Matt Cupper[1], Hugo Bowman

1 The University of Melbourne, Parkville, VIC, Australia

Lake Victoria is a freshwater lake in southwestern New South Wales. It lies within the Murray Darling Basin some 55 km downstream of the confluence of the Murray and Darling Rivers. Prior to artificial river regulation from 1928, Frenchmans Creek and the Rufus River connected the lake to the Murray River. River levels in the Murray determined natural lake levels with high seasonal flows inundating the southern part of the lakebed and major floods filling the entire lake basin.

Lakeshore sediments were investigated in a geomorphic study involving field transects and aerial photographic interpretation and subsurface examination through shallow trenches and hand augering. Chronometric constraint was provided by 17 optically stimulated luminescence ages of quartz sand, complemented by 15 previously obtained radiocarbon ages[1].

Geomorphic investigation showed that clayey silt benches up to 3-m-thick outcropping at around 24-25 mAHD along the eastern shoreline formed under shallow (up to a couple of metres water depth) lacustrine conditions during the terminal Pleistocene to mid-Holocene (14,000-5500 years ago).

Coarse sandy deposits exposed in a gully on the northern beach outcropping at 27.3 mAHD are also terminal Pleistocene and are the beach facies of the same high lake regime under which the near shore clayey silts were deposited. These terminal Pleistocene to mid-Holocene elevated near shore and beach units correspond to higher discharge events (i.e. large flows and high lake levels) known to have occurred in the Murray at this time[2].

Sandy sediments of Talgarry Barrier at 25 mAHD are a lower level beach barrier, constructed over the mid- to late Holocene (8000-500 years ago) on the shore of a shrunken lake set within the larger basin. This relates to the relatively smaller flows and lower lake levels characteristic of the modern (pre-regulation) Murray[2].

1. Hope, J.H. (1998). Lake Victoria: finding the balance—a response to the competing interests of cultural heritage, environment and resource use. Background Report No. 1, Murray-Darling Basin Commission, Canberra.
2. Fitzsimmons, K.E., Cohen, T.J., Hesse, P.P., Jansen, J., Nanson, G.C., May, J-H., Barrows, T.T., Haberlah, D., Hilgers, A., Kelly, T., Larsen, J., Lomax, J. and Treble, P. (2013). Late Quaternary palaeoenvironmental change in the Australian drylands, Quaternary Science Reviews 74, 78-96.

Dry lake beds as sources of dust in Australia: a volumetric approach based on lake basin and deflated dune volumes

***Will Farebrother[1] , Paul Hesse[1] , Hsing-Chung Chang[1] , Claudia Jones[2]**

1. *Macquarie University, NSW, Australia*
2. *Research School of Earth Sciences, Australian National University, Canberra, ACT, Australia*

Ephemeral lake basins are some of the most significant sources of dust today and are suspected of supplying even larger volumes of dust to the atmosphere and the oceans during the LGM. The LGM flux of dust from Australia to the Tasman Sea and southern Pacific Ocean was three times the modern levels yet the sources of dust are not constrained. In this study we investigated the potential contribution of deflationary lake basins in Australia to late Quaternary dust flux. We applied GIS-based volumetric measures to the SRTM DEM of lake basins in a transect from Lake Urana, Lake Tyrrell and Willandra Lakes, to Lake Eyre. Our hypothesis is that these basins have been formed by deflation and that the difference between the basin volume and the sediment stored in proximal dunefields is the volume transported in suspension: i.e. dust. This simple model is complicated to some degree by local considerations.

We found that there is log-log relationship between lake area and lake volume. In our study sites, the lake volume also has a strong positive relationship with the volume of sediment in source-bordering dunes, despite the range of dune styles along the transect (including lunettes, parabolic and longitudinal dunes). There is also a very significant relationship between lake volume and the dust (missing) volume. Based on known ages of source-bordering dunes, most deflation has taken place over the last glacial cycle.

We compared total dust volumes from the lake basins against the available dust deposition flux values for the Tasman Sea and found that they can only account for several thousand years of dust deposition, at LGM fluxes. Therefore, the ephemeral lake basins cannot account for the bulk of dust transported from Australia and the largest sources must be other, poorly-defined, sources such as floodplains and dunefields.

A last glacial cycle paleoclimate record from the Mt Cass loess section, North Canterbury, New Zealand

Peter Almond[1] **, Sandor Gulyas**[2] **, Pál Sümegi**[2] **, Balázs Sümegi**[2]

1. *Lincoln University, Christchurch, New Zealand*
2. *Department of Geology and Paleontology, University of Szeged, Szeged, Hungary*

The stratigraphy and paleontology of loess has contributed to the wider understanding of of late Quaternary palaeoclimate and landscape evolution of New Zealand. Dating loess in New Zealand has proved problematic, however, which has limited the scope to interpret loess records. Radiocarbon ages from organics have suffered from problems of contamination, and luminescence ages have been of low precision and often prone to stratigraphic reversals. In the North Island, loess chronologies can be supported by tephrochronology, but aside from one tephra, the South Island lacks unequivocal tephra marker beds. The loess of Mt Cass in North Canterbury has a provenance that includes calcareous rocks and as a result it has a high pH, which favours preservation of carbonate-based fossils such as terrestrial gastropods, bones and egg shell fragments. We have carried out a detailed sampling (2 cm increments) of a ca 8 m-thick loess deposit at Mt Cass for grain size, magnetic susceptibility and total element analyses. Chronology is provided by radiocarbon ages of gastropods and Moa egg shell fragments, as well as by the stratigraphic position of the Kawakawa tephra isochron (25.4 ka). We present a well-dated, high-resolution paleoclimate record interpreted from (1) grain size and magnetic susceptibility data, (2) environmental tolerance envelopes of gastropod taxa, and (3) carbon and oxygen isotope composition of pedogenic carbonate. The independent data are synthesised into a composite picture of climate and environmental change that overlap a significant period of the Southern Hemisphere Interpretation of Paleoenvironments (SHAPE) time frame (0-60 ka).

Dunes as archives of climatic changes and tectonic processes on Hindmarsh Island, South Australia

***Deirdre Ryan**[1]

1. University of Wollongong, North Wollongong, NSW, Australia

Hindmarsh Island is the largest island within the complex coastal lowland system at the terminus of the River Murray. Two extensive Holocene coastal barriers, Young husband and Sir Richard peninsula, flank the river mouth south of Hindmarsh Island. The island provides an archive of multiple generations of interglacial and glacial dunes. Dunes were distinguished using visual and lithological characteristics. Interglacial dunes, sourced from adjacent marine/coastal environments during high sea levels, are yellowish/pale brown, and associated with calcrete and occasional marine shell deposits. The red/yellow, siliceous glacial dunes formed under arid, cold and windy terrestrial conditions when the coastline stood on the continental shelf margin, ~200 km south. Dune relationships were studied using stratigraphic analysis, amino acid racemization, and thermoluminescence. The island's northern margin comprises stacked interglacial sediments: MIS 5e dunes overlie truncated MIS 7 dunes and remnants of an older dune system, reflecting ongoing tectonic subsidence. To the west MIS 5e recurved spit deposits indicate a former river course. Last glacial maximum dunes drape the older interglacial deposits. Since the middle Holocene the migrating Murray Mouth has facilitated deposition of extensive sand-flats forming the southern half of the island and small jumbled dunes on its southern margin. The Hindmarsh Island interglacial dunes are an extension of coastal barrier systems on the Coorong Coastal Plain. Their southeast to northwest orientation reflects longshore drift. The west-east orientated last glacial maximum dunes conform to the dominant glacial anti-cyclonic wind regime. Dune sediments reflect changing environmental conditions. Near-marine interglacial dunes are composed predominately of carbonate. Glacial dunes are carbonate-free, predominantly quartzose, with variable sediment sources from the west, including the Mount Lofty-Flinders Ranges. Hindmarsh Island dunes reflect the rich geological history and dynamic environment of the region that include river and mouth migrations during ongoing tectonic subsidence and alternating interglacial and glacial palaeo-climates.

How do longitudinal dunes respond to climate forcing? A new approach to analysis of luminescence ages from Australia's dunefields

Paul Hesse[1] **, John Jansen**[2 3] **, Tim Cohen**[2]

1. *Macquarie University, NSW, Australia*
2. *School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW, Australia*
3. *Bolin Centre for Climate Research, Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm, Sweden*

A meta-analysis of 689 luminescence age estimates of Australian desert sand dunes aimed to examine the hypothesis that Quaternary climate changes have forced dune accumulation. A novel approach to the analysis of probability density curves of dune age frequency has been developed (Hesse, in press, Quaternary International) as well as interpolation and weighting methods to overcome inherent sampling biases and the taphonomic effect on dune preservation. The analysis shows that in the Mallee dunefield of SE Australia only the interval 34 – 18 ka experienced marked dune growth which cannot be explained as random background activity. During the LGM, many, but not all, Mallee longitudinal dunes were accumulating more rapidly than before or after. In the Strzelecki dunefield of central Australia source-bordering longitudinal dune TL and OSL ages are more frequent at the Pleistocene – Holocene transition but nearby free longitudinal dunes were only active above background levels during the LGM. Even during the LGM, many dunes do not record active growth and the dunefield was most likely a mosaic of stable dune surfaces and bare mobile patches, supported by the scant pollen data from the arid zone. Hyper-aridity has not been experienced in these dunefields. These vegetated dunes exhibit conservative behaviour with limited response to the range of climate forcing experienced in the late Pleistocene. A more complete understanding of dunefield response to Quaternary climates would require an intensive and structured dating program yet the strong possibility remains that no coherent palaeoclimate record will result because of the strength of self-organising and stochastic processes in these dunes.

10

Climate, vegetation and the stability of longitudinal dunes: insights from Landsat TM/ETM+ derived fractional cover

Adrian Fisher[1] **, Paul Hesse**[2]

1. *Joint Remote Sensing Research Program, School of Geography, Planning and Environmental Management, University of Queensland, St Lucia, QLD, Australia*
2. *Department of Environment and Geography, Macquarie University, Sydney, NSW, Australia*

To advance the use of longitudinal dunes as 'geoproxies' of late Quaternary environmental change, a greater understanding of several aspects of dune geomorphology and its response to climate is required. One key control on dune activity is vegetation cover, which stabilizes dune sediments and reduces wind velocity. Vegetation cover appears to be principally controlled by rainfall, and theories have been proposed for rainfall thresholds, below which vegetation cover is reduced and dunes transition from stable to active. These theories have been difficult to test, especially when considering that vegetation cover can also vary considerably at local scales. Recent improvements in the availability of satellite imagery, and in its processing, have allowed the spatial and temporal variability in vegetation cover to be quantified. The archive of Landsat 5 TM (1984-2013) and Landsat 7 ETM+ (1999-2014) imagery available from the United States Geological Survey provides multi-spectral reflectance data at 30 m resolution approximately every 16 days. A newly developed spectral unmixing model for TM/ETM+ data, designed and calibrated in Australia, provides a method to calculate the bare, green vegetation and non-green vegetation fractions of each pixel. Examining the relationship between these satellite-derived estimates of fractional cover, field measurements of vegetation cover, and rainfall records for several sites in the Strzelecki and Simpson dunefields of eastern central Australia, provides new insights into the climate response of longitudinal dunes.

11

Using micromorphology to investigate the relationship between environmental changes and human behaviour in prehistoric Australia: contributions to the understanding of the LGM discontinuities in north western Australian archaeological sequences.

***Dorcas Vannieuwenhuyse**[1]

1. *Archaeology, University of Western Australia, CRAWLEY, Western Australia, Australia*

Human occupation patterns in arid Australia, particularly during the Last Glacial Maximum (LGM), continue to be a major discussion area in Australian archaeology. In order to investigate the human-environment relationship in prehistoric Australia, a number of Pleistocene and Holocene archaeological sites in the southern Kimberley, including Carpenter's Gap 1 & 3 and Riwi, have been re-investigated since 2012, as part of the multi-disciplinary project ''Lifeways of First Australians''. This geoarchaeological study is investigating in particular the discontinuities (stratigraphic hiatus, break in deposition rate or sterile layer) identified around the timing of the LGM, in several north western Australian archaeological sequences, in order to distinguish their cultural or natural origin. Examples from the ongoing research will be presented to demonstrate the benefits that a geoarchaeological approach, and specifically a micromorphological approach, can bring to the understanding of an archaeological sequence in terms of site formation processes, palaeoenvironmental signals and anthropogenic signatures within the sediment.

12

The Demon Duck of Doom: Quaternary mysteries of western New South Wales.

Jeannette Hope[1]

1. *River Junction Research, Wentworth, NSW, Australia*

Travelling and working in western NSW over the last 30 or so years, I have occasionally come across puzzling landscape features. On investigation, it often turns out that no research has ever been done (at least none that's easily findable), or that the theories advanced are even more puzzling. For example, the Explanatory Notes to the 1:100,000 Nuchea Geology Mapsheet speculate that the hundreds of stony mounds northeast of Broken Hill can be attributed to the extinct giant emu Genyornis. To quote the surprisingly poetic geological note: 'Discovery of gastrolith and or egg shell material in an excavated mound in the Koonenberry Belt would indeed be a smoking gun pointing towards 'Demon Mound Dwelling Duck of Doom'.

My theory is that if a geologist can't explain a geological feature, they kick-pass it to the palaeontologists who similarly toss to the archaeologists, who pass it back to geologists, who… well, you see what I mean. My regular reaction is 'Why doesn't somebody study this?'(on occasion I've tried myself).

This paper is a light-hearted tour through some Quaternary mysteries that are just waiting for the right researcher. As well as big mounds, you'll meet preserved bettong warrens, giant polygonal cracks, organic peats, a kilometre long stratified archaeological site, deep layered gypsum beds, and glacial dropstones (OK, they're Cretaceous, but some are sitting in Quaternary lakebeds). If these have been investigated already, please let me know; if not, you're welcome to have a go!

13

Establishing a chronology for first arrival in Australia; OSL dating of Kimberley occupation and rock art

Kira E Westaway[1] **, June Ross**[2] **, Mike J Morwood**[3] **, Mark Moore**[2]

1. *Department of Environment and Geography, Macquarie University, Sydney, NSW, Australia*
2. *Department of Geography and Archaeology, University of New England, Armidale, NSW, Australia*
3. *CAS, School of Earth and Environmental Sciences, Wollongong University, Wollongong, NSW, Australia*

Optically-stimulated luminescence (OSL) dating provides the time since sediments and their associated artefacts and fossils were last exposed to sunlight prior to deposition, and is therefore an essential tool for establishing chronologies for many disciplines. Furthermore, OSL dating provides the chronological link between the landscape/surface processes, which is inferred from the archaeological evidence within the sediment, and human activities inferred from the rock art. No other dating technique of this age range (100 yrs-200 ka) provides this intimate connection between the sedimentary processes, the evidence for first arrival and human behaviour. In this paper, we demonstrate the use of OSL dating techniques on the rock shelters of northern Kimberley, Western Australia. OSL dating has proved to be the key to understanding how the geomorphological and geological processes within the rock shelters are intimately related to human activity. Furthermore, the OSL dating of the sand sheets within the occupation sites and mud wasp nests over the rock art is critical for understanding the behaviour of the first Australians and for assessing their impact on the virgin landscape. This framework is of particular importance as these locations may contain some of the oldest signs of modernity on the continent.

14

Fire histories of the Australian Wet Tropics - natural and human patterns

Richard Cosgrove[1] , Åsa Ferrier[1]

1. *La Trobe University, MELBOURNE, VIC, Australia*

Aboriginal creation and maintenance of grass - eucalyptus pockets within tropical rain forests was probably by fire. Their maintenance can be thought of in three ways. First fire was used to maintain existing late Pleistocene open woodland into the Holocene, second small patch disturbance created opportunities to create open pockets in the rainforest for habitation and third, large-scale burning occurred after cyclonic events that destroyed large tracts of rainforest. We examine the likelihood of these three approaches using archaeological and environmental evidence from the north east Queensland rain forests over the past 8,000 years.

15

Human-environment interactions in Australia's tropical north during the Holocene: early results from the Weipa Archaeological Research Program (WARP)

Patricia C. Fanning[1] , Simon J. Holdaway[2] , Justin Shiner[3] , Fiona Petchey[4] , Sally Brockwell[5] , Janelle Stevenson[5] , Craig Sloss[6] , Geoffrey Bailey[7]

1. *Macquarie University, NSW, Australia*
2. *Anthropology, The University of Auckland, Auckland, New Zealand*
3. *Riotinto Alcan Pty Ltd, Brisbane, Queensland, Australia*
4. *Radiocarbon Dating Laboratory, The University of Waikato, Hamilton, New Zealand*
5. *Archaeology and Natural History, The Australian National University, Canberra, ACT, Australia*
6. *Earth, Environmental and Biological Sciences, Queensland University of Technology, Brisbane, Queensland, Australia*
7. *Archaeology, York University, York, United Kingdom of Great Britain and Ireland*

Western Cape York Peninsula, particularly the Weipa region, has seen sustained archaeological investigation since the 1960s. Studies have primarily concentrated on shell mounds associated with coastal environments first observed in the early 20th century. Despite claims that the shell mounds were of "natural" origin, archaeological investigations have convincingly demonstrated that they are primarily cultural deposits. Geomorphological studies indicate that chenier (beach ridge) formation occurred after sea-level stabilisation and is connected to the formation of estuaries at the mouths of the Mission, Pine, Hey and Embley Rivers. *Anadara* sp. shell bed formation is in turn connected with the evolution of the estuaries. However, the relationship between shell mound age and location relative to the coastline at Weipa is neither well defined, nor tested at multiple locations. Given that the coast is susceptible to the effects of sea-level fluctuations and environmental change, and the *Anadara* beds can become depleted as a result of environmental shifts, the shell mounds provide a datable record of human reaction to coastal landscape change, and of environmental change. We report early results from a new investigation of the shell mounds of the Weipa region. Radiocarbon and OSL-based age determinations from samples of shell, charcoal and sediment collected from auger holes, cores, and trenches excavated into shell mounds near the Wathayn Outstation, about 20 km east of Weipa on the northern shore of the Embley River, provide insights into the relationships between shoreline evolution, shellfish availability, and mound construction. Spatial and temporal patterns in mound size and shape, and internal structure, are being investigated, and pollen and charcoal analyses from cores collected from nearby wetlands will provide insights into Holocene environmental change in the region. All of these data are directed at understanding how Aboriginal people lived within the environment in the past, particularly since the mid-Holocene.

16

Occupation and abandonment of the South Wellesley Islands: Fire regimes during the late Holocene

***Lydia Mackenzie[1] , Patrick Moss[1] , Sean Ulm[2] , Craig Sloss[3] , Lynda Petherick[1]**

1. *UQ, Brisbane, QLD, Australia*
2. *JCU, Cairns, Qld, Australia*
3. *QUT, Brisbane, QLD, Australia*

Palaeoecological studies from northern Australia's 'wet tropics' depict local trends of environmental change during the late Quaternary. However a paucity of Holocene records outside of the Atherton Tablelands limits our ability to accurately reconstruct the wider seasonally dry tropics history. Sediment archives from the South Wellesley Islands, Gulf of Carpentaria, provide a valuable record of Holocene dynamics within a tropical sclerophyll landscape. Occupied exclusively by traditional owners until the mid- 20th century the Islands remain undisturbed by European land use. Additionally the Islands are adjacent to the Indo-Pacific Warm Pool, seasonally affected by the Inter-Tropical Convergence Zone, and sensitive to variations in the El Niño Southern Oscillation phenomenon.

This research interprets macroscopic charcoal (> 125 µm: local fire history), microscopic charcoal (< 125 µm: regional fire history) and pollen from a coastal swamp on Bentinck Island. We aim to identify relationships between fire, climate and human occupation. Continuous charcoal analysis provides a 1300 year record of fire and local archaeological research identifies periods of population intensification in the immediate region. Variations in the fire regime and vegetation community are compared to records of human presence and absence providing a Holocene record of environmental change from a tropical sclerophyll landscape.

17

Population and mobility of prehistoric Australia – Developing a regional framework for archaeological and palaeoclimatic correlations.

Alan N Williams[1 2]

1. *Archaeological & Heritage Management Solutions Pty Ltd, 2/729 Elizabeth Street, Waterloo, NSW 2017, Australia*
2. *Fenner School of Environment and Society, The Australian National University, Canberra, ACT, Australia*

Archaeological research is often constrained to one or a handful of sites, resulting in data that are highly localised. Frequently data are also sampled at a coarse resolution and/or are qualitative in nature. This makes correlation with palaeo-climatic records, usually representing regional or global systems, problematic. The development and ongoing improvement of time-series approaches (sum probability distributions) in tandem with large radiocarbon archaeological datasets now provide one method that allows development of both regional and quantitative data with which to correlate the two disciplines. In this paper, I focus on the human side of this equation, using 5,044 radiocarbon ages from 1,748 sites across Australia to explore continental spatial and temporal trends. I present a population curve in which regional populations become established prior to the Last Glacial Maximum before declining through the Terminal Pleistocene, and recovering in step-wise fashion through the Holocene, peaking in only the last 2,000 years. Spatial patterns of these populations are also explored, including the contraction into refugium during the Terminal Pleistocene, and shifting mobility patterns in the mid- to late Holocene resulting in the complex societies observed at European contact.

18

Human-fire interactions in Australia: The statistical comparison of charcoal and archaeological records from multiples spatial scales within Australia.

Scott D Mooney[1] , Alan N Williams[2] , Jennifer Marlon[3] , Scott A Sisson[1]

1. *The University of New South Wales, Randwick, NSW, Australia*
2. *Fenner School of Environment and Society, The Australian National University, Canberra, ACT,Australia*
3. *School of Forestry & Environmental Studies, Yale University, New Haven, CT, USA*

Ideas about the role of humans in the history of fire continue to be contentious in Australian palaeoenvironmental sciences. A recent compilation of Australasian charcoal records (Mooney et al., 2011 in *QSR* vol 30) found no distinct change in fire corresponding to the arrival of humans in Australia and no obvious correlation between archaeological evidence and the history of biomass burning during the past 40 ka. In this presentation we explore the *statistical* relationship between the continental compilation of charcoal records and archaeological indices. As this continental-scale comparison could arguably mask any relationship, we also examine the evidence for any relationship at two finer spatial scales: within southern Australia (30^{o} to 44^{o}S) and in the Sydney Basin bioregion. We find little evidence for any significant relationship between archaeological information and charcoal beyond a weak correlation over the terminal Pleistocene and perhaps in the late Holocene. We conclude that systematic or deliberate strategies involving the use of fire by prehistoric people appear to be unlikely at any of the spatial scales examined. This is a distinctly different conclusion compared to Gammage's (2011 *The Biggest Estate on Earth: How Aborigines made Australia*) country-wide land management based on the use of fire and raises questions concerning the pervasiveness and persistence of the *impacts* of 'fire-stick farming'.

19

Megafaunal Extinctions in Late Quaternary Sahul

Judith H Field[1]

1. *UNSW, Randwick, NSW, Australia*

There is a general consensus that the first human arrivals on Sahul (Pleistocene Australia-New Guinea) are likely to have encountered a number of remnant species of large, now-extinct fauna, commonly referred to as megafauna. What follows is not so clear. Assertive rhetoric attributes the extinctions of this suite of animals to human activities, whether it be a consequence of overhunting or habitat modification. The only obstacle to wide acceptance of these beliefs is the absence of any supporting empirical evidence. Thin datasets typify the Quaternary fossil record, and known archaeological sites with megafauna number only two. This paper will provide an overview of what we know about the decline and disappearance of megafauna. No new evidence has come to light in the last few decades that provides clear evidence of a human role. On the contrary, the wealth of palaeoenvironmental data now available reveals climatic variability as the likely driver in population decline and eventual extinction of these remarkable animals.

Developing a New Zealand tephrochronological framework for the SHAPE timeframe

Katherine Holt[1] , David J Lowe[2] , Shane Cronin[3] , Phil Shane[4] , Martin Danisik[2] , Alan Hogg[5]

1. *Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand*
2. *Department of Earth and Ocean Sciences, Waikato University, Hamilton, New Zealand*
3. *Volcanic Risk Solutions, Massey University, Palmerston North, New Zealand*
4. *School of Environment, University of Auckland, Auckland, New Zealand*
5. *Radiocarbon Dating Laboratory, Waikato University, Hamilton, New Zealand*

Tephrochronology has played an integral role in the NZ-INTIMATE project. A framework of 22 marker tephra erupted from Taupo Volcanic Zone (TVZ), Tuhua (Mayor Island) Volcanic Centre (VC), and Egmont volcano from 30 cal. ka to the present underpins the NZ-INTIMATE climate event stratigraphy. It is now timely to review the potential for extending the New Zealand tephrochronological framework to 60 cal. ka as part of the SHAPE project.

An examination of the tephrostratigraphy of long sediment records from terrestrial sites (Auckland maars, Lake Omapere, Lake Poukawa) and offshore (Bay of Plenty, Hawkes Bay, and wider Southwest Pacific Ocean) yields six well-defined tephra deemed as suitably widespread markers, including one from Taupo VC, namely Tahuna tephra, and five from Okataina VC, namely Omataroa (unit K), Mangaone (unit I), Hauparu (unit F), Maketu (unit D), and Rotoehu. Furthermore, several units from Tuhua Volcanic Centre preserved in offshore cores in the Bay of Plenty offer potential if they can be correlated to other sites. The framework may be further expanded through recognition of well-known eruptions in cryptotephra form thus expanding their known distribution, and through further fingerprinting and correlation of widespread andesitic tephra from Egmont and Tongariro Volcanic Centres.

Of the tephra named above, most have relatively poor age control, limited to a relatively few radiocarbon dates or ages interpolated from sedimentation rates. The Rotoehu tephra has received considerable attention, its age most recently being determined as 45 to 50 cal. ka using a combination of $^{238}U/^{230}Th$ disequilibrium and (U–Th)/He ages on zircon, and radiocarbon. Maximising the potential of these markers to help achieve the goals of SHAPE clearly requires better age control. High-precision radiocarbon dating of charcoal, and $^{238}U/^{230}Th$ disequilibrium and (U–Th)/He zircon ages, are viewed as the best methods to obtain new dates.

New palynological investigations from New Zealand provide insights into regional and hemispheric climate variations during the last glacial-interglacial cycle

***Ignacio A Jara[1] , Rewi M Newnham[1] , Marcus J Vandergoes[2] , Janet M Wilmshurst[3]**

1. *School of Geography, Environments & Earth Sciences , Victoria University of Wellington, Wellington, New Zealand*
2. *GNS Science, Wellington, New Zealand*
3. *Ecosystem & Global Change , Landcare Research, Lincoln, Canterbury, New Zealand*

Palynological reconstructions of vegetation and climate are particularly well suited to New Zealand (34-47° S; NZ) due to its location across sub-tropical and extra-tropical latitudes, an extensive pre-human forest cover and a late settlement history. Previous palynological studies in NZ have revealed the presence of important vegetation changes since the transition out of the last Ice Age, and the use of numerical techniques have allowed to quantitatively reconstruct the temperature variations associated with those changes. However, since rainfall is not usually a limiting factor for NZ vegetation, precipitation reconstructions have proved more elusive.

Here we present two new postglacial pollen profiles from different vegetation-climate settings in NZ: (1) a 13,000 year-long sequence from Adelaide Tarn (40°56' S; 172°32' W), a small lake near the tree line in the beech (Nothofagus) forest of the northwestern South Island; and (2) an estimated 15,000-17,000 year-long sequence from Moanatuatua (37°58' S; 175°21'E; 60 masl), a lowland peat bog in the Broadleaf-conifer forest area of the northern North Island.

A quantitative temperature reconstruction from Adelaide Tarn and a preliminary integration of both records suggest significant early-Holocene warming in the South Island while a more modest temperature increase is observed in the northern North Island. At the same time, multiple proxies from tropical and extra-tropical latitudes imply that precipitation sourced from the extra-tropics (westerly) may have reduced over most of the country. This reduction could have been compensated in northern and eastern areas by an enhanced subtropical (easterly) precipitation, a circulation pattern in some ways analogous to the present-day positive phase of SAM. Evidence for this scenario will be examined using the pollen records from Adelaide Tarn & Moanantuatua.

A chironomid temperature reconstruction characterising change through the Antarctic Cold Reversal from Lake Rangatauanui, North Island, New Zealand

Andrew Rees[1] , Katherine Holt[2] , Shaun Eaves[1] , Marcus Vandergoes[3] , Rewi Newnham[1] , Janet Wilmshurst[4]

1. *School of Geography, Environment and Earth Sciences, Victoria University of Wellington, Wellington, 6012, New Zealand*
2. *Institute of Agriculture and Environment, Massey University, Palmerston North, 4442, New Zealand*
3. *GNS Science, Lower Hutt , 5011, New Zealand*
4. *Ecosystems and Global Change, Landcare Research, Lincoln , 7640, New Zealand*

It has been difficult to quantify the magnitude and extent of the Antarctic Cold Reversal (ACR) in the mid-latitudes of the Southern Hemisphere. Previous work has suggested there was a latitudinally-controlled Antarctic signal during the Last Glacial-Interglacial Transition (LGIT), highlighting some of the complexities in New Zealand (NZ). While southernmost pollen-inferred temperature patterns resembled the ACR, northernmost sites exhibited a later, more subdued late-glacial temperature reversal. A multi-proxy pollen and chironomid record from Boundary Stream Tarn, another southern site, provides further support for the ACR, although differences between proxies hint at possible seasonal controls. While the overall pattern is consistent with the bipolar seesaw model, the variability between records suggests other factors must be involved.

Here we aim to better understand the expression of the ACR in NZ by developing a new late-glacial (16 to 11 ka) chironomid record and temperature reconstruction from Lake Rangatauanui, just southwest of Mount Ruapehu. At ~39°S and 570 masl, Lake Rangatauanui fills a gap in NZ's latitudinal and elevational coverage of the ACR. Our goals are to: (1) help advance understanding of late-glacial climate change in NZ in relation to the bipolar seesaw; and (2) eventually develop a multi-proxy record including chironomid and pollen stratigraphies from Lake Rangatauanui and glacier reconstructions from the nearby Ruapehu massif. Regarding the former goal, resolving the geographical pattern and timing of key events will help discern between potential causal mechanisms, while the latter goal may help fine-tune our understanding of the seasonal expression of the ACR.

23

Uniform summertime cooling drove glacier re-advance across New Zealand during the late-glacial (15-11 ka).

***Shaun R Eaves[1] , Brian Anderson[1] , Andrew Mackintosh[1] , Gisela Winckler[2] , Joerg Schaefer[2] , Dougal Townsend[3]**

1. *Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand*
2. *Lamont-Doherty Earth Observatory, New York, USA*
3. *GNS Science, Avalon, Lower Hutt, New Zealand*

Rapid, millenial-scale climate events characterise the last global glacial-interglacial transition (18-11 ka). In New Zealand, questions remain outstanding concerning the absolute timing and magnitude of climatic events during this period, as well as possible latitudinal and seasonal variability. Resolving these issues can help to identify the mechanisms via which rapid shifts in climate occur. In this study, we report results from geomorphological mapping, cosmogenic ^{3}He exposure dating and numerical glacier modelling, which show evidence for readvance of mountain glaciers on Mt Ruapehu in central North Island, New Zealand (39°S) during the late glacial chron (15-11 ka). Using a distributed energy balance model, coupled with a 2D ice flow model, we perform a range of experiments and sensitivity analyses to constrain estimates of past temperature associated with the mapped and dated former ice limits. We find that glaciers in North Island re-advanced early in the late glacial period in response to a likely temperature cooling of 2.5 - 3.4 °C relative to present day, assuming precipitation remained within ± 20 % of present. This magnitude of cooling is greater than recorded in nearby pollen archives, which may reflect a seasonal bias between climate proxies. Strong agreement between our results and other summer temperature proxy records (mountain glaciers, chronomids) from the Southern Alps, suggest New Zealand experienced uniform summertime cooling during the late-glacial climate reversal.

24

A stomatal frequency-based reconstruction of mid-Holocene CO_2 dynamics from Adelaide Tarn, New Zealand, 8-2 ka BP

***Alexandra J. C. Hincke[1] , Rewi Newnham[2] , Marcus Vandergoes[3] , Friederike Wagner-Cremer[1]**

1. *Palaeoecology, Utrecht University, Utrecht, Netherlands*
2. *Victoria University of Wellington, Wellington, New Zealand*
3. *GNS Science, Lower Hutt, New Zealand*

Here we present a stomatal frequency-based atmospheric CO_2 reconstruction from *Nothofagus menziesii* (silver beech) from Adelaide Tarn, New Zealand. A CO_2-stomatal index inference model is derived from analysis of herbarium and modern samples of *N. menziesii*. Our record spans the period from 8-2 ka BP and we compare these results to a Holocene CO_2 reconstruction based on *Betula pubescens* from Lille Gribsoe, Denmark. The CO_2 shifts in the extended Lille Gribsoe dataset are closely comparable to the Adelaide Tarn CO_2 reconstruction in the magnitude and timing of CO_2 shifts. The close comparisons between the CO_2 reconstruction between Adelaide Tarn and Lille Gribsoe suggests that the stomata-inferred CO_2 regime for the Holocene is both more dynamic than Antarctic ice cores suggest and that short-term CO_2 variability occurs contemporaneously in the northern and southern hemispheres.

Our results demonstrate the first application of the stomata-CO_2 proxy for a southern hemisphere CO_2 reconstruction and emphasise that vegetation proxies record a more dynamic (and potentially more highly-resolved) global CO_2 regime for the Holocene than ice core records.

Assessment of Mid Holocene atmospheric circulation and synoptic forcing of regional climate using New Zealand speleothems and terrestrial proxy data: application of the Past Interpretation of Climate Tool (PICT).

Andrew Lorrey[1] , Nicolas Fauchereau[1] , Helen Bostock, Duncan Ackerley, Paul Williams, NZ SHAPE Members

1. NIWA, Auckland, New Zealand

Previous work has indicated a significant climate change happened during the mid-Holocene in New Zealand. However, the timing of the changes observed in proxies, especially those derived from sedimentary archives, appear asynchronous. The apparent lack of coherent response and poor clarity of timing for a mid-Holocene event, or whether there was more than one significant change, is a result of insufficient dating control, low archive sampling resolution, and different dating techniques applied to the array of archives.

We make use of a network of speleothem archives to identify the characteristics of mid-Holocene climate in New Zealand. All of the speleothems were dated using thermal ionisation mass spectrometry (TIMS) or U-Th methods. Age models and errors for individual isotope points between speleothem dates were determined using a piecewise cubic Hermite (PCH) polynomial interpolation, which is a relatively new approach for age modeling in New Zealand speleothem-based palaeoclimate research. We also apply a new set of principles to the construction of master speleothem chronologies for cave systems that had multiple isotopic records available.

Supporting multi-proxy terrestrial data were integrated with the speleothem signals into millennial-resolution past atmospheric circulation time slices for the mid-Holocene. We discuss the key evidence for the mean climate state and changes on land, and corroborate the integration with marine proxy data and climate model simulation results. Palaeoclimate model simulations from GCM and RCM correspond well to the parts of the reconstructed circulation patterns, but differences may indicate the inability to verify a model result centred on a climate transition.

New insights on tropical vegetation productivity and atmospheric methane over the last 40,000 years from speleothems in Sulawesi, Indonesia

***Claire E Krause[1] , Mike K Gagan[1] , Gavin B Dunbar[2] , John C Hellstrom[3] , Hai Cheng[4 5] , R. Lawrence Edwards[4] , Wahyoe S Hantoro[6] , Peter O Hopcroft[7] , Paul J Valdes[7] , David J Beerling[8] , Nerilie J Abram[1] , Hamdi Rifai[9]**

1. *Research School of Earth Sciences, The Australian National University, Australian Capital Territory, Australia*
2. *Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand*
3. *School of Earth Sciences, University of Melbourne, Victoria, Australia*
4. *Department of Earth Sciences, University of Minnesota, Minneapolis, Minnesota, USA*
5. *Institute of Global Environmental Change, Xi'an Jiatong University, Xi'an, China*
6. *Research Center for Geotechnology, Indonesian Institute of Sciences, Bandung, Indonesia*
7. *Bristol Research Initiative for the Dynamic Global Environment (BRIDGE), School of Geographical Sciences, University of Bristol, Bristol, United Kingdom*
8. *Department of Animal and Plant Sciences , University of Sheffield, Sheffield, United Kingdom*
9. *Department of Physics, State University of Padang, Padang, Indonesia*

Speleothem $\delta^{13}C$ remains an underutilized proxy because a number of factors can contribute to the $\delta^{13}C$ signal, including climate change, karst processes, vegetation productivity and soil temperature. In this study, we combine speleothem $\delta^{13}C$ data with model experiments to better understand the relationship between speleothem $\delta^{13}C$ variability, tropical vegetation productivity, and glacial-interglacial changes in atmospheric methane.

Our speleothem record from southwest Sulawesi, Indonesia spans the last 40,000 years and serves as a proxy for tropical vegetation and soil productivity. Changes in soil CO_2 and temperature during the last glacial-interglacial cycle appear to be the key driver of speleothem $\delta^{13}C$ variability in southwest Sulawesi. Other proxy records from the region and trace element analysis of the Sulawesi speleothem support this interpretation.

These results are compared with output from a series of simulations with the Sheffield Dynamic Global Vegetation Model (SDGVM) forced with snapshot climate simulations covering the last glacial-interglacial cycle using the HadCM3 coupled ocean-atmosphere global circulation model. Temporal changes in the soil and vegetation carbon in these model experiments show similar trends as the speleothem $\delta^{13}C$ time series for Sulawesi, suggesting a role for atmospheric CO_2 and surface temperature in driving speleothem $\delta^{13}C$.

The Sulawesi speleothem $\delta^{13}C$ record and SDGVM model results provide new insights into the role of tropical vegetation in driving the global methane budget over the last 40,000 years. Notably, the relationship between speleothem $\delta^{13}C$, tropical vegetation and atmospheric methane is particularly strong during the last glacial when methane production in high-latitude boreal wetlands was suppressed. Our speleothem $\delta^{13}C$ record allows us to directly attribute global methane emissions at this time to tropical ecosystems, highlighting their importance in driving glacial methane production.

27

Holocene rainfall variability recorded in an aragonite speleothem from Sumatra and the role of the Indian Ocean Dipole

***Jennifer B Wurtzel[1] , Nerilie J Abram[1] , Michael K Gagan[1] , Wahyoe S Hantoro[2] , Hamdi Rifai[3] , Stephen Eggins[1]**

1. *Research School of Earth Sciences, Australian National University, Acton, ACT, Australia*
2. *Research Center for Geotechnology, Indonesian Institute of Sciences, Bandung, Indonesia*
3. *Department of Physics, State University of Padang, Padang, Indonesia*

Climate variability in the tropical Indian Ocean strongly influences rainfall across the Australian continent. Research has suggested that the intensity of this variability, known as the Indian Ocean Dipole (IOD) may be changing due to anthropogenic forcing over the last few decades. The effects of a changing climate on the IOD and related patterns (e.g. El Nino-Southern Oscillation, Australasian monsoon) are not well understood and are currently poorly constrained in model simulations of future climate changes. Our ability to predict the response of the system is limited by short instrumental records, from which we cannot infer low-frequency cycles, or a regional response to changes in long-term global climate. A detailed history of rainfall in the tropical eastern Indian Ocean region over the last ca. 14,000 years will contribute to quantifying our understanding of changes in IOD variability at time-scales relevant to society.

Here we present high-resolution (~15-year intervals) stable isotope data from an aragonite stalagmite collected just south of the equator in western central Sumatra, strategically located in the eastern sector of the IOD. This data represents the first stalagmite record of rainfall variability from Sumatra, which, in conjunction with other Indo-Pacific records, may be used to distinguish between the zonal (i.e. IOD, ENSO) and meridional (i.e. ITCZ, monsoon) controls on regional climate.

28

What can isotope-enabled climate models tell us about Heinrich Events?

Katrin Meissner[1] , Laurie Menviel[1] , Witold Bagniewski[1]

1. *UNSW, Sydney, NSW, Australia*

Between 20 and 80 thousand years ago several cooling cycles occurred in the Northern Hemisphere, which culminated in a discharge of icebergs into the North Atlantic. Most of these so-called “Heinrich Events” were synchronous with a substantial increase in atmospheric carbon dioxide. A similar pattern can be observed during the last deglaciation, when atmospheric carbon dioxide increased and atmospheric radiocarbon decreased during large meltwater events. I will discuss possible mechanisms that can lead to the ventilation of “old” oceanic carbon when the Atlantic Meridional Circulation (AMOC) is weakened or shut down. I will show that a weakening of the AMOC can result in either higher or lower atmospheric carbon dioxide, and therefore reconcile previous modelling studies that have shown conflicting results. I will also discuss the oceanic $\delta^{18}O$ signal and propagation after a Heinrich Stadial.

29

Progress in inferring past climate from glacier modelling

Andrew Mackintosh[1] , Brian Anderson[1] , Alice Doughty[2] , Shaun Eaves[1] , Andrew Lorrey[3]

1. *Victoria University of Wellington, Wellington, New Zealand*
2. *Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire, USA*
3. *NIWA, Auckland, New Zealand*

Glacier mass balance is governed by energy balance of the Earth's surface, and is influenced by meteorological variables such as air temperature, precipitation, wind speed, cloud cover, and humidity. However, in mid latitude mountain settings, air temperature exerts a dominant influence on glacier mass balance, and hence, glacier length changes through time. Glacier modelling provides a means for inferring past climate from changes in glacier length, as defined by moraine records. I will review recent applications of glacier models to moraine records from the Last Glacial Cycle in the New Zealand Southern Alps, with emphasis on applications of a coupled energy balance – two dimensional glacier flow developed at Victoria University of Wellington. The aim is to highlight opportunities as well as challenges presented by this methodology.

30

The Antarctic Cold Reversal: A Data-Model Synthesis

Helen Bostock[1] , Joel Pedro[2] , Tim Barrows[3]

1. *NIWA, Wellington, New Zealand*
2. *Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, Washington, USA*
3. *College of Life and Environmental Science, University of Exeter, Exeter, England*

The Antarctic Cold Reversal (ACR) is a millennial-scale cooling period observed in Antarctic ice cores that is synchronous with Greenland Interstadial 1 (GI-1). As part of the INQUA-SHAPE initiative we have conducted a systematic assessment of Southern Hemisphere records for the presence of ACR signals. Our results show that ACR cooling is expressed most strongly in the South Atlantic and at latitudes close to and south of the sub-tropical front. ACR signals are weak or absent in the remainder of the Southern Hemisphere, including the sub-tropics to tropics of South America, Oceania and Africa.

This observed pattern is compared to that simulated by a recent coupled atmosphere-ocean transient general circulation model experiment. The modelled spatial extent of the ACR is in good agreement with observations. We show that changes in inter-hemispheric heat flux in both the ocean and atmosphere are a key to understanding the regional differences in climate response. Observed cooling in the South Atlantic and Southern Ocean is consistent with a positive anomaly in northward ocean heat transport. At the same time, the observed warming at lower latitudes of the Southern Hemisphere is consistent with enhanced atmospheric heat transport, a strengthened Hadley circulation and regions of decreased precipitation. Together, the results show that the atmosphere fluxes heat southwards in order to counteract the energy imbalance set up by the anomalous northward flux in the ocean. Deviations from this general picture may be explained in part by movement of ocean fronts, changes in climate modes (including Southern Annular Mode and ENSO) and the non-linear and/or threshold responses to climate changes that are expected in some proxies.

Southern Hemisphere climate variability over the past 8,000 years: an integrated data-model perspective

Steven J Phipps[1 2]

1. *ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, NSW, Australia*
2. *Climate Change Research Centre, University of New South Wales, Sydney, NSW, Australia*

The increasing volume of climate model simulations and proxy data is enabling fresh insights into the climate of the Southern Hemisphere. New model simulations of the past 8,000 years are becoming available, largely thanks to the Palaeoclimate Modelling Intercomparison Project. Through the integration of these simulations with proxy data, including new syntheses being developed by SHAPE, we can study the evolution and drivers of the modes of Southern Hemisphere climate variability.

Both the data and the models show that there has been an increase in El Niño-Southern Oscillation (ENSO) variability over the past 8,000 years, combined with a shift towards a more positive phase of the Southern Annular Mode (SAM). On millennial timescales, the model simulations show that both of these trends are driven by orbital forcing. However, on shorter timescales, internal variability dominates. While volcanic eruptions and changes in solar irradiance can affect the mean state of the climate system, they do not appear to influence the strength of either ENSO or SAM. The industrial period is an exception, with evidence that anthropogenic influences caused a further strengthening of ENSO variability and a further positive shift in SAM during the late 20th century.

Thus a picture emerges of high-frequency internal variability, superimposed on top of long-term trends driven by orbital changes. These results suggest that care must be taken when interpreting proxy records, and particularly when trying to synchronise records from different sites, as variations on sub-millennial timescales may simply represent random internal variability within the climate system.

Ochre through the late Quaternary at Gledswood Shelter 1, northwest Queensland

Lynley A Wallis[1 2 3] , Kelsey M Lowe[1 2] , Rachel Popelka-Filcoff[4] , John W Bennett[5] , Claire St George[1 3] , Caroline Watson[4] , Kathryn Fitzsimmons[6] , Chantal Wight[3] , Alan Watchman[3] , Claire Lenehan[4] , Jacqueline Matthews[1 7]

1. *Wallis Heritage Consulting, Brighton, SA, Australia*
2. *School of Geography, Planning and Environmental Management, University of Queensland, St Lucia, QLD, Australia*
3. *Department of Archaeology, Flinders University, Adelaide, SA, Australia*
4. *School of Chemical and Physical Sciences, Flinders University , Adelaide, SA, Australia*
5. *Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights, NSW, Australia*
6. *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany*
7. *Archaeology / School of Social Science, University of Western Australia, Nedlands, WA, Australia*

Gledswood Shelter 1 (GS1) is a sandstone rockshelter located in northwest Queensland containing archaeological evidence for human occupation dating from at least 35 ka to the recent past. Considerable quantities of ochre fragments (many with striations caused by grinding) have been recovered from the 2.5 m deep cultural sequence, particularly in the pre-LGM levels. The abundance of ochre varies through time, in line with recovered stone artefacts, suggesting that these materials reflect different periods and intensities of site use. This evidence possibly indicates that the production of painted or stencilled art in this region may be earlier than previous evidence suggests (ca 9,000 years ago). The GS1 ochre samples were initially characterised according to visual characteristics including colour, texture and inclusions using low powered microscopy. This work suggests there are several groups of pigment present, including fragments that would more normally be referred to as ironstone and not considered as an 'ochre', but that have anthropogenic ground surfaces indicating their use as a source of pigment. In this paper we present the initial characterisation and preliminary neutron activation analysis results of the GS1 ochres, and consider their implications for the human history of the northwest Queensland region.

Further stories from the 'rain gauge' of Western Victoria

Jessica M Reeves[1] , Jonathon Tyler[2] , Chris Gouramanis[3] , Patrick De Deckker[4]

1. *Federation University Australia, Ballarat*
2. *University of Adelaide, Adelaide*
3. *Earth Observatory of Singapore, Singapore*
4. *The Australian National University, Canberra*

Lake Keilambete, one of the Western Victorian crater lakes, is a gift that keeps on giving. Since very early work in the 1960-70s by Bowler and colleagues, a Late Pleistocene history of the lake has been alluded to, based on the sequence of terraces within the crater rim (Bowler and Hamada, 1971). Since then, the most intensive work has been performed on sediment records recovered from the centre of the lake basin and has focussed on the Holocene, including pollen (Dodson, 1974; Mooney, 1997), ostracod (De Deckker, 1982; Wilkins *et al*., 2013), geochemical (Chivas *et al*., 1985, 1986 Wilkins) and dating studies (Barton and Polach, 1980; Wilkins *et al*., 2012). These have been also used to make inferences about possible future climate scenarios (Jones *et al*., 2001) and were critical to understanding local and regional palaeoclimate variation in southeastern Australia (Gouramanis et al 2013).

In 2012 a >5m core was obtained from the lake, with a basal date of ~30 cal. ka BP (^{14}C AMS on ostracods) taken from stiff, gleyed clays. iTRAX data was collected at 2 mm increments providing a very-high resolution record for sediment chemistry (e.g. Ca, Na, Ti) variation from ca. 30 ka. The scans have also enabled correlation with the previous cores. Ostracod species were identified from subsamples extracted from the core and salinity variation for the 30 ka period was determined using an ostracod-salinity transfer function (Wilkins *et al* 2013). Stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) were analysed on pre-cleaned ostracod valves from the glacial section, using an AP2003 continuous-flow stable isotope mass spectrometer. These preliminary results reveal drier conditions ~30 ka (<10 m water depth), followed by a relatively wetter phase (>20 m) and then increased variability during the glacial.

1. Barton, C.E. and Polach, H.A., 1980. 14C ages and magnetic stratigraphy in three Australian maars. Radiocarbon 22, 728–739.
2. Bowler, J.M., Hamada, T., 1971. Late Quaternary stratigraphy and radiocarbon chronology of water level fluctuations in Lake Keilambete. Nature 232, 330-332.
3. Chivas, A.R., De Deckker, P., Shelley, J.M.G., 1985. Strontium content of ostracods indicates lacustrine palaeosalinity. Nature 316, 251-253.
4. Chivas, A.R., De Deckker, P. and Shelley, J.M.G., 1986. Magnesium and strontium in nonmarine ostracod shells as indicators of paleosalinity and paleotem¬perature Hydrobiologia 143, 135–142.
5. De Deckker, P., 1982. Holocene ostracods, other invertebrates and fish remains from cores of four maar lakes in southeastern Australia. Proceedings of the Royal Society of Victoria 94, 183-219.
6. Dodson, J.R., 1974. Vegetation and climate history near Lake Keilambete, western Victoria. Australian Journal of Botany 22, 709-717.
7. Gouramanis, C., De Deckker, P., Switzer, A.D., Wilkins, D., 2013. Cross-continent comparison of high-resolution Holocene climate records from southern Australia - deciphering the impacts of far-field teleconnections. Earth-Science Reviews 121, 55-72.
8. Jones, R.N., McMahon, T.A., Bowler, J.M., 2001. Modelling historical lake levels and recent climate change at three closed lakes, western Victoria, Australia (c.1840e1990). Journal of Hydrology 246, 159-180.
9. Mooney, S., 1997. A fine-resolution paleoclimatic reconstruction of the last 2000 years, from Lake Keilambete, southeastern Australia. The Holocene 7, 139–149.
10. Wilkins, D., De Deckker, P., Fifield, L.K., Gouramanis, C., Olley, J., 2012. Comparative optical and radiocarbon dating of laminated Holocene sediments in two maar lakes: Lake Keilambete and Lake Gnotuk, south-western Victoria. Quaternary Geochronology 9: 3-15.
11. Wilkins, D., Gouramanis, C., De Deckker, P., Fifield, L.K., Olley, J. Revised Holocene lake level fluctuations in Lake Keilambete and Lake Gnotuk, south-western Victoria, Australia. The Holocene 23, 784-795.

Sedimentation rates in eastern Australia: evidence for rapid change from 12 - 6 ka (mid- to early-Holocene)

***Lennard F Martin[1] , Scott D Mooney[1] , James Goff[1]**

1. The University of New South Wales, Randwick, NSW, Australia

Peat-forming environments are relatively rare in Australia, and due to their nature as accumulating, relatively stable environments are often utilised as archives of palaeoenvironmental information, especially for the Holocene. This project constructed and analysed a database of 44 existing sites (121 ^{14}C dates at 100 year intervals from 21Ka to present) from a range of depositional environments around the Sydney Basin. A subset of 10 of the sites have Loss-On-Ignition data for organic content, and this was analysed in corresponding 100-year intervals.

Here we focus on the possible causes and implications of two abrupt increases in sedimentation rates and the first abrupt increase in organic content during the early to mid-Holocene, superimposed over an increasing trend in both records from ~14Ka. Several researchers have suggested that as peat dominated environments exist in such narrow environmental niches, small climatic fluctuations within the Holocene are likely to be readily observed in changes to accumulation rates [4,5] . This compilation allows for temporal and spatial comparisons that can aid in elucidating a variety of teleconnections between regions susceptible to changing climatic forcing through time.

Sedimentation rates are observed to increase abruptly at 11.5-11.8ka, coeval with the beginning of the Holocene, after stable, low rates of accumulation from the LGM-Holocene, along with gradual increases in organic content. This initial rapid increase of sedimentation rates at the beginning of the Holocene is coeval with the post-ACR increase in EPICA-$\delta^{18}O$. This compilation shows similar trends to lake level records from southern Victoria between 6 and 8 Ka [6] , when lake levels are at their highest. This period also represents a period of decreased fire activity in a nearby charcoal record[12] , while also being the first major peak in El Nino-Southern Oscillation events[3] .

1. Black, M.P., Mooney, S.D., Attenbrow, V., 2008. Implications of a 14 200 year contiguous fire record for understanding human--climate relationships at Goochs Swamp, New South Wales, Australia. The Holocene 18, 437–447. doi:10.1177/0959683607087933
2. Black, M.P., Mooney, S.D., Haberle, S.G., 2007. The fire, human and climate nexus in the Sydney Basin, eastern Australia. The Holocene 17, 469–480. doi:10.1177/0959683607077024
3. Moy, C.M., Seltzer, G.O., Rodbell, D.T., Anderson, D.M., 2002. Variability of El Nino Oscillation activity at millennial timescales during the Holocene epoch. Nature 420, 162–165. doi:10.1038/nature01163.1.
4. Muller, J., Wust, R., Weiss, D., Hu, Y., 2006. Geochemical and stratigraphic evidence of environmental change at Lynch's Crater, Queensland, Australia. Glob. Planet. Change 53, 269–277. doi:10.1016/j.gloplacha.2006.03.009
5. Nanson, R.A., 2009. The Evolution of Peat-Swamp Channels and Organic Floodplains, Barrington Tops, New South Wales, Australia. Geogr. Res. 47, 434–448. doi:10.1111/j.1745-5871.2009.00596.x
6. Wilkins, D., Gouramanis, C., De Deckker, P., Fifield, L.K., Olley, J., 2013. Holocene lake-level fluctuations in Lakes Keilambete and Gnotuk, southwestern Victoria, Australia. The Holocene 23, 784–795. doi:10.1177/0959683612471983

Microtextural characteristics of quartz grains from large scale marine inundations: case studies from the eastern coastline of Australia

***Naomi J Riggs[1] , Brian G Jones[2] , Craig R Sloss[3] , Colin V Murray-Wallace[2]**

1. *School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW, Australia*
2. *University of Wollongong, Wollongong, NSW, Australia*
3. *Faculty of Science and Engineering, Queensland University of Technology, Brisbane, QLD, Australia*

Large-scale inundation events, such as storm and/or tsunami, represent a major coastal hazard with the potential to damage property, infrastructure and resources, and cause loss of life. To advance understanding of modern tsunami and their potential affects, we must recognise the signatures of palaeotsunami. Many palaeotsunami deposits undergo alteration after deposition, resulting in loss of some potential identification proxies used in the identification of such deposits. For example, in swampy/peaty environments, the decomposition of organic matter produces acids. These, in turn, dissolve carbonates out of the deposit, such as marine macro- and microfossils that could be used for identification of a marine inundation. However, quartz grains are abundant in coastal inundation deposits. When the quartz grains are transported via strong hydrodynamic processes, they undergo surface abrasion, resulting in distinctive microtextural features.

In this study, cores were collected from several back-barrier estuaries and swamps along the eastern coastline of Australia. These sites are often swampy or peaty, resulting in poor microfossils preservation. Therefore quartz grains were used as a proxy for identifying extreme marine inundations. The specific microtextural signatures for tsunami transported quartz grains observed in these deposits were fresh surfaces and percussion marks. Also observed was the angularity and dissolution of the surface of the quartz grains, and adhering microparticles. Within the suggested tsunami deposits[1,2], an increase in fresh surfaces and percussion marks were observed, with almost complete resurfacing of some grains.

1. Clark, K., Cochran, U., and Mazengarb, C. (2011) Holocene coastal evolution and evidence for palaeotsunami from a tectonically stable region, Tasmania, Australia. The Holocene. 21: 883-895.
2. Switzer, A.D., and Jones, B.G. (2008) Large-scale washover sedimentation in a freshwater lagoon from the southeast Australian coast: sea-level change, tsunami or exceptionally large storm. The Holocene. 18: 787-803.

Drip hydrology monitoring in caves to inform stalagmite palaeoclimate records, Yarrangobilly, NSW.

***Monika Markowska[1 2] , Pauline C Treble[1] , Andy Baker[2] , Martin S Andersen[2] , Stuart Hankin[1]**

1. *ANSTO, Lucas Heights, NSW, Australia*
2. *Connected Waters Initiative, University of New South Wales, Sydney*

Palaeoclimate research using speleothems has significantly increased over the last decade, owing to their potential to provide multi-proxy high resolution (sub-annual) terrestrial records of past climate variability. A crucial step in using these archives as high resolution proxies is understanding the connectivity between the surface climate and the signal transferred to the speleothem. This study investigates the modern karst hydrology at Yarrangobilly Caves, in the Snowy Mountains NSW. A high-frequency, spatially-dense drip water monitoring campaign in Harrie Wood Cave, was conducted over a 13 month period to characterise the hydrology of 14 sites within the same cave. By utilising the cave as a natural observatory we can determine 1) vadose-zone flow regimes, and 2) thresholds of recharge at the site. Using a statistical approach (PCA and AHC) 5 main drip hydrological regimes were established. Depth was found to have a moderate relationship ($r2 = 0.4$) with discharge, whereby increasing depth was associated with a dampening of flow and drip response. However, depth could not account for all the variability observed in the drip hydrology, suggesting complex controls unrelated to depth, such as unsaturated zone storage and mixing, appear to have a significant impact on vadose-zone flow regimes. As a speleothem is a function of the infiltrating drip water, we suggest that stalagmites fed by different drip types may thus contain different parts of the climate record i.e. smoothed mean annual vs. an extreme event record. These findings will be used to assess three suitable stalagmites for palaeoclimate reconstruction, fed by drip waters with different hydrological regimes and the preliminary results presented here.

Debris flow dominated alluvial fans in the Victorian high country indicate that landscape denudation through the Holocene has been dominated by post-bushfire runoff events

Philip Marren[1] , Stephanie Kermode[2] , Petter Nyman[3]

1. *Department of Resource Management and Geography, University of Melbourne, Parkville, VIC, Australia*
2. *Australian Nuclear Science and Technology Organisation, Lucas Heights, NSW, Australia*
3. *Department of Forest and Ecosystem Science, University of Melbourne, Parkville, VIC, Australia*

Bushfires play a major role in shaping the Australian landscape. Whilst the role of fire in shaping and changing vegetation assemblages is relatively well understood, there is still debate about the significance of fire in driving landscape denudation, relative to other processes, such as major rainfall and flood events. Studies of post-fire landscape impact of recent bushfires indicate that the response is sensitive to the frequency and magnitude of extreme bushfires and intense rainstorms, with the greatest response occurring when storms occur in the post-fire period before vegetation has recovered. Where storm events occur shortly after a major bushfire, hillslope erosion is enhanced, due to debris flows and erosion of both primary hillslope sediment and sediment stored in hillslope channel networks.

We excavated nine trenches, in five alluvial fans at the base of hillslopes on the floodplain of the Nariel valley, northeast Victoria. This area was burnt by the 1939 and 2003 bushfires, although some of the fans were unburnt in 2003. The trenches were up to 3.5 m deep, and in four cases intersected the underlying floodplain sediment at the base of the trench, indicating that they provide a full record of sedimentation for that sector of the fan. Fan stratigraphy consisted of sub-horizontal (parallel to the fan surface) units 0.3–0.5 m thick, with occasional units 1–1.2m thick, and cross-cutting channelized units. Debris flow deposits accounted for 80–90 % of the observed sediments, with water-laid gravels and soil units forming the remainder. Most soil layers were burnt, and most (but not all) debris flow units contained charcoal. A typical stratigraphy consisted of 6–8 debris flow units per fan, with four units containing a fire signature or overlying a burnt soil layer. Radiocarbon dating of the fire-associated units is underway: preliminary results will be reported at the AQUA meeting.

Human arrival and impact on the environment enroute to Australia

***Lani Barnes[1] , Kira Westaway[1] , Rasmi Shoocongdej[2] , Fabrice Demeter[3] , Anne-Marie Bacon[4] , Philippe Duringer[5]**

1. *Environment and Geography , Macquarie University , Sydney , NSW, Australia*
2. *Silpakorn University, Bangkok, Thailand*
3. *Department Homme Nature Société (HNS), National Museum of Natural History, Paris , France*
4. *Centre National de la Recherche Scientifique (CNRS) Unité Propre de Recherche (UPR) , Paris , France*
5. *Institut de Géologie, Université de Strasbourg (UDS), Strasbourg, France*

Establishing modern human arrival in mainland southeast Asia is important for understanding modern human dispersal through southeast Asia enroute to Australia and their impact on the environment. The value of Optically Stimulated Luminescence (OSL) as a dating technique has not been fully recognised in this region due to limited application and unfavourable sample characteristics. OSL dating has been applied to two regions of tropical southeast Asia with similar occupation sites as found in northern Australia in an attempt to address this research gap and address the missing chronologies. The sites have the potential to contain the oldest evidence of modern humans in their region but lack a secure chronological framework. The Tham Lod limestone rock shelter in northern Thailand contains a combination of skeletal and lithic remains. Previous radiocarbon dating solely from the disturbed layer in the depositional sequence denotes the need for applied dating to the whole sedimentary deposit to establish a secure chronology. Similarly the limestone cave of Tam Pa Ling in northern Laos contains modern human skeletal evidence. Major issues and criticism associated with past dating included the presence of a large chronological hiatus combined with reliance on radiocarbon dates at the upper limit of the radiocarbon barrier for charcoal from non in-situ burning. As such a confident chronology for the site needs to be established using an alternate dating technique. Robust chronologies at both sites will establish the temporal context for modern human presence to assess their impact on the environment. Parallels between the timing of human presence, the behaviour of modern humans and their impact on the environment can be drawn between the tropical sites in southeast Asia that are the focus of this research and the tropical environments of northern Australia, home to the first Australians.

39

First recorded evidence of subaqueously-deposited late Pleistocene interstadial coastal strata above present sea level in Australia

***Amy Blakemore[1] , Colin V Murray-Wallace[1] , Terry J Lachlan[1]**

1. *University of Wollongong, Wollongong, NSW, Australia*

Significant variations in the elevation of late Pleistocene interstadial coastal strata have been noted at the global scale resulting from the combined effects of tectonism, proximity of field sites to Pleistocene ice sheets, and the variable effects of glacio-hydro-isostatic adjustment processes. In this poster we report the first recorded example of subaqueously deposited late Pleistocene interstadial coastal sediments above present sea level in Australia, a far-field location characterised by minimal to modest rates of vertical crustal movements. Located at Port MacDonnell, 20 km south of a Pleistocene-Holocene volcanic complex in southern Australia, the sediments are represented by a flint conglomerate beach facies with interstratified shells. Through stratigraphical analysis of sedimentary units surrounding and including the beach facies and through the application of geochronological techniques we are able to constrain the timing and elevation of the interstadial sea-level highstand. An optically stimulated luminescence (OSL) age of 53 ± 4 ka for an aeolianite unit that unconformably overlies the shelly deposit indicates that the beach facies is older than early MIS 3. OSL analysis of quartz grains from a barrier shoreline 7 km inland from the modern coastline indicates it is last interglacial (MIS 5e) in age (124 ± 10 ka) and is not related to the shelly beach facies. Radiocarbon dating of the operculum of Turbo undulatus from the shelly conglomerate yielded a minimum age of 47,905 ± 2106 yr BP (Wk 34733). The extent of amino acid racemization (AAR) on the Turbo sp. from the shelly unit beneath the aeolianite suggests an interstadial age (102 ± 16 ka). Palaeo-sea level at the time of deposition of the shelly flint conglomerate was approximately -14 m during MIS 5c. These results are consistent with palaeosea-level estimates from other far-field sites around the globe and oxygen isotope-inferred sea levels for this interval.

40

Paleoceanography of the Southern Hemisphere oceans from 60-30 ka

Helen Bostock[1] , Bruce Hayward[2] , Zanna Chase[3] , Giuseppe Cortese[4] , Patrick De Deckker[5] , Helen Neil[1]

1. *NIWA, Wellington, New Zealand*
2. *Geomarine Research, Auckland*
3. *Institute of marine and Antarctic science, University of Tasmania, Hobart, Tasmania, Australia*
4. *GNS Science, Lower Hutt*
5. *Research School of Earth Sciences, The Australian National University, Canberra, ACT, Australia*

Marine Isotope Stage (MIS) 3 is an anomalous cool interglacial. Its general global character is an initial warming from MIS 4 and then a gradual cooling towards MIS 2 and the Last Glacial Maximum. However, high resolution data from Antarctic ice cores show a series of millennial scale events during MIS 3. These warmer periods in Antarctica, evident from Antarctic Isotope Maxima (AIM) lead the dramatic warming of the Northern Hemisphere Dansgaard-Oeschger (D-O) events identified in Greenland ice cores. These millennial events have been associated with variations in the ocean circulation and are evident in some high-resolution marine sediment cores.

As part of SHAPE we have compiled the published high-resolution marine sediment core data from around the Southern Hemisphere for the period 60-30 ka to look for evidence of millennial changes in the oceans, along with other temporal and spatial trends across the MIS 3 period. The aim is to look for changes in sea ice extent, ocean circulation, biogeochemistry and to compare with terrestrial, glacial and ice core records from the different SHAPE regions.

A multi-archive synthesis of decadally resolved Australian palaeoclimate records over the past 2000 years

***Bronwyn C Dixon[1] , Joelle Gergis[1] , Jonathan J Tyler[2] , Russell N Drysdale[1]**

1. *University of Melbourne, Parkville, VIC, Australia*
2. *University of Adelaide, Adelaide, SA, Australia*

Knowledge of natural climate variability over the past two thousand years is essential for placing recent climate anomalies into a long-term perspective. To date, high-frequency climate variability has been examined within Australia by the PAGES Aus2k initiative through the use of annually resolved records. To complement this effort, low-frequency decadal to multi-decadal scale variability is now being investigated through the examination of non-annually resolved palaeoclimate records.

In this study, high-quality, non-annually resolved datasets from the Australian region (90°E - 140°W, 10°N - 80°S) were compiled in a central database. To date, ~30 records have met the selection criteria relating to appropriate resolution, precise chronology, and presence of a climate signal. Metadata for each record retain vital information, including site characteristics, author-interpreted climate variables and raw, uncalibrated dates. New age models were created for each record, providing consistency in calibration method and the parameters of age model creation. This information reduces chronological error in each record and any future multi-record comparisons.

The first application of this data compilation will be a reconstruction of Australian rainfall over the past two millennia. This will allow examination of decadal-scale trends in rainfall across the continent, and regional rainfall patterns caused by large-scale circulation. Regional signals will be investigated as indicators of climate-mode teleconnections associated with El Nino–Southern Oscillation, Indian Ocean Dipole and the Southern Annular Mode. Additionally, a new speleothem record from South Australia will be developed to fill a geographical gap currently present in long-term rainfall records of Southern Ocean-sourced precipitation. Knowledge of rainfall response to the influence of climate circulation shifts in the region may help to understand projected rainfall changes associated with the anthropogenic warming trend.

42

Surface exposure dating in igneous domains: development and application of cosmogenic ^{3}He as a geochronological tool in the southwest Pacific region.

***Shaun R Eaves[1] , Gisela Winckler[2] , Andrew Mackintosh[1] , Joerg Schaefer[2] , Marcus Vandergoes[3] , Brent Alloway[4] , Dougal Townsend[3] , Matthew Ryan[4]**

1. *Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand*
2. *Lamont-Doherty Earth Observatory, New York, USA*
3. *GNS Science, Avalon, Lower Hutt, New Zealand*
4. *Victoria University of Wellington, Wellington, New Zealand*

Surface exposure dating using cosmogenic nuclides is now established as the premier tool for resolving the timing of past glacier and ice sheet fluctuations, over timescales of centuries to millions of years. Whilst ^{10}Be is the isotope of choice for the vast majority of applications, lithological constraints (i.e. lack of quartz) in some regions requires alternative nuclides. Cosmogenic ^{3}He is produced and quantitatively retained in pyroxene and olivine phases, which are commonly found in igneous domains. Here, we report progress in constraining local cosmogenic ^{3}He production rates in the southwest Pacific region, using an independent radiocarbon chronology of a c. 11 ka debris avalanche deposit in central North Island, New Zealand. Our preliminary results show strong agreement with existing production rate estimate derived from a recent, global compilation of calibration datasets. Applying this, we provide the first direct constraint on orbital-scale glacier fluctuations on Mt. Tongariro, central North Island, New Zealand, during the last glacial cycle. Our cosmogenic ^{3}He chronology shows evidence for extensive glaciation during MIS 4 that culminated c. 59 ± 6 ka, as well as prolonged glacial expansion of similar magnitude during the local Last Glacial Maximum (c. 31 – 22 ka). These findings support existing hypotheses that invoke astronomical forcing of austral summer duration, rather than mid-summer intensity, as a key driver of orbital-scale climate change in the Southern Hemisphere, over the late Quaternary.

43

The potential of ITRAX core scanning: Applications in Quaternary Science

Patricia P Gadd[1] , Henk H Heijnis[1]

1. *ANSTO, Lucas Heights, NSW, Australia*

The ITRAX is a multi-function core scanner and is being increasingly used in the fields of Quaternary geology, environmental science and climate science. The scanner is equipped with micro-XRF (X-Ray Fluorescence) instrumentation, which is capable of measuring a wide range of elements at very small scanning intervals. In addition to this, the instrument can also take high resolution optical and X-radiograph images and measure magnetic susceptibility. An ITRAX has been located in the laboratories of the Australian Nuclear Science and Technology Organisation (ANSTO) since 2012, and was funded by an ARC-LIEF grant. ANSTO was able to provide a purpose build room and ancillary facilities, such as Geotek core-splitter, dendrocut saw and sample storage, as part of the upgrade of the Environmental Radioactivity Measurement Centre. The ITRAX is capable of scanning resolutions of 200µm for XRF measurements and optical images, and 60µm for X-radiograph images. The ITRAX at ANSTO is unique in its capability to measure sediments, carbonate systems and tree ring samples. An overview of the applications of the ITRAX-scanning in various fields is presented in this poster.

44

Identifying Aboriginal hearths in Late Quaternary northwest Victoria: an experimental study to replicate the production of 'clay ball' and carbonate nodule heat retainers

Jillian Garvey[1] , Chris Silvester[1] , Emily Dillion, Sara Lombardo, Adam Valka, Anthony Romano, Ada Dinckal, Alex Blackwood, Maurizio Campanelli, Jeffrey Clarke, David Clark, Anthony Dall'Oste

1. *La Trobe University, Melbourne, VIC, Australia*

The Late Quaternary cultural record of northwest Victoria consists of a diverse archaeological assemblage. One component of this includes isolated heat retainers and hearths utilised by Aboriginal people to cook a variety of foods in cooking pits. In the absence of suitable stone heat retainers, it is presumed that clay and carbonate nodules were used. Recent surveys at Neds Corner Station, as part of an Australian Research Council funded project, highlighted the difficulty in distinguishing between culturally versus naturally fired clay.

This poster presents the results of four firing experiments, which form the basis of ongoing studies. In order to replicate the heat-retainers identified during the survey, different heating regimes and a variety of raw materials sourced from local land systems were used. The fired clay produced in these experiments was then compared with natural, cultural and ambiguous baked clay observed in the field. Ethnographic records and other firing experiments are discussed. These studies have implications in the understanding and management of the archaeological record in this region.

45

In search of relationships between forms of and processes that created and modified the sandy southeastern Queensland coast

Allen Gontz[1] , Patrick Moss[2] , Adrian McCallum[3]

1. *School for the Environment, University of Massachusetts-Boston, Boston, MA, United States*
2. *School of Geography, Planning and Environmental Management, University of Queensland, St Lucia, QLD, Australia*
3. *Department of Engineering, University of the Sunshine Coast, Sippy Downs, QLD, Australia*

The southeast coast of Queensland is the world's largest downdrift sand system and hosts the three largest sand islands: Fraser, North Stradbroke and Moreton. Quaternary sea-level changes and climate variation are hypothesized as the strongest drivers for creation, modification and maintenance. A suite of processes, including storms and societal activities, has added additional variability to the system.

Over the past three years, we have been conducting an integrated approach to decipher the drivers and linkages that have produced the system. Our work has included ground penetrating radar lines and cores. The GPR surveys have identified a 2 km long sequence of beach ridges on Flinders Beach, North Stradbroke Island. The sequence is punctuated by storm horizons and shows a pattern with progressive spit and cat-eye pond development. The GPR also indicated that a similar pattern is preserved beneath. We've begun to relate the dunes and fens at Dilli Village and Moon Point, Fraser Island. The GPR shows thick > 6 m of peat deposits with intermittent sand horizons occur beneath an area that is currently buried by a thin blanket of aeolian sands, suggesting dune migration. Coring at Moon Point and North Stradbroke has placed some constraints on the system based on ^{14}C and palynological work.

46

Environmental changes at Australia's roundest lake - preliminary results

***Cara Hull[1] , Cameron Wynford[1] , Simon Connor[1]**

1. *School of Geography and Environmental Science, Monash University, Clayton, VIC, Australia*

The Western Plains of Victoria have yielded some of the most important Quaternary palaeoenvironmental records in Australia, providing detailed information on past lake levels, vegetation, salinity, fire and human impacts. Many of these records have been derived from large crater lakes, which have a large source-area for pollen and charcoal and are therefore representative of regional vegetation and fire. Lake Mumblin is a small crater lake in the Terang district on the Western Plains of Victoria. It is expected to provide a more local picture of environmental change that can be compared with previous regional records. This poster presents preliminary results from diatom, pollen and contiguous macrocharcoal analyses of a 3.3-m core from the centre of the lake. Pollen and charcoal records show major change associated with the arrival of European colonists, while the diatom record is suggestive of climatically-driven changes in lake salinity and trophic status. Our preliminary observations provide useful baseline data for ecological restoration and management of the lake and its catchment.

47

Slavery in the Caribbean: Isotopic Evidence of Forced Migration

***Hannah James[1] , Malte Willmes[1] , Ian S Williams[1] , Rainer Grün[1] , Patrice Courtaud[2]**

1. *Research School of Earth Sciences, Australian National University, Canberra, ACT, Australia*
2. *University of Bordeaux, Talence, France*

Isotopic analysis of human tissues is being increasingly used in archaeological studies as tools for identifying human migration. Oxygen isotopes in precipitation differ according to temperature and precipitation intensity and strontium isotopes differ in bedrock both forming geographical profiles. This information can be used to form pictures of historical human migration.

The African slave cemetery, Anse Sainte Marguerite (ASM) in Guadeloupe, contains the remains of 278 individuals. Cultural dental modification, known to be present only in enslaved individuals transported from Africa, was present at the site suggesting its use by both enslaved individuals and subsequent generations.

Previous work on carbon and nitrogen isotopes (Sparkes et al, 2012) at ASM identified two groups based on differences in diet; terrestrial based versus marine based diets. The group with the marine signature is taken to represent those individuals born in the Caribbean. The terrestrial group is taken to represent enslaved individuals, whose childhood diets would have relied heavily on terrestrial sources.

To strengthen the carbon and nitrogen results, strontium and *in situ* oxygen isotope analysis in tooth enamel were employed to identify the local environment during an individual's childhood, indicating which individuals were enslaved or Caribbean born.

Oxygen and strontium isotopes in the seventeen samples analysed, agreed with the two groups identified in carbon and nitrogen analysis. Enslaved individuals, migrants to the Caribbean, have an oxygen isotopically lighter value than the isotopically heavier non-migrants, those born in the Caribbean. This represents differences in the isotopic value of drinking water at each location. All individuals with dental modification showed migrant values confirming these were enslaved individuals.

48

Sedimentation effects of salinity-control weirs in Illawarra streams

Adam Skorulis[1] , Brian G Jones[1] , Carl A Hopley[1 2]

1. *School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW, Australia*
2. *Environmental Strategy & Planning, Wollongong City Council, Wollongong, NSW, Australia*

Macquarie Rivulet and Mullet Creek are the two main rivers draining the Illawarra escarpment west of Lake Illawarra, NSW. Both rivers have low run-of-river salinity-control weirs to prevent brackish water from Lake Illawarra penetrating upstream into the main agricultural areas.

The weir on Mullet Creek has been in place since the late 1800s associated with a river crossing whereas the Macquarie Rivulet weir was only emplaced in 1963. Detailed GIS analysis of aerial photographs shows no signs of sediment build-up behind the weirs and no significant scouring on the downstream side of the weirs. This is especially apparent on Macquarie Rivulet when pre- and post-weir construction could be analysed. The results show that channel surface areas and rates of change through time occur independently of the weirs with most change occurring after major floods, e.g. the 1984 flood on Mullet Creek.

Surface sediment samples and vibracores were collected both upstream and downstream from the weirs in both rivers. Upstream from both weirs showed significant scouring with almost no sediment accumulation in the middle of the rivers and only minor accumulations of both coarse and fine material near the banks. During flood conditions when the river level is 2-3 m above the weir both coarse and fine material are entrained by the turbulence upstream of the weir and transported over the weir. Immediately downstream of the weir a scour pool is present with sediment deposition occurring 30-50 m below the weir. Coarse layers, up to 50 cm thick in bank-attached bars, represent flood deposits that may be separated by finer grained low flow deposits. The progressive fining of sediment downstream towards the mouth of the river is a function of the backwater effect caused by the lake. No anthropogenic pollution is being stored in fine material upstream of the weirs.

49

Vegetation and environments since the Last Glacial Maximum in the Southern Tablelands, New South Wales

Justine Kemp[1] , Geoffrey Hope[2]

1. *Griffith University, Nathan, Brisbane, QLD, Australia*
2. *Archaeology and Natural History, The Australian National University, Canberra, ACT, Australia*

Regional changes in vegetation and environment since <16 ka have been reconstructed from Micalong and Willigobung Swamps (35 °S), montane fens at 980 m and 780 m AHD on the western Southern Tablelands of NSW. Micalong Swamp lies close to the subalpine treeline at this latitude, and both sites approach the modern dry/montane forest ecotone. Their vegetation histories record shifts in temperature and precipitation and are the first reported pollen records from the western montane slopes of NSW. A radiocarbon-based chronology indicates that Micalong Swamp supported a swampy, gravel floodplain within alpine grassland before 15.9 ka. Organic fen sedimentation developed <11.8 ka at Willigobung, and 11.3 ka at the higher Micalong Swamp. Subalpine woodland may have become established at 1000 m by 15.6 ka. Wet forest elements were present at both sites around 10 ka and persisted for 3-4 ka. Shallow lake sediments between 10 and 8 ka supports the evidence for wetter conditions in the early Holocene. In the late Holocene a re-expansion of subalpine flora between 3.2 and 1.5 ka preceded by shallow lake sedimentation is consistent with the regional evidence for neoglacial cooling at this time.

Digging your own grave: OSL signatures in experimental grave plots

Justine Kemp[1] **, Timothy J Pietsch**[1] **, Jon Olley**[1]

1. Griffith University, Nathan, Brisbane, QLD, Australia

Excavation of mock graves in sediments of aeolian and fluvial origin were conducted to test the bleaching efficiency of grave digging in materials that commonly host ancient burials in Australia. Grave size pits were dug into Pleistocene aeolian sediments at Willandra Lakes, and younger fluvial sediments on the Lachlan River, backfilled, and re-excavated. Samples for optical dating were taken from sediment infilling the mock graves and from the adjacent, undisturbed substrate, and analysed using the SAR protocol applied to single quartz grains. The resulting equivalent dose (D_e) distributions revealed that ≤ 1 % of grains had been fully bleached in both settings, and an additional 1-6% of poorly bleached grains was apparent in the fluvial sediments. Partial and incomplete bleaching of sediments during excavation and backfilling produced a decrease in the central dose of between 3 and 6 Gy, and an increase in over-dispersion values of between 5 and 10%. These differences were insufficient to clearly distinguish the disturbance event from the effects of bioturbation, biological mixing, or other sources of D_e variation. The use of the minimum age model substantially over-estimated the burial age (zero) in both depositional environments, with the degree of over-estimation increasing with the age of the host sediments. These results suggest that OSL techniques will not produce accurate ages for grave infill in a number of forensic and archaeological settings. Further study of the bleaching susceptibility of grains within grave infills, as well as the effectiveness of grave-digging as a bleaching mechanism is required.

Alluvial terraces of the upper Shoalhaven River, New South Wales: the influence of climate change in a temperature, highland setting.

Stephanie J Kermode[1 2], Brian G Jones[2], Gerald C Nanson[2], Toshiyuka Fujiyoka[1] , Josef Stocker[2] , Brent Peterson[2]

1. *ANSTO, Lucas Heights, NSW, Australia*
2. *GeoQuest Research Centre, School of Earth & Environmental Science, University of Wollongong, Wollongong, NSW, Australia*

Australia has experienced vast climate fluctuations during the Quaternary, with wet and dry periods associated with enhanced and reduced fluvial activity, respectively. Terraces of the upper Shoalhaven have been interpreted to be climatically forced (Nott et al, 2002; Kermode et al, 2012) with the landforms subsequently influencing valley-scale aggradation and incision. Ancient terraces, MIS 7 and older, in both the headwater areas and in the lower Shoalhaven gorge are possibly a response to basin-wide changes in discharge and sediment supply conditions. Preliminary dating shows some correspondence between sites, although the limited available dates at this stage make it impossible to draw definitive conclusions regarding Quaternary fluvial activity.

An alternate interpretation of these landforms is presented by Bridgland and Westaway (2008), who cite these terraces as primarily influenced by epeirogenic uplift. Based on (undefined) modelling and subsequent extrapolation, they provide estimated uplift rates of ~0.05 mm/a for the Mid-Late Pleistocene. Supporting evidence of coastal uplift in the order of ~0.002 mm/a during the Pliocene and Early Pleistocene, and 0.01 mm/a since (Young and Bryant, 1993) is stated to support these estimates. Incision rates for the upper/middle Shoalhaven system, as measured by K-Ar dating of basalt flows, are reported to be in the range of 0.00017-0.003 mm/a (Nott et al, 1996).

This study will examine fluvial terraces in upper/middle catchments of the Shoalhaven River, constrain their chronology over the mid-late Quaternary, and then reconstruct fluvial activity in the area. New data will provide better description of terrace deposits, higher precision chronology, and be expected to resolve the debate regarding influence of tectonic effect in these areas. The outcome will have implications for river, climate and tectonic interaction in the SE Australian region. Additionally, this study provides the opportunity to integrate this information with recent work conducted in Lake George.

1. Bridgland, D., Westaway, R., 2008. Climatically controlled river terrace staircases: A worldwide Quaternary phenomenon. Geomorphology, 98, 285-315.
2. Nott, J., Price, D., Nanson, G., 2002. Stream response to Quaternary climate change: evidence from the Shoalhaven River Catchment, southeastern highlands, temperate Australia. Quaternary Science Reviews, 21, 965-974.
3. Nott, J., Young, R., McDougall, I., 1996. Wearing Down, Wearing Back, and Gorge Extension in the Long-Term Denudation of a Highland Mass: Quantitative Evidence from the Shoalhaven Catchment, Southeast Australia. The Journal of Geology, 104, 224-232.
4. Young, R.W., Bryant, E.A., Price, D.M., Wirth, L.M., Pease, M., 1993. Theoretical constraints and chronological evidence of Holocene coastal development in central and southern New South Wales, Australia. Geomorphology, 7(4), 317-329.
5. Kermode, S.J., Cohen, T.J., Reinfelds, I., Nanson, G.C., Pietsch, T.J., 2012. Alluvium of antiquity: polycyclic terraces in a confined bedrock valley. Geomorphology, 139-140, 471-483.

'Age', recharge rates and connectivity of groundwater in deeper aquifers of the Sydney Basin.

Stephanie J Kermode[1 2] , Dioni Cendon[1] , Stuart Hankin[1] , Gregory Russell[3]

1. *ANSTO, Lucas Heights, NSW, Australia*
2. *GeoQuest Research Centre, School of Earth & Environmental Science, University of Wollongong, Wollongong, NSW, Australia*
3. *New South Wales Office of Water, Parramatta, NSW, Australia*

The Permo-Triassic Sydney Basin covers almost 50,000 km^2 with major lithological units including Permian Coal Measures, the Permo-Triassic Narrabeen Group, Triassic Hawkesbury Sandstone and Wianamatta Shale. The Hawkesbury Sandstone is generally consolidated quartz sands, with minor discontinuous shale units, hosting complex, dual porosity, fractured aquifer systems. It is the deeper regional system which is the focus of this study.

The Hawkesbury Sandstone aquifers form part of emergency water supply strategies for the region to cope with future severe droughts. Despite the significance of this resource, there are still data gaps in our knowledge of the deep aquifer systems, including the groundwater age, recharge and mixing rates. Addressing these knowledge gaps will aid the assessment of future coal mining and coal seam gas developments targeting the underlying Illawarra Coal Measures. Understanding of these systems has been complicated by a lack of data at the required depths. Water bore drilling contractors logs usually are limited to the shallower parts of the sequence, and the results of investigations carried out for specific mining developments are not often publicly available. Additionally, large variations in hydraulic properties have been noted over localised areas.

A loosely east-west transect across urban Sydney, targeted the deeper aquifer systems within the Hawkesbury Sandstone. Very high salinities were recorded for several samples; these may relate to the influence of the overlying Wianamatta Group shales in those locations, as well as contributions along the length of the groundwater flow path. Laboratory results show inconsistencies between tritium and radiocarbon groundwater 'ages' in multiple locations, suggesting that extensive mixing occurs between aquifers. A relationship between bicarbonate, depth and $\delta^{13}C$ isotopic ratios highlights the influence of methanogenesis for deeper samples and either interaction with localised organic matter or deeper inputs derived from the coal measures.

53

Trunk stream evolution from lateral to vertical accretion and channel breakdown in the Holocene Macquarie River, eastern Australia

Zacchary Larkin[1] , Timothy J. Ralph[1] , Paul P. Hesse[1] , Kira E. Westaway[1] , Anthony Dosseto[2]

1. *Department of Environment and Geography, Macquarie University, NSW 2109, Australia*
2. *School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia*

Channel breakdown and floodplain wetlands are common features of lowland rivers in the Murray-Darling Basin, eastern Australia, in the Holocene (e.g. Gwydir, Macquarie, Lachlan). The lower Macquarie River is characterised by four discontinuous, meandering trunk stream reaches separated by areas of channel breakdown and unchannelised wetlands in the Macquarie Marshes. Channel breakdown is driven by in-stream sedimentation and avulsion, while trunk stream reformation is triggered by steepened floodplain gradients at the downstream ends of floodouts and wetlands. Morphometric analyses, sedimentology and geochronology of the discontinuous reaches of the Macquarie River indicate that the trunk stream was characterised by lateral migration in the mid-Holocene, with meanders and cut-offs developing until at least ~4.8 ka. More recently (since ~1 ka), low levees have developed over lateral migration features (e.g. scroll bars), reflecting a shift in the dominant style of channel adjustment from lateral to vertical accretion, with periodic avulsion. An upward-fining sediment sequence in a modern point bar also shows a transition to a lower-energy environment in the last ~0.8 ka. Avulsion appears to have increased the degree of longitudinal connectivity in the system by short-circuiting some reaches that were previously separated by channel breakdown and unchannelised wetlands. A pilot study using Uranium-series disequilibrium methods suggests a significant reduction in sediment residence time in the modern channel (58 ± 2 ka) compared with a meander cut-off (153 ± 5 ka) abandoned next to the trunk stream ~4.8 ka. These changes in channel morphology and processes of fluvial adjustment may be caused by a combination of local channel change and catchment-scale change in sediment dynamics and hydrology, and may be reflected in other rivers in the Murray-Darling Basin.

54

An overview of palaeoclimate and palaeoenvironmental change records for New Zealand covering 60 ka-Present as a contribution to the Southern Hemisphere Assessment of PalaeoEnvironments (SHAPE) project

Brent Alloway, Peter Almond, Paul Augustinus, David JA Barrell, Ian Fuller, Kat Holt, Andrew Lorrey[1] , David Lowe, Matt McGlone, Rewi Newnham, Tom Stephens, Marcus Vandergoes, Paul Williams, NZ SHAPE members

1. *NIWA, Auckland, New Zealand*

Since the close of phase II for the AUS-INTIMATE project, new proxy records outlining past climate variability and change have emerged for New Zealand. In addition, there have been significant improvements on radiocarbon calibration and revised ages of tephras since a New Zealand proxy compilation (previously termed a Climate Event Stratigraphy) was compiled, which represented a major effort for the palaeoclimate community to synthesize available high-quality data. Here, we provide an up-to-date collection of proxy records that are either temporally continuous or discontinuous in nature that should be considered for use in the SHAPE project. We expect the interpretation and use of these records will be discussed in detail ahead of a wider integration with other Southern Hemisphere data with an aim of reconstructing past atmospheric circulation modes and comparison to palaeoclimate model simulations.

55

Using Holocene vertebrate fossils to facilitate the management and restoration of Australian ecosystems

Matthew McDowell[1]

1. Flinders University, Adelaide, SA, Australia

European-settlement-related impacts over the past 200 years pose many challenges for the conservation and restoration of Australia's ecosystems. Landscape modification, associated habitat loss and the introduction of exotic species have caused the extinction and mainland extirpation of numerous vertebrates. This process happened so quickly that many species became locally or functionally extinct before their presence was documented. A growing body of research on Holocene fossil accumulations is providing insights into the composition and biogeography of Australian ecosystems prior to European settlement. This paper explores the similarities between palaeo- and neo-ecology and how Holocene (last 10,000 years) assemblages can be used by neo-ecologists, conservation managers and policy makers to identify and fill gaps in knowledge and contribute to the management and restoration of Australia's degraded ecosystems.

56

Millennial-scale variability in precipitation during the Last Glacial Maximum: A record from Tortoise Lagoon, subtropical Queensland, Australia

Lynda Petherick[1] **, Patrick Moss**[2] **, Hamish McGowan**[2]

1. Xi'an Jiaotong-Liverpool University, Suzhou, JIANG, China

2. The University of Queensland, Brisbane

A continuous, record encompassing the termination of the Last Glacial cycle (defined here as ca. 30-18 cal. kyr. BP) has been developed using multiple proxies (viz. sediment flux, grain size, moisture content, pollen and charcoal) archived in lake sediments from Tortoise Lagoon, North Stradbroke Island, Australia. The presence of key pollen taxa (e.g. Asteraceae *(Tubuliflorae)* and *Tubulifloridites pleistocenicus*) indicates temperatures up to 6^{o}C colder than modern in the subtropics during the termination of the Last Glacial cycle with onset of relatively cool conditions from ca. 30 cal. kyr BP. This provides further evidence for an extended Last Glacial Maximum across temperate and subtropical Australia. Millennial-scale climate and corresponding environmental variability during the Last Glacial Maximum is indicated by the presence of two phases of increased inorganic sediment flux centered on ca. 27.6 cal. kyr. BP and ca. 20.8 cal. kyr. BP. These are interpreted to represent changes in precipitation superimposed on a cool climate regime during the termination of the Last Glacial cycle.

Climate model simulations from the Last Glacial Maximum to today

Steven J Phipps[1 2], **Duncan Ackerley**[3], **Maisa Rojas**[4 5]

1. *ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, NSW, Australia*
2. *Climate Change Research Centre, University of New South Wales, Sydney, NSW, Australia*
3. *Monash Weather and Climate, Monash University, Melbourne, Victoria, Australia*
4. *Depart of Geophysics, University of Chile, Santiago, Chile*
5. *Millennium Nucleus on PaleoClimate of the Southern Hemisphere, Santiago, Chile*

The SHAPE project aims to reconstruct and understand past changes in the atmospheric and oceanic circulation of the Southern Hemisphere. Within this context, climate modelling plays a critical role in testing the interpretation of the proxy data and exploring the underlying dynamical mechanisms.

SHAPE will utilise the simulations generated using state-of-the-art climate system models by the Paleoclimate Modelling Intercomparison Project Phase Three. PMIP3 includes four experiments that are also an official part of the Coupled Model Intercomparison Project Phase Five (CMIP5): snapshot simulations of three key time slices (0 ka, 6 ka and 21 ka), and a transient simulation of the last millennium (850-1850 CE). However, PMIP3 is also performing a much wider range of experiments than earlier phases. Additional experiments include transient simulations of the 8.2 ka event and the present interglacial (8-0 ka).

Other initiatives have generated climate model simulations of direct relevance to SHAPE. In particular, the SynTraCE-21 project has produced transient simulations spanning the full period from 21-0 ka. The CSIRO Mk3L climate system model has also been used to conduct multiple transient and time slice experiments spanning the Holocene (12-0 ka), while members of the PAGES 2k Network have simulated the response of the climate system to different natural and anthropogenic forcings over the past 2,000 years.

This presentation will summarise the diverse range of climate model simulations that are available to members of the SHAPE project, and will highlight some of their key features.

In future, SHAPE will complete further simulations to study key phenomena identified by the regional- and hemispheric-scale proxy syntheses. Suggestions from members of the proxy community are welcome.

58

SHAPE – Australia: 60-30 ka

Tim Cohen[1] , Jessica Reeves[2] , Claire Krause[3] , OZ INTIMATE

1. *University of Wollongong, Wollongong*
2. *Federation University Australia, Ballarat*
3. *The Australian National University, Canberra*

The time slice of 60-30 ka is arguably one of the most interesting in Australia's prehistory. A time when people appeared and megafauna disappeared, lakes and rivers, particularly in the south, expanded and vegetation changed. As more research is focussed around this time period, we are seeing increased climatic variability across the Australian mainland, once thought to be a phenomenon restricted to the northern hemisphere. The expanded maritime continent is influenced by the monsoon in the north, said to be significantly altered at this time, and warming periods in Antarctica and the Southern Ocean to the south, resulting in significantly altered hydro-climatic patterns. This research is another output from the OZ-INTIMATE group under the SHAPE (Southern Hemisphere Assessment of PalaeoEnvironments) banner which compiles our best climate records of the 60-30 ka period. Very much a work in progress, this poster presents the records we have thus far and highlights areas that need further work.

59

Dunes as archives of climatic changes and tectonic processes on Hindmarsh Island, South Australia

***Deirdre Ryan[1]**

1. *University of Wollongong, North Wollongong, NSW, Australia*

Hindmarsh Island is the largest island within the complex coastal lowland system at the terminus of the River Murray. Two extensive Holocene coastal barriers, Younghusband and Sir Richard peninsula, flank the river mouth south of Hindmarsh Island. The island provides an archive of multiple generations of interglacial and glacial dunes. Dunes were distinguished using visual and lithological characteristics. Interglacial dunes, sourced from adjacent marine/coastal environments during high sea levels, are yellowish/pale brown, and associated with calcrete and occasional marine shell deposits. The red/yellow, siliceous glacial dunes formed under arid, cold and windy terrestrial conditions when the coastline stood on the continental shelf margin, ~200 km south. Dune relationships were studied using stratigraphic analysis, amino acid racemization, and thermoluminescence. The island's northern margin comprises stacked interglacial sediments: MIS 5e dunes overlie truncated MIS 7 dunes and remnants of an older dune system, reflecting ongoing tectonic subsidence. To the west MIS 5e recurved spit deposits indicate a former river course. Last glacial maximum dunes drape the older interglacial deposits. Since the middle Holocene the migrating Murray Mouth has facilitated deposition of extensive sand-flats forming the southern half of the island and small jumbled dunes on its southern margin. The Hindmarsh Island interglacial dunes are an extension of coastal barrier systems on the Coorong Coastal Plain. Their southeast to northwest orientation reflects longshore drift. The west-east orientated last glacial maximum dunes conform to the dominant glacial anti-cyclonic wind regime. Dune sediments reflect changing environmental conditions. Near-marine interglacial dunes are composed predominately of carbonate. Glacial dunes are carbonate-free, predominantly quartzose, with variable sediment sources from the west, including the Mount Lofty-Flinders Ranges. Hindmarsh Island dunes reflect the rich geological history and dynamic environment of the region that include river and mouth migrations during ongoing tectonic subsidence and alternating interglacial and glacial palaeo-climates.

A reconstruction of Pliocene climate using speleothems from the Nullarbor Plain, southwest Australia

***Safana Sellman[1] , Russell Drysdale[1] , Jon Woodhead[1] , John Hellstrom[1] , Mathieu Daëron[2]**

1. *The University of Melbourne, Flemington, VIC, Australia*
2. *CNRS / LSCE, France*

The Pliocene (~2.5-5 Ma) is an important time interval for study of the Earth's climate system due to its potential as an analogue for future climates. However, there is a significant lack of terrestrial archives of palaeoclimate information for this period, and even fewer reliable estimates of palaeotemperature. There is also a distinct lack of data from Southern Hemisphere locations. This project is part of a larger study that aims to address these gaps by providing palaeohydrological and palaeotemperature reconstructions for the Pliocene using speleothems obtained from caves beneath the Nullarbor Plain, southern Australia.

U-Pb dating of numerous Nullarbor speleothems shows that their growth spans the late Miocene, through the Pliocene, and into the Pleistocene (Woodhead et al. in prep). This project aims to complement the broader study by focussing on long speleothem sections (>1m), potentially spanning complete Pliocene "stadial-interstadial" cycles. Internal chronologies will be established, allowing interpretations to be made regarding climatic changes during stadial-interstadial cycles.

Both fluid-inclusion mass spectrometry and clumped isotope carbonate palaeothermometry will be used to produce palaeohydrological and palaeotemperature estimates. Fluid-inclusion analyses will provide a direct proxy for the isotopic composition of past precipitation, which can be used to reconstruct regional rainfall patterns. Modern rainfall samples from the region will be used to isotopically fingerprint dominant sources of precipitation, informing interpretations of conditions at the time of deposition.

Clumped isotope carbonate palaeothermometry is a relatively new technique, based on the statistics of ^{13}C-^{18}O bonds in carbonate minerals ("Δ_{47}"). Although clumped isotopes in modern speleothems generally appear to be affected by significant isotopic disequilibrium effects, it has been suggested that disequilibria can be accounted for by combining Δ_{47} analyses with fluid-inclusion $\delta^{18}O$ data, potentially allowing for independent measurements of continental palaeotemperatures.

This research will provide a unique dataset of terrestrial temperature estimates during the Pliocene.

Late Holocene temperature variability in Tasmania inferred from borehole temperature data

***Asadusjjaman Suman[1] , Duanne White[1] , Fiona Dyer[1]**

1. Institute for Applied Ecology, University of Canberra, Bruce, ACT, Australia

Australia has a dearth of climate records that unambiguously reconstruct paleotemperatures. Borehole records show promise in reconstructing low-temporal resolution paleotemperature histories, but have to date been underutilised.

We analysed 36 temperature depth profiles to reconstruct last 500 years ground surface temperature history (GSTH) from north-east Tasmania, Australia. This high-spatial resolution borehole array was also used to investigate the importance of geologic, topographic and other factors in producing variability in paleotemperature reconstructions.

Comparisons between profiles indicate a high variability in the suitability of these boreholes for paleotemperautre reconstructions. Approximately 40 % of the borehole network provided high quality results with limited misfit between modelled and measured temperature profiles. These high quality records correlate strongly with each other, and meteorological records of the past 100 years. Correlations between records with a larger data/model misfit were substantially lower, and reconstructed temperatures sometimes departed significantly from meteorological records.

Record quality appears to have been most affected by disturbance from groundwater. Overall, borehole lithology does not appear to be a strong predictor of temperature record quality. There is also no strong relationship between borehole quality and potential indicators such as slope, aspect, elevation and land use.

A compilation of the high quality records reveals that temperatures have risen by 1.7K during the past 500 years, with most warming occurring in the late 20th century. A little Ice Age (LIA) did not show across Tasmania within the study period. Spatially, warming was slightly higher around south-east coast compared to central and northern Tasmania. The modelled GSTH also agrees well with the low-frequency Tasmanian tree ring reconstruction.

Industrial Past, Urban Future; assessing risks of metal mobilisation in a historically contaminated wetland

***Adam Trewarn**[1]

1. Federation University Australia, Ballarat, VIC, Australia

In contaminated wetlands, typically the focus is monitoring current impact and addressing subsequent remediation. However, knowing the past of the system can play just as important role in determining its future. This is particularly the case if the source of the contaminants is historical.

This project investigates the effects that changes in environmental conditions may have on the mobility and bioavailability of heavy metals within a historically contaminated wetland. The project specifically addresses the likely impact of proposed management application for *Phragmites australis* control in Reedy Lake, near Geelong, Victoria. Proposed water regimes involve either regular drying periods of the lake, sea water inundation or a combination of the two (Alluvium, 2013).

The Lower Barwon wetlands, listed under the Ramsar Convention, have seen a series of agricultural and industrial impacts since the early 1800s with changes involving land clearing, wool scours, tannery and tails from mining operations (Dahlhaus et al. 2007). Throughout this time, the Connewarre complex has been infilling, due to ongoing inputs of sediment from the catchment (Victorian Saltmarsh Study, 2011).

This three stage project addresses,

1; The timing and source of the spikes of contamination within sediment of the wetland, correlating to known periods of historical significance for the lake.

2; The possible mobilisation of metal contaminants under proposed water regimes.

3; The current biological uptake of metal contaminants in resident eel and duck populations.

1. Alluvium, 2013. Analysis - mobilising contaminants at Reedy Lake. Report by Alluvium to the Corangamite Catchment Management Authority.
2. Dahlhaus PG, C.A. Billows, S.P. Carey, J. Gwyther, Nathan EL (2007) 'Lake Connewarre Values Project: Literature Review.'Corangamite Catchment Management Authority, Colac, Victoria
3. Victorian Saltmarsh Study (2011). Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management. Institute for Sustainability and Innovation, Victoria University, Melbourne 513 pp

63

A compilation of climate records from the Antarctic region spanning 0 to 60 ka

Duanne A White[1] , Joel B Pedro[2 3] , Andrew Mackintosh[4] , Krystyna M Saunders[5] , Tessa Vance[6] , Andrew D Moy[7] , Sonja Berg[8] , Bernd Wagner[8]

1. *University of Canberra, University Of Canberra, ACT, Australia*
2. *Centre for Ice and Climate, University of Copenhagen, Copenhagen, Denmark*
3. *Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, WA, USA*
4. *Victoria University of Wellington, Wellington*
5. *Institute of Geography & Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland*
6. *Antarctic Climate and Ecosystems CRC, University of Tasmania, Hobart, TAS, Australia*
7. *Department of the Environment, Australian Antarctic Division, Kingston, TAS, Australia*
8. *Institute for Geology and Mineralogy, University of Cologne, Cologne, Germany*

As part of the Southern Hemisphere Assessment of Paleo-Environments (SHAPE) initiative we have compiled a set of the most reliable and accurately dated climate records from the Antarctic region for the period 0 to 60 ka. These records are drawn from a wide variety of sources, including high resolution ice cores, sediments from lakes and the continental shelf, evidence of biotic occupation, and well-dated geomorphic evidence of glacial advance and retreat. We recommend these records for use in regional and hemispheric climate reconstructions and syntheses over this period. Copies of the records will be made available on the SHAPE website.

64

A Glacial cryptic refuge in southeast Australia: Human occupation and mobility from 36,000 years ago in the Sydney Basin, New South Wales

Alan Williams[1 2] , Fenella Atkinson[1] , Michelle Lau[1] , Phillip S Toms[3]

1. *Archaeological and Heritage Management Solutions Pty Ltd, Waterloo, NSW, Australia*
2. *Fenner School of Environment and Society, The Australian National University, Canberra, ACT, Australia*
3. *Luminescence Dating Laboratory, University of Gloucestershire, Cheltenham, United Kingdom*

Excavations across a source-bordering dune overlooking the Hawkesbury River suggest an initial occupation of the region by at least 36 ka, with variable but uninterrupted use until the early Holocene; following abandonment, the site was then re-occupied by ~3 ka. Along with a handful of other sites, the results provide the earliest reliable evidence of permanent regional populations within southeastern Australia, and support a model in which early colonisers followed the coastal fringe with forays along the main river systems. The evidence is consistent with Williams' (2013) demographic model, which suggested low, but established regional populations prior to the Last Glacial Maximum (LGM), a population nadir following the LGM, and increasing use of the region from ~12-8 ka. The site exhibits increased use at the onset and peak of the LGM, and provides an example of a cryptic refuge as defined by Smith (2013). Specifically, changing artefact densities and attributes show the site was used repeatedly, but for shorter periods through this time, and suggest it formed one of a series of key localities in a point-to-point (rather than home-base) subsistence strategy. This strategy was maintained until the site's abandonment in the early Holocene, despite changing population and climatic conditions through the Terminal Pleistocene. The findings here demonstrate the importance of the Hawkesbury River as a resource area for the early occupation and survival of Aboriginal people over the last 46,000 years; and highlight its importance as a focus for future research.

65

Radiocarbon dating bone in warm, arid environments using ninhydrin: a case study at Cloggs Cave, Victoria.

Rachel Wood[1] **, Stewart Fallon** [1] **, Josephine Flood**[1]

1. Australian National University, Acton, ACT, Australia

Bones and teeth are often ideal materials to radiocarbon date as they can often be directly related to the archaeological event that is of interest. However, radiocarbon dating of bone from arid and warm environments, such as those that exist over much of Australia, is made extremely difficult by the poor preservation of the protein collagen, the fraction normally targeted for dating. We will present initial results for a method involving ninhydrin[1]. Rather than attempting to clean collagen with a series of treatments which damage the delicate protein, this relatively simple method aims to date carbon from amino acids. It therefore holds the potential to date bone that contains low levels of collagen, but collagen that is too degraded to survive the normal extraction and purification of bulk collagen. We use this technique to date bone that was too poorly preserved to survive the ultrafiltration protocol at Cloggs Cave, Victoria. This site was originally dated using radiocarbon on charcoal in the 1970s, placing the first humans and megafauna around the time of the Last Glacial Maximum[2] . We examine the impact of the new bone dates on this unusually late chronology.

1. Tisnerat-Laborde et al. (2003) Radiocarbon, 45, 409-419
2. Flood (1980) The Moth Hunters, AIAS, Canberra

66

Shifts, shocks and thresholds – what does palaeoclimate have to say to decision makers about managing climate change?

Roger N Jones[1]

1. Victoria University, Melbourne, VIC, Australia

Palaeoclimatological research describes numerous analyses of abrupt changes in climate or of threshold responses within systems influenced by climate. However, when future climate change is communicated to decision makers, it is portrayed as a gradual change mediated by random climate variability. This gives decision makers the idea that adaptation can be approached as an incremental process. Evidence will be presented that the output from climate models is not being analysed appropriately and that past and future climate change can be reconciled if climate is considered as a complex, non-linear system. Evidence of regional, abrupt change during the Holocene from south-eastern Australia will be presented. These will be contrasted with step-like changes of future climate from climate models. Suggestions for how palaeoclimatic and palaeoecological can contribute to decision-making on adaptation to future climate change will be presented.

Salinity management in Central West NSW: informing land management decisions through use of quaternary fluvial models.

Andrew Wooldridge[1], Allan Nicholson[2] , Rob Muller[3]

1. *NSW Department of Primary Industries, Cowra, NSW, Australia*
2. *NSW Department of Primary Industries, Wellington, NSW, Australia*
3. *NSW office of Environment and Heritage, Wagga Wagga, NSW, Australia*

Hydrogeological landscape (HGL) frameworks have been developed in many areas in NSW to inform Natural Resource Management (NRM) decisions making with particular focus on salinity. The development of HGL frameworks has involved a multi disciplinary team of landscape scientists who are working across government agencies and within universities.

HGL frameworks for Central West Catchment Management Authority were completed in 2011. Products derived from HGL frameworks have proved a robust tool to inform decisions at a paddock and farm scale as well as defining hazard, priority and appropriate action at a catchment scale.

A full understanding of quaternary fluvial models as described by Watkins and Meakin (1996) by has been critical in the development of HGLs in Central West NSW. Understanding of the Trangie Formation, Carabear Formation, Bugwah Formationa and Marra Formation (Watkins and Meakin 1996) has been a vital step in the development of HGLs particularly as low levels of soil, groundwater and salinity information exists in many areas. The application of these models has been important to both understand the range of processes that are present across the catchment and also to spatially attribute these processes. Understanding of these models and recognising their landscape position has been a vital part in training programs conducted for both agency staff and landholders

Detailed site analysis has been conducted to improve understanding of salinity processes in areas that have been highlighted by the HGL framework as having high hazard.

1. Watkins, J.J & Meakin, N.S. 1996. Nyngan and Walgett 1:250,000 Geological Sheets: Explanatory Notes. Geological Survey of NSW

Identifying historical flood deposits in a sediment core from an oxbow lake

***Anna Lintern[1], Paul J Leahy[2] , Ana Deletic[1] , Patricia Gadd[3] , Henk Heijnis[3] , David T McCarthy[1]**

1. *Civil Engineering, Monash University, Clayton, VIC, Australia*
2. *Monitoring and Assessment Unit, EPA Victoria, Macleod, VIC, Australia*
3. *Institute of Environmental Research, Australian Nuclear Science and Technology Organisation, Lucas Heights, NSW, Australia*

River floods are a risk, not only because of the large volume of water that is mobilized, but also because of the potentially high level of nutrients and pollutants contained in these waters. There is limited understanding of flood water quality, which hinders the implementation of appropriate mitigation strategies. Therefore we must better understand the trends in flood water quality to protect society and the natural environment from risks associated with poor quality flood waters. Fluvial flood water quality data could be obtained using sediment cores from floodplains, as sediment cores can preserve historical flood deposits and can also be used to infer long term trends in the water quality of aquatic environments.

This presentation aims to identify and separate flood-deposited fluvial sediments from in-situ biogenic sediments in a sediment core from a floodplain lake, and to then identify the pollutant levels contained in these flood-deposited sediments. The Yarra River (South-East Australia) and its floodplain lake (Willsmere Billabong) was used as a case study. Cores taken from Willsmere Billabong were analysed using the ITRAX micro-X-Ray Fluorescence (XRF) core scanner and the optical and radiographic images, magnetic susceptibility and elemental composition profiles were used to infer the sediment type and origins.

Using the data obtained from the core scanner, we found that flooding frequency of the Yarra River into Willsmere Billabong decreased in the early to mid-20th century. This is most likely due to increased water extraction with the construction of large reservoirs in the upper river catchment in 1927, 1932 and 1957. Indeed, there is also a decrease in measured flow rates for the Yarra River. Having identified the flood-deposited sediments within the Willsmere Billabong sediment cores, we have determined pollutant levels within the flood-deposited sediment layers, to identify water quality trends in river flood water quality.

Eight-years of cave monitoring at Golgotha Cave, SW Australia: implications for speleothem paleoclimate records

Pauline C Treble[1] , Ian J Fairchild[2] , Andy Baker[3] , Chris Bradley[2] , Anne Wood[4] , Liz McGuire[4]

1. *Australian Nuclear Science and Technology Organisation, Lucas Heights, NSW, Australia*
2. *University of Birmingham, Edgbaston, UK*
3. *University of New South Wales, Kensington, NSW, Australia*
4. *Department of Parks and Wildlife, Busselton, WA, Australia*

Speleothems are an important archive of paleoenvironmental information but a thorough understanding of processes are necessary for their interpretation. In order to better understand speleothem records from the climatically-sensitive southwest region of WA, we have conducted a detailed eight-year monitoring study at Golgotha Cave, southwest WA.

Oxygen isotopic data demonstrated that the majority of water moved through the porous Quaternary calcarenite as matrix-flow with an inferred transit time of <1 year. A zone of high-flow dripwater is fed by high-magnitude rainfall events (Treble et al., 2013). Prior calcite precipitation (PCP) signals of increased Mg/Ca and Sr/Ca in dripwater are attributed to stalactite deposition. This signal is enhanced at low-flow sites and minimised at the high-flow site as degassing and subsequent stalactite deposition are a function of drip interval. Long-term rising trends found in most solutes are attributed via a mass-balance approach to increasing forest bioproductivity, consistent with an increase in forest understorey following a low-intensity burn in 2006.

A fundamental message from this study is that individual speleothem records from within Golgotha Cave will differ, e.g. speleothem $\delta^{18}O$ at our high-flow site is biased to recording high-magnitude rainfall events, whilst PCP will be the main driver of speleothem Mg/Ca and Sr/Ca at low-flow sites. Forest biomass appears to be modulating transpiration-sensitive ions and these may serve as an indicator of fire history.

Managing the future is a thing of the past.

Stuart Pearson[1] , Roel Plant[2] , Jasmyn J Lynch[3] , Roel Plant[2] , Steve Cork[4] , Kathryn Taffs[5] , Simone Maynard[6] , Joelle Gergis[7] , Peter Gell[8] , Richard Thackway[9] , Lynne Sealie[10] , Jim Donaldson[11]

1. *UNSW Canberra (ADFA), Canberra, ACT, Australia*
2. *Institute for Sustainable Futures, University of Technology, Sydney, Australia*
3. *Institute for Applied Ecology, University of Canberra, Canberra, ACT, Australia*
4. *Crawford School of Public Policy, Australian National University and EcoInsights, Australia, Canberra , ACT, Australia*
5. *School of Environment, Science & Engineering, Southern Cross University, Lismore, NSW, Australia*
6. *Australian National University, Canberra, ACT, Australia*
7. *School of Earth Sciences, University of Melbourne, Melbourne, VIC, Australia*
8. *Centre for Environmental Management, School of Science, IT & Engineering, University of Ballarat, Ballarat, Australia*
9. *School of Geography, Planning and Environmental Management, University of Queensland, Brisbane, QLD, Australia*
10. *Formerly - Atlas of Living Australia, Australia, Canberra, ACT, Australia*
11. *Fenner School of Environment and Society, Australian National University, ACT, Australia*

We contribute a narrative of how Australian researchers are creating, and environmental policy makers and managers are using, palaeo-environmental and ecosystem service information. Australian palaeo-environmental science is contributing to improved environmental understanding through local studies and regional syntheses that inform about past conditions, extreme conditions, and altered ecosystem states. Australia has contributed some innovations in ecosystem services and palaeo-environmental science is contributing to 5 important contexts at the moment: discussions about environmental understanding and management; improving knowledge about natural resources; understanding environmental processes and resource availability; and engaging interdisciplinary approaches to address ecosystem services.

However this is not enough. Transformational changes are needed in management and that requires collaborative efforts between communities, leaders, scientists, planners and managers. The perspective provided by knowledge of the past is an important starting point for setting resource management objectives, anticipating consequences of trade-offs, sharing risk and providing strategies for evaluation and monitoring of ecosystem services. Steps are needed to translate the ecosystem services concept into ecosystem services policy, tangible management objectives and actions that are practical (useful), practicable (feasible) and incorporate the range of benefits that people obtain from ecosystems. We believe that a long-term perspective is necessary to reduce risk and human vulnerability and achieve further development of evidence-based adaptive management.

Potential of multi-proxy approach to detect human-induced disturbances on floodplain wetland ecosystems: A case of Kings Billabong, River Murray System (Australia)

Giri Kattel[1]

1. *Collaborative Research Network, Federation University Australia, Ballarat, VIC, Australia*

The ecology of the River Murray systems in southeast Australia is adapted to 'natural drivers' of flooding and drying cycles maintaining connectivity between the river and associated floodplain wetlands thereby help sustaining landscape at a regional scale. Kings Billabong, a shallow floodplain wetland complex of the River Murray system is known for its high conservation values for wildlife and aquatic communities. However, following the arrival of Europeans, the pre-regulation condition in the River Murray has switched Kings Billabong from a less regularly inundated system to a more permanent water regime. This permanent inundation appears to have had implications for the dynamics of pelagic-benthic ecosystem altering the source and flow of energy across the higher trophic levels. However, the response of Kings Billabong to recent anthropogenic disturbances and prolonged drought and unprecedented flood events has not yet been investigated in detail. A continuous, long term sediment record with good preservation of biological and chemical proxies retrieved from Kings Billabong was used to reconstruct any possible transition of the ecosystem of Kings Billabong from a natural flood pulse environment to a human-induced, permanent water regime. The subfossil assemblages of cladocerans, diatoms and stable isotope ratios of carbon and nitrogen derived from the bulk sediment samples reflected a gradual deviation of the historic natural cycle-based submerged macrophyte-rich clear water ecosystem to a phytoplankton dominant, less resilient ecosystem following river regulation.

Late Pleistocene lake level history of Lake Mungo, Australia

Timothy Barrows[1] , Kathryn Fitzsimmons [2] , Rainer Grün[3] , Stephanie Mills[4] , Daryl Pappin[5] , Nicola Stern[5] , Jacqueline Tumney[5]

1. *University of Exeter, Exeter, United Kingdom*
2. *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany*
3. *Research School of Earth Sciences, Australian National University, Canberra, Australia*
4. *School of Geography, Earth and Environmental Sciences, Plymouth University, Plymouth, United Kingdom*
5. *Archaeology Program, La Trobe University, Melbourne, Australia*

Lake Mungo is a dry lake in western New South Wales at the southern end of the Willandra Lakes World Heritage Area. The eastern margin of the lake bed is flanked by a crescent shaped dune system (lunette) 30 km in length and up to 40 m above the lake bed. Extensive erosion has exposed the internal architecture of the lunette revealing a discontinuous series of sandy and clayey deposits deposited over more than 100,000 years. These sediments reveal that Lake Mungo has repeatedly filled and emptied through time, oscillating between permanent, ephemeral and dry lake phases in response to long term climate change. The sedimentary layers have preserved human remains from some of the earliest inhabitants of the continent of Australia including the site of the world's oldest known cremation and ritual ochre burial. As part of a recent study to examine the archaeological record within the lunette, approximately 90 samples were collected for optical stimulated luminescence dating (OSL) from several locations along the lunette. The samples targeted the younger levels of the lunette where archaeological evidence is abundant, but samples were also collected from deeper units to provide context for the depositional history of the lake. In this paper we present a revised depositional history for the lake based on the new dating within the context of previous research. The OSL chronology reveals the complexity of the lunette's stratigraphic record which shows variable deposition and preservation along the lunette. Integration of the geological and archaeological histories will provide a basis for understanding how indigenous Australians in this region responded to long-term landscape and climate change.

Joulni as key data centre with basin overflow data from the Amphitheatre Basin west of Lake Leaghur

Jim Bowler[1] , Michael Kelly[2] , Richard (Dick) R. Green[3]

1. *School of Earth Sciences, University of Melbourne, Melbourne*
2. *NSW Dept Office of Environment & Heritage, Buronga, NSW*
3. *Charles Sturt University, Wagga Wagga*

In terms of World Heritage foundational significance, the Joulni area of the Lake Mungo lunette remains of central importance. It preserves the following features:

- location of the iconic burials, Mungo Man and Mungo Lady,
- near-horizontal truncation exposure of the longest continuous sequence in planimetric form permitting detailed mapping of soil-sediment units
- sequence of concordant beach gravels defining levels of system overflow outlet
- record of sub-lacustrine barrier sands implying a pre-Mungo(?) shoreline east of Joulni homestead
- stratigraphic continuity between lacustrine and aeolian events.

Water level records from Joulni are amplified by new evidence from a deep depression against the Neckarboo Ridge west of Lake Leaghur (the Amphitheatre Basin, Rick Farley Reserve). Although connected with Lake Leaghur, its lacustrine environments were geochemically different from the main basin system. A narrow deep, non-calcareous freshwater lake with high strandlines suggests overflow relationships above those of the Joulni gravels, the equivalent levels of present Leaghur channel outlet. The Amphitheatre strandlines appear higher than current outlet levels would define.

Uncoupling of neotectonic deformation requires more precise levels of early outlet channel history than present data permits.

This area, currently outside the boundary of the World Heritage designation, warrants amendment of the boundary to ensure its inclusion. It forms an integral part of the Willandra lakes system.

Fish otolith geochemistry, environmental conditions and human occupation at Lake Mungo

***Kelsie E Long**[1]

1. Australian National University, Acton, ACT, Australia

Fish otoliths are structures that form within the inner ear of teleost fish by the incremental deposition of calcium carbonate onto an organic matrix forming annual growth rings. Otolith growth is continuous and occurs even when somatic growth has ceased. As calcium carbonate is laid down so too are elements from the surrounding water, some with distinctive isotopic compositions, incorporated into its matrix. Oxygen isotope compositions and trace element ratios in otoliths are close to being in equilibrium with those in the ambient water[1]. For O isotopes, fractionation caused by temperature, salinity and kinetic or metabolic changes have been observed in a range of marine and freshwater fish species[2 5 6]. A positive relationship between the Sr content of otoliths and ambient salinity has also been observed, but the magnitude of this effect varies with ambient water Sr concentrations[3 7 8].

The Willandra Lakes are a series of now-dry lakes situated in south western NSW that once formed the major overflow outlet for the Lachlan River. Fish otoliths found in hearth sites at Lake Mungo provide a direct link between human occupation and environmental conditions, as well as chronological information. This has been demonstrated in a number of studies including Long *et al.*[4], in which high resolution *in situ* methods were used to measure $\delta^{18}O$ (SHRIMP-SI) and Sr/Ca (LA-ICP-MS) from across the annual rings of golden perch otoliths from hearth sites at Lake Mungo. By comparing these records to otolith age lines, fish entry into a more saline body of water (Sr/Ca and Ba/Ca) and a subsequent evaporative trend ($\delta^{18}O$) could be inferred in all samples.

This presentation will provide updates in the development of U-series dating of otoliths, the construction of lake level chronologies from excavated otoliths and the future directions of this research.

1. Campana, S.E., 1999. Chemistry and composition of fish otoliths: pathways, mechanisms and applications. Marine Ecology Progress Series 188: 263-297.
2. Kalish, J., 1991. Oxygen and carbon stable isotopes in the otoliths of wild and laboratory-reared Australian salmon (Arripis trutta). Marine Biology 110: 37-47.
3. Kraus, R.T., Secor, D.H., 2004. Incorporation of strontium into otoliths of an estuarine fish. Journal of experimental marine biology and ecology 302: 85-106.
4. Long, K., Stern, N., Williams, I.S., Kinsley, L., Wood, R., Sporcic, K., Smith, T., Fallon, S., Kokkonen, H., Moffat, I., Grün, R., 2014. Fish otolith geochemistry, environmental conditions and human occupation at Lake Mungo, Australia. Quaternary Science Reviews 88: 82-95
5. Radtke, R.L., 1984. Cod fish otoliths: Information storage structures. Fledevigen rapportser 1.
6. Radtke, R.L., Showers, W., Mokesness, E., Lenz, P., 1996. Environmental information stored in otoliths: insights from stable isotopes. Marine Biology 127: 161-170.
7. Secor, D.H., Rooker, J.R., 2000. Is otolith strontium a useful scalar of life cycles in estuarine fishes? Fisheries Research 46: 359-371.
8. Tabouret, H., Lord, C., Bareille, G., Pécheyran, C., Monti, D., Keith, P., 2011. Otolith microchemistry in Sicydium punctatum: indices of environmental condition changes after recruitment. Aquatic Living Resources 24: 369.

75

A question of scale: Investigations of localised archaeostratigraphy on the Mungo Lunette

***Emily Dillon[1] , Tim Denham[1] , Nicola Stern[2]**

1. *School of Archaeology and Anthropology, The Australian National University, Acton, ACT*
2. *Department of Archaeology and Community Planning, La Trobe University, Melbourne, Vic*

Lake Mungo, part of the Willandra Lakes system in southeastern Australia has been the focus of archaeological and geomorphological research since the 1970s. Previous research has established a series of generalised stratigraphic models for different locales within this highly dynamic landscape, subjected to a range of environmental and cultural processes. Understandably these macroscale stratigraphic models are guides that have been applied to the lunette as a whole; each unit representing thousands or tens of thousands of years.

New research conducted at two locations on the lunette in 2012 and 2013 has been designed to construct detailed archaeostratigraphic sequences from specific locales of archaeological interest. In this talk we present the preliminary results of these investigations, with a focus upon how these local sequences correspond to published stratigraphic models. The focus here is to construct highly detailed and specific archaeostratigraphic records for different localities, or site complexes, on the lunette.

76

Insights into life at Lake Mungo during the Last Glacial Maximum

Nicola Stern[1] , Katherine Crowder[1] , Tim Denham[2] , Emily Dillon[2] , Jillian Garvey[1] , Andy Herries[1] , Marnie Baklis[1] , Kathryn Fitzsimmons[3]

1. *Archaeology Program, La Trobe University, Bundoora, VIC, Australia*
2. *School of Archaeology and Anthropology, The Australian National University, Acton, ACT, Australia*
3. *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany*

Recent geological and archaeological research shows that far from being inhospitable during the Last Glacial Maximum, Lake Mungo held a significant volume of water, albeit fluctuating. Prevailing winds contributed to the rapid accumulation of a predominantly sandy lunette that helped preserve traces of the activities people undertook there. Each discrete hearth, cluster of food remains or set of refitting stone artefacts arguably represents the debris of a single event. Each conjures an evocative image of life at Lake Mungo during the Last Glacial Maximum, although collectively they present archaeologists with all the challenges inherent in studying landscape palimpsests.

New faunal analyses from the late Quaternary of Lake Mungo

Jillian Garvey[1] , Marnie Baklis[1]

1. La Trobe University, Melbourne, VIC, Australia

This study aims to integrate data from faunal assemblages in open sites gathered from the Lake Mungo lunette over several field seasons from 2007 to 2012. An honours project beginning in 2007 provided the initial framework for studying the taphonomic history of animal bones scattering a lunette within the Willandra. Over a twelve month period research was carried out on the faunal material exposed on the surface of a large blowout, in order to develop a methodology for generating meaningful behavioural information from bone scatters exposed on the surfaces of eroding late Quaternary landforms. The observation and recording of five distinct bone scatters enabled the development of criteria for distinguishing modern death assemblages from those belonging to the late Pleistocene. It also allowed investigation into past human subsistence activities during this time period. Since then, one of the initial bone scatters associated with a complex of hearths has been recovered and analysed. Analysis of the vertebrate fauna indicates that the majority consists of mammal, predominately medium to large macropod. Most of the bones are unweathered and exhibit few surface modifications. In order to determine the weathering stages of bone fragments we are currently using Behrensmeyer's (1978) five stages. This process highlighted the need for detailed weathering stages of Australian fauna as Behrensmeyer's study is difficult to apply to the Australian context, and especially to marsupials. As a result we have initiated a study to determine the weathering stages of eroding macropod bone located on the surface of the Lake Mungo lunette.

The data from the five scatters in the initial study showed that contrary to popular opinion, open sites such as those found on the eroding Lake Mungo lunette *do* have the potential to provide meaningful information concerning late Quaternary human subsistence activities. Analysis of the excavated material will help determine which faunal species humans were selecting, as well past butchery processes. The detailed study of modern weathering will help determine the origins and exposure time of the surface bone fragments.

78

Researching the people of Ice Age Willandra

Michael C Westaway[1] , Arthur C Durband, David Lambert[1]

1. *Griffith University, Nathan, QLD, Australia*

The Willandra Lakes human remains series has played a key role in reconstructing our understanding of the origins of the First Australians as well as contributing to the global narrative relating to the dispersal of modern humans outside of Africa. Over the past 5 years we have been provided with consent from the Willandra Aboriginal Elders to undertake research incorporating new technologies, such as CT, micro CT and ancient DNA. In this presentation we shall provide an overview of this research and how it is delivering a new and exciting chapter for our understanding of the Willandra story.

79

Holocene Coastal Landscape Change in Albatross Bay near Weipa, North Queensland, Australia

***Stacy Oon[1] , Craig Sloss[2] , Lynda Petherick[3] , Patricia Fanning[1] , Kira Westaway[1]**

1. *Department of Environment and Geography, Macquarie University, Sydney, NSW, Australia*
2. *Earth, Environmental and Biological Sciences, Queensland University of Technology, Brisbane, QLD, Australia*
3. *Department of Environmental Science, Xi'an Jiaotong-Liverpool University, Suzhou, Jiangsu, China*

There is a lack of detail from the Gulf of Carpentaria (GoC) about the timing and elevation of sea level fluctuations during and following the culmination of the Holocene marine transgression, and how the marginal marine environment responded. Such information is critical since this time period corresponds with the known record of human occupation within the region. To address this gap, research has been conducted at three sites in Albatross Bay near Weipa on the far northeast coast of the GoC. The overall aim of this project is to present a revised glacial eustatic sea-level curve for the eastern GoC and address issues associated with hydro-isostatic influences on sea level change. A transect of pits were dug across relict beach ridges present at the three sites to describe the stratigraphy and interpret the depositional history of the area. At Red Beach, a sequence of eight beach ridges runs parallel to the shoreline. It is hypothesised that this sequence formed over three time periods during the mid to late Holocene. The innermost ridges formed during the culmination of the last post glacial marine transgression, around 6,500 yr BP. The middle set of ridges then formed during a Holocene sea level highstand that lasted to around 3,000 yr BP where, as sea level stabilised, increased terrestrial input resulted in a prograding shoreline. The regression of sea level from 3,000 yr BP to present resulted in the formation of the proximal set of beach ridges at Red Beach. At Wathayn and at Kwamter, located further inland along the Embley River which flows into Albatross Bay, a single relict beach ridge is present that also appears to be associated with the Holocene marine transgression. Preliminary radiocarbon age determinations on shell and OSL age determinations on quartz sand will be presented that support this model.

80

East Antarctic ice volume during the last glacial cycle

Duanne A White[1] **, Sonja Berg**[2] **, Nicholas Golledge**[3]

1. *University of Canberra, University Of Canberra, ACT, Australia*
2. *University of Cologne, Cologne, Germany*
3. *Victoria University of Wellington, Wellington*

Ice sheet models require former ice histories for model validation and sensitivity analysis. Most existing models have been assessed relative to the present day and the Last Glacial Maximum (LGM, circa 21 thousand years before present). This focus has effectively tied ice models to two distinct, but highly divergent climate states. As models have several key internal parameters (e.g. basal sliding coefficients) required for tuning, the two periods are insufficient for resolving the relative importance of the key forcing parameters. Thus, investigating ice sheet histories during other climate states are important.Resolving paleoenvironmental records prior to the LGM has traditionally been difficult due to the influence of ice that subsequently advanced over key sites. However, lake sediment records and other proxies are increasingly being resolved near the glacial margin during Marine Isotope State 3, particularly between 30-40 ka. In this paper, we review the evidence for ice sheet geometry during the 30-40 ka time slice. These sites indicate the footprint of the pre-LGM ice sheet was no greater than present. Further, diatoms in marine inlets document seasonally open water conditions, similar to today. Using conceptual and numerical ice sheet models, we investigate some of the likely drivers for a small East Antarctic ice sheet during a period that was much closer to 'full glacial' conditions in many of the key paleoclimate records.

81

To and Fro across the North Sea: analysis of the pattern of thermophilous non-volant mammalian immigration into the British Isles during successive interglacials from MIS 17 to MIS 1 as an indication of the position and duration of the landbridge connecting Britain to northwest Europe

Esmee Webb[1]

1. *Edith Cowan University, Joondalup, WA, Australia*

The seas around the British Isles are extremely shallow: less than 200 m deep. Hence, due to eustatically lowered sea levels, for 90% of the past 800,000 years, Britain has been connected to northwest Europe by a landbridge that permitted non-volant mammals to colonise the peninsula. During these periods, however, much of the country was covered by ice, while periglacial conditions obtained in unglaciated southern Britain; making the area inhospitable for thermophilous mammals. Conversely, during successive interglacials Britain was isolated from Europe as sea level rose and flooded the landbridge. There was, therefore, only a brief 'window of opportunity' at the end of each glacial when thermophilous non-volant mammals could establish themselves in Britain without swimming. Moreover, the position of the landbridge moved over time; before the Anglian glaciation (MIS 12) it formed near the Dover Strait because the Rhine and Thames flowed northwards, after it formed in the southern North Sea. This shift northwards may have determined which thermophiles managed to reach Britain during MIS 11-1. The number and range of non-volant thermophilous mammals found in the British Isles during MIS 17-1 is analysed as an indication of the position and duration of the landbridge. The pre-Neolithic fauna known from MIS 1 in Ireland is also compared with that from Britain, since the non-volant thermophilous mammals that reached Ireland had additional barriers to overcome. This presentation is an updated and expanded version of that given at CAVEPS in October 2013.

Nature, causes and impacts of the Mid-Pleistocene Transition in southeastern Australia

Peter Kershaw[1] **, Barbara Wagstaff**[2] **, Paul OSullivan**[3] **, Kale Sniderman**[2]

1. *Monash University, St Kilda, VIC, Australia*
2. *School of Earth Sciences, University of Melbourne , Melbourne, Vic, Austalia*
3. *Apatite to Zircon Inc , Idaho, USA*

Palynology of accumulated sediments in Yallock Marsh, an old volcanic crater at Garvoc in western Victoria, Australia, has provided a long and detailed record of vegetation and biomass burning. It is estimated, from a limited number of fission track dates on tephras within the sequence and on a comparable but discontinuous sequence from nearby Pejark Marsh (Wagstaff et al. 2001), that the record extends from about 1.2 Ma to 0.7 Ma. This period embraces much of the Mid-Pleistocene transition (MPT), a major episode in Earth's climatic history that witnessed the progressive replacement of low amplitude 40 ka obliquity forced cycles of the earlier Pleistocene by high amplitude 100 ka orbital cycles of the later Pleistocene. The actual timing and causes of the transition have been subjects of debate over the last 20 years but explanations, derived mainly from ocean records in the north Atlantic region, have generally involved increased ice build-up in the northern hemisphere during glacial periods due to progressively decreasing global temperatures. Recently, evidence from southern ocean oxygen isotopes provides little indication of global cooling during the MPT, and it is suggested that the transition was initiated by an abrupt increase in Antarctic ice volume about 0.9 Ma and largely completed within the next 100 ka (Elderfield et al. 2012). Although interpretable largely in terms of precipitation, the pattern and timing of vegetation variation from Yallock Marsh is not inconsistent with this reconstruction. Furthermore, it suggests that the event was likely associated with a shift in climatic seasonality from a summer to winter rainfall regime and the development of characteristic southeast Australian cool temperate rainforest and wet sclerophyll forest vegetation.

Changes in the position of the Subtropical Front around New Zealand over the last 30 kyr from sea surface temperature estimates: potential implications for the strength and position of the Southern Hemisphere Westerly Winds

Helen C Bostock[1], Bruce W Hayward[2], Helen L Neil[1], Ashwaq T Sabaa[2], George H Scott[3]

1. *NIWA, Wellington, New Zealand*
2. *Geomarine Research, Auckland*
3. *GNS Science, Lower Hutt*

The modern Southern Subtropical Front (S-STF) is forced south of New Zealand by the bathymetry. Paleo-sea surface temperatures (SST) were estimated from planktic foraminiferal census counts from a transect of core tops and cores from the Solander Trough and Campbell Plateau straddling the STF. Modern analogue technique (MAT), random forest (RF) and % *Neogloboquadrina pachyderma* were used to estimate paleo-SST, and show similar temperatures for most of the cores. The *Neogloboquadrina incompta/(N. pachyderma + N. incompta*) ratio was also used as a surface water indicator. The results suggest that the STF did not sit south of New Zealand during the glacial and this region was overlain by Subantarctic surface waters (SAW). The influence of the S-STF is evident in the northern-most core during the last glacial maximum and shifted south during the deglaciation, reaching its most southerly position in the early Holocene. During the mid-Holocene the STF shifts back to its modern position. The results fill in a gap in the previous research from the southwest Pacific and show that the STF is not continuous between east and west of New Zealand during the last glacial. Using the SST information from around the southwest Pacific we postulate what changes in the position and strength of the STF may have been caused by variability in the Southern Hemisphere Westerly Winds (SWW). Stronger SST gradient during the glacial suggests an increase in the strength of the SWW in accordance with the models. While during the early Holocene SWW may have been weaker or further south.

Land-sea correlations in the Australian region: post-glacial onset of the monsoon in northwestern Western Australia

Patrick De Deckker[1] , Timothy T Barrows[2] , John Rogers[1]

1. *ANU, Canberra, ACT, Australia*
2. *Geography, University of Exeter, Exeter, UK*

Deep-sea core Fr10/95-GC17, taken offshore North West Cape at the western tip of Western Australia, is located below the path of the shallow, warm and low salinity Leeuwin Current, an offshoot of the Indonesian Throughflow that transfers water from the West Pacific Ocean into the Indian Ocean. The core was taken on the edge of the Indo Pacific Warm Pool, the source of a huge transfer of moisture and heat from the ocean to the atmosphere. For this core, we collate previously published data as well as new one with a revised chronology to re-examine the timing of climate change during the last 34,000 years in the tropics of northern Australia. This study draws on an extensive range of analyses that have been performed on the core, including micropalaeontology of planktic and benthic foraminifera and coccoliths, stable isotopes analysis of foraminifera and their faunal composition, clay content, sediment composition and pollen analyses. The age model for the core is based on 15 radiocarbon dates and an oxygen isotope model.

Sea-surface and land temperatures are estimated from the foraminifer faunal analyses and from pollen spectra, respectively. The clay fraction and sediment composition and radiogenic isotopes of that fraction helped identify changes both on land and at sea, such as rainfall shown by river discharges, and oceanic current by neodymiun, strontium and lead isotopes obtained from sediments.

The significant finding is that a major threshold was crossed at 13 ka BP. Prior to that time, rainfall over NW Western Australia was low as were sea-surface temperatures (SST); river discharge to the ocean was also low as a result of the lack of monsoonal activity and finally ocean alkalinity was lower due to the uptake of atmospheric CO_2. By 13 ka BP, the entire system changed in contrast to the glacial period.

Development and application of a chironomid based transfer function for reconstructing summer temperatures in south eastern Australia

***Jie Chang[1] , James Shulmeister[1] , Craig Woodward[1]**

1. *School of Geography, Planning and Environmental Management, University of Queensland, St Lucia, Queensland, Australia*

We present a new chironomid based temperature transfer function which was developed from a training set of 33 natural and artificial lakes from southeast Australia from subtropical Queensland to cool temperate Tasmania. Multivariate statistical analyses were used to study the distribution of chironomids in relation to the environmental and climatic variables. Eight out of eighteen available variables were shown to be significant ($P<0.05$) for explaining chironomid species variance, these are precipitation (12%), mean February temperature (9.5%), pH (9.5%), specific conductance (8.2%), total phosphorous (8%), potential evapotranspiration (8%), chlorophyll-a (6.9%) and depth (6.2%). Further pCCA analyses show that mean February temperature (MFT) is most robust and independent variable explaining chironomid species distribution. The best MFT transfer function was a partial least squares (PLS) model with a coefficient of determination ($r^2_{Jackknifed}$) of 0.69, a root mean squared error of prediction of 2.33˚C, and maximum bias of 2.15°C. We tested the transfer function by applying it to a Late Glacial to Holocene record from Blue Lake,New South Wales using data published in Schakau (1993)[2] . The reconstruction displays an overall pattern very similar to the Milankovitch driven summer insolation curve for 30°S and to the chironomid based summer temperature reconstruction from Eagle Tarn, Tasmania (Rees and Cwynar 2010)[1] suggesting that the model is robust. In a context where there are few reliable and no continuous estimates of paleotemperature available from mainland Australia, the transfer function represents a significant advance.We also conclude that environmental gradients rather than biogeographic factors are the primary control on chironomid distribution. This raises the possibility of integrating the existing chironomid transfer function for Tasmania with this new model for the SE Australian mainland. This transfer function will also be applied to Last Glacial Maximum section of lake sediment samples collected from North Stradbroke Island, Queensland to perform summer temperature reconstructions covering the LGM.

1. Rees ABH, Cwynar LC (2010) Evidence for early postglacial warming in Mount Field National Park, Tasmania. Quat Sci Res 29: 443-454.
2. Schakau. B (1993) Palaeolimnological studies on sediments from Lake Grasmere, South Island, New Zealand, with special reference to the Chironomidae (Diptera). University of Canterbury, New Zealand, Chapter 9: pp203-286

Life on the edge: fire and the fate of Tasmania's montane rainforests

***Haidee Cadd**[1]

1. *Department of Resource Management and Geography, The University of Melbourne, Melbourne*

Tasmania's montane rainforests contain some of Australia's most ancient and endemic flora. These are relicts of the forests that covered Gondwanaland prior to advance of the now dominant and fire-prone Australian sclerophyll vegetation. Montane rainforest is now confined to tiny fire refugia in southeast Australia, a legacy of increasing aridity and the effects of fire through the Tertiary and Quaternary. Fire can facilitate the replacement of rainforest by flammable vegetation via positive feedback's between vegetation. The rate at which this occurs is dependent on local site characteristics, such as the species pool, soil type, topography and fire history. Tasmanian montane rainforests are dominated by long-lived species and the rate of recovery from disturbance in these forests is slow, often measured in multiple centuries to millennia. Fires in the mountains of Tasmania since the arrival of Europeans have burnt vast tracts of montane rainforest. This has resulted in the death of long-lived endemic conifers across entire landscapes, with little evidence for recovery. The threat of more frequent and prolonged droughts under future climate change scenarios places the future of these forests under question. In order to sustainably manage the ecological integrity of these forest systems into the future we need to address some critical gaps in our knowledge: How resilient these forests are to fire? What causes transitions between rainforest and flammable vegetation? Are these changes uniform across the landscape? In an attempt to shed light on these critical issues, I will present results of a multi-proxy palaeoecological analysis (charcoal, pollen, grain-size analysis and geochemistry) of lake sediments located in two small montane catchments in southern Tasmania. Both study sites show clear evidence of previous a transition from montane rainforest to flammable *Eucalyptus* forest that may reflect the fate of Tasmania's remaining montane rainforests.

Murrumbidgee Gum Creek phase - revisited

***Daniela Mueller[1] , Tim Cohen[1] , Ivars Reinfelds[2] , Zenobia Jacobs[1] , James Shulmeister[3]**

1. *School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW, Australia*
2. *NSW Office of Water, Wollongong, NSW, Australia*
3. *School of Geography, Planning and Environmental Management, University of Queensland, St Lucia*

The palaeoenvironmental importance of large relict river channels along the Murrumbidgee River has been recognized since the middle of the last century. Initial dating of these palaeochannels by Page et al. (1996) led to the identification of 4 phases of channel activity over the last glacial cycle. Two of these phases – *Gum Creek* and *Yanco* – are characterized by larger bankfull widths, meander wavelengths and coarse bedload (in comparison to today's channel). Such morphologic differences provide evidence for regimes of higher stream power stemming from significant changes in runoff volumes, flood-frequency regimes and sediment supply. Importantly, these two phases were identified as occurring either side of the peak of the Last Glacial Maximum (LGM) and the absence of exact LGM ages was interpreted to represent decreased fluvial activity during the LGM. Recent developments in dating techniques (i.e. single-grain OSL dating) allow for an examination of these previous findings which were mostly based on multi-grain, thermoluminescence (TL) dating. Using such an approach in high-resolution down-core will allow the identification of partial bleaching and/or post-depositional modification for such landforms. This paper presents preliminary findings on the high resolution chronology, sedimentology and morphology of six key sites of the *Gum Creek* palaeochannels. We discuss the chronology and the palaeohydrological implications of such large river channels.

Page, K., Nanson, G., Price, D. (1996). Chronology of Murrumbidgee River palaeochannels on the Riverine Plain, southeastern Australia. Journal of Quaternary Science 11(4): 311-326.

A Palaeoclimate Interpretation of Little Llangothlin Lagoon, Eastern Australia

***Daniel Ellerton[1] , James Shulmeister[1] , Craig Woodward[1]**

1 School of Geography, Planning and Environmental Management, University of Queensland, St Lucia, Queensland, Australia

A palynological investigation was carried out on a core obtained from Little Llangothlin Lagoon located on the New England Tableland of New South Wales, Australia. Little Llangothlin Lagoon sits at an elevation of 1300 m near the northern limits of modern winter westerly penetration and is likely to be sensitive to temperature and precipitation changes. The record presented here spans the latter part of the Last Glacial Maximum (LGM), the Last Glacial/Interglacial Transition (LGIT) and the early Holocene.

The Lagoon was a permanent water body during the latter part of the LGM and early part of the deglaciation. During the LGM local vegetation was dominated by herbaceous taxa but a significant presence of rainforest taxa indicates humid and temperate climates close to the site. By c.17,000 cal. yr BP herbaceous taxa (daisies) declined and trees became dominant indicating that post-glacial warming had commenced. Over time the lagoon became more seasonal and finally became ephemeral by 13,000 cal yr BP. Burning increased reaching a maximum at c.11,000 cal. yr BP. After 11,000 cal yr BP the site became wetter again.

In contrast to the traditional viewpoint of a cool and hyper arid climate during the Last Glacial Maximum, the Little Llangothlin record reflects cool and wet conditions along and to the east of the Great Dividing Range during the latter part of the LGM and the initial stages of deglaciation. The climate dried after this, until the early Holocene when the summer monsoon was fully re-established and the site became summer wet-winter dry.

89

Geomorphic evidence for periodic easterly rainfall on the Australian east coast during the last glaciation

***Adrian Slee[1] , Peter McIntosh[2] , James Shulmeister[1] , Timothy Barrows[3]**

1. *University of Queensland, Brisbane, Queensland*
2. *Forest Practices Authority, Hobart, Tasmania*
3. *University of Exeter, Exeter, United Kingdom*

Since the 1960s the consensus is that eastern Australia was significantly drier and colder during the last glaciation than under the current prevailing climate. However, recent studies of landforms in New England in northern NSW and northeast Tasmania suggest that not all of eastern Australia was drier than at present during the last glaciation the distribution of block streams and a possible pro-nival rampart in northern New England potentially indicate an enhanced moisture and /or precipitation zone on and east of the Great Divide. Further south the age and morphologic characteristics of extensive landslides on the Nicholas Range in northeast Tasmania indicates significant mass movement linked to likely enhanced soil moisture and precipitation during stages OIS 2, 3 and 5b. A prominent paleosol within dune sands at Dunlin near Bridport in northeast Tasmania, dated to the last glacial maximum (oxygen isotope stage 2), lends further support to the proposition that there were periods of substantially increased precipitation along the eastern seaboard of Australia during the last glaciation.

90

The LGM in eastern Australia - an overview

Jamie Shulmeister[1] , Craig Woodward[1] , Jie Chang[1] , Adrian Slee[1]

1. *University of Queensland, St Lucia, QLD, Australia*

This paper will examine evidence for conditions in eastern Australia at the LGM and argue that a sub-humid to humid zone was maintained along the east coast, most likely extending all the way from the tropics to Tasmania. The existence of a sub-humid zone helps reconcile clear evidence of drier conditions west of the divide with mounting evidence of available moisture in LGM rivers and along the divide. It is also consistent with background conditions including strong summer insolation and the maintenance of the East Australia Current at the LGM.

Quaternary fluvial history and neotectonics in the Lower Darling Valley, Western NSW

John Magee[1] , Ken Lawrie[1] , Larysa Halas[1] , Ross S Brodie[1]

1. Geoscience Australia, Canberra, ACT, Australia

The Geoscience Australia Broken Hill Managed Aquifer Recharge (BHMAR) Project detailed groundwater resources and managed aquifer recharge (MAR) potential in the lower Darling Valley (LDV) to define alternative more efficient water-supply options for Broken Hill. To understand recharge and palaeorecharge processes, the geomorphology, sedimentology, stratigraphy and chronology of the LDV Quaternary fluvial sequence has been elucidated. Optically-stimulated luminescence (OSL) and radiocarbon dated periods of scroll-plain activity indicate tracts of different ages incised into a higher, older and more featureless floodplain, also originally deposited by lateral-migration fluvial phases. The youngest scroll-plain phase associated with the modern Darling River was active in the period 7-2 ka but is now inactive. A previous anabranch scroll-plain phase was active during the Last Glacial Maximum (17-22 ka). Older tracts with indistinct scrolls are associated with both the anabranch (~30ka) and Darling (~45-50 ka) tracts. Lateral-migration sands without visible scroll-plain traces underlying the higher floodplain show older dates of 85 ka and >150 ka. This chronological sequence suggests recurrent ~5 ka lateral-migration episodes separated by ~10 ka quiescent periods of with no obvious correlation to glacial-interglacial climate cycles indicative of climate forcing.

Active, lateral-migration phases, with deeply scoured channels, clean coarse channel and point-bar sands and probably higher stream-flow discharges are associated with enhanced palaeorecharge episodes.

A key project finding is the importance of Neogene-to-Recent tectonics in controlling landscape evolution and hydrology. Significant, previously unrecognized, neotectonic intraplate strike-slip zones control major drainage and palaeo-drainage features, key aquifer and aquitard distribution, surface-groundwater interaction and inter-aquifer leakage. Structures were identified using high-resolution geophysics (AEM and LiDAR), and validated by drilling. Fault systems formed by reactivation of Darling Geological Basin structures, mapped independently using regional magnetics, seismic reflection and gravity data. Identification of significant intra-plate neotectonics has important implications for Quaternary sequences and groundwater studies throughout Australia.

Geophysics, palaeochannels and groundwater resources in alluvial plains: Lower Murrumbidgee catchment, NSW

Éva Papp[1] **, D. C. McPhail**[1] **, L Burraston**[1]

1. Research School of Earth Sciences, The Australian National University, Canberra, ACT, Australia

The alluvial plain of the Lower Murrumbidgee Catchment, NSW, hosts major agricultural irrigation areas, including the Coleambally Irrigation Area (CIA). Ongoing use of groundwater resources for irrigation is problematical because of the complexity of multiple aquifer systems there, a result of past changes in fluvial environments. Groundwater extraction from deep aquifers, plus groundwater mounding and associated shallow salinity, represent a significant threat to the future of irrigation in the CIA.

In this study, we combined several methods to characterise the complex alluvial environment at a site in the CIA and understand the potential impacts of extraction and irrigation on water resources. From radiometrics images, we discovered a previously unmapped branch of a known palaeochannel system. Detailed subsurface geometry of this palaeochannel from resistivity imaging, combined with information from geological logs, revealed a broad sandy feature partially filled with clay sediments. There is also evidence of leakage from nearby irrigation channels into the groundwater system. Hydrogeological and hydrogeochemical data help understand how the partially clay-filled palaeochannel can act as an aquitard to groundwater flow, contributing to rising water tables and elevated levels of shallow groundwater salinity.

This study highlights the need to identify major geomorphological features and how they can influence the use of groundwater resources, especially in irrigated areas, and shows the effectiveness of using multiple geophysical techniques, in combination with other methods, to characterise complex alluvial paleoenvironments.

Novel isotopic proxy for studying Quaternary pedogenic processes: insights from the Murrumbidgee palaeo-channels

Anthony Dosseto[1] **, Damien Lemarchand**[2]

1. *School of Earth & Environmental Sciences, University of Wollongong, Wollongong, NSW, Australia*
2. *École et observatoire des sciences de la Terre, Université de Strasbourg, Strasbourg, France*

While progress has been made on reconstructing past climatic conditions, we have a far worse understanding of the environmental response to Quaternary climate variability, e.g. how soil evolution, sediment delivery to streams and fluvial transport respond to changing climate and plant ecosystems. Recently, new isotopic proxies have emerged that offer the opportunity to probe into these questions. In the Murrumbidgee catchment, we used uranium isotopes to show that sediment mobilisation has responded to changes in plant ecosystems over the past 100 ka (Dosseto et al. 2010). Here, we investigate additional innovative approaches with the measurement of boron (B) isotopes in palaeo-channel sedimentary deposits.

Results show that while the B isotopic composition of sands and silts record changes in the source of sediments and/or hydrodynamic mineral sorting, clays yield information on weathering processes. By comparing the B isotopic composition of clays from the Murrumbidgee palaeo-channels with that of different soil types, we are able to show that pedogenic processes have significantly varied in the Murrumbidgee catchment during the late Pleistocene. In MIS1 and 5 palaeo-channels, clays deposited are characteristic of soils where mineral dissolution dominates over secondary phase precipitation; while in MIS2 palaeo-channels, clays deposited have B isotopic compositions diagnostic of soils where secondary phase precipitation and cycling of B through the vegetation are dominant. These contrasting soil types could be the response to changes in plant ecosystems, as studied by Kershaw et al. (2007), and complete the picture of strongly varying environments in south-eastern Australia during the late Pleistocene (Petherick et al. 2013).

1. Dosseto, A., Hesse, P., Maher, K., Fryirs, K., Turner, S.P., 2010. Climatic and vegetation control on sediment dynamics. Geology 38, 395-398.
2. Kershaw, A.P., McKenzie, G.M., Porch, N., Roberts, R.G., Brown, J., Heijnis, H., Orr, M.L., Jacobsen, G., Newall, P.R., 2007. A high-resolution record of vegetation and climate through the last glacial cycle from Caledonia Fen, southeastern highlands of Australia. Journal of Quaternary Science 22, 481-500.
3. Petherick, L., H. Bostock, T. J. Cohen, K. Fitzsimmons, J. Tibby, M. S. Fletcher, P. Moss, J. Reeves, S. Mooney, T. Barrows, J. Kemp, J. Jansen, G. Nanson and A. Dosseto (2013). "Climatic records over the past 30 ka from temperate Australia – a synthesis from the Oz-INTIMATE workgroup." Quaternary Science Reviews(0).

Late Quaternary Palaeohydrology of the Macquarie River and the Murray-Darling Basin

Rory Williams[1] , Paul Hesse[1] , Tim Ralph[1] , Kirstie Fryirs[1] , Kira Westaway[1]

1. Macquarie University, NSW, Australia

More than 40 palaeochannels of the Macquarie River are preserved on its alluvial plain in northern NSW. We developed empirical relationships between modern river gauge discharges and channel dimensions (width; meander wavelength) from the Murray-Darling basin to estimate palaeo-discharges of the Macquarie palaeochannels. The largest of these channels carried a peak (bankfull) discharge around 1000 m^3s^{-1}, more than 60 times that of the modern river. The same relationship was applied to other MDB palaeochannels. Northern rivers (Gwydir, Macquarie, Namoi) were found to have much higher palaeo to modern discharge ratios than the southern rivers (Murrumbidgee, Murray), with Lachlan river palaeochannels forming an intermediate group. The small, modern rivers in the north all show channel breakdown and wetland morphology in their lower reaches. When all palaeochannels are normalized to the discharges of the modern rivers at the point at which they enter their alluvial plains, the differences between the northern and southern rivers disappear. The northern catchments have seen a threshold transition to channel breakdown and floodouts in the late Holocene.

Single-grain OSL ages from three conspicuous, and larger, Macquarie palaeochannels have yielded minimum age model estimates ranging from around 40 ka to around 20 ka. Combining these palaeo-discharge estimates of the dated Macquarie channels with published ages for other MDB palaeochannels and our new palaeo-discharge estimates, some trends are evident. Discharge was highest in early or mid MIS3 (except Murray/Goulburn), decreasing in late MIS3, then remaining steady into MIS2 before decreasing greatly in the Holocene. Data in MIS 4 and 5 is too sparse to see any overall pattern. However, the large discrepancy between single grain and single aliquot OSL ages for the Macquarie channels suggests there may be some substantial revision of other palaeochannel ages in the future once single grain techniques are applied to these systems.

How can knowledge of mechanisms and timescales of avulsion and floodout formation in floodplain wetlands inform interpretation of Quaternary fluvial sedimentary records?

Timothy J. Ralph[1] , Stephen Tooth[2] , Paul P. Hesse[1]

1. *Department of Environment and Geography, Macquarie University, NSW 2109, Australia*
2. *Department of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, Ceredigion SY23 3DB, United Kingdom*

River avulsion and floodout formation play crucial roles in the development and dynamics of floodplain wetlands in relatively unconfined, semiarid landscapes. Avulsions laterally redistribute water and sediment, while floodouts form where channels terminate and therefore represent discrete sediment sinks. In the absence of neotectonics or sea-level change, channel-belt aggradation rate related to extrinsic (e.g. climate change) or intrinsic processes (e.g. downstream declines in stream power) is often regarded as a primary control on avulsion frequency. Yet avulsion style (e.g. progradational, incisional or reoccupational) and floodout morphology vary depending on physiographic setting, flood regime and sediment supply. We describe mechanisms and timescales of avulsion and floodout formation in southern African and southeastern Australian floodplain wetlands. In the Blood River wetlands, South Africa, aggradation rates are up to 15 mm a^{-1} around the channel belt and progradational avulsions occur every 10-30 years on average. In the larger Macquarie Marshes, Australia, aggradation rates are up to ~11 mm a^{-1} around the channel belt and progradational avulsions occur every 50-60 years on average. Both systems exhibit evidence of a late Holocene transition from sinuous, through-going channels to straighter distributary channels that terminate on floodouts with locally higher aggradation rates (>30 mm a^{-1}) resulting from organo-clastic sedimentation. Positive feedbacks between avulsion, sedimentation and vegetation growth influence contemporary wetland dynamics. Knickpoints form on locally steepened slopes created by organo-clastic lobes and potentially reconnect river reaches separated by floodouts. Discontinuous late Holocene sediments are likely to be found atop more laterally continuous older sediments deposited by through-going channels. In these semiarid settings, long-term preservation of organic matter is limited by factors including desiccation and fire, and so many of the subtle surface feedbacks characterising the late Holocene development of these systems will not be recognisable in longer-term sedimentary records.

Investigating controls on dryland fluvial geomorphology and sedimentology: Case studies from the Neales River, Peake Creek and Lake Yamma Yamma, Lake Eyre Catchment

***Kathryn Amos, Sandra Mann, Sara Morón[1]**

1. The University of Adelaide, Adelaide, SA, Australia

Dryland endorheic basins have been prevalent throughout geological history, yet modern dryland environments are not well understood, which can lead to misinterpretation of the ancient record. The Quaternary Lake Eyre Basin provides an excellent environment in which to study the deposits of dryland systems. This project aims to improve the understanding of fluvial dryland deposits from both a geomorphologic and sedimentologic perspective. A key research question surrounds the controls on river planform, and the often complex geomorphology and sedimentology that is related to transitions in planform from single to multiple channel reaches. We present case studies from two rivers that exhibit a downstream transition from single to multiple channel pattern; the Neales River and Peake Creek, in the western Lake Eyre Basin, central Australia. Detailed topographic and sedimentologic survey data will be presented, and compared with global channel geometry datasets. We propose a conceptual model that explains the geomorphic and sedimentologic characteristics, related to differing sediment transport and deposition processes and loci during discharge events of different magnitude. Age-dating (OSL) of Quaternary sediments from cut-bank exposures has been conducted, but with little success; these findings will be presented and discussed. Ongoing work includes two new field localities. First, a study of a tropical river with similar downstream planform change, the Magdalena River, Colombia; preliminary observations will be presented. Second, we will introduce a new study locality focusing on Lake Yamma Yamma, in the eastern Lake Eyre Basin, which will investigate the interaction between dryland fluvial and lacustrine processes, and the impact of these on preserved deposits. Placing field data obtained to date in the global Quaternary and geologic contexts highlights the need for more investigation of Quaternary river deposits, as well as some key issues to consider when applying data from Quaternary dryland rivers to the subsurface.

Late Quaternary human occupation and subsistence along the Central Murray River corridor, semi-arid northwest Victoria

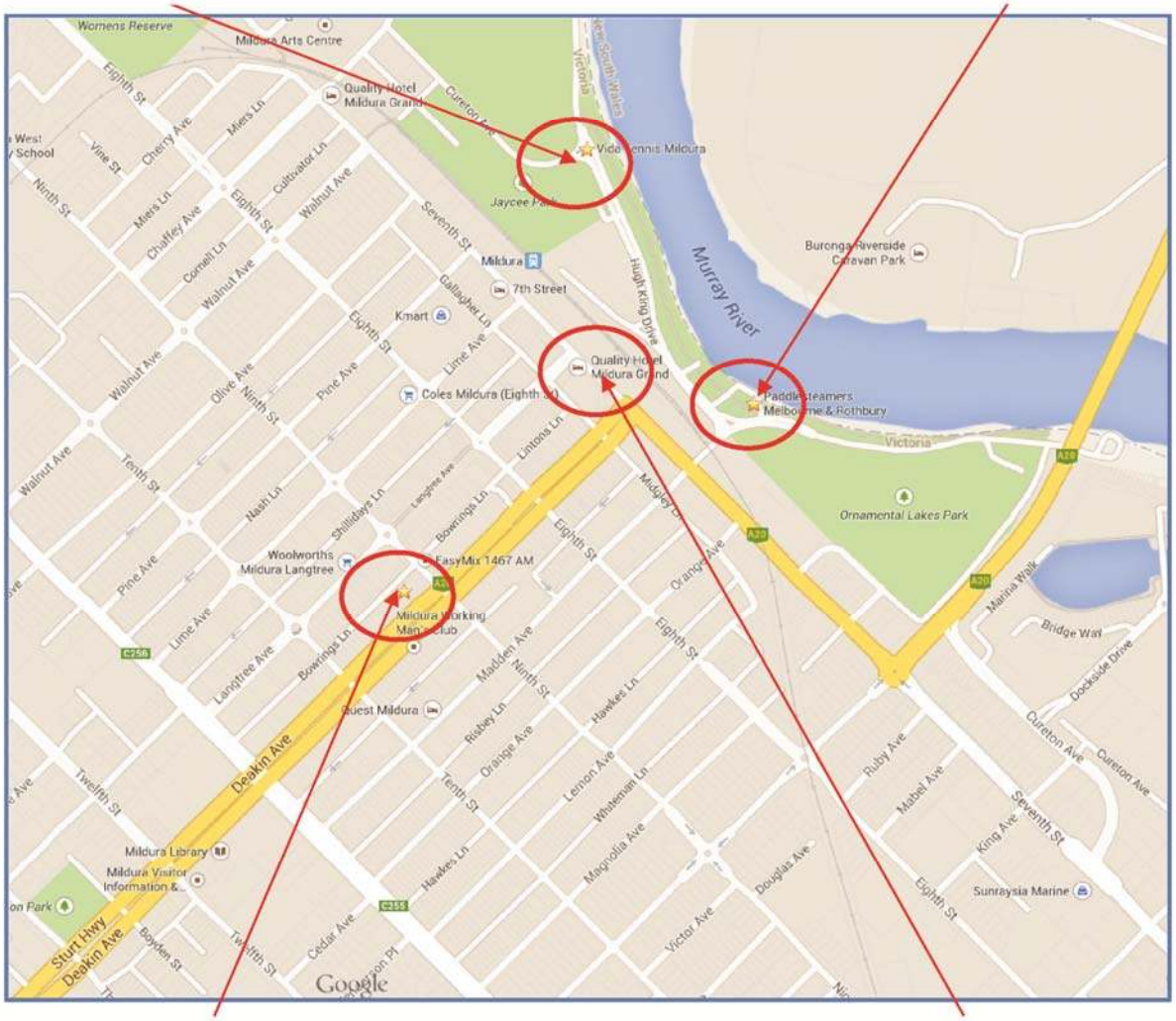
Jillian Garvey[1]

1. La Trobe University, Melbourne, VIC, Australia

This project addresses the important problem of the antiquity of human occupation and their subsequent long-term behavioural responses and adaptive strategies to environmental change in the Central Murray River region during the late Pleistocene – a time of significant climatic variability. It will provide the first integrated investigation of the history and chronology of human settlement, landscape structure, palaeoenvironmental and faunal change. It aims to develop an understanding of how people inhabited this landscape, and the foraging strategies and social networks used to survive the long term, large scale changes in the environment and local landscape. Based at Neds Corner Station and the adjacent Murray-Sunset National Park, it is investigating the spatial and temporal distribution of cultural sites and material across several land systems spanning the Last Glacial Maximum (LGM) to the present. In particular, the project is focusing on shell middens from the Neds Corner Land System (thought to have been active during the last LGM). These middens have the potential to inform about economic resource patterning during the late Quaternary, with the Murray River mussel *Alathyria jacksoni* and the River Snail *Notopala sublineata* common prey species. These shellfish can also inform about past environmental reconstruction via isotopic analysis. Analysis of the shellfish from the archaeological midden was compared to the results of a nutritional and economic utility analysis of the modern Murray River mussel A. jacksoni to determine the potential dietary return in the archaeological assemblage. This project will address this significant lack of knowledge concerning when people first occupied and utilised one of Australia's greatest resources, the Murray River, and how late Quaternary climatic and environmental variability impacted the fauna, flora and Indigenous people.

Mildura Tennis Club
Trivia Night

Mildura Wharf
Conference Dinner



Mildura Club
Ice Breaker

The Mildura Grand
Conference Venue