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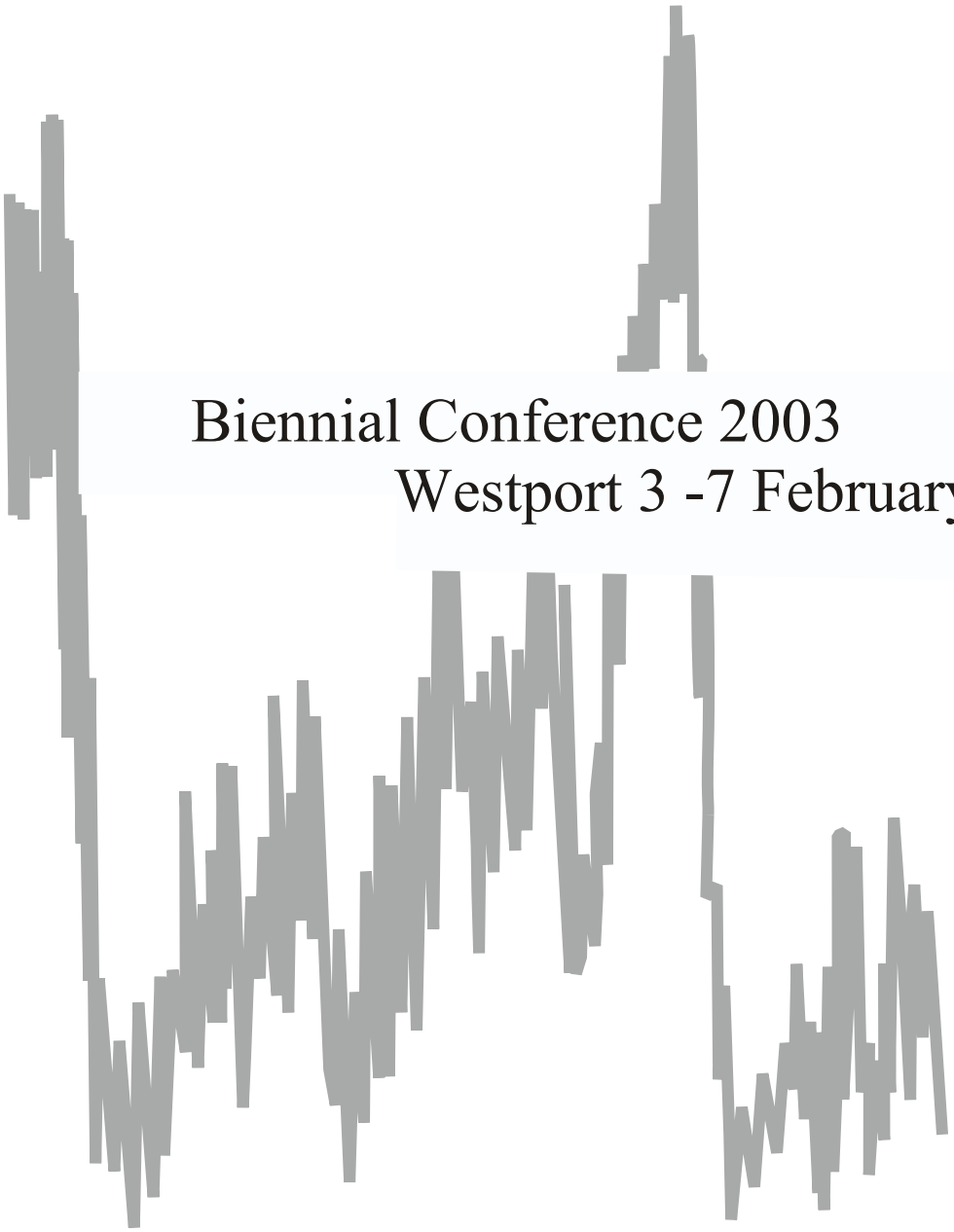

Biennial Conference 2003
Westport 3 -7 February

Victoria

LINCOLN UNIVERSITY

Manaaki Whenua Landcare Research

Programme & Abstracts

Compiled and edited by

Maureen Marra and David Kennedy

School of Earth Sciences, Victoria University of Wellington

Biennial Conference

2003 Organising Committee

Conference Secretary & Treasurer:	David Kennedy
Programme Co-ordinator:	Jamie Shulmeister, Maureen Marra, David Kennedy
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Pre-Conference Field Trip:	David Kennedy
Mid-Conference Field Trip:	Peter Almond, Pat Suggate
Post-Conference Field trip:	Peter Almond, Pat Suggate, Phil Tonkin, Bruce Harrison
Conference Dinner and Lunches:	John Carter and Jamie Shulmeister
Venue Co-ordination:	Jamie Shulmeister

Conference Programme

Monday 3rd February

11.00-13.00	Conference registration
13.30	Introduction Jamie Shulmeister
13.40 -	Holdaway Keynote 1: - Megafauna

14.10 - Session 1: Megafauna. Chair: Jamie Shulmeister

Magee	Genyornis extinction versus Emu survival: A key to unravelling the cause and process of megafaunal extinction in Australia
Barrows	Direct dating of fossil megafauna using cosmogenic Cl-36
Cammack	Can geophysical surveys locate moa bone clusters in North Canterbury swamp deposits? Results from Pyramid Valley, Strathblane and Treasure Downs.
15.10	Afternoon tea

15.40 - Session 2: Evolution of drylands + paleoecology. Chair: John Magee

Hesse	OSL Chronology of an Australian Loess deposit; correlations and climatic implications
Hilgers	The onset and subsequent history of dune formation in the Strzelecki desert and adjacent dunefields, South Australia
Marra	LGM and Holocene vegetation reconstruction of the Awatere Valley using fossil beetle assemblages
Morris	Salinity and vegetation changes in SW Australia

7 pm Evening: Informal get together Bailey's Irish Pub

Tuesday 4th February

09.10- Fink Keynote 2:– Cosmogenic radioisotopes for dates and rates!

09.40 - Session 3: Dating Techniques/ landscapes. Chair: John Chappell

Grun	Laser Ablation ICP MS analysis for the determination of U-concentration profiles and *in situ* U-series dating
Heijnis	The use of ^{210}Pb, ^{226}Ra and ^{137}Cs profiles in marine sediments to assess the 'sudden' occurrence of a toxic dinoflagellate species in Australian and New Zealand waters.
Schmidt	Modelling spatial Loess occurrence for South Island (New Zealand) based on experiences
Alloway	A terrestrial record of Interglacial climate preserved by voluminous debris avalanche inundation in Taranaki, western North Island, New Zealand.
11.00	Morning tea

11.30 - Session 4: Vegetation changes. Chair: Tim Barrows

Kenyon	The history of fire in Barmah Forest, Victoria, Australia
Mooney	Holocene Fire History in the Sydney Basin, NSW, Australia: what do we really know?
Gayler	The palaeoenvironmental history of Paroo region, NW NSW, Australia.
Sniderman	Plio-Pleistocene vegetation and climate cyclicity in upland Victoria, SE Aust.

12.50 Poster session and lunch

14.10 - Session 5: Vegetation changes. Chair: Vanessa Thorn

Connor	Preliminary palynological investigations in the Caucasus.
Fletcher	Holocene Stability of Tasmanian Buttongrass Moorlands..
Flett	The History Of Algal Blooms in the Myall Lakes, NSW.

15.10 Afternoon tea

15.40 - Session 6: Glacial. Chair: Tim Naish

Suggate	The Last Glacial Maximum in western South Island, New Zealand.
Rose	Late Quaternary tectonic uplift, marine planation, fluvial incision, and sea level, North Westland, New Zealand.
Augustinus	Cosmogenic 10Be and 26Al Ages from Quaternary Glacial Sequences from Western Tasmania: Implications for Regional Paleoclimate.

Evening: Informal discussion: Where to Quaternary Science in New Zealand ? (Conference centre)

Wednesday 5th February

9.00 IGBP 2 and Quaternary Science

9.20 PEP-II introduction – Paul Hesse

9.40 - Session 7: PEP-II last 2000 years. Chair Paul Hesse

Harle	Timber, tin and convicts: Evidence for 180 years of colonial impact in western Tasmania derived from high resolution records.
Gergis	Late-Twentieth Century ENSO Variability in the Context of Holocene Climatic Change.
Palmer	Delta 13 C signal over the past millenium from tree-ring samples.
Rowe	Human colonisation and landscape dynamics in Torres Strait.

11.00 Morning tea

11.30 - Session 8: Marine. Chair: David Kennedy

Bob Carter	South Island and Antarctic Quaternary climate at ODP Site 1119, Canterbury Bight.
Chappell	Downstepping reef cycles, Late Quaternary sea level changes, ice-cycles and isotopes.
Couapel	The Gulf of Carpentaria through the Late Pleistocene: OSL dating and nannofossil evidence.
DeDeckker	The Role Of Tropical Oceans In Climate Forcing: Evidence From The Indo-Pacific Warm Pool During The Late Quaternary.
Naish	Response of a Late Quaternary fluvial-marine margin to the 100,000 year climate cycle, Canterbury Plains and shelf, New Zealand.

13.10 Lunch

14.10 - Session 9: Neotectonics. Chair: Paul Williams

Langridge The last three paleo-earthquakes on the Conway segment of the Hope Fault from Greenburn stream, South Island, N. Z.

Korup Landscape response to neotectonics in alpine catchments of South Westland and Fiordland.

Nobes Three-dimensional imaging of the Benmore segment of the Ostler Fault using ground-penetrating radar (GPR), resistivity tomography and differential GPS.

Jol Three Dimensional GPR Visualization of an Earthquake Induced Coastal Scarp.

15.30 Afternoon tea

16.00 - Session 10: Phytoliths. Chair: Maureen Marra

Marx Phytoliths from all extant New Zealand species of *Chionochloa* and *Festuca* and their potential use in Quaternary studies

Carter Terrestrial climate and environmental history from phytolith occluded carbon.

Prebble TBA

Thorn Phytolith evidence for C4-dominated grassland throughout the Holocene at Long Pocket, northeast Queensland, Australia.

Thursday 6th February

Mid-Conference fieldtrip to Punakaiki Rocks etc.
Evening: Conference dinner

Friday 7th February

9.10 - McGlone: Keynote 3 –Asynchronous climate change between New Zealand and the Northern Atlantic during the last deglaciation and the early Holocene.

9.40 - Session 11: Younger Dryas/Deglaciation. Chair: Janet Wilmhurst

Fink The last deglaciation in the Southern Hemisphere - can cosmogenic exposure dating find the Younger Dryas?

Pepper Climate change during the LGM and deglaciation in the Auckland region, New Zealand.

Sidorchuk	Megafloods of the Late Pleniglacial - Younger Dryas in the southern Russian Plain.
Hagg	Abrupt climate changes over the LGM-Holocene transition inferred from a maar lake record at Onepoto Crater, Auckland.
11.00	Morning tea

11.30 - Session 12: Glacial + speleothems. Chair: Pat Suggate

Rother	Late Quaternary river development in Mecklenburg/Vorpommern, NE Germany. - A case study of valley formation in a moraine sequence of the Weichselian glaciation.
Shulmeister	Geomorphic evidence for a Piedmont Glaciation in N. W. Nelson, New Zealand, at the Last Glacial Maximum.
Mackintosh	Glacier-Climate relationships as an aid to interpreting moraine records in New Zealand.
MacDonald	Mid-Holocene climate change based on the age and geochemistry of stalagmites from Cliefden Caves, central NSW, Australia.
Williams	Speleothem evidence for climatic change in New Zealand
13.10	Lunch

14.10 - Session 13: Sea level change and coasts. Chair: Pat De Decker

Riggs	Post-Glacial palaeosea levels, inferred from foraminifera in Gulf St. Vincent, South Australia.
Sloss	Dating Holocene estuarine succession using Aspartic Acid Racemisation
Switzer	Set-up, deposition and sedimentary characteristics of two storm overwash deposits, Abrahams Bosom Beach, eastern Australia.
15.10	Afternoon tea
15.30	AQUA AGM
17.0	Conference Closes

ABSTRACTS

A TERRESTRIAL RECORD OF INTERGLACIAL CLIMATE PRESERVED BY VOLUMINOUS DEBRIS AVALANCHE INUNDATION IN TARANAKI, WESTERN NORTH ISLAND, NEW ZEALAND

Brent Alloway [1] & Rewi Newnham [2]
[1] Institute of Geological & Nuclear Sciences, Private Bag 2000, Taupo, New Zealand
[2] School of Geography and Geology, University of Plymouth, Plymouth PL4 8AA, England.

Complete vegetation records spanning the interval from marine isotope stages 5e to 4 are rarely preserved in the terrestrial environment. At Airedale Reef, western North Island, New Zealand, a c.4 m thick voluminous debris avalanche deposit, sourced from an ancestral Egmont Volcano, has facilitated the preservation of an enveloping sequence of peats with interbedded andesitic tephras. The debris avalanche deposit with associated organic sequence is overlain by alternating reddish and loess-like yellowish andic beds with andesitic and silicic tephra inter-beds including the Rotoehu and Kawakawa Tephras deposited during early Stage 3 and mid-Stage 2, respectively. The entire sequence closely overlies a wave cut terrace correlated to Stage 5e.

Pollen analysis of the organic sequence confirms a coherent pattern of fluctuating climate for the Last Interglacial-Last Glacial transition that corresponds with marine isotope stratigraphy. A five-stage subdivision of Stage 5, followed by a harsh cooling interval (Stage 4) is recognised. Several examples of volcanic impact on vegetation and the landscape are also evident. The Airedale Reef sequence enables the proxy record of southern mid-latitude climatic variability during the Last Interglacial to be extended. For instance, the climate of substage 5b appears to have been drier than substage 5d, while the transition from 5a to Stage 4 may have also been comparatively dry and characterised by natural fire, perhaps associated with volcanism. Such climate variability cannot so far be substantiated from equivalent-aged terrestrial deposits of the soil-forming environment. Results exhibit strong similarities with fragmentary Last Interglacial pollen records preserved elsewhere in New Zealand, and clearly support orbital variations being a primary factor in late Quaternary southern mid-latitude climate change.

HOLOCENE VEGETATION CHANGE IN WHANGANUI INLET, NORTHWEST NELSON, SOUTH ISLAND

Rachel K Armour and David M Kennedy
School of Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington,
armourrach2@scs.vuw.ac.nz, david.kennedy@vuw.ac.nz.

Whanganui Inlet, in north west Nelson, is an enclosed drowned river valley that has remained tectonically stable throughout the Holocene. The Inlet is 13km long and 1-2km wide and is characterized by an expanse of tidal flats that are exposed at low tide.

Seven vibrocores were taken from the Southern half of the inlet and 2 Russian D-sections were collected from Mangarakau Swamp, adjacent to the inlet's southern margin. These cores penetrated to a depth of 5 and 7 m respectively. Subsurface sediment in the inlet is dominated by mud interspersed with layers of coarse sand and shells while the swamp is composed of immature peat. 13 radiocarbon ages suggest that estuarine sediment accumulation during the late Holocene is low with material at 2 m below the surface dating at 7 ka. Conversely the swamp records more rapid accumulation with material at 7 m depth dating at 5.7 ka.

Pollen is well preserved in both the estuary and the swamp and records two scales of vegetation change. It is assumed that ~90% of pollen extracted from the vibrocores is stream borne (Peck, 1973) hence changes in this pollen spectra represent changes in the inlet's hinterland. Peat cores however, record more local vegetation change around Mangarakau Swamp. Beech occurred adjacent to the inlet 5 ka but was present earlier in the hinterland 7 ka, increases in beech correspond with declining rimu and matai forest. Peat cores record a dominance of wetland taxa, kahikatea, *Cyperaceae,* and manuka/kanuka, which is not registered in the inlet cores. From 5.7 – 3 ka a transitional zone between forest and swamp facies is present, which is represented by a high number of shrub and small tree taxa. Tree ferns are over-represented in the vibrocores and the quality of palynomorph preservation is less. Exotic pollen taxa are not found in the peat cores however, vibrocores document the presence of pine in the modern pollen rain. A clear signature of human modification is not evident from the pollen record in both and swamp and inlet cores.

Reference

Peck, 1973: Pollen budget studies in a small Yorkshire catchment. *In* Quaternary Plant Ecology (eds) Birks, H.J.B. and West, R.G.). Blackwell.

COSMOGENIC ^{10}Be AND ^{26}Al AGES FROM QUATERNARY GLACIAL SEQUENCES FROM WESTERN TASMANIA: IMPLICATIONS FOR REGIONAL PALEOCLIMATE

Paul Augustinus
Department of Geology and School of Geography and Environmental Science, University of Auckland, Private Bag 92019, Auckland, New Zealand.

David Fink
ANTARES-AMS, Physics Division, Australian Nuclear Science and Technology Organisation, Menai NSW 2234, Australia.

Eric Colhoun
School of Geosciences, University of Newcastle, Callaghan, NSW 2308, Australia.

Rod Brown
School of Earth Sciences, University of Melbourne, Parkville, Victoria 3052, Australia.

The application of cosmogenic nuclides ^{10}Be and ^{26}Al to the exposure age dating of the middle to late Quaternary glacial sequence from Pieman River basin western Tasmania, has forced a re-examination the existing chronology. Previous work using a range of numerical and relative-age criteria produced a chronosequence that substantially underestimated their age. The oldest moraines provided total exposure ages of in excess of 2 Myrs using a multiple nuclide approach, whilst presumed middle Pleistocene moraines gave dual nuclide total exposure ages greater than 1 Myrs at several sites indicating that not only are the boulders older, but their exposure histories are extremely complex and reworking of boulders by latter glacial advances occurred. This variability demonstrates clearly the difficulty in obtaining reliable single nuclide exposure ages from glacial moraines, especially those that have undergone significant degradation.

Nevertheless, the exposure dating indicates that glacial moraines previously attributed to marine δ^{18}O Stage (MIS) 6 and 8 were most likely deposited during MIS 8, 10, or earlier cold events. There is no clear evidence for an MIS 4 advance although moraine ridges immediately beyond the LGM limit north of Lake Rolleston provided ^{10}Be and ^{26}Al ages ranging from 77 to 35 kyr. MIS 2 and 6 advances appear to have been restricted to the West Coast Range, as well as being much less extensive than suggested previously. Until recently, the Last Glacial Maximum in western Tasmania has been regarded as involving a single glacier advance ~19 kyr BP largely on the basis of relative age criteria, with few radiometric ages available to reliably constrain the age of the last advances in western Tasmania. However, recent ^{10}Be and ^{26}Al exposure age dating of LGM moraines from a range of sites in western Tasmania indicates that the sequence is more complex than hitherto considered. Glaciated sites on the Mt Murchison Massif and Tyndall Range that should be sensitive indicators of changing climate during the LGM to late Glacial support a model of multiple advances of ice during the LGM, with major ice retreat commencing at ~19-20 with a readvance phase and final deglaciation ~ 15-16 kyr BP. Significantly, there is no evidence for a Younger Dryas glacier readvance in western Tasmania which supports palynological evidence for no significant regional cooling at this time. The implications of this chronology of glacial events for middle to late Pleistocene paleoclimate in Tasmania will be discussed.

DIRECT DATING OF FOSSIL MEGAFAUNA USING COSMOGENIC CL-36

Barrows, T. T.[1], Fifield, L. K.[1] and Reed, E.[2]

1. Department of Nuclear Physics, Research School of Physical Sciences and Engineering, Australian National University, ACT, 0200, Canberra, Australia. Contact email: Tim.Barrows@anu.edu.au.
2. School of Biology, Flinders University of SA

The age of fossilized skeletal remains is usually determined by association with radiocarbon dates, luminescence dating of the encasing sediments, or uranium-series dating of bracketing speleothems. However, in all of these cases the age of the bones can be very different, even if reworking is not a factor. Direct dating has proven difficult, because bones tend to exchange isotopically with the environment and therefore not act as closed systems. In this paper we describe a new approach to directly dating tooth enamel using the cosmogenic isotope ^{36}Cl. This radionuclide is produced from a nuclear reaction with argon in the atmosphere, where it is dissolved into rain, and delivered to the Earth's surface. The isotope is incorporated into hydroxyapatite during tooth formation and provides a decay clock with a half-life of 301,000 years. For initial dating trials, we chose the exceptionally well-preserved and independently dated fossil remains at the Naracoorte World Heritage Area. We defined the modern ^{36}Cl/Cl ratio in the environment using widespread, large, grazing kangaroos (*Marcopus giganteus* or *M. fuliginosus*). Because of the close proximity of the site to the ocean, the modern ^{36}Cl/Cl is very low due to dilution by sea salt. In the caves there is some background ^{36}Cl production due to neutron production resultant from the decay of uranium and thorium in the sediments, and a minor contribution from muons penetrating the roof. Using a novel stepped-dissolution method, we were able to remove post-depositional contamination, minimize sample size and greatly reduce isobaric interference from collagen sulfur. The background-corrected fossil ^{36}Cl/Cl ratio in Victoria Fossil Cave gives an age of ~270,000 years, consistent with existing U/Th ages on bracketing speleothems. In Cathedral Cave the ratio gives a background-corrected age of ~430,000 years, older than existing U/Th ages.

PALAEOFLORISTIC METHOD OF THE LANDSCAPE AND CLIMATIC RECONSTRUCTION: EXAMPLES FROM THE RUSSIAN PLAIN

Olga Borisova
Institute of Geography, Russian Academy of Sciences, Staromonetny 29, Moscow 109017 Russia

The use of palaeobotanical data for palaeoclimatic and palaeolandscape reconstructions implies that the flora of a particular region, or the composition of plant species growing there, is directly related to the natural environment as a whole and the climate in particular. The method of reconstructing vegetation and climate from the composition of fossil floras was developed by V.P. Grichuk (1969, 1985), based upon an earlier concept developed by Szafer (1946). Geographical analysis of the modern spatial distribution of all the plant taxa of certain fossil flora (compilation of a so-called arealogram) allows the location of the closest modern floristic analogue to the past vegetation at the site to be found. By identifying the region where all the species of plants grow at the present time it is possible to determine the closest modern landscape and climatic analogue to the past environment under consideration. Usually the conditions suitable for all the plants of a given fossil flora can be found within a comparatively small area. The present-day features of plant communities and main climatic indices of such a region-analogue should be close to if not identical to those that existed at the site in the past.

A series of such regions-analogues was established on the basis of the fossil floras for six time intervals within the Holocene at the site near the Vychegda River mouth (northern Russian Plain, taiga forest zone, 61.3ºN, 47ºE). For this purpose the fluvial and peat deposits of the floodplain dated with radiocarbon method were subjected to detail palynological study. An attempt was made to achieve the highest possible taxonomic resolution: pollen identifications have been made to species or genus levels for arboreal plants and for certain groups of herbaceous plants. Where identifications were possible only to the family level, they were not included into the resulting lists of fossil floras. The region currently inhabited by the species of each fossil flora was determined from map sources by superimposing their modern ranges. Locations of the regions-analogues of successive fossil floras of different ages form a large loop over the Russian Plain. It begins app. 550 km east from the site, at the western slope of the Ural Mountains (61ºN, 57ºE, 8.8K yrs B.P.), to continue towards the south as far as 500 km from the site (57.5ºN, 49ºE, app. 6K yrs B.P.), then over 400 km to the west of it (59,5ºN, 39.5ºE, 3.5K yrs B.P.), and finally back to the north-east towards the modern site. This broad geographical range corresponds to a considerable climate change, which occurred at the site during the Holocene. Thus, the mean air temperature of the coldest month (January) changed from - 17º at the beginning of the Boreal to - 14ºC in the climatic optimum of the Holocene (the Late Atlantic), that of July rising from 16 to 19ºC, respectively. The annual precipitation rapidly decreased from 850 to 630 mm in the Boreal, then increased more gradually during the Atlantic and Subboreal (up to 750 mm) to decrease again in the Subatlantic reaching the present-day value of 700 mm per year.

Method of the arealograms permits to avoid the step of vegetation reconstruction based on the pollen assemblages on the way to a palaeoclimatic reconstruction. This is especially important in the case if there is no direct modern analogue of the vegetation of a particular epoch, as, for example, is the case for the Younger Dryas. Periglacial forest steppe which covered almost the entire Russian Plain at this cold interval was a complex vegetation which combined herbaceous communities similar to the modern cold dry steppe, open woodlands formed by tree species growing at present in the Siberian interior with the cold and continental climate, and meadow communities with some microtermal tundra elements. Reconstruction shows that the modern region-analogues for the fossil floras of the Younger Dryas from central, western and southern regions of the Russian Plain can be found in southern Siberia, in the depressions within the Altai and Sayan Mountains.

RESPONSE OF DIATOMS TO THE INFLUX OF TEPHRAS IN A FRESHWATER LACUSTRINE ENVIRONMENT

Isaac Burwell
University of Canterbury, Private Bag 4800, Christchurch, New Zealand

The object of this project is to determine the responses of diatoms to an influx of tephras of differing composition into a freshwater lacustrine environment. This is achieved by sampling cores extracted from two volcanic lakes (Pupuke and Pukaki Maars) in the Auckland region, New Zealand, and investigating the diatom flora directly above and below multiple tephra beds.

The core recovered from Lake Pupuke contains a near-continuous sedimentological record covering the period ~9000 yrs to present. Lake Pukaki contains a similar, yet older record, covering 9000 – 120000 years. Within these cores, multiple volcanic events from Auckland Volcanic Field, Taupo Volcanic Zone, Taranaki Volcano, Okataina Volcanic Centre and Mayor Island Volcanic Centre are preserved. High-resolution sampling of these cores was undertaken across nine individual tephra beds of differing thickness and composition. Beds were chosen so that a wide range of volcanic compositions were sampled; basaltic tephras from the Auckland Volcanic Field; andesitic tephras from the Taranaki Volcano and rhyolitic tephras from the Taupo Volcanic Zone, Okataina Volcanic Centre and the Mayor Island Volcanic Centre were all sampled. The effect of different thicknesses of tephra on diatoms will also be investigated, so where applicable, a thick and thin tephra layer of each composition was sampled. One cubic centimetre samples were extracted at 10 mm intervals from ~50 mm below the tephra to ~50 mm above. Additional sampling was done at 20 mm intervals to 90 mm above and below the tephras, and then for some of the thicker tephra layers, samples were collected up to 300 mm above and 150 mm below the ash layer.

From this sampling regime, it is hoped a high-resolution picture of the responses of diatoms to the input of tephra into their environment can be produced. Latest results will be presented.

CAN GEOPHYSICAL SURVEYS LOCATE MOA BONE CLUSTERS IN NORTH CANTERBURY SWAMP DEPOSITS? RESULTS FROM PYRAMID VALLEY, STRATHBLANE AND TREASURE DOWNS

Erica Cammack[1*], David C. Nobes[2], and Richard N. Holdaway[3]
1. Department of Geological Sciences, University of Canterbury
2. Formerly Department of Geological Sciences, University of Canterbury
3. Palaecol Research, Christchurch

The study of macrofossil remains recovered from Quaternary sediments throughout New Zealand can provide much paleoenvironmental and paleoecological information. Such knowledge may be useful for the protection and preservation of the currently surviving native ecosystems. Fossil remains are commonly found in swamp deposits where animals have become trapped and subsequently preserved under anoxic conditions.

Fossil deposits are common within swamps of the North Canterbury fold and fault zone. Damage or destruction of the fossil remains is common when there is no prior knowledge of their existence. A non-destructive, inexpensive and rapid method of detection would allow protection and preservation of more sites to allow both an increased knowledge base of our past and to preserve New Zealand's valuable heritage.

Near-surface geophysical methods such as electromagnetic (EM) methods and ground-penetrating radar (GPR) are commonly used in non-invasive, non-destructive surveys for archaeological and forensic studies. Geophysical methods do not require exposure of the subsurface and are relatively straightforward to apply. However, little research has gone into the search for fossilised bones using geophysical methods, but the nature of the methods suggests that such applications could succeed.

This study is the first systematic investigation into the use of near-surface geophysics for identification of fossil deposits in New Zealand. Three contrasting swamp sites have been studied in the North Canterbury region using a combination of EM, GPR and resistivity methods. Calibration with the subsurface sediments has revealed a number of distinctive features of these sites that hindered the potential for these methods, but also provides important insight into the Quaternary paleoenvironmental characteristics of the North Canterbury region and the formation of swamp deposits.

The investigations show that GPR is likely to be hindered in North Canterbury due to the common occurrence of high conductivity sediments, whereas EM is a useful tool in determining subsurface characteristics often not discernible from the surface and this may guide the location of remains within the deposits. The ability to confirm the presence or absence of fossil remains, however, is not currently possible using geophysical methods.

TERRESTRIAL CLIMATE AND ENVIRONMENTAL HISTORY FROM PHYTOLITH OCCLUDED CARBON

John Carter
Victoria University of Wellington

This aim of this project is to provide a unique insight in global atmospheric CO_2 variation over the last 125,000 years. The major line of investigation is to develop a method to reconstruct the past terrestrial carbon dioxide record by measuring the changes in carbon isotope ratios in phytolith occluded carbon and relating these changes to changes in atmospheric carbon dioxide concentration. An adjunct study is to provide a method of relating DNA from phytolith-occluded carbon to species of phytolith origin.

Plant phytoliths are microscopic opaline particles formed in plant cells. They are produced in many living plant cells as the cell fills with silica, forming a solid body. Fragments of the original cellular material are often trapped inside the silica body. Phytoliths are highly resistant to decomposition, thereby protecting the original cellular material from post-depositional contamination, and these phytoliths are released directly to the adjacent soil when a plant dies and decays. Phytoliths exist as stable entities in sediments for long periods of time and morphological analysis has been widely used to reconstruct vegetation histories.

This study has established a relationship between the carbon isotopic ratios of the vegetable matter and the phytolith occluded carbon for a number of modern New Zealand indigenous species of grasses, trees, shrubs and ferns. Following these initial experiments, data will be collected for a terrestrial CO_2 curve from the last interglacial (~ 125,000 yr BP) to the present. The data will provide additional information to as how vegetation patterns changed in response to climatic changes through time. A 10-meter loess deposit in the Wairarapa has been identified and cored. Phytoliths have been extracted and assemblages calculated for suitability for carbon isotope analysis. An initial two samples from the core have been analysed. One sample, from the Last Glacial Maximum, consisting of mainly grass phytoliths, and another from Marine Isotope Stage 3 of mainly tree and shrub phytoliths.

SOUTH ISLAND AND ANTARCTIC QUATERNARY CLIMATE AT ODP SITE 1119, CANTERBURY BIGHT

Carter, R.M.
Department of Geology & Geophysics, University of Adelaide
Marine Geophysical Laboratory, James Cook University

ODP site 1119 is located at water depth 396 m near the subtropical front (STF), and just downslope from the shelf edge of eastern South Island. The site contains an expanded stratigraphic record of Quaternary oceanographic change. Four palaeoceanographic proxy measures vary in consonance with the main lithological glacial-integlacial cyclicity at the site. Interglacial intervals are characterised by high $\delta^{13}C$ and colour reflectance (a proxy for carbonate content), and low γ-ray (a proxy for clay content) and $\delta^{18}O$; conversely, glacial intervals exhibit low $\delta^{13}C$ and reflectance, and high gamma ray and $\delta^{18}O$. Early interglacial intervals are represented by silty clays which enclose intervals of 10-65 cm thick, sharp-based, *Chondrites*-burrowed, shelly, graded, very fine sands. The sands are rich in foraminifers, including species of warm water affinities, and were deposited distant from the shoreline in deep water and under the influence of longitudinal flow along the STF. The enclosing glacial units, which comprise mostly micaceous silty clay, though with some thin (3-25 cm thick) sands present also at peak cold periods, contain the cold-water scallop *Zygochlamys delicatula*.

The 1119 core records the seaward movement of the STF during glacial periods, accompanied by the incursion then of warmer subtropical water above the site, and landward movement during interglacials, resulting in a dominant influence then of colder subantartic surface water. Intervals of thin, sharp-based, graded sands-muds occur within cold periods MIS 2-3, 6.2 and 7.4. These sands indicate the onset of intermittent bottom currents caused by strengthened frontal flows along an STF which lay east of site 1119, in relatively close proximity to seaward-encroaching subantarctic waters within the Bounty gyre.

Back to ~340,000 ybp, the climatic history of site 1119, and especially the gamma ray record, matches closely that of the Vostok ice core. A close climatic coupling is demonstrated between the waxing and waning of glaciers in the Southern Alps and on the Antarctic ice cap. For the period older than 340 kybp, and back to the base of the core at ~3.6 mybp, the 1119 core provides a unique planetary archive which reflects Antarctic climate history.

DOWNSTEPPING REEF CYCLES, LATE QUATERNARY SEA LEVEL CHANGES, ICE-CYCLES AND ISOTOPES

John Chappell
Research School of Earth Sciences,
Australian National University, Canberra

Introduction. Fluctuating ice-house conditions set in during the later Cenozoic, affecting all components of the climate system: continental ice sheets, the oceans, sea-ice and vegetation. The atmosphere varied not only in circulation but also in its greenhouse gases and dust load. Cycles of ice-sheet advance and retreat were synchronised by orbitally-driven ("Milankovitch") variations of seasonal radiation, but superimposed on these were much shorter ("millenial-scale") shifts of climate - as shown by oxygen isotopes in Greenland ice cores and sediments from several marine basins. A number of theories seek to explain the millenial-scale changes, ranging from luni-solar forcing to unstable behaviour of the ice-sheets, plus feedbacks between ice and the thermohaline circulation, methane pulses from the oceans and fluctuating atmospheric dust. Critical to each is the exact timing of events throughout the system, such as sea level and isotopic peaks.

Sea levels. Upper Quaternary sea level changes are recorded in coral reef terraces at Huon Peninsula (HP) in Papua New Guinea. The sequence of downstepping reef cycles includes major, trangressive reef tracts topped by ancient lagoons and barriers, formed during sea level rises of ~100 m at terminations of major glacial cycles. These are separated by downstepping sequences of smaller reef tracts that formed during sea level fluctuations of 10-50 m within each glacial period. The relative sea level history is derived with the aid of $^{230}Th/^{234}U$ age measurements of corals and is reduced to a regional sea level curve by subtracting tectonic uplift. Results are tested by comparing by computer simulations of downstepping reefs with the observed stratigraphy (Figure 1A). Taking global isostasy into account, the regional HP sea level curve (Figure 1B) was converted to a curve of global ice-volume over the last glacial cycle (Lambeck and Chappell 2001).

Ice-cycles. As with Quaternary marine isotope records, HP sea levels show cyclic patterns at dominant Milankovitch periods (~20 and 42 ka). Within the last glacial cycle, the HP record also shows oscillations with amplitudes ranging from ~9 m to >20 m between 30 and 65 ka. Comparisons with North Atlantic marine cores reveal that sea level highstands follow episodes of ice-rafted detritus (IRD) from Labrador in north Atlantic marine sediments, at 38, 44.5 and 52 ka (Heinrich events 4, 5 and 5.2: van Kreveld et al. 2000), and probably at 58-60 ka. Table 1 summarises details of these events. The rates of sea level rise, constrained by HP terrace geometry and thicknesses of shallow-water reef, suggest that each Heinrich ice retreat was progressive rather than catastrophic. Evidence from marine cores shows that abrupt D-O warming occurred as IRD deposition ceased, which occurred at or shortly before the termination of sea level rise (Table 1). Simultaneous IRD from Greenland and the Laurentide sheets suggests that ice breakout from both sources had a common trigger. This is unlikely to be atmospheric forcing because SST and Greenland isotopic temperatures rise at the end of each breakout, not at the beginning. A sea level rise could act as a trigger when both sheets are potentially unstable: a rise caused by breakout from one could initiate breakout of the other.

Oxygen isotopes. Because ^{18}O relative to ^{16}O in ice sheets is depleted compared with the ocean, the oceanic isotope composition varies with ice volume. Hence, oxygen isotopes from marine sediments are widely used as proxy records of ice volume or sea level. However, the oxygen isotope composition of microfossil in marine sediments varies not only with ice volume but also with temperature and salinity. For a given cycle,

(1) $\Delta\delta^{18}O = \Delta\delta^{18}O_S + \Delta\delta^{18}O_T + \varepsilon$, with $\Delta\delta^{18}O_S = k_S \Delta S$ and $\Delta\delta^{18}O_T = k_T \Delta T$,

where $\Delta\delta^{18}O = (\delta^{18}O_{max} - \delta^{18}O_{min})$, sub-$_S$ and -$_T$ refer to sea level and temperature, and ε covers the effects of any change of oceanic salinity gradients. The temperature coefficient is well established (k_T = -0.23 ‰ ºC^{-1}), but k_S depends on both the volume and the isotopic composition of ice melted (deposited) during a given sea level rise and differs with the method of calculation. Based on pore-water $\delta^{18}O$ in marine cores (Schrag et al. 1996) and Lambeck & Chappell's (2001) sea level for the last glacial maximum (LGM), k_S = -0.007±0.0005 ‰ m^{-1}. Earlier, on the basis of HP sea levels and benthic isotopes within the last glacial period, Chappell and Shackleton (1986) evaluated k_S as close to -0.01 ‰ m^{-1}, and also estimated that about 25% of the glacial-interglacial variation in Pacific benthic isotopes arises from changes of ~1.5°C in deep water temperatures.

Although ice volume is the major signal in benthic $\delta^{18}O$ at Milankovitch time scales, temperature can dominate these records at millenial scales. Benthic isotopes from a high-resolution core taken near Portugal (MD95-2042: Shackleton et al. 2000) co-vary with HP sea levels (Table 1). Using (1) to calculate temperature changes from these data (assuming ε = 0 and using an upper-limit value of -0.01‰ m^{-1} for k_S), deep Atlantic temperatures rose by 0.6-2.1°C during Heinrich events H4 - H6. These shifts are quite large compared with the full interglacial-glacial temperature shift in the deep ocean (Pacific ~1.5-2.5°C; Atlantic 2-4°C), and comprise 50-80% of the isotopic signal.

Conclusions Sea level is a primary parameter of the earth system at all scales, from the domain of human experience (e.g. tides; ENSO) to the geologic realms of sea floor spreading and continental drift. In analysing the dualism between regional sea level and sequence stratigraphy, and by reducing regional sea level changes to global curves, Peter Vail and his colleagues have provided keys to other components of the earth system, such as global tectonics or glacial cycles. The stratigraphic analysis of Huon Peninsula sea levels and their reduction to a global ice-volume-equivalent curve illustrates this. Without sea levels, oxygen isotope records cannot fully be interpreted; with sea levels and isotopes together, past behaviour of the complex earth becomes more intelligible.

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TABLE 1: Timing of key sea level and abrupt warming events

HP reef	IIb	IIa	IIIb	IIIam	IIIau
Highstand age (ka)	33	38	44.5	52	60
Lowstand age (ka)	34	40	46	54	62
Highstand sl. (m)	-72	-71	-56	-46	-50
Minimum sl. rise ΔS (m),	9	9	14	16	26
GISP-2 Interstadial[1]	DO5	DO8	DO12	DO14	DO17
D-O warming (ka)	***32.3***	***38.4***	***45.4***	***52.2***	***58.5***
Heinrich number[2]	-	H4	H5	H5.2	H6?
IRD, start age (ka)	32.6	39.4	45.8	53.5	-
IRD, finish age (ka)	32.3	38.4	45.4	51.5	-
N.Atlantic benthic $\delta^{18}O$ (core MD95-2042[3])					
Highstand (ka)	?	38.4	45.3	51.7	57.7
Lowstand (ka)	-	40.1	47.6	55.0	61.1
High-Low $\Delta\delta^{18}O$ ‰	-	0.35	0.52	0.27	0.7
Temperature rise, °C	-	1.2	1.8	0.6	2.1

Notes: [1]D-O warmings from GISP-2 (Stuiver and Grootes 2000); [2]Heinrich events and Greenland-Labrador IRD (van Kreveld et al. 2000); [3]Shackleton et al. (2000).

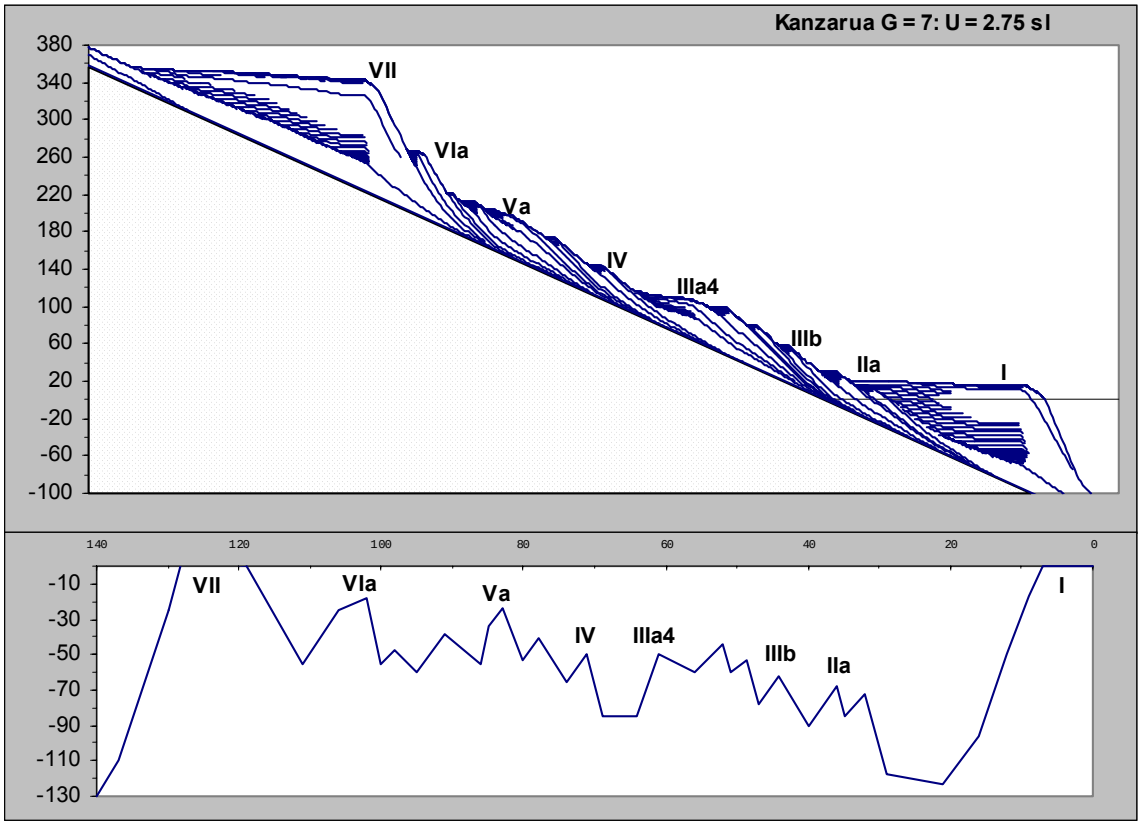

Figure 1. (A) Model section of downstepping reef tracts at Kanzarua, HP, (uplift rate 2.75 m.ka^{-1}) showing shallow transgressive facies (hatchured) plus high- and lowstand surfaces, generated by sea level curve at (B). The model closely fits the observed section.

RELIMINARY PALYNOLOGICAL INVESTIGATIONS IN THE CAUCASUS

Simon E. Connor
School of Anthropology, Geography and Environmental Studies
University of Melbourne, Victoria, Australia

Vegetation and modern pollen representation have been surveyed in the southern part of formerly-Soviet Georgia. Eight lake and swamp sites were sampled along an altitudinal transect, passing through treeless semidesert, oak-dominated forest and subalpine grassland environments with varying degrees of human impact.

Recent sediments from saline swamps in the semidesert region of Gareji are dominated by Chenopodiaceae, Poaceae and Polygonaceae, with very little representation of arboreal taxa. High charcoal counts attest to the annual firing of the landscape by local herders. The representation of trees increases as one approaches the forest belt, where *Pinus, Quercus, Fagus* and *Carpinus* are well represented in pollen counts and vegetation surveys. Surprisingly, it is in the subalpine and alpine meadows where arboreal pollen percentages are greatest, suggesting a strong regional input and low pollen production from local sources. The identification of Holocene tree-line shifts thus relies heavily on the presence or absence of indicator species.

A late-Holocene pollen record from the Pasinler Valley, eastern Turkey, provides evidence of relative stability in high-diversity subalpine rangelands under a regime of burning and extensive cattle grazing.

THE GULF OF CARPENTARIA THROUGH THE LATE PLEISTOCENE: COCCOLITH EVIDENCE AND OSL DATING

Martine Couapel,

University of Wollongong, Australia; mjjc01@uow.edu.au

The Gulf of Carpentaria is a near-equatorial region, a domain in which past environmental changes are not well understood, but in which much of the world's weather has its origin. Indeed this region could be a key point to monitor the palaeocirculation between the Pacific and the Indian oceans that records the switching on and off of the global thermohaline circulation during glacial/interglacial alternations. This circulation is driven by sea-level and climate changes and influences the regional palaeoceanographic conditions. Being situated adjacent to the Western Pacific Warm Pool, responsible for the largest transfer of heat and moisture between the surface and the atmosphere, the Gulf of Carpentaria is an epicontinental sea (maximum depth 70 m) bordered to the east by Torres Strait (12 m depth) and to the west by the deeper Arafura Sill (53 m depth). Throughout the Late Quaternary, during times of sea-level low-stands, the gulf was separated from the open waters of the Indian and Pacific oceans, forming Lake Carpentaria with outlet channels to the Arafura Sea.

In 1997, six sediment cores were collected from the Gulf of Carpentaria using a giant piston-corer deployed from the *Marion Dufresne*, as part of the International MArine Global changEs Study (IMAGES). These cores reached depths of 6 to ~15 m, encompassing the environmental history of this area for the last 130 ka. This study involves the two longest cores, MD972131 and MD972132, respectively collected from 59 and 64 m water depth, close to the modern centre of the basin.

Coccolithophores are planktonic marine algae distributed from the open ocean to nearshore littoral and lagoonal environments. They secrete minute calcified plates, coccoliths, which are a major component of pelagic carbonates. Coccolith assemblages preserved in marine sediments are excellent proxies of palaeoceanographic conditions. The lack of coccoliths could be either due to bad preservation conditions or to a freshwater environment. Environmental stress is implicated by the degree of dissolution and the morphological variations of coccoliths. In the Gulf of Caropentaria, coccolith assemblages confirm at least two non-marine/marine cycles, during the past 130 ka, as well as some short marine intervals, as minor incursions of seawater during a non-marine sequence.

The shallowness of the Gulf of Carpentaria, as well as its restricted basinsize, allows the use of Optically Stimulated Luminescence (OSL) to date the sediment. Indeed, these parameters mean that the quartz grains were bleached soon before deposition and thus that the event date is also the time of deposition.

THE ROLE OF TROPICAL OCEANS IN CLIMATE FORCING: EVIDENCE FROM THE INDO-PACIFIC WARM POOL DURING THE LATE QUATERNARY

Patrick De Deckker
Department of Geology, The Australian National University, Canberra ACT 0200. Australia.
e-mail: patrick.dedeckker@anu.edu.au

Tropical oceanic water that surrounds Southeast Asia and northern Australia today is characterised by constantly high (>28°C) sea-surface temperatures, a low-salinity and shallow 'cap' called the barrier layer that prevents much exchange with the deeper water and the atmosphere. This region, abbreviated to the Warm Pool, sees the formation of high convective clouds that are critical to climate forcings on either sides of the Pacific and Indian Oceans. Today, the Warm Pool is the location of vast amounts of moisture and heat exchange between the atmosphere and the oceans, with ensuing contrasting monsoonal climates that affect the bordering land masses and its people and biota.

I will argue that any slight change in sea-surface temperature in the Warm Pool, and/or a change in the ocean to land ratio - the latter resulting from cyclic sea level changes so typical of the Quaternary - can substantial consequences for climate, very likely on a global scale.

A reduction in deep convective clouds over the Indo-Pacific Warm Pool would engender the following:
(1) increase the radiative loss to the upper atmosphere, thus causing its cooling, but also force sea-surface surface heating associated with strong diurnal temperature contrasts on land;
(2) change the precipitation/evaporation ratio over the Warm Pool region and associated landmasses, and also change the moisture of the upper atmosphere;
(3) destabilise the upper layers of the oceans, and alter the freshwater flux to the global ocean (and consequently affect its upper layer density);
(4) alter wind regimes, their strengths and patterns in the region. This would eventually cause significant changes in the upper layers of the Indian and Pacific Oceans at least;
(5) alter the poleward transport of heat and moisture, thus affecting the characteristics and formation of oceanic deep water, and lapse rates in the tropics; and
(6) the albedo ratio between land and ocean.

In-situ cosmogenic radionuclides for dates and rates !

David FINK
Physics Division, ANSTO, PMB 1, Menai, NSW 2234 Australia

Earth scientists have long sought an analytical technique based on radiometric methods that would quantify both temporally and spatially, the chronology of exposed bedrock surfaces and the magnitude of geomorphologic processes of landscape change. Such a technique is now developing based on the in-situ production of long-lived cosmogenic radioisotopes ^{10}Be ($T_{1/2}$=1.5Ma), ^{26}Al (0.7Ma) and ^{36}Cl (0.3Ma) by cosmic ray bombardment of exposed rocks, surfaces and within the first meter or so of the Earth's crust.

Production of these cosmogenic radionuclides (CRN) takes place predominately in the upper atmosphere. Through atmospheric transport and precipitation, they become distributed over the earth's surface and can be used as tracers and clocks of various geophysical and geochemical global process (ie radiocarbon dating). An additional production mode of CRNs is in the first few meters of the earth's lithosphere. In contrast, the rate of in-situ production in surface rocks is extremely low - a few tens of atoms per gram per year. However, the ultrasensitive technique of Accelerator Mass Spectrometry (AMS) with a detection limit of ~100,000 atoms, can now be used to readily measure this telltale signal. Meaningful measurements can be made with as little as ~100 grams of rock sample exposed at sea-level for times as short as a few thousand years. With half-lives ranging from 0.3 to 1.5 Ma, they are ideally suited to study Quaternary geomorphology and paleoclimate change.

The build up over time of in-situ radioisotope concentrations can be utilised as radiometric clocks to elucidate an "exposure history" of a rock surface or landform. Alternatively, if exposure has been sufficiently long for the in-situ signal to reach equilibrium, only an estimate of the long-term erosion rate (averaged over a few half-lives) can be determined. Improvements in AMS practices, refinement of production rates, and improved multi-isotope modelling have provided a strong foundation for a robust and mature technique. Recently a new dimension has been added to the versatility of applications of in-situ CRNs through the integration of exposure age dating with various other geochronological techniques, such as thermoluminescence (and OSL), apatite fission track and U-Th/He thermochronology, noble gas ages, and Ar-Ar.

In addition to providing 'simple model' ages for glacial moraine deposits and bedrock erosion rates, CRNs are now applied to more complex scenarios such as soil production rates, burial histories, regolith accumulation rates, escarpment retreat, river incision rates and terrace ages, large scale (regional) sediment tracing and catchment evolution processes, alluvium deposition and fault ages.

The talk will present an overall picture of the cosmogenic radionuclide method in the earth sciences, describing the basic ideas and principles. It will highlight some of the complexities and limitations involved in converting measurements of radionuclide atom concentrations made by AMS into meaningful parameters which can be used to better understand geomorpholgical processes. Some select examples of applications will be described and the talk will conclude with some insights and ideas to what lies ahead for in-situ cosmogenic dating.

THE LAST DEGLACIATION IN THE SOUTHERN HEMISPHERE - CAN COSMOGENIC EXPOSURE DATING FIND THE YOUNGER DRYAS?

David Fink[1], Mike Prentice [2], Paul Augustinus [3] And James Shulmeister [4]
1 Physics Division, ANSTO, PMB 1, Menai, NSW 2234 Australia
2 Climate Change Research Center, Univ of New Hampshire, Durham, NH, 03824, USA
3 Dept of Geology, University of Auckland, Auckland, New Zealand
4 Dept of Geological Sciences, Univ of Canterbury, Christchurch, New Zealand

The Younger Dryas (YD) was a major short-term and intense climatic reversal towards colder temperatures between 11,500-12,800 cal year BP superimposed on the last deglaciation. Recently, investigations have centered on searching for a similar cooling reversal in the Southern Hemisphere that is coeval with the Northern Hemisphere YD chronozone. The implications of such an appraisal are significant as a positive outcome directly supports the presence of a global triggering mechanism coupled with climate change synchronicity across the equator.

We have sampled 104 glacially transported boulders from moraine sequences within glacial valleys covering latitudes from the equator to 50^{o} S to produce a series of exposure ages using both in-situ cosmogenic ^{10}Be and ^{26}Al as a measure of continental deglaciation. The sites selected were Mt Trikora region, Irian Jaya, (3500masl), Cobb Valley, South Island, New Zealand (1100m), and the West Coast Ranges, Tasmania (three sites; 600-1000m). All sites displayed evidence of late Pleistocene glacial activity and of the total boulder set, 83 were derived from moraines identified to be of the last deglaciation period (ie younger than ~25ka). This data set offers the possibility to determine the timing of the LGM and the most recent glacial re-advance during the last deglaciation in the Southern Hemisphere.

A subset of this population (N=44) were from perched moraine boulders classified as either proximal terminal, cirque or the youngest recessional moraine based on geomorphic field evidence. At each site, sample multiplicity was high and, critically, paired ^{10}Be and ^{26}Al exposure ages allowed rejection of outliers inconsistent with simple, single-stage exposure (n=1) or with inherited ages (n=10). Of the remaining 33 samples, only 3 have either a ^{10}Be or an ^{26}Al age within the YD chronozone (ie 11-13ka) – none has both. For ^{26}Al, this increases to 6 if we include ages where the 1-sigma age error (typically ~8-12%) intercepts the YD upper limit of 13ka. No ^{10}Be ages fit this criteria. Production rates of 5.1 and 31.7 at/g-Q/a for ^{10}Be and ^{26}Al were used. Corrections for sample thickness, shielding and surface erosion are included and increase ages by about 5-7%; geomagnetic field variations are not yet included.

For the Southern Hemisphere locations investigated in this work, our exposure ages suggest an absence of a glacial readvance coeval with the Northern Hemisphere YD and that these valleys were effectively ice-free 15-16ka years ago. Alternatively, we acknowledge site-specific sensitivity of ice conditions to climate change, and the possibility that, YD-type cooling was of a minor intensity resulting in an absence of moraine material amenable for exposure age dating.

HOLOCENE STABILITY OF TASMANIAN BUTTONGRASS MOORLANDS

Michael-Shawn Fletcher
University of Melbourne

The response of plants with well dispersed pollen to the termination of the Last Glacial Maximum and the Holocene are well understood in the cool perhumid environs of western Tasmania. An up-slope migration of rainforest taxa is evident in all palynological studies of the region, as is a mid-Holocene rainforest maxima, assumed to indicate a climatic optimum, and a late-Holocene regression of rainforest species. It is thought that the present day heterogeneous mix of fire sensitive rainforest and fire promoted Buttongrass Moor is the result of the increased effectiveness of fire in the face of late-Holocene climatic deterioration. It is also thought that fire has acted to expand Buttongrass (*Gymnoschoenus sphaerocephalus*) from poorly drained areas onto well-drained hill slopes, formerly occupied by rainforest.

There has been a bias toward high altitude and/or forested sites in the reconstruction of the palynofloras of this region. As a consequence, the possibility of large tracts of treeless areas persisting throughout the Holocene has been over looked. The region wide absence of pollen from *G. sphaerocephalus* from all but two lowland Buttongrass studies should be considered conspicuous. Modern pollen data collected in this study highlights the "invisible" nature of *G. sphaerocephalus* in the modern pollen rain. *G. sphaerocephalus* is a rhizotomous species (a Cyperaceae) that has adapted to living in oligotrophic conditions. It is able to quickly invade freshly burnt areas, inducing ponding and impeding drainage and forming a barrier to other vegetation types.

Recent results from a number of moorlands throughout the, wetter, western half of Tasmania indicate that little has changed, at the local scale, throughout the Holocene. The region wide signature of expansion, optimum and regression of rainforest taxa is present, but not enough to suggest a replacement of moorland by rainforest.

THE HISTORY OF ALGAL BLOOMS IN THE MYALL LAKES, NSW

Iona Flett[1], Henk Heijnis[2], Kate Harle[2], Greg Skilbeck[1]
[1]Department of Environmental Science, University of Technology, Sydney, Broadway, NSW 2007
[2]Environment Division, Australian Nuclear Science and Tehnology Organisation,PMG1, Menai, NSW 2234

The Myall Lakes, 50km North of Newcastle, Australia, are quite unique among the hundreds of coastal lakes lining the NSW coast. They are a barrier lake system covering 10 000ha, and are brackish (ranging from Oligohaline to Mesohaline under the Venice System classification), with only two small streams providing a freshwater input. Flushing times for some parts of the Lakes are in the order of 600 days. This long water-retention time is of concern, because any changes to nutrient regimes, or pollution in the catchment affecting the Lakes, may take a long time to be corrected. So far, the Myall Lakes are far less disturbed than similar coastal lakes, and as an important migratory bird habitat, they are protected under the RAMSAR agreement. They are also fully encompassed by the Myall Lakes National Park, declared in 1972, and are important to the local tourism and fisheries industries. Concern has arisen, however, over a series of cyanobacteria blooms in recent summers. Are these blooms an indication that human influences are affecting the Myall Lakes?

Four sediment cores, up to 95cm long, were taken in February and September this year. Sub-samples taken at 0.5cm intervals were analysed for trace elements, palynological assemblages, sediment grain size and organic/carbonate content. ^{210}Pb was used to date the cores and determine sedimentation rates. An important aspect of this investigation was the use of fossilised algal remains, specifically the akinetes of cyanobacteria, to estimate previous algal populations in the lake system. Preliminary results indicate that there have been cyclical fluctuations in the populations of aquatic plants and algae throughout recent history. Population trends and the likelihood of their relationship to anthropogenic influences on the catchment will be discussed.

The reconstruction of past environments using fossilised cyanobacteria has the potential to be an important tool in catchment management.

A LAKE SEDIMENT RECORD OF LATE HOLOCENE ENVIRONMENTAL CHANGE AND EUROPEAN SETTLEMENT IMPACTS IN EASTERN NSW, AUSTRALIA

Nikki Franklin[1]*, Stephen GALE[1], Kate Harle[2] & Henk Heijnis[2]
[1]Division of Geography, School of Geosciences, University of Sydney, Sydney, NSW 2006
[2] Australian Nuclear Science and Technology Organisation, Private Mail Bag 1, Menai, NSW 2234
*Email: nfrankli@mail.usyd.edu.au

The late Holocene period has seen a dramatic increase in the human impact on the environment and in Australia, the start of permanent European settlement and land use. A reliable record of environmental change during this period is therefore essential for any attempt to predict future human-induced changes on the environment.

This study reconstructs environmental conditions throughout the late Holocene at Redhead Lagoon, an enclosed lake basin located within the Newcastle region of NSW, by the use of various palaeoecological and sedimentological analyses of the lake sediments. A geochronology for the upper part of the sedimentary sequence has been established using both caesium-137 and lead-210 techniques in combination with a variety of historical markers in the sediments. These include an influx of European pollen and trace heavy metal fallout which is attributed to the start of production at the nearby Cockle Creek Pb-Zn smelter. Two basal dates have been provided by AMS Radiocarbon analysis, indicating that the sequence extends back to mid Holocene times. This has allowed the construction of baseline data for the pre-European landscape in the area, so that a more reliable assessment of the impacts of subsequent European land use practices and activities can be made.

Research of historical accounts has uncovered a variety of human land uses in the region. The area was originally used as a camping ground for the Awabakal Aborigines. Europeans settled around the lagoon permanently in the 1860s, and soon after cleared for small-scale agricultural activities. Subsequent activities that dramatically modified the landscape within the catchment include the establishment of a colliery in the 1890s and a phase of large-scale urbanisation, which began in the 1960s. The latest phase has been the establishment of a nature reserve since the 1970s.

The sedimentary, pollen and charcoal records indicate that the vegetation and landscape of the catchment area has been very sensitive to the varying human land uses and practices since European settlement in the region. After European settlement, both sedimentation rates and charcoal preserved within the sediments increase significantly and changes in the vegetation and lake levels are evident. The most significant and damaging impacts of European settlement occurred during the initial post-contact period probably as a result of activities such as clearance of the land for settlement and orchards, and coal mining within the catchment area.

PALEOENVIRONMENTS OF THE PAROO REGION, FAR NORTH-WESTERN NSW.

L. Gayler and S. Pearson
School of Environmental and Life Sciences, University of Newcastle, Callaghan NSW 2308
e-mail: lucyna.gayler@studentmail.newcastle.edu.au or l_gayler@yahoo.com

Preliminary sampling of lakes in the semi-arid Paroo Region led to selection of a small playa for reconstruction of palaeoenvironmental conditions. Given the ephemeral nature of the playa and bordering dune construction, some gaps in the record were expected. To improve the continuity of the record, analyses have included palynological, geomorphological and sedimentological techniques. Bordering gypsum and sand dunes were cored to detect sediment deflation from the lake basin and indicate discontinuities in the lake sediment record. Dune and lake sediments were described using texture characteristics, mineral magnetic susceptibility, organic matter content, pH, salinity, gypsum, caesium-137 content, mineral composition and zooplankton content (Figure 1; Pearson et al. 2001).

Four distinctive stages in the environmental history of the playa have been identified: a large/deep lake stage (possibly 50-25 Ka), a drying lake stage (30-18 Ka), a fluctuating water stage (25-15Ka, incl. C^{14} date of 14400±150BP close to the top of the sequence), and a recent ephemeral lake stage. These match signals in other arid and semi-arid zone lakes, such as L. Eyre, L. Tyrell, and Willandra Lakes.

Following the success of the preliminary study, five other lakes have been cored in the Paroo Region. The lakes were selected to represent different drying regimes (size), origin (e.g. playa and waterhole along a creek line), and characteristics (e.g. fresh, saline and hypersaline). Each of those environments preserves different diagnostic features, such as pollen, phytoliths, zooplankton and gypsum. Those are supported by analysis of general sediment texture and characteristics, mineral content (XRD), organic matter content and mineral magnetic susceptibility. Compared they will complement each other filling in the gaps and creating high resolution paleoenvironmental history of the region. Considering the climate record for the Paroo region consists of only just over 100 years of weather observations, this project is crucial for regional long-term planning with respect to the future directions in climate change and water availability. In addition, the revised methodology (to cater for the unique needs of the semi-arid, incl. ephemeral lake, environment) will aid research projects in other arid and semi-arid regions.

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LATE-TWENTIETH CENTURY ENSO VARIABILITY IN THE CONTEXT OF HOLOCENE CLIMATIC CHANGE.

Joelle Gergis.
School of Biological, Earth and Environmental Sciences
University of New South Wales, Sydney Australia.
Email: jgergis@unsw.edu.au

El Niño Southern Oscillation (ENSO) phenomenon is a complex interaction of ocean-atmospheric processes resulting in a massive redistribution of climatic regimes. It is a natural part of the global climate system recognised as being the most potent source of global annual climate variability (Wang *et al.*, 1999; Allan, 2000). ENSO events result in a far-reaching system of climate anomalies which influence climate variability worldwide over a range of time scales important to society (Dunbar and Cole, 1999). ENSO is known to modulate climatic extremes such as drought, flooding, bushfires and tropical cyclone activity across vast areas of the Earth, affecting hundreds of millions of people, having multi-billion dollar impacts on economies worldwide (Dunbar and Cole, 1999).

The primary aim of this research is to investigate some of the key uncertainties associated with the nature and long-term history of the El Niño Southern Oscillation (ENSO) phenomenon. This study will contribute to the understanding of the amplitude, frequency and duration of late Twentieth Century ENSO events, and the spatial extent of teleconnection patterns and signatures, in relation to a variety of long-term climatic records such as coral, tree-ring and ice core sequences. This involves the creation of a comprehensive, multiproxy framework, predominately derived from Southern Hemisphere locations, in which past ENSO events can be assessed. This is achieved by analysing, comparing and integrating numerous highly resolved, spatially distributed palaeoclimatic indicators responding to different aspects of the ENSO phenomenon, allowing the patterns of variability operating within the climate system over seasonal to century time scales to be evaluated. This objective will also incorporate an investigation of the use of appropriate ENSO indices in climatic reconstructions through the incorporation of other climatic oscillation indices such as the Pacific Decadal Oscillation. Preliminary results generated to date will be presented.

Furthermore, this study will be contributing to the few high-resolution ENSO teleconnection records currently known from global climatic sequences by addressing the "data gap" of the Southern Hemisphere mid-latitude locations, recognised by the international climate programmes such as Climate Variability and Predictability (CLIVAR), Past Global Changes (PAGES) and Annual Records of Tropical Systems (ARTS), as being a area of significant research priority (Dunbar and Cole, 1999). This involves active collaborative with researchers from the University of Auckland who have published a dendrochronological sequence of the New Zealand Kauri (*Agathis australis*) which displays a relationship between kauri growth and the Southern Oscillation Index (SOI). This represents an excellent opportunity for long-term ENSO reconstruction from the currently under-represented southern latitudes of the globe (Buckley *et al.*, 2000; Fowler *et al.*, 2000.

This study will contribute to the near-continuous 4,000-year Kauri chronology by updating some of the modern Kauri records to include extreme ENSO events of the 1990s, allowing the nature of Late Twentieth Century ENSO-related climatic anomalies to be assessed. Resolving such uncertainties would not only represent a significant advance in the understanding of the global climate system, but would generate significant innovation in the skill of ENSO prediction (Dunbar and Cole, 1999). This has practical relevance to the implementation of appropriate mitigation strategies and the minimisation of the impacts of climatic extremes associated with ENSO episodes.

LASER ABLATION ICP MS ANALYSIS FOR THE DETERMINATION OF U-CONCENTRATION PROFILES AND *IN SITU* U-SERIES DATING

Rainer Grün, Stephen Eggins and Michael Shelley
The Australian National University

We have conducted an exploratory study to assess the feasibility of employing laser ablation ICP-MS to profile U concentrations and to measure U-series disequilibria on human and faunal fossils. Compared to micro-drilling a small number of spots (e.g. 8 along a profile of 2 mm), laser ablation offers a number of clear advantages;

- continuous profiling with very high spatial resolution (<50 microns);
- a total analysis time of only a few minutes;
- minimal and straightforward sample preparation, and can be carried out over a relatively flat yet rough surface such as presented by a break (though planar polished surfaces are ideal).

Moreover, valuable new information has already been obtained from our preliminary investigations using laser ablation ICP-MS, namely:

- the partitioning of U between dentine and enamel is much higher then expected;
- the boundary between dentine and enamel is very sharp;
- the U-concentration in dentine is very homogeneous;
- uranium tends to migrate predominantly from the dentine into the enamel, rather than from the outer (sediment) side (confirming earlier observations of Grün et al. 1999);
- many enamel samples do not show the U-concentration profiles predicted by the D-A model;
- enamel samples that do show a χ-shaped U-concentration profile had diffusion coefficients that are many orders of magnitude smaller than predicted by the D-A model; and
- the ^{232}Th concentrations in dentine and enamel are very low (< 0.01 ppm).

To test the *in situ* U-series dating capabilities of laser ablation ICP-MS, we applied the technique to a 4 million year old hippopotamus tooth. The U-concentrations in the dentine are of the order of 200 ppm. The ^{230}Th/ ^{234}U ratio has been able to be determined with a precision of better than 2%, and agrees well with a TIMS U-series analysis. Surprisingly, this ratio indicates a very recent U-mobilisation within the dentine. The laser ablation profile also defines a central region that is virtually U-free, and reveals the outer region to be in or near Th/U equilibrium, also in agreement with TIMS results. These data were obtained using a relatively low sensitivity quadrupole mass spectrometer yet clearly demonstrate the techniques capability of *in-situ* Th/U dating. By employing the far more sensitive multi-collector sector mass-spectrometer, a sensitivity increase of about 20 to 50 can be achieved, and much more precise isotope ratios be measured. This will allow *in situ* Th/U dating of materials with U-concentrations as low as 1 ppm.

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ABRUPT ENVIRONMENTAL CHANGE OVER THE LGM-HOLOCENE TRANSITION RECORDED IN LACUSTRINE SEDIMENTS FROM ONEPOTO MAAR CRATER, AUCKLAND

Joseph H. Hägg [1] and Paul C. Augustinus [2]
[1] School of Geography & Environmental Science, University of Auckland
[2] Department of Geology and School of Geography & Environmental Science, University of Auckland

We present the initial results from a near-continuous, high-resolution record of lacustrine sedimentation obtained from the former Onepoto Crater maar lake in the Auckland region. The section of interest spans the period from ca. 28 to 7.4 ^{14}C kyr BP during which ~ 4 m of laminated organic-rich sediments accumulated in a quiescent freshwater lake. Interbedded tephra from distal sources are present throughout the sequence, and the excellent record of rhyolitic tephra from the Taupo Volcanic Zone, supported by AMS ^{14}C ages, provides a well-constrained chronology for the sequence. Environmental changes within the lake and catchment are deduced from downcore variations in a range of physical, chemical, and biological indicators including: sediment texture, major oxide and trace element chemistry, total organic matter content, elemental carbon/nitrogen ratios, δ^{13}C, magnetic susceptibility and diatom assemblages. These indicators have allowed us to infer changes in the extent and productivity of vegetation in the lake and catchment, as well as changes in the sediment source. In particular, the bulk organic matter content of the sediments has preserved a high-resolution record of vegetation response to climate perturbations, even during climatic events that were probably insufficient to induce a major changes in the vegetation cover. Two key aspects of this record are: (a) variations in the δ^{13}C of sediments that reflects changes in water supply and atmospheric CO_2 concentrations; and (b) an indication of plant productivity from variations in the amount of organic matter incorporated into the sediments (TOC / LOI / CAR). These indicators provide a complimentary record of environmental changes, indicating: (1) an interval of low plant productivity and reduced δ^{13}C fractionation (dry) leading up to 14 ^{14}C kyr BP; when (2) there are indications of an amelioration of climate with increasing plant productivity accompanied by increased δ^{13}C fractionation (wetter and increased atmospheric and aquatic pCO_2); followed (3) by an abrupt climate reversal during the lateglacial with a marked decline in biomass productivity and δ^{13}C enrichment suggesting cooler and/or drier conditions at ~ 11-10 ^{14}C kyr BP; and finally (4) the onset of early Holocene conditions with high productivity and increased δ^{13}C fractionation. The details of the palaeoenvironmental interpretations from these and other indicators will be discussed.

The apparent reversal of the lateglacial amelioration of climate at ~11-10 ^{14}C kyr BP and bound by the Waiohau (ca. 11.9 ^{14}C kyr BP) and Opepe (ca. 9.1^{14}C kyr BP) tephra in the Onepoto Crater sediments is of particular significance to reconstructions of climates during the deglaciation in New Zealand. The presence/absence of a lateglacial climate reversal is controversial in the New Zealand context, with uncertainty arising from the nature of the proxies, and the low-resolution and poor age control of the mostly short-core pollen sequences used in the environmental reconstructions. However, the lateglacial climate reversal apparent in the Onepoto Crater record seems to correlate with that from Kaipo Bog in the eastern North Island (also constrained by Waiohau and Opepe tephra), as well as with isotopic variations in speleothems from Mt Arthur in NW Nelson, and glacial advances in the Southern Alps. This suggests that a lateglacial reversal in climate was probably a regional event, although whether it correlates with other events (YD or ACR) is still unclear.

TIMBER, TIN AND CONVICTS: EVIDENCE FOR 180 YEARS OF COLONIAL IMPACT IN WESTERN TASMANIA DERIVED FROM HIGH RESOLUTION RECORDS

Katherine J. Harle, Hendrik Heijnis and Robert Chisari
Environment Division, Australian Nuclear Science and Technology Organisation, PMB 1 Menai, NSW 2234, Australia.

Pollen, charcoal, trace metal and ^{210}Pb analyses of sediment cores obtained from several sites in western Tasmania have provided evidence of the impacts of mining and forestry in the region over the last 180 years. The sites were selected to encompass a range of environments from highly human impacted to relatively pristine. They include sub-alpine tarns and coastal lowland lakes. In the disturbed areas, the forest in the region (predominantly rainforest and wet sclerophyll) has been significantly impacted by activities associated with logging, mining and colonial settlement. In contrast, the near-pristine sites were located in areas with little disturbance, such as the Tasmanian Wilderness World Heritage Area.

Sediment cores were extracted from the sites using a modified hammer driven piston corer (Neale and Walker, 1996) and a gravity corer. Both of these enabled samples to be collected at 0.25 cm intervals. This fine sampling interval allowed high resolution records to be obtained, with each sample representing between two and 16 years of history. Lead-210 analyses was used to determine sedimentation rates and age profiles. The records derived from the cores span the period of colonial settlement in the region.

The pollen data was expressed as accumulation values to overcome the problem of statistical interdependence of taxon curves associated with expressing the data as relative percentages. This not only allowed real ecological changes to be identified but also fluctuations in the abundance of pollen. From this shifts in both community composition as well as vegetation cover could be determined. These included the effects of isolated convict logging along the Gordon River in the 1820s and 1830s and the regional loss of rainforest trees in response to increased burning caused by ore prospecting and settlement in western Tasmania from the mid-18th century (Harle et al., 2002). Charcoal records from the cores provided some evidence of the fires history of the region, although this at times did not accurately reflect the historic records. It is suspected that the charcoal records are dominated by local signals, whereas the rainforest pollen provided a regional signal.

The records of trace metal concentrations obtained demonstrated significant temporal and spatial trends. Levels of lead, copper, arsenic and tin began rising ca 1900, increased sharply in the 1950s and 1960s, then decreased in the 1970s and early 1980s. This trend was identified in several records, with levels being highest near the Queenstown mining region, and lowest in the more remote locations. These results provided clear, previously unidentified evidence for the aerial transport of trace metals across the Tasmanian landscape.

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THE USE OF ^{210}Pb, ^{226}Ra AND ^{137}Cs PROFILES IN MARINE SEDIMENTS TO ASSESS THE 'SUDDEN' OCCURRENCE OF A TOXIC DINOFLAGELLATE SPECIES IN AUSTRALIAN AND NEW ZEALAND WATERS.

H. Heijnis[1], A. McMinn[2], G. Hallegraeff[3], A. Irwin[3] and J. Harrison[1]
[1] ANSTO-Environment, New Illawarra Road, Lucas Heights 2234 NSW, Australia
[2] Institute for Antarctic and Southern Ocean Studies, University of Tasmania, Box 252-77, Hobart 7001, Tasmania, Australia
[3] School of Plant Science, University of Tasmania, Box 252-55, Hobart 7001, Tasmania, Australia

Sediment cores from Tasmania and South Australia were analysed for ^{210}Pb and ^{226}Ra to construct a chronology of sediment deposition. The Tasmanian site was done in duplicate and was also analysed for ^{137}Cs. We will discuss the isotopic profiles and the chronologies obtained. Cysts of the toxic dinoflagellate *Gymnodinium catenatum* were present only in the top sections of marine sediment cores from Deep Bay in southern Tasmania, Australia. ^{210}Pb and ^{137}Cs analyses indicate that the appearance of the cyst of this toxic dinoflagellate (one of the causative organisms of paralytic shellfish poisoning) occurred after 1972.

In association with a major tuna kill in Boston Bay, Port Lincoln, SA, in 1996, an intensive phytoplankton survey identified the presence of the toxic dinoflagellate *Gymnodinium catenatum* at this site for the first time. *Gymnodinium catenatum* had not previously been recognised in SA and has only been identified from a few sites on the mainland of Australia (notably Victorian coastal waters). Three sediment cores were taken from Boston Bay. Each contained abundant *Gymnodinium catenatum* cysts in the top 6 cm but these disappeared rapidly with depth. 210Pb profiles indicate that bioturbation extends down to no more than 5 cm in each core and that their sedimentation rate is approximately 0.2 cm/yr. Modelling of the cyst and 210Pb profiles suggests that the observed profiles are consistent with an introduction event within the last 25 years.

The New Zealand study focussed on sediment cores from Manukau and Hokianga Harbours. After major blooms of *Gymnodinium catenatum* in both 2000 and 2001, which affected some 1500 km's of coastline, sediment cores were taken in order to establish a history of occurrences in the North Island.

OSL CHRONOLOGY OF TWO AUSTRALIAN LOESS DEPOSITS; CORRELATIONS AND CLIMATIC IMPLICATIONS

Paul P.Hesse[A], Geoff S. Humphreys[A], Bart Smith[B], James Campbell[A] and Elizabeth K. Peterson[A]
[A] *Department of Physical Geography, Macquarie University, Sydney, NSW 2109 Australia*
[B] *Department of Earth Science, University of Melbourne, Parkville, VIC 3 , Australia*

Basal optical (OSL) ages of 40 to 60 ka in two loessic (parna) mantles on the Central Tablelands of New South Wales indicate significant silt (c. 30 μm mode) deposition commenced well before the onset of the last glacial maximum. Both dated sections show no detectable change in mass accumulation rate around the LGM. The basal ages coincide with both major paleochannel and source-bordering dune activity in the western slopes and plains of NSW and the first dated linear sand dunes of the last glacial cycle, but not strong evidence of dramatic aridity.

The extremely linear age-depth relationship suggests quite constant accumulation over the last 40-60 ka, rather than a single LGM deposition event. The possibility remains that this is partly the result of low age resolution, however other aspects of the sites suggest slow, protracted accumulation. In detail, each mantle consists of > 1m of reddish silty clay loam with an earthy fabric which sits atop manganese and iron/silica hardpans and saprolite. Mixing of saprolitic derived material into the hard pan and also into the silty layer and destruction of internal sedimentary layering suggests slow accumulation with sufficient time for extensive bioturbation to occur. Presently, bioturbation is mostly restricted to the conspicuous topsoil where it has resulted in textural and fabric differentiation not seen deep in the profiles. In other words, there are no buried soils.

The apparent insensitivity of the loess accumulation rates to the sweeping environmental changes of the late Pleistocene is surprising. We cannot rule out post-depositional erosion (by wind or water) as an important factor in producing the measured accumulation rates at these sites and are therefore unable to speculate about changes in the true dust deposition rates.

THE ONSET AND SUBSEQUENT HISTORY OF DUNE FORMATION IN THE STRZELECKI DESERT AND ADJACENT DUNEFIELDS, SOUTH AUSTRALIA

A. Hilgers[1], J. Lomax[1], H. Wopfner[2], R. Grün[3], C.R. Twidale[4], J.A. Bourne[4] & U. Radtke[1]
[1]Department of Geography, University of Cologne, D-50923 Cologne, Germany, a.hilgers@uni-koeln.de
[2]Department of Geology, University of Cologne, D-50923 Cologne, Germany.
[3]Research School of Earth Sciences, Australian National University, Canberra 0200, Australia
[4]Department of Geology and Geophysics, University of Adelaide, Adelaide 5005, Australia

This study investigates aspects of the environmental history of the lower Lake Eyre basin in central Australia, focussing on late Quaternary aeolian dynamics and the onset and subsequent history of dune formation. The north- or NNE–trending sand ridges comprise layers of quartz sand some of which include palaeosol horizons with carbonated rootlets. These indicate phases of vegetational stabilisation of the dune systems. Such stratigraphy permits the dating of alternations of dune building and stability. The dunes provide an excellent opportunity to use optically stimulated luminescence (OSL) for dating phases of aeolian activity. In addition, radiocarbon dating was carried out on calcareous concretions. The dating results of eight dune sites, providing a data set of 38 OSL samples and several ^{14}C dates of carbonated rootlets, are reported and discussed in the context on already existing studies on this topic (e.g. Readhead, 1988; Gardner et al., 1987; Nanson et al., 1992; Twidale et al., 2001). From the crosscheck of OSL and ^{14}C dating results it is concluded that under the given environmental conditions radiocarbon dating of the calcareous rootlets is not able to provide reliable ages for the phase of soil development.

At two sites in the Strzelecki dunefield (~28°44‘S, 140°11‘E and ~27°53‘ S, 139°49‘ E), deep trenches were dug by a backhoe which enabled sampling particularly of the basal parts of the dunes. By dating these basal layers as well as the underlying fluvial-lacustrian units it was possible to obtain some restraints for onset of the present dune systems in the Strzelecki Desert, while dating of the top layers give evidence for the reactivation of the dunefield in recent times. For both sites examined so far, dating of the other sites is still in progress, chronologies based on OSL ages are consistent with the stratigraphic relationship and, furthermore, show similar results for comparable stratigraphic features. The ^{14}C ages of the carbonated rootlets are considerably younger than the depositional ages of the sediments that overlie the palaeosol horizons. No evidence on such a distinct overestimation is found in the OSL data set. From this we infer that the ^{14}C ages do not date the period of enhanced humidity and dune stabilisation itself.

Finally, it has to be underlined that this study can only serve as a starting point and further dating studies have to be carried out to draw conclusions on a regional scale and to understand the complexity of dune formation and aeolian dynamics in the Strzelecki Desert and adjacent deserts, as this complexity already becomes obvious at just the few sites investigated here.

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THREE DIMENSIONAL GPR VISUALIZATION OF AN EARTHQUAKE INDUCED COASTAL SCARP

Harry M. Jol
Department of Geography and Anthropology, University of Wisconsin-Eau Claire, 105 Garfield Avenue, Eau Claire, WI 54702-4004 USA E-mail: jolhm@uwec.edu

The objectives of three dimensional (3-D) ground penetrating radar (GPR) surveys are to construct images of the subsurface and to utilize this data to better understand the internal stratigraphy and geometry of geomorphic environments. Studies involving the use of GPR along the southwest Pacific Ocean coastline of Washington State, USA show a shingle-like accretionary depositional pattern of beach and upper shoreface reflections interrupted by steeper dipping erosional scarps (Jol *et al.* 1996; Smith *et al.* 1999). These scarps are dated to coseismic subsidence events associated with regional subduction earthquakes during the late Holocene (Meyers *et al*. 1996). A 3-D GPR survey was conducted along one of these earthquake induced coastal scarp to better visualize the stratigraphic relationships of a prograding shoreline within a tectonically active coastal environment.

The survey site was located on the Willapa barrier spit, north of the community Long Beach, Washington, USA. Identical length GPR profiles (225 MHz) running parallel to each other along an x-y grid (6 m x 30 m) were collected on a level unpaved road running parallel to the slope of a previously imaged scarp (Meyers *et al.* 1996). The GPR transects were spaced 0.25 m apart with a step size of 0.10 m to provide a high amount of horizontal resolution. The traces have a sampling interval of 400 ps and were vertically stacked 8 times. Data was collected with a pulseEKKO 1000 system using an automatic step odometer which proved to be significantly more time-efficient than manual data collection; total survey took 3 hours, including setup. The profiles were processed using pulseEKKO software, compiled and viewed in several 3-D graphics rendering program. A CMP survey was performed at the site resulting in an average near surface velocity of 0.09 m/ns being calculated.

Through the use of the collected 3-D GPR dataset internal stratigraphy of this coastal geomorphic environment can be imaged. The data shows reflections to 140 ns (approximately 7 m) with one facies interpreted as normal coastal progradation. A second facies of steeper dipping reflections from 10 to 30 m is interpreted as the uppermost boundary of an erosional scarp which was formed by massive erosion due to coastal subsidence. The project demonstrates that 3-D GPR can be an effective and time-efficient method of data collection and stratigraphic interpretation of the subsurface.

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THE HISTORY OF FIRE IN BARMAH FOREST, VICTORIA, AUSTRALIA

Christine Kenyon
School of Anthropology, Geography and Environmental Studies, University of Melbourne,
Victoria, Australia, 3010.

The flooded plain of the Barmah Forest in northern Victoria is dominated by River Red Gum (*Eucalyptus camaldulensis)* forests with extensive Moira Grass (*Psuedoraphis spinescens*) Plains. Extensive wetlands and box woodlands are also important components of the vegetation. Macro-charcoal particles in floodplain sediments are derived from local fires and from fluvial sedimentation. Land management practices using fire have been integral to both Aboriginal people and Europeans. Originally patch-burning occurred on the grasslands and wetlands while, in the semi-arid hinterland low fuel loads meant few fires. However, Europeans cleared the forests using fire and burnt grasslands frequently to promote new growth to feed stock. Since 1936 river regulation has meant the forest is often flooded in summer, reducing the likeli-hood of summer forest fires. Intensive cattle grazing has been an important activity in the forest for 150 years. One of the arguments for continuing cattle grazing in Barmah Forest is that fuel loads are remain minimal reducing the likeli-hood of fires. Stratigraphic analyses of floodplain charcoal and sediments provide information on fire frequency in a situation where historical records are scarce.

In this paper the macro-charcoal and floodplain sediment stratigraphic records are examined to determine charcoal transport processes and to identify changes in fire frequency over time. Sediment cores from five floodplain sites in Barmah Forest were sampled contiguously using 0.3 mm slices. Macro-charcoal and floodplain sediments are analysed in the size ranges >100<250 μm; >250<1,000 μm and >1,000 μm.

Despite their close proximity within the floodplain system each site has an individual record that shows charcoal production from nearby fires, fires on site and influx values determined by vegetation type. Regional fire frequency was low in the pre-historic period. Fire frequency in, and adjacent to, the forest increased at the time of European settlement and the increase in charcoal peaks suggests more frequent fires. Vegetation type and the quantity of litter available as well as fire frequency are also important considerations when interpreting the macro-charcoal palaeo-record. The Moira Grass Plains at Reedy Swamp, Hut Lake and Top Island provide little fuel for fires resulting in low charcoal influx; while the open forests at Rowe's Swamp and Gower's Gate have higher charcoal influx. The commencement of charcoal-burning at Gower's Gate was identified from the largest charcoal size class and used as a proxy date for the sediments. The micro-charcoal record provided evidence for charcoal transport in flood waters after river regulation. At Top Island, the closest site to the river, the larger particle sizes indicate reduced fire frequency after river regulation as the site to become wetter due to increased flood frequency.

Within this large riverine system another consideration is the importance of fluvial transport of charcoal to the floodplain. Unlike lake sediments where all particles >125 μm are used to identify local fires; on floodplains several charcoal particle size classes need to be analysed separately to determine the importance of fluvial transport. Changed flow regimes due to river regulation and the occurrence of more frequent small floods means that charcoal particles are being transported onto and deposited on the floodplain. At the time of river regulation charcoal influx increases again. This increase only occurs in the smaller charcoal size fractions (<250 μm) and correlates with sediment distribution of a smaller size range due to the lower density of the charcoal particles.

LANDSCAPE RESPONSE TO NEOTECTONICS IN ALPINE CATCHMENTS OF SOUTH WESTLAND AND FIORDLAND

Oliver Korup
School of Earth Sciences, Victoria University Wellington, P.O. Box 600, New Zealand,
e-mail: oliver.korup@vuw.ac.nz

Coseismic landsliding is an important geomorphic consequence of neotectonic activity in mountain belts throughout the world. Instantaneous generation of large volumes of landslide debris may exert significant disruption of alpine river systems, thus upscaling local physical impact by means of reach-scale valley-floor aggradation or formation of natural reservoirs (landslide-dammed lakes). Though the amount of sediment produced by earthquake-triggered mass movement correlates well with event magnitude, the processes controlling sediment delivery and evacuation somewhat differ between localities.

This study examines the geomorphic imprints and scaling effects of large ($> 10^6$ m^3) landslides on alpine river systems in South Westland and Fiordland, New Zealand. Though the physiography of both regions are conditioned by high endo- and exogenic energy inputs, i.e. neotectonic activity and orographic precipitation, respectively, Fiordland exhibits a significantly higher number of landslide-driven river fragmentation on a scale of 10^2 to 10^4 years. There, tentatively coseismic deep-seated bedrock failures have created numerous lakes and alluvial flats in their backwaters, forming prominent steps in many river long profiles. In contrast, alpine catchments in South Westland appear to exert tight constraints on the longevity of landslide dams, while fluvial and valley-floor architectures are mainly dominated by prograded tributary debris fans.

It is suggested that differences in uplift rates, seismicity, and lithology, account for the different types of landslide impacts observed. Reach-scale fluvial response to these mass movement-induced disruptions is primarily controlled by the inherent base-level changes. Large landslides prove to be not only sources of, but also regulators of sediment and its delivery to the drainage network.

THE LAST THREE PALEO-EARTHQUAKES ON THE CONWAY SEGMENT OF THE HOPE FAULT FROM GREENBURN STREAM, SOUTH ISLAND, N. Z.

R. M. Langridge[1], N. Hill[1], J. Pettinga[2], J. Campbell[2], V. Pere[2], and J. Pope[2]
[1]Geological & Nuclear Sciences, P.O. Box 30-368, Lower Hutt, N.Z.
[2]Dept. of Geological Sciences, University of Canterbury, P.B. 4800, Christchurch, N.Z.

The eastern end of the Hope fault is one of the fastest slipping fault segments along New Zealand's plate boundary, but has not ruptured in the historic period and little paleoseismic data exists to constrain its earthquake record.

Two new paleoseismic trenches were opened adjacent to Greenburn Stream, north Canterbury (NZMS 260 O31/423678). Both trenches were excavated into deposits laid against an uphill-facing scarp developed by a shutter ridge.

Trench 1, dug through a cobbly surface deposit was dominated by a thick fan/fluvial sequence that was C-14 dated at 4409 ± 60 C-14 yr BP at the base of the trench. This trench exhibited evidence of complex deformation from multiple paleoseismic events. The most recent earthquakes are difficult to constrain due to a lack of cover stratigraphy on the fan deposits. A preliminary slip rate of 18.9-24.8 mm/yr is calculated from the minimum fan age and the offset/deflection along the shutter ridge (from Pope, 1994).

Trench 2, dug ~50 m to the west, has an expanded sequence of similar aged cover deposits. Three recent paleoseismic event horizons have been recognised from the combined evidence of offset units, upward-terminating faults, sandblow, and abrupt landscape change. Two paleosols underlying the modern soil are clearly faulted by two rupture events. The second event horizon is overlain by a dome of sand interpreted as a liquefaction sandblow. Both paleosols are overlain by metre-thick debris deposits, interpreted as rock avalanches that cascaded off the hillslope following M 7+ shaking events. A radiocarbon date (548 ± 60 C-14 yr BP) below the second paleosol constrains the duration of time in which the last 2 events have occurred in.

In concert with his estimate of single event displacement (4-5 m), these results show that the Conway segment of the Hope fault is fast-slipping and has ruptured (i.e. M 7+) twice in the last ~650 to 160 years before present. Event III, confirmed after the trench was deepened, corresponds to a shift toward a new incision of the nearby "Urquhart" Stream rather than fault-guided streamflow.

THE INFLUENCE OF DEEP-SEATED LANDSLIDES ON THE GEOMORPHIC EVOLUTION OF THE ESK RIVER VALLEY, HAWKE'S BAY, NEW ZEALAND

Kerry Leith
Dept. of Geological Sciences, University of Canterbury, k.leith@geol.canterbury.ac.nz
Jim McKean
Dept. of Geological Sciences, University of Canterbury, j.mckean@geol.canterbury.ac.nz
Jarg Pettinga
Dept. of Geological Sciences, University of Canterbury, j.pettinga@geol.canterbury.ac.nz

A geomorphic investigation of the Esk River Valley has been undertaken in order to quantify the effect of the many deep-seated landslides on the evolution of the valley. The region is underlain by soft, gently eastward dipping Pliocene marine sediments. The dominant structure within the valley appears to be an emergent thrust fault which runs roughly N-S through the centre of the valley and has produced a very broad, shallow area of doming. This has been identified in seismic profiles. Extension of sediments within the area of doming has lead to the formation of structural defects that have in turn been instrumental in controlling the subsequent formation of the valley.

Longitudinal profiles of all rivers within the valley are very well described by exponential functions. This is characteristic of a system in which a reduction in sediment size along the channel length is dominant in controlling the process of incision (Knighton, 2000) and reflects the homogeneity and low resistance to weathering of sediments within the area. A deviation from this exponential profile can be observed as rivers run above their grade across the inferred area of uplift, indicating the tectonic doming is likely to be active.

A survey of rock mass defects within a sample area has highlighted four main joint sets running sub-parallel to the uplift and perpendicular to bedding. These defects correlate well with lineations identified in aerial and satellite photographs and are attributed to extension of the sediments across the top of the domed area. The generally low power streams present have exploited these defects and highly incised channels now run almost exclusively along them.

Deep seated landslides occur generally on the down-dip side of the doming and their extents usually correspond to inferred joints, or are defined by channels. This indicates a lateral releasing mechanism is important and slopes where this is not available remain stable. Preliminary results indicate flexural shear, as described by Hutchinson (1995), may be a mechanism enabling the reduction of sediment shear strengths to a residual value. This would enable the observed low angle failures present in material suited to much steeper failure.

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GLACIER-CLIMATE RELATIONSHIPS AS AN AID TO INTERPRETING MORAINE RECORDS IN NEW ZEALAND

Andrew Mackintosh,
School of Earth Sciences
Victoria University of Wellington
Email: andrew.mackintosh@vuw.ac.nz

The aim of this presentation is to identify key relationships between climate, glacier dynamics and geomorphological features, and to demonstrate the importance of the links between them for interpreting moraine records in New Zealand. Moraines are a primary source of information regarding the prior extent of glaciers and thus are a direct indicator of response to climatic change. However, understanding the climatic significance of their deposition and preservation, particularly during intervals of rapid change, requires knowledge of the interplay of several factors. Glacio-dynamic factors are controlled by local climate and topography and influence the glacier response time and magnitude of response (Oerlemans, 1989; Mackintosh et al., 2002). Geomorphic factors include the role of topography and meltwater in moraine deposition and preservation, and also the potential for glaciers to 'self-censor', or selectively remove, moraine records (Kirkbride and Brazier, 1998; Mackintosh, 2000).

I argue that New Zealand glaciers should not respond uniformly to climatic change, and that moraine records formed during minor climatic changes will not be preserved in all places. In particular, West Coast valley glaciers that cover a large elevational range (for example the Fox and Franz Josef glaciers) are likely to have short response times and be very sensitive to small temperature changes, and relatively insensitive to changes in precipitation. Moraines will seldom be preserved in situations where glaciers terminate on outwash plains. Moraine deposition and preservation is more likely to occur where proglacial drainage is channelled through a single meltwater outlet, a common feature on mountain slopes.

Applying this logic to the last deglaciation (8-18 ka), an interval of overall warming punctuated by "cool snaps", suggests that West Coast glaciers will have been more sensitive to these cooling events than other, more marginal areas of glaciation. The Waiho Loop moraine, assigned to a Younger Dryas age by Denton and Hendy (1994) is a good example of sensitive response and fortuitous preservation. This theory can be used to help identify other sites where late glacial moraine records might be found in New Zealand.

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GENYORNIS EXTINCTION VERSUS EMU SURVIVAL: A KEY TO UNRAVELLING THE CAUSE AND PROCESS OF MEGAFAUNAL EXTINCTION IN AUSTRALIA

John Magee[1], Gifford Miller[2], Marilyn Fogel[3]
1. Department of Geology, Australian National University, Canberra ACT 0200,
2. INSTAAR, University of Colorado, Boulder, CO, USA, gmiller@colorado.edu
3. Carnegie Institute, Washington, USA., fogel@gl.ciw.edu

In Australia the extinct megafauna include all 19 marsupial species greater than 100 kg, 22 of 38 species of marsupials between 10 and 100kg, 3 large reptiles and the ostrich-sized bird *Genyornis.* It seems likely that amongst herbivores, the extinction was selective for browsers rather than grazers. Since the discovery of the first fossils more than 150 years ago and their description by English anatomist Richard Owen, debate has raged about the timing, cause and process of the extinction, focussed initially on climate change versus human predation and with human-induced environmental change emerging as a third possibility in the 1960's. The debate has been bedevilled throughout by poor numerical chronology due to dependence, until recently, on radiocarbon which has been compromised by both the innately poor preservation of original carbon in bone under Australian conditions and the proximity of the extinction event to the resolution limits of the technique. Additional, difficulties have arisen from recourse to dating material associated with faunal remains where uncertainty exists that the association is to an animal contemporary with material dated. Incorrectly younger dates due to contamination with younger carbon and association of reworked older faunal remains with younger dates have combined to suggest an almost certainly erroneous late survival of megafauna and long overlap with humans. Two recent studies, using non-radiocarbon chronologies and direct dating of megafaunal remains or rigorous criteria to exclude faunal reworking have determined extinction dates of 50±5 ka for *Genyornis* (Miller et al, 1999) and 46.4±2.5 ka for a number of marsupial megafaunal species (Roberts et al, 2001), though some researchers still support younger megafaunal survival (Field and Dodson, 1999).

An extinction date coeval across climatic zones and for a variety of taxa at 46-50±5ka, soon after the likely date of human arrival on the continent (55±5 ka), implicates a human role in the extinction but says nothing of the process. It is unlikely that the archaeological record will ever provide more than proof of human-megafauna overlap. To finally resolve the extinction debate we need to obtain an unequivocal extinction chronology for a wide variety of taxa across a wide transect of climatic zones and to determine whether extinction was selective for dietary preference from an improved eco-physiological understanding of the animals and palaeodietary analyses. Before its extinction, *Genyornis* coexisted with emus at least across the arid and semi-arid zones where eggshells of both species occur relatively abundantly in aeolian sediments. While both are large flightless birds, they are taxonomically distant and are probably best regarded as convergent evolution within the bird lineage, with significant behavioural and physiological differences which resulted in *Genyornis* extinction and emu survival. In addition to being the most commonly occurring fossil bio-mineral, eggshell is far superior to bone for the preservation of its original chemistry, allowing excellent opportunities for chronology and isotopic palaeodietary studies. We believe that a comparison between *Genyornis* and emu characteristics across an environmental and climate gradient coupled with an examination of the timing and environmental context of *Genyornis* extinction offers the best prospects for unravelling the cause and process of the extinction event.

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LGM AND HOLOCENE VEGETATION RECONSTRUCTION OF THE AWATERE VALLEY USING FOSSIL BEETLE ASSEMBLAGES.

Maureen Marra
Victoria University of Wellington

One hundred and forty-five beetle species belonging to 33 families were identified from silty organic deposits, dated as Last Glacial Maximum (LGM) and Holocene, from the lower Awatere Valley. The LGM fossil fauna indicates that the site vegetation was characterised by a forest patch surrounded by an open tussock/grassland landscape. The presence of the host specific taxon *Hypotagia lewisi*, showed that *Nothofagus* was present. This discovery of a LGM forest patch is significant because until now the eastern South Island was considered largely treeless. *Nothofagus* also dominated at the site in the early Holocene. By mid Holocene, the fossil fauna is characterised by high beetle diversity associated with podocarp forest habitats. Herbivores dominate in the early stage, suggesting a relatively new forest environment. Later there is a replacement by detritivores indicating an older more established forest. *Myrsine, Pseudopanax*, *Pittosporum, Phormium tenax* and podocarps are confirmed by the presence of the host beetles *Psepholax coronatus*, *Psepholax crassicornis, Ectopsis ferrugalis*, *Chaetoptelius mundulus, Phloeophagosoma pedatum*, *Isanthribis phormii* and *Platypus apicalis*. The late Holocene is characterised by low diversity and the absence of forest species. This fauna indicates that by 500 years ago, the forest is absent and this resulted in an almost compete loss of beetle biodiversity.

PHYTOLITHS FROM ALL EXTANT NEW ZEALAND SPECIES OF *CHIONOCHLOA* AND *FESTUCA* AND THEIR POTENTIAL USE IN QUATERNARY STUDIES

*Ray Marx, *Daphne Lee, #Kelvin Lloyd, #Bill Lee
*Geology Department, University of Otago, PO Box 56, Dunedin
#Landcare Research, Private Bag 1930, Dunedin

Morphology and abundance of phytoliths were determined for all 22 species and 17 subspecies of Chionochloa, and 8 species and 2 subspecies of *Festuca* from New Zealand. The samples were harvested from specimens growing in standard potting mix under controlled conditions. Three *Chionochloa* species can be distinguished from all others on the basis of phytolith types, while the main discriminant of *Festuca* species is the abundance of points. Eight *Chionochloa* species are characterised by panicoid short-cells, which are never present in *Festuca*. Overall *Chionochloa* exhibits a wider range of phytolith morphology than *Festuca* spp. Some phytolith types which have previously been attributed to ferns or trees occur in some *Chionochloa* species.

We provide a reference set of illustrations of all phytolith types extracted from these grasses, and a table showing % abundance of each phytolith type. This compendium should assist in Quaternary paleoclimate and paleoenvironmental studies by making it possible to determine the presence (or absence) of grasslands and should provide a useful tool in vegetation reconstruction when used in conjunction with pollen studies. However, further work is needed to discover which shapes are preserved in the fossil record.

MID-HOLOCENE CLIMATE CHANGE BASED ON THE AGE AND GEOCHEMISTRY OF STALAGMITES FROM CLIEFDEN CAVES, CENTRAL NSW, AUSTRALIA

Janece McDonald[a], Russell Drysdale[a], Graham Mortimer[b], Malcolm McCulloch[b], Henk Heijnis[c] & David Hill[c]

[a] *Environmental Geoscience Group, School of Environmental and Life Sciences, University of Newcastle, Callaghan 2308, Australia*

[b] *Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia*

[c] *Environment Division, Australian Nuclear Science and Technology Organisation PO Box 1 Menai 2234, Australia*

This study investigates the age, geochemistry and palaeoclimatic significance of three stalagmites (MC2, MC11 & MC16) collected from Murder Cave, central NSW, Australia. Uranium-series thermal ionisation mass spectrometric ages show that two of the stalagmites commenced growth during the Holocene (MC2: 9.0 ± 0.4 ka and MC11: 8.5 ± 0.3 ka). All three possess a distinctive break (hiatus) in deposition towards their tip. The ages of two of these yielded statistically indistinguishable ages of 4.9 ka ± 0.20 ka (MC2) and 5.1 ka ± 0.15 ka (MC16). Growth resumption of stalagmite MC2 occurred at 3.8 ± 0.20 ka.

Changes in stable isotope and trace element geochemistry for the three stalagmites prior to and following the growth hiatuses show contrasting trends. MC2 and MC11 display a marked increase in Mg/Ca, Sr/Ca and Ba/Ca ratios nearing the hiatus, interpreted as longer water/bedrock residence time and possible prior calcite precipitation, both of which are indicative of reduced effective precipitation (Fairchild *et al* 2000). MC16 does not show the same trend with the trace element response remaining constant nearing the hiatus; however, its morphology indicates migration of the source cave water drip that is related to prior calcite precipitation above the cavern. Analysis of present-day calcite and its parent drip waters also indicates that trace elements can be influenced by characteristics such as drip rate and residence time.

Previous studies of the Late Quaternary have indicated that a mid-Holocene cooling and/or drying event occurred in southeastern Australia (e.g Margraf *et al* 1992). Comparison of the geochemical changes along the growth axis approaching and following significant interruption in the deposition of the Murder Cave stalagmites and the timing of growth hiatuses themselves may provide important evidence to support these previous findings.

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HOLOCENE FIRE HISTORY IN THE SYDNEY BASIN, NSW, AUSTRALIA: WHAT DO WE REALLY KNOW?

Scott Mooney and Emma Dixon
School of Biological, Earth & Environmental Sciences,University of New South Wales, Sydney, NSW, Australia, 2052.s.mooney@unsw.edu.au

There are several contentious issues regarding the prehistoric use of fire in south-eastern Australia (eg. Head, 1989 in *Aust. Geographer*; Bowman, 1998 in *New Phytol*.). This includes claims that the manipulation of fire by Aborigines resulted in vegetation change, such that the vegetation witnessed by European settlers was a cultural artefact. This interpretation relies heavily on evidence gleaned from the observations of early settlers, especially in the Sydney region, which may be misinterpreted and/or exaggerated (eg. Benson and Redpath, 1997 in *Cunninghamia*).

Unfortunately, an almost clichéd mantra describing Aboriginal fire regimes has evolved. This describes Aboriginal use of fire as high frequency, low intensity, within the fire season and in a small patch/mosaic. These generalisations have meant that questions regarding how prehistoric fire was used within a landscape have rarely been addressed. For example, it is possible to get the impression that Aboriginal people burnt all landscape elements (biotic communities, physiographic settings etc) in a similar manner.

The way in which fire regimes changed with the arrival of European settlers is another issue surrounded in controversy. It is often reported that the removal of Aboriginal influences initially resulted in a build-up of fuel and an increase in the frequency and intensity of fires (e.g. Pyne, 1992 *Burning Bush*) and that, at least in areas that retain some semblance of the natural vegetation, fire now consists of a low frequency, high intensity regime. The management of fire in south-eastern Australia has obviously also undergone major shifts through time (eg. recent hazard reduction burning) with the potential for any longer temporal perspective to influence policy.

In addition, untangling the inter-relationships between climate, humans and fire has rarely been attempted in Australian studies. For example, the possibility of late Holocene socio-economic intensification of Aboriginal land-use and the initiation of the modern ENSO in the mid-Holocene have hardly been tested against fire records.

Despite this negativity, the sophistication of the interpretation of prehistoric fire in south-eastern Australia recently increased with the publication of Kershaw *et al*. (2002 *Flammable Aust*.). They concluded that although fire activity was relatively constant in the Holocene, a slight reduction was evident between 7 and 5 ka BP, followed by an increase in burning after 5 ka BP. They also demonstrated that fire in the early post-European period was of a higher magnitude than at any other time in the Holocene. However, it is notable that these conclusions were based almost exclusively on charcoal 'quantified' on pollen slides, which is predominantly small and potentially reflects a very large source area.

This study aims to address these issues with a review of previous palaeoenvironmental studies located in the Sydney Basin, which is arguably one of the most data rich locations in south-eastern Australia. In addition, several recent studies are presented using the 'Oregon sieving method' (and image analysis) and the results are compared to previous interpretation. We have identified a total of 26 relevant studies in the Sydney Basin of which 73% are unpublished. Analysis of this data set reveals that 50% are located in the Blue Mountains (and a further 31% represent coastal, near coastal or estuarine locations), and 62% of the studies are (or were in prehistoric times) located in vegetation classified as the Sydney Sandstone Complex. The consequences of these biases in location are discussed and the overall aims of the UNSW 'SydFire' project are described.

RESPONSE OF A LATE QUATERNARY FLUVIAL-MARINE MARGIN TO THE 100,000 YEAR CLIMATE CYCLE, CANTERBURY PLAINS AND SHELF, NEW ZEALAND

Tim R. Naish and Greg H. Browne, Institute of Geological and Nuclear Sciences Ltd, P O Box 30 368, Lower Hutt, New Zealand

The Canterbury Plains, South Island New Zealand, comprise a c. 7,500 km^2 coarse-grained, braidplain that accumulated during Quaternary glacio-eustatic, sea-level fluctuations. The adjacent Canterbury Bight shelf covering c.13,000 km^2, comprises coeval shelf-slope deposits, that are punctuated by advances of the braidplain onto the shelf during periods of sea-level fall. This study examines the sedimentological and stratal characteristics of outcropping last-glacial braidplain deposits, and then traces oscillations in the position of the fluvial-marine transition over several Late Quaternary sea-level cycles using high-resolution seismic reflection profiles of the Canterbury shelf and slope. Outcropping last-glacial Burnham Formation sediments display numerous, aggradationally-stacked massive and cross-stratified gravel deposits with minor intercalated sand and mud. The gravels accumulated as longitudinal bars and channel fills within an extensive braidplain succession, with some evidence of frozen ground conditions during deposition based on sedimentological features.

High frequency (3.5 kHz) seismic reflection data of the subsurface Canterbury shelf identify up to 7 unconformity-bound, Milankovitch-duration (5^{th}-order), depositional sequences. These sequences are inferred to correlate with successive 100-kyr, sea-level cycles spanning oxygen isotope stages 16 to 1 (last c. 700ka). Each sequence displays a distinctive stratigraphic motif comprising 4 recurring seismic units:

1. Basinward of the glacial maximum shoreline, wedge-shaped units displaying steeply dipping clinoforms that onlap the continental slope are interpreted as "perched lowstand deltas" belonging to the lowstand prograding wedge systems tract (LST).
2. Irregular hummocky units up to 10 m thick, containing high-amplitude discontinuous reflectors, are interpreted as representing stranded coastal deposits of the transgressive systems tract (TST).
3. Low-amplitude seismic units which offlap and downlap onto the TST, infilling local paleotopography, and interpreted as comprising fine-grained marine sediments of the highstand systems tract (HST).
4. Basinward thickening units (up to 40 m thick), containing a strongly progradational series of offlapping, inclined (0.5-1.0°), high-amplitude reflectors, that down-step towards the basin are interpreted as coarse-grained, fluvio-deltaic sediments, similar to the last-glacial Burnham Formation, deposited during glacio-eustatic sea-level fall, or forced regression. We assign this unit to the regressive systems tract (RST), which displays a gradational lower boundary overlain by a sharp planar regionally extensive sequence boundary or ravinement surface.

2-D forward stratigraphic modelling, constrained by outcrop and seismic data, indicates that rivers of the Canterbury region did not necessarily incise during eustatic sea-level fall. This may be the case elsewhere too, where a coastal plain is flanked by a lower gradient shelf. On the Canterbury shelf, fluvial incision did not occur during Quaternary forced regressions, but instead subaerial accommodation was created and infilled by thick, fluvio-deltaic deposits, as contemporary rivers graded to the glacial maximum shoreline. Incision was restricted to three zones: (1) The lowstand shelf break, where canyons of limited extent formed by nickpoint retreat, (2) the transgressive coastline where rivers incised due coastal erosion, and (3) the inner braidplain adjacent to the Southern Alps where degradation was caused by tectonic uplift.

ORBITALLY-INFLUENCED DEEP SEA RECORD OF TERRESTRIAL VEGETATION RESPONSE TO THE MID-PLEISTOCENE CLIMATE TRANSITION, OFFSHORE EASTERN NEW ZEALAND

D.C. Mildenhall, C.J. Hollis, T.R. Naish, Institute of Geological and Nuclear Sciences, P.O. Box 30 368, Lower Hutt, New Zealand, d.mildenhall@gns.cri.nz

Pollen analysis of Pleistocene deep-sea sediment from ODP Site 1123 (Leg 181), located 1100 km offshore from eastern New Zealand and in a water depth of 3300 m, reveals marked variations in warm (*Cyathea* + *Prumnopitys*/*Podocarpus* + *Dacrydium cupressinum*) and cold (*Nothofagus fusca* + *Phyllocladus* + *Halocarpus* + *Coprosma*) climate indicator taxa at Milankovitch-scale periodicities. Near-synchroneity between Northern Hemisphere glaciations and New Zealand terrestrial climate is indicated by the close correlation between SPECMAP-derived ages for glacial terminations and peaks in the warm/cool pollen ratio and tree fern (*Cyathea* spores) abundance. Time series analysis indicates that the vegetation record is covariant with local marine climate indicators and is strongly coherent at the 41- and 100-kyr orbital frequency bands. A gradual change from more mesothermal taxa (*Brassospora*), in the Pliocene and early Pleistocene, to less mesothermal (*Fuscospora* and podocarp conifers) taxa in the middle and late Pleistocene reflect a general decrease in humidity and cloud cover over time

In deep sea sediments, uncertainty surrounds the degree to which variation in palynomorph abundance is a real reflection of changes in vegetation on land or is an artefact of changes in the marine environment which may affect transport and sorting processes. Despite long distance from land and significant water depth, terrestrial palynomorphs are relatively abundant at Site 1123. Overall, the assemblage indicates a North Island podocarp/hardwood forest source which, coupled with lack of an obvious South Island signature, implies that westerly winds and the east-flowing East Cape Current (ECC) are the primary source of palynomorphs at this site. It is possible that increases in the dominant warm climate indicators (robust *Cyathea* spores and bisaccate pollen from *Prumnopitys* and *Podocarpus*) are concentrated by increased winnowing during intensification of the ECC in interglacials. A plot of the cold climate indicators listed above, with relative abundance recalculated to exclude bisaccates, reveals a much weaker correlation with glacial cycles. This suggests that ocean currents and winds may be more important than terrestrial climate in modulating the terrestrial palynomorph record in the open ocean.

THREE DIMENSIONAL IMAGING OF THE BENMORE SEGMENT OF THE OSTLER FAULT USING GROUND-PENETRATING RADAR (GPR), RESISTIVITY TOMOGRAPHY AND DETAILED TOPOGRAPHIC SURVEYING

David C. Nobes*[1], Shamus Wallace[1], Kenneth Davis[2], Antony White[3] and Douglas Burbank[2]1. Department of Geological Sciences, University of Canterbury
2. Department of Geological Sciences and Institute of Crustal Studies, University of California-Santa Barbara
3. School of Chemistry, Physics & Earth Sciences, Flinders University, Adelaide

The Ostler Fault is a thrust fault in the Mackenzie District on the eastern side of the Southern Alps. The nature of thrust deformation creates a series of complex two-dimensional features that are projected onto the earth's surface. These features change in orientation, scale and significance along the strike of the fault. A detailed geophysical study was carried out on a number of segments of the Ostler Fault, as part of a larger study of the change in the geometry of active thrust fault systems along the strike direction. Specifically, this larger study investigates the relationship between fault length and displacement along strike. The geophysical investigation complemented detailed geomorphic mapping and an analysis of topographic variations as using differential GPS surveying.

Fault length and scarp height were measured on numerous segments of the Ostler Fault. The fault segments cut broad glacial outwash surfaces and fluvial terraces that provide a reference surface against which scarp height can be measured. Ground-penetrating radar (GPR) investigations provide subsurface images that constrain the fault dip and occurrences of subsidiary faults, which in turn can be correlated with the detailed surface mapping.

Previous GPR studies have shown the potential for the method to accurately map sub-surface features in two dimensions. However an understanding of the possibly complex subsurface geometry of multiple fault features requires a recognition of the three-dimensional relationships. Such studies have been completed along faults that are predominantly strike-slip in nature, but few if any have been carried out on thrust faults. In addition, complementary multi-electrode resistivity surveys provide additional information on the physical properties of the subsurface and help image the fault system.

We present here the results of the geophysical surveys for the Benmore segment of the Ostler Fault. The main fault scarp breaches a fault-tip anticline which is approximately 1 km long in the north-south direction and 600 m wide. The anticline is bounded by multiple small scarps on the east, and a backthrust fault on the west. A series of closely-spaced GPR profiles have been surveyed across the strike of the fault, providing images of subsurface layering and structure to depths of ~10 m, on average, and interpreted in combination with the limited multi-electrode resistivity survey. The GPR data have been further collated and analyzed to provide a three-dimensional image of the subsurface features associated with the anticline. The features identified in the GPR results can be readily correlated with those features that are recognized at the surface, and thus allow the detailed surface mapping to be extended to the subsurface both along and across the strike of the fault.

$\delta^{13}C$ OVER THE LAST 1000 YEARS FROM TREE-RINGS: A CLIMATESIGNAL?

Jonathan Palmer
P.O. Box 64, Tai Tapu, Canterbury, NZ. E-mail: palmerama@paradise.net.nz

Tree-rings, or more specifically tree cellulose formation, contain carbon incorporated through photosynthesis so its $^{13}C/^{12}C$ isotope ratio (or $\delta^{13}C$) is thought to reflect that of atmospheric CO_2. However, there is an ongoing debate about the extent of environmental influences on $\delta^{13}C$ or for that matter its delayed response or lag.

The recent completion of a Southern Hemisphere calibration curve for the past millennium (McCormac *et al.* 2002; Hogg *et al.* 2002) provided the opportunity to explore the relationship between tree-rings and their associated $\delta^{13}C$ values. In the study, decadal samples of dendro-chronologically dated wood were supplied from oak (*Quercus petraea*) in the British Isles, and New Zealand cedar (*Libocedrus bidwilli*) and silver pine (*Lagarostrobos colensoi*). To reduce the possibility of bias, duplicate measurements were made in two laboratories.

Initial observations show significant fluctuations in the $\delta^{13}C$ values over time. In particular, those from the British Isles seemed to broadly correspond to the Medieval Warm Period (MWP) and Little Ice Age (LIA). The lack of a similar pattern from the New Zealand samples could be inferred as an inter-hemisphere difference. On closer inspection it was rapidly apparent that observed steps in successive decades were often tied to changes in sites/trees sampled. In order to objectively assess any linkage, the mean ring-width per corresponding decade was obtained for each tree used in the project. The aim was to see if "wider-than-average" decades of tree growth (or the reverse situation) were related to their corresponding $\delta^{13}C$ values. Results show no such relationship for any of the species. This means "good" or "bad" decades for tree growth had no bearing on their $\delta^{13}C$ values. Both New Zealand cedar and silver pine tree-rings have shown good climate sensitivity and used to reconstruction past periods of climate (Cook *et al.* 2002; Palmer & Xiong 2001). Consequently this casts doubt on any coherent climate signal from the $\delta^{13}C$ values.

Finally, further evidence of marked inter-tree variability of $\delta^{13}C$ values is apparent when the results from two different oak series are compared. In an earlier radiocarbon calibration study (Pearson *et al.* 1994) another series of oak samples was analysed by the same laboratory and their $\delta^{13}C$ values showed no relationship to those reported most recently in Hogg *et al.* (2002).

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CLIMATE CHANGE DURING THE LGM AND DEGLACIATION IN THE AUCKLAND REGION, NEW ZEALAND

Andrea Pepper, James Shulmeister and David C. Nobes
Department of Geological Sciences, Unievrsity of Canterbury, Private Bag 4800, Christchurch.

Annually laminated lake sediments from a maar crater in Auckland, New Zealand, were analysed spectrally for three times slices; an eight hundred year period just prior to the last glaciation maximum (LGM), nearly two thousand years during the deglaciation and a three hundred and fifty year period during the early Holocene. Strong spectral power in 2-7 year, 15-20 year and a centennial (80-120 year) timescale during the LGM and during two brief intervals during the deglaciation contrasts with virtually no spectral power during the rest of the deglaciation and during the early Holocene. The Antarctic Cold Reversal (ACR) appears to be the younger deglacial event. The results indicate that El Nino Southern Oscillation (ENSO) and possibly the Pacific decadal oscillation (PDO), two of the primary drivers of modern New Zealand climate, operated in a modern mode during the LGM, pulsed on and off during the deglaciation and were suppressed or absent from northern New Zealand during the early Holocene. The ACR was a period of enhanced south-westerly flow over northern New Zealand.

POST-GLACIAL PALAEOSEA LEVELS, INFERRED FROM FORAMINIFERA IN GULF ST. VINCENT, SOUTH AUSTRALIA.

Naomi J. Riggs and Colin V. Murray-Wallace
School of Geosciences, University of Wollongong NSW 2522, Australia

Gulf St. Vincent is an elongate, sheltered, marine basin on the continental shelf of South Australia. The fault bounded depression contains a record of sedimentation that dates back to the Tertiary. Post-Glacial sediments overlie a Pleistocene calcrete cap and record the marine transgression and subsequent highstand. Prograding coastal sedimentation dominates the sheltered, northern part of the gulf where extensive seagrass beds, mangroves and cyanobacterial mats trap the small amount of terrigenous sediment derived from the arid catchment. The gulf floor substrate is considered a carbonate factory with bioclastic cool-temperate sediments dominated by prolific marine molluscs and foraminifera. A record of post-Glacial palaeosea levels was determined using foraminiferal assemblages superimposed on a geochronological framework from amino acid racemisation (AAR) and AMS radiocarbon dating derived from fossil molluscs.

Distinctive assemblages of benthic foraminifera are associated with various marine environments and are related to water depth. The shallow saline environment of northern Gulf St. Vincent is characterised by shallow water foraminifera, including *Spiroloculina lucida, Spiroloculina canaliculata, Spiroloculina antillarum* and *Triloculina tricarinata*, and the saline tolerant species, *Ammonia beccarii*. As the gulf deepens to the south foraminiferal species including *Elphidium macelliforme, Elphidium botaniensis, Elphidium depressulum, Helenia perlucida, A. beccarii* and *Quinqueloculina lamarckiana* become the dominant taxa as they favour deeper water.

The three cores SV4 (39.2 m), SV24 (41.4 m) and SV77 (17.7 m) recovered between two and three metres of late Quaternary sediments. Amino acid racemisation (AAR) and AMS radiocarbon dating revealed two chronostratigraphic units of sediments: interstadial oxygen isotope stage 3, and post-Glacial oxygen isotope stage 1. Within the cores, preserved assemblages of foraminifera allowed interpretations of palaeoenvironments and palaeosealevels. Sections of the cores representing the commencement of the post-Glacial marine transgression contained assemblages of foraminifera representing a shallow water environment. These foraminiferal species include *Discorbis dimidiatus, Ephidium jenseni, E. crispum, Elphidium macellum, Peneroplis planatus, Quinqueloculina poeyana, Triloculina oblonga, T. tricarinata, S. lucida, S. canaliculata* and *S. antillarum*. Up core expression of the postglacial transgression is indicated by an increase in the relative abundance of deeper water species including, *Ammobaculites reophaciformis, Flintina triquetra, E. macelliforme, E. botaniensis, E. depressulum* and *Q. lamarckiana*. Further research could be directed towards the palaeoenvironmental impacts of changing water levels in the gulf.

LATE QUATERNARY TECTONIC UPLIFT, MARINE PLANATION, FLUVIAL INCISION, AND SEA LEVEL, NORTH WESTLAND, NEW ZEALAND

R. V. Rose and U. Rieser

The Late Quaternary stratigraphy of North Westland, including marine, fluvial and glacial deposits, has been dated largely by correlation with the global sea level curve and the sequence of marine oxygen isotope stages. The Buller – Westland coastline contains a series of raised shore platforms commencing with the Holocene and extending an unknown distance into the past. Strandlines have previously been assigned to known global sea level highstands. Fluvial and glacial deposits older than MIS 2 have been dated via normal stratigraphic methods on the basis of relationships with the marine strandline sequence.

Deposits younger than about 25 ka have been dated successfully largely by ^{14}C. However, older deposits have proved more difficult to date by direct means. ^{14}C dating has been tried at some localities but traditional interpretations of the ages of various strata tend to preclude the acceptance of the ^{14}C data. Some samples have been interpreted as being contaminated by young carbon. This has been clearly demonstrated at one locality where the Kawakawa tephra is present and forms a convenient marker horizon. Consequently for North Westland there is a dearth of acceptable direct data on the age of most pre MIS 2 Quaternary deposits.

The correlation with the global sea level curve and the marine isotope stages is still open to alternative interpretations. Examination of loess outcrops on several glacial outwash terraces where the Kawakawa tephra is preserved has shown that the tephra is rather deeper in the loess cover at two sites (Grahams Terrace in the Grey Valley and at Chesterfield) than one might expect given the supposed ages of the surfaces (MIS 6 and MIS 4 respectively). One possible interpretation is that the sequence of glacial outwash terraces might be younger than traditionally supposed. If correct this ultimately leads back to the correlation of marine strandlines with the global sea level curve. Any revision of the model would have significant implications for local glacial histories and tectonic rates.

In order to resolve the age of the various deposits and surfaces with more precision a programme of sampling for optical luminescence dating has been carried out. The samples have been taken from buried soils and sandy marine strandline deposits at numerous sites. Localities are within the glacial Loopline Formation and the Nine Mile, Awatuna, Rutherglen, Karoro, Scandinavian and Caledonian marine benches. The first four dates are younger than expected. If confirmed by further work a revision of the oxygen isotope stage correlation may be required.

LATE QUATERNARY RIVER DEVELOPMENT IN MECKLENBURG/VORPOMMERN, NE GERMANY. - A CASE STUDY OF VALLEY FORMATION IN A MORAINE SEQUENCE OF THE WEICHSELIAN GLACIATION -

by Henrik Rother
Department of Geology University of Canterbury

The studied river stretch of the Nebel River is adjacent to Lake Krakow in the central part of Mecklenburg within the North German plain. Leaving Lake Krakow in a north east direction, the Nebel River cuts through a 2.5 km wide sequence of terminal moraines that border the lake on its northern side. The moraines are correlated with a readvance of the Fennoscandian ice sheet during the Weichselian glaciation at about 16 ka BP. Cutting through these Pomeranian moraines, the Nebel River crosses the regional watershed divide thereby draining Lake Krakow and its tributaries into the Baltic Sea instead of the North Sea. The valley geomorphology in the moraine zone comprises a repeated succession of incised erosional stretches and small basins. The aim of the study was to investigate Late Pleistocene and Holocene river development, determining timing and processes of Nebel valley formation. The work involved an extensive coring campaign and detailed field mapping supported by palynological as well as lithological and geochemical sediment analysis.

Results indicate that initial valley formation was caused by subglacial channel erosion of a Pre-Pomeranian advance. The direction of the subglacial channel is demonstrated by the alignment of present lakes and bogs, as well as the pattern of isobaths in Lake Krakow through which the channel continued. During deglaciation the structure was filled with dead ice preserving the channel geomorphology. Melting of the buried dead ice occurred between 13.5 - 13.0 ka BP leaving an open channel across the Pomeranian moraines. However, the valley floor gradient was discontinous and a chain of unconnected small lakes separated by moraine barriers occupied the valley. Sedimentation in the lakes started at about 12.9 ka BP ('Oldest Dryas') with the deposition of silica rich gytja showing little or no organic content. There is no record of fluvial activity in the Nebel valley during this time span.

Fluvial connection between Lake Krakow and the smaller lake basins in the Nebel valley was established during the Younger Dryas due to an overspill event of Lake Krakow, thereby dissecting the remaining moraine barriers in the Nebel valley. The high water level of Lake Krakow during the Younger Dryas is indicated by a lake terrace positioned about 2 m above the current lake level. The overspill event initiated the deposition of deltas in the paleo-lake basins in the Nebel valley. Beginning with the activation of the fluvial outlet of Lake Krakow during the Younger Dryas, incision of the Nebel River occurred at a rate of 1.1 m per 1ka. In the course of the Holocene the remaining lakes in the Nebel valley filled in due to organic sedimentation and eventually accumulated peat. The phases of Late Pleistocene to Holocene transformation of a subglacial channel into the Nebel River valley are summarized below:

1) Subglacial channel formation (Pre-Pomeranian stage: > 16.0 ka BP)
2) Subglacial channel conservation by buried ice (Deglaciation phase: ca. 14.0 - 13.5 ka BP)
3) Dead ice melt down and initial lake phase in the former subglacial channel (Oldest Dryas: 13.5 - 13.0 ka BP)
4) Connection of lake basins due to water overspill from Lake Krakow causing incision in channel steps (Younger Dryas: 11.0 ka BP)
5) Inflilling of organic sediments into small lake basins in the Nebel valley leading to the accumulation of peat (Pre-Boreal - Atlantikum: 10.0 - 6.6 ka BP)
6) Phase of human induced alteration of the Nebel River (starting at ca. 1200 AD)

HUMAN COLONISATION AND LANDSCAPE DYNAMICS IN TORRES STRAIT.

Cassandra Rowe
School of Geography and Environmental Science
Monash University

The general chronology of human settlement through the islands of Torres Strait is not well understood, with the earliest archaeological evidence for human occupation on the islands of western Torres Strait derived from occupational sites in late Holocene coastal landforms around 2500 years B.P. The fact that palaeoenvironmental records for the study area are sparse suggests an understanding of local, late Quaternary climatic and environmental conditions could benefit the interpretation of human arrival and occupation by contextualising the archaeological record within environmental parameters.

This paper explores island palaeoenvironments across western Torres Strait, and the causes of vegetation change through the Holocene. Palynological results from archaeological and other late Quaternary sediments on Moa and Badu Islands are presented, with the aim to investigate the history of island occupation by researching landscape dynamics. Initial results indicate broad shifts in local vegetation at key points in the Holocene. Results from the analysis of charcoal as a means of reconstructing the ecological role of fire and detection of fire regimes are also reported.

MODELLING SPATIAL LOESS OCCURRENCE FOR THE SOUTH ISLAND (NEW ZEALAND) BASED ON EXPERIENCES

Jochen Schmidt[*], Peter C. Almond[+], Sam Carrick [*], Allan E. Hewitt[*], Ian H. Lynn[*], Trevor H. Webb[*]
[*]Landcare Research NZ Ltd
[+]Lincoln University

Occurrence of loess in the landscape influences to a large degree other environmental subsystems, e.g. soils, vegetation, and soil water balance, and therefore has important implication for land resource management. Loess occurrence generally is dependent on the loess sources, the transport path and agents (wind direction), the local potentials for loess deposition, and erosion. In order to predict Loess accumulation on a process basis, parameters describing source area, transport path, deposition potential, and erosion potential could be used. These factors however, vary in space and time. Therefore any spatial loess distribution at any time will be highly complex. Models developed for modelling spatial distribution of loess tend to be conceptual and highly uncertain. A specific problem in New Zealand is field data for rule generation and validation. With respect to this situation it is assumed, that modelling spatial loess distribution from present spatial data sets using process-based approaches is not possible.

Loess occurrence, on the other hand, is often related to specific landscape forms and patterns (e.g. smoothness). Therefore, experts can give a judgement about loess distribution using spatial data sources. The New Zealand Soil map gives some ideas about the coarse scale loess distribution, i.e. for each soil set loess occurrence is documented qualitatively. The New Zealand Land Resource Inventory (NZLRI) contains information about loess occurrence in the description of parent material (ROCK). I.H.Lynn and M.McLoed (Landcare Research NZ Ltd) produced a soil parent material layer as a rework of ROCK (NZLRI) aimed at quantifying potential phosphorous supply for ecosystems. These information sources can be used to produce maps relating NZLRI units (polygons) to probability/thickness of loess occurrence. Initial attempts showed that these approaches could not predict spatial loess occurrence sufficiently. Therefore, a new classification scheme was developed.

It is the objective of this paper to present an approach in modelling recent spatial occurrence of loess on coarse (land system) scales. The approach is based on expert knowledge about patterns of land systems in New Zealand. A classification rationale for loess occurrence was developed, and applied to the map of soil sets for the South Island. The soil sets thereby served as a surrogate for land systems in the South Island. Five experts classified the soil sets of the South Island with respect to loess occurrence. As a result, a loess map of the South Island was produced, which combines loess coverage and thickness.

The map shows a great improvement in spatial resolution and mapping detail (depth, cover) in comparison to previous maps (Bruce 1973). The quality of the spatial representation, however, is dependent on the quality of the mapping of the South Island soil sets in the NZLRI. Proposed future steps would be to devise loess-landscape regions for New Zealand using the results and to study the internal fine scale distribution of loess within a loess-landscape using window studies. The findings could then be aggregated to loess-landscape models on finer (land component) scales.

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GEOMORPHIC EVIDENCE FOR A PIEDMONT GLACIATION IN N. W. NELSON, NEW ZEALAND, AT THE LAST GLACIAL MAXIMUM.

James Shulmeister[1], Glenn Thackray[2], David Fink[3] and Paul C. Augustinus[4]
[1]Department of Geological Sciences, University of Canterbury, Private Bag 4800, Christchurch, New Zealand
[2] Department of Geosciences, Idaho State University, Pocatello, ID 83209-8072, USA
[3] AMS-ANTARES, ANSTO, Private Bag 1, Menai 2234, Sydney, Australia
[4] Departments of Geography and Geology, University of Auckland, Private Bag 92019, Auckland, New Zealand

We present evidence for greatly expanded glaciation at the last glacial maximum (LGM) in the Cobb-Takaka valley system, N.W. Nelson, New Zealand. Shulmeister et al. (2001) outlined the then existing evidence for glaciation in the Cobb Valley. They identified a LGM advance which, they argued, terminated at the head of the Cobb Reservoir, 19 km upstream of the main Takaka Valley. Nested over 100 m above and several kilometres downstream of these deposits, were a series of high level glacial features, including basal tills, provisionally attributed to a Late Pliocene to mid-Quaternary advance. A new series of twenty one matched ^{10}Be and ^{26}Al ages from the Cobb System, dismantled the model of two widely separated glaciations, as all samples collected within and beyond the putative LGM limits yielded LGM to deglaciation ages. These results clearly implied much more extensive ice in the Cobb and adjacent Takaka river systems at the LGM.

Glacial mapping has consequently been extended onto the main Takaka valley floor, well beyond the recognised limits of Late Quaternary glaciation. Geomorphic evidence for glaciation includes a variety of glacial deposits and landforms, with weathering and degradation characteristics consistent with a LGM age. The findings may be summarised as follows;

1. Outcrops of till are plastered onto bedrock obstructions and terraces edges on the western side of the main Takaka valley, 20 km downstream of the Cobb Reservoir.
2. End moraines and kame terraces associated with ice debouching from the Cobb-Takaka valley are recognised on the western side of the Takaka valley as far north as Uruwhenua (c. 25 km beyond the Cobb Reservoir).
3. Ice also advanced down the Anatoki river system constructing moraines at the confluence with the lower Takaka Valley. The ice breached a low divide with the Waingaro River at Go Ahead Creek, where a small lateral moraine and putative kame terrace complex is preserved.

In order to accommodate this ice in the Cobb-Takaka and Anatoki systems we map a piedmont ice cap over the whole of the NW Nelson ranges at the LGM. This piedmont cap was the second largest ice cap in New Zealand at the LGM. Its recognition increases the known area of glaciation by about 7%.

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MEGAFLOODS OF THE LATE PLENIGLACIAL - YOUNGER DRYAS IN THE SOUTHERN RUSSIAN PLAIN

Aleksey Sidorchuk & Andrey Panin
Geographical Faculty, Moscow State University, 119899 Moscow, Russia
Olga Borisova
Institute of Geography, Russian Academy of Sciences, Staromonetny, 29, 109017 Moscow, Russia

Extreme floods at the rivers fed by the melt water from glaciers or glacial lakes are well studied in the past periglacial areas. Palaeohydrology of the rivers with no source of glacial melt water in cold climates with widespread permafrost attracted less attention, though such rivers drained an area over $30x10^6$ km^2 in the Northern hemisphere at the termination of the Last Glaciation. The periglacial zone with continuous permafrost and low soil permeability spread then over the Russian Plain and the West Siberian Plain as far south as 49°N. The relicts of large palaeochannels are found on the lower levels of river terraces and on the flood plains all over the former periglacial zone. The majority of these palaeochannels had a meandering pattern. Their widths exceeded those of the recent channels up to 15 times.

Based on the detail coring of the sediments filling in several palaeochannels, the geometry of cross-sections of these palaeochannels was reconstructed. Calculations with Chezy-Manning formula for the palaeochannels of the Protva River (the Oka River basin, mixed broadleaved-coniferous forest zone), the Seim River (the Dnieper River basin, forest-steppe zone), and the Khoper River (the Don River basin, steppe zone) show that the reconstructed megafloods were up to 14 times greater than the modern ones (Table). All these large palaeorivers were active in the Late Pleniglacial. The beginning of filling of the Protva River large channel with sediments occurred app. 12 700±110 yrs BP (Ki-7312). The large channel of the Khoper River was active 14 430±110 yrs BP (Ki-7694). Its filling has begun about 12 000 yrs BP (11 900±120 yrs BP, Ki-5305; 11 325±120 yrs BP, Ki-7680). The large palaeochannels of the Seim and Svapa Rivers were abandoned about 14 000 yrs BP (13 800±85 yrs BP, Ki-6984; 14 030±70 yrs BP, Ki-6997; 13 510±85 yrs BP, Ki-6991). All the dates are given as uncalibrated ^{14}C years.

Table. Extreme flood discharges at several Late Pleniglacial rivers of the Russian Plain.

River	Protva River	Seim River	Khoper River
Morpho-hydrological characteristics	mod/palaeo	mod/palaeo	mod/palaeo
Basin area (km^2)	2170/2170	10700/10700	19100/19100
Channel width (m)	80/180	60/1000	60/1400
Meander wavelength (m)	760/1600	780/5600	720/5000
Longitudinal slope	$4.1\ 10^{-4}/3.24\ 10^{-4}$	$1.3\ 10^{-4}/7.5\ 10^{-5}$	$6.3\ 10^{-4}/1.54\ 10^{-4}$
Mean discharge ($m^3\ s^{-1}$)	11.6/240	37.1/490	67.8/450
Mean maximum discharge ($m^3\ s^{-1}$)	250/3100	575/6400	991/5800
Extreme discharge ($m^3\ s^{-1}$)	507/7000	1920/14500	2910/13200

The next stage of megafloods is related to the Younger Dryas cold interval. The Khoper River channel width was then 150-200 m, still exceeding the present channel parameters. The mean maximum discharge in that channel was about 2000 $m^3\ s^{-1}$, two-fold a modern flood. These meanders were abandoned by the end of the Preboreal (9420±90 yrs BP, Ki-7693).

The main cause of megafloods formation with the discharges 6-14 times more than recent ones were periglacial conditions with deep permafrost and very sparse vegetation. The transformation of the large periglacial channels into significantly smaller Holocene channels occurred mainly due to the degradation of permafrost, decrease in the winter precipitation (snowfall) and surface runoff.

Dating Holocene estuarine successions using Aspartic Acid Racemisation

C.R. Sloss, C.V. Murray-Wallace, and B.G. Jones
School of Geoscience, University of Wollongong, NSW 2522, Australia

Aspartic acid racemisation has the potential to provide a chronology for infilling of Holocene estuaries and dating geologically-recent (<500 yr) estuarine successions. The degree of aspartic acid (Asp) racemisation observed in radiocarbon dated fossil specimens of *Anadara trapezia* is compared with the kinetic trend of Asp observed in laboratory-induced racemisation established in simulated aging experiments (heating). The results confirm that, within the D/L ratios obtained for this study, the simulated kinetic trends generally agree with the kinetic pattern observed in nature (Fig 1 A & B). These results and similar results for *Notospisula trigonella* provide the framework for an aminostratigraphy of Lake Illawarra based on the extent of racemisation (expressed as a D/L ratio) calibrated against results from the radiocarbon method (Fig 1 C). This was achieved using twenty-eight fossil specimens of the common estuarine molluscs *A. trapezia* and *N. trigonella*, recovered from nine vibracores from Lake Illawarra on the southern coast of New South Wales, Australia.

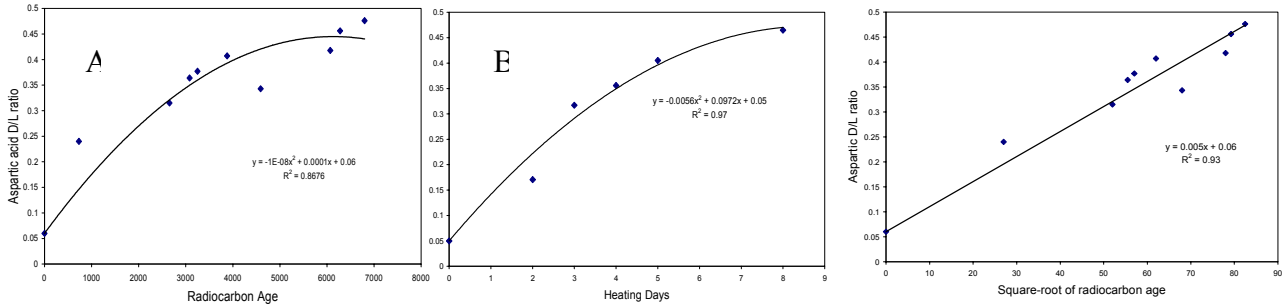


Figure 1: A) Laboratory induced Asp racemisation; B) Asp D/L ratio plotted against ^{14}C ages obtained on the same fossil mollusc. C) Asp D/L ratio plotted against square root of ^{14}C age on the same fossil mollusc

When examined within a lithostratigraphic framework, racemisation data permit the comparison of pre- and post-European sedimentation rates for Lake Illawarra (Fig. 2A & B). For example sedimentation rates using the top 50 cm of a core collected from the central lagoon of Lake Illawarra have been calculated using Asp-derived ages obtained from *in situ N. trigonella*. The results indicate that the rate of sedimentation was ca 0.3 mm/a for 600 years prior to European settlement. The period between ca130 and 40a shows an increase in sedimentation rate to 0.6 mm/a, and the period from 40a to the present has a sedimentation rate of 4.5 mm/a indicating a dramatic increase since European settlement and extensive urbanisation of the

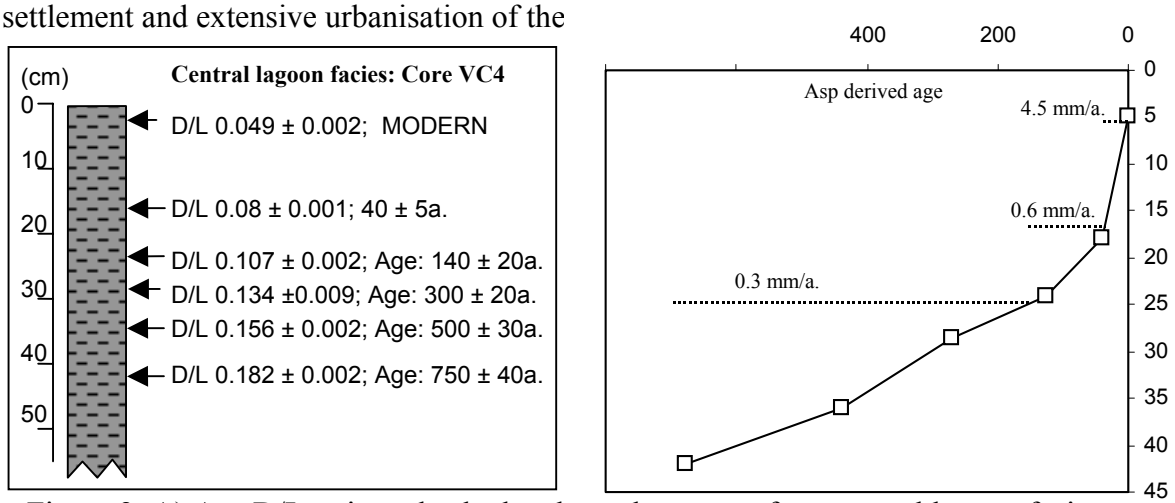
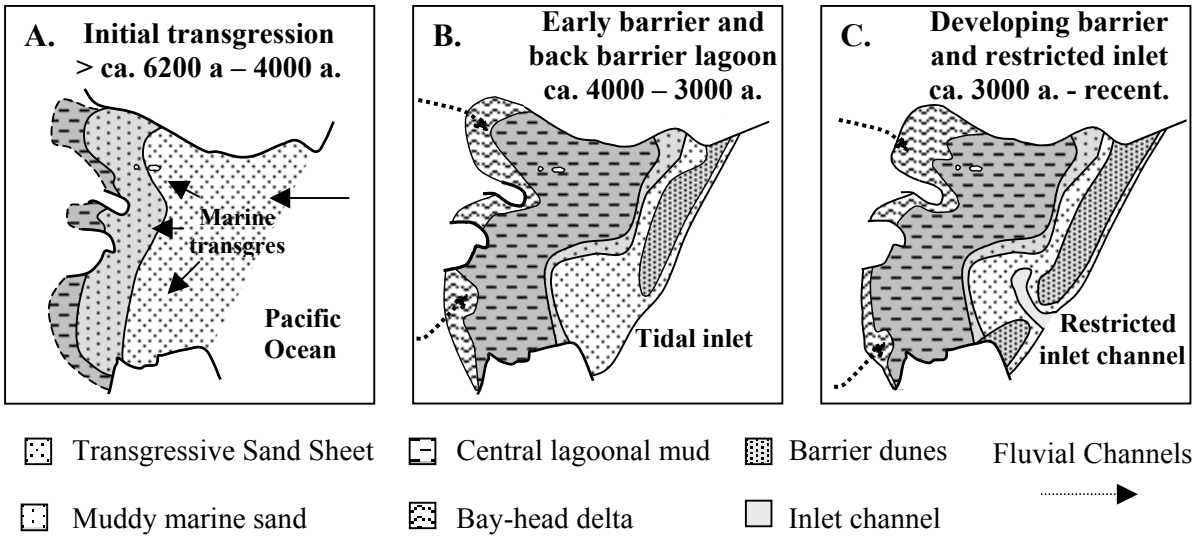


Figure 2: A) Asp D/L ratio and calculated age down core from central lagoon facies, Lake Illawarra

HOLOCENE EVOLUTION OF A BARRIER ESTUARY: LAKE ILLAWARRA, NEW SOUTH WALES, AUSTRALIA

C.R. Sloss, C.V. Murray-Wallace, and B.G. Jones
School of Geoscience, University of Wollongong, NSW 2522, Australia

Twenty seven vibracores, fifty five aspartic acid racemisation ages and four radiocarbon ages from Lake Illawarra, New South Wales, have been used, in conjunction with extensive seismic surveys and lithostratigraphic analysis, to construct a detailed chronostratigraphy for the infilling of this Holocene barrier estuary. These results show that the evolution of the barrier estuary diverges from previously constructed models of estuary evolution on tectonically stable coasts; especially in the early deposition of a basal transgressive marine sand sheet with a diverse assemblage of estuarine and high salinity tolerant mollusc species. The marine sand sheet directly overlies the Late Pleistocene incised valley system and was deposited as sea level rose during the last post-glacial marine transgression. It indicates that the barrier estuary was originally operating as a more open estuarine system similar to present-day drowned river valley.



With the post-glacial marine transgression the more open estuarine system (drowned river valley) was inundated with marine sediment until the later emergence of the Holocene barrier, which restricted the influence of oceanic water and resulted in the characteristic deposition of mud in a back-barrier lagoonal environment. This is in direct contrast to the previously accepted model that had marine sands associated with the post-glacial marine transgression stabilising in the mouth of the incised valley and the deposition of central lagoonal mud directly over the incised valley deposits. The cause for the divergence of the previously constructed evolutionary models of barrier estuaries evolution lie in the shallow nature of the Late Pleistocene antecedent landscape conditions of the incised valley system (<20 m) and the rapidly rising Holocene sea surface that breached the last-interglacial barrier some time before 6200 a Another controlling factor influencing the timing of the infilling barrier estuary system is the stabilising of the Holocene barrier at ca 4000a and a subsequent fall in sea level following the Holocene highstand at ca 3000a While this research adds greater detail to the regional influence of Holocene sea-level change on a barrier estuary, it also potentially provides an alternative model for the early evolution of Holocene barrier estuaries on tectonically stable coastlines with a shallow lowstand basin morphology.

PALYNOLOGICAL EVIDENCE FOR PLIO-PLEISTOCENE VEGETATION AND CLIMATE CYCLICITY IN UPLAND VICTORIA, AUSTRALIA.

J.M. Kale Sniderman[1], Brad Pillans[2], and Paul B. O'Sullivan[3]
[1]School of Geography and Environmental Science, Monash University, Clayton, Vic 3168 Australia
[2]Research School of Earth Sciences, The Australian National University, Canberra, ACT 0200 Australia
[3]Apatite to Zircon, Inc, 1075 Matson Road, Viola, ID 87872-9709 USA

Global Neogene climatic cooling was expressed in southeastern Australia by progressive reduction of formerly widespread mesotherm and microtherm rainforests, and their replacement by more drought- and fire-adapted, open-canopied vegetation. These long-term trends of vegetation replacement accelerated with the relatively abrupt climatic shifts marking the initiation of the Quaternary. However, the response of vegetation to increasingly high amplitude orbital scale climatic cycles during the Late Pliocene-Early Pleistocene remains poorly understood. Pollen analysis of intermittently laminated sediments from a small volcanic palaeolake in upland southeastern Australia, the Stony Creek Basin, illustrates the orbital-scale response of both "Tertiary" and "Quaternary" floristic elements to the evolving climatic cyclicity of the late Cenozoic.

11 cycles in the 40m lacustrine record from Stony Creek Basin are indicated by variations in organic matter and pollen abundance. The primary pattern of change is alternation between presence and absence of Podocarpaceae-dominated rainforest, including several taxa now extinct/very restricted in Australia (eg. *Ilex*, *Lophosoria, Dacrydium*, *Dacrycarpus*, *Beauprea*, *Podosporites* cf. *microsaccatus* [Podocarpaceae], *Dilwynites* cf. *granulatus =Wollemia*?) against a background of open-canopied sclerophyll forest dominated by *Eucalyptus*, Casuarinaceae and Cupressaceae (probably *Callitris*). The repetitive changes suggest pronounced differentiation of Plio-Pleistocene "interglacial" and "glacial" climatic stages, possibly related to 40kyr variation in orbital obliquity.

A latest Pliocene-earliest Pleistocene age is supported by three independent lines of evidence. First, the pollen assemblages include taxa for which the Plio-Pleistocene forms both the last (*Beauprea*, *Dacrycarpus*, *Dacrydium*) and first (*Plantago*, *Pomaderris*) previously known southeastern Australian appearances (Macphail 1997, 1999). Second, zircons recovered from inwashed basal sands and from a pyroclastic horizon at 29m downcore give fission track ages of 1.99 ± 0.43Ma and 1.93 ± 0.18 Ma, respectively. Third, palaeomagnetic analysis indicates that the sediments in the upper 25m of the core are of reversed polarity, and must predate the Brunhes/Matuyama polarity transition at 0.78 Ma. A zone of normal polarity below 25m is tentatively attributed, consistent with the 1-sigma error of fission track ages, to the Olduvai subchron, the upper boundary of which has an age of 1.78 Ma (Lourens *et al* 1996). It is therefore concluded that the record embraces the final two climate cycles of the Pliocene, and the initial seven or eight cycles of the Pleistocene.

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THE LGM IN WESTERN SOUTH ISLAND, NEW ZEALAND

R. P. Suggate
Institute of Geological & Nuclear Sciences, P.O.Box 30368, Lower Hutt, New Zealand,
P.Suggate@gns.cri.nz
P. C. Almond
Division of Soil, Plant and Ecological Sciences, P.O.Box 84, Lincoln University, almondp@lincoln.ac.nz

Mapping of morainic and glacial outwash deposits and of coverbed sequences, together with pollen studies of peats and radiocarbon dating, provide the basis for understanding the LGM in western South Island, New Zealand. The principal deposits of the late Otira (Last) Glaciation have been mapped as Larrikins Formation (la) in north Westland and as M5 in south Westland. These deposits are now recognised as having been produced by two separate advances ($la_1/M5_1$ and $la_2/M5_2$) of essentially similar extents. Interpretation of pollen sequences extending from before to after the Aokautere Ash (26.5 cal. yr BP) indicates an extensive period of cold with a short slight amelioration closely following the ash; this amelioration separates the $la_1/M5_1$ and $la_2/M5_2$ advances. Published records for DSDP 594 east of the South Island, particularly of $CaCO_3$ and pollen, show the effects of glacier fluctuations on the east side of the Southern Alps, where the glaciers were fed, as were those on the west side, by icefields straddling the crest of the range. DSDP 594 shows the last major cold period as lasting from c.32 to c13 ka cal. yr BP, a period that extends from well before to well after the culminations of both the $la_1/M5_1$ and $la_2/M5_2$ advances at c.26.5 ka and c.22 ka cal. yr BP. Both of these are equally to be regarded as representing the LGM in New Zealand, but only the latter comes within the preferred range of the global LGM: 19-23 cal. yr BP. If MIS2 is regarded as representing the coldest part of the Last Glaciation, its beginning would be better placed at 34 ka cal. yr BP than at 24.1 ka cal yr BP as presently adopted.

SET-UP, DEPOSITION AND SEDIMENTARY CHARACTERISTICS OF TWO STORM OVERWASH DEPOSITS, ABRAHAMS BOSOM BEACH, EASTERN AUSTRALIA

Adam D Switzer[1], Brian G Jones[1], Edward A Bryant[1], and S.K. Haslett[2]
1. School of Geosciences, University of Wollongong NSW 2522, Australia
2. Quaternary Research Unit, Bath Spa University College, Newton Park, Bath BA2 9BN, U.K.

Two storm events in March and July 2001 generated large swell from the northeast that breached a small barrier complex at Abrahams Bosom Beach on the southeast coast of Australia. The embayment is orientated to the northwest and is sheltered from all but the largest of northeast swells. Both events are associated with large swells from the northeast generated by intense low-pressure systems in the southwest Pacific. The March event is not considered a storm surge event. This event produced a larger swell component and the breaching event can be entirely attributed to swell magnitude and direction superimposed on evening high tides. The July overwash event is different and can be considered as a classic storm surge characterised by a super-elevation of coastal sea level associated with the landward fall of a small east coast low that was superimposed on high tides with significant storm swell.

Both events were capable of breaching the barrier and depositing a fan shaped tongue of marine sediment into the back-barrier estuary. The July event was considerably larger and was able to remove reed beds from the lagoon and carry marine sediment more than 100 m into the estuary. The internal stratigraphy of the sand sheets consist of a series of fining up sequences that are generally less than 20 mm thick and fine in a landward direction. Footprints and aeolian reworking identified in the upper parts of the March deposit define the break in sedimentation between the events.

This project provides a unique opportunity to study the sedimentary characteristics of overwash sedimentation in an estuary from the southeast coast of Australia that may provide a modern analog to assist in the characterisation of overwash sand sheets identified in Holocene cores taken from estuaries along the southeast coast.

The study also indicates that periodic storm generated swells that strike the coast from the north to northeast are not in equilibrium with the ambient setting of north facing embayments on this coast. This ambient setting is the result of a dominant southeast swell and associated beach set-up and we imply that such embayments are more likely to be breached during episodic high-energy events.

PHYTOLITH EVIDENCE FOR C4-DOMINATED GRASSLAND THROUGHOUT THE HOLOCENE AT LONG POCKET, NORTHEAST QUEENSLAND, AUSTRALIA

V.C. Thorn
Antarctic Research Centre, Victoria University of Wellington, PO Box 600, Wellington, New Zealand;
Email: vanessa.thorn@vuw.ac.nz

Palaeoclimatic information from northeast Australia is derived primarily from pollen records collected from the Atherton Tablelands, a region that is climatically atypical of most of tropical Australia. However, well-preserved pollen records outside the Tablelands, where the climate is much drier, have proved difficult to find. Although still developing as a discipline, the greater preservation potential of plant silica remains (phytoliths) can also usefully contribute to palaeoclimate reconstructions.

Phytolith analysis of ephemeral lake-fill sediment, which contains only rare terrestrial palynomorphs, from Long Pocket, near Toomba, northeast Queensland, indicates a C4-dominated grassland has been present in the region since *c.*10 ka. Based on the modern distribution of C4 and C3 native grasses in Australia, this suggests mean summer temperatures of at least 14°C (*c.*10°C cooler than present) and summer maximum rainfall were maintained as far back as the Pleistocene/Holocene boundary in this region. This interpretation is comparable with previous studies, which together imply the establishment of C4-dominated grasses in central and northeast Australia occurred between the Last Glacial Maximum (most likely after 16ka) and *c.*10ka.

Taxonomic composition of the grassland appears relatively consistent throughout the Holocene at Long Pocket and includes phytoliths comparable with those from modern Panicoideae, Arundinoideae, Chloridoideae and possibly Stipoideae. Rare non-grass phytoliths are also present. A gradual decrease of saddle phytolith forms (attributed to Chloridoideae grasses) from the base of the record at c.10ka to near the top at c.0.65ka suggests early Holocene aridity, decreasing towards the latest Holocene. This trend could reflect a locally drawn out effect of the end of the postglacial arid period due to the well-drained basalt flow catchment maintaining a local arid habitat for the Chloridoideae grasses.

RADAR STRATIGRAPHY OF A LARGE ACTIVE DUNE ON PARENGARENGA SANDSPIT, NEW ZEALAND: A FIRST ASSESSMENT

Remke L. Van Dam
New Mexico Tech, Department of Earth & Environmental Science, 801 Leroy Place, Socorro, NM 87801, USA, e-mail: remke@geopuls.nl
Scott L. Nichol, Paul C. Augustinus, Kevin E. Parnell, Peter L. Hosking
The University of Auckland, School of Geography and Environmental Science, New Zealand
Roger F. McLean
Australian Defense Force Academy, University of New South Wales, School of Geography and Oceanography, Australia

Parengarenga sandspit is New Zealand's only coastal source of silica and concerns about the environmental effects of sand extraction from the harbor mouth led to the instigation, in 1982, of a monitoring program of the beach and foredune system. In addition to the twice-a-year surveying, past research has focused on the long-term spit evolution. The interior of the spit is characterized by several solitary, unvegetated dunes separated by interdune flats. The solitary dunes, which are not incorporated into the coastal monitoring program, may be important sediment source or sinks. The interdune area covers around 70% of the spit and is characterized by occasional outcrops of so-called *coffee rock*. This semi-consolidated podzol has been dated by ^{14}C to 32.9 ± 1.65 to 20.6 ± .05 cal ky BP. However, little is known about the lateral extent of the coffee rock surface.

With this in mind a ground-penetrating radar (GPR) survey was undertaken to 1) map the lateral continuity of the coffee rock, and 2) study the sedimentary stratigraphy and development of the solitary dunes. GPR measures changes in electromagnetic properties of subsurface features, often related to variations in grain size and water content, and allows rapid acquisition of high-resolution images of the sedimentary architecture. We used a GSSI SIR 2000 system at 35MHz and 200MHz to survey two perpendicular lines on one of the large dunes on the spit and its adjacent interdune flats.

The dune we studied has a height of ~12 m, measured from the top of the coffee rock. The GPR data show that both dune and interdune flats are underlain by the coffee rock. Numerous hyperbolae in the coffee rock radar signature are the result of its irregular, weathered surface.

The GPR images show foreset reflections dipping in all windrose directions and allow identification of several phases of dune development. The core of the dune is characterized by eastward dipping cross-bedding in up to 1.5m thick cross-strata sets. This core is overlain and partly truncated by a sediment body with up to 4m thick cross-strata sets with steep westward dipping cross-bedding. This westward migration of the dune is still active. The N-S trending profile shows active lateral dune expansion towards the north and south. This phase of lateral dune growth coincides with the ongoing process of westward progradation.

Geomorphological observations and the sedimentary architecture point towards a combined star and transverse dune origin, which is supported by the configuration and morphology of the other dunes on the spit. At present, the dune is migrating to the west and growing in northerly and southerly directions, which indicates that the dune may be a major sand sink. However, the interpretation of phases of dune development currently lacks any absolute age control. Further understanding of modes and rates of dune development on the Parengarenga sandspit will incorporate luminescence dating of the dune units, as well as integrating GPR data from the solitary dune system with the foreshore and foredune data.

SPELEOTHEM EVIDENCE FOR CLIMATIC CHANGE IN NEW ZEALAND

Paul W. Williams
University of Auckland

Dated speleothems with associated stable isotope records from New Zealand occur as discontinuous series to about 500 ka BP. Older material also exists but is only dated by palaeomagnetism.

Oxygen isotopes reflect both temperature and precipitation conditions, rather than temperature alone as is commonly assumed. In New Zealand the $\delta^{18}O$ – T relationship is direct rather than inverse, as occurs in some places, because of the dominance of the oceanic source effect. The $\delta^{18}O$ – P relationship is inverse and exponential, and more noticeable in northern New Zealand than in the south.

The palaeoclimatic significance of $\delta^{13}C$ is more difficult to interpret, but in New Zealand seems most closely related to water balance, although $\delta^{13}C$ also varies with T. The commonly assumed relationship with vegetation is not clear, because effectively all New Zealand vegetation follows the C_3 photosynthetic pathway.

Too fine an interpretation of an individual speleothems record is unreliable because of dating errors, as is shown when separate records from various speleothems are overlain (a similar problem is found in the construction of chronologies from tree-rings). Consequently, a more reliable approach is to average records from several overlapping series, though sufficient samples are not always available to permit this.

Available records from New Zealand clearly show the variation of climatic conditions from the Late Glacial through the Holocene and many records provide evidence of climatic change in the Late Pleistocene. These records are presented and discussed. Speleothems interdeposited with glacifluvial sediments also provide discontinuous evidence of interstadial conditions, their dates bracketing intervals of glacial advance, identified as at 12-14, 16-18, 19-25, 37-40, 44-49 and ~65 ka BP in Fiordland.

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