Australian and New Zealand Geomorphology Group

12th Conference
Taipa Bay, New Zealand
February 13-17, 2006

Buried ancient kauri forest, semi-lithified sand, and relict soil horizons at Johnston's Gumdigger's Park, 90 Mile Peninsula

Conference Program
Abstracts

ANZGG Occasional Paper No. 4

The University of Auckland
School of Geography and Environmental Science
Occassional Publication 47
ISBN 1-877320-20-X: ISSN 1175-8457

WELCOME!

Welcome to the 12th Conference of the Australian and New Zealand Geomorphology Group Inc. (ANZGG 2006). We have chosen Taipa Bay in far Northland, New Zealand as the site to host the meeting because of the proximity to many essential elements of the distinctive Northland landscape are within easy reach- as are the stunning beaches and harbours within 100m of the conference venue!

ANZGG 2006 aims to bring together geomorphologists to promote new techniques and a greater appreciation of applied Earth surface processes understanding at across a wide range of spatial and temporal scales.

This volume includes abstracts accepted for oral and poster presentations.
Each conference theme commences with a keynote address, and papers that do not address a specific theme have been incorporated into general geomorphology sessions.

ANZGG 2006 Conference themes include:

1.) Timescales in landscape evolution
2.) Modelling and prediction in geomorphology
3.) Morphodynamics
4.) Extreme events and tectonic geomorphology

We hope you enjoy the meeting and make the most of this opportunity to explore the geomorphic and scenic wonderland that is far Northland, New Zealand.

Conference Organising Committee:
Dr. Paul Augustinus
Professor Gary Brierley
Dr. Paul Kench
Dr. Scott Nichol

Program Editor:
Andrew Lorrey

School of Geography and Environmental Science
The University of Auckland
New Zealand

MONDAY, FEBRUARY 13, 2006

TIME	SPEAKER	TITLE
8.30	PAUL AUGUSTINUS	OPENING COMMENTS
8:45	JOHN CHAPPELL	MESSAGE FROM ANZGG PRESIDENT
MORNING SESSION: LANDSCAPE EVOLUTION: SESSION CHAIR- NICK PRESTON		
8.50-9.40	**KEYNOTE ADDRESS:** BRAD PILLANS	TIMESCALES IN GEOMORPHOLOGY
9.40-10.00	LISA WORRALL	EVOLUTION OF THE TANAMI LANDSCAPE FROM THE CAMBRIAN TO THE PRESENT
10.00-10.20	JOHN WEBB	EOCENE SILCRETE DEVELOPMENT IN CENTRAL AUSTRALIA – THE REHABILITATION OF THE CORDILLO SURFACE
10.20-10.50	**MORNING TEA**	
10.50-11.10	VIC GOSTIN	EFFECTS OF TERTIARY MARINE FLOODING ON THE LANDSCAPE OF THE SOUTHERN MT. LOFTY RANGES, SOUTH AUSTRALIA
11.10-11.30	IAN HOUSHOLD	GEOMORPHIC RESPONSE TO INTRAPLATE NEOTECTONICS – BIRCH'S INLET, SW TASMANIA
11.30-11.50	ROSLYN CHAN	PALAEOGEOGRAPHY AND NEOTECTONICS IN THE COBAR REGION, CENTRAL NSW, AUSTRALIA
11.50-12.10	PATRICIA FANNING	EPISODIC NON-EQUILIBRIUM AS A GEOMORPHIC MODEL FOR UNDERSTANDING THE SURFACE ARCHAEOLOGICAL RECORD IN ARID AUSTRALIA
12.10-12.30	JOSEPH HAGG	APPLICATION OF COSMOGENIC NUCLIDES TO LANDSCAPE EVOLUTION AND LONG-TERM EROSION RATES IN SW ENGLAND
12.30-13.30	**LUNCH**	
AFTERNOON SESSION: QUATERNARY SCIENCE: SESSION CHAIR- ANDREW LORREY		
13.30-13.50	ED RHODES	ANCIENT SURFACES? DATING ARCHAEOLOGICAL SURFACES IN WESTERN NSW USING OSL
13.50-14.10	GERALD NANSON	HAVE THE LINEAR DUNES OF AUSTRALIA FORMED BY LINEAR EXTENSION?
14.10-14.30	KATHRYN FITZSIMMONS	TIMESCALES IN DUNEFIELD EVOLUTION: AN OPTICALLY STIMULATED LUMINESCENCE (OSL) CHRONOLOGY OF THE STRZELECKI AND TIRARI DESERT DUNEFIELDS, SOUTH AUSTRALIA
14.30-14.50	PAUL HESSE	CLIMATE VARIABILITY, CLIMATE CHANGE AND DESERT DUNE MOBILITY
14.50-15.10	HAIM TSOAR	THE EFFECT OF CLIMATE CHANGE ON MOBILITY AND STABILITY OF SAND DUNES
15.10-15.30	LEVI ROBERTS	NDVI DERIVED FLUCTUATIONS IN VEGETATION COVER AND HORIZONTAL AND VERTICAL WIND PROFILES OVER LONGITUDINAL SAND DUNES IN THE STRZELECKI DESERT, SOUTH AUSTRALIA
15.30-16.00	**AFTERNOON TEA**	
16.00-16.20	NAVIN JUYAL	SOUTHWEST MONSOON AND LATE QUATERNARY LANDSCAPE EVOLUTION IN THE SOUTHERN MARGIN OF THAR DESERT, INDIA
16.20-16.40	QUAN HUA	ATMOSPHERIC 14C DURING THE YOUNGER DRYAS DERIVED FROM TASMANIAN HUON PINE
16.40-17.00	OLAV SLAYMAKER & CHRISTINE EMBLETON-HAMANN	HEINRICH JACKLI'S CONTRIBUTION TO ALPINE MORPHODYNAMICS
17.00-17.20	ANDREW MACKINTOSH	THE SENSITIVITY OF NEW ZEALAND GLACIERS TO CLIMATIC CHANGE
17.20-17.40	KATHERINE LILLY	GLACIAL HISTORY OF DALTON CORNER, SOUTH MAWSON ESCARPMENT, EAST ANTARCTICA
17.40-18.00	MAUREEN MARRA	PALEOENVIRONMENTAL RECONSTRUCTION OF A WELL-PRESERVED STAGE 7 FOREST SEQUENCE CATASTROPHICALLY BURIED BY BASALTIC ERUPTIVE DEPOSITS, NORTHERN NEW ZEALAND
18.00-18.20	MICHAEL BONTE-GRAPENTIN	THE STORY OF AN ANCIENT LAKE IN VITI LEVU, FIJI

TUESDAY, FEBRUARY 14, 2006

TIME	SPEAKER	TITLE
MORNING SESSION: FLUVIAL GEOMORPHOLOGY (SEDIMENT BUDGETS): SESSION CHAIR- INGRID TAKKEN		
8.30-9.20	**KEYNOTE ADDRESS**: IAN PROSSER	MODELLING SPATIAL PATTERNS OF SEDIMENT TRANSPORT IN LARGE RIVER BASINS: A GEOMORPHOLOGIST'S FORAY INTO CATCHMENT WATER QUALITY MODELLING
9.20-9.40	KEN PAGE	IMPACTS OF EUROPEAN SETTLEMENT ON CHANNEL MORPHOLOGY OF GILMORE CREEK, SE AUSTRALIA
9.40-10.00	IAN FULLER	CATASTROPHIC OR NOT? CHANNEL RESPONSE TO THE '150 YEAR' STORM, MANAWATU, NEW ZEALAND
10.00-10.30	**MORNING TEA**	
10.30-10.50	BASIL GOMEZ	SIMULATING THE EFFECTS OF C21 CENTURY CLIMATE CHANGE ON SEDIMENT DISCHARGE TO THE POVERTY SHELF
10.50-11.10	JOCHEN SCHMIDT	SOURCE-TO-SINK SEDIMENT TRANSPORT MODELLING IN THE RAGLAN CATCHMENT
11.10-11.30	PETER COLE	SEDIMENT BUDGET MODELLING OF THE MOTUEKA RIVER CATCHMENT
11.30-11.50	JOANNA HOYLE	SEDIMENT ORGANISATION AND WITHIN-REACH VARIABILITY IN A HIGHLY ADJUSTED RIVER CHANNEL
11.50-12.10	VIKRANT JAIN	DERIVING CATCHMENT SCALE DISTRIBUTIONS OF STREAM POWER – A COMPARATIVE STUDY OF THREE DIFFERENT APPROACHES IN THE UPPER HUNTER RIVER CATCHMENT, NSW, AUSTRALIA
12.10-12.30	FRÉDÉRIC GOB	CRITICAL STREAM POWER IN HIGH ENERGY BOULDER-BED RIVERS
12.30-13.30	**LUNCH**	
AFTERNOON SESSION: FLUVIAL GEOMORPHOLOGY (RIVER PROCESSES): SESSION CHAIR- JUSTINE KEMP		
13.30-13.50	**KEYNOTE ADDRESS:** PETER COWELL	COASTAL MORPHOKINETICS
13.50-14.10	JONATHAN CLARKE	SEDIMENTARY ARCHITECTURE AND GEOMORPHIC CLASSIFICATION OF THE LOWER BURDEKIN RIVER, QUEENSLAND
14.10-14.30	JACKY CROKE	THE NATURE AND TIMING OF FLUVIAL CHANGE IN THE FITZROY RIVER BASIN, QUEENSLAND
14.30-14.50	ANDREW HUGHES	THE IMPACT OF CATCHMENT DISTURBANCE ON THE SEDIMENT FLUX OF THE FITZROY RIVER, CENTRAL QUEENSLAND
14.50-15.10	KATHRYN AMOS	ANABRANCHING IN THE FITZROY RIVER QUEENSLAND: FROM BROAD CATCHMENT CONTROLS TO LOCAL-AT-A-SITE CHARACTERISTICS
15.10-15.30	JAMES TERRY	INVESTIGATING THE EVOLUTION OF THE JOURDAIN RIVER BRAIDPLAIN ON SANTO ISLAND, VANUATU
15.30-16.00	**AFTERNOON TEA**	
16.00-16.20	TIMOTHY COHEN	THE RELATIONSHIP BETWEEN HYDROLOGY AND CHANNEL GEOMETRY IN TASMANIAN RIVERS
16.20-16.40	RACHEL NANSON	EXTREME ADJUSTMENTS IN SWAMP CHANNEL MORPHOLOGY, BARRINGTON TOPS, NEW SOUTH WALES
16.40-17.00	MICHAEL SAYNOR	MORPHODYNAMICS OF A TROPICAL SAND-BED STREAM
17.00-17.20	CHRIS THOMPSON	FINE SEDIMENT RESIDENCY IN MOUNTAIN CHANNELS IN SOUTHEASTERN AUSTRALIA
17.20-17.40	INGRID TAKKEN	THRESHOLD FOR GULLY INITIATION AT ROAD DRAIN OUTLETS
TUESDAY EVENING (19.30-20.00):		**RIVERS DISCUSSION GROUP**

THURSDAY, FEBRUARY 16, 2006

TIME	SPEAKER	TITLE
MORNING SESSION: GEOMORPHOLOGY AND LANDSLIDES: SESSION CHAIR- AMY DOUGHERTY		
8.30-9.20	PAUL RUSTOMJI	HOLOCENE VALLEY AGGRADATION CONTROLLED BY POST-GLACIAL SEA LEVEL RISE AND ESTUARINE INFILLING : EXAMPLES FROM AUSTRALIA
9.20-9.40	CRAIG SLOSS	A REVISED HOLOCENE SEA-LEVEL CURVE AND ESTUARINE EVOLUTION MODEL FOR THE SOUTHEAST COAST OF AUSTRALIA
9.40-10.00	PAUL KENCH	IMPACTS OF THE SUMATRAN TSUNAMI ON MALDIVIAN REEF ISLANDS
10.00-10.30	**MORNING TEA**	
10.30-10.50	DIEDRE HART	MODELLING REEF PLATFORM CARBONATE AND SEDIMENT PRODUCTION
10.50-11.10	MARK DICKSON	EROSIONAL EVOLUTION OF THE WAITAKI ALLUVIAL FAN
11.10-11.30	JAMES GOFF	SHIFTING SANDS
11.30-11.50	JIASHU CHEN	BEACH MORPHOLOGY CHANGE RELATED TO THE VARIATION IN COASTAL HYDRODYNAMICS AT MORUYA, NSW
11.50-12.10	MAREE HEMMINGSEN	ABRASION – MORE THAN A MECHANICAL PROCESS
12.10-12.30	IAN RUTHERFORD	WHAT INITIATES AVULSIONS ON RIVERS?
12.30-13.30	**LUNCH**	
13.30-13.50	NICHOLAS PRESTON	MULTIPLE OCCURRENCE REGIONAL LANDSLIDE EVENTS AS A FORMATIVE GEOMORPHIC PROCESS
13.50-14.10	GABI HUFSCHMIDT	LANDSLIDE RISK EVOLUTION: CONCEPT AND APPLICATION
14.10-14.30	JAMIE SHULMEISTER	GLACIAL GEOMORPHOLOGY, SEDIMENTOLOGY AND CHRONOLOGY IN THE RAKAIA VALLEY, CANTERBURY, NEW ZEALAND.
AFTERNOON SESSION: SOILS/KARST GEOMORPHOLOGY: SESSION CHAIR- KERRIE TOMKINS		
14.30-14.50	GEOFF HUMPHREYS	HOW ANCIENT ARE AUSTRALIAN LANDSCAPES AND SOILS?
14.50-15.10	MARSH WILKINSON	SOIL PRODUCTION RATES INFERRED FROM COSMOGENIC RADIONUCLIDES, AND LAST GLACIAL MAXIMUM EROSION RATES IN UPLAND S.E. AUSTRALIA
15.10-15.30	VICTORIA FARWIG	RESERVOIR SEDIMENT STACKS: THEIR POTENTIAL FOR DETERMINING POST-FIRE HISTORY, SEVERITY AND FREQUENCY FROM SELECTED SEDIMENT CHARACTERISTICS
15.30-16.00	**AFTERNOON TEA**	
16.00-16.20	GLEN BANN	DRYLAND SALINITY IN SOUTH EASTERN AUSTRALIA:FALLACIES AND MISCONCEPTIONS
16.20-16.40	MICHAEL CRAIG	MAPPING THE DISTRIBUTION AND CHARACTER OF THE NORTHERN TERRITORY REGOLITH
16.40-17.00	MAREK ŻBIK	FROM MICROMORPHOLOGY TO GEOMORPHOLOGY; NANOMORPHOLOGY OF CLAY MINERALS
17.00-17.20	R.R. DAVIES	LANDFORM AND KARST EVOLUTION OF THE NULLARBOR PLAIN, AUSTRALIA: NEW INSIGHTS FROM SHUTTLE RADAR DATA AND SURFACE GEOPHYSICAL OBSERVATIONS
17.20-17.40	STEFAN DOERR	ORIGIN AND KARST GEOMORPHOLOGICAL SIGNIFICANCE OF THE ENIGMATIC NULLAROR 'BLOWHOLES' AND THEIR BAROMETRIC DRAUGHTS
17.45-19.00		**ANZGG ANNUAL GENERAL MEETING**
19.30 ONWARDS		**ANZGG CONFERENCE DINNER AT THE TAIPA BAY RESORT**

ANZGG Inc. Annual General Meeting

Thursday 16 February 2006, 17:45-19:00
Taipa Bay Resort, North Island, New Zealand

Agenda

- Apologies
- Minutes of General Meeting Held at University of Melbourne, February 20045 & Matters Arising
- Financial Reports for Year Ended 30 September 2005
- IAG Conference 2009
- Jennings Award
- Professional Practice and Accreditation
- Australasian Fluvial Group
- Next ANZGG Conference
- Budget 2006/07
- Election of New Committee
- Other Business

FRIDAY, FEBRUARY 17, 2006

TIME	SPEAKER	TITLE
MORNING SESSION: LANDSCAPE EVOLUTION: SESSION CHAIR- MARSH WILKINSON		
8.30-9.20	KEYNOTE ADDRESS: KELVIN BERRYMAN	TECTONIC GEOMORPHOLOGY AND THE ROLE OF EXTREME EVENTS: NEO-CATASTROPHISM ASSESSED
9.20-9.40	DAVID GIBSON	MAPPING BASALTIC REGOLITH WITH AIRBORNE GEOPHYSICS IN THE LAKE CORANGAMITE CATCHMENT, WESTERN VICTORIA
9.40-10.00	KAROLY NEMETH	TEPHRA-RING GULLY DEVELOMENT IN TROPICAL CLIMATE - THE RELATIVE ROLES OF SYN- AND POST-ERUPTIVE EROSION: A CASE STUDY ON THE 1913 WEST-AMBRYM ERUPTION, VANUATU
10.00-10.30	**MORNING TEA**	
10.30-10.50	JOHN CHAPPELL	CHANGING LANDSCAPES: LATE CENOZOIC ARIDITY IN THE AUSTRALIAN INTERIOR
10.50-11.10	TOSHIYUKI FUJIOKA	INITIATION OF AUSTRALIAN STONY DESERT, DATED BY COSMOGENIC 21NE AND 10BE
11.10-11.30	PHIL TONKIN	REVISION OF THE AGES OF RIVER TERRACE AND FAN SURFACES IN THE MIDDLE CLUTHA VALLEY AND MANUHERIKIA BASIN, CENTRAL OTAGO, NEW ZEALAND
11.30-11.50	KERRIE TOMKINS	VALLEY SIDE-WALL RETREAT VIA EXTREME EROSION EVENTS, SOUTH-WEST SYDNEY BASIN
11.50-12.10	DAVID FINK	SIGNATURES OF ANTARCTIC CLIMATE CHANGE RECORDED IN CONTINENTAL GLACIAL CHRONOLOGIES OF THE SOUTHERN HEMISPHERE BETWEEN 10 TO 30 KA
12.10-12.30	E.J. HODGE	SPELEOTHEMS AS INDICATORS OF CATCHMENT STABILITY IN THE LATE QUATERNARY: EVIDENCE FROM THE WESTERN MEDITERRANEAN
12.30-13.30	**LUNCH**	
AFTERNOON SESSION: APPLIED FLUVIAL GEOMORPHOLOGY: SESSION CHAIR-ANDREW HUGHES		
13.30-13.50	ANDREW BROOKS	RIVER REHABILITATION IN HIGHLY ALTERED RIVERINE LANDSCAPES OF SOUTH-EASTERN AUSTRALIA: MEETING COMMUNITY AND POLITICAL EXPECTATIONS WITHIN THE PREVAILING GEO-ECOLOGICAL CONSTRAINTS
13.50-14.10	ALEX SPINK	AN ASSESSMENT OF RIVER MORPHODYNAMICS AND REHABILITATION WORKS WITHIN THE UPPER HUNTER CATCHMENT, NEW SOUTH WALES
14.10-14.30	DAVID OUTHET	A METHOD FOR QUANTIFYING CATCHMENT-SCALE TEMPORAL CHANGES IN RIVER GEOMORPHIC TYPE PATTERNS
14.30-14.50	SANDRA BRIZGA	HYDROLOGIC AND GEOMORPHOLOGIC EFFECTS OF WATER RESOURCE DEVELOPMENT ON QUEENSLAND'S EAST COAST RIVERS
14.50-15.10	JUSTINE KEMP	REFINING DOCUMENTARY FLOOD RECORDS FROM REMOTE AREAS: RIVER BEAULY, SCOTTISH HIGHLANDS
15.10-15.30	BRENDA ROSSER	STATISTICAL ANALYSIS OF STREAMBED SEDIMENT GRAIN SIZE DISTRIBUTIONS: IMPLICATIONS FOR ENVIRONMENTAL MANAGEMENT AND REGULATORY POLICY IN NORTHERN CALIFORNIA
15.30-16.00	**AFTERNOON TEA**	
16.00-16.20	MARK TAYLOR	DISPERSAL AND STORAGE OF SEDIMENT-ASSOCIATED METALS IN THE LEICHHARDT RIVER, MT ISA, QUEENSLAND
16.20-16.40	JAMES GROVE	FROM WOLMAN TO WHERE? : A REVIEW OF URBAN FLUVIAL GEOMORPHOLOGY

POSTER PRESENTATIONS

1	GLENN BANN	THE JERVIS BAY VOLCANO, SOUTH EAST NSW: GEOLOGY, GEOMORPHOLOGY AND BIOGEOGRAPHY
2	MARTIN BROOK AND TYNE CROW	ASPECTS OF GLACIATION IN THE TARARUA RANGE, NORTH ISLAND, NEW ZEALAND
3	ANDREW BROOKS, JOHN SPENCER, PETER BRUNNER, PU LIN	A GEOMORPHIC CLASSIFICATION FOR AUSTRALIAN TROPICAL RIVERS: A FRAMEWORK FOR MULTI-DISCIPLINARY RESEARCH
4	AMY J. DOUGHERTY AND SCOTT L. NICHOL	3-D STRATIGRAPHIC MODELS OF PROGRADING BARRIERS ALONG THE NORTH-EAST COAST OF NEW ZEALAND PROVIDE DETAILED INSIGHT INTO COASTAL EVOLUTION
5	DAVID. FINK, G. SKILBECK, M. GAGAN	INTER-GLACIAL AND HOLOCENE PALEO-ENSO VARIABILITY IN LAMINATED SEDIMENT RECORDS FROM THE PERU CONTINENTAL MARGIN
6	CARGILL J. HENDERSON & IAN C. FULLER	SLOPE-CHANNEL COUPLING DURING THE FEBRUARY 2004 STORM IN THE MANAWATU, NEW ZEALAND: TOWARDS AUTOMATED IDENTIFICATION
7	LINDSAY KILLIN	IDENTIFYING AND FINGERPRINTING SOURCES OF LONG-TRAVELLED DUST ALONG THE SOUTHEAST DUST PATH OF AUSTRALIA
8	SONIA LEONARD AND JONATHAN NOTT	UNDERSTANDING FLUVIAL PROCESSES IN CATCHMENT MANAGEMENT: BANK EROSION IN THE MULGRAVE RIVER, NORTHEASTERN AUSTRALIA
9	SAM MORGAN	THE LATE HOLOCENE EVOLUTION OF A NORTHLAND ESTUARY
10	TIM RALPH, PAUL HESSE, DAVID YONGE	DRYLAND WETLANDS: THE HOLOCENE RESPONSE OF INLAND RIVERS IN AUSTRALIA
11	ED RHODES	OSL DATING OF LINEAR DUNES IN THE SIMPSON DESERT, AUSTRALIA
12	PAUL RUSTOMJI, TIM PIETSCH	PRE- AND POST EUROPEAN SEDIMENT REDISTRIBUTION PATTERNS: LAKE BURRAGORANG CATCHMENT, AUSTRALIA
13	JOCHEN SCHMIDT, PETER C. ALMOND, LES BASHER, SAM CARRICK, ALLAN E. HEWITT, IAN H. LYNN, TREVOR H. WEBB	LOESS SOILS IN THE SOUTH ISLAND, NEW ZEALAND
14	CAROL .M SMITH, F.L. SHANHUN, AND P. C. ALMOND	SOIL STRATIGRAPHY AND CHEMICAL CHARACTERISATION OF THE BIRDLINGS FLAT LOESS, AHURIRI QUARRY, BANKS PENINSULA, NEW ZEALAND
15	AMALIA SHORT AND GUY LAMPERT	SETTING GEOMORPHIC PRIORITIES FOR RIVER CONSERVATION AND REHABILITATION IN THE NAMOI RIVER CATCHMENT, NSW
16	ANKE TIMMERMANN, MICHAEL J. CROZIER	APPLICATION OF GIS TO LANDSLIDE SUSCEPTIBILITY MODELLING, WAITAKI REGION, SOUTH ISLAND, NEW ZEALAND
17	KATE WILSON, KELVIN BERRYMAN, TIM LITTLE, URSULA COCHRAN, NICOLA LITCHFIELD	EARLY HOLOCENE ESTUARY EVOLUTION UNDER CONTRASTING TECTONIC UPLIFT PROCESSES: THE PAKARAE AND HICKS BAY PALEO-ESTUARIES, RAUKUMARA PENINSULA, NEW ZEALAND
18	TOM PAULIN, ANDREW MACKINTOSH, BRIAN ANDERSON, AND HARRY KEYS	UNDERSTANDING THE CAUSE OF CONTEMPORARY GLACIER RETREAT ON MT RUAPEHU, NEW ZEALAND

Poster Session Themes

(Authors in attendance to field questions during lunch hour)

Monday: Landscapes and Climate (Posters 1, 2, 5, and 18)
Tuesday: Rivers and Loess (Posters 6, 7, 10, 13, 14 and 15)
Thursday: Coasts and Estuaries (4, 9, 11 and 17)
Friday: Rivers and Landslides (Posters 3, 8, 12 and 16)

ORAL PRESENTATIONS

Monday, February 13th 2006

KEYNOTE ADDRESS:
TIMESCALES IN GEOMORPHOLOGY

Brad Pillans
CRC LEME, Research School of Earth Sciences, ANU, Canberra

In 1758, when Archbishop Ussher made his now famous proclamation that the Earth was created in 4004 BC, timescales in geomorphology were rather short! However, by the end of the 19th century, estimates of the age of the Earth had lengthened to hundreds of millions of years, and in 1907 Boltwood calculated U/Pb ages for some minerals in excess of 1 billion years. Thus, when W.M. Davis was elucidating his cycle of erosion, the antiquity of geological (and geomorphological) time was already being realized.

From the 1950's onwards, particularly in the Southern Hemisphere, and nowhere more so than in Australia, the extreme antiquity of landscapes was reinforced through the work of King, Twidale, Ollier and Mabbutt, for example. Indeed, from stratigraphic evidence and application of modern regolith dating techniques, the history of some Australian landscapes can now be confidently traced back at least 300 million years, to times when Australia was part of Gondwana.

Meanwhile, back in the Northern Hemisphere, the well known American geomorphologist, William Thornbury, wrote in 1954: "Little of the earth's topography is older than the Tertiary and most of it is no older than Pleistocene". Such a statement was not surprising considering that Thornbury was based in Indiana, surrounded by a sea of Pleistocene glacial deposits. Indeed he stressed the major role of Pleistocene climatic change in manner that would comfortably apply to studies of landscape evolution in New Zealand today.

In this talk, I will highlight the importance of numerical dating methods in constructing timescales for landscape evolution, using examples that may include:
Soil chronosequences on basalt flows in North Queensland and on glacial moraines in Westland (and mention of rock weathering rates determined from headstones in cemeteries and soil production rates from cosmogenic nuclides).

Drainage network and slope evolution on terraces in South Taranaki, in the context of classic early studies in the USA (e.g. Horton, Ruhe), and Wales (Savigear), respectively. The history of aridity and "redness" of rocks, saprolite and sand dunes in Central Australia. The age and dissection of volcanic landforms on Mars and Earth, including the use of tephra marker beds for dating New Zealand landscapes.

The talk will also demonstrate the application of quantitative models of landscape evolution to practical problems including land management and mineral exploration. Such models not only reconstruct the past, but also predict the future, as embodied in a restated principle of uniformitarianism: "The present is the key to the past, but both are the keys to the future".

In his book, "Life on the Mississippi", published in 1883, Mark Twain used a combination of his own observations and historical records of meander cutoffs to calculate that 742 years into the future the lower Mississippi between Cairo and New Orleans would be shortened from 973 miles to just over 1 mile long! As Twain concluded "There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact".

Approved for publication by CRC LEME

EVOLUTION OF THE TANAMI LANDSCAPE FROM THE CAMBRIAN TO THE PRESENT

Lisa Worrall, and Brad Pillans.
Cooperative Research Centre for Landscape Environment and Mineral Exploration. www.crcleme.org.au

The Tanami Desert straddles the Western Australia-Northern Territory border, approximately 600 km northwest of Alice Springs. The region hosts significant gold deposits, but mineral exploration is hampered by the extensive development of both in situ and transported regolith. An understanding of processes which have sculptured the landscape and formed the regolith is fundamental to the development of an effective mineral exploration strategy and the identification of an appropriate geochemical sampling media.

The Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) is working in

collaboration with Geoscience Australia, the Northern Territory Geological Survey, the Geological Survey of Western Australia, Tanami Gold NL, Newmont Australia and Barrick Gold to establish a model of landscape and regolith evolution in the Tanami. The model, which is sketched out below, builds on work done by Wilford (2000), and will be used to constrain a developing understanding of the physical and chemical (including hydrogeochemical and biogeochemical) processes which have been dispersing metals into and through the regolith over time.

The oldest dated elements of the regolith are the Cambrian Antrim Plateau Basalts. These valley-fill and flood basalts are essentially flat-lying and are underlain by fluvial and aeolian deposits. The Cambrian Period is, therefore, an appropriate starting point for the evolutionary model. From the Cambrian through to the Permian, the Tanami region was exporting sediment to the marginal basins including the Canning Basin. The nature of the sediments in the Canning Basin suggests that the Tanami was intermittently glaciated between the Late Carboniferous and the Early Permian. A deeply oxidised regolith profile developed during this time, and we speculate that this deep oxidation was driven by falling groundwater levels possibly associated with glacial low sea levels and/or tectonism on the margin of the Canning Basin.

The region continued to erode and export sediments during the Triassic and the Jurassic but in the Cretaceous the marginal basins were flooded by a marine transgression. Sediments were retained within the palaeovalleys, the relief was lowered, and the drainage became disorganised. After the sea regressed the palaeovalleys remained choked with sediments, possibly because the competency of the fluvial network declined with the onset on aridity in the Tertiary. Groundwater has also been trapped in the palaeovalley fill and the maturation of this water has important consequences for the subsequent weathering of oxidised regolith in the valley floors and the dispersion of gold and other metals in solution.

The palaeovalleys are now the locus of playa lakes, with precipitation of gypsum and other salts as a consequence of intermittent wetting and drying. The playa lakes may be the source of sand which has formed linear dunes that have an east-west alignment in the Tanami region. These dunes are part of a continental dune field which was known to be active during the Quaternary.

References:
Wilford, J.R., 2000. Regolith Landform mapping and GIS synthesis for mineral exploration in the Tanami region. CRC LEME, Perth. Exploration and Mining Report 146R. 95pp.

The authors publish with the permission of the CEOs of CRC LEME and Geoscience Australia

EOCENE SILCRETE DEVELOPMENT IN CENTRAL AUSTRALIA – THE REHABILITATION OF THE CORDILLO SURFACE

John A. Webb
Environmental Geoscience
La Trobe University
Victoria 3086

Silcrete occurs extensively through large parts of inland Australia as resistant caps on mesas, and these outcrops have been regarded as remnants of a widespread silcrete sheet called the Cordillo Palaeosurface that formed during the Tertiary. More recently the concept of an extensive land surface that originated over a relatively short period of time has been called into question, and it has been proposed that such surfaces could represent extended periods of formation and cannot be used as stratigraphic horizons.

Silcretes of the Cordillo Palaeosurface are well exposed in the Tibooburra area of northwestern New South Wales. In the Mount Wood Hills east of Tibooburra a pedogenic silcrete up to 2m thick, with well-developed concretionary and columnar horizons, outcrops discontinuously for over 50 km. The silcrete has formed in kaolinised Early Cretaceous marine sediments and in the overlying Paleocene-Eocene sands and gravels of the Eyre Formation, and has been gently tilted, probably in the Oligocene, to form the Tibooburra Dome.

The age of silcrete formation is constrained by dating of the silicified sediments and the timing of deformation, and is most likely Eocene. Elsewhere in inland Australia silcretes of the Cordillo Palaeosurface appear to have formed at the same time as the Tibooburra silcretes, as they have developed in Eyre Formation sediments that contain leaf impressions commonly dated as Eocene. Thus it appears likely that in fact the Cordillo Palaeosurface does represent a stratigraphic marker that formed over a relatively brief period of time.

In this case, what were the conditions that led to such laterally extensive but temporally restricted silicification? It is relevant to note that Eocene siliceous marine sediments are widespread, from the Princess Royal Spongolite of the Eucla Basin in southern Australia to the widespread middle Eocene cherts of the North Atlantic, and have been ascribed to a “silica burp” in the Eocene ocean. Silica is a limiting nutrient in the surface layer of the modern ocean, in that populations of organisms with siliceous skeletons (diatoms, radiolarians, siliceous sponges) are limited largely by the availability of dissolved silica in the ocean water. Thus a sudden explosion in the numbers of these organisms, sufficient to deposit spongolites and cherts, is most likely driven by an influx of dissolved silica into the ocean. This evidence of silica mobility in the marine realm is matched by the formation of the Cordillo Palaeosurface silcretes onshore.

The silica mobility could reflect a period of intense weathering. The Paleocene-Eocene Thermal Maximum raised the global temperature by as much as 8°C and increased rainfall during a sudden climate shift 55 million years ago. This event was associated with the release of huge amounts of carbon into the atmosphere, acidifying the oceans and probably also rainfall. Under these conditions terrestrial weathering would be greatly intensified. It is notable that the Early Cretaceous sediments that underlie the silcretes through large parts of inland Australia are volcanogenic, and contain large amounts of easily weathered volcanic glass and feldspar. These materials would have released large amounts of dissolved silica during the active weathering associated with the Paleocene-Eocene Thermal Maximum. This silica could then be precipitated within the soil profiles as silcrete, and transported down the rivers to be rapidly removed from the ocean water by sponges and siliceous microplankton.

Thus the Cordillo Palaeosurface can be used in the original way it was defined, as a land surface formed over a short period of time that is a stratigraphically correlatable surface across large parts of inland Australia.

EFFECTS OF TERTIARY MARINE FLOODING ON THE LANDSCAPE OF THE SOUTHERN MT. LOFTY RANGES, SOUTH AUSTRALIA

Victor Tokarev & Vic Gostin
School of Earth & Environmental Sciences, The University of Adelaide

The Tertiary marine sedimentary record clearly indicates that marine inundation occurred deep into the southern Australian continental margin. Marine transgressions often result in marginal basin flooding and burying of ancient low landscapes. However the tremendous erosional power and sedimentary transport potential of ancient marine currents are often underestimated in morphodynamic models. We use a combination of methods such as lithostratigraphic analysis, high resolution DEMs, marine flood simulations, and the eustatic sea-level curve to demonstrate that effects of marine floods on the Tertiary landscape of the southern Mt Lofty Rangers was more significant than previously considered.

There is abundant evidence of Oligocene marine presence in the interior basins of the southern part of the Mt Lofty Ranges. The Myponga and Hindmarsh Tiers basins contain respectively ~119 and ~170m of fossiliferous sediments presently at about 220m above present sea-level (PSL). Marginal-marine sediments are found at about 350m above PSL in the Meadow-Kuitpo area, north of the Myponga basin. The formation of these basins is attributed to tectonic subsidence associated with crustal segmentation that affected the pre-Tertiary Palaeoplain between subsiding St. Vincent and Western Murray basins. This lead to landscape submergence and marine sedimentation in both flanking and intramontane basins. The present altitude of these sediments was used for marine flooding simulation that showed the extent of marine inundation.

Geomorphological evidence for marine abrasion is confirmed by the uniform and gently undulating surface recognized along the summit of the Sellicks Hill Ranges. The products of this marine erosion formed the Oligocene Compton Conglomerate that occurs southeast of the Mt Lofty Ranges in the marginal-marine Buccleuch Embayment (SW Murray Basin). The Compton Conglomerate contains an extremely variable lithology from glauconitic and fossiliferous calcareous clays and sandstones, to quartz sand, pebbles and cobbles (up to 20cm grainsize) packed with a

ferruginous matrix. Our flooding model indicates that most of the landscape in this area was submerged during the mid-Tertiary high sea level stand. Therefore the abundance of ferruginous material is a product of marine erosion of the iron-rich regolith developed on the Pre-Tertiary Palaeoplain. The quartzose sediment was probably derived from erosion of widespread Permian fluvioglacial sediments preserved in the proto-Mt Lofty Ranges. The absence of analogous conglomerates in the St Vincent Basin is attributed to the strong west to east marine currents that surged through the southern part of the Ranges. The evidence of young (post-Late Tertiary) regolith on the present summit surfaces is consistent with the stripping of older regolith, still preserved beyond any marine influence.

The above evidence demonstrates that the mid-Tertiary landscape evolution of the southern Mt Lofty Ranges is mainly due to a combination of tectonic subsidence and marine flooding with only minor fluvial erosion. This corresponds to the carbonate dominant facies accumulated in the flanking and intarmontane basins. Marine erosional landforms have not been previously recognized in the Mt Lofty Ranges. This case study provides an example of an integrated approach for better understanding of the morphodynamics of the southern Australian continental margin, including the powerful processes of marine abrasion and sediment transport.

GEOMORPHIC RESPONSE TO INTRAPLATE NEOTECTONICS – BIRCH'S INLET, SW TASMANIA

Ian Houshold1, John Chappell2 and Keith Fifield3
1Earth Science Section, Dept. Primary Industries, Water & Environment, Tasmania
2Research School of Earth Sciences, Australian National University
3Research School of Physical and Engineering Sciences, Australian National University

Whilst many of Australia's highland landforms are ancient, with rates of development amongst the slowest on Earth, recent work on intraplate neotectonics has demonstrated the existence of comparatively young landforms in the Flinders Ranges and Western Victoria – inferred to be the result of post-Miocene changes to the crustal stress field in SE Australia (Sandiford et al. 2004).

Significant neotectonic activity has been suggested in the Bass Strait islands - particularly King Island (Jennings 1961), NE Tasmania (Bowden & Colhoun 1984), and the west and south coasts of Tasmania (Kiernan 1997). The extensive Henty Surface of Western Tasmania cuts through Pliocene sediments southeast of Strahan, at an elevation of 330 m asl (Baillie et al. 1985), suggesting relatively rapid tectonic uplift in that area. Further south the Birchs Inlet area contains what is arguably the best developed and preserved flight of coastal terraces in Australia. Over 15 surfaces have been recognised, up to an elevation of 400m a.s.l. at Flat-Top Hill above the estuary of the Gordon River, extending south beyond Birch's Inlet.

Developed in semi-lithified Tertiary conglomerates of the Macquarie Graben, the terraces have erosional basal surfaces capped by a few metres of sediments, dominantly coarse gravel and cobbles deposited by meandering streams, apparently grading at some sites into beach deposits. Fluvial channel and gravel bar forms are well preserved on the lower terraces, beneath a thin peat mantle. Capture of west-flowing rivers by headward erosion of tributaries of the Gordon River has rearranged the drainage as terrace sequences have developed, and abandoned channels are well preserved.

10Be determinations for ensembles of quartz clasts from present stream bedload and three fluvial terraces of the Sorrell River indicate that the terrace deposits are well suited to cosmogenic dating, and that a complete chronology may be obtained. Samples from the present streams have a low 10Be content (equivalent to an exposure "age" of 25 ka). Exposure ages were calculated for the sampled terraces, assuming that the terrace deposits had a similar pre-depositional "inherited" 10Be content. Present results range to 600 ka and suggest that major terraces formed during interglacial periods (for example, the exposure age of Sorrell Northwest Terrace 6, 145 metres a.s.l., is 320 ka, equivalent to MIS 9), while subsidiary terraces apparently formed during glacial periods. Based on height relationships amongst the terraces, the uplift is about 0.1 m ka-1. Building on this pilot study, we intend to (i) trace the marine-fluvial connections for the entire flight; (ii) to develop a complete exposure-age chronology for the terraces, and (iii) to compare this chronology with that potentially obtainable from cave deposits and slackwater deposits in the karstic upstream reaches of the Gordon.

References:
Baillie, P.W., Corbett, K.D. & Green, G.R. 1985. Geological Atlas 1:50 000 series. Sheet 57(7913N). Strahan. Explan. Rep. Geol. Surv. Tasmania.
Bowden, A.R. & Colhoun, E.A. 1984. Quaternary emergent shorelines of Tasmania. pp. 313-342 In: B.G. Thom (ed) Coastal geomorphology of Australia. Academic Press, Sydney.
Jennings, J.N. 1961. Sea level changes in King Island, Bass Strait. Z. Geomorph NF 3: 80-84.
Kiernan, K. 1997. Conserving Tasmania's geodiversity and geoheritage: The conservation of landforms of coastal origin. Forest Practices Unit, Hobart..
Sandiford, M., Wallace, M. & Coblentz, D. 2004. Origin of the in situ stress field in south-eastern Australia. Basin Research 16: 325-338.

PALAEOGEOGRAPHY AND NEOTECTONICS IN THE COBAR REGION, CENTRAL NSW, AUSTRALIA

Roslyn A. Chan
CRC LEME / Geoscience Australia, GPO Box 378, Canberra, ACT 2601

A major regolith study in the Cobar region of central NSW has recently been completed by the Cooperative Research Centre of Landscape Environments and Mineral Exploration. This study included both a regional study encompassing most of the Cobar Uplands, and a detailed study of the north-eastern part of the Cobar Uplands in the Girilambone region.

The Cobar Uplands in the north-west Lachlan Fold Belt lie at the north-western end of the Canobolas Divide, which is a major drainage divide between the Murray River catchment to the south and the Darling River catchment to the north. The drainage in general follows the north-trending physiography, but in the western part of the Cobar Uplands the drainage follows the westerly trending diagonal faults and fractures between the major north-northwest to north-northeast trending faults. Drainage classification over the Cobar Uplands indicates an anomaly in the Sandy Creek catchment in this western part of the Cobar Uplands with a rapid increase in drainage order to the west of the town of Cobar. Reconstruction of the drainage evolution of the Cobar Uplands, derived from the reconstruction of the palaeotopography using topographic and geological maps, indicates that neotectonic activity has significantly influenced the drainage evolution. A tectonic model that has two major north-south aligned morphotectonic blocks that diverge to the south, explains the drainage evolution in six stages (Duk-Rodkin et al, 2003) from late in the Mesozoic to late in the Cenozoic, and relates to the reactivation of Palaeozoic faults due the formation of the surrounding Eromanga and Murray Basins.

The detailed Girilambone study in the north-east part of the Cobar Uplands was based on a program of shallow air core drilling of 248 holes and regolith-landform mapping within an area from Bourke to the north, Nymagee to the south, Cobar to the west and Nyngan to the east. The objective of this study was to gain improved knowledge and understanding of the regolith of this poorly known and explored region. A model of regolith and landscape evolution for the Girilambone region (Chan, 2005) is derived from the association and nature of preserved regolith materials and their inherent geomorphic processes, and is critically underpinned by detailed petrography and Portable Infrared Mineral Analyser (PIMA) characterisation, together with interpretation of palynological, palaeomagnetic, apatite fission track, and airborne magnetic data. The model explains the derivation of the three main sediment sequences: a Late Jurassic fluvial sequence, an Early Cretaceous fluvio-lacustrine to estuarine to shallow marine sequence (both sequences are part of the Surat Basin), and a Late Pliocene to Holocene colluvial-alluvial sequence. Significant implications of this model are that much, if not all, of the Cobar Uplands were covered by a shallow sea in the Early Cretaceous, and that consequent neotectonic reactivation of north trending Palaeozoic faults, perhaps due to sediment loading, caused the formation of a north-plunging and diverging graben that contains the Mulga-Tindarey Palaeovalley System.

By integrating the landscape evolution models from the regional study over much of the Cobar Uplands with the sub-regional study of the Girilambone region a fuller understanding of the palaeogeographic evolution and the neotectonic history of the Cobar region is gained.

References:
Chan R.A. 2005. Girilambone regolith and landscape evolution. In: Roach I.C. (Ed). Ten Years of CRC LEME: Proceedings of the CRC LEME Regional Regolith Symposia, 2005.
Duk-Rodkin A., Chan R.A. and McQueen K.G. 2003. Drainage evolution and implications for neotectonics and mineral exploration in the Cobar Uplands, NSW. In: Roach I.C. (Ed). Advances in regolith 2003: Proceedings of the CRC LEME Regional Regolith Symposia, 2003.

ANCIENT SURFACES? DATING ARCHAEOLOGICAL SURFACES IN WESTERN NSW USING OSL

Ed J. Rhodes, Patricia C. Fanning, Simon J. Holdaway and Cynthia Bolton
Research School of Earth Sciences and Research School of Pacific and Asian Studies, Australian National University, Canberra, ACT 0200, Australia
Graduate School of the Environment, Macquarie University Sydney, NSW 2109, Australia
Department of Anthropology, University of Auckland, PB 92109 Auckland, New Zealand
Research School of Earth Sciences, The Australian National University, Canberra, ACT 0200, Australia

The interpretation of archaeological material found lying on the present ground surface across Australia is generally considered at least problematic, as material from different time periods may be intermixed. Recent research by the Western New South Wales Archaeological Program has made a significant advance in the understanding of the deposition and subsequent visibility of artefact scatters in these contexts. Using robust geomorphological and sedimentological investigation, surfaces of different age and duration can be recognised. A key element is the development of a very full chronology based on radiocarbon dating of the charcoal preserved in heat-retainer hearths, and occasional charcoal fragments in the sediment. More recently, optically stimulated luminescence (OSL) of sediment has been used to dates surfaces directly.

We will discuss advantages and limitations of using OSL to determine a chronology of sediment deposition, based on experience at several locations in arid NSW. The nature of sedimentary processes in these landscapes provides a challenge for OSL dating which we are tackling using single grain approaches. We have also developed the use of OSL for dating hearth stones, which is advantageous as it is almost entirely non-destructive, and does not require excavation. We will discuss how OSL approaches may be developed to help maximize our understanding of this rich archaeological resource.

EPISODIC NON-EQUILIBRIUM AS A GEOMORPHIC MODEL FOR UNDERSTANDING THE SURFACE ARCHAEOLOGICAL RECORD IN ARID AUSTRALIA

Patricia C. Fanning and Simon J. Holdaway
Graduate School of the Environment, Macquarie University, NSW 2109, Australia
Department of Anthropology, University of Auckland, New Zealand

Surface deposits of stone artefacts and associated heat-retainer hearths are the most common form of the archaeological record in arid Australia but are the least understood in terms of the history of occupation by Indigenous Australians. One reason for this is the lack of a suitable theoretical and methodological framework that takes into account the geomorphic dynamics of the surfaces upon which the artefacts rest. In this paper, we present data from our western NSW study areas that support episodic non-equilibrium (sensu Renwick 1992) as a suitable model for developing such a framework in archaeology. Here, long periods of little or no geomorphic activity are punctuated by discrete catastrophic events which erode or deposit sediments, and hence remove or cover up the archaeological record.

First, we demonstrate the impact of a single rainfall event of moderate magnitude on the surface archaeological record, based on duplicate surveys before and after the event. We then use the results of OSL dating of the landsurfaces to suggest that landscape chronology is a reflection of a series of episodic events like this rain event. This has three sets of implications:
1. That the archaeological record is discontinuous in time because events like this have removed the record equating to particular time periods. This process is cumulative so that the record of recent times is much more common when compared to that from times past.
2. That the episodic nature of environmental processes also had an effect on human behaviour, such that occupation of place was discontinuous.
3. That this has implications for the way that we conduct archaeological research (e.g. survey design) and interpret the archaeological record.

References:
Renwick, W.H. (1992). Equilibrium, disequilibrium and nonequilibrium landforms in the landscape. Geomorphology 5, 265-276.

APPLICATION OF COSMOGENIC NUCLIDES TO LANDSCAPE EVOLUTION AND LONG-TERM EROSION RATES IN SW ENGLAND

Joseph Hägg1, Michael Summerfield1, Christoph Schnabel2 and Stewart Freeman2
1School of Geosciences, University of Edinburgh (contact: j.hagg@ed.ac.uk)
2Scottish Universities Environmental Research Centre, East Kilbride

The landscape of South West England has been a significant location for the development of key geomorphological concepts. In particular, the origin of tors and the related concepts of two-phase vs single phase landscape development and weathering (seminal work by Linton (1955) and Palmer & Neilson (1962) was conducted on Dartmoor). Although there has been a long history of research in the area, this has previously been limited by the lack of applicable quantitative techniques for dating and the measurement of long-term erosion rates.

This research investigates landscape evolution and the development of landforms on the granitic terrain of Dartmoor. It has a particular interest in the development of tors in non-glaciated regions, variable erosion rates within a landscape under differing climate conditions, and the applicability of catchment-averaged denudation rates. The following are key working questions for this ongoing research:

At what rate are the tors of Dartmoor eroding? And do these rates correspond to the type of tor and its position in the landscape? How do these compare with proposed models of tor emergence?

What are the long-term erosional dynamics of the Dartmoor landscape? And how do measured erosion rates vary between alluvial sediments, slopes and bedrock outcrops? When were the characteristic features of the Dartmoor landscape generated (presumed periglacial) and over what timescales did this occur?

How applicable are catchment-averaged erosion rates in the Dartmoor landscape? And what variability is there from the differing areas of Dartmoor (e.g. High moors, southern moorlands, central valleys)?

Does the methodology of cosmogenic nuclide dating require adaptation for application to the Dartmoor landscape (e.g. coarse grain sizes, peat moorlands, anthropogenic impact, complex surfaces)?

HAVE THE LINEAR DUNES OF AUSTRALIA FORMED BY LINEAR EXTENSION?

Gerald C. Nanson, Cameron B. Hollands and Brian J. Jones, School of Earth and Environmental Science, University of Wollongong, New South Wales, 2522, Australia
gnanson@uow.edu.au

Broad-crested linear dunes cover about 40% of Australia and constitute about 40% of the world's dune area. Given this extensive distribution, it is surprising that so little is known as to how they actually form. In central Australia, the easterly extent of the MacDonnell Ranges borders the Simpson Desert. In Camel Flat basin, widely spaced strike ridges intercept and isolate pockets of broad-crested linear dunes. Between about 75 ka and now, regional changes in Late Quaternary climate and flow regime associated with periodic avulsion of the Todd River have destroyed portions of the older dunefield, producing desert surfaces and associated dunes of younger age. This chronological diversity has enabled a study of the evolution of linear dunes. Large, widely-spaced fine-grained red dunes, 75-65 ka in basal age, occur on the western floor of the basin that has been isolated from fluvial activity. They are ramped against the foot-slopes of the Train Hills that block their migration northwards. The paucity of aeolian sand accumulated against this range, and the detailed luminescence chronology of the dunes in the basin, indicate negligible downwind sand and dune migration over this considerable period. We propose three models of possible linear dune formation: 1) Long distance sand transport with linear extension; 2) Windrift linear-extension; 3) Windrift vertical-accretion. Linear dunes in the northwestern Simpson Desert are formed mostly by wind rifting involving the vertical accumulation of sand swept from adjacent swales and dunes (Model 3) and some linear extension as sand becomes trapped in the lee of the nose of the existing dune (Model 2), but not as has been previously proposed by long-distance sand transport with linear extension (Model 1). Linear dunes evolve by becoming larger and more widely spaced, growing by vertical accretion (Model 3), as they cannibalise adjacent, smaller, more closely-spaced dunes.

TIMESCALES IN DUNEFIELD EVOLUTION: AN OPTICALLY STIMULATED LUMINESCENCE (OSL) CHRONOLOGY OF THE STRZELECKI AND TIRARI DESERT DUNEFIELDS, SOUTH AUSTRALIA

Kathryn E. Fitzsimmons
Department of Earth and Marine Sciences, Australian National University, Canberra ACT 0200.

This study presents a late Quaternary chronology of longitudinal desert dunes within the Strzelecki and Tirari Deserts of South Australia using optically stimulated luminescence (OSL). In presenting 82 dates from 28 longitudinal dunes across the region, this paper effectively resolves any debate claiming a Holocene age for the Australian continental dunefields (Wopfner and Twidale 1988; Twidale et al 2001). Although some Holocene dune building was measured, it was by no means the most significant phase of aeolian activity across the region. There was good age agreement between sites across the dunefield.

The Strzelecki and Tirari Desert dunefields, located within the southern Lake Eyre Basin, form a largely fossil landscape of stable dune forms with minor crestal activity. In some areas, dune crests have mobilized and diverged from their original orientation in a reflection of the present wind regime, confirming a directional difference in the winds responsible for dune building over time. Episodes of aeolian activity and pedogenesis are preserved within the dune stratigraphy. Palaeosols represent evidence of stable environmental conditions, whereas dune activity is recorded in undisturbed laminated sediments beneath the palaeosols. The stratigraphic horizons of each dune were sampled in order to understand the timescales involved in overall dune formation. Individual dunes were sampled according to geomorphic setting across the region, taking into account relationships with other landforms as well as other dunes.

The OSL chronology yielded few ages greater than 100ka, suggesting that any periods of aridity and dune activity older than this are no longer commonly preserved within this part of the Australian dunefield. However, several ages between 100ka and 130ka, and 210ka and 225ka (approximately), represent the oldest record of dune activity in the region and suggest that dunefields were indeed present and active. Widespread dune building occurred between approximately 54ka and 65ka, possibly commencing from 73ka. More humid, stable conditions inferred from palaeosols occurred around 35-38ka. The most widespread aeolian activity occurred across the region between 11ka and 26ka, with a clear hiatus occurring around approximately 16ka. This time period corresponds generally with the Last Glacial Maximum, interpreted by many previous studies to have resulted in cold, arid, windy conditions across much of the Australian continent (Hesse et al 2004). Minor dune reactivation occurred during the middle Holocene between 4ka and 6ka, and again from approximately 2ka to the present.

References:

Hesse PP, Magee JW, Van der Kaars S 2004. Late Quaternary climates of the Australian arid zone: a review. Quaternary International 118-119: 87-102.
Twidale CR, Prescott JR, Bourne JA, Williams FM 2001. Age of desert dunes near Birdsville, southwest Queensland. Quaternary Science Reviews 20: 1355-1364.
Wopfner H and Twidale CR 1988. Formation and age of desert dunes in the Lake Eyre depocentres in central Australia. Geologische Rundschau 77(3): 815-834.

CLIMATE VARIABILITY, CLIMATE CHANGE AND DESERT DUNE MOBILITY

Paul Hesse
Dept. Physical Geography, Macquarie University, Sydney, 2109, Australia
phesse@els.mq.edu.au

Optical dating of linear sand dunes in the Simpson Desert has recently confirmed the great depth (> half dune height) of sand mobilised in the Holocene in some dunes. These data, and the observation today of locally mobile dunes, contradict the long-held belief that the Australian desert has been inactive since the end of the last glacial interval and force us to reassess how these dunes have became mobile in part, or at times, during the Holocene.

Several sites in the Simpson and Strzelecki Desert dune fields were examined to determine the local effect of vegetation on sand mobility on the dune surfaces. The vegetation structure comprises both perennial bushes and ephemeral herbs and forbs which contribute protective cover while growing after rains and for some time after while dead. Cyano-bacterial crusts further enhance the surface area with some protective cover. The responsiveness of the vegetation to drought may see cover vary from >60% to <20% over a drought cycle. As expected there is a positive relationship between sand mobility

and the proportion of unvegetated dune surface. There is no strict threshold of sand movement at high cover levels but the exponential relationship between bare area and volume of mobile sand sees effective total mobility at about 50% cover. At this level there is also a morphological shift from hummocky dune surfaces to mobile dunes with avalanche faces.

These two states represent contrasting morphodynamic relationships: at high levels of cover the fluctuation of cover with climate variability (especially rainfall modulated by ENSO and PDO) determines the amount of sand transport while at low levels of cover sand transport is free of the influence of vegetation at all times. Extreme, prolonged and rare drought may be required to remove perennial vegetation from dune crests showing this level of activity.

Despite these findings, mobile dunes are comparatively rare in Australia today. Most appear to be in areas of localised vegetation disturbance (from grazing, roads etc.) but there is low net lateral transport (it is 'back-and-forth'). The few dated dunes also suggest spatially and temporally variable activity in the Holocene with low volumes of mobile sand. The supply of erodible sand on the dunes themselves is thought to combine with seasonally opposed winds to minimize net sand transport.

THE EFFECT OF CLIMATE CHANGE ON MOBILITY AND STABILITY OF SAND DUNES

Haim Tsoar
Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Beer Sheva 84105, Israel (E-mail: tsoar@bgu.ac.il)

Sand dunes are known to be: (i) free of vegetation and active (ii) partly vegetated and active (iii) fully vegetated and fixed. It is common to believe that low rainfall and high potential evaporation result in sparse or non-existence vegetation and hence active sand dunes. The amount of vegetation on sand dunes is also checked by sand transport when winds are strong enough. Considering the above three factors, an equation was developed by Lancaster (1988), known as the M-index equation, which calculates the mobility of sand dunes by referring directly to the percent of days during the year with sand moving winds and indirectly to the ratio of mean annual precipitation to mean annual potential evapotranspiration. This equation is widely used to determine whether sand dunes would be active or fixed and the expected effect of climate change on sand dunes.

According to the M-index equation, sand dunes are fixed in humid areas and mobile in arid areas. There are many examples of unvegetated active sand dunes in humid areas and of vegetated fixed dunes in semi-arid and arid regions. This is the result of the singular characteristics of dune sand where precipitation and evaporation are not very effective on vegetation. Dune sand is devoid of runoff and is known to have high rates of infiltration because of its relatively big pore spaces. As a result, dune sand quickly reaches its field capacity, which is less than 5%, and with abundant rainfall water infiltrates to the groundwater where plants cannot reach. Because easy and deep percolation occurs in dune sand, moisture is stored at depths where it is protected from evaporation during the long dry periods. Hence, precipitation and evaporation have a different effect on vegetation, which grows on sand, as opposed to on other soils.

Wind power is the most important factor in sand dune mobility because of the non-cohesiveness of the sand. Wind above a certain wind velocity can erode sand to such an extent that it prevents seeds from germinating in the sand and stabilizing it. A much better index for the wind magnitude is the drift potential (DP) of the wind (Fryberger 1979), which refers to the wind power equation. Results of field data support the premise that the predominant factor affecting sand dune mobilization is wind erosion. The wind power of several sites in the Australian deserts indicates low values of DP. Other factors that influence the mobility and stability of sand dunes are related to human activity. There are many examples of the destruction of vegetation by grazing, trampling and off-road vehicles. On the other hand, human are also making efforts to artificially stabilize sand dunes because of their apprehension of shifting sands. Most of the coastal sand dunes in Europe have been undergoing processes of fixation for the last 200 years.

The relationship between wind power and vegetation cover can be recapitulated by a hysteresis curve. When climate changes in the form of a decrease in wind power, vegetation will start covering the sand dunes in increasing numbers as the wind power decreases below 500 DP. However, when

this process is reversed, increase of wind power over vegetated dunes will not cause the extinction of vegetation when DP increases above 1000. The threshold for the destruction of vegetation by tempest winds is not definitely known. The artificially stabilized sand dunes along the coasts of Western Europe have DP values above 1000 and they are in the upper reverse side of the hysteresis curve.

References:
Fryberger, S.G. 1979: Dune forms and wind regime. In: McKee E. D. ed. A study of global sand seas. Washington, U.S. Geological Survey Professional Paper 1052. Pp. 137-169.
Lancaster, N. 1988: Development of linear dunes in the southwestern Kalahari, Southern Africa. Journal of Arid Environments 14: 233-244.

NDVI DERIVED FLUCTUATIONS IN VEGETATION COVER AND HORIZONTAL AND VERTICAL WIND PROFILES OVER LONGITUDINAL SAND DUNES IN THE STRZELECKI DESERT, SOUTH AUSTRALIA

Levi J. Roberts and Paul P. Hesse
Department of Physical Geography, Macquarie University, Sydney, Australia
Corresponding author E-mail: levi.roberts@els.mq.edu.au

Vegetation plays a key role in the stabilisation of sand dunes in the Strzelecki Desert and fluctuations in cover create opportunities for erosion to occur. Through the use of an Advanced Very High Resolution Radiometer (AVHRR) time series of Normalised Difference Vegetation Index (NDVI), from 1992-2004, a link has been found between large rainfall deviations from the mean and fluctuations in NDVI. The rapid response in NDVI occurs due to the flourish of ephemeral vegetation and the greening up of existing perennial vegetation present in the Strzelecki Desert. Higher resolution Landsat TM data was used for comparison with ground measurements of vegetation cover. Through vegetation surveys taken across longitudinal sand dunes a good correlation has been formed between perennial vegetation cover and Landsat TM derived NDVI. The field sites used cover a wide extent of the north eastern Strzelecki Desert.

Horizontal and Vertical wind profiles, constructed using two arrays of three cup anemometers set up perpendicular to longitudinal sand dunes, have revealed that log-linear profiles are not apparent due to the acceleration of wind up windward slopes of sand dunes in the Strzelecki Desert. The amount of acceleration is determined by the presence of perennial vegetation cover on the upper and lower flanks of the dunes. Dunes found with a perennial cover of greater than 40-50% displayed deceleration close to the ground, up the windward slope, resulting in surface protection. Dunes with less vegetation than this showed acceleration. This all combines to reaffirm the notion that vegetation plays an important role in the stabilisation of desert sand dunes due to the decrease in wind speed and therefore an increase in the threshold for sand movement.

SOUTHWEST MONSOON AND LATE QUATERNARY LANDSCAPE EVOLUTION IN THE SOUTHERN MARGIN OF THAR DESERT, INDIA

1N. Juyal, 2L. S. Chamyal and 1A. K. Singhvi
1Physical Research Laboratory, Navrangpura, Ahmedabad-380 009, India
2Department of Geology, M. S. University of Baroda, Vadodara-390 002, India

Landscape evolution in the southern margin of the Thar Desert (latitudes 220 - 250 N and longitudes 720 – 73.50 E) is intimately associated with the southwest monsoon. Field stratigraphy, sedimentology and luminescence dating of the exposed fluvial and aeolian sequences from the southern desert margin were used to discern the evolution of desert margin landscape during the late Quaternary. The sedimentary architecture and textural attributes of the sediments belonging to the period 130 – 120 ka suggests the existence of a meandering river system consequent to enhanced southwest monsoon conditions. A shift from a meandering to a braided pattern was widespread during 120 – 100 ka indicates a phase of reduced precipitation. Presence of flood plain fines and bedded calcretes during ~100 – 70 ka suggest a period of enhanced monsoon with seasonality. Following this, a phase of weak monsoon activity was observed during 70 – 60 ka. Regional flood plain aggradation and pedogenesis during the period < 60 – 30 ka indicated landscape stability (enhanced southwest monsoon). Following this, after 30 ka evidences suggest gradual decline in fluvial activity and initiation of aeolian sedimentation indicating weakening of the southwest monsoon. A regionally extent aeolian sedimentation began after 20 and continued intermittently until around 5 ka. This observation accords well with the total organic carbon (TOC) data indicating a vegetation /moisture control on the aeolian sedimentation in the region.

The study further suggests that the development of the incised landscape began early in areas proximal to the coast. This was attributed to the eustatic base level lowering during the Last Glacial Maximum. However, in the inland locations, incision of the late Quaternary alluvium began with the reestablishment of the southwest monsoon around 11 ka.

THE INFLUENCE OF WINDFLOW ON A COASTAL LONG-WALLED ASYMMETRIC PARABOLIC DUNE

Frances A Mowling
Department of Geography & Environmental Studies
University of Tasmania
fmowling@utas.edu.au

Quantitative data were collected to describe process–response in the bedform of a long-walled asymmetric parabolic dune situated on the North West coast of Tasmania, Australia. The data were acquired over a period of three years from a composite of geomorphic survey techniques that incorporated repeated surveys of the ground surface level by using kinematic GPS and arrays of erosion pins, which were linked to analysis of wind flow patterns acquired from an on-site 2 m high meteorology station. Wind shear velocity (u*) and roughness length (z0) were measured close to the ground on windward slopes; speed-up ratios were determined. Analysis of temporally spaced ortho rectified and georeferenced aerial photography extended the duration of the survey by fifty years to establish the downwind and lateral migration rates.

The level of accuracy (planimetric accuracies typically in the range of 2-5 cm and vertical accuracies of 3-10 cm) achieved in the six epochs of repeated kinematic GPS surveys provided reliable GPS data that were used to construct three-dimensional topographic models of the dune system on 5 m x 5 m grids using kriging. Sequences of two dimensional cross-section profiles were selected at representative locations across the dune area, and heights were interpolated to these cross-section locations from the topographic models, again using kriging. The topographic models displayed the general patterns of displacement and accretion of sediment that maintain dune form. The two-dimensional cross-section profiles, when read in sequence, clearly display the pattern of process–response between wind speed / wind direction on the direction of sand movement and on morphodynamics. A series of morphological parameters were extracted from the kinematic GPS data to quantify dune migration rates, dune volumes, and dune reconstitution time.

The measured migration rate of the parabolic dune head is 21.5 m/yr (mean value) measured over 4 years, and 27.3 m/yr measured from a fifty-year sequence of ortho-rectified, georeferenced, digitised aerial photography. The head of the dune reconstitutes at the rate of 8.90 years, with a volume of 100,797 m3. Volumetric change for the study site over an interval of thirty months was in the range of 656,400 m3. The majority of sand transport is generated by moderate velocity wind flows, which have a higher frequency of occurrence. Forty one percent of wind events occur in the moderate velocity category (4 to < 12 m/s), twenty seven percent occur in the high velocity category of > 12 to > 20 m/s. Some seventy percent of wind events are topographically aligned, maintaining the parabolic dune form, although across dune flow from the SW sector results in lateral migration of the trailing arms, with the smaller south trailing arm migrating ENE at more than twice the rate of the north trailing arm. This rate of lateral displacement maintains the 3:1 length to width ratio of the asymmetric parabolic dune by maintaining the dimensions of the deflation plain, which in turn maintains the dynamic equilibrium of the aerodynamic envelope of the dune form.

ATMOSPHERIC 14C DURING THE YOUNGER DRYAS DERIVED FROM TASMANIAN HUON PINE

Quan Hua1, Mike Barbetti2, Ugo Zoppi1 and David Fink1
1Australian Nuclear Science and Technology Organisation (ANSTO), PMB1, Menai, NSW 2234, Australia.
2Advanced Centre for Queensland University Isotope Research Excellence (ACQUIRE), Richards Building, University of Queensland, Brisbane, QLD 4072, Australia.

There is immense scientific interest in radiocarbon variations over the Younger Dryas (YD), the last prolonged cold period (~12,800 to 11,600 cal BP) during the transition from the Last Glacial Maximum to Holocene. For the latter part of the YD, atmospheric 14C is reliably based on the absolute tree-ring chronology, which now extends back to 12,410 cal BP (Friedrich et al. 2004). For the early part of the episode, 14C values are derived from terrestrial and marine varve samples, and corals. However, these data are less than ideal as there are difficulties in varve counting and in the assumption of a constant marine reservoir correction for marine samples, which is unlikely to be valid for periods of large climate change such as the onset of the YD.

We have measured atmospheric 14C during the YD using a sub-fossil Huon pine log (SRT-783) containing 414 rings from western Tasmania. Forty-two samples, mostly decadal, were taken from SRT-783 for AMS 14C analysis. The samples were pretreated to alpha-cellulose, then converted to graphite and measured by AMS using the ANTARES facility at ANSTO, with a precision of 0.3-0.35% (equivalent to 25-30 14C years). The AMS 14C results of this investigation will be compared with those of previous studies derived from floating tree-ring sequences in southern Europe (Kromer et al. 2004) and marine varves in the Cariaco Basin (Hughen et al. 2004). Variations in atmospheric 14C during the YD and their possible mechanisms will then be discussed.

This work was supported by AINSE grants 01/003 and 03/165.

References

Friedrich, M.; Remmele1, S.; Kromer, B; Hofmann, J.; Spurk, M.; Kaiser, K. F.; Orcel, C.; Küppers, M. 2004: The 12,460-Year Hohenheim oak and pine tree-ring chronology from central Europe – A unique annual record for radiocarbon calibration and paleoenvironment reconstructions. Radiocarbon 46: 1111-1122.
Hughen, K. A.; Southon, J. R.; Bertrand, C. J. H.; Frantz, B.; Zermeño, P. 2004: Cariaco basin calibration update: Revisions to calendar and 14C chronologies for core PL07-58PC. Radiocarbon 46: 1161-1187.
Kromer, B.; Friedrich, M.; Hughen, K. A.; Kaiser, F.; Remmele, S.; Schaub, M.; Talamo, S. 2004: Late glacial 14C ages from a floating, 1382-ring pine chronology. Radiocarbon 46: 1203-1209.

HEINRICH JACKLI'S CONTRIBUTION TO ALPINE MORPHODYNAMICS

Olav Slaymaker and Christine Embleton-Hamann
Department of Geography, The University of British Columbia and the Institute of Geography and Regional Research, University of Vienna.
Email: Olav.Slaymaker@ubc.ca

Although Leopold, Wolman and Miller (1964) gave prominence to the work of Heinrich Jackli, the original Jackli text has been rarely consulted and has only recently enjoyed a revival among researchers based in Germany, Austria and Switzerland (Hinderer, 2001; Schrott, 2003). It appears that Jackli's ideas were original and without specific connection to the emerging paradigm of hydrogeomorphology inspired by Horton (1945). The goal of Jackli's research was "a quantitative analysis of the dynamics of a mountainous area" and the uniqueness of his study is two-fold: (i) the comprehensive analysis of contemporary processes in a river drainage basin in order to understand its geological evolution and (ii) the determination of rates of denudation and deposition of sediment as an aid to engineers and planners. An analysis of the contents of this classic paper reveals a profound understanding of alpine morphodynamics and a grappling with problems which are still current.

THE SENSITIVITY OF NEW ZEALAND GLACIERS TO CLIMATIC CHANGE

Andrew Mackintosh and Brian Anderson
School of Earth Sciences and Antarctic Research Centre
Victoria University of Wellington
PO Box 600 Wellington New Zealand
Andrew.Mackintosh@vuw.ac.nz

New Zealand glaciers are sensitive to climatic change but the magnitude and timing of response is dependent on several geographic factors. We use glacier-climate theory, empirical evidence and numerical modelling to assess the importance of these factors. The most sensitive glaciers in New Zealand occur in Westland, where a combination of high relief and high precipitation result in two glaciers that descend 11 km from the Main Divide to terminate a few hundred metres above sea level. Ice ablation at this altitude and latitude is probably the highest in the world, exceeding 20 m/yr, and ice velocity exceeds 1 km/yr. Numerical modelling of the Franz Josef Glacier demonstrates that temperature change is the major driver of glacier fluctuations. Recent glacial advances reflect a short-term, dynamic response to several positive mass balance years. However, the glacier has retreated by several kilometers since the Little Ice Age maximum. In contrast to the Franz Josef Glacier, ablation and ice velocity on small alpine glaciers can be an order of magnitude lower. The Brewster Glacier near Haast Pass is 2 km long and teminates at ~1650 m above sea level. Annual ablation on the Brewster Glacier is approximately 2-4 m/yr and ice velocity is less than 30 m/yr. Although the Brewster Glacier has experienced several years of positive mass balance, it continues to retreat in response to 20th Century warming as a result of its longer response time and lower sensitivity. Our findings support the hypothesis that New Zealand glaciers may not have responded similarly to past climatic changes. For example, evidence for a glacial advance 13,000 years ago is geographically restricted to a few glaciers, including the Franz Josef, which we have identified as the most sensitive to climatic change.

GLACIAL HISTORY OF DALTON CORNER, SOUTH MAWSON ESCARPMENT, EAST ANTARCTICA

Katherine Lilly1, Derek Fabel2, Kurt Lambeck1, David Fink3.
1Research School of Earth Sciences, The Australian National University, Canberra, Australia.
2Department of Geographical and Earth Sciences, University of Glasgow, Glasgow, UK.
3Institute for Nuclear Geophysiology, Australian Nuclear Science and Technology Organisation, Sydney, Australia.

To date only scant onshore geological evidence has been obtained that can be used to constrain former ice margins in Antarctica. Particularly difficult to find is evidence for past changes in the vertical extent of the ice sheet. The use of in situ produced cosmogenic nuclides, such as 10Be and 26Al, can allow the dating of glacial landforms such as moraines, erratics, and glacially eroded bedrock surfaces, at elevations above the present ice height.

Here 10Be and 26Al exposure ages of both bedrock surfaces and glacial erratics are presented for Dalton Corner, located at the southernmost end of the Mawson Escarpment, on the flanks of the Lambert Glacier. These data show that at the last glacial maximum the Lambert Glacier was thicker at this locality, with a vertical extent at least 165m greater than at present, and that the ice retreated rapidly from this extent at 10 ka. Glacially transported debris from previous glacial advances remains preserved despite having been overridden by ice during the last glacial maximum, and exposure ages of bedrock surfaces show that subglacial erosion during these glacial advances has been minimal.

PALEOENVIRONMENTAL RECONSTRUCTION OF A WELL-PRESERVED STAGE 7 FOREST SEQUENCE CATASTROPHICALLY BURIED BY BASALTIC ERUPTIVE DEPOSITS, NORTHERN NEW ZEALAND

M. J. Marra 1, B. V. Alloway 2 & R.M. Newnham 3
1 Department of Geological Sciences, University of Canterbury, NZ
2 GNS-Science, Gracefield Research Centre, PO Box 30368, Lower Hutt, NZ
3 School of Geography, University of Plymouth, Plymouth PL4 8AA, UK

The well-preserved remnants of a forest sequence, catastrophically inundated by proximal to medial phreatomagmatic deposits, are identified on the shores of the Manukau Harbour. In this study the stratigraphy and age of this forest succession was examined in detail along with palaeoecological proxies (palynology and beetle assemblages) from carbonaceous muds associated with the forest sequence. Optically Stimulated Luminescence dating of the phreatomagmatic deposit together with palaeoecological evidence for interglacial climate suggests deposition in late Marine Isotope Stage (MIS) 7. This extends the known age of Auckland volcanism by up to 40 ka.

Ninety-eight fossil beetle taxa were identified. All but two of the fossil taxa occur in the local modern fauna. Based on an extensive survey of the local modern fauna, the fossil beetle fauna represents 48% of families, 20% of genera, and 13% of species in the local modern fauna. The fossil assemblage comprises taxa from forest, wetland and beach habitats.

Both beetle and pollen assemblages indicate a kauri/podocarp forest growing adjacent to a wetland on or near a coastal plain. The pollen record shows Agathis australis- dominance between two phases of Dacrydium cupressinum dominance. Despite overall similarity to the modern flora and fauna, both the beetle and pollen assemblages include elements that are found today at higher elevations in the region, indicating that slightly cooler climate conditions existed during late MIS 7 compared to present. We estimate this temperature depression at less than 1oC relative to the present, broadly consistent with other terrestrial reports and marine (ODP-1123) record for Late MIS 7.

THE STORY OF AN ANCIENT LAKE IN VITI LEVU, FIJI

Michael Bonte-Grapentin1 and Tariq Rahiman2
1SOPAC, Fiji and 2University of Canterbury, NZ

A new layer in the Geology of the interior of Viti Levu, Fiji's main island has been discovered: Quaternary Lake Deposits. These finely interbedded, partly organic lake deposits are silent witnesses of a huge, probably late Pleistocene (42 000 BP?) landslide at the Namosi Gorge, which caused the damming of a lake some 150 sq km wide and vast landscape alterations with the separation of two major watersheds.

The Namosi Gorge is a peculiar geomorphological feature in central SE Viti Levu. It presently forms a wind gap between

the Navua and Waidina river catchments and is known commonly as the Namosi Gap. Several previous studies [e.g. Woolnough 1907, Band 1966, Terry et al. 2002] discussed a palaeo Navua-Waidina river once flowing through the Namosi Gorge, though the process of the disruption of flow and forming of present topography was never fully understood. Recent mapping shows that the gorge is filled for nearly its entire length by over 50 Mio m3 of landslide debris forming a dam with an estimated height of some 100 m. The debris consists of coarse and angular andesitic boulders embedded in a loamy matrix with some of these boulders are over 15 m in diameter. The landslide material is derived from the adjacent ridges comprised of poorly stratified volcanoclastics of the Namosi Andesite. Exposures along the riverbank reveal basement rocks overlain by the landslide deposits overlain by some 20 m of lacustrine with fluvial sediments on top, approx. 50 m above present river level. The lake sediments and overlying fluvial gravels form a distinct terrace level at about 140 m AMSL across the Navua river catchment and are suggestive of a drowned topography with isolated peaks of the Late Miocene Navua Mudstone projecting out of the flat terrace ground.

This discovery is one of the most important in Fiji's geology over the last few decades. The lacustrine sediments cover parts of three 1:50 000 geological maps. But beside revealing parts of the geologic history and the development of the Navua catchment there are several more widespread implications:

Continuous series of laminated Quaternary lake sediments, rare in the SW-Pacific, are potentially an invaluable record of palaeo-climatologic and palaeo-environmental research. The sedimentation under natural, pre-human conditions establishes a valuable benchmark for erosion and aggregation processes and rates. Studies of the processes that lead to the disruption of the proto Navua-Waidina river may add to the poorly understood seismo-tectonic history of south eastern Viti Levu. The Namosi landslide event and related processes, which created the third largest catchment in Viti Levu, emphasis the risks of extreme events for downstream communities.

The narrow and deeply incised Navua gorge – a product of the drainage of the lake - is prone to blockage by major landsliding from the extremely steep side slopes. According to a flood legend and an event from the 1830s, such an event might have happened twice already in the relatively recent (historic) past [Anonymous & Rodda 1995].

References:

Anonymous & Rodda, P. 1995: A legend from Fiji: the flood, Fiji MRD Note BP1/112: 5 pp.
Band, R.B. 1966: Geomorphological aspects of the Namosi Gap, Fiji MRD Note BP30/39: 2 pp.
Terry, J.P., Ollier, C. & Pain, C.F. 2002: Geomorphological evolution of the Navua River, Fiji, Physical Geography 23, 5: 418-426.
Woolnough W.G. 1907, A contribution to the Geology of Viti Levu, Fiji. Prox. Linnaen Society NSW, Vol. 32

Tuesday, February 14th 2006

KEYNOTE ADDRESS:
MODELLING SPATIAL PATTERNS OF SEDIMENT TRANSPORT IN LARGE RIVER BASINS: A GEOMORPHOLOGIST'S FORAY INTO CATCHMENT WATER QUALITY MODELLING

Ian P. Prosser
CSIRO Land and Water, GPO Box 1666 Canberra, ACT 2601, Australia (ian.prosser@csiro.au)

Geomorphologists routinely construct catchment sediment budgets and have found them useful for investigating the sources and fate of sediment in catchments, and the patterns of various processes in those catchments. The inclusion of these principles in catchment modelling has not been as common, yet the approach offers much potential to both the geomorphology community and broader interests in catchment water quality and sediment transport.

I share in this paper my experiences with spatial modelling of catchment sediment budgets, showing how a geomorphologist's approach offers fresh insights into large scale patterns of catchment water quality and of river bed habitat. I outline the advantages of catchment modelling as a complement to other research approaches. These include the abilities to address the implications of experimental research at a large scale and across diverse environments, and to identify critical knowledge gaps that require further attention. Challenges that were faced in developing the model included defining appropriate complexity in the models, and parameterising and testing models at large scales. Residual challenges include the calculation and representation of uncertainty in spatially distributed modelling.

IMPACTS OF EUROPEAN SETTLEMENT ON CHANNEL MORPHOLOGY OF GILMORE CREEK, SE AUSTRALIA.

Ken Page1, Remy Dehaan1 and Paul Frazier2
1. School of Science and Technology, Charles Sturt University, Wagga Wagga, NSW 2678 Australia;
2. Department of Ecosystem Management, School of Environmental Sciences and Natural Resources Management, University of New England, Armidale, NSW 2351, Australia

Historical records, anecdotal evidence and recent fieldwork indicate that the channel morphology of many rivers in south eastern Australia have been strongly modified as a result of catchment change following European settlement. Many low-capacity channels that were once stable and sinuous with predominantly suspended loads and swampy floodplains have been converted by channel incision and straightening into steep, large capacity, bedload-dominated systems with reduced frequencies of floodplain inundation. However, there is little published research on preserved examples of pre-European settlement channels in this region. Recent research based on airborne remote sensing data and fieldwork has demonstrated the existence of several reaches of well-preserved pre-European channel on the floodplain of Gilmore Creek, a tributary of Tumut River. Here, the incised and almost straight modern channel is dominated by bedload transport. Channel widening and bend elimination at the expense of arable valley flats have posed problems for local land holders. Where pre-European reaches of channel have been preserved, they are highly sinuous (> 2.0) and are much smaller than their modern counterparts. Floodplain stratigraphy revealed in bank exposures, auger holes and trenches reveals a sequence of events beginning with the channel infilling and burial of organic-rich floodplain soils by up to one metre of sandy alluvium, followed by avulsion and incision, a sharp reduction in channel sinuosity and the progressive destruction of valley fills. These channel changes have sometimes been exacerbated by early 'river improvement' strategies including de-snagging and the removal of reed-swamps. We suspect, on the basis of reconstructed channel morphology, that the pre-European channels were poised at a threshold between stable meandering and unstable sand-braided channel patterns. Returning these degraded channels to their earlier morphology is proving to be a daunting river restoration challenge.

CATASTROPHIC OR NOT? CHANNEL RESPONSE TO THE '150 YEAR' STORM, MANAWATU, NEW ZEALAND

Ian C. Fuller
Geography Programme, Massey University, Private Bag 11-222, Palmerston North, New Zealand
Email: I.C.Fuller@massey.ac.nz

Widespread flooding occurred in the Manawatu region in the lower North Island, New Zealand, during a 'winter storm in summer', 15-16 February 2004. Rainfall

amounts associated with the storm exceeded 150 year return periods in the western Manawatu catchment. This rain fell on already saturated ground producing the largest recorded floods in the major western tributaries of the Manawatu: the Pohangina (547 km2, 1111 m3 s-1), Oroua (329 km2, 450 m3 s-1) and Kiwitea (224 km2, 358 m3 s-1). ARIs for the floods in these catchments were up to 115 years (Fuller and Heerdegen 2005). Flooding produced considerable erosion of these comparatively steep gradient, wandering, gravel-bedded river channels, which drain the western slopes of the southern Ruahine Ranges (1695 m) and adjacent soft-rock hill country. The flood impacts on these channels were quantified using georeferenced, orthorectified aerial photograph overlays of 30 km long valley reaches of the Kiwitea, Oroua and Pohangina rivers. The question to be addressed is whether these impacts could be considered as catastrophic.

Catastrophic channel change is associated with major morphological adjustment via erosion, deposition or channel realignment (Magilligan 1992). The greatest impacts of the February 2004 floods were measured in the Kiwitea, with a 500% increase in channel width measured in places as the river eroded 1.1 km2 of floodplain (bank erosion) along the 30 km study reach. Areas of land loss were greatest at bends where steep banks of unconsolidated alluvium confined the channel, and thus the energy of the floodwaters. In less confined reaches of the Kiwitea, overbank flood flows dissipated the energy across the floodplain and limited channel erosion. Bank erosion in the Oroua and Pohangina rivers was of a lower magnitude (0.6 and 0.36 km2 respectively), with more erosional activity reworking active and inactive bars in the much wider macro-channels. The differences between the Kiwitea, Oroua and Pohangina in response to the flooding are attributed to the precise configuration of valley floor / macro-channel and the magnitude of the flood event relative to the mean annual flood.

Steep, narrow valleys are considered to be the most likely environments in which catastrophic channel change or stripping occurs (e.g. Kochel 1988). In gentle-gradient, humid, alluvial channels, catastrophic channel adjustment is rare: Magilligan (1992) suggests it occurs where unit stream powers approximate 300 W m-2; perhaps only occurring at discharges between 2 and 15 times the Q100. However, flood power magnitude may be either enhanced or diminished by local geomorphic controls. Miller (1995) indicated local geomorphic controls may raise the shear stresses on the outside of a bend to three times those in straight, narrow, canyons. The discontinuous nature of channel erosion in the Kiwitea reflects the importance of such local controls. Channel response to the storm in the Kiwitea may thus be considered as locally catastrophic: stream powers locally approached or exceeded 300 W m-2 and the scale of change observed in discrete reaches is best defined as catastrophic. Geomorphic change in the Pohangina and Oroua channels was substantial, but the nature of the adjustments precludes the classification of these changes as catastrophic.

References:
Fuller, IC, Heerdegen RG 2005. Causes and consequences of the February 2004 floods in the Manawatu, New Zealand. Journal of Hydrology (NZ) in press.
Kochel RC 1988. Geomorphic impacts of large floods: review and new perspectives on magnitude and frequency. In: Baker VR, Kochel RC, Patton PC eds. Flood Geomorphology. Chichester, John Wiley & Sons. Pp. 169-187.
Magilligan FJ 1992. Thresholds and the spatial variability of flood power during extreme floods. Geomorphology 5: 373-390.
Miller AJ 1995. Valley morphology and boundary conditions influencing spatial patterns of flood flow. In: Costa JE, Miller AJ, Potter KW, Wilcock PR eds. Natural and Anthropogenic Influences in Fluvial Geomorphology. American Geophysical Union, Geophysical Monograph 89: 57-81.

SIMULATING THE EFFECTS OF C21 CENTURY CLIMATE CHANGE ON SEDIMENT DISCHARGE TO THE POVERTY SHELF

Basil Gomez1, Albert J. Kettner2, and James P.M. Syvitski3
1Geomorphology Laboratory, Indiana State University, Terre Haute IN 47809, USA.
2Section of Applied Geology, Faculty of Civil Engineering and Geosciences, Delft University of Technology, 2628 RX Delft, The Netherlands.
3Environmental Computation and Imaging Group, Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder CO, 80309-0450, USA.

The 2203 km2 Waipaoa River basin annually delivers ~15 Mt of suspended sediment to Poverty Bay and the adjacent continental shelf. Much of this sediment currently is generated during frequent runoff events by gully erosion, which was initiated in the early part of the twentieth century when the headwaters were deforested and converted to pasture by European farmers. In the East Coast region, climate change during the twenty-first century is projected to decrease

annual precipitation by up to -17% by 2030 and by up to –31% by 2080, while the mean annual temperature correspondingly will increase by as much as +1.4 and +3.8 °C, respectively, as greenhouse gas concentrations in the atmosphere increase (Climate Change Effects and Impacts Assessments, New Zealand Climate Change Office, 2004). Over the same period, targeted reforestation could increase the area of exotic timber plantations in the Waipaoa River basin by as much as 50%.

We modeled the effect of these projected changes on basin sediment yield using HydroTrend, which is a numerical model that creates synthetic river discharge and sediment load time series over long periods as a function of climate trends and basin morphology. HydroTrend accepts input based on daily meteorological station data (e.g., statistics of temperature and precipitation and their interannual variations), and basin morphometry (derived from a 20 m DEM). Altitudinal variations across the basin were characterized using climatological records from four stations, with between 10 and 100 years of record. Both the modeled contemporary water and suspended sediment discharge exhibit good agreement with 25 years of observations from the gauging station at Matawhero, located ~10 km from the coast. The model runs also suggest that, in terms of the effect on suspended sediment discharge, over the 80-year period under consideration the beneficial effects of targeted reforestation of gully- and landslide-prone terrain may outweigh any adverse impacts of climate change.

SOURCE-TO-SINK SEDIMENT TRANSPORT MODELLING IN THE RAGLAN CATCHMENT

Jochen Schmidt, Sandy Elliott, Malcolm Green
National Institute of Water and Atmospheric Research (NIWA), PO Box 8602, Christchurch, New Zealand, j.schmidt@niwa.co.nz, ph. 03-343-8058, fax 03-348-5548.

The Fine-Sediment Study (FSS) is a NIWA-lead research project into the generation and transport of sediment in a larger catchment. The goal of the Fine-Sediment Study (FSS) is to develop the capability to seamlessly predict the generation, transfer, and transformation of fine sediment throughout a single event for the Raglan catchment using physically-based models. To achieve that goal we have coupled a series of sediment transport models in a linked model framework called SEDSUITE.

Sediment generation in catchments and transfer to streams is modelled using SHETRAN, a 3D finite difference model for coupled water flow, sediment & solute transport, based on the popular SHE model. Sediment transport in the channel network is modelled using RICOM, a 3D finite element model (variable in spatial dimension) for flow hydraulics, including sediment generation and transport developed at NIWA.
Dispersal in the estuary is modelled using DHI MIKE 3 FM, a 3D finite element model (variable in spatial dimension) for hydrodynamics & sediment transport in coastal environments, developed at DHI Water & Environment, Denmark.
Flocculation and reflocculation is modelled by FLOCSIM, a process-based function for calculating settling velocities based on flocculation and reflocculation processes. FLOCSIM is used as a subroutine in both RICOM and DHI MIKE 3 FM.

We are currently parameterizing the models of SEDSUITE for the Waitetuna catchment in the Raglan area. In this presentation we will present the modelling concepts and some initial modelling results for generation of sediment throughout the Waitetuna catchment. These model runs suggest diverse patterns of runoff and sediment generation over the Waitetuna catchment, which are dependent on spatial rainfall gradients and land use and soil parameters: these patterns could be used in catchment management to reduce sediment input in the estuary. Field data, including stream flow, turbidity, and transported sediment are currently captured which will be used for the model calibration. Model linkages between SEDSUITE components are established by data transfer protocols. Later this year we will carry out a series of field experiments to measure and to model the source-to-sink sediment transport under intensive rainfall conditions, for calibration and validation of the models.

SEDIMENT BUDGET MODELLING OF THE MOTUEKA RIVER CATCHMENT

Peter R. Cole
Dept. Geography
Otago University

The Motueka River has historically carried one of the highest trout populations in New Zealand. In recent years the number of trout being caught has declined and a claimed

increase in fine sediment caused by commercial practices in the catchment has been identified as a possible cause. As well, gravel extraction from the Motueka River has been difficult to manage, as the volume available has been irregular, and possibly over calculated. The primary aim of this research project is to develop a computer model that can reproduce the movement of sediment through the catchment, especially sediment slugs, so that gravel supplies can be anticipated. As well it is hoped that some sediment sources may be identified.

SEDIMENT ORGANISATION AND WITHIN-REACH VARIABILITY IN A HIGHLY ADJUSTED RIVER CHANNEL

Joanna Hoyle1, James Lander, Kirstie Fryirs1, Andrew Brooks2, Gary Brierley3
1 Department of Physical Geography, Macquarie University, NSW, Australia
2 Centre for Riverine Landscapes, Griffith University, Queensland, Australia
3 School of Geography and Environmental Science, University of Auckland, New Zealand

Rivers are seldom static as the nature, intensity and distribution of erosional and depositional processes adjust along a reach. Given the site-specific nature of these factors, pronounced diversity of river responses to past, ongoing, and future disturbance events is to be expected, as differing systems have variable capacities to absorb change. Some landscapes are seemingly insensitive to metamorphosis and are able to absorb impacts or perturbations with only minor adjustments to their configuration over considerable timeframes. In contrast, sensitive landscapes undergo a fundamental and persistent change in their morphology over very short timeframes when subject to disturbance. Hence, landscape responses to human disturbance are far from uniform in space and time.

This paper examines the causes of within-reach variability in channel change following European settlement of the upper Hunter Valley, NSW, Australia. Analyses of floodplain sedimentology, archival records, parish maps and aerial photographs along an 8 km reach of the Upper Hunter River document marked spatial variability in the timing, type and degree of channel change since European settlement in the 1820's. This variability reflects local susceptibility to varying (altered) hydraulic and geomorphic conditions across seven zones of adjustment. The contemporary width of the macro channel reflects the sinuosity of the channel at the time of European settlement. In formerly sinuous, high-adjustment zones, the post-European channel is fairly sensitive to adjustment and now acts as an active meandering river, in which the position of the low flow adjusts within the macro channel. In contrast, low sinuosity subreaches are low adjustment zones which have been subjected to negligible geomorphic adjustment since European settlement.

Sediment fluxes through the Hunter River have changed significantly as a result of European settlement and the subsequent planform adjustments. Understanding of large scale sediment fluxes requires, among other aspects, an appreciation of the types of sediment mix available for transport, its spatial organization within a channel and the relative mobility of particles in different locales. Gravel mobility varies for differing hydraulic (microscale and mesoscale) bedforms, whose development is linked to local flow conditions over the bed, and sediment-storage (macroscale and megascale) forms. Bed surface texture depends on the sizes of material that flow is competent to transport, the size distribution of the available sediment supply and the rate at which that sediment is supplied. The sensitivity of alluvial sediment storage units to reworking depends on the type of store, the volume and calibre of materials stored, vegetation cover, elevation above the low flow channel and the frequency of potentially mobilising flows.

This paper documents the sediment size mixes and forms of particle organisation along the 8km study reach. Differing scales of gravel organisation measured for various macroforms and mesoforms on each bar are explained in terms of historical changes that have occurred in this river system. The lack of structural organisation in gravel patterns on the bars relative to most rivers described in gravel bed literature, is considered to reflect the relatively recent availability of gravels associated with channel adjustments since European settlement and the infrequency of flows of sufficient intensity and duration that have been able to rework materials into well-sorted structures.

DERIVING CATCHMENT SCALE DISTRIBUTIONS OF STREAM POWER – A COMPARATIVE STUDY OF THREE DIFFERENT APPROACHES IN THE UPPER HUNTER RIVER CATCHMENT, NSW, AUSTRALIA

Vikrant Jain, Nicholas Prestonb, Kirstie Fryirsa and Gary Brierleyc
a Department of Physical Geography, Macquarie University, North Ryde, NSW 2109, Australia
b School of Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
c School of Geography and Environmental Science, The University of Auckland, P.O. Box 92019, Auckland, New Zealand

Channel processes and forms are governed by the rate of geomorphic work done by stream water, which is commonly expressed as stream power. Stream power ($\Omega = \gamma.Q.s$) is the function of unit weight of water (γ), discharge (Q) and channel slope (s). A catchment scale understanding of channel processes and morphological variations required the distribution pattern to be assessed across a catchment. In the absence of catchment scale distribution of stream power, the traditional approach to geomorphic enquiry lacks the basic understanding of driving force. The current work provides a methodology for deriving stream power plots at the catchment scale. In this study, three different approaches are used to appraise the stream power distribution along 11 different streams in the upper Hunter River catchment, New South Wales, Australia.

Discharge data was determined through catchment area-discharge analysis for different return period floods using the Pinneena dataset. Stream long profiles were produced in a GIS environment using DEM data of 25 m resolution. These profiles were analysed using three approaches, namely long profile smoothing, curve fitting and a theoretical model. In the smoothing method, the anomalous kinks in the long profile were removed through applying an algorithm, while real knick points were remained unaltered. The curve fitting method tested the applicability of different orders of exponential curves in the long profile, while the theoretical model provided a mathematical expression of catchment scale stream power distribution pattern. Channel slope was determined through application of the “horizontal slice” approach on these corrected long profiles. The downstream distribution of stream power was derived by multiplying discharge by channel gradient along the long profile.

The long profile smoothing method provides a good approximation of the sub catchment variability in stream power trends. The curve fitting method shows that higher order exponential curves provide a better fit for long profile data. For the streams of the upper Hunter River catchment, second order exponential curves fit well with significantly less error. The curve fitting method predicts a bimodal (upstream and midstream) distribution of stream power, which is a deviation from earlier understanding of stream power distribution that shows a single midstream peak. The bimodal distribution emphasises the erosion potential of headwater reaches. The theoretical approach provides a mathematical expression of the observed bimodal stream power distribution, which can be applied in modelling of channel processes at catchment scale. The resultant stream power distribution provides a catchment-scale characterisation of the variability of available energy in any given system. This pattern of variability in the stream power distribution will thus be helpful to predict the variability in channel morphology and behaviour.

CRITICAL STREAM POWER IN HIGH ENERGY BOULDER-BED RIVERS

Frédéric Gob(1), Nicolas Jacob(2), Jean-Paul Bravard(2), François Petit(1)
University of Liège, Allée du 6 août, 2 4000 Liège Belgium fgob@ulg.ac.be
University of Lyon 2, Avenue Pierre Mendès-France,5 69676 Bron Cedex France

Sediment transport in boulder-bed rivers is relatively unknown. These rivers are generally found in mountainous environments. Their morphology is therefore confined, inducing extremely high shear stress and high specific stream power during flood events. Because of the confinement, the high energy of these streams can be only consumed by sediment transport (Wohl, 1992). Very few relations linking the transport of blocks over 50 cm in diameter to the critical specific stream power exist. Only Costa (1983) and Williams (1983) have established models that have been widely used to reconstruct the paleo-discharge from the sediment size of the riverbed. Unfortunately, the relations are made by the data from several rivers, regardless their size and sediment characteristics. This study aims to evaluate the competence of such rivers in term of specific stream power. Geomorphologists increasingly use this technique to determine river dynamics, adjust bedload transport equations and, more

particularly, establish formulae linking bedload blocks and the floods that mobilised them.

In order to better understand the transport of blocks in mountainous rivers, six streams from the south of France (In the Central Massif and Corsica) have been studied. Two of them have been presented in Gob et al. (2005). All of these rivers experience very powerful floods created by heavy autumnal rainfall. Some of the rivers studied are among the strongest in Europe and the world with a C Meyer of over 160 and stream powers over thousands of W/m². The competences of the rivers studied were calculated using lichenometry and the elaboration of historical and recent flood series. Lichenometry allows substratum to be dated from the diameter of the lichen thalli that have colonised this substratum. After morphogenetic flood events, new lichen generations colonise boulders that have been transported. Therefore once a lichen growth curve for the studied region had been made, the age of these new lichens may be determined and it is then possible to associate boulder transport and the flood that created the transport.

Formulae linking critical specific stream power to the dimensions of the mobilised sediment have been established for each river studied. These equations differ greatly from one river to another showing the role played by the size of sediment present in the riverbed. The ratio between the average diameter of the ten largest particles and the median diameter (D10+/D50) clearly shows the energy lost when very large blocks are present within the bed. This resistance of the riverbed features increases the critical specific stream power and therefore slows down the bedload transport.

References:
Costa J. E. 1983. Paleohydraulic reconstruction of flash-flood peaks from boulder deposits in the Colorado Front range. Geological Society of America Bulletin, 94. 986-1004 pp.
Gob F., Bravard J.-P., Jacob N. and Petit F. (2005) Determining the competence of mountainous Mediterranean streams using lichenometric techniques. In : R J. Batalla and C Garcia (eds) Geomorphological Processes and Human Impacts in River Basins. Proceedings of the International Conference held at Solsona, Catalonia, Spain, May 2004. IAHS Red Book, 299.
Williams G. P., 1983. Paleohydrological methods and some examples from Swedish fluvial environments. Geografiska Annaler, 65A (3-4). 227-243 pp.
Wohl E. E., 1992. Bedrock benches and boulder bars: Floods in the Burdekin Gorge of Australia. Geological Society of America Bulletin, 104. 770-778 pp.

KEYNOTE ADDRESS:
MORPHOKINEMATICS: BEYOND MORPHODYNAMICS

Peter Cowell
School of Geosciences
University of Sydney
cowell@mail.usyd.edu.au

In 1979, Don Wright and Bruce Thom published the world's first paper on a new paradigm, morphodynamics, in the inaugural volume of the obscure journal, Progress in Physical Geography. Regardless, the paradigm is now an international science in its own right, so well established that few of its practitioners know its origins.

For geomorphology, the morphodynamic paradigm postulates that we need to observe and understand each of the system components. That is, to know about geomorphic change (and hence stratigraphy), we must know about sediment transport patterns. In turn, to know about sediment transport, we need to know about fluid boundary layers and the flows driving them. And to know about the flows we need to know about the processes forcing the flows and the morphology that constrains them.

This last part, the constraints (which confer the quintessential morphodynamic feedback), means that the problem contains circularity: we need to know the morphology to predict morphology. Thus, morphodynamics is non linear, and morphology is self determining (at least in part).

Now we know that we know less than we thought we knew in the early days of morphodynamics. Limits to knowledge are evident today because we now know that (a) non linear systems are subject to 'complex behaviour', and (b) the significance of residuals in material fluxes increases compared to gross transports for larger space and time scales.

However, if we had been right, that a morphodynamic approach would allow us to obtain high fidelity prediction and explanation of geomorphic change, then from information theory the following postulate arises:
The mutual dependence of each component in a morphodynamic system means that information about the behaviour (state) of the system overall, and all its components, is contained separately in each of the component sub systems.

In principle therefore, we need only observe and model one of the sub systems, from which we could infer the behaviour of the whole system and all its other components. The question then arises, which component should we choose for study? The most accessible component would seem to be the morphologic sub system. The additional advantage accrues that geomorphic change is a good integrator of coherent morphodynamic behaviour. That is, geomorphic change provides a more useful signal than contained in the fluid and sediment-dynamics sub systems.

From this choice we get a new (abbreviated) paradigm, morphokinematics:
morphokinematics ≈ morphodynamics

Actually, the concept is not so new. Although the postulate can be expressed mathematically, in essence it simply reflects classical geoscience practice: i.e., inference of cause from effect (the inverse approach). More specifically, the classical approach reads processes from morphology, sediments and strata.

Thus, we now have a formal justification for the classical approach. In addition, radiometric methods for measuring geomorphic change, including the new cosmogenic isotope dating of denudational landscapes, together with modeling techniques that use tools from information science (e.g., stochastic simulation and fuzzy logic methods) provide the means to implement morphokinematics for practical prediction of geomorphic change and quantification of relevant morphodynamic drivers.

SEDIMENTARY ARCHITECTURE AND GEOMORPHIC CLASSIFICATION OF THE LOWER BURDEKIN RIVER, QUEENSLAND

Jonathan Clarke
CRC LEME, Geoscience Australia, PO Box 378, Canberra, ACT 2601, Australia jon.clarke@ga.gov.au

The lower Burdekin region of northern Queensland is an area of intensive irrigated agriculture where high quality characterisation and validation of aquifer properties and architecture is essential for accurate modelling and good management of the water resources. Natural flows along the Burdekin River have been extensively modified by dams and there has been extensive groundwater extraction, resulting in a high risk of intrusion by marine waters. The system overlies major groundwater supplies, is close to environmentally sensitive wetlands, waterways, and estuaries, and discharges into the lagoon of the Great Barrier Reef. In the past, the lower Burdekin depositional environment has been interpreted in many different ways, including as a wave, wave and tide, tide, or river-dominated delta. Research by CRC LEME has led to us to conclude that the system is actually a fan-delta. This distinction is not simply a question of semantics, but one that has major implications for the aquifer architecture and materials. Hydrogeological units in deltas are typically well differentiated, whereas in fans these tend to be much less differentiated with poorly sorted muddy sands and gravels predominating. Longitudinal variability is comparatively low in deltas, whereas fans slope towards their terminus along their entire length. Deltas show well developed and abrupt systematic lateral changes across boundaries between distributary and interdistributary facies. However, in fans lateral variation is poorly differentiated and internally variable, vertical variability in deltas typically is high but in fans the variation between units may be as great or greater, but because of the heterogeneity of fan systems a less systematic relationship will be displayed. Depending on the tectonic and base-level setting, fans may show an overall upward fining or upward coarsening trend, whereas deltas are always upwards coarsening.
The Burdekin River descends 150 m from the Hervey Range, part of Australia's Great Escarpment, and approximately 130 km upstream of the delta mouth. For approximately 70 km it flows through an incised valley before debouching onto the coastal plain at an elevation of ~50 m. A major constriction in the present channel occurs where the river passes through two hills at a location known as The Rocks (elevation ~20 m). The 30 km from this point to the mouth of the river is characterised by a sub-aerial gradient of 1:1500, or 0.038 of a degree. This gradient is very low compared to other documented fan deltas and most alluvial fans.

Despite the low gradient and long transport distance from the scarp, the sediments of the Burdekin Delta are dominated by coarse sediments. Analysis of logs from 73 bore holes shows that the succession consists of 37% gravels and 32% sand. The predominance of coarse-grained, especially gravelly, sediments indicate that high energy river-flood processes dominate. Fine-grained sediments make up 29%, with organic-rich (marginal marine)

sediments 1%. The gravels are composed of subrounded to rounded clasts of volcanics, intrusives, and metasediments. The sand grains are composed of angular to subangular quartz and feldspar. Some quartz grains preserve crystal terminations which indicate limited weathering and rapid erosion of the source area and comparatively short transport distances.

The distributary system of the Burdekin Delta consists of an upper delta plain with a single entrenched low sinuosity braided channel. Several fossil distributary lobes are preserved on the upper plain. The lower delta plain consists of a series of active and inactive distributaries associated with the current or sub-recent complex of channel estuaries, tidal flats, and accretionary beach ridges. Progradation is occurring onto a shallow water shelf. Despite its low gradient, the Burdekin Delta has many of the characteristics of alluvial fan deltas found in higher relief areas.

Acknowledgements
The author publishes with the permission of the CEOs of CRC LEME and Geoscience Australia.

THE NATURE AND TIMING OF FLUVIAL CHANGE IN THE FITZROY RIVER BASIN, QUEENSLAND.

Jacky Croke1 Dirk Platzen1 Simon Mockler1 Kathryn Amos1 Damien Kelleher2 , and Eugene Wallensky3.
1School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, , ACT 2600.
2 School of Earth Sciences, Australian National University, ACT 2600.
3 School of Resource, Environment and Society, Australian National University, ACT 2600.

The Fitzroy River, which drains a diverse 143,000 km2 area in central Queensland, before discharging into the Great Barrier Reef (GBR) Marine Park, is used here to discuss the nature and timing of major fluvial change in a large sub-tropical basin in Australia. The catchment has been identified in recent continental-scale modeling predictions as the most severely degraded coastal catchment in Australia with an estimated ~2.5 million t of sediment discharged annually to the GBR. While there has been much speculation regarding the timing of fluvial response to land clearing in this catchment, the detailed nature and timing of this change is largely unknown.

The catchment consists of an extensive array of channel and floodplain types, predominantly anabranching channels (>50% of the channel network) but with examples of single-thread, confined and unconfined meandering also present throughout the basin. Air-photo and remotely sensed sources reveal a detailed image of fluvial change with notable changes in channel planform, geometry and sinuosity. Of particular interest is the superimposition of a contemporary anabranching system over a relict meandering channel network. Optically stimulated luminescence (OSL) dating of quartz sediments from several deep-cores taken from floodplains is used to construct the broad chronology.

The majority of OSL samples return an age >10ka with the distribution mode located within Oxygen Isotope Stage 3. In contrast to the lateral stability of the contemporary channel form, OSL samples from palaeo-meanders and distal parts of floodplains suggest that the Fitzroy and its subcatchments were laterally active 40-50ka ago. Downstream samples from pronounced scroll bars in the vicinity of the tidal limit indicate their progressive development between 19-25ka most likely in response to sea-level changes associated with the LGM. These data are compared with existing accounts of the nature and causes of major fluvial change in basins elsewhere in Australia. The significance of these findings for interpreting the response of Australia's rivers to major changes in climate and vegetation removal is discussed.

THE IMPACT OF CATCHMENT DISTURBANCE ON THE SEDIMENT FLUX OF THE FITZROY RIVER, CENTRAL QUEENSLAND

Andrew Hughes Jacky Croke and Celia Thompson
School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, Canberra, ACT 2600, Australia

The Fitzroy River catchment (FRC) in central Queensland, at 143,000 km2, is the largest catchment draining into the GBR lagoon and has been identified as a significant source of sediment and nutrients. Since European settlement it has been estimated that the sediment yield from the FRC has increased in the order of 4 to 10 times (Neil et al., 2002). This increased sediment yield has been directly attributed to land degradation which has occurred as a result of vegetation clearing and overstocking (Brodie et al., 2003).

The aim of this research is to detect and explain changes in sediment sources and sediment flux of the Fitzroy River since European settlement. We have predicted sediment sources and catchment sediment yield for pre- and post-European settlement

conditions using the spatial sediment budget model SedNet. Floodplain cores have also been obtained from various locations throughout the catchment and preliminary OSL dating results have been obtained. Sediment fingerprinting of core sediment will be carried out to determine changes in sediment sources.

In terms of identifying the major sediment sources, SedNet modelling results predict that hillslope erosion derived sediment comprises over 60% of the material that enters the river system. Spatially, the Isaac and Fitzroy sub-catchments contribute ~40% of the sediment to the system while only comprising ~20% of the catchment area. It is also predicted that these two sub-catchments have the highest rates of sediment contribution to the GBR lagoon. The high contribution rate of the Fitzroy sub-catchment can be attributed, in part, to its close proximity to the catchment outlet and therefore the reduced opportunity for deposition. However, the Isaac River is sufficiently distant from the outlet for it to indicate the potential importance of this sub-catchment as a significant source of sediment. These results are in contrast to a recent sediment fingerprinting study (Douglas et al., 2005) that found sediment from the Nogoa sub-catchment makes up the majority of sediment found in the Fitzroy River estuary and may comprise 70-80% of the fine sediment in the river system.

Determining recent floodplain sedimentation rates from fallout 137Cs has proved to be problematic due to very low concentrations of the radionuclide. We attribute this mainly to the spatial and temporal variability in rainfall patterns throughout the catchment. Despite the low concentrations of 137Cs it is apparent from the depth at which 137Cs is detected, recent floodplain sedimentation rates are very low. Recent sedimentation rates do, however, need to be put into context by establishing longer-term sedimentation rates using other dating methods. We conclude by outlining some of the limitations of existing models and demonstrating some of the complexities of modeling floodplain deposition in large basins.

References:

Brodie, J.E. et al., 2003. Sources of sediment and nutrient exports to the Great Barrier Reef World Heritage Area. ACTFR Report No. 03/11, Australian Centre for Tropical Freshwater Research, James Cook University, Townsville.

Douglas, G., Ford, P., Palmer, M., Noble, R. and Packett, R., 2005. Identification of sediment sources in the Fitzroy River Basin and estuary, Queensland, Australia. CRC for Coastal Zone, Estuary and Waterway Management Technical Report No. 13.

Neil, D.T., Orpin, A.R., Ridd, P.V. and Yu, B., 2002. Sediment yield and impacts from river catchments to the Great Barrier Reef lagoon. Marine and Freshwater Research, 53: 733-752.

ANABRANCHING IN THE FITZROY RIVER QUEENSLAND: FROM BROAD CATCHMENT CONTROLS TO LOCAL-AT-A-SITE CHARACTERISTICS.

Kathryn Amos, Jacky Croke, Andrew Hughes, Leo Lymburner, and Simon Mockler.
School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, Northcott Drive, ACT 2600 Australia.

Anabranching is now a well recognised channel pattern which overall is characteristic of low slope, low stream power environments with resistant channel bank materials. Previous work on these channels have identified a number of forms which broadly identify the relative role of island aggradation or channel incision and/or avulsion in their formation (Nanson and Knighton, 1996). Comparatively little attention has been given to the role of these channel patterns in fine sediment storage at the whole of catchment scale.

Anabranching is the dominant channel pattern in the 143,000 km2 Fitzroy River Basin in central Queensland where low gradients, wide alluvial valley floors and cohesive bank materials are all common characteristics. Using digital elevation models and GIS, the distribution of these channel types and the range of potential controlling variables such as slope (S), discharge (Q), gross stream power (Ω) and valley width (Vw), is analysed throughout the basin. Anabranching channels are differentiated from single thread meandering channels on the basis of traditional parameters of S, Q or Ω. One particular type of anabranching channel, characteristic of numerous channels of approximately equal proportions, occurs predominantly in the upper reaches of high order streams with marginally steeper slopes and narrow valleys, upstream of major bedrock constrictions and significant reductions in local valley width. Major bottle necks in the downstream conveyance of sediment thereby induce local valley floor aggradation. Pronounced downstream reduction in width appears as a dominant variable in explaining the distribution of certain types of anabranching in the catchment.

Elsewhere throughout the basin anabranching occupies entire subcatchments where long linear channels converge and redivide to form narrow islands. Using a 4km reach in the

Funnel subcatchment, to the north west of the basin, we outline in detail some of the site characteristics of these channels and the resultant spatial pattern of floodplain sedimentation. Topographic and sedimentological data from 3 transects across the channel belt, including some 45 channel cross-sections, 47 shallow cores (1.5m) and 10 deep sediment cores (6-18m) are presented. OSL derived ages from floodplain and island facies provide a broad chronology which suggests that the major channels have incised into an older alluvial unit. Radionuclide concentrations in the upper units of several floodplain cores indicate relatively low rates of overbank sedimentation post 1960. Floodplain topography is complex, however, with gilgai, high-stage meander cutoffs and floodplain drains all present throughout the reach suggesting a complex flow path inundation pattern. These findings are discussed within the context of sediment delivery and specifically the role of anabranching in fine sediment storage and residency in large river basins.

References:
Nanson G.C. and A.D. Knighton (1996). Anabranching rivers; their cause, character and classification, Earth Surface Processes and Landforms, 21: 217-239.

INVESTIGATING THE EVOLUTION OF THE JOURDAIN RIVER BRAIDPLAIN ON SANTO ISLAND, VANUATU

James P. Terry1, Ray A. Kostaschuk2, Sitaram Garimella3 and Anupama Ratiram4
1Head of Geography Department, The University of the South Pacific, Suva, Fiji Islands
2Geography Department, The University of Guelph, Guelph, Ontario, Canada
3Physics Department, The University of the South Pacific, Suva, Fiji Islands
4Geography Department, The University of the South Pacific, Suva, Fiji Islands

Fluvial geomorphology on many islands in the tropical South Pacific is not well understood compared to other regions, in part because of the difficulties posed in researching remote and isolated island locations. The Jourdain is the largest river in the South Pacific island nation of Vanuatu, and runs through Vanuatu's first national park, the Vatthe Conservation Area on Santo Island. This is the first designated national forest park in Vanuatu, which protects 2,276 hectares of rich and diverse lowland alluvial rainforest. This project investigates the evolution of the Jourdain's unusual braidplain landscape and interprets its contribution to this major heritage area.

The Jourdain rises from 1879 m at the volcanic peak of Mt. Tabwemasana and its basin covers an area of 369 km2. The river atypically exhibits a large braidplain near its estuary into Big Bay. Although braided rivers are common in pro-glacial and semi-arid environments, where vegetation cover is lacking and bedload sediment is in abundance, most large rivers in the tropical South Pacific islands normally develop meandering alluvial reaches. Our preliminary work utilises the Caesium-137 technique to determine the rate of sediment deposition on the braidplain. It is found that the accumulation rate is high compared to other Pacific Island rivers. This suggests high erosion rates in the basin and effective sediment transport processes, and factors such as tectonic uplift, exposure of Quaternary marine gravels and the regular impacts of tropical cyclones are probably important influences on braidplain evolution.

THE RELATIONSHIP BETWEEN HYDROLOGY AND CHANNEL GEOMETRY IN TASMANIAN RIVERS

Timothy J. Cohen
Dept. Primary Industries, Water & Environment, Tasmania.

The hydrology of Tasmanian rivers is driven by the large spatial variation in rainfall characteristics across the state. Total annual rainfall varies from 3000 mmyr-1 on the west coast (with strong seasonal patterns) to 500 mmyr-1 on the east coast (with large inter-annual variability). As such, flood variability varies considerably across the state. Hughes (1987) demonstrated that the east coast rivers of Tasmania generally exhibit high coefficients of variation of annual flows (Cv) and high values for the index of variability of log peak flows (Iv). The reverse was demonstrated for the west coast rivers.

East coast rivers exhibit flashy hydrological regimes similar to that experienced on the east coast of NSW. Their morphology is characterised by large channel capacities and bed widths per unit area in contrast to west coast rivers with equivalent catchment areas. This paper examines the premise that flood hydrology determines channel morpho-dynamics. It presents a preliminary analysis using existing hydraulic geometry data from the state-wide gauge network with additional field data from the contrasting east and west coasts of Tasmania.

References
Hughes, J.M.R. 1987. Hydrological characteristics and classification of Tasmanian Rivers. Aust. Geog. Studies (25) 61-82.

EXTREME ADJUSTMENTS IN SWAMP CHANNEL MORPHOLOGY, BARRINGTON TOPS, NEW SOUTH WALES

Rachel Nanson
School of Physical, Environmental and Mathematical Sciences, University of New South Wales, Australian Defence Force Academy

Swamp incision is often a catastrophic process leading to significant changes in swamp hydrology and hence vegetation and hydraulic function. However, radiocarbon dating and palynological analyses of several channelled swamp environments on the Barrington Tops, NSW, have demonstrated that the channels have persisted for up to 800 years and have attained stability via extreme adjustments in channel morphology. The notion of stable, channelled, upland swamps is a relatively new one and the processes by which they attain and maintain stability are of particular interest.

Channels can adjust their geometry through three elements which each result in slope adjustment: cross-section, bedform and planform. In the Barrington Tops swamp channels, each of these elements illustrate unusual extremes in channel adjustment and these are described below.

Cross-sectional adjustment was described using at-a-station hydraulic geometry. In swamp channels, very high bank strength is afforded by dense vegetation that has enabled the channels to achieve unusually low width/depth ratios, ~2.5. The resultant at-a-station hydraulic geometry is such that width barely increases with flow stage, depth increases moderately and velocity increases markedly; the channels are very hydraulically efficient. Du Boys (total) shear stress calculations suggest that bankfull flows are more than capable of transporting the scant sediment with which they are supplied. Because the channels have such efficient sections (w/d ~2.5) and are transporting very little sediment, excess energy must be consumed by the remaining elements; bedforms and planform.

Analyses of the longitudinal profiles of the channel thalwegs identified large variations in the scale of bedforms between the channels. Bedform magnitude (steepness) is strongly linked to the resistance to flow that they provide. In the smaller Polblue Creek system stream powers are moderate (Ω = 5.2 W/m, ω = 3.6 W/m2) and bed features displayed moderate steepness (amplitude / wavelength) values of 0.01, highly consistent with riffles. In contrast, the larger Barrington River and Edwards Creek channels have relatively higher stream powers (Ω ~ 16.2 W/m, ω ~ 5.8 W/m2) and armoured bedforms have developed with steepness values of 0.06 and 0.11, respectively.The considerable turbulent energy losses associated with these features are sufficient to reduce channel energy and therefore grain shear stresses and bed erosion, but such turbulence does not cause bank instability that might in environments with markedly lower bank strengths.

The Polblue Creek, Barrington River and Edwards Creek swamp channels have developed sinuous planforms (P < 1.98), with some examples of very tight bends (rc/w > 0.6). The reduction in the energy slope associated with planform development and substantial turbulence in these tight bends (Nanson, 2005) combine with bedform development to counter the exceptional hydraulic efficiency of the channel cross-sections. The development of extreme bedform and planform morphologies have enabled system stability, despite high shear stresses and sediment supply limitations. This research suggests that bed armouring, high bank strengths and the development of highly sinuous planforms are integral to the maintenance of swamp channel stability.

References:
Nanson, R.A., 2005. (Abstract). Channel flow and swamp evolution in two upland swamp systems, Barrington Tops - New South Wales, Australia., The Fluvial System - Past and Present Dynamics and Controls, Bonn, Germany, p49.

MORPHODYNAMICS OF A TROPICAL SAND-BED STREAM

M.J. Saynor1, Wayne D. Erskine2, K.G. Evans1 & D.R. Moliere1.
1Environmental Research Institute of the Supervising Scientist – Supervising Scientist Division
2 School of Applied Sciences, The University of Newcastle

Ngarradj creek is a sand-bed stream located within Kakadu National Park and flows through the Jabiluka project area mineral lease. The catchment experiences a tropical wet-dry climate and as a consequence is seasonally flowing. Data on channel morphodynamics have been collected since late 1998. To

reliably assess any future impact of Jabiluka erosion on stream sediment loads in the Ngarradj catchment, it was essential to determine the morphodynamics of the stream under pre-mining conditions.

In 1998 three gauging stations were installed within the catchment, two upstream and one downstream of the project area, to monitor hydrology and suspended sediment transport within the catchment. At each station rainfall, streamflow and suspended sediment concentration data were collected throughout the wet season. In addition, numerous cross sections, scour chains and erosion pins were installed along the main channel and several tributaries within the Ngarradj catchment to determine the channel stability and geomorphological characteristics of the catchment under pre-mining conditions.

The rainfall and streamflow data collected at each station were used to calibrate a hydrology model which was then used to generate a long-term runoff record using 20 y of rainfall data collected within the region. The predicted flow data were used to establish a flood frequency curve for the catchment, which has important implications for the assessment of erosion risk and geomorphological change. Mean annual suspended sediment concentrations and loads at the downstream gauge are low at 5.2 ± 1.2 mg L-1 and 148 ± 26 t yr-1, respectively and are among global minima.

A total of 56 cross sections have been surveyed each dry season between 1998 and 2004. In nearly all the reaches the channels are reasonably stable apart from active knickpoint retreat and some channel erosion by lateral migration and channel widening on the project area tributaries. Aerial photograph interpretation showed that these geomorphic processes were occurring before the construction of the Jabiluka project area and their rates of activity have not accelerated since development.

A total of 30 scour chains were installed on some of the cross sections to measure scour and fill during wet seasons. Mean scour and fill rates were determined for each reach for each wet season. Allowing for plus or minus twice the standard error of estimate of the mean, average scour and fill for the scour chains during each wet season in each reach usually overlap with each other. This indicates that mean annual scour and fill are not significantly different between reaches.

Bed material samples were also collected from each of the 56 cross sections during each dry season between 1998 and 2004. Particle size analysis was completed on all of these samples and showed that any annual changes at sites downstream of the site also occurred at the upstream sites. The grain size statistics data constitute thorough information on the current conditions for the Ngarradj catchment and can now be used for impact assessment.

Up to four years of erosion pin measurements have established that substantial bank erosion (up to 285 t/a) has occurred during wet seasons on the project area tributaries by rapid lateral migration (Tributary Central) and by erosion of gully sidewalls due to a combination of within-gully flows and overland flow plunging over the sidewalls (Tributary North). Aerial photograph interpretation showed that these geomorphic processes were occurring before the construction of the Jabiluka project area and their rates of activity have not accelerated since development. Channels with dense riparian vegetation did not generate significant amounts of sediment by bank erosion.

Sufficient information has now been collected on the morphodynamics of the Ngarradj catchment to reliably assess possible future mine-related impacts or catchment disturbance. The results of this study show that the geomorphic processes operating in the Ngarradj catchment have not been impacted on, or accelerated, as a result of the construction of the Jabiluka project area.

FINE SEDIMENT RESIDENCY IN MOUNTAIN CHANNELS IN SOUTHEASTERN AUSTRALIA.

Chris Thompson1, Jacky Croke1, Ed Rhodes2, Celia Thompson1
1School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, ACT 2600 Australia.
2School of Erath Sciences, Australian National University, ACT 2601 Australia.

A detailed understanding of channel forming and maintenance processes in mountain streams requires some measurement and/or prediction of bed load transport and sediment mobility. Traditional field based measurements of such processes are often problematic due to the high discharge characteristics of these streams. In part to compensate for such difficulties, empirical flow competence equations have also been developed to predict armour or bedform stabilising grain mobility.

These equations have been applied to individual reaches to predict the entrainment of a threshold grain size and the vertical extent of flushing. In cobble- and boulder-bed channels the threshold grain size relates to the size of the bedform stabilising grains (eg. D84, D90). This then allows some prediction of when transport of the matrix material occurs. Understandably given the heterogenous nature of grain sizes, shape and packing in mountain rivers, all interacting with variable flow frequencies, magnitude and duration, different competence or entrainment equations have given quite variable results.

The application of Optically Stimulated Luminescence (OSL) dating is considered here as an alternative and innovative way to determine fine sediment residency times in mountain streams. Age estimates derived from the technique are used to assist in calibrating sediment entrainment models to specific channel types and hydrological regimes. The objective of this research, therefore, is twofold. Firstly, we aim to characterize the competence of two mountain channel types using sediment transport entrainment relationships and to use these predictions to determine the residency of fine-grained material. Secondly, we seek to explore the application of OSL to deriving meaningful burial ages for the fine material in these two reaches and to compare results with model predictions.

Model predictions of sediment mobility for selected step-pool and plane-bed reach types in a catchment in south eastern Australia are initially calculated using hydraulic competence equations and the one-dimensional HEC-RAS model. Results indicate that recurrence interval floods exceeding bankfull up to 13 years are competent to mobilise the maximum overlying surface grain sizes at the sites. OSL minimum age model results of well bleached quartz in the fine matrix particles are in general agreement with selected competence equation predictions.

The apparent long (100-1400y) burial age of most of the mineral quartz suggests that competent flows are not able to flush all subsurface fine-bed material. Maximum bed load exchange (flushing) depth was limited to ≤ twice the depth of the overlying D90 grain size. Application of OSL in this study provides important insight into the nature of matrix material storage and flushing in mountain streams.

THRESHOLD FOR GULLY INITIATION AT ROAD DRAIN OUTLETS

Ingrid Takken1, Jacky Croke1 and Patrick Lane2
1School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, Northcott Drive, Canberra ACT 2600
2School of Forest and Ecosystem Science, University of Melbourne

Various studies have shown that roads can have significant geomorphic impacts. Not only do compacted road surfaces increase runoff and sediment generation rates, roads also alter natural drainage patterns. Runoff generated on the road surface, as well as intercepted surface and subsurface flow from upper hillslopes, is concentrated along the road and discharged onto the hillslope through road drainage structures. This concentrated overland flow can result in gully initiation at the outlet of road drains. Once such gullies are formed they act as efficient delivery pathways for road derived runoff and sediment and increase road to stream connectivity.

In order to minimize runoff and sediment delivery from road networks, a means for predicting where gully initiation may occur is required. Various studies have addressed gully initiation thresholds at road drain outlets. Threshold equations based on contributing road area (m2) and hillslope gradient at the drain outlet (sin θ) have been successfully used to predict gully occurrence at road drainage structures in both North America (Montgomery, 1994) and Australia (Croke & Mockler 2001). Other studies have indicated that additional factors such as hillslope curvature or the location of an obstacle at the road drain outlet are also important factors (La Marche & Lettenmaier 2001).

For this paper, we collected field data to study gully initiation in three forestry catchments in south-east Australia; the Albert River and Tyers River catchments in Victoria and the Sandy Creek catchment in NSW. Logistic regression analysis shows that contributing road area and discharge hillslope gradient are significant variables explaining gully occurrence in all three catchments (with a 0.05 significance level). However, the overall accuracy of predictions based on these two variables only ranges from 63 to 67 %. This indicates that contributing area and slope gradient are important variables, but do not fully explain gully occurrence within the catchments. Subsequently, stepwise logistic regression was used to test the significance of a range of additional variables, including the

height of the cut batter, the slope position of the drain, the gradient of the road surface, plan curvature at the drain outlet, and the presence or absence of an obstacle at the drain outlet. While a large range of variables were included in the equations for each catchment, the overall accuracy of the predictions could only be improved by about 7%. This highlights that gully initiation is a complex process, which is difficult to assess. Many factors affecting gully initiation thresholds can be considered 'random' and can be difficult or even impossible to measure. For this reason, road contributing area and hillslope gradient at the drain outlet are still considered the two most dominant factors in explaining gully formation at drain outlets and can provide a simple field index to assess the risk of gully initiation.

References:

Croke, J.; Mockler, S. 2001: Gully initiation and road-to-stream linkage in a forested catchment, southeastern Australia. Earth Surface Processes and Landforms 26: 1-13.

La Marche, J.L.; Lettenmaier D.P. 2001: Effects of forest roads on flood flows in the Deschutes River, Washington. Earth Surface Processes and Landforms 26: 155-134.

Montgomery, D.R. 1994: Road surface drainage, channel initiation, and slope instability. Water Resources Research 30: 1925-1932.

Thursday February 16th, 2006

HOLOCENE VALLEY AGGRADATION CONTROLLED BY POST-GLACIAL SEA LEVEL RISE AND ESTUARINE INFILLING : EXAMPLES FROM AUSTRALIA.

Paul Rustomji1,2, John Chappell2 and Jon Olley1
1 CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2061
2 Research School of Earth Sciences, Australian National University
Paul.Rustomji@csiro.au.

Progradation of river deltas into estuarine embayments has been a global phenomena over the last 6800 years. The responses of upstream alluvial river reaches to this progradation has received little attention. Here, the hinterland valley aggradation patterns for the Macdonald and Tuross rivers in southeastern Australia are used to explore the linkages between post-glacial sea level rise and estuarine evolution for rivers flowing to drowned river-valley type estuaries. Optical and radiocarbon dating of floodplain sediments indicates that since the mid-Holocene sea level highstand 6800 years ago, vertical floodplain aggradation along these two valleys occurred at a rate generally consistent with the rate each river prograded into its estuary. We show that over the Holocene, post-glacial sea level changes have been an important, if not the dominant control upon alluvial aggradation and floodplain formation for many tens of kilometers upstream of the estuarine limits in these coastal valleys. Both rivers have abandoned their main Holocene floodplains over the last ~2000 years and their channels have contracted. A regional shift to smaller floods was most likely responsible, though a greater relative sea level fall experienced by the Macdonald River since the mid-Holocene sea level highstand appears to have been an additional influence upon floodplain evolution in this valley.

A REVISED HOLOCENE SEA-LEVEL CURVE AND ESTUARINE EVOLUTION MODEL FOR THE SOUTHEAST COAST OF AUSTRALIA

Craig Sloss and Brian Jones
School of Earth and Environmental Sciences, University of Wollongong, NSW 2522, Australia

This study presents a database of 121 previously published radiocarbon ages obtained from fossil molluscs, organic material and fixed biological indicators from back-barrier sedimentary successions and the marginal marine environment on the southeast coast of Australia. An additional 42 radiocarbon ages and 50 aspartic acid racemisation-derived ages have been obtained from fossils preserved in the Holocene post-glacial marine transgression (PMT) sandsheets deposited in these shallow incised estuaries. A synthesis of the previously published radiocarbon ages and the new data has permitted a revised Holocene sea-level curve for the southeast coast of Australia to be determined. Results show that rising sea level during the most recent PMT attained an elevation of around -10 m by 10,000 cal yr BP and continued to rise to ca. -5 m by 8,500 cal yr BP. Between 8,300 and 8,000 cal yr BP sea level had risen to at least 3 m below present mean sea level (PMSL) and inundated the shallow incised estuaries, resulting in deposition of shell-rich transgressive sandsheets. The sea attained its present elevation around 7,700 cal yr BP, slightly earlier than a previously proposed culmination of ca. 7,000 cal yr BP. Results indicate that sea level continued to rise to between 1 and 1.5 m above PMSL by 7,400 cal yr BP during the culmination of the most recent PMT and this sea-level highstand lasted to some time between 3,000 and 2,000 years ago. The highstand was followed by a relatively slow and smooth regression of sea level from ca +1.5 m to present sea level. A series of minor negative and positive oscillations in relative sea level, associated with variations in ocean topography and/or climate change during the mid to late Holocene, appear to be superimposed over the Holocene sea-level highstand and subsequent smooth sea-level regression. The sea-level highstand and subsequent regression has had a significant influence on the geomorphological evolution of wave-dominated barrier estuaries on the southeast coast of Australia. Using thermoluminescence dating, radiocarbon ages, aminostratigraphy and the litho- and biostratigraphic analysis of 141 vibracores, a detailed assessment of the geomorphological evolution of wave-dominated barrier estuaries that formed in both broad and narrow incised valleys has been made (Sloss et al., 2004, 2005). Results show that the estuaries investigated have an evolutionary pathway that is different to previous models of barrier estuary evolution (cf. Chapman et al., 1982; Roy 1984, 1994). In contrast to the earlier models, this study places a greater emphasis on the influence of rising PMT sea level and the deposition of near basin-wide shell-rich

deposits that extend almost up to present sea level. These transgressive sandsheet facies lie unconformably over the Late Pleistocene antecedent landsurface and represent deposition immediately above the initial flooding surface as rising sea level inundated the incised valley systems ca. 8,000 years ago. This contrasts with established models for barrier estuary evolution where Holocene PMT sandsheets were restricted to the mouths of incised valleys and back-barrier central basin mud facies lay directly over the antecedent Pleistocene landsurface.

References:
Chapman, D.M., Geary, M., Roy, P.S. and Thom, B.C., 1982. Coastal Evolution and Coastal Erosion in New South Wales. Sydney: Coastal Council of New South Wales, 341 p.
Sloss, C.R., Murray-Wallace C.V., Jones B.G, and Wallin T. 2004a. Aspartic acid racemisation dating of mid Holocene to recent estuarine sedimentation in New South Wales, Australia: a pilot study. Marine Geology, 212, 45-59.
Sloss, C.R., Jones, B.G., Murray-Wallace, C.V. and McClennen, C.E., 2005. Holocene sea level change and the evolution of a barrier estuary: a case study, Lake Illawarra, NSW, Australia. Journal of Coastal Research, 21, 943-959.
Roy, P.S., 1984. New South Wales estuaries: their origin and evolution. In: Thom, B. G (Ed.), Coastal Geomorphology in Australia. Academic Press, Sydney, pp. 99-121.
Roy, P.S., 1994. Holocene estuary evolution - stratigraphic studies from southeastern Australia. In: Dalrymple, R., Boyd, R. and Zaitlin, B.A. (Eds.), Incised-valley systems: origin and sedimentary sequences. SEPM Society of Sedimentary Geology Special Publication 51, pp. 241-264.

IMPACTS OF THE SUMATRAN TSUNAMI ON MALDIVIAN REEF ISLANDS

Paul Kench
School of geography and Environmental Science
The University of Auckland

Mid-ocean reef islands have been affected by multiple tsunami during their geological history, but there is no published work detailing the affect of tsunami on reef island stability or development. Detailed observations of the affects of the Sumatran tsunami on mid-ocean reef islands are presented, based on pre- and post-tsunami topographic and planform surveys of 13 Maldivian islands. Results show no substantial island erosion and no significant change in island area (<5%). The tsunami accentuated predictable seasonal oscillations in shoreline change promoting localised retreat of exposed island scarps, commonly by up to 6 m; deposition of cuspate spits to leeward; and, vertical island building through overwash deposition, up to 0.3 m thick, of sand and coral clasts covering a maximum 17% of island area. Results indicate Maldivian reef islands are physically robust and the geological signature of tsunami on atoll island development is minor.

MODELLING REEF PLATFORM CARBONATE AND SEDIMENT PRODUCTION

Deirdre E. Hart
Department of Geography, University of Canterbury, Private Bag 4800, Christchurch, New Zealand. Email: deirdre.hart@canterbury.ac.nz. Phone (+64-3) 3642987 ext7916.

Sand cays, small sandy islands formed on the surface of coral reefs, provide habitable land for indigenous communities throughout the tropical Pacific. These islands appear particularly responsive to changes in the ecological and oceanographic regimes of surrounding reef systems. It is important to understand the processes by which they are nourished and accumulate in the face of increasing anthropogenic modification and potential climate-change impacts.

Sand cay maintenance and growth depends a multitude of processes, operating over different time scales, including the rate and pattern of sediment supply, which are functions of the ecology, existing sediment stores and hydrodynamic regime of the surrounding reef. Ecological-census and component-specific sediment analyses were used to determine the types and spatial distributions of carbonate produced on an emergent reef platform, and their relation to island maintenance. Results were then integrated with information on sediment textures and hydrodynamic conditions in order to determine sediment sources, sinks and transport pathways.

Carbonate production rates were found to vary by several orders of magnitude between, and within, different reef-flat sub-environments depending on the type and pattern of cover. Total carbonate production, 17 399 ± 662 t $CaCO_3$ y-1, was dominated by coral (73%) with subordinate contributions by coralline algae (19%), and molluscs, foraminifera and Halimeda (<4%). Reef-flat sediments did not, however, reflect this potential. Instead, they were dominated by molluscs (35-55%), coralline algae (16-26%), coral (8-13%), Halimeda (7-8%) and foraminifera (5-10%).

Results indicate that different organisms' spatial distributions and rates of carbonate to sediment conversion are critical when

considering the types and amounts of carbonate available to be stored in the various reef sinks. In using both the hydraulic and constituent compositional properties of sediments, as well as information on local biological and physical processes, the model approach developed offers progress towards an integrative, interdisciplinary analysis of carbonate environments.

ASSESSMENT OF MORPHOLOGICAL CHANGE ON AN ERODING COAST USING REPEAT LIDAR SURVEYS

Mark E. Dickson1,2, D.Murray Hicks2, Chloe Auffret3, Ude Shankar2 and Helen Hurren2
1Postdoctoral Fellow, Foundation for Research Science and Technology
2National Institute of Water and Atmospheric Research, Christchurch
3Ecole Nationale Des Travaux Publics de l'Etat, France

This paper presents results from the middle stages of a three-year research programme focussed on rapidly eroding coasts around the alluvial fan of the Waitaki River, east coast South Island.

The protruding fan of the Waitaki River was built seaward by river outwash during the Last Glacial. In the Holocene transgression and subsequent still-stand, coastal processes have eroded the fan landward, decreasing the convexity of the coast and forming cliffs up to 20 m high that are fronted by a mixed sand and gravel beach.

Development of coastal land over the last century has resulted in increasing concern over rates of cliff retreat, and questions have been raised regarding the relationship between erosion rates and activities such as irrigation and the construction of dams for hydro-electric power generation. To address such questions a numerical model is being developed that will seek to represent cliff and beach evolution over long temporal scales and wide spatial scales using abstract descriptions of process interactions. To assist in the development and subsequent calibration of this model a range of physical data have been collected. Offshore of the coast, bathymetric, sidescan and seismic profiling data have been collected, whereas beach stratigraphy and cliff morphology and are being investigated using Ground Penetrating Radar surveys and LiDAR surveys completed in 2001 and 2004. This paper focuses upon the use of LiDAR surveys for assessing morphological change and sediment exchanges between cliffs and the fronting beaches. A suite of methods were developed in ArcGIS to automatically detect features such as cliff edge, berm top, and talus edge, and an algorithm has been developed to calculate the volume of material held in storage in features such as talus slopes. Progress has been made in the development of methods of appropriate gridding and differencing of point data, as well as categorisation and quantification of results along- and across-shore. This paper will describe zones of beach accretion and erosion, and investigate along-shore patterns in talus volumes and cliff recession rates.

SHIFTING SANDS

James R. Goff1 and Bruce G. McFadgen2
1National Institute of Water & Atmospheric Research Ltd., Christchurch; 2ArchResearch, Wellington

Conventional wisdom tends to dominate our interpretation of the tectonic geomorphology of New Zealand's coast, producing mainly details of uplifted beach ridges and subsidence. Recent models link coastal transverse dune building phases with seismic activity, and field work in the Haast and Okuru River systems of South Westland indicates that this association applies for at least the last four Alpine Fault ruptures. In essence, for another coastal transverse dune ridge to form there needs to be a significant supply of new sand to the coast. Land clearance following Maori and subsequently European colonisation has had no similar effect.

In the SW North Island new transverse dune systems have been attributed to anthropogenic land clearance. Ages for initial transverse dune formation however, coincide with past seismic activity; c. AD1800 (Younger Waiterere dunes: Paihiatua Fault, Hikurangi Subduction), c. AD1450 (Older Waiterere dunes: Wellington Fault, Hikurangi), c. 2100-2400 cal. yr BP (Motuiti dunes: Wairarapa/Ohariu/Pahiatua Faults). Furthermore, the start of two parabolic dune phases and dune advances inland coincide with past tsunami inundation, c. AD1500 (Older Waiterere), and c. AD200 (Motuiti). Younger Waiterere transverse dunes are an exception – once formed they were unable to stabilise because of ongoing and sustained anthropogenic land clearance and stock farming.

There are two points here. First, anthropogenic land clearance has not created transverse dunes nor has it remobilised them, in the case of the Younger Waitarere dunes it simply

stopped them from stabilising. Second, tsunami inundation has driven dune remobilisation.

Evidence from the Chatham Islands, Matakana Island, and 90 Mile Beach corroborates the SW North Island story. Furthermore, geomorphological evidence for past tsunami inundation is still preserved in the landscape. Investigation of sandy coasts that the Indian Ocean tsunami recently inundated, shows the presence of sand pedestals separated by relict scour surfaces that the moving water formed. Similar features appear to be present on New Zealand coastlines. At some places, reworked sand available for aeolian remobilisation is found as tsunami-laid sheets landward of coastal dunes. To follow this argument through, we suggest that relict pedestals and landward parabolic dune systems are evidence for large palaeotsunamis. Sandy coastlines that do not have such features have either not been inundated by sufficiently large tsunamis in the recent past, or have received a sufficient supply of new sand to obscure the record of relict pedestals.

BEACH MORPHOLOGY CHANGE RELATED TO THE VARIATION IN COASTAL HYDRODYNAMICS AT MORUYA, NSW

Jiashu Shen and Roger McLean
School of Physical, Environmental and Mathematical sciences
University of New South Wales at the Australian Defence Force Academy
Canberra, ACT 2600, Australia
j.shen@adfa.edu.au r.mclean@adfa.edu.au

Moruya Beach is located on the south coast of New South Wales, about 300 km south of Sydney. The 5.5 km beach compartment is subjected to a micro-tidal and moderate to high wave environment. A new foredune system was established at Moruya between 1979 and 1983 replacing the one which was completely eroded away by storms in mid-1974. The major source of replenishment sand was from the nearshore/surf zone. Critical to the re-establishment of the foredune during this four-year period was the development of a planar basement in the form of a backshore berm with an elevation of 2.3 to 2.8 m above local mean sea level (MSL) and a width of greater than 30 m (McLean and Shen, 2006). The lower limit of the berm (2.3 m) is higher than the sum of the mean high water spring level, MHWS (0.5 m above the local MSL) and the mean maximum wave amplitude (1.5 m). Under these conditions, upwash and/or overwash of sediment is needed to build up the berm by lifting sediment to a level between 2.3 and 2.8 m which is at the limit of upwash and/or overwash. The persistence of the berm represents a dynamic balance between morphology and swash hydrodynamics, because increasing wave height will cause beach erosion rather than accretion. That is, higher wave energy will degrade the beach berm with a change in the direction of net sediment movement from onshore to offshore. Sediment deposited above the 2.8 m level and further landward from the edge of the berm is transported by aeolian processes, but not wave induced processes. In this presentation, the different stages of berm development will be related to the wave condition and tidal regime, and the position of the berm edge will be related to the location of the shoreline, notably the intercept of the beach profile with the MSL.

References:
McLean, R. and J. Shen 2006 From foreshore to foredune: foredune development over the last 30 years at Moruya Beach, New South Wales, Australia. Journal of Coastal Research, in press.

ABRASION – MORE THAN A MECHANICAL PROCESS

Maree A. Hemmingsen
maree.hemmingsen@xtra.co.nz

The Canterbury Bight coastline, between Timaru and Banks Peninsula, is geologically recent and comprises cut and fill elements developed on vast thicknesses of alluvial gravel. This coastline from Timaru and the southern end of Kaitorete Barrier is in long-term erosion and the 29 km long Kaitorete Barrier has been stable, or only mildly accretional, yet longshore sediment transport along the coast is strongly net northward. It is suggested that sediment is lost from these beaches due to abrasion.

Abrasion studies have stated that larger clasts abrade more quickly than smaller sizes. Results from tumbler experiments demonstrated that the textural mixture of the sediment samples based on the cumulative frequency of actual beach sediment samples found within the mixed sand and gravel beach environment of the Canterbury Bight influenced the rates of loss attributable to abrasion. Estimations of loss within a sediment budget that might be attributable to abrasion have been calculated with abrasion values ranging from 4.8 % to 95 %.

Results from this study showed that textural mixture can be used as a predictor of losses attributable to abrasion. Using this technique it is possible to calculate the susceptibility of abrasion at a large scale along an entire coastal system or at a site specific scale.

Additionally, chemical weathering was found to significantly influence abrasion rates for the greywacke sediments within the Canterbury Bight. The quality of sediments, not previously addressed in abrasion studies, demonstrated the importance of the quality of sediments both from the rivers coming into the coastal system and sediments in storage in the storm berms or in the coastal cliffs along the coast.

WHAT INITIATES AVULSIONS ON RIVERS?

Dean Judd1, Ian Rutherfurd2, Bob Keller3, John Tilleard4
1, 2 University of Melbourne, SAGES, VIC, 3010, djudd@unimelb.edu.au; idruth@unimelb.edu.au
3 Monash University, PO Box 60 Clayton, VIC, 3800, http://www.catchment.crc.org.au, Bob.Keller@eng.monash.edu.au
4 Engineering consultant, Moroka Pty Ltd. john.tilleard@moroka.com.au

Many meandering streams move through a cycle in which long sections of channel are progressively abandoned, and replaced by new channels. This avulsion process is an important component of floodplain aggradation. Most research on this phenomenon has, very profitably, used space-for-time approaches to reconstruct the stages and mechanisms of avulsion. There are two steps: diversion of water onto the floodplain, and cutting of a new channel through the floodplain. The problem is that authors have identified several plausible cutting mechanisms that are associated with the avulsion sequence. These mechanisms can be summarized as top-down or bottom-up scour progressing from the following possible points: levee crevasses, points of floodplain constriction, paleochannels, and the downstream confluence. Using hydraulic models of a large avulsion on the Ovens River (Deep Creek, NE Victoria, Australia), we have tested which of these four mechanisms can exceed erosion thresholds and trigger the avulsion cycle.

Since 1934, the Deep Creek avulsion has degraded by between three and six meters, and widened from around 16 meters in 1964 to up to 80 meters at present. The hydraulics at the site suggest that floodplain constriction and levee crevasses will not develop into avulsions. One mechanism emerges as the key process: confluence scour. The contrast between the high hydraulic efficiency of the parent channel, and the, initially, inefficient-flow down the developing avulsion channel, produces a steep hydraulic gradient at the confluence. This translates into knickpoint migration up the avulsing channel. .Once we recognize this mechanism, it provides a model for the broader evolution of floodplains formed by avulsions.

Contrary to the accepted model of avulsion development, which argues that avulsions develop in large floods, the maximum shear stresses on knickpoints in the Ovens River, occur during relatively frequent events (3 to 5 year events).

The outcomes of this research explain much about the sequence, origin and timing of the evolution of floodplain features. The high conveyance channels generated by avulsions, and the tendency for avulsions to migrate between points of transverse channel shift across the floodplain, provide the basis for the concepts of avulsion extension and anabranch succession, whereby a river avulsion predisposes the next reach upstream to an avulsion.

Overall, we conclude that channel abandonment by avulsions should be considered the natural tendency of meandering rivers, rather than an unusual event. Avulsion in meandering streams can be constrained by confinement, or avulsions may not be recognized because of the short time of observation, or by anthropogenic effects.

CENTENNIAL SCALE VARIATIONS IN EXTREME TROPICAL CYCLONE ACTIVITY IN THE CORAL SEA FROM SEDIMENTARY AND ISOTOPIC EVIDENCE

Jonathan Nott
School of Tropical Environment Studies and Geography, James Cook University, Cairns

Assessing risk from tropical cyclones and predicting the impact of this hazard under a human altered climate is based exclusively upon the behaviour of these events over the past 50 - 100 years, and often less. Critical to these determinations is an understanding of the full extent of the natural variability of this hazard. The coarse resolution of millennial scale sedimentary records, brevity of the instrumental record, imprecision of longer

historical accounts and lack of any long-term, high resolution records has led to the assumption that the total variability of tropical cyclone behaviour is encompassed within the seasonal to multi-decadal oscillations observed to date. I present a near 800 year long, annual resolution isotope record of tropical cyclones in northeast Australia which displays marked centennial scale regimes. The record demonstrates that the frequency variability of intense landfalling cyclones is greatest at centennial scale compared to seasonal and decadal oscillations. Switching between centennial scale regimes in this record occurred rapidly (10-20 years) highlighting the importance of accounting for this phenomenon in coastal planning and risk assessment. It is likely that natural systems too have had to adjust to these rapid longer-term regime shifts and natural erosion regimes and accrual of ecosystem resilience both follow these time scales. The study highlights the importance of obtaining high resolution multi-century records of tropical cyclone activity for all ocean basins globally. This will allow a more accurate assessment of future impacts of this hazard on human society, and the adaptations that natural systems must make to the rapid and prolonged changes in cyclone behaviour under anthropogenic stresses.

MULTIPLE OCCURRENCE REGIONAL LANDSLIDE EVENTS AS A FORMATIVE GEOMORPHIC PROCESS

Nicholas J. Preston and Michael J. Crozier
School of Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
Nick.Preston@vuw.ac.nz

Landsliding can be shown to be the dominant geomorphic process in many parts of New Zealand. Of particular importance are episodes of extensive slope failure associated with intense rainfall and seismic triggers. Mass movement response to triggers such as these can be localised, but is more often regional in its extent, reflecting the spatial distribution of the triggering energy. These events are common, occurring somewhere in New Zealand several times a year, generating both social/economic and geomorphological impacts. Multiple Occurrence Regional Landslide Events (MORLEs) have a number of defining characteristics: they involve multiple mass movement failures, with effects on a regional scale; they are 'events' in the sense that they are a response to a temporally discrete trigger, typically storm rainfall or seismic shaking. While economic consequences of MORLEs have been considered elsewhere, they are also worthy of attention as a geomorphic phenomenon.

MORLEs have generally been characterised in a frequency/magnitude framework. The most widely documented of these events in recent times, Cyclone Bola (1988), has become the de facto benchmark (the standard unit of measurement) against which other events are compared. This may have validity in an economic sense. Yet in many ways, this means of characterisation has no geomorphological basis. Rainfall magnitude is often used as a surrogate index for the magnitude of geomorphic events. Yet there is clear evidence that rainfall events of given magnitude can have very different impacts in terms of, for example, landslide density or total volume of sediment mobilised. However, characterising the geomorphic event itself is problematic. It is difficult to quantitatively define the extent of landsliding, and typically an envelope will be used to delimit the affected region. Nevertheless, within an envelope defining a rainfall-triggered event impacts can vary substantially. Density of landsliding varies considerably, influenced by local precipitation, topography, vegetation, slope hydrology and contemporary landsurface condition. For example, the density of landsliding produced by Cyclone Bola at Tutira varies considerably when measured over a range of spatial scales, although data suggest asymptotic behaviour of the relation between spatial scale and density at approximately 25 km2. Objectively quantifying the geomorphic significance of MORLEs is difficult. Although the geomorphic work they perform over a discrete period can be measured, this does not necessarily fully reflect their geomorphic significance in terms of, for example, their contribution to regional sediment fluxes and landscape development. While MORLEs exhibit frequency/magnitude behaviour that is asynchronous with that of fluvial sediment transport, and it can be argued that mass movement directly produces only a small proportion of the terrestrial/marine fluvial sediment flux, it is nevertheless clear that there is a complex interaction between these two broad divisions of the terrestrial sediment budget; if episodic hillslope sediment supply were shut off, overall sediment flux would ultimately be dramatically reduced – because fluvially entrained sediment is frequently derived from storage sources generated by mass movement processes. Hillslope mass movement is thus an integral

component of the medium- to long-term regional sediment flux.

MORLEs are important to medium- to long-term landscape development. Clearly, mass movement produces morphological change at local scales. Cumulatively MORLEs also make a contribution to broader landform development in many parts of New Zealand. At the scale of the low order drainage basin, mass movement source slopes develop an enhanced micro-topography of swales and sharply defined spurs or, in the words of Charles Cotton, feral landscape. Beyond the primary source area, however, topography can become subdued as colluvial material overprints the existing fluvial signature. In terrains dominated by MORLEs, colluvial footslopes and fans act as buffers between hillslope and channel, controlling sediment delivery and landform development. The significance of MORLEs can thus be assessed from the extent to which the landscape shows the imprint of these phenomena, Variation in the extent of this imprint over time and space may be an important indicator of changing environmental and geomorphic boundary conditions.

LANDSLIDE RISK EVOLUTION: CONCEPT AND APPLICATION

Gabi Hufschmidt and Michael J. Crozier
School of Earth Sciences, Victoria University of Wellington
Gabi.Hufschmidt@vuw.ac.nz, Michael.Crozier@vuw.ac.nz

Time is a crucial aspect when dealing with natural risk. The natural process itself, the elements at risk and their vulnerability are variable in time. Additionally, their interactions change, as well as the rate of processes. Within natural systems, a reaction can occur long after the actual cause. Therefore, it is difficult to identify the cause, especially when time scales of analysis are not of sufficient length. Also, effects can be intentionally or unintentionally exported into the future, a phenomenon often referred to as 'risk-transfer'. An example is the use of measures that provide only short term mitigation without actually reducing the long term risk associated with a high magnitude event. Because of a false sense of security, investment e.g. in housing continues and losses are even higher when the measure fails.
Although the significance and constraints of time frameworks are appreciated in some disciplines, e.g. in geomorphology, their application and implications within natural risk research are incomplete, because historical perspectives on risk development are lacking and future scenarios are still sparse.

The current project proposes to analyse the spatio-temporal variability of landslide risk. Three different study sides in New Zealand are chosen, each representing an important process shaping the economic and social development of the country. The Western Hutt Hills, dormitory suburbs of Wellington, are characterised by suburban sprawl, Mt. Cook/Aoraki Village has become a synonym for tourist development, and parts of the Waipaoa catchment, East Coast North Island, represent changing land use patterns and rural development. The time period under consideration encompasses the decades from 1945 until today. A comprehensive comparison of landslide hazard, elements at risk and their vulnerability for several time slices will provide an assessment of overall risk evolution. Causes, correlations and interactions between the factors determining risk are identified and analysed.
This paper illustrates the application of the conceptual approach of landslide risk evolution for the Western Hutt Hills. This area (28km2) is characterised by steeply dissected terrain. Shallow earth flows and slides and debris flows are the dominant processes. Landslide hazard analysis is based on multi-temporal aerial photo interpretation. The magnitude of an event is derived by the overall size of the affected area, and the frequency at which this magnitude occurred during the 60 years of analysis. An extreme event took place in 1976, when a rainstorm with 350mm within 24 hours triggered nearly 800 landslides with an overall affected area of 314,000 m2. Suburban sprawl and therefore residential numbers and infrastructures have increased rapidly since the 1940s. Today, nearly all of the preferred building sites (plateaus) are fully exploited. This paper will further investigate the first results of landslide risk evolution within the Wellington region.

GLACIAL GEOMORPHOLOGY, SEDIMENTOLOGY AND CHRONOLOGY IN THE RAKAIA VALLEY, CANTERBURY, NEW ZEALAND.

James Shulmeister1, Henrik Rother1 Olivia Hyatt1, Uwe Rieser2, Glenn D. Thackray3 David Fink4
1 Department of Geological Sciences, Private Bag 4800, Christchurch, New Zealand.
2 School of Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington
3 Department of Geosciences, Idaho State University, Campus Box 8072, Pocatello, Idaho, USA.
4. ANSTO Environment, ANSTO, Private Mail Bag 1, Menai, Sydney 2234, Australia

This paper summarises some recent advances in understanding the nature of glaciation in the valley systems of North Canterbury, during the last two glacial cycles. In the Middle Rakaia Gorge region of the Rakaia Valley numerous moraine lines, outwash fans, kame terraces and other glacial deposits are preserved. These landforms have been previously classified into four glacial advance systems, the Woodlands, Tui Creek, Bayfield and Acheron systems. New surface exposure ages provisionally date the older three of these advances to late OIS 6, c. 25 ka and c. 20ka respectively. These younger deposits rest on thick sequences of older glacio-fluvial and glacio-lacustrine sediments. IRSL dating of these valley fills indicate an earlier glacial advance in early OIS 6 or OIS 8 and confirm advances late in OIS 6 and during early OIS 4.

The moraines contain only slightly modified fluvial material and can barely be distinguished (if at all) from outwash. They cap tens to a hundred metres of (glacio)fluvial outwash material. These in turn unconformably overlie older lacustrine and fluvial beds of kame terrace and proglacial lake/sandur systems. The moraines and the buried glaciofluvial/lacustrine deposits together indicate that sediments and landforms generated by active ice have poor preservation potential in these systems. The ages of the buried deposits preclude significant glacial erosion of these valley reaches during the LGM. This is in stark contrast to early OIS 6/OIS 8 advances in the valley which were thick and pervasive, scouring the valleys to at least the modern valley floor depth and emplacing tens to hundreds of metres of glacial marginal and proglacial sediments. This implies a significant reduction in glaciation in the last glacial cycle. We will discuss this and present a conceptual model for glaciation in these valleys under small and large ice scenarios.

HOW ANCIENT ARE AUSTRALIAN LANDSCAPES AND SOILS?

Geoff S. Humphreys & Marsh T. Wilkinson
Department of Physical Geography, Macquarie University, Sydney, Australia
geoff.humphreys@mq.edu.au
marsh.wilkinson@people.net.au

Old soils on ancient landscapes in a dry and fire-prone continent is how Australia is portrayed by its citizens and by others across the globe. This message, initially developed by various researchers, has entered the public domain by a variety of pathways but especially by books and articles in popular journals and magazines. Mary White's After the Greening: the Browning of Australia and Tim Flannery's The Future Eaters are prime examples. But how old are its landscapes and soils, and how might this be tested?

Recent work using terrestrial cosmogenic nuclides and OSL dating provide valuable insights on this since they allow dating of exposed rock and mantled rock providing that a suitable soil production function can be determined (Wilkinson and Humphreys 2005). These methods display similar results to denudation rates established by other means (e.g. river loads, hillslope processes, catchment averages etc). In SE Australia, denudation rates are mostly between 5-50 m/Ma and these results are similar to those from other regions, across a variety of lithologies including basalt, granite, sandstone, and limestone. On this basis a 1 m mantle, a typical maximal thickness in upland SE Australia, is formed (renewed) in 20–200 ka. In drier parts of Australia denudation rates decline to 1–2 m/Ma. Even at these rates and when considered over long periods of time a landscape might expect at least c. 600 m of lowering since the beginning of the Palaeozoic. Truly ancient landscape remnants, if they exist, will be rare. Equally, truly ancient soils that preserve their essential quality despite residing at the surface of a landscape for long periods will be very special indeed.

References:
Wilkinson, M.T. & Humphreys, G.S. 2005 Exploring pedogenesis via nuclide-based soil production rates and OSL-based bioturbation rates. Australian Journal of Soil Research 43,767-779

SOIL PRODUCTION RATES INFERRED FROM COSMOGENIC RADIONUCLIDES, AND LAST GLACIAL MAXIMUM EROSION RATES IN UPLAND S.E. AUSTRALIA

Marsh T. Wilkinson1, Geoff S. Humphreys1, David Fink2, John Chappell3, and Keith Fifield4
1. Department of Physical Geography, Macquarie University, NSW 2109.
2. ANSTO Institute for Nuclear Geophysiology, ANSTO, PMB 1 Menai, NSW 2234, Australia
3. Research School of Earth Sciences, Australian National University, ACT 0200.
4. Research School of Physical Sciences and Engineering, Australian National University, ACT 0200.

Cosmogenic radionuclides are commonly used to determine local surface lowering rates e.g., erosion rates of outcrops, and can be used to infer soil production rates by sampling saprolite and using the saprolite lowering rate as the conversion rate of saprolite to soil (Wilkinson and Humphreys, 2005). Among the various cosmic ray scaling considerations, inferring soil production rates requires an account of saprolite shielding by soil, and situations where time-invariable soil depth applies are commonly sought. However, invariable local soil depth over tens of thousands of years is unrealistic at many sites, especially where the last glacial period may have been accompanied by different rates of erosion than those observed today. Testing the constant soil depth assumption has been accomplished in two ways: morphometric analysis and slope process modelling (Heimsath et al., 1997; Heimsath et al., 2000) and, the emergence of tors from the surrounding soil (Heimsath et al., 2001).

A further method involves measuring erosion rates from various parts of the catchment. For instance, in the Blue Mountains (33°S and ~ 1000 m. a.s.l. in the southeastern highlands of Australia), the erosion rate of a small catchment, determined from the 10Be concentration of stream sediment, is greater than all soil production rates from within that catchment. This casts doubt on the veracity of the apparent soil production rates since calculations of catchment erosion rates are not dependent upon a constant soil depth assumption. Apparent soil production rates may be artificially low if the modern soil depth, used in surface lowering calculations, was thinner for the bulk of the 10Be accumulation time. Considering the site was above the treeline during the LGP (Hesse et al., 2003), soil production rates are recalculated using a soil cover 30 cm thinner than that observed; this revision corresponds with the absence (and probable erosion) of saprolite below soils less than ~ 30 cm deep, and the presence of saprolite under deeper soil. Revised soil production rates overlap the catchment average; furthermore, the revised soil production function (plot of soil production rate v. soil depth) accords with models from the literature.

This TCN data set adds to mounting evidence that the Blue Mountains were dramatically affected by the last glacial period. Not only was aeolian transport and sand dune formation active, but generally, soils were probably ~ 30 cm thinner on plateaux surfaces, and ~ 10% of surfaces likely experienced total soil and saprolite erosion. These phenomena were probably a result of sparse, treeless vegetation (Hesse et al., 2003) which contrasts with heath and forest that currently covers the entire plateau surface.

References:

Heimsath, A.M.; Chappell, J.; Dietrich, W.E.; Nishiizumi, K; Finkel, R.C. 2000: Soil production on a retreating escarpment in southeastern Australia. Geology 28: 787–790.
Heimsath, A.M.; Chappell, J.; Dietrich, W.E.; Nishiizumi, K; Finkel, R.C. 2001: Late Quaternary erosion in southeastern Australia: a field example using cosmogenic nuclides. Quaternary International 83–85: 169–185.
Heimsath, A.M.; Dietrich, W.E.; Nishiizumi, K; Finkel, R.C. 1997: The soil production function and landscape equilibrium. Nature 388: 358–361.
Hesse, P.; Humphreys, G.S.; Selkirk, P.M.; Adamson, D.A.; Gore, D.B.; Nobes, D.C.; Price, D.M.; Schwenninger, J.L.; Smith, B.; Tulau, M.; Hemmings, F. 2003: Late Quaternary aeolian dunes on the presently humid Blue Mountains, Eastern Australia. Quaternary International 108: 13–32.
Wilkinson, M.T.; Humphreys, G.S. 2005: Exploring pedogenesis via nuclide-based soil production rates and OSL-based bioturbation rates. Australian Journal of Soil Research 43: 767–779.

RESERVOIR SEDIMENT STACKS: THEIR POTENTIAL FOR DETERMINING POST-FIRE HISTORY, SEVERITY AND FREQUENCY FROM SELECTED SEDIMENT CHARACTERISTICS

Victoria J. Farwig1, William H. Blake2, Stefan H. Doerr1, Geoff S. Humphreys4, Ed J. Rhodes3 & Richard A. Shakesby1
1Department of Geography, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP, UK, e-mail: 257715@swan.ac.uk
2School of Geographical Sciences, University of Plymouth, Plymouth, PL4 8AA, UK
3Research School of Earth Sciences and Research School of Pacific and Asian Studies, The Australian National University, Canberra, ACT 0200, Australia
4Department of Physical Geography, Macquarie University, NSW 2109, Australia

Forest fires tend to cause accelerated soil erosion with some of the redistributed sediment entering the fluvial system. Where there is a reservoir downstream, enhanced sediment accumulation will tend to take place on its floor. This paper concerns the application of different techniques to sediment cores obtained from the floor of Lake Burragorang, the main water supply reservoir for Sydney and explores the possibility not only of discriminating between sediment from burnt and unburnt sources but also between sediment derived from areas subject to different fire severities.

Two main soil properties have been investigated: mineral magnetism and thermal activation characteristics (TAC). Laboratory heating experiments have been conducted on long unburnt material (>30 years) to ascertain temperature thresholds at which changes to the soil characteristics occur. Owing to the dominance of the mineral magnetite in soils from the study area, only high severity fires can be detected using mineral magnetic analysis due to the high temperature at which magnetite properties transform (577 °C). Lower temperature thresholds have been explored by TAC analysis. Using this technique it is possible to detect whether temperatures in excess of 110 °C have been reached. These experiments have shown that individual soil grains have retained a 'memory' effect of previous fire events, so that it has been necessary to find sources of material not previously exposed to fire (unexposed bedrock) to test the validity of the assumptions of the technique.

The influence of the well-documented fire history has been explored in different parts of the Lake Burragorang catchment using mineral magnetic analysis and reference to SCA records of burn events within the catchment since 1960. This has enabled assessment of the influence of (i) different landscape units, (ii) the number of fires, and (iii) the time since the last fire on various magnetic signatures derived from within the catchment, which could possibly be used to build a picture of the sources of sediment within the catchment deposited on the lake floor.

The potential and limitations of applying these techniques to sediment stacks for the purpose of reconstructing fire history, severity and frequency are discussed.

DRYLAND SALINITY IN SOUTH EASTERN AUSTRALIA: FALLACIES AND MISCONCEPTIONS

Glen Bann and John Field.
CRC LEME; and School Resources, Environment & Society, ANU, Canberra 0200

Dryland salinity is an environmental issue of paramount concern in southern Australia. It threatens agriculture, water quality, infrastructure, towns and biodiversity. Although considerable funding, research and remediation activities are being directed at salinity, the ongoing and increasing problem suggests the current understanding of the fundamental processes requires urgent reassessment.

The current universally accepted cause of dryland salinity in southern Australia invokes 'rising' watertables (groundwater) associated with recharge and discharge zones. The process is believed to have followed the removal of deep rooted perennial vegetation (trees) after European settlement. Preliminary results from current research indicate that this model on the cause of dryland salinity might not be applicable to many upland environments, particularly on the Southern Tablelands of NSW. This scenario is overly simplistic and neglects many fundamental processes acting upon and within the regolith and lithology. Although promoted nationally as the cause of dryland salinity, this type has the potential to affect 16% of total agricultural land, whereas, another type of salinity, termed transient salinity, may potentially affect 67% of agricultural land and is therefore of much greater consequence. Transient salinity is common in upland landscapes and is not associated with rising groundwater. It occurs within the soil surface profile, particularly on/in sodic duplex soils, from soil degradation processes such as those induced by intensive grazing.

Despite the widespread effect, the transient salinity scenario is not promoted as a possible cause to dryland salinity, with significant consequences for mitigation and remediation activities. The current model does not consider treating and eliminating soil degradation, but instead targets revegetating recharge zones in the landscape, thereby reducing the excess of water. Airborne Electromagnetics (AEM) is currently promoted as the preferred salinity mapping technique, but as transient salinity usually occurs within the top few meters of the surface, and is not associated with the groundwater, the AEM technique will not detect increased salinity in these landscapes. In addition, surface bulk soil conductivity as

measured by the EM38 (<1.5m depth) and EM31 (<6m depth) varies considerably both spatially (horizontally and vertically) and temporally, and readings are a consequence of several factors. The complexities of the geology and regolith, in addition to anthropogenic influences on the landscape, suggest that AEM is questionable in these upland landscapes.
Research investigating the interactions between dryland salinity, regolith and terrestrial biodiversity in south-eastern Australia is scarce. The research project outlined herein employs an holistic, multidisciplinary approach to identify the fundamental processes acting within the system. Preliminary results suggest that on the uplands of south-eastern Australia, salinity may not be as critical a stress upon terrestrial biodiversity as previously suggested. Many species of invertebrates are common and abundant on saline sites including insects, spiders, centipedes, millipedes, mites and worms. Endemic flora species, including Eucalyptus melliodora and E. blakelyi, and at least six native perennial grass species, appear to tolerate increased salinity levels. This is to be expected, as (primary) salinity is a naturally occurring phenomenon in southern Australia, as are sodic soils common, particularly where salinity predominantly expresses itself in the lower parts of the landscape.
Furthermore, most salinity outbreaks appear to be associated with intensive grazing and subsequent soil degradation and erosion, not with an excess of water from rising groundwater. Sites with stock excluded and/or revegetation, appear to respond favorably and quickly.

MAPPING THE DISTRIBUTION AND CHARACTER OF THE NORTHERN TERRITORY REGOLITH

Michael A. Craig
Cooperative Research Centre for Landscape Environment and Mineral Exploration/Geoscience Australia

The Northern Territory Regolith project aimed to provide the Northern Territory Geological Survey with a regolith-landform map of the Northern Territory, with supportive regolith material characterisations, and shed some light on the evolution of major landscape domains and their associated weathering history.

A simple geomorphic "provinces" map was prepared during a scoping meeting from existing data for use during a major trans-NT reconnaissance traverse and also to serve as a general guide for later detailed fieldwork. A Trans-NT regolith traverse was completed during September-October 2003, via the Stuart Highway from 200km south of Alice Springs through to the Darwin coastal plain including some additional east-west excursions. Such a large-scale regolith calibration traverse has not been previously undertaken in the NT or, perhaps, anywhere else in Australia. Results from this traverse served as a guide for later fieldwork planning.

Over 250 regolith samples were collected during project fieldwork (June to September 2004). The results derived from geochemical analysis, thin sectioning and slabbing of these samples form the basis of entries in an Atlas of NT Regolith Materials. All 1200 sites visited are fully described using Geoscience Australia's Regolith Terrain Mapping (RTMAP) guidelines, and are supported by a project photo database (~2000 entries), with selected photos being used in constructing the Regolith Atlas. To assist with field data collection for such a large portion of Australia, a digital data collection system was developed using Pocket PC technology (HP-IPAQ 5550 with Bluetooth wireless GPS technology [EMATC]). Customised software was written to allow data collected and exported in a format fully compatible with Geoscience Australia's national regolith database.

A pilot palaeomagnetic sample program was conducted to address the lack of age control in NT regolith materials, landforms and weathering events. Overall, palaeomagnetic ages ranged from 2Ma in a weathering profile along the Darwin foreshore to 295Ma in a road cutting at Tennant Creek. Follow-up fieldwork was conducted in May 2005, to collect additional palaeomagnetic samples to help improve the reliability of the initial results. Project field data helped to provide the necessary critical controls for the physical and geochemical characterisation of NT regolith materials, construction of the regolith-landform map and legend, the regolith-landform unit description, the NT regolith GIS attribute tables and the Regolith Atlas descriptions and tables.

The results and products generated by this project add significant new knowledge to the broader understanding of the Australian regolith especially within the Northern Territory. The most important achievements of this two year project are the:

Northern Territory Regolith-Landforms map (1:2,500,000) first edition;
Detailed NT Regolith-Landforms GIS and supportive geospatially-located geochemical data that allows reliable NT-wide data interrogation between scales of 1:250k to 1:2.5 Million;
Atlas of NT regolith materials (thin section to hand specimen), that provides a pictorial and a descriptive account of territory-wide regolith materials together with an account of their geochemical signatures;
Results of reconnaissance palaeomagnetic dating of regolith samples from the Northern Territory that indicate relict ferruginous regolith is widespread and consistent in palaeomagnetic age with major oxidation events reported elsewhere in southern Australia;
Cost-effective and innovative Pocket PC-based regolith digital data collection system that allows large amounts of reliable regolith data to be collected with a high degree of geospatial accuracy; and
Summary Report detailing the regolith-landform character and variability across the Northern Territory.

FROM MICROMORPHOLOGY TO GEOMORPHOLOGY; NANOMORPHOLOGY OF CLAY MINERALS

Marek Żbik
Ian Wark Research Institute, University of South Australia, Mawson Lakes 5095, Australia

The diversity of micromorphology in clays significantly affects their behavior in the regolith and ultimately in the landscape. This paper deals with nano-morphological surface features of well-crystallised kaolinite from Georgia (USA) and Kiralyhegy (Hungary) and poorly crystallised, interstratified kaolinite from Birdwood (SA) and Weipa (Queensland) as well as micronised talc and montmorillonite have been comared using field emission scanning electron microscopy (SEM) and atomic force microscopy (AFM). In general, there is good agreement in information from the 2 very different imaging techniques. AFM gives more detailed information on step and ledge dimensions, micro-valleys and crystallographic orientation of irregularities on basal planes and edges of the crystallites. There are major differences in nano-morphology and surface structure between well crystallised and interstratified kaolinite samples. When well crystallised kaolinite showing 1-2 μm in diameter flat and atomically smooth basal planes with some cascade-like step growth 50 – 100 nm wide. The edges are rough and right – angled in SEM images appear bevelled in AFM images due to artefacts from the aspect ratio of the AFM tip. Poorly cristallised, interstratified kaolinite forms very thin platelets with much more complex surface morphological patterns. High density of steps and valleys formed by surface dissolution are common. These high density of steps area which occur in basal planes may contribute significantly to pH dependency of electrokinetic potential and cation exchange capacity in this mineral and may influence massive changes in physical properties when minor environmental changes occur. There is also evidence from both SEM and AFM techniques, of curvature in the thinner, poorly ordered kaolinite.

Montmorillonite forms extremely thin and large in lateral dimension flexible sheets. This morphological difference play crucial role in stability of aqueous suspensions prepared from these minerals. When well crystallised kaolinite forms edge to face oriented compact aggregates in low viscosity suspension, interstratified kaolinite and smectites form edge to edge oriented spanned three-dimensional network with pronounced cellular honeycomb structure. Such gelled suspension has high viscosity and is almost impossible to dewater and stabilise.

In contrast to well crystallised kaolinite, talc show irregular, thin and curved platelets with much larger aspect ratios. The low edge contribution to total surface area in micronised talc contributes to its poor dispersion. High porous re-entrants and folds are frequently displayed at the edges and between sheets of the micronised talc. These voids, observed in both SEM and AFM micrographs, are filled by air nano-bubbles causing poor dispersion and high flotability when the talc is mixed with water. After grinding, the micronised talc particles are smaller, have reduced aspect ratios and much reduced porosity at edges and between sheets. Hence, lack of surface charge due to isomorphological substitutions, the morphological differences in aspect ratio and air entrapment in the porous structure of talc are possible causes for the poor dispersability in aqueous solutions of micronised talc in comparison to kaolinite and smectites.

LANDFORM AND KARST EVOLUTION OF THE NULLARBOR PLAIN, AUSTRALIA: NEW INSIGHTS FROM SHUTTLE RADAR DATA AND SURFACE GEOPHYSICAL OBSERVATIONS

R.R. Davies1*, S.H. Doerr2,3, A. Lewis4 and M. Harwood4
1School of Earth Sciences, Victoria University, Wellington, NZ
2Department of Geography, University of Wales Swansea, UK
3Research School of Earth Sciences, Australian National University, Canberra, Australia
4Terradat UK Ltd., Cardiff, UK

Geomorphological studies of remote and extensive landform units have traditionally relied primarily on information from air-photographs and extrapolation of few and widely spaced ground observations. This is especially true of the Nullarbor Plain, Australia, a ~200,000 km2 limestone plateaux with subdued topography and relative paucity of karst features. It is widely accepted that since final emergence in the Late Miocene, topographic development has been limited by the prevailingly semi-arid climate, the initial flatness of the surface and the high porosity of the limestone. Some palaeochannels have been identified, which drained onto the gently southward dipping plain from the interior during a postulated wet phase 3-5 million years ago. Near the current coastline, few but spectacularly large collapse dolines occur, where upward stoping of cave passages have punctured the surface. Their restricted range has been explained by enhanced karst formation due to the currently higher annual rainfall near the coast (~400 mm compared to ~250 mm inland) coupled with salt weathering. The presence and distribution of palaeochannels and shallow depressions in the interior has previously been examined using air-photos and isolated ground observations. In contrast to the collapse dolines, these features are barely discernible on the ground and their presence has not challenged the model of restricted semi-arid karst development.

The advent of high (vertical) resolution elevation data derived from SRTM (Shuttle Radar Topography Mission) data, coupled with multi-spectral satellite data allows a much more detailed landform analysis than has hitherto been possible. Here we present results of such an analysis for the Nullarbor Plain, together with ground observations obtained using microgravity and traditional survey techniques. Key outcomes are (i) elevation of the plain does not rise continuously to its northern margin, but instead dips inland over a large area in the north west; (ii) spectral analysis of SRTM data reveals an extensive palaeochannel network, which apparently did not drain south onto the plain from the interior, but instead drained from the plain towards this depression; (iii) large areas of numerous small (<200 m) shallow depressions (<4 m deep) can be identified in the interior: those examined exhibit significant gravity anomalies and some are actively draining, indicating their origin as true karst dolines; (iv) small (m-scale) blowholes, which exhibit strong barometric draughts, are associated with comparatively large negative gravity anomalies, consistent with large air-filled voids below the Nullarbor Limestone. The results suggest that not only the southern margin, but the entire plain has undergone significant modification through fluvial and karst processes at the surface and extensive cavernous development below ground. The coastal prevalence of deep dolines can be explained by surface elevation and depth to the water table alone. The karst development of the Nullarbor is discussed in the light of these new findings and the potential for geomorphological investigations of the methods used here are also explored in a global context.

ORIGIN AND KARST GEOMORPHOLOGICAL SIGNIFICANCE OF THE ENIGMATIC NULLAROR 'BLOWHOLES' AND THEIR BAROMETRIC DRAUGHTS

S.H. Doerr1,2*, R.R. Davies3, A. Lewis4, M. Harwood4, G. Pilkington5, P. Ackroyd5
1Department of Geography, University of Wales Swansea, UK
2Research School of Earth Sciences, Australian National University, Canberra, Australia
3School of Earth Sciences, Victoria University, Wellington, NZ
4Terradat UK Ltd., Cardiff, UK
6CEGSA (Cave Exploration Group of South Australia), Adelaide, Australia

The Australian Nullarbor Plain (~200,000 km2) is thought to be the world's largest exposed limestone plateaux. For its size, it exhibits relatively limited surface karst features. A few dozen collapse dolines exist, where upward stoping of deep cave passages has punctured the surface and, in some cases, allows access to extensive cave systems. More common features are the perhaps several thousand blowholes; dm-m scale vertical tubes of up to several m depth, which can display strong

barometric draughts. Little is known about the origin and distribution of these blowholes, but they are thought to be common across the plain and have been speculated to originate from downward dissolution along rootholes and/or salt weathering. As blowholes rarely lead to open cave passages, the barometric draughts were thought to derive from air exchange with the micro-porosity (intergranular) or meso-porosity (cm-scale dissolution tubes termed 'protokarst') of the underlying rock.

Here we report on the results of geological, geomorphological and geophysical observations aimed at elucidating the origin of blowholes and their draughts. Over 20 blowholes were examined at a variety of southern and central locations on the plain using (i) morphological and geological mapping incl. Schmidthammer hardness tests to elucidate their mode of formation, (ii) high-resolution paired draught and atmospheric pressure loggers to investigate draught velocities, volumes, fluctuations and synchronicity, and (iii) microgravity measurements to explore the nature and extent of the voids providing the underground air reservoirs from which barometric draughts originate.

Many blowholes lead to small or, in some cases, extensive, but typically shallow cavities that exhibit numerous bellholes (vertical cylindrical tubes with a dome shaped ceiling). Blowholes appear to occur where bellholes happen to punctuate the surface. Statistical arguments suggest that shallow cavities with bellholes are common, but in comparatively few cases do bellholes protrude through to the surface. Hardness measurements indicate that salt weathering does not play a major role in their genesis or punctuation. We speculate that shallow caves and bellholes were formed under phreatic or semi-phreatic conditions at higher ground water levels stands in the past. Root penetration, condensation corrosion from below and perhaps surface weathering may eventually puncture a bellhole situated close to the surface. Draught measurements show velocities > 80 km h-1 and air reservoir volumes of 1-100×106 m3. At all draughting blowholes where microgravity measurements were carried out, we found large gravity anomalies. The nature of these anomalies, together with draught characteristics and petrological observations in deeper caves, suggest that the draughts originate at least in part from extensive cave systems in the underlying Wilson Bluff and/or Abrakurrie limestones that are sufficiently connected to the blowholes to exchange large air volumes. The genesis of blowholes is discussed in the relation to cavernous development in the Nullarbor Plain and other karst regions elsewhere.

Friday, February 17th 2006

KEYNOTE ADDRESS:
TECTONIC GEOMORPHOLOGY AND THE ROLE OF EXTREME EVENTS: NEO-CATASTROPHISM ASSESSED

Kelvin R. Berryman
Institute of Geological & Nuclear Sciences, PO Box 30368, Lower Hutt, New Zealand

To address the topic, definitions of both tectonic geomorphology and extreme events are required. There are challenges with the definitions of both. Classifying landforms as being of tectonic origin is often problematic. Certainly we would include fault scarps, many aspects of mountain building, and sometimes the formation of marine and fluvial terrace sequences, rock-fall avalanches, landslides, and alluvial fans, as being of tectonic origin. However, along this trendline these landforms have a greater and greater involvement with climate-related processes. Thus, the separation of landforms into those generated by tectonic processes from those generated by climatic processes becomes moot, and feedbacks have long been recognised to operate between the two.

New insights into the amplitude, rate, and variability, of tectonic and climate-related processes affecting landscapes are arising using remote sensing tools, and computer-aided visualisation and analysis. Combining these tools with an expanding range of dating options and numerical modelling of geomorphic processes, has enabled topics such as threshold states, critical pathways, and continuous versus event-based change (uniformitarianism versus catastrophism), to be debated. In many cases these new approaches have given rise to the neo-catastrophism in geomorphology research evident in the past 20-30 years. A catastrophic approach is certainly well-established in active fault studies, using concepts of event horizons and event stratigraphy.

So we might ask whether all tectonic processes are, by definition, “extreme” events? Perhaps it depends on whether they bring about “significant” (catastrophic?) change. Perhaps extreme needs to be defined in terms of variance from the norm. A hydrologist often thinks of any event with >100 yr return period as extreme, while major earthquakes at a particular place on a fault with return period as long as 10,000 years may be part of the expected frequency/magnitude distribution. Different perspectives probably exist as to whether the February 2004 Manawatu storms were an extreme event. Hydrologists, farmers, local civil defence would probably think so, but there is some suggestion that a similar event occurred in the 1880’s, and the Holocene geological record of the region documents progressive, probably event-based infill and progradation of the shoreline from its 6.5 ka BP position. The hillsides of the region have attained their present form through a long succession of landslides and debris flows, with intervening stability as evidenced by paleosols.

The existence of threshold states is also important to tectonic geomorphology and the catastrophism debate. Smaller and more frequent events that do not go above a threshold state do not trigger a geomorphic response, but once that threshold is reached then a new landform results. For example, faulting during the Mw 6.6 Edgecumbe earthquake of 1987 produced a fault scarp about 14 km long and widespread subsidence of the Rangiteiki plains, but the recent Rotoehu or Matata earthquake swarms with maximum magnitude, in among 100 or so events, of about Mw 5 resulted in no significant landscape change. Is exceeding the threshold state for geomorphic change what we label, or should label, as “extreme”?

By examining a few case studies some refinement of “tectonic geomorphology” as against geomorphology resulting from climate-driven processes, and “extreme” and “catastrophic”, may become apparent. Examples to explore include Alpine Fault-driven landscape change in Westland, and landscape change, including the formation of flights of marine and fluvial terraces, in the Hikurangi Subduction Margin.

MAPPING BASALTIC REGOLITH WITH AIRBORNE GEOPHYSICS IN THE LAKE CORANGAMITE CATCHMENT, WESTERN VICTORIA

David Gibson, Andrew Fitzpatrick & Heike Apps
CRC LEME, Geoscience Australia, PO Box 378, Canberra, ACT, 2601, Australia.

The Lake Corangamite catchment in Western Victoria was chosen for a desktop study of how airborne geophysics can be used to map variations in regolith in areas of Cenozoic basalt, as
it is an area of saline groundwater with saline playas forming windows in to water table

high yield agricultural lands are being affected by salinity
a high quality DEM, radiometrics and magnetics are available.

The greater part of the catchment is underlain by the Western Victorian Newer Volcanics. This study explores the variations in microtopography and radiometric response of basalts to try and predict regolith properties, and how these may affect groundwater salt storage and flow. Magnetics (particularly the first horizontal derivative) are used to show the distribution of basalt beneath sediment cover.

Earlier studies show that weathering of Cenozoic basalt in Western Victoria is accompanied by a decrease in K and increase in Th compared with fresh rock, and that these variations can be demonstrated in both hand specimens of soil and weathered rock, and radiometric surveys. Thus it is possible that some indication of the degree of weathering of basalt may be gained from radiometric response, particularly the K and eTh channels and the eTh/K ratio. However, variations in the chemistry of the fresh basalt must be taken into account in comparing response from different lava flows. The basalt in the area has been mapped at regional scale using a four-fold subdivision, but there are no detailed polygons of individual flows or groups of similar flow type.

The LiDAR (Light Detection and Ranging) DEM was acquired using an airborne oscillating laser scanner system which records distance from the scanner, and reflectance data. A ground model was constructed after correcting for the attitude and altitude of the aircraft and elimination of non-earth returns. The Corangamite LiDAR DEM data as supplied to us consisted of several hundred tiles that had not been edge matched. These were warped to give a continuous coverage, and the DEM resampled at 2x2 m pixels. It is far superior to the 20 m DEM of Victoria (derived from 10 m contours, spot heights and drainage line locations) as it clearly and accurately shows features down to a scale of 10s of metres with local vertical accuracy of around 10 cm. The extent of long wavelength warping has not been assessed, but is not important for this study.

The DEM shows great detail of surface morphology in areas of young flows, such as wavelength and relief of stony rises, flow fronts, collapse features, low relief flow surfaces, and importantly, the presence of ponded sediment in topographic lows. Areas of uniform morphology (which are assumed to represent areas with similar basalt lithology and chemistry) from each volcanic centre are being mapped using the DEM, and radiometric response (particularly the eTh/K ratio) studied for each polygon. Radiometric variations within landform morphology polygons are being quantified by use of residual values techniques. Note that areas containing ponded sediment need to be studied separately from areas without, as the sediment may contain an allochthonous component (ash, dust, or sediment deposited from suspension during high water level phases of the palaeo Lake Corangamite).

A large area of old, weathered flows to the north of the lake displays a north-south gradient in eTh/K ratio over 10s of kilometres (higher ratio in the north), indicating a possible gradient in degree of weathering. Smaller areas of younger flows in the south of the area display variations in ratio within polygons of uniform flow type, which may also relate to weathering or degree of allochthonous soil cover. All variations are being noted for field checking.

Acknowledgements
The authors publish with the permission of the CEOs of CRC LEME and Geoscience Australia.

TEPHRA-RING GULLY DEVELOMENT IN TROPICAL CLIMATE - THE RELATIVE ROLES OF SYN- AND POST-ERUPTIVE EROSION: A CASE STUDY ON THE 1913 WEST-AMBRYM ERUPTION, VANUATU

Károly Németh, Shane J. Cronin
Massey University, Institute of Natural Resources, P.O. Box 11 222, Palmerston North, New Zealand
Email: k.nemeth@massey.ac.nz and S.J.Cronin@massey.ac.nz

Gully erosion over volcanoes play an important role in mass redistribution of tephra over short period of time. Description of short-term erosion of tephra of monogenetic volcanoes with good record of the timing of events is relatively rare. The erosion of scoria cones is well-documented, however, erosion of phreatomagmatic tephra/tuff rings and cones are poorly understood. In spite of the lack of data on the initial erosion of such volcanoes, they are commonly used for long-term erosion rate calculations. Here we present field observations of syn- and immediate post-volcanic erosion of a tephra ring erupted in

1913 on west Ambrym Island, Vanuatu. The exact date of the eruption and the sedimentological study of the tephra ring and its neighbouring vents allowed us to develop a timing of events for the main phases of the erosion of a tephra/tuff ring. In west Ambrym, a cliff section at sea level exposes ~15 m thick phreatomagmatic tephra units. The tephra ring surrounds an oval shape maar depression (~ 1200 x 600 m) filled by water. The highest point of the tephra ring is ~85 m, and the rim gently slopes (<10°) over 600 m length. The pyroclastic succession can be subdivided into 4 units, with a basal ~10 m thick succession of weakly to moderately bedded, poorly sorted, cross-bedded to dune bedded tephra with coral fragments, overlain by the next unit, a metre thick clast-supported scoriaceous fall deposit. The top sequence of ~10 m thick phreatomagmatic ash and lapilli beds are similar to the basal unit and they both are interpreted to be varying particle-concentration base-surge deposits interbedded with phreatomagmatic fall beds and explosion breccias (marking vent-clearing events). A scoriaceous air fall dominated tephra ring with abundant coral fragments in the distal area of the volcanic edifice mark the fourth statigraphic unit. In the distal sections, the base surge dominated beds are gradually replaced by reworked dm-thick beds of fine ash deposited from syn-volcanic reworking by debris flows and/or hyperconcentrated mass flows. The inter-fingering of phreatomagmatic deposits with syn-volcanic reworked volcaniclastic sediments indicates an ongoing remobilisation of freshly deposited tephra during the eruption. This remobilisation appears to be due to high water availability from condensing steam plumes of passing base surges, and has produced a large volume of remobilised tephra up to ~700 metres away from the vent. The mud flows and debris flows in the distal areas form tabular beds mantled by predominantly base surge generated tephras. Gully development, and erosion-scar formation were restricted in syn-eruptive time, and scouring by the passage of base surges can be recognised. The proportion of reworked tephra in the volcaniclastic succession increases with distance from the vent. The northern shoreline follows the semicircular architecture of the tephra ring where gully geometry can be studied. The gullies are typically <4 m deep and are cut into the primary tephra succession. There are no soil horizons on the top of the tephra units below the gullies, suggesting that the gully formation was immediately followed the deposition of the tephra. The gullies filled by ~1 m thick debris-flow dominated sediments. The gully walls are steep and post-formation collapses are common. The gullies are now covered by thin soil layers with vegetation mats. The flank of the tephra ring is now stable and vegetated by trees. The gully floors are mostly covered by scrub and tree vegetation although there are rare active channels. This suggests that the tephra remobilisation must have been intense immediately after the eruptions. We conclude that the majority of the erosion of a tephra rings in such tropical climate takes place immediately during after the eruption. After formation of the gullies, remobilisation of tephra is concentrated only within the established gully networks. Therefore it can be concluded that the shape of the erosion modified volcanic landform predominantly develops shortly after the eruption ceases. This observation indicates that long-term erosion of tephra rings should be reviewed critically as time-averaged processes. The initial erosional condition is strongly controlling the geometry of the resulting erosion modified tephra ring.

CHANGING LANDSCAPES: LATE CENOZOIC ARIDITY IN THE AUSTRALIAN INTERIOR

John Chappell
Research School of Earth Sciences
Australian National University

Previous research shows that forest in central Australia began to give way to dry-adapted vegetation, some 25-30 Ma ago, as our north-drifting continent entered sub-tropical desert latitudes. Other factors also affected the climate, including Miocene growth of the Antarctic ice sheet, intensified zonality, and establishment of the Sub-Antarctic oceanic convergence. Alkaline lakes developed as conditions became drier in the Miocene but wetter conditions apparently returned in the Pliocene, before the onset of deepening aridity in the last few million years.

Aridity transformed the landscape, with the development of stony (gibber) deserts accompanied by loss of soil cover and the growth of regional dune-fields. Recent exposure-age dating shows that stony deserts were forming 4 Ma (million years) ago and were extensive by 2.5 Ma, decreasing available surface water and enhancing runoff. New dating results also show ages of the Simpson Desert dunes ranging to ~1.7 Ma, while aeolian silt has been accumulating

outside the dunefields for more than 1 Ma. Increased aridity in the last million years is indicated by sedimentary changes in central Australian playa lakes.

Although stony deserts and dunefields have existed since Pliocene to earliest Pleistocene times, the climate has not been continuously arid but was punctuated repeatedly by periods when there was substantially more water in the Australian interior than today. Dated sediment cores from central Australian dunes and from the Tasman Sea show that Upper Quaternary wet periods alternated with aridity about every 100,000 years; regional variations in patterns of dune ages suggest that arid episodes were most intense around Lake Eyre. Moreover, detailed studies show that these cycles were not in lock-step with glacial cycles in the northern hemisphere, and differed in pattern and frequency between the summer rainfall regions of northern and central Australia, and the winter rainfall region of the south.

INITIATION OF AUSTRALIAN STONY DESERT, DATED BY COSMOGENIC 21NE AND 10BE

Toshiyuki Fujioka1, John Chappell1, Masahiko Honda1, Igor Yatsevitch1 and Keith Fifield2
1Research School of Earth Sciences, Australian National University, Canberra, Australia
2Research School of Physical Sciences and Engineering, Australian National University, Canberra, Australia

In principle, the history of aridity in Australia can be determined by dating the landforms and deposits that form under arid conditions. Over 75% of Australian continent is semi-arid to arid, and stony deserts are a major feature of these regions. Stony deserts are characterized by a surface monolayer of pebble- to cobble-sized rocks (gibbers) which, once formed, tend to remain in place with little subsequent modification. Some gibbers were formed in situ by breakdown of their underlying parent rock; others were fluvially transported to their present positions. We propose that the age of the stony deserts can be estimated by determining the time when gibbers were formed.

In this study, we measured cosmogenic nuclides, 21Ne and 10Be, in silcrete gibber samples collected from stony deserts in central Australia, to determine their exposure ages. The use of cosmogenic 21Ne, which is a stable cosmogenic nuclide, allows us to examine the history of gibber formation beyond the exposure dating range of 10Be, which limited by radioactive decay to a few million years. We note that we have developed a reliable method for determining cosmogenic 21Ne in the presence of 21Ne from other sources.

Apparent exposure ages calculated from the concentrations of cosmogenic 21Ne and 10Be in the gibber samples from stony deserts west of Lake Eyre in northern South Australia ranged from two to five million years, but the apparent 21Ne ages are significantly greater than the apparent 10Be ages. The discordance indicates that the parent silcrete, from which the gibbers were derived, was buried at a shallow depth for a considerable period before being stripped and broken into gibbers. Calculations indicate that the silcrete was stripped and gibbers began to form around 4 m.y. ago, and that gibber-mantled tablelands were widely developed and dissected around 2-3 m.y. ago. These ages correspond to the time of late Cenozoic global cooling inferred from benthic oxygen isotope records in marine sediment cores.

REVISION OF THE AGES OF RIVER TERRACE AND FAN SURFACES IN THE MIDDLE CLUTHA VALLEY AND MANUHERIKIA BASIN, CENTRAL OTAGO, NEW ZEALAND.

Russ Van Dissen1, David Barrell1, Philip Tonkin2 and Uwe Rieser3
1 GNS Science.
2 Department of Geological Sciences, University of Canterbury.
3 Luminescence Dating Laboratory, School of Earth Sciences, Victoria University of Wellington.

River terrace and alluvial fan deposits of the middle Clutha valley and lower Manuherikia Basin comprise gravelly alluvium dominated by quartz, schist and greywacke clasts from the Clutha catchment (terraces), or schist clasts from local catchments (fans). The terraces and fans have been correlated in age with Pleistocene glacial moraines and outwash terraces in the upper Clutha catchment (Turnbull, 2000, and references therein). The 17 km long Cromwell Gorge separates the middle and upper Clutha valleys across an uplifting mountain range, and contains a discontinuous and incomplete set of terraces. This prevents any robust interpolation of terrace surface profiles from the middle to upper Clutha valley.

The ages of the terraces and fans assigned by Turnbull (2000), are based primarily on terrace surface height profiling, tempered by the degree of geomorphic preservation of the

landforms, sparse radiometric dates, and 'counting back' through glacial events. In all cases the inferred ages differ markedly from previous age estimates (e.g. NZGS, 1983). Recently obtained OSL ages from the Manuherikia and middle Clutha areas (this study) permit some reassessment of the ages.

Comparable sequences of Semiarid and Pallic Soils have formed on both terrace and fan surfaces. The degree of weathering and soil formation in gravelly alluvium, together with secondary accumulation of interstitial clays filling voids and in some cases the accumulation of precipitated calcium carbonate is more pronounced on the higher (older) terrace and fan surfaces. The OSL dates, together with the soil sequences, provide a basis for recognizing geomorphic surfaces on these landforms. A long and complex history is indicated by the pattern and stratigraphy of soils on the Airport, Reservoir and higher terrace remnants and on the Waikerikeri fan.

References:
NZGS 1983. Seismotectonic hazard evaluation of the Clyde Dam site (Volumes I & II). Unpublished NZ Geological Survey Engineering Geology Report EG375.
Turnbull, I.M. (compiler) 2000. Geology of the Wakatipu area. GNS 1:250000 geological map 18.

VALLEY SIDE-WALL RETREAT VIA EXTREME EROSION EVENTS, SOUTH-WEST SYDNEY BASIN

Kerrie M. Tomkins1, Geoff S. Humphreys1, Marshall T. Wilkinson1, Richard A. Shakesby2, Stefan H. Doerr2, Peter J. Wallbrink3 and William H. Blake4
1Dept. of Physical Geography, Macquarie University, NSW 2109, Australia
2Dept. of Geography, University of Wales, Swansea, UK
3CSIRO Land & Water, Black Mountain, ACT 2601, Australia
4School of Geography, University of Plymouth, Plymouth, UK
Corresponding author email: ktomkins@els.mq.edu.au

The spectacular incised valleys of the Blue Mountains Plateau in the west and south-west of the Permo-Triassic Sydney Basin are the focus of this paper. The evolution of these valleys has been shown to be controlled by knickpoint retreat following uplift along the Lapstone Structural Complex. However, very little investigation has been conducted into the processes which dominate after the knickpoint has past, in particular those processes which facilitate valley widening.

Investigations in the incised Nattai River valley, a tributary of the Wollondilly River in the south-west of the Basin, found hillslopes which are characterized by mass movement, particularly rock fall, debris flows, rotational slumping and large landslides. To determine the relative importance of mass movement in denudation, we compared modern rates of sediment yield from hillslope plots and suspended load in the Nattai catchment with long term rates of sediment yield and denudation calculated from incision below Tertiary basalts, cosmogenics and apatite fission track ages determined for the Blue Mountains Plateau. The comparison revealed that the average modern background denudation rate is an order of magnitude less than the long term average, which implies a very low sediment yield for the majority of the time and compares well with field observations. The background rates are episodically punctuated by short term sediment yield events which are at least an order of magnitude higher than the long term average and higher than erosion rates measured following the 2001/02 bushfires. We suggest that following knickpoint retreat, the primary process of denudation in the Nattai valley is extreme erosion events on hillslopes which facilitates valley side-wall retreat. Sediment generated through mass movement directly enters the stream network or is stored on the lower slopes and valley floor to be progressively reworked by floods capable of remobilizing sand to boulder sized material. The mass movement events appear to be linked to lithology which suggests that mass movement and side-wall retreat is an important geomorphic process in the evolution of the incised valleys of the Blue Mountains Plateau.

SIGNATURES OF ANTARCTIC CLIMATE CHANGE RECORDED IN CONTINENTAL GLACIAL CHRONOLOGIES OF THE SOUTHERN HEMISPHERE BETWEEN 10 TO 30 KA

David Fink (1), Paul Williams and Paul Augustinus (2), James Shulmeister (3)
(1) Australian Nuclear Science and Technology Organisation, Sydney, Australia. (2) School of Geography & Environmental Science, Univ of Auckland, New Zealand (3) Department of Geological Sciences, Univ. of Canterbury, Christchurch, New Zealand

Correlations of millennial-scale glacial transitions across Earth's hemispheres are presently the centre of much debate. Issues such as synchronicity or otherwise of Younger Dryas cooling prevalent in the Northern Hemisphere, the determination of a 'global' nature for the Last Glacial Maximum, and linkages of continental glacial and ocean

records are key questions in understanding the teleconnections of past global climate change. These issues are now being addressed within a Southern Hemisphere perspective based on cosmogenic exposure dating using 10Be and 26Al in alpine moraine systems. Our exposure-age data sets from numerous recessional and advance moraine sequences in Tasmania and New Zealand covering altitudes from 200 to 1200 masl plus new data from Patagonia (Kaplan et al, GSAB, v116, (2003), 308) indicate :
no strong evidence to support a significant glacial readvance commensurate with the YD chronozone suggesting that Late Glacial (during the LGIT) amelioration of warming was weak ;
no proximal or cirque moraines younger than 15 ka indicating most major ice sources had dissipated 2-3 ka earlier in the Southern Hemisphere with the initiation of an abrupt warming phase;
a definitive, common age for the LGM remains elusive though it appears that peak glacial conditions were at 25-27 ka;
dissipation of LGM conditions commenced at ~19-20 ka and continued unabated to 14-15ka;
the extent of MIS 2 (local LGM) in Tasmania appears less than that in New Zealand and that from glacial terrace sequences at Te Anau in the South Island of New Zealand MIS-4 (65-75 ka) may have been by far the largest glacial stadial during the last glacial cycle.

These exposure-age glacial chronologies are remarkably similar both in timing and in style to similar deglaciation studies from moraine systems at similar high southern hemisphere latitudes from Patagonia, southern Chile (Kaplan et al,) from 30 ka to 15 ka. Moreover, the exposure age sequence at Te Anau correlates remarkably with the major (negative) variations in δ-18O profiles in ice-core records (ie colder periods) from Byrd and Law Dome, Antarctica. This suggests that the long-term millennial-scale climate change trends observed in Antarctica from MIS-3 through the last glacial maximum and into the Holocene are recorded (with a phase delay of about 2ka) in the continental glacial chronology of alpine ice volume fluctuations determined from exposure age dating.

SPELEOTHEMS AS INDICATORS OF CATCHMENT STABILITY IN THE LATE QUATERNARY: EVIDENCE FROM THE WESTERN MEDITERRANEAN

Hodge, E.J.(1), Smart, P.L.(2), Richards, D.A.(2), Andreo, B.(3), Gines, A.(4) and Mattey, D.P(5)
(1) Australian Nuclear Science and Technology Organisation, Sydney, Australia.
(2) School of Geographical Sciences, Univ of Bristol, UK
(3) Departmento de Geologia, Facultad de Ciencias, Univ de Malaga, Spain
(4) Facultat de Ciències, Univ de les Illes Balears, Palma, Mallorca, Spain (5) Department of Geology, Royal Holloway, Univ of London, UK

The western Mediterranean is a key region for geomorphological and palaeoenvironmental research. Vegetation, soils and most importantly water availability dictate human population dynamics, both in modern times and as far back as the replacement of Neanderthals by anatomically modern humans. Speleothems represent excellent archives for recording past changes in soil, vegetation and effective precipitation through long periods of the Quaternary. Here speleothems from caves in Spain and Mallorca record surface conditions through structural fabric and geochemical proxies (trace elements and stable isotopes) indicating that the catchments are prone to sudden collapse. The timing of these collapses, determined by high-resolution MC-ICPMS U-series dating, in addition to information from stable isotopes and trace elements indicates threshold levels of effective precipitation are reached at the termination of warm/moist stages. These interpreted as extremely rapid responses to much longer-term climate forcing. Comparison of records suggests that catchment stability in the western Mediterranean is highly sensitive to SST fluctuations in the adjacent Atlantic Ocean.

RIVER REHABILITATION IN HIGHLY ALTERED RIVERINE LANDSCAPES OF SOUTH-EASTERN AUSTRALIA: MEETING COMMUNITY AND POLITICAL EXPECTATIONS WITHIN THE PREVAILING GEO-ECOLOGICAL CONSTRAINTS.

Andrew P Brooks, Timothy Howell
Centre for Riverine Landscapes, Griffith University, Nathan Qld 4111 Australia

There is now an extensive literature on the profound nature of alluvial river response in south-eastern Australia to human/agricultural disturbance. In the post-war period substantial

resources were spent on engineering rivers, and much of this effort added to the preceding natural river degradation and is thought to have had a major effect on simplifying in-stream habitat. In recent decades there has been a major shift in community perceptions towards rivers, and there is now an expectation that rivers should be repaired and returned to functioning ecosystems. However, in general only a fraction of the resources used to engineer the degraded condition are available for the rehabilitation efforts, and there is an expectation that significant improvements can be made within a relatively short timeframe (e.g. 1 – 2 political cycles). In this paper we report on a study that was established to evaluate river rehabilitation techniques that emulate natural systems as a means of increasing channel stability and complexity (and hence habitat diversity), and hence ecosystem functioning. Five years after the implementation of this relatively large, reach-scale treatment we are now in a position to evaluate the effectiveness of the strategy on modifying reach morphodynamics and ecological response.

The experiment involved the reintroduction of 436 logs (350 T) within 20 engineered log jams (ELJs) over a 1100m reach. Commencing in 1999, the experiment was set up as a standard BACI design, with a control reach 3 km upstream. In the 5 years since implementing the rehabilitation strategy, the study reach has experienced 5 floods greater than the mean annual, and a further 5 events capable of mobilising the gravel bed. Five full 3D surveys of channel morphology have been completed since treatment implementation, and the changes to net sediment storage and morphologic diversity assessed in comparison to the control reach. Seven surveys of the reach fish population have also been undertaken during the project to measure the ecological response to the introduced wood.

The treatment has been highly effective at increasing sediment storage, with the treatment reach now storing, on average, around 40m3/1000m2 more than the control. Pool and bar area (areas of the channel bed experiencing scour or deposition >0.4m) in the treatment reach increased by around 5% and 3.5% respectively, while the corresponding values in the control were around 1.5% and 1%. Three indices were used to measure changes in reach scale morphologic complexity (as a proxy for habitat diversity), and they al show remarkably little change, considering the magnitude of the treatment. Correspondingly, the study shows no significant changes in either the fish species diversity or abundance. The results from this experiment highlight the challenges river managers face in achieving measurable improvements in aquatic ecosystem health, given the low signal to noise ratios associated with the response to these sorts of treatments. The scale of treatment implemented in this experiment was at the upper end of the spectrum of rehabilitation efforts currently being undertaken in Australia, suggesting either greater resources and longer timescales or a more strategic approach are required to achieve the levels of improvement expected by the community.

AN ASSESSMENT OF RIVER MORPHODYNAMICS AND REHABILITATION WORKS WITHIN THE UPPER HUNTER CATCHMENT, NEW SOUTH WALES

Alexandra M. Spink, Kirstie A. Fryirs, and Gary J. Brierley
Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, Sydney, Australia. Corresponding author e-mail: aspink@els.mq.edu.au
Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, Sydney, Australia
School of Geography and Environmental Sciences, University of Auckland, New Zealand

River rehabilitation to date has revolved around notions of control and stability, with numerous projects worldwide being based on engineering methods and techniques. Due to lack of geomorphological knowledge and understanding of river processes and river adjustment, the symptoms of river degradation have been treated instead of the causes. This has also been aggravated/magnified by insufficient strategic planning and prioritisation, leading to ad-hoc implementation of rehabilitation projects; resulting in reactive management driven by institutional, social and political concerns, as opposed to an understanding of processes occurring along the river system. Only recently has geomorphology been incorporated into rehabilitation plans, with recognition that rivers are dynamic systems where change is natural. Governments, scientists and the community are also becoming increasingly aware of the importance and need for community participation and ownership in securing the success of rehabilitation projects.
In this presentation, river rehabilitation projects within the upper Hunter catchment, New South Wales are used to highlight the evolution of

river management practices since the 1950s. From this, valuable lessons can be learned regarding the future focus and requirements of river rehabilitation.

A METHOD FOR QUANTIFYING CATCHMENT-SCALE TEMPORAL CHANGES IN RIVER GEOMORPHIC TYPE PATTERNS

David Outhet1, Martin Thoms2 and Guy Lampert3
1NSW Dept. Natural Resources, 2University of Canberra, 3GHD Consultants

The River Styles® framework (Brierley and Fryirs, 2005) contains a protocol for consistent labelling of river reach geomorphic types. This allows catchments to be mapped for the present-day river geomorphic type. The maps and reports provide essential geomorphic behaviour information to river managers. They also allow the type pattern of one catchment or valley to be compared to another on a spatial basis. Many coastal and inland valleys in NSW have been mapped since 1997.
If geomorphic change information is available, the catchment reach type at some point in the past (or after some expected time interval in the future) can also be mapped. This allows a temporal comparison and analysis of type pattern changes. River managers are very keen to know what their catchment will be like in the future so they can assign priorities for rehabilitation efforts.
The temporal mapping of catchment type can only be done if we know how each type changes over time ('evolves'), the indicators of those changes and what different type will be produced by that evolution. The changes can follow either degradation or recovery pathways. If a river reach proceeds far enough along either pathway, the type can change to a different one, according to Brierley and Fryirs. It therefore acquires a different label under the protocol and appears as a difference on the map.
Some types are fragile and change easily to a different one, such as valley fill to channelised fill. (The clues to the former presence of a valley fill are a flat featureless floodplain and swampy meadow soil in the strata of the channel banks). Other types are very robust and seldom change (eg gorge).
Determining past geomorphic changes and likely future ones is the biggest challenge for geomorphologists. It requires careful analysis of extensive field and historical information. Often, only one or two 'clues' are available for assessing changes and the geomorphologist is reluctant to make conclusions. However, without any conclusions, river management becomes paralysed.

A sub-catchment of the Namoi River (north central NSW) is used to illustrate the method used by the Sustainable Rivers Audit for quantifying the temporal changes in river type pattern since pre-European settlement. The geomorphic change data are very scant for this area so we had to assign a confidence 'rating' to the decision for each mapped reach. This is standard practice when using expert opinion for decision making. Comparing only the reaches with higher confidence levels about changes, the resulting GIS map of the 'most likely' pre-European pattern of types was compared with a GIS map of the present-day types (Lampert and Short, 2004). The GIS statistics show the temporal differences in type abundance (number of reaches of each type) and extent (length of all reaches of each type). This analysis of temporal change in spatial patterns can only be done if a strictly consistent typology is used by all the geomorphologists who are labelling the geomorphic type of each reach in each time-lapse survey. The River Styles framework provides such a typology.
It is anticipated that such analyses, coupled with monitoring of geomorphic change, can be used to produce catchment maps of the likely future river type pattern for use by river managers.

References:
Brierley, G. J. and Fryirs, K. A., 2005, geomorphology and river management: applications of the River Styles framework, Blackwell Publishing, 398pp, ISBN 1-4051-1516-5
Lampert, G. and Short, A., 2004, Namoi River Styles report, NSW Department of Natural Resources, Tamworth, unpublished.

HYDROLOGIC AND GEOMORPHOLOGIC EFFECTS OF WATER RESOURCE DEVELOPMENT ON QUEENSLAND'S EAST COAST RIVERS

Dr S.O. Brizga
S. Brizga & Associates Pty Ltd, PO Box 68, Clifton Hill Vic. 3068, Australia
sbrizga@ozemail.com.au

Queensland has three major groups of river systems: 1) east cost rivers, which drain to the Pacific Ocean and Coral Sea, 2) gulf rivers, which drain to the Gulf of Carpentaria, and 3) upper Darling tributaries, which drain to the sea via the Murray mouth in South Australia. The east coast rivers are characteristically

short and steep compared to the other river systems. Water resource development in Queensland's east coast rivers includes dams, weirs, surface water extraction, flow supplementation, interbasin transfers, groundwater extraction and artificial groundwater recharge to provide water supplies for agriculture, urban and industrial uses and mining.

Assessments of the environmental effects of existing water resource development have been undertaken as part of environmental investigations for the development of water resource plans by the Queensland Government. Hydrologic effects were assessed using daily time-step simulations of developed and undeveloped flow regimes, as well as analysis of historical flow records. Geomorphologic effects were assessed based on site inspections and historical documentary records, including sequential aerial photographs and specific gauge plots. Investigations were also undertaken for other ecosystem components including water quality, flora and fauna.

The greatest hydrologic changes have occurred immediately downstream of large dams. The magnitude of impact varies depending on dam size and operation – in the most extreme cases all natural flows except the largest floods have been eliminated. Impacts are generally mitigated with distance from the dam by inflows from unimpounded downstream tributaries. However, downstream impacts of dams on channel morphology have in many instances been relatively minor, despite the often large changes in hydrologic regime and, by implication, sediment transport and other geomorphological processes. Some reaches downstream of large dams appear to be physically "frozen in time" with senescing riparian zones. Flow supplementation in Queensland's east coast rivers has generally involved augmenting small to medium flows (rather than bankfull flows, as in southeast Australian rivers, such as parts of the Murray, Mitta Mitta and Goulburn). In a number of instances, such supplementation has contributed to significant changes in geomorphological processes and channel morphology via changes in instream and bar vegetation. The most conspicuous geomorphological changes resulting from water resource development have occurred on the Nogo River, a sand-bed river in a relatively low rainfall area, which is dammed and subject to flow supplementation.

REFINING DOCUMENTARY FLOOD RECORDS FROM REMOTE AREAS: RIVER BEAULY, SCOTTISH HIGHLANDS

Justine Kemp
Division of Geography, Northumbria University, Newcastle-upon-Tyne, U.K. Justine.Kemp@unn.ac.uk

Documentary and other historical records have become increasingly important to determine the natural flood range and variability of rivers in poorly-gauged catchments, particularly in the U.K., where most gauged records commence after 1970. In the Scottish highlands, historical flood records have been difficult to construct owing to the low population density and relative isolation before road improvements commenced in the early C19th. Newspapers provide a continuous source of information on large floods after they began circulating in the 1810s, but peak magnitudes are often difficult to estimate, owing to the paucity of important stone buildings or other permanent features where flood depth might be marked. Before the C20th, bridges were often absent, or were swept away during larger flows. The Beauly River at Strathglass, 30 km southwest of Inverness, is a large highland stream, partially regulated for hydro power in the 1950s, with a semi-natural catchment. The north glen road into Strathglass hugs the steep valley side above a terraced floor. Its position is known from a 1795 map, and together with farmhouses and other buildings, provides a reference point for historical flood estimation. Reconstructed cross-sections from cutoff meanders on the floodplain indicate that river bankfull dimensions and bed height have not significantly altered since c. 8,000 yr B.P. Transects of the valley and the roadway were levelled, and flood stages were reconstructed from documented water depths back to 1768. Peak discharges were estimated using the slope-area method. Flood stages differ in detail from qualitative estimates of flood class based on documented damage and reveal a number of "catastrophic" floods in the last 170 years that exceed the estimated Probable Maximum Flood. Documentary sources from relatively remote areas can provide quantitative flood records in situations where the landscape and floodplain are stable, and may provide a useful indirect method of flood estimation on many Australian rivers.

STATISTICAL ANALYSIS OF STREAMBED SEDIMENT GRAIN SIZE DISTRIBUTIONS: IMPLICATIONS FOR ENVIRONMENTAL MANAGEMENT AND REGULATORY POLICY IN NORTHERN CALIFORNIA

Brenda Rosser and Matt O'Connor
O'Connor Environmental, Inc., PO Box 794, Healdsburg, CA 95448; (707) 431-2810; brendar@oe-i.com

Fish habitat in cold water streams in many northwestern California watersheds has been declared degraded by sedimentation by both Federal and State water quality agencies. It is believed that past and present land management activities induce erosion that contributes excess sand-size and finer sediment to stream systems, which then causes an increase in the proportion of fine sediment in spawning gravels. The higher proportion of fine sediment can reduce the rate of survival of eggs. Target thresholds for desirable fine sediment concentrations in spawning beds have been identified based on scientific literature and watershed studies. There are few data describing natural or unimpaired sediment size distributions. This is of concern in the region owing to high natural erosion rates.

This study examines data from gravel bed streams collected by McNeil sampling and bulk sediment sampling in northern California (samples typically 25-30 kg), and New Zealand (samples typically 50 kg). McNeil samples are the preferred method to determine stream substrate quality for salmonids in the fisheries literature. Confidence intervals for various percentiles of the grain size distributions were computed from these data using a two-stage sampling approach. Accuracy and precision of data from these sampling programs are considered in relation to the biological/regulatory thresholds as well as the effort required to obtain, process and analyze grain size distributions. Either very large samples, or a large number of samples are often required to obtain data with high precision, suggesting that in many circumstances, it may be difficult to assess whether regulatory thresholds are exceeded.

DISPERSAL AND STORAGE OF SEDIMENT-ASSOCIATED METALS IN THE LEICHHARDT RIVER, MT ISA, QUEENSLAND

Mark Patrick Taylor1 and Karen Hudson-Edwards2
1Department of Physical Geography, Macquarie University Sydney, North Ryde NSW 2109, Australia. mark.taylor@mq.edu.au
2School of Earth Sciences, Birkbeck, University of London, Malet St., London WC1E 7HX, UK. k.hudson-edwards@bbk.ac.uk

This paper discusses the results of a study examining sediment metal concentrations from the urban area of Mt Isa city and along the adjacent main and tributary channels and cut riverbank sections along the Leichhardt River, north-west Queensland. The study area focuses on a stretch of the Leichhardt River above and below the Mt Isa Mine, and details the impacts of historic and contemporary contaminant storage and dispersal in the system. The data indicate that mining has and continues to supply elevated sediment metal concentrations to the Leichhardt River, causing sediment quality guideline values to be grossly exceeded adjacent to the mine and to a lesser extent downstream, eventually falling below guidelines values and instrumental detection limits. Metal concentrations of soil samples from the residential area of Mt Isa reveal that sections of the city are seriously contaminated with respect to a range of heavy metals, a problem that warrants further investigation.

FROM WOLMAN TO WHERE? : A REVIEW OF URBAN FLUVIAL GEOMORPHOLOGY

James R. Grove
Department of Civil Engineering, Monash University, VIC 3800, Australia

In the 1960's Gordon Wolman proposed a model of channel change, and sediment fluxes, in rivers subjected to urbanisation. This work seeks to review the current understanding about the effects of urbanisation, and suburbanisation, on fluvial geomorphology. Frequently the original work by Wolman is cited as a basis for managing and understanding urban catchments. The progression of understanding from this early work will critiqued, and the ability of geomorphologists to benchmark urban streams for condition assessments will be evaluated.

POSTER PRESENTATIONS

THE JERVIS BAY VOLCANO, SOUTH EAST NSW: GEOLOGY, GEOMORPHOLOGY AND BIOGEOGRAPHY

Glen Bann
CRC LEME and School of Resources, Environment & Society, ANU, Canberra 0200

Jervis Bay is a prominent bay, projecting off the coast of south-east NSW. It is a popular tourist attraction with outstanding scenic and recreational qualities, including some of the highest vertical sea cliffs (135m) and most pristine beaches in Australia.

The regional geology consists of shallow marine siltstones and quartzose sandstones deposited on a continental shelf, which belong to the Permian Shoalhaven Group of the southern Sydney Basin. The geomorphology and biogeography of the bay are inextricably controlled by the regional geology. During the formation of the Mid Permian southern Sydney Basin, Jervis Bay was one of a number of active island volcanoes belonging to an arc within a shallow seaway (Bann and Jones 2001a; Campbell et al. 2001). The igneous remains of this volcano lie beneath the post last glacial sediments of the Bay and exhibit a circular magnetic anomaly identified on the Ulladulla (156/B1-20) 1:25,000 Total Magnetic Intensity Map (Bann 2004). Other intrusions (dykes and sills) that outcrop around the Bay are associated with the same period of volcanism and show soft-sediment deformation and hydrothermal alteration with the host sedimentary rocks (Bann and Jones 2001b). Petrographic observation indicates that these intrusions are of similar composition to the latites comprising the latite flows of the Gerringong Volcanics, which outcrop along the coast to the north. Samples observed of the igneous rock beneath the bay, indicate that it is of similar composition to the surrounding igneous intrusions but contain larger phenocrysts due to its dimensions and slower cooling. Joints formed within this plug (from tremors, post eruption collapse and cooling), combined with the increased weathering associated with these larger phenocrysts, have preferentially eroded out, creating the bay.

Jointing and faulting around the bay shows a preferred regional north-easterly strike direction, controlling the formation of many smaller bays, inlets, sea caves and sea cliffs. The increased heat flow from the ancient volcanic activity has presumably partially metamorphosed the surrounding quartzose sediments, leaving them relatively erosion resistant.

Endemic fauna and flora of Jervis Bay are unique, with the mafic volcanic rock providing fertile soils for flora and fauna to flourish. A rich and diverse range of habitats have developed on soils containing a variable clay content, including relict littoral rainforests and eucalypt forests, predominantly along the drainages and southern slopes, with the transition to heathlands on the less fertile sandstone derived soils. A varied fauna has arisen from the range of landforms and mosaic of habitats.

References:
Bann G. R. 2004. The Wandrawandian Tuffs: Felsic volcanism associated with the Currarong Orogen, southern Sydney Basin. LAVA News 9, 10-16. Geological Society of Aust. Sydney.
Bann G. R. and Jones B. G. 2001a. The Coolangatta Latite Member and associated tuffs: Newly identified basal units in the Gerringong Volcanics, southern Sydney Basin, NSW. Proceedings of the Linnean Society of NSW. 123 23-37.
Bann G.R. and Jones B. G. 2001b. Physical properties of a Permian andesite intrusion into wet, unconsolidated shallow marine sediments, southern Sydney Basin, Australia. Geological Society New Zealand 2001 Conference Abstracts, Waikato University, Hamilton NZ. p16.
Campbell L. M., Conaghan P. J. and Flood R. H. 2001. Flow-field and palaeogeographic reconstruction of volcanic activity in the Permian Gerringong Volcanic Complex, southern Sydney Basin, Australia. Australian Journal Earth Sciences 48 357-375.

ASPECTS OF GLACIATION IN THE TARARUA RANGE, NORTH ISLAND, NEW ZEALAND

Martin S. Brook and Tyne V.H. Crow
Geography Programme, School of People, Environment & Planning, Private Bag 11 222, Massey University, Palmerston North, New Zealand

Evidence for late Quaternary glaciation on New Zealand's North Island has mostly been restricted to Mt Ruapehu, with the origin of possible glacial landforms in the south-west facing Park Valley, Tararua Range, remaining controversial (e.g., Shepherd 1987; Moffat 1990). Differences in opinion exist concerning the geomorphological processes that have produced the landscape and the accompanying climatic implications (Brook & Brock 2005). The objective is to use established glacio-geologic approaches to test the possible origins of the features (specifically a debris ridge, though three cirque basins and a U-shaped valley are also evident), including an analysis of topographic positioning, sedimentology and palaeo-climatic

extrapolations. Alternative hypotheses are considered.

The debris ridge is located on the west side (true right) of Park Valley, to the west of Arete Peak. The ridge separates two cirque-like basins, is linear in plan-form, extends for c. 300 m down-valley, has a surface slope of c. 9-11°, is steepest on its eastern side, and is c. 5 m in height. Four 1 m wide x 1.5 m deep trenches were dug through the upper, mid and lower crest sections of the ridge. Sedimentological analysis was undertaken at c. 20 cm depth intervals in each trench. Clast fabrics were assessed in the field, based on the presence of distinct a-axis (a–b ratios of >1.5:1). Clast shape was assessed at each trench through measurement of a, b and c axis, and C40 indices calculated. Clast roundness was also assessed, together with percentage of striated clasts. Results were compared with clast data from scree slopes and debris cones within close proximity. RA-C40 covariance analysis indicates all four sets of clast samples from the debris ridge display a degree of rounding and 'blockiness'. The debris ridge deposits can be differentiated from the adjacent slope deposits in terms of roundness and shape. As pronival ramparts usually have highly angular clasts and an absence of fines, we question that supranival debris transport or snow-push processes would have produced such a ridge.

Shulmeister et al. (2005) report a present-day ELA of 2050m in (the formerly glaciated) Cobb Valley, north-west Nelson, c. 25 km south of Park Valley, across Cook Strait. Using the 1.4 m/km northwards increase in ELA reported by Lamont et al. (1999), this gives a present-day ELA of 2085m in Park Valley, well above the surrounding summit elevations of ~1500 m. Using an environmental lapse rate of 6ºC/1000m to estimate the ELA lowering at Park Valley, a cooling of only 3ºC gives an ELA depression of 500m and a cooling of 4ºC gives an ELA depression of 667m, allowing the prospect of Quaternary glaciation of the slopes surrounding the head of Park Valley. These results support the conclusion that the debris ridge is a moraine and that the valley was glaciated during the Quaternary.

Acknowledgements
Funding from Massey University (MURF Grants 04/2022 and 05/2059) is appreciated.

References

Brook MS, Brock BW 2005. Valley morphology and glaciation in the Tararua Range, southern North Island, New Zealand. New Zealand Journal of Geology and Geophysics 48: 717-724.
Lamont GN, Chinn TJ, Fitzharris BB 1999. Slopes of glacier ELAs in the Southern Alps in relation to atmospheric circulation patterns. Global and Planetary Change 22: 209-219.
Moffat JG 1990. Surficial geology of the Park Valley, Northern Tararua Range, New Zealand. Unpublished BSc Hons thesis, Victoria University of Wellington, New Zealand.
Shepherd MJ 1987. Glaciation of the Tararuas: fact or fiction? Proceedings of the 14th New Zealand Geography Conference, Palmerston North, 114-115.Shulmeister J, Fink D, Augustinus PC 2005. A cosmogenic chronology of the last glacial transition in North-West Nelson, New Zealand – new insights in Southern Hemisphere climate forcing during the last deglaciation. Earth and Planetary Sciences Letters 233: 455-466.

A GEOMORPHIC CLASSIFICATION FOR AUSTRALIAN TROPICAL RIVERS: A FRAMEWORK FOR MULTI-DISCIPLINARY RESEARCH

Andrew Brooks, John Spencer, Peter Brunner, Pu Lin
Centre for Riverine Landscapes
Griffith University
Nathan Qld
4111, Australia

The catchments of the tropical rivers in northern Australia (AWRC Divisions 8& 9) possess an incredible diversity of river types, and represent what might be regarded as one of the last great frontiers for undertaking basic research on biophysical processes in relatively undisturbed rivers. Land and Water Australia has recently established a major new research initiative that will focus on developing a better understanding of geomorphic and ecological processes in Australia's tropical rivers. An integral component of this program was the need to develop a geomorphic river classification procedure to provide some basis for understanding the variability of geomorphic and ecological process zones within these rivers, and to enable the extrapolation of site specific detail within, and between, river systems. Furthermore, as one of the principal program objectives is the development of sediment and nutrient budgets at a catchment and regional scale, there is a need to develop a rational basis for the spatially distributed parameterisation of sediment budget models.

A plethora of river classification procedures have been employed in southern Australia by various state government agencies and researchers (see Parson et al. 2004). Schemes such as River Styles (Brierley & Fryirs, 2000), and derivates like the Geomorphic Assessment of Rivers (GAR) (Brennan & Gardiner, 2004), and other microhabitat classification schemes (e.g. Maddock, 1999), all rely heavily on field assessment to determine the reach or site

classification. Logistical constraints within the vast, remote expanses of northern Australia prohibit the use of a classification based on field assessment, therefore an approach was required that could be applied using remotely sensed data, with limited ground truthing. The limited availability of high-resolution geospatial data covering northern Australia required us to employ a multi-resolution hierarchical approach, that allows for higher resolution classifications to be overlaid on the coarser broad classification, in those areas where higher resolution data is available. A "multiple lines of evidence" has been used in deriving a classification that allows for different levels of certainty depending on the local availability of data.

An overview of the four-tiered nested classification procedure we have derived will be presented. The approach adopted incorporates a method for partially automating the reach scale classification based on reach slope, catchment area and valley confinement. This removes some of the subjectivity that typically plagues categorical river classification procedures.

References:
Brennan, S. and E. Gardiner (2004). Geomorphic Assessment of Rivers Series: Gulf Basins and Mitchell Catchment. Brisbane, Qld Dept Natural Resources and Mines: pp.254.
Brierley, G. J. and K. Fryirs (2000). "River Styles, a geomorphic approach to catchment characterisation: implications for river rehabilitation in Bega catchment, New South Wles, Australia." Environmental Management 25(6): 661-679.
Maddock, I. (1999). "The importance of physical habitat assessment for evaluating river health." Freshwater Biology 41(2): 373-391.
Parsons, M., M. C. Thoms, et al. (2004). "Development of a standardised approach to river habitat assessment in Australia." Environmental Monitoring and Assessment 98(1-3): 109-130.

3-D STRATIGRAPHIC MODELS OF PROGRADING BARRIERS ALONG THE NORTH-EAST COAST OF NEW ZEALAND PROVIDE DETAILED INSIGHT INTO COASTAL EVOLUTION

Amy J. Dougherty and Scott L. Nichol
a.dougherty@auckland.ac.nz; School of Geography and Environmental Science, The University of Auckland, Private Bag 92019, Auckland, New Zealand

Barriers exist along every heavily populated continent and comprise approximately 15% of the world coastline. Humans tend to gravitate to these malleable landforms regardless of the fact that they are one of the most vulnerable coastal features in today's global regime of accelerated sea-level rise. In order to best predict how barriers will respond to external controls, like sea-level rise, it is imperative to decipher their past evolution. In New Zealand, barriers line an estimated 12% of the coastline providing what has been frequently regarded as a 'world class natural laboratory of coastal geomorphology'. Despite their prevalence, and potential to produce a wealth of information about past processes influencing coastal evolution, remarkably little is known about New Zealand barriers. With few studies investigating the details of barrier evolution, their stratigraphy and chronology remain poorly understood. The aim of this poster is to present, for the first time, 3-D stratigraphic models of prograding sandy barriers along the East Coast of North Island, New Zealand. The ultimate purpose is to use this detailed stratigraphy to gain insight into barrier evolution and examine the role of sea-level rise, sediment supply, and antecedent topography. This study will not only fill a gap in the base knowledge of barriers in New Zealand, but add detailed information to the existing general models of progradation applicable worldwide.

Over the past few decades coastal geologists have created morphostratigraphic models of barrier formation for coastlines around the world. However, these investigations have yielded rather simplistic stratigraphic models due to their construction from point source data. With the advent of Ground-Penetrating Radar (GPR) it is now possible to remotely sense a continuous cross-sectional view of barrier subsurface stratigraphy, including large-scale features and facies boundaries previously undetected by coring alone. Augmenting the existing coring and dating techniques with this new technology enables detailed three dimensional images of barrier architecture to be modeled. Utilizing this improved methodology to study sandy barriers along New Zealand's varied coastline offers a unique opportunity to evaluate barrier evolution.

The meso-tidal East Coast of New Zealand is predominantly a rocky indented coastline with intermittent barriers. This northern portion of the country has a unique geologic setting with variable accommodation space and sporadic sediment supply dependant on the switching of the Waikato River, which is presently feeding the West Coast. Additionally, this region as compared to other parts of New Zealand has never been subject to major

glaciation and is considered tectonically quiet, therefore limiting the influence of extraneous variables that could complicate evolution. These East Coast barriers began to form at the cessation of sea-level rise ~6,000 years ago. During the ensuing stillstand offshore sediment was reworked onshore by wave action. Sand accumulated in areas with sufficient accommodation space to form progradational barriers with characteristic foredune ridges. The three study sites presented are: Omaha, East Beach and Bream Bay, selected due to their high preservation potential. At each barrier a comprehensive study was preformed by initially collecting large-scale shore parallel and perpendicular GPR transects. Then a representative subsection was selected to acquire the dense grid network optimal for constructing the 3-D model. Finally, a vibracoring system was used to collect sediment cores along the geophysical transects in order to ground-truth the reflectors.

The resulting GPR and core data have precisely imaged the barrier lithosome and delineated three barrier facies: near shore, beach face, and dune. This highly detailed model of a regressive facies succession includes small scale ridge and runnel systems within the near shore. The overall internal architecture is similar to previous evolutionary studies like those from New South Whales, Australia and parts of North America. However, small scale details like bars migrating onshore indicate a more intricate construction than the perceived bulk addition of sigmoidally-shaped accretionary wedges. Future work will involve using this stratigraphy to reconstruct depositional settings while adding some chronological control. Ultimately this research will span to include reconstructing the stratigraphy and evolution of a Last Interglacial barrier on the East Coast, as well as two West Coast barriers.

INTER-GLACIAL AND HOLOCENE PALEO-ENSO VARIABILITY IN LAMINATED SEDIMENT RECORDS FROM THE PERU CONTINENTAL MARGIN

D. Fink (1), G. Skilbeck (2), M. Gagan (3),
Australian Nuclear Science and Technology Organisation, PMB1, Menai, 2234. Australia.
Department of Environmental Sciences, University of Technology, Sydney, NSW. Australia. 2007.
Research School of Earth Sciences, The Australian National University, Canberra, A.C.T. 0200. Australia.

As part of a wider palaeoclimate and palaeoceanographic study of Holocene-Late Pleistocene laminated sediments from the Peru continental margin, we completed 33 AMS 14C dates from 3 cores (1227,1228 and 1229) recovered during Leg 201 of the ODP to reconstruct a history of sediment accumulation over the past 20,000 years. Although the sediments are predominantly diatomaceous oozes they contain sufficient inorganic (e.g. foraminifer tests and nannofossil plates) and organic carbon to allow 14C dating. The Peru margin cores are located below a well-developed oxygen minimum zone where distinct laminated diatomaceous oozes contain a multiproxy geochemical signature of interannual El Niño variability Sample preparation and measurement were carried out at the ANTARES AMS facility.

Our analyses of these marine sediment cores have yielded new evidence for multidecadal to century-scale ENSO variability over the past 20,000 years.. Well preserved sections of the core dated by AMS C-14 have provided continuous, high-resolution records for the intervals 0 to 3ka, 5 to 9 ka and 15-17 ka cal BP. Average sedimentation rates during the late Holocene are ~70 cm/ka and exceedingly high accumulation rates (~265 cm/ka) have been calculated for the early Deglaciation period. For one core, 1228, 14C dating is progressing over the transition period of 9 to 12 yrBP . In order to investigate an El Nino origin for the laminae on this part of the Peru shelf, we have undertaken two independent lines of study : (1) high resolution (0.1 mm per pixel) scanned colour images to carry out time series analysis of ENSO-band (2-8 year) base variability and (2) given the mixed volcaniclastic - upwelling setting, selected geochemical and mineralogical analyses of dark and light laminae to determine if they contain a climate signal. These include del-13C analyses of bulk sediments and planktonic foraminifer, del-18O of the latter, as well as bulk organic carbon, carbonate, quartz

and feldspar percentages of representative "dark" and "light" laminae.

Layer counting of the ~1500 year deglacial sequence reveals that each couplet of dark (El Niño) and light (La Niña) layers (~8 mm per couplet) represents a mean time duration of 5.6 years, well within the 2-7 year periodicity of the interannual ENSO cycle. Frequency analysis of the down-hole high-resolution red colour intensity variation reveals strong spectral peaks at 4.8 and 7.1 years, and additional but significant peaks at 11, 21 and 149 years, strongly suggestive of a solar influence on long-term ENSO variability.

SLOPE-CHANNEL COUPLING DURING THE FEBRUARY 2004 STORM IN THE MANAWATU, NEW ZEALAND: TOWARDS AUTOMATED IDENTIFICATION

Cargill J. Henderson & Ian C. Fuller
Geography Programme, Massey University, Private Bag 11-222, Palmerston North, New Zealand
Email: xenolith@ihug.co.nz

Extensive landsliding occurred during the storm event of 15-16 February 2004 in the western Manawatu catchment. Damage to farmland and infrastructure was severe across the region, especially in the Mangawhero, Whangaehu, Turakina, and Pohangina valleys (Hancox and Wright, 2005). In some locations >10% of slope area was affected by landsliding (Dymond et al., 2005).

This poster focuses on preliminary work undertaken in part of the Beehive Creek catchment, which is a sub-catchment of the Pohangina River (547 km2). Beehive Creek is right-bank tributary of the Pohangina, draining the weakly lithified sands and gravels overlying the Pohangina anticline to the west of the Ruahine Ranges. Land-use is mixed, primarily pastoral farming with some plantation forest. Dymond et al. (2005) have already indicated that land-use strongly influences probability of landsliding and hence the possibility of slope-channel coupling.

Landsliding is being mapped in Beehive Creek using orthorectified aerial photography flown in May 2004. This mapping is further refined using a 20 m contour-generated digital elevation model. Areas of landsliding have been identified using unsupervised classification with Idrisi Kilimanjaro TM. This uses ISOCLUST, an iterative, self organising cluster analysis algorithm to delineate areas of bare-ground, corresponding to areas of landslide scar and tail. Slopes <5˚ have been excluded using the digital elevation model as being unlikely to have generated landsliding (Dymond et al. 2005). Various numbers of iterations, clusters and pixels per class for ISOCUST were trialled to determine the best combination for detection of bare ground.

Another method of determining areas of bare ground is also being used. The time and date of each photograph can be used to determine the appropriate sun azimuth and angle for correct illumination. These illumination classes are then used to separate out similar areas on the aerial photograph. Bare ground is located through interactive modification of the red band of the visible spectrum for each photograph (Dymond pers. comm. 2005).

The accuracy of these automated mapping techniques is being validated using a manually digitised map of landsliding in the same area within Beehive Creek. Use of the aerial photography draped over a 20 m DEM to provide a 3D image has been used to aid identification of landslides, especially in areas of shadow and low contrast. Comparison between manual digitising and unsupervised classification indicates that the automated approach identifies 44% of total landslide area in the study area. The current approach to automation thus requires further refinement, which is the focus of ongoing study.

Initial identification of landslide areas coupled to the channel network indicates that ~50% of landslide area in this part of the catchment was coupled to the stream system during this storm event.

References:
Dymond, J.R., Ausseil, A-G., Shepherd, J.D., Buettner, L., in prep: Validation of a region-wide model of landslide risk in the Manawatu/Wanganui region of New Zealand. Paper submitted to Geomorphology, October 2004.
Hancox, G.T., and Wright, K, 2005. Landslides caused by the February 2004 rainstorms and floods in southern North Island, New Zealand. Institute of Geological & Nuclear Sciences science report 2005/10. 32p.

IDENTIFYING AND FINGERPRINTING SOURCES OF LONG-TRAVELLED DUST ALONG THE SOUTHEAST DUST PATH OF AUSTRALIA.

Lindsay M. Killin
Department of Physical Geography, Macquarie University, Sydney.
lkrebel@hotmail.com.au

Currently a lack of high resolution dust transport studies across the globe has resulted in dust source identification commonly being limited to regional scales. This lack of resolution presents a significant barrier to our understanding of the rates of emissions from specific landforms, preventing a comprehensive understanding of the dust cycle. Common approaches to dust provenancing include, meteorological observation, magnetic mineralogical tracing, mineralogical comparisons, sedimentary comparisons, air parcel trajectory modelling of specific dust plumes, and remote sensing. Geochemical comparisons were recently combined with trajectory modelling to provide resolutions down to 200km (McGowan et al., 2005).

The current approach involves comparison between the particle size, mineralogy, and geochemistry of potential dust sources in western NSW and the Strzelecki Desert, with a dust deposit located in the Central Tablelands of NSW. The aim of this approach was to determine distinct physical and chemical signatures for sediment from a range of dust sources, which may then be used as a 'fingerprint' for comparison with sediment from dust sinks, or deposits. This is a preliminary study into the viability of such a technique, however, it is hoped that correlations will be discovered, allowing the determination of relative contributions of specific dust sources to the Central Tablelands deposit.

Reference:
McGowan, H.A.; Kamber, B.S.; McTainsh, G.H.; Marx, S.K. 2005. High resolution provenance of long travelled dust deposition in the Southern Alps, New Zealand. Geomorphology 69: 208-221.

UNDERSTANDING FLUVIAL PROCESSES IN CATCHMENT MANAGEMENT: BANK EROSION IN THE MULGRAVE RIVER, NORTHEASTERN AUSTRALIA

Sonia Leonard and Jonathan Nott
School of Tropical Environment Studies and Geography, James Cook University, Cairns, Australia.

The dramatic decline in the integrity of Australian River systems in recent decades has seen the development of landcare and catchment management groups as the main facilitators of river rehabilitation works. In the Mulgrave River Catchment of Northeastern Queensland, management priorities are based on a limited understanding of natural processes and management directions are derived from oral histories of the catchment since European settlement. These oral histories suggest that there has been extensive bank erosion supplying sediment to accreting river channels which in turn is promoting further bank erosion and impinging on valuable cropping lands. This study, through textural analysis of bank and channel material from 30 locations, demonstrated that bank erosion is not the source of sediment for in-channel accretion. Furthermore, qualitative analysis of historic parish maps and aerial photographs shows that there has only been moderate bank erosion in selected locations along the Mulgrave River. The study demonstrates the important role that geomorphological investigations have at the interface of catchment management and the need for managers to understand the natural processes of a system for sustainable management of river landscapes.

THE LATE HOLOCENE EVOLUTION OF A NORTHLAND ESTUARY

Sam Morgan
School of Geography and Environmental Science, University of Auckland
s.morgan@auckland.ac.nz

The Matapouri Estuary is bar-built, wave–dominated estuarine system. The system is deemed to be close to maturity, with much of the infill apparent over the past 50-60 years. With the infill, successions of habitat changes are apparent from the data collected for this study.
Twelve habitats representing three ecosystems-sand flat, mangrove and salt marsh- have been identified from within the estuary. Sedimentological and neoichnological investigation were conducted on these

habitats. With stratigraphic data collected from cores and shallow pit investigations, the presence of a range habitats and habitat change is clear.
The present day system is dominated by Glossifungites ichnofacies, and has been associated with mangrove communities of the estuary. The domination of the ichnofacies appears to be a function of the estuaries infill maturity. From this study it seems apparent that the habitat composition and distribution within the Matapouri Estuary is influenced by a limited accommodation space.

RELATING OLD BEACH CUSPS TO STORM-WAVE OVERTOPPING

Tim Nolan
Ph.D. Candidate
University of Canterbury
blackant@snap.net.nz

The conspicuous rhythmic topographies of beach cusps are a well-recognised characteristic of reflective beach faces. They are generally regarded as ephemeral features of the active beach system, with lifespans no greater than a few years. In this poster I describe the occurrence of palaeo cusps in relict-beach ridges of the South Island of New Zealand, with emphasis on what their morphology can tell us about storm-wave overtopping.

Beach cusp morphology consists of regularly-spaced sediment mounds, called horns, separated by low areas, called bays. Cusps can range in scale from small, with 0.5 m horn-to-horn spacings and 0.1 m horn-to-bay amplitudes, to large, with 120 m wide spacings and 2 m amplitudes. In New Zealand's South Island, they are common and particularly well-formed along high-energy mixed sand and gravel beaches. Here multiple sets of cusps may occupy vertically-distinct parts of the active beach system.

Palaeo-beach cusps have been identified in relict beach ridges landward of the modern day Leithfield and Rarangi beaches, through aerial photograph analysis and field surveys. Like their modern-lagoon barrier counterparts, the bays of these palaeo cusps are often associated with overwash fan deposits on the lee side of the beach ridges. These associations result in a distinctive 'anti-cusp' morphology.

The presence of beach cusps on a beach results in regular alongshore variation in beachface elevations, with differences in elevation between cusp bays and horns often up to or exceeding 2 m. This three-dimensional alongshore variation in beach morphology provides conduits through which run-up is focussed during high-energy events, resulting in beach overtopping and over-wash fan deposition on the lee side of beach ridges. The findings of this research indicate, not only that beach cusps persist for much longer than previously though, but also that the presence of beach cusps can dictate the alongshore positions where beach overtopping occurs during storm events.

DRYLAND WETLANDS: THE HOLOCENE RESPONSE OF INLAND RIVERS IN AUSTRALIA

Tim Ralph, Paul Hesse, David Yonge
Department of Physical Geography, Macquarie University, Sydney, NSW 2109, Australia. E-mail: phesse@els.mq.edu.au

Wetlands characterise the lower reaches of interior Australian rivers. These are floodouts of various scales and style, some perennially wet, others only occasionally flooded, some terminal, some not. Major rivers of the Murray-Darling Basin are fed by humid headwaters but drain to the semi-arid lowlands where all (except the Murray and Darling trunk streams) break down into wetlands. These wetlands form a distinctive style of alluvial sediment accumulation and floodplain morphology characteristic of the Holocene.

The Macquarie Marshes (147°30'E 31°S) occupy the lower reach of the Macquarie River on the Quaternary alluvium of the Upper Darling Riverine Plain. The river decreases in discharge and capacity downstream before finally breaking down into a complex arrangement of marshes in which the river is lost completely. Upstream of the breakdown the single-channel sinuous river has shown very little lateral migration since surveys were first made in the late 19th century. By contrast, the marshes show great dynamism with channel avulsion in the historical period forming new channels and marshes and the complete abandonment of others. Subsurface investigation has revealed that channels and marshes may have life spans of decades to centuries.

The marsh sediments are a uniform sheet of heavy clays (with minor silt and fine sand) 2 to 4 metres thick with no preserved sedimentary structures. Only thin sand beds mark the location of former marsh channels. Organic content of the sediments is low (5%) despite

the profusion of reed growth at the surface. They sit as extensive but thin units within larger, coarse-grained convex alluvial ridges of Pleistocene palaeochannels. The style of deposition and sedimentation rate appears to be typical of other marshes in the Murray-Darling Basin.

The basal age of the marsh deposit is around 8000 (calendar) years. The Holocene marshes are a response to the post-glacial catchment climate and hydrology. As temperature and atmospheric carbon dioxide concentrations increased over the last glacial termination, forests and woodlands returned to the highlands and interior of southeastern Australia. Although the return of the trees is commonly interpreted as indicating an increase in rainfall, this is not reflected by evidence of increased runoff. Holocene stabilisation of sand dunes may provide better evidence of greater moisture availability, in which case the decreased discharge from these northern rivers is probably attributable to greater biospheric utilisation of precipitation. The wetlands, then, are a geomorphic response to decreased runoff under a 'humid' climate.

OSL DATING OF LINEAR DUNES IN THE SIMPSON DESERT, AUSTRALIA

Ed Rhodes
Research School of Earth Sciences and Research School of Pacific and Asian Studies
Australian National University

Thirty samples from eight cores collected from dunes in the western Simpson Desert, near Finke, NT, have been dated using OSL. Of these, 50% are in saturation, indicating depositional ages older than around 150,000 years. This suggests the present dune structures are of considerable antiquity. The younger samples, which provide finite OSL ages, demonstrate that deposition was episodic, with significant dune building occurring in the late glacial, and around 30 and 70 ka.

Novel slow-component (SC) OSL methods have been applied to attempt to date samples for which the conventional OSL signal is in saturation. These samples contain at least 5 OSL components, as recognised in other quartz samples, though they display some significant departures in the behaviour of these signals. I will asses the results obtained with this SC-OSL approach in comparison to paired 10Be/26Al cosmogenic burial age data.

The relative positions and sizes of the different dunes sampled provides interesting comparisons with the chronological data. In several cases, dune flanks were sampled, giving age profiles in contrast to those of the crests. This perhaps suggests that we can recognise dune building events at the crests and dune erosion periods within the flanks. Age-depth profiles also suggest a difference in response between dunes of different size and location.

PRE- AND POST EUROPEAN SEDIMENT REDISTRIBUTION PATTERNS: LAKE BURRAGORANG CATCHMENT, AUSTRALIA

Paul Rustomji, Tim Pietsch
CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2061
Paul.Rustomji@csiro.au.

The Lake Burragorang catchment supplies much of Sydney's drinking water, hence management of the catchment to minimise pollutant delivery to the reservoir is critical. As part of a research project for the Sydney Catchment Authority combining geochemical sediment tracing and application of the SedNet sediment and nutrient model, field based observations of sediment redistribution within the catchment have been obtained with a chronology provided by optically stimulated luminescence dating. The lake's catchment comprises the Wollondilly River flowing across the low relief Southern Tablelands of New South Wales, the Cox's River in the Blue Mountains and a deeply incised reach in the vicinity of Lake Burragorang.

Estimated sediment yields from small (~100 km2) headwater catchments are consistent with existing models for the Southern Tablelands. A large increase in sediment yield is recorded in the period following European settlement, yet much of this sediment has been stored close to its source. This is demonstrated by vertical aggradation rates at headwater break-of-slope positions increasing by a factor of ten relative to their pre-European conditions. Contemporary headwater sediment yields now appear much lower.

At larger catchment areas on the Southern Tablelands (~1000 km2), considerable volumes of sediment have been stored in alluvial benches within the channel of the Wollondilly River over the post-European period. No clear evidence was found for

increased deposition rates upon the pre-European Holocene floodplain despite the gully erosion upstream. Dating of six in-channel bench sections, aggrading below the floodplain, showed them to have aggraded over multiple depositional cycles in the post-European period. These benches represent a substantial and stable sequestration of sediment in the middle reaches of the catchment. Sequestration of sediment within these channel margin benches appears to have enabled the pool-riffle structure of the Wollondilly River to remain intact.

Along the gorge reach of the Wollondilly River leading to Lake Burragorang, sediment deposition upon Holocene floodplain surfaces appears minimal. However, coarse sediment has accumulated upon point bars and in the channel in the form of large, poorly consolidated sand and gravel bars. Bar ages fell predominantly within the period of enhanced flooding that affected the region from AD 1950, indicating episodic transport during large events. These sediments may be available for erosion and downstream transport if comparable hydrologic conditions return.

The Cox's River catchment has also experienced substantial post-European gully erosion. Substantial accumulations of sediment are observed along lower gradient river reaches. Dating shows their accumulation to be predominantly post-European in age, however, unlike the Wollondilly River, this sediment has formed a channel wide sand slug, markedly changing the river bed structure and habitat. This difference in post-European sediment sequestration between the Cox's and Wollondilly Rivers may be due to the coarser particle size distribution of sediments derived from the Cox's catchment that makes them less amenable to stable storage within bars or benches.

LOESS SOILS IN THE SOUTH ISLAND, NEW ZEALAND

Jochen Schmidt1, Peter C. Almond2, Les Basher3, Sam Carrick3, Allan E. Hewitt3, Ian H. Lynn3, Trevor H. Webb3
1National Institute of Water and Atmospheric Research (NIWA),PO Box 8602, Christchurch, New Zealand, j.schmidt@niwa.co.nz, ph. 03-343-8058, fax 03-348-5548.
2Soil and Physical Sciences Group, Division of Soil, Plant and Ecological Sciences, Lincoln University, PO Box 84, Lincoln, New Zealand.
3Landcare Research NZ Ltd, PO Box 69, Lincoln, New Zealand.

The occurrence of loess in the landscape strongly influences other environmental subsystems (e.g., soil types, vegetation species and vigour, and soil water balance). Knowledge about the spatial distribution of loess is therefore of crucial importance for land resource management in many areas of the world including New Zealand. Loess distribution is generally dependent on the loess sources, climatic factors, the transport path of loess, and the local potentials for loess deposition and erosion. This study estimates loess thickness and percent cover based on expert knowledge, and provides loess landscape models for the distribution of loess for all land units in the South Island. Over several decades of field investigation, soil scientists have accumulated a general knowledge of the distribution of loess throughout most landscapes of the South Island. Pre-1960s knowledge was summarised in the annotations of the parent material descriptions of the soil sets of the South Island. The soil sets represent land units that are characterized by environmental attributes – parent material, altitude, and climate – and therefore depict relatively homogeneous landscape patterns. The soil sets are related to the land system mapping concept. The expert knowledge, captured in those concepts, can be applied to map the spatial distribution of silty material in the landscape. For each mapped soil set, loess occurrence in the typical soil profile is documented qualitatively. This information was used, together with the authors' expert knowledge derived from field observations or familiarity with previous loess studies, to assign ratings for dominant loess cover and dominant loess thickness for a soil set, and finally to assign ratings for loess cover and loess thickness patterns within a soil set. Classifications were defined to describe these attributes. The soil sets were then grouped to define a hierarchical system of loess landscapes of the South Island, based on physiography, lithology, and rainfall (erosion) characteristics. These loess landscapes were then related to spatial patterns of loess

occurrence. The soil sets underpinning the map units of the New Zealand Land Resource Inventory (NZLRI) were classified according to loess depth, loess cover, and loess pattern. New loess maps of the South Island were produced from those classifications, displaying loess coverage, thickness, loess pattern, and loess landscapes. These maps present our current knowledge of the coarse-scale loess distribution and provide a framework for fine-scale loess landscape modelling, using e.g., environmental correlation.

SETTING GEOMORPHIC PRIORITIES FOR RIVER CONSERVATION AND REHABILITATION IN THE NAMOI RIVER CATCHMENT, NSW

Amalia Short1 and Guy Lampert2
1 Macquarie University/ Northern Rivers CMA, 2 GHD Pty. Ltd.

The methodology for setting river geomorphic conservation and rehabilitation priorities within the River Styles® framework (Brierley and Fryirs, 2003) is comprised of four stages. Essentially, after a catchment wide assessment of River Styles (Stage 1), assessments of river evolution and condition (Stage2) provide the basis for determining river recovery and trajectory (Stage 3) from which target conditions and priorities (Stage 4) can be developed. This involves acquiring a sound appreciation of the historical and spatial contexts of the biophysical processes operating within a catchment. Applying such a procedure over large catchments can be extremely resource intensive and can take several years to accomplish, posing a risk of information redundancy. Also, as catchment areas increase, it becomes increasingly difficult to both detail the range of processes operating at different spatial and temporal scales and, more significantly, to conceptualise the interactions between them. Additionally, the River Styles prioritisation procedure may not always be the most applicable approach for setting priorities for river conservation and rehabilitation. For example, in lowland areas where river character and behaviour can be relatively uniform it may be more appropriate to determine priorities through other procedures such as assessments of the type and condition of riparian vegetation and/or modifications to the hydrological regime.

Given these concerns, this paper advocates that over larger catchments the Stage 1 component of the River Styles methodology include a qualitative catchment wide assessment of river condition to allow broad priorities to be developed. An example of such a process is the Namoi River Styles Report (Lampert and Short, 2004), an assessment of River Styles and 'indicative condition' of streamlines in the Namoi catchment. Indicative condition (good, moderate and poor) was determined in conjunction with the Stage 1 assessment of River Styles through the interpretation of the most recent aerial photography and rapid ground truthing. Catchment wide priorities were determined through analysis of the abundance and distribution of River Styles and their indicative condition combined with a broad, conceptual understanding of River Style fragility. River Style fragility was based on an understanding of the potential capacity for different River Styles to adjust for three major characteristics of rivers (channel geometry, channel planform and bed character) over three degrees of significance (minimal, localised and significant) (cf. Fryirs, 2003). Four broad priority categories were used, reflecting the philosophies and principles of the River Styles prioritisation methodology. These are Conservation, Strategic, High Priority Rehabilitation and Remediation priorities. Further differentiation within these categories is based on rarity, fragility and the proportions of good condition reaches of specific river styles.

The analysis of the distribution and spatial relationships of the priority categories identifies sub-catchments where the more detailed assessment stages of the River Styles procedure are best applied. Also, areas have been identified where it may be more appropriate to determine river conservation and rehabilitation priorities using other procedures or combinations thereof. Hence this initial catchment wide determination of priorities provides a cost-effective means for identifying sub-catchments for more detailed investigation and initial direction for on-ground investment, thereby ensuring resources are targeted to the most appropriate parts of the catchment.

References:

Brierley G. and Fryirs K. (2003) The River Styles® framework: the short course conceptual book. Department of Physical Geography, Macquarie University.
Fryirs K. (2003) Guiding principles for assessing geomorphic river condition: application of a framework in the Bega catchment, South Coast, NSW, Australia. Catena 53, 17 – 52.
Lampert G. and Short A. (2004) The Namoi River Styles® Report. Namoi Catchment Management Authority.

SOIL STRATIGRAPHY AND CHEMICAL CHARACTERISTICS OF THE BIRDLINGS FLAT LOESS, AHURIRI QUARRY, BANKS PENINSULA, CANTERBURY, NEW ZEALAND

C.M. Smith, F.L. Shanhun, and P. C Almond
Soil and Physical Sciences Group
Agriculture and Life Sciences Division
Lincoln University, Canterbury New Zealand

Studies of loess have focussed on establishing the stratigraphy and more recently the age of the loess to provide a proxy climate record. Less attention has been placed on pedological features of buried soils, which have the potential to produce qualitative or even quantitative records of past climate change.

Birdlings Flat formation loess is a coarse-textured quartzofeldspathic loess found on the lower flanks of Banks Peninsula in Canterbury. An exposure at Ahuriri Quarry shows 12 m of strongly texturally-banded loess with pedogenic carbonate deposits throughout most of the loess below 2.5 m depth.

In this study, soil morphological features were used to define soil stratigraphic units that were traced and mapped across the exposed section. Four soil stratigraphic units, excluding the surface soil were recognised. Soil features are generally very subtle and much of the stratigraphic interpretation relied on the carbonate morphology. Former surface horizons were recognised by concentrations of carbonate filaments or pseudomorphs emphasising the biofabric produced by root channels and burrows. Nodular carbonate accumulations were associated with these surface soil features in three of the soil stratigraphic units.

Citrate dithionite-extractable Fe (Fed), soil pH and electrical conductivity (EC) analyses were carried out in order to corroborate the morphological identification of soil stratigraphic units. Fed appeared to respond as much to textural variability as to soil features. Soil pH measurements were complicated by the overprinting of carbonate and salt accumulations from different phases of pedogenesis. EC was confounded by an unknown complex interaction between carbonate and salts that reduced EC in regions were it was expected to be very high. Further cation and anion analysis confirms this complex interaction.

Optically stimulated luminescence (OSL) dating of the loess and radiocarbon dating of carbonate were generally consistent with each other and indicate the loess accumulated since about 35 000 years ago. The position and age of Kawakawa tephra (26 500 cal. yr BP), however, suggests that the OSL ages are underestimates.

APPLICATION OF GIS TO LANDSLIDE SUSCEPTIBILITY MODELLING, WAITAKI REGION, SOUTH ISLAND, NEW ZEALAND

Anke Timmermann, Michael J. Crozier
School of Earth Sciences
Victoria University of Wellington
anke.timmermann@web.de

Landslides worldwide and in New Zealand in particular have the potential to cause significant human and economic costs. The assessment of areas, which are prone to landsliding, is an important step in reducing those costs. The designation of areas susceptible to landsliding requires the determination of the causative factors and their interrelationships that lead to slope instability. The evaluation of the spatially varying terrain conditions as well as the spatial representation of landslides is essential for this procedure. This form of analysis has already been carried out in several former studies worldwide using a wide range of different approaches. Many of these have been undertaken with the aid of Geographic Information Systems (GIS), which provide tools for collecting, storing, manipulating and displaying spatial data.

In this project a landslide susceptibility map for the Waitaki area in North Otago, New Zealand, has been developed within a GIS using a quantitative approach based on heuristic and statistical methods. The main aim is the prediction of locations that are likely to produce landslides based on the geological and geomorphological characteristics of the terrain. The spatial distribution of landslides has been correlated with topographic, geological and landscape features in order to determine which factors best explain landslide occurrences specific to this area. GIS are used to analyse and generate parameters of significance to slope stability. The project involves the identification of important input parameters to the landslide susceptibility model. The generation and assembling of the corresponding data layers within GIS forms the database of the model. For the final map construction each data layer (factor map) is

assigned a weight according to the importance of the factor in the identification of landslides. Those weights are derived by the application of the statistical method 'weights of evidence'. The weighted data layers can eventually be combined to the final landslide susceptibility map, representing the posterior probability of landslide occurrences. Different combinations of those factor maps are tested by the development of a success rate. The final model includes conditions relating to rock type, dip angle, slope aspect, slope steepness, distance to streams, stream order of the nearest stream, elevation difference to the nearest stream, and distance to active faults. The model is built using the northern part of the area, whereas the validation of the best matching combination of factors maps is done in form of a prediction rate, on the basis of the existing landslides in the southern part. This prediction rate shows a satisfactory result, having 85% of the existing landslides in the first half of the higher susceptibility class.

EARLY HOLOCENE ESTUARY EVOLUTION UNDER CONTRASTING TECTONIC UPLIFT PROCESSES: THE PAKARAE AND HICKS BAY PALEO-ESTUARIES, RAUKUMARA PENINSULA, NEW ZEALAND

Kate Wilson1, Kelvin Berryman2, Tim Little1, Ursula Cochran2, and Nicola Litchfield2.
1 School of Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington, New Zealand.
2 Institute of Geological and Nuclear Sciences, PO Box 30368, Lower Hutt, New Zealand.

This study investigates the relationship between tectonic uplift and Early Holocene estuary evolution along the East Coast of the Raukumara Peninsula, North Island, New Zealand. Early Holocene sequences exposed beneath the maximum marine transgression surfaces at Hicks Bay and Pakarae record infilling of the respective paleo-valleys during post-glacial SL rise. Both locations were undergoing tectonic uplift synchronously with valley infilling. We compare the sequences with facies models of incised valleys developed from stable coasts to estimate the rate of uplift and style of tectonic uplift.
Drill cores collected from Hicks Bay display a gradational sequence of fluvial to estuarine sediments as sea level transgresses and infills the valley. A gradual transition back to a fluvial environment occurs following mid-Holocene sea level (SL) stabilisation and the completion of infilling of the valley. This facies sequence closely matches models of incised-valley infill developed from stable coasts. The main difference is a lesser thickness of sediment preserved relative to the amount of accommodation space created by eustatic SL rise during the depositional period. The differential thickness (~7 m) represents the amount of tectonic uplift during infilling of the valley from 9 – 5 ka. The maintenance of an intertidal estuary from 9 – 7 ka, with no detectable unconformities, indicates that uplift probably occurred by constant, gradual mechanisms.

At Pakarae the basal fluvial package and the immediately overlying estuary-head delta package represent the initial SL transgression into the paleo-valley. Models predict only central estuary basin sediments would be present between the transgressive estuary-head delta and the barrier package at the top, which represents the maximum marine transgression. In contrast, the Pakarae sections display three separate vertically stacked estuarine beds with intervening fluvial packages. The sharp transitions from estuarine to fluvial at the top of the two lower estuarine beds probably represent sudden uplift events. These caused major paleoenvironmental shifts. The lowest estuarine bed was abandoned at ~9 ka. Fluvial deposition followed and paleosols downstream indicate a prolonged period above SL before the estuary re-established under rising SL. Abandonment of the middle estuary bed occurred ~8.55 ka. Post-uplift fluvial deposition occurred upstream and the estuary re-established soon after the event in a location ~ 160 m seaward. The upper estuarine unit displays a sharp transition from estuarine to barrier packages; this represents a tidal ravinement surface produced by tidal scouring as the barrier migrated landward under rising SL. The sequence is not overlain by a fluvial package as the stable-coast models predict. Tectonic uplift probably caused the river to incise rather laterally spread following SL stabilisation.
Pakarae and Hicks Bay demonstrate that tectonically uplifting coastlines produce distinctive characteristics within incised-valley sedimentary infills when compared with stable coasts. However the style of uplift - constant and gradual (aseismic) or intermittent and sudden (coseismic) – determines the type and rate of paleoenvironmental change. Transgressive estuary sequences can be used to extend the paleoseismic record of a location, and these examples demonstrate changing tectonic uplift mechanisms along the East Coast of the Raukumara Peninsula.

UNDERSTANDING THE CAUSE OF CONTEMPORARY GLACIER RETREAT ON MT RUAPEHU, NEW ZEALAND

Tom Paulin1, Andrew Mackintosh2, Brian Anderson2, and Harry Keys3
MSc Student, School of Earth Sciences, Victoria University of Wellington,
PO Box 600 Wellington, New Zealand.
School of Earth Sciences and Antarctic Research Centre, Victoria University of Wellington, New Zealand.
Department of Conservation, Tongariro/Taupo Conservancy
Email: paulinthom@student.vuw.ac.nz

Located on the Central Plateau of North Island, the glaciers on Mt. Ruapehu are the northernmost in New Zealand, and as such are extremely sensitive to climatic changes. Glaciers on this mountain provide us with an indication of North Island climate and may behave differently to glaciers in the Southern Alps, with synoptic weather patterns favourable to high winter snowfall in this region producing low snowfall in the Southern Alps, as illustrated in winter 2005.
While glaciation in New Zealand has been studied in detail in the Southern Alps, North Island's glaciers on Mt. Ruapehu have received less attention with no major studies since the 1960s. Extending glacier monitoring to Ruapehu will greatly enhance the latitudinal (and altitudinal) scope of current glacial research in New Zealand. Volcanism on the active Mt. Ruapehu adds an interesting element to glacial dynamics. Tephra cover on the snow surface may act to enhance or decrease ablation, and large volumes of water stored within the glaciers and ice-dammed Crater Lake has major implications for lahar hazard.

Questions:
What is the current mass balance state of Ruapehu's Glaciers?
Which climatic variables (e.g. increased temperature, reduced precipitation, increased windiness) are controlling the present-day retreat of Ruapehu's glaciers?
To what extent does tephra cover effect spatial variability of mass balance?
What is the likely affect of future climate warming on glacier mass balance and ice extent?

This MSc study will use a study of mass balance to obtain accumulation and ablation gradients for the Whangaehu Glacier on Mt Ruapehu. The focus will be to establish links between climate and mass balance, and ascertain how the glaciers will respond to future climate warming. Total winter accumulation on the glacier will be measured by snow pits, with ablation and surface velocity monitored with stakes from Spring 2005 until accumulation resumes in 2006. Linking mass balance gradients to the local climate will be achieved by installing a weather station at Dome Shelter (2670m) to measure climate variables, and these data will be compared to climate data collected at lower elevations in Whakapapa and/or Turoa ski areas. The baseline mass balance, velocity dynamics, and climatic data will be used to construct a computer model of the glacier, which will be used to predict future glacier behaviour. It is anticipated that the results of this study will concur with other studies from New Zealand and around the world which show a general retreat of mid-latitude glaciers.