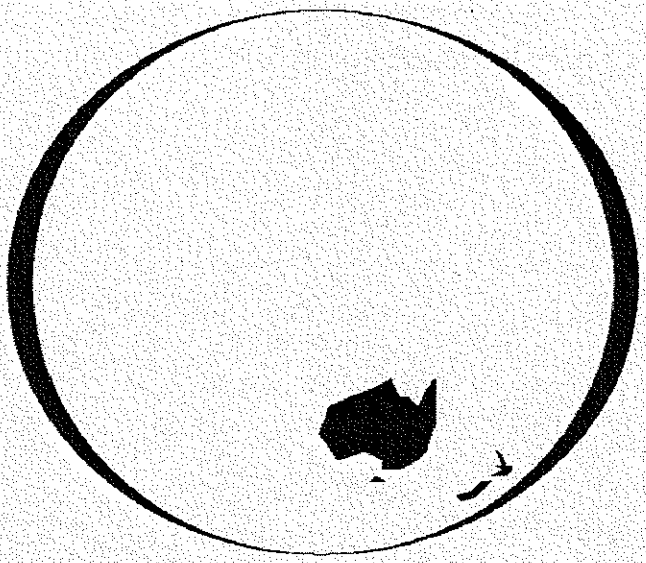
Australian and New Zealand Geomorphology Group



11th Conference
Mount Buffalo, Australia
February 15 - 20, 2004

Conference Program

Abstracts and Participants

Conference Organising Committee

Sandra Brizga
Derek Fabel
Ruth Lawrence
Meredith Orr

and

David Outhet (Pre-conference field trip)

Conference Program Editor

Derek Fabel

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Contents

Monday 16 February 2004		
8.45	Welcome	
	Geochronology and landscape evolution	
9.00	Ed Rhodes	OSL Dating of sediments: a tool for developing models of fluvial activity and deposition
9.15	Derek Fabel	Do different geomorphic features created by the same glaciation give the same exposure age?
9.30	Toshi Fujioka	Evaluation of nucleogenic components in cosmogenic ^{21}Ne surface exposure dating
9.45	Jonathan Brown	Some preliminary magnetic results from Caledonia fen
10.00	Brad Pillans	Dating Longterm landscape evolution in Australia: Highlights from the CRC LEME geochronology project.
10.15	Kathryn Fitzsimmons	Evolution and dynamics of dunes in the Lake Frome region, South Australia
10.30	MORNING TEA	
11.00	Maureen Marra	Last glacial maximum beetle fauna, Lyndon Stream, Rakaia River valley, South Island, New Zealand
11.15	Paul Augustinus	Late Cenozoic glacial history of the Rennick Glacier, Northern Victoria land, Antarctica
11.30	Gerald Nanson	Aeolian-fluvial interaction: Late Quaternary channel change and dune formation in the Simpson Desert near Alice Springs, Australia
11.45	Ian Lewis	Horizontal and vertical controls on the caves of the Naracoorte East Range, South Australia
12.00	Matthew Forbes	Late Pleistocene geomorphological interpretation of cave stratigraphy from Naracoorte, southeast South Australia
12.15	Jonathan Clarke	Comparatively rapid fluvial landscape evolution, lower Balonne region, southern Queensland
12.30	Timothy Cohen	Late Quaternary floodplain processes in a partly confined valley of New South Wales, Australia
12.45	Marshall Wilkinson	Soil production and landscape evolution in the Blue Mountains, NSW, derived from cosmogenic ^{10}Be and OSL
13.00	LUNCH	
14.00	Peter Almond	The soil catena through geomorphological glasses
14.15	Erick Bestland	Sources of dust and base cations in red brown earth soils of South Australia: Evidence from Strontium isotopes
14.30	Lisa Worrall	The impact of mid-Tertiary fluctuations in sea level on the geochemical evolution of the West Australian regolith
14.45	David Kennedy	Shore platform morphology on a rapidly uplifting coast, Wellington, New Zealand
	Mars	
15.00	Colin Pain	Geomorphic processes, landforms and regolith on Mars
15.15	Matilda Thomas	Application of regolith-landform mapping to Mars analogue research at the Mars desert research station in Utah
15.30	AFTERNOON TEA	
16.00	Bernie Joyce	The geomorphology of Victoria: A new view of the landscape
16.15	Nick Preston	It all depends.....Implications of a newly emerging geomorphic paradigm
16.30	John Chappell	Implications of flat land surfaces

Tuesday 17 February 2004		
Geomorphology and Society		
9.00	Michael Crozier	The characterisation of multiple-occurrence landslide events
9.30	Nicholas Boyens	Geomorphic effects of the August 6th 2002 storm, Gisborne, New Zealand: An overview
9.45	Gabriele Hufschmidt	Natural hazard and risk evolution in Wellington, NZ - Survival of the fittest?
10.00	Wayne Erskine	Mass movement on the central elevated core of the middle Miocene Canobolas volcanic complex, NSW
10.15	Richard Hawke	Geomorphology: Its application for optimal forestry management
10.30	MORNING TEA	
11.00	Scott Seymour	The benefits of substantive geomorphological appraisal in applied waterway management - a manager's perspective
11.15	Louise Ormerod	Urban creek assessment and prioritisation within Newcastle LGA
11.30	Sandra Brizga	Underfit rivers in Queensland - evidence and management implications
11.45	Kirstie Fryirs	Sedimentary cascades in Australian river systems: Using examples from the Bega and Hunter catchments to demonstrate the (dis)connectivity of sediment movement and its implications for geomorphic river recovery
12.00	Mark Ruse	Examples of geomorphological influences on sediment production in Hong Kong
12.15	Kirsten Hennrich	Identification of contributing areas for phosphorus export
12.30	Jonathan Nott	Geomorphology, tropical cyclones, community safety and governments
12.45	James Campbell	Is aeolian dust a source of dryland salinity?
13.00	LUNCH	
14.00	Nina Stahl	Geomorphic factors and stream salinity, Bega, NSW
14.15	Amy Kernich	Regolith, landforms and salt in the lower Balonne area, southern Queensland
Mountain Geomorphology		
14.30	James Shulmeister	A mountain of water or a desert of ice: Implications of contrasting glacial styles in the mountains of New Zealand and Australia at the LGM
15.00	Oliver Korup	The relevance of landslides in alpine fluvial geomorphology
15.15	Ruth Lawrence	Comparing the effects of the 1939 and 2003 fires on the stream flow of the Bogong High Plains
15.30	AFTERNOON TEA	
16.00	Kerrie Tomkins	Mid-Miocene active uplift of the western margin of the southeastern highlands of Australia
16.15	John Webb	Irreconcilable differences: Apatite fission track analysis and the concept of old erosion surfaces in the southeastern highlands
16.30	Meredith Orr	Denudation rates and the Cenozoic history of the Australian Alps in Victoria

Wednesday 18 February 2004 - FIELDTRIPS

Thursday 19 February 2004

Geomorphology and Fires

9.00	Rob Ferguson	Geological and physiologic controls on erosion and sedimentation following the January 2003 bushfires in northeast Victoria
9.15	Stefan Doerr	Effects of different fire severities on soil wetability: Experimental evidence and field observations following the 2001 Sydney bushfires
9.30	Rick Shakesby	Why aren't severe fires always a trigger for 'serious' soil erosion? Case studies in eucalypt stands in Portugal and New South Wales
9.45	Peter Wallbrink	Use of tracer budgets to assess post fire sediment redistribution in a catchment of the Nattai tablelands, NSW
10.00	Victoria Farwig	Testing the validity of mineral magnetic enhancement of Australian eucalypt soil as an indicator of burning: A controlled laboratory simulation of different heating scenarios
	Geomorphology and the Biota	
10.15	John Field	Geomorphology and the Biota
10.30	MORNING TEA	
11.00	Jenna Leonard	Effects of trees on regolith and landscapes
11.15	Vanessa Wong	The effects of clustered and isolated trees on soil fertility in an Australian box woodland
11.30	David Little	Inter-relationships between soil and regolith patterns and nutrient processes at a subalpine inverted treeline
11.45	Paul Hesse	What controls the activity of desert sand dunes in Australia: Vegetation or insufficient wind?
	Fluvial Geomorphology	
12.00	Ken Page	The effect of flow regulation on the frequency of floodplain inundation on the Murrumbidgee River, Australia
12.15	Dominic Blackham	A fraction too much friction: The role of riparian grass in stream geomorphology
12.30	Mike Saynor	Influence of riparian vegetation on bank erosion rates in the Ngarradj catchment around Jabiluka mine
12.45	Peter Kershaw	A high resolution record of the full last glacial-interglacial cycle from Caledonia Fen, Victorian Alps
13.00	LUNCH	
	INTIMATE Meeting	
14.00	James Shulmeister / Simon Haberle	Introduction to the Australasian INTIMATE project
14.20	James Shulmeister	Summary of main points from first NZ meeting in Dunedin
14.35	Simon Haberle	Summary of discussion on Australasian INTIMATE project at Southern Connections
14.50		General discussion
15.30	AFTERNOON TEA	
16.00	AQUA Meeting	
19.00	CONFERENCE DINNER	

Friday 20 February 2004

Fluvial Geomorphology

9.00	David Dunkerley	Flow threads in surface runoff: Implications for assessment of flow properties and friction coefficients in soil erosion and hydraulics investigation
9.15	Bamutaze Yazidhi	An assessment of runoff and soil loss under major land uses in Wanale micro-catchment, Mt. Elgon
9.30	Peter Johnston	Late Quaternary river evolution of floodplain pockets along Mulloon Creek, New South Wales, Australia
9.45	Geoff Vietz	A classification of in-channel benches to assist in relating river hydrology and morphology
10.00	Teresa Rose	Channel redefinition after an environmental flow release in the Snowy River
10.15	Ian Rutherfurd	Controls on historic bedform changes in a partially confined sand-bed river
10.30	MORNING TEA	
11.00	Chris Thompson	Reach morphology in SE Australian mountain-type streams
11.15	Gresley Wakelin-King	Fowlers Creek: One river, five fluvial styles
11.30	Justine Kemp	Downstream hydraulic geometry of contracting, anabranching river systems
11.45	Rachel Nanson	Channel geometry of upland swamp streams, Barrington Tops
12.00	Vanessa Gorecki	Organic matter distribution along the Kangaroo River, NSW
12.15	Chad Bailey	Submerged jet testing device to determine the influence of riparian tree roots on cohesive riverbank's resistance to fluvial scour
12.30	James Grove	What you see is not always what you get: Riverbank erosion rates and processes on the Kiewa River, N.E. Victoria
12.45	Andrew Brooks	Catastrophism vs threshold exceedence: Does catastrophic channel change require catastrophic flooding?
13.00	LUNCH	
14.00	Timothy Ralph	Scales and mechanisms of channel breakdown, lower Macquarie River and Macquarie Marshes, N.S.W.
14.15	James Lander	Within-reach variability in channel adjustment along an 8km reach of the Hunter River, New South Wales; implications for assessing future river rehabilitation options

Middle East and Africa

14.30	Emily House	The geology and geomorphology of Zahrat Adh-Dhra', Dead Sea plain, Jordan
14.45	Martin Williams	Geomorphic evolution of the Nile basin
15.00	AFTERNOON TEA	
15.30	**ANZGG General Meeting**	

POSTERS

Sandra Brizga	Barbers Creek fluvial geomorphology study and rehabilitation plan
Tom Gardner	Late Pleistocene calcareous and siliceous Aeolian and alluvial fan deposits, Cape Liptrap, southeast Australia
David Rees	Evolution of a Geomorphic Framework for Victoria-The Role of the Geomorphology Reference Group (GRG)
Gresley Wakelin-King	OSL dating of Fowlers Creek silt: A correction
Victor Tokarev	Neotectonics and geomorphology of the Mt Lofty ranges, South Australia

THE SOIL CATENA THROUGH GEOMORPHOLOGICAL GLASSES

Peter C Almond
Soil, Plant and Ecological Sciences Division, Lincoln University, New Zealand

A soil catena is a sequence of soils on a slope whose member soils develop in an interrelated way depending on the geomorphic, pedological and hydrological processes acting along the slope. In pedology the soil catena is the concept that unifies soil and slope development processes, although in many studies the nature of slope development processes is only given qualitative treatment. For example, much of the catenary differentiation in soils is attributed to pedogenic processes such as enhanced weathering in moister downslope positions, and downslope translocation of mobile (dissolved or dispersed) soil constituents. Although these processes are likely to have significant influence in many humid temperate regions, the simple influence of increased residence time for soils at progressively lower slope positions is not considered. If a slope is envisaged as a conveyor belt of soil material it follows that the age of the soil increases further downslope. The duration of transport should be reflected in the abundance of secondary minerals such as clays and oxides. In this paper I start from first principles using a special case of a soil-mantled hillslope at steady state (dynamic equilibrium) where transport is gravity-driven creep. Under these conditions the average soil age, which is determined by the time since detachment from the underlying bedrock, should increase according to the natural logarithm of the horizontal distance from the ridge crest:

i.e.

$$\text{Soil age} = C + \frac{\rho_s}{\rho_r}\frac{h}{E}\ln x$$

where C = constant, ρ_s = soil density, ρ_r = density of substrate (bedrock)

h = steady state soil depth, E = steady state soil production rate,

and x = horizontal distance from the ridge crest

I test the value of this relationship using published data of meteorically-derived Be accumulated in soils on a convex slope formed in Eocene shale (McKean *et al.*, 1993). In these clay-rich soils Be is thought to accumulate in direct proportion to soil age.

Secondary soil compounds formed by weathering accumulate in a non-linear way; first order rate reactions, which produce a reducing weathering rate with time, are sometimes used to model such processes. The accumulation of weathering products down a convex slope at steady state should, therefore, increase at less than a linear rate when plotted against the natural log of horizontal distance (x). In this manner it may be possible to isolate the effects of soil residence time on the slope versus secondary mineral translocation in catenary differentiation. By the time of the conference I hope to have gathered appropriate data to test this idea.

Reference

MCKEAN, J.A., DIETRICH, W.E., FINKLE, R.C., SOUTHON, J.R. & CAFFEE, M.W. 1993. Quantification of soil production and downslope creep rates from cosmogenic Be accumulations on a hillslope profile. *Geology* **21**, 343-346.

LATE CENOZOIC GLACIAL HISTORY OF THE RENNICK GLACIER, NORTHERN VICTORIA LAND, ANTARCTICA

Paul Augustinus[1], Jane Olsen[2], David Fink[3], John Hellstrom[4], Derek Fabel[5]
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Controversial and conflicting interpretations have been proposed regarding the history of the East Antarctic ice sheet based on data from different sectors of the Transantarctic Mountains. Nevertheless, understanding these complex controls on glaciation is essential due to the ongoing and crucial debate regarding the long-term stability of the ice sheet and sensitivity of the ice sheets to climate change. The project described here involves a detailed assessment of fluctuations of the Rennick Glacier system which flows directly from the Northern Victoria Land sector of the Transantarctic Mountains into the Southern Ocean. The record from the Rennick Glacier is significant for understanding ice sheet response to Late Cenozoic global climate change as such a history would be difficult to obtain from outlet glaciers draining Southern Victoria Land due to the influence of the Ross Ice Shelf buffer on the timing of glacier expansion. This information is essential to allow comparisons with the marine and ice core records global climate cycles, as well as to ascertain whether there are regional differences in timing of glacial events due to local tectonics.

The timing of the phases of glacial expansion remains virtually unknown over Northern Victoria Land, although exposure-age dating using cosmogenic nuclides has recently proved successful in dating phases of ice sheet growth elsewhere in the Transantarctic Mountains. This method is ideally suited to dating moraines developed during phases of expansion of the Rennick Glacier system as there are no materials available for dating these episodes using more conventional methods. The Be and Al exposure age technique used here allows dating over the whole of the last few million years, a time range unavailable to any other method. In addition, pilot isotopic and multi-collector ICP-MS U-series dating of subglacial calcite collected from ice-moulded bedrock surfaces is providing a tightly constrained series of ages that complement the exposure age dating of the same sites.

The project was provided with logistical support by Antarctica New Zealand during seasons 2000-2001 and 2001-2002, with fieldwork undertaken in both the upper and lower sections of the 350 km long Rennick Glacier to enable development of a model of the late Cenozoic behaviour of the entire system. Over 150 samples were collected for Be and Al dating from critical sites, the processing and analysis of which is ongoing. In addition to sampling for dating, we undertook detailed weathering studies at a number of sites that involved assessment of drift weathering status using a range of surface and subsurface weathering criteria. The weathering data allows separation of the moraines and drift sheets into different relative age surfaces, many of which are being exposure age dated using the cosmogenic nuclides

The combination of the Be, Al, and U-series dating with glacial geological mapping and weathering observations provides important new data pertaining to the late Cenozoic stability of the Rennick Glacier system. In particular, it is apparent that rather than a simple sequence of two glacial events as suggested by earlier workers, we are able to demonstrate that a complex suite of lateral moraines and ice-abraded bedrock surfaces generated by multiple glacier level fluctuations is present throughout the upper as well as the lower part of the Rennick Glacier system.

SUBMERGED JET TESTING DEVICE TO DETERMINE THE INFLUENCE OF RIPARIAN TREE ROOTS ON COHESIVE RIVER BANK'S RESISTANCE TO FLUVIAL SCOUR

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[2]Department of Civil Engineering, University of British Columbia, Vancouver, British Columbia, Canada

A device that was designed in the United States to measure the shear strength of channel beds (Hanson 1990) has been modified to be utilized on non-horizontal surfaces (Hanson *et al.* 2002). This device uses a submerged jet to produce a shear stress that is applied to the soil surface. A relationship between the jet diffusive properties and the distance from the jet orifice to the bed surface supplies an estimate of the effective shear stress on the bed. This relationship, in conjunction with a hyperbolic asymptotic relationship formulated by Blaisdell et al. (1981), allows the user of the jet device to estimate the equilibrium depth of scour and resulting critical shear stress of the soil, where the critical shear stress is the stress required to cause erosion of the bank sediment. This device used in a discreet manner may reveal a relationship between the critical shear stress of the soil and any other measurable property of the soil or root network. In the past, it was believed that soil erodibility and standard soil property measurements, such as bulk density, antecedent soil moisture, Atterberg limits, grain size distribution, etc., were related. But, according to the current literature, this correlation is either too complicated to be useful, too site specific to be widely applicable, or simply does not exist. The current literature supports the use of an in situ device to measure soil strength, or erodibility, and researchers such as Hanson and Simon (2002) suggests that "parameters such as plasticity index and gradation by themselves will never do better than serve as crude indicators."

The goal of the project is to produce a set of results for the critical shear stresses and erodibility of cohesive riverbanks, while attempting to isolate the magnitude impact of riparian tree roots (i.e. gum, wattle, tea tree, and willow) on bank faces devoid of surface vegetation. Ideally, these tests will be performed on the lower portions of the bank, as close to the toe as possible, to investigate the location of the theoretically greatest spatial and temporal applied shear stress. The in situ jet device, in conjunction with soil and root samples, will be applied to relatively homogenous bank sections under contrasting vegetation conditions. The primary result is an examination of a correlation between root density of different riparian tree species and the calculated critical shear stress for the bank from the jet device. If a meaningful correlation is discovered between the root density and critical shear stress, a more discreet analysis may be formulated to examine this correlation. Potentially, a model may be formulated that is designed to appraise the contribution of replanting or removing particular riparian tree species from cohesive banks and the resulting influence to bank strength based on a potential change in root density.

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HANSON GJ, SIMON A, COOK KR. 2002. Non-vertical jet testing of cohesive streambank materials. In: 2002 ASAE Annual International Meeting/ CIGR XVth World Congress. Chicago, Illinois, USA

SOURCES OF DUST AND BASE CATIONS IN RED BROWN EARTH SOILS OF SOUTH AUSTRALIA: EVIDENCE FROM STRONTIUM ISOTOPES

Erick A. Bestland, Matthew S. Forbes, Graham P. Green, and Kelly A. Rivett
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Strontium isotopic ratios (87/86), as well as Sr/Ca and Ba/Ca ratios of soil solid, soil solute extracts, bedrock, silicate-organic dust, dust extract, irrigation water, and grapes have been analysed in order to better understand the origin and pathways of strontium, and therefore Ca, and by extrapolation the other base cations in the soil-water-plant system. This investigation into the strontium isotope signature of soil solids, associated dust and fine-grained aeolian deposits (lunette deposits), and bedrock is an attempt to determine the origin of selected Red Brown Earth soils in South Australia. That is, what component of these soils has weathered from bedrock and what component has accumulated in the soil from atmospheric deposition?

Seven Red Brown Earth soil profiles were examined; two each from the Padthaway area and Clare Valley, and three from the Coonawarra; all well-known vitaculture districts in South Australia. In all the seven soil profiles studied, soil solute extracts (labile, exchangeable cations) are dominated by atmospheric sources (rainfall and dust). In the case of irrigated soils, irrigation water is an additional major source of base cations to the soil solute system. The strontium signature of grapes follows very closely the soil solute extracts, as would be expected. Likewise, pedogenic carbonate follows very closely the soil solute extracts. Aeolian sourced material dominates the soil solids of the Coonawarra and Padthaway soils. At these sites, the clayey Bt horizons are remarkably homogenous both vertically within profiles and between the two localities, albeit with a small, yet significant difference between the Coonawarra and Padthaway sites. In contrast, the Clare Valley profiles have bedrock as a major contributor and show down-profile mixing trends between local dust and bedrock end-members. The Clare Valley profiles are also much more heterogenous both within soil profiles and between profiles when compared to the Coonawarra and Padthaway soils. Thus, the Coonawarra and Padthaway Red Brown Earths appear to be a relatively homogenous dust mantle, whereas, the Clare Valley soils have composite sources with bedrock, colluvium, and dust adding to the mix.

Identifying the sources of dust is problematic. Overall, the fine-grained (non-carbonate) lunette deposits from the southeast of South Australia and dust from Clare Valley, as well as very fine-grained suspended sediment from the Murray River (Douglas et al., 1995) all have similar strontium isotopic values (approximately between 0.71 and 0.72). This surprising result could reflect the importance of the clay-oxide-organic matter complex in preserving and cycling base cations in weathering systems. The strontium composition of the clay-oxide-organic matter complex in turn reflects mixing of atmospheric sources and bedrock sources. It is suggested that the similarity of these ratios could be a result of dilution of high-ratio silicate bedrock sources with low-ratio atmospheric sources (marine derived strontium and carbonate dust derived strontium).

A FRACTION TOO MUCH FRICTION: THE ROLE OF RIPARIAN GRASS IN STREAM GEOMORPHOLOGY

Dominic Blackham, Ian Rutherfurd and Michael Stewardson
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Riparian vegetation plays an important role in controlling the adjustment of stream channel form by interacting with flow hydraulics and sediment transport processes. The currently poor understanding of the erosion resistance of common riparian vegetation has limited the development of predictive models of vegetation and channel response to extreme flow events. An approach to determining the erosion resistance of common riparian grass species that combines lab-based flume testing and detailed hydraulic and hydrological modelling is described in this paper.

A custom-built flume was designed that allowed high levels of shear stress to be exerted on samples of riparian grass and substrate taken from a range of streams in Victoria. The flume was used to establish the erosion resistance of grass species that commonly occur in Victorian riparian zones, and to investigate the relationships between the physical characteristics of the vegetation and the erosion resistance.

In order to investigate the role of riparian grass in controlling stream channel adjustment, detailed hydraulic and hydrological models were developed for a range of sites. The models focussed on horizontal surfaces such as benches and bars within the bankfull channel that are periodically inundated during high flow events. The models provided a detailed simulation of the distribution of hydraulic shear stress both in space (across specific cross-sections) and time (variations in shear stress exerted on a horizontal surface during an event). Data from the flume and model components were combined to develop a response model that predicted the response of the vegetation and geomorphological surface to a range of flow events. The potential application of the response model to streams in a range of locations and environments is discussed.

GEOMORPHIC EFFECTS OF THE AUGUST 6 2002 STORM, GISBORNE, NEW ZEALAND: AN OVERVIEW

Nicholas S. Boyens and Michael J. Crozier
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On august 6 2002 a storm resulted in severe erosion and flooding in the Gisborne District, East Cape, New Zealand. The storm was very intense with rainfall levels of up to 287mm in 24 hours in some parts of the district (Brackley and Preston, 2003). The worst affected areas were Te Arai and Muriwai in the southern part of the district near to the coast. Hillslopes in these areas experienced severe erosion during the storm, predominantly this was in the form of shallow translational landslides. These effected most slopes to some extent with north facing slopes experiencing more landslides than other slopes. There were also instances of activation of large deep-seated landslides, one in particular blocked a small stream and formed a temporary lake that reached a depth of 20-30m and a length of 200m. Downstream parts of the catchment experienced severe flooding resulting in erosion of the stream banks and the deposition of large amounts of sediment on the floodplains.

Reference

Brackley, H.L. and Preston, N.J. 2003. The August 2002 storm: impacts and lessons to be learnt. *Conservation Quorum* 30. 8-9

UNDERFIT RIVERS IN QUEENSLAND – EVIDENCE AND MANAGEMENT IMPLICATIONS

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[2]School of Anthropology, Geography and Environmental Studies, University of Melbourne, Parkville 3052

Many of Queensland's east coast rivers are "underfit" – that is, the presently active channel is confined within a high flow channel that appears to be too large to have been formed by the existing hydrological regime. In this paper, we review evidence for underfitness and alternative hypotheses. We conclude that although large floods that are part of the present flow regime may have some effect on the high flow channels, their infrequent occurrence means that the timescale for high flow channel formation is long, dating back to periods when environmental conditions were different to the present. The implications of underfitness for river management – including sand/gravel extraction and environmental flow allocation – are examined.

BARBERS CREEK FLUVIAL GEOMORPHOLOGY STUDY AND REHABILITATION PLAN (POSTER)

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Melbourne Water undertakes fluvial geomorphology studies on waterways affected by management issues that arise from geomorphological processes such as accelerated erosion and sedimentation. These studies assess historical and contemporary physical processes using available information and develop appropriate management strategies. A fluvial geomorphology study was undertaken on Barbers Creek, a tributary of the Plenty River in the Yarra catchment, as it is affected by extensive erosion that is contributing to elevated turbidity in downstream receiving waters. S. Brizga & Associates Pty Ltd was commissioned in 2002 to undertake the study – study team members were Dr Sandra Brizga, Mr Neil Craigie and Mr Pat Condina. A summary of the methodology and results are presented below. Earth Tech Pty Ltd has subsequently been engaged to develop a detailed design. Construction of the first stage of stabilisation works is scheduled for this summer.

Extensive topographic surveys were undertaken of the main waterways, including stream alignments, cross-sections and key features such as rock outcrops and significant trees – with the distinction made between natives and exotics (mainly willows).

Geomorphological analysis was undertaken using a range of information sources including historical and recent aerial photographs, geological maps, recent survey data, historical survey plans and site inspections.
Barbers Creek used to be a discontinuous dry watercourse with swamps in the middle reaches. By the 1950s the major streams were incised and the catchment was extensively denuded by rampant sheet, tunnelling and gully erosion. Channelisation associated with swamp drainage appears to have been a key casual factor in stream incision. Historical clearing altered catchment runoff processes, contributing to slope and gully erosion. The catchment soils and sediments are naturally prone to erosion, being derived from Silurian to Devonian Humevale and Dargile Formation sedimentary rocks. The creek system now appears to be more stable than in the 1950s, as a result of stabilisation measures and revegetation, but significant management issues related to erosion remain, including major active knickpoints and bank erosion and lateral gullying along incised reaches.

A one-dimensional steady state hydraulic model was developed for the main stem reaches of the study area. Return periods for bankfull capacity varied from around 2 years (unincised reaches) to >100 years (deeply incised reaches). Higher flows in most reaches have sufficient stream power to cause erosional problems.

The development of management options involved assessment of present conditions and likely future trends in regard to stream stability, instream habitat and riparian zone condition. Stream values were assessed in terms of social, economic and environmental factors. Risk levels were determined by considering the severity of threatening processes in relation to local and external values. The highest risk scores occur in the actively eroding reaches where stream incision threatens instream and riparian habitat and local and downstream water quality. The study identified a number of opportunities for stream system rehabilitation, including stream stabilisation and soil conservation measures, instream works to restore habitat values, riparian zone rehabilitation and re-creation of ephemeral wetlands and marshlands.

THE BENEFITS OF SUBSTANTIVE GEOMORPHOLOGICAL APPRAISAL IN APPLIED WATERWAY MANAGEMENT - A MANAGER'S PERSPECTIVE

Sandra Brizga[1] and Scott Seymour[2]
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The role of substantive geomorphological assessment as a vital tool in waterway management decision making is discussed in this paper. In a climate of highly competitive bidding and generally limited funding and where a high degree of success in the outcome of rehabilitation works is expected, the waterway manager must be well informed in the decision making process. In many cases, the apparent status of stream processes can be easily misread – consequently, whilst rapid assessment methodologies have become popular for providing input to natural resource management reporting and decision-making processes (and decision support systems), the information they yield is not necessarily sufficiently robust or reliable. This is particularly so when applied by unqualified or inexperienced observers. Although more detailed geomorphological analysis may cost more initially, substantial savings are often possible and a more effective and ecologically-sound management outcome can be achieved as a consequence, leading to increased net benefits (economic and otherwise) in the longer term. This paper examines two case studies where detailed geomorphological studies led to substantially different interpretations of management issues than initial application of rapid assessment methodologies, resulting in significantly different management outcomes.

Bare vertical banks in the floodplain reaches of the Yarra River between Wesburn and Warrandyte were initially interpreted on the basis of rapid assessment methodology criteria as "severely eroding" and extensive rock armouring and groyne work was recommended. This recommendation was queried and a detailed geomorphological study was carried out. The geomorphological study showed that the bank erosion is caused by natural meander processes and that erosion rates are generally low. The viability of extensive rock lining to control a natural process in a rural setting was queried. The result is a much less expensive and lower interventionist approach to management that involves an increase in vegetative management.

Loss of flood capacity in the artificially straightened, channelised and leveed section of the Bunyip River (Bunyip Main Drain) in the Koo Wee Rup Flood Protection District prompted investigations into remedial options. The initial subjective appraisal was that the waterway was basically stable and the response was to consider reducing vegetation plus raising the levees at great cost. A geomorphological analysis showed that the river banks and levee system were highly unstable and that confining additional flood flows by raising the levees would lead to a substantially increased risk of catastrophic failure. As a result, an alternative management strategy was developed that saw a longer term program of asset rehabilitation where initial priority is given to increasing river channel and levee bank stability. Had the works indicated by the initial appraisal been allowed to be undertaken, not only would the asset have failed but a substantial investment would have been misdirected.

CATASTROPHISM VS THRESHOLD EXCEEDENCE: DOES CATASTROPHIC CHANNEL CHANGE REQUIRE CATASTROPHIC FLOODING?

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The documentation and analysis of catastrophic landscape change is a recurring theme in the geomorphic literature. Schumm (1969) coined the term "channel metamorphosis" to describe rivers that have undergone major historical channel change in which channel morphodynamics have shifted to a new regime. A range of channel and/or catchment disturbances are cited as causes of channel metamorphosis, but it is generally assumed that these must be accompanied by "catastrophic floods" to drive the change (Stevens, et al, 1975; Rutherfurd 2000). In this paper data will be presented from the sand-bed Cann River in East Gippsland to show that "catastrophic floods" or even large floods are not a prerequisite for channel metamorphosis. Rather, increased sediment transport capacity associated with LWD removal, which has reduced in-channel roughness and bed stability, has set up a cascade of feedbacks that lead to channel metamorphosis. All that is required to drive this process is the "normal" sequence of relatively low magnitude floods. Our analysis shows that a large flood that occurred on the Cann River in 1971 (estimated as a 1:200 year event), while speeding up the metamorphosis process somewhat, would have had little effect on the ultimate endpoint. Once disturbance had initiated the channel change the crossing of numerous stability thresholds meant the contemporary incised channel endpoint was inevitable, irrespective of the occurrence of large floods.

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SOME PRELIMINARY MAGNETIC RESULTS FROM CALEDONIA FEN ✓

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Caledonia Fen is a small alpine bog located at an altitude of 1280 m, on the western edge of the Bennison High Plains in the Australian Alps. An outline of the current project aims and methods was presented at the 10 ANZGG conference in Kalgoorlie in 2002. The data presented today represents the magnetic analyses performed on one of three long sediment cores collected from the site, and is to be used as a basis of slope process/sediment deposition record for the last glacial-interglacial cycle. Using the magnetic properties of magnetic susceptibility, Anhysteric Remnant Magnetisation and Isothermal Remnant Magnetisation (from 10-1000mT), the general magnetic properties of the sediment sequence have been established. Cluster analysis of the magnetic properties has been used to determine sediment groupings within the record. These results are discussed in the framework of the pollen record from the site as well as other sediment properties being investigated. The cluster groupings within the record are believed to represent different deposition environments during the last 150 000 years, and are related to vegetation cover, slope stability and fluvial processes within the catchment.

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IS AEOLIAN DUST A SOURCE OF DRYLAND SALINITY?

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The deposition of salt carried by dusts raised from the interior of the continent has been raised by many authors as a significant factor in dryland salinity (Munday et al, 2000; Melis and Acworth, 2001). Such a scenario would have widespread implications in the mapping and management of dryland salinity and, as such, requires careful evaluation.

A loess deposit in the central tablelands of NSW is well described by Hesse *et al.* (2003). Electrical conductivity results show low salinities in 1:5 soil-water extracts. Values ranging from a near surface maximum of 6.4mS/m, a mid-profile low of 1.9mS/m at 1.5m, and a value of 2.4mS/m at a depth of 3.5m. Overall the values are similar to those found by Munday *et al.* (2000) for the partly aeolian derived Marinna cutting near Junee. These levels are not unexpected considering the delivery rate of marine chlorides through precipitation and dry fallout listed by Simpson and Herczeg (1994).

The presence of two aeolian profiles with low conductivities together with the high mobility of chloride ions highlights the difficulty of proving the 'saline dust' scenario with existing soil profiles. A highly saline primary dust deposit in a crestal position is the required proof, the exact opposite of what is found. The observed salt profile is, conversely, that expected from ongoing addition to the surface and rapid leaching. For soils lower in the landscape the situation is worse, regardless of provenance, highly saline soils from lower in a catchment can be easily explained in terms of concentration of salts along the drainage lines and subsurface water tables.

The low conductivities in these aeolian deposits indicate two possibilities. Firstly that the salts associated with the dust has long since washed out and been stored lower in the landscape. Or, secondly that the salt is unrelated to the dust deposits and represents accumulation of marine aerosol salts though precipitation and dry fallout.

As yet no study has demonstrated that chloride salts found in salinised soils are sourced from aeolian dusts. Measurement of in-situ soluble salts or ratios of ions are unlikely to show whether this is the case as groundwater salt in the Murray Basin and southern Great Artesian Basin are evolved from marine aerosol input. The only possibility of proof lies in any differential in isotopic or radionuclide composition of contemporary marine salts, as compared with aged salts from the various inland closed groundwater basins. Until such a proof has been found separating marine aerosol salt from 'saline dust' salts, it is difficult to argue that aeolian dust has been a significant source of soil chlorides.

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IMPLICATIONS OF FLAT LAND-SURFACES

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Flat (planar) landsurfaces include tidal flats, shore platforms, floodplains (or parts thereof), playas, scree slopes, long rectilinear hillslopes, many gibber pavements, and duricrusted mesa-tops. The Nullarbor Plain, parts of the northwest shelf, and abyssal plains are flat. Ancient landsurfaces, perceived as having been generally flat, have been reconstructed from dissected remnants and accordant summits.

It is obvious that flatness arises in different ways: flat, vertically-accreted floodplains represent sedimentation of suspended load in floodwater whereas talus slopes represent sliding of rough particles, for example. It is less obvious that some flat surfaces are unlikely to have been generated by the processes apparently acting today, such as soil-mantled rectilinear hillslopes presently dominated by soil creep, with or without slopewash. Accordant summits on mountainous tracts can develop without any inheritance from hypothetical flat regional surfaces.

A hydrologic cycle is essential for the formation of certain classes of flat surfaces (eg. floodplains) but not for others such as high rock cliffs and scree slopes, for which tectonics is an essential requirement (but not the only one). Without an atmosphere, basalt plains may be the only large-scale flat surface. With an eye to both terrestrial geomorphology and the surfaces of other planets, this paper examines the origins and some enigmas of flat land-surfaces.

COMPARATIVELY RAPID FLUVIAL LANDSCAPE EVOLUTION, LOWER BALONNE REGION, SOUTHERN QUEENSLAND

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Aggrading fluvial systems of inland Australia are largely characterized by very slow aggradation rates and inheritance of architecture from underlying controls. Examples include the centripetal palaeovalley systems to the Eucla Basin and the "Channel Country" of western Queensland. The study area differs markedly from other, more studied fluvial successions in both these respects.

The lower Balonne River of southwestern Queensland is a tributary of the Darling system. The fluvial architecture and evolution of the region was studied as part of a salinity management program of the lower Balonne River. Salinity management issues in the region include identification or salt stores, groundwater flow paths, and areas at risk from salinisation. The study methods used to determine the architecture of the fluvial succession included regolith-landform mapping, airborne gamma spectroscopy, airborne electromagnetics (AEM) and drill data, including lithology, down-hole gamma, down-hole conductivity, and palynology. Three stages of fluvial fill have been interpreted:

Stage 1: The palaeo-Moonie and palaeo-Balonne Rivers occupy incised palaeovalleys up to 100 m below surface. The sediments transported by the palaeo-Balonne and the palaeo-Maranoa fed into the Dirranbandi trough, a fault-bounded depression that reaches depths of over 200 m below surface, and trends through the western part of the study area from north-east to south-west. There are no obvious unconformities between the three stages, indicating that the changes are due to climatic and hydrological factors, rather than changes in base level or tectonics.

Stage 2. This succession was deposited as a series of braidplain deposits of the paleo-Moonie and palaeo-Balonne Rivers. The Maranoa fan was active during this phase, depositing anastomosing channel and floodplain complexes in the west. Local bradied stream facies developed in the southern part, locally distrupting the anastomosing pattern.

Stage 3: The present land surface consists of a series of anastomosing fans, the relict Maranoa Fan, currently being laterally eroded by the Balonne River, and the active Lower Balonne and Moonie Fan systems. The fans drain from the southern highlands of Queensland, and the sediments are sourced from Mesozoic sediments of the Surat Basin, Tertiary basalts, and recycled sediments from the inactive segments of the fans. The sediments of Stage 3 are only 5-10 thick at a maximum, and probably less. The Balonne fan is encroaching on the Maranoa fan through lateral erosion, aided by sapping of the Maranoa fan edge.

Spores and pollen in the sediments indicate that the environment during deposition of the succession had approximately twice the rainfall it receives at present. Palynological dating of the sediments from the deeper parts of the Dirranbandi trough suggest that the entire succession is Pliocene and younger in age. This indicates 200 m of aggradation over the past 5 million years, 4 mm every 1000 years. The depositional architecture has changed markedly at least three times over this period, from the fault bounded basins and incised valleys of the earliest stage, to the braidplain dominant architecture of the next phase, to the present fan-dominant architecture. Each change in architecture inherited little from the previous system.

These data and interpretations have two main implications for salinity management. Firstly, salt stores in the succession are extremely young, perhaps Holocene in age, and are related to the geologically recent increase in aridity. Secondly, groundwater flow systems are likely to be complex, due to the complex and predominantly anastomosing architecture of the host succession.

LATE QUATERNARY FLOODPLAIN PROCESSES IN A PARTLY CONFINED VALLEY OF NEW SOUTH WALES, AUSTRALIA.

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The partly confined valleys of south-eastern Australia provide suitable conditions for the formation of vertically accreted floodplains with laterally stable channels. Three reaches in the Bellinger catchment in the New England Fold Belt on the mid-north coast of New South Wales (NSW) provide sites to assess the nature of Late Quaternary floodplain processes. The morphology, sedimentology and chrono-stratigraphy of confined floodplains in a bedrock-dominated landscape are investigated.

The Bellinger catchment is characterised by an assemblage of laterally stepped Late Quaternary alluvial units. Late Pleistocene terraces represent large competent rivers that reworked almost entire valley floors, however, a progressive decline in discharge since the Last Glacial Maximum has resulted in the abandonment of these deposits as elevated terraces or residual alluvium onlapped by contemporary floodplains. The Bellinger catchment exhibits complex evidence of both intrinsic and climatically induced controls on floodplain formation. What appears to have been a fluvially active period from 12 – 3 ka reworked Late Pleistocene terraces and is termed the *Nambucca Phase*. It is suggested that the *Nambucca Phase* was more fluvially active than present, but less active than the period prior and during the Last Glacial Maximum. However, there has been very little preservation of alluvium from the *Nambucca Phase* in the confined valleys of the Bellinger catchment. In this system, two floodplain surfaces, one higher than the other, both started to vertically accrete from 4 ka onwards, but with some valley locations remaining vulnerable to episodes of reworking as evidenced by substantial units of even younger basal alluvium. The high floodplain is dominated by horizontally laminated, vertically accreted sequences, while the low floodplain is characterised by pronounced somewhat coarser cut-and-fill stratigraphy. In both instances, vertical processes are the dominant mode of floodplain construction. However, an extensive AMS radiocarbon chronology, supplemented with limited OSL analyses, suggest that these two surfaces are not chronologically distinct.

To add to the complexity, polycyclic terraces and floodplains along the valley share much the same elevation but are very different in age. Alternatively, alluvial units may share the same age but vary in their elevation above the channel. Thus, the assumption that the continuity of terrace or floodplain profiles along a valley represents coeval formation is shown to be frequently invalid for such confined valleys. As such, the validity of assuming an age-to-elevation relationship in landscapes where alluvial units are clearly polycyclic is questioned. The chrono-stratigraphic evidence for the confined valleys of the Bellinger catchment clearly show variable rates of vertical accretion at different positions on the valley floor. In locations protected by bedrock spurs or Late Pleistocene terraces some floodplains exhibit vertical accretion rates of 2 – 3 mm/yr, while in more exposed settings other alluvial units exhibit vertical accretion rates of 10 – 15 mm/yr. Both floodplains may have accumulated the same volume of sediment (*i.e.* 5 – 7 m), but over very different timeframes. This would suggest that the valley fill in any given reach of a confined valley consists of a mosaic of floodplains accumulating at very different rates. Some floodplain units may record the transition from the *Nambucca Phase* to the current discharge regime at ~ 4 ka while others may simply record a more recent (*i.e* late Holocene) breaching of an intrinsic threshold.

GEOMORPHOLOGY: ITS APPLICATION FOR OPTIMAL FORESTRY

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Plantation forestry in New Zealand, of which 90% is *Pinus radiata*, currently provides approximately 12% of New Zealand's export income, 4% of New Zealands GDP and covers approximately 7% of New Zealand's land area. The ongoing management of this important and significant resource requires an increasingly sophisticated ability to predict future productivity. In addition, the ability to predict productivity from new forestry plantings would greatly assist forest management. Furthermore, demands for assessments of forestry and environmental sustainability require an increased capacity to model and predict forest productivity. Land resource information in forested lands is often inadequate or non-existent; however, it has been proposed that the information necessary for sound forestry management may be adequately provided through predictive terrain modelling in a GIS framework.

This study is based on the North Kinleith Forest near Tokoroa in the central North Island of New Zealand. This is an area of extensive plantation forestry (≈35,000 ha) situated on the southern Mamaku Plateau, an region with elevation varying from 160 to 700m asl and rainfall varying from 1400 to 2400 mm/year. The landscape of this area has evolved as a result of deposition events of ignimbrites, tephras and loess and by subsequent weathering and erosion. Broadly the landscape can be subdivided into three regions: 1. An upper plateau area of higher elevations, dominated by hillocks or hummocks; 2. Broad interfluves separated by steep-sided gullies; and 3. Rolling hills, wide valleys and rounded ridges. Previous researchers have conducted detailed soil and physiographic mapping; however, the patterns are complicated by the complex geomorphic history of the region.

Rather than attempt to represent the land surface as discrete units (e.g. a map of soil polygons) DTMs, allow the landscape to be treated as surfaces of quantitative variables. Numerous researchers have successfully applied DTMs to model landscape characteristics, such as soil attributes. This research moves beyond using a DTM to model landscape characteristics to directly modelling site quality [a measure of forest productivity] from terrain attributes. The essential hypothesis is "Is it possible to use digital terrain analysis to characterise a landscape in terms of its relative suitability as a habitat for tree growth?" This research is novel because of the resulting model's ability to rapidly and cheaply predict the relative quality of the terrain for *Pinus radiata* growth.

The final predictive model is surprisingly simple, clearly corresponds to the known controls on *Pinus radiata* growth, and has a predictive capability similar to other models using terrain attributes to predict natural resource attributes. The ability to predict site quality from terrain attributes has significant practical application, for example, the design of optimal management units, the design of fertiliser application regimes and the valuation of current and future production.

Given the importance of forestry to the make-up of New Zealand's society and economy this research clearly demonstrates the significance, usefulness and practical application of geomorphology. Of course, it also opens up a number of possible research opportunities and questions.

GEOMORPHOLOGY AND SOCIETY

Michael J. Crozier
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Keynote address

EFFECTS OF DIFFERENT FIRE SEVERITIES ON SOIL WETTABILITY: EXPERIMENTAL EVIDENCE AND FIELD OBSERVATIONS FOLLOWING THE 2001 SYDNEY BUSHFIRES

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The wettability of topsoil can influence the hydro-geomorphological response of the land surface to rainstorms. Enhanced runoff and erosion following bushfires has often been associated with a reduced soil wettability (water repellency, hydrophobicity) according mainly to North American studies. Burning can volatilize, redistribute and pyrolyze organic compounds in soils and thereby induce or enhance water repellency. For many native and introduced Australian forest types, however, the situation can be more complex as high levels of water repellency may already be present in the soil prior to burning and, where severe burning has occurred, the fire may have oxidized the relevant organic compounds, resulting in the destruction of water repellency in the topsoil.

We used (i) controlled laboratory heating experiments (T=250-400°C; in 10°C steps; duration: 5, 10, 20 and 40 mins) to determine any temperature-duration thresholds on the presence and degree of water repellency for three long unburnt soils from different eucalypt stands (*E. siberi, E. ovata* and *E. baxteri*), and (ii) in the field and laboratory we examined the wettability of *ca.* 600 long unburnt and burnt surface (0-2.5cm) and subsurface (2.5-5cm) soil samples from the Nattai Tablelands subjected to different fire severities during the Christmas 2001 Sydney bushfires.

Water Drop Penetration Time (WDPT) tests showed that water repellency was already present in the three unburnt sample types subjected to laboratory heat treatments. Repellency increased initially in all cases during heating, but was abruptly eliminated at $260 \leq T \leq 340$°C. The actual temperature for repellency destruction varied somewhat between samples, but was lowest (260-280°C) for 40-minutes and highest (310-340°C) for 5-minutes of heating. As this pattern tallies with experimental evidence from various US-based studies, it may be that these heating thresholds for repellency destruction are of general applicability.

In situ field testing and repeated WDPT laboratory tests on the same samples following air drying showed that all long unburnt surface samples were repellent, with 70% exhibiting severe to extreme repellency (> 900 s). Subsurface samples were only slightly less repellent. Repellency, as determined in the laboratory, had been eliminated in nearly half of the surface samples from predominantly severely burnt terrain and in about a third of samples from predominantly moderately burnt terrain. Subsurface repellency was somewhat enhanced for severely burnt, but for moderately burnt terrain there was little change. Contrasting with the general consensus on bushfire effects, it appears that for the mature eucalypt terrain examined in the Nattai Tablelands, the 2001 bushfires have not necessarily led to an increase in soil water repellency. Instead soils here seem to be highly repellent where long unburnt. Where subsequent burning is sufficiently severe to heat the soil above a critical threshold, however, repellency is eliminated. The hydro-geomorphological implications of these patterns are evaluated in a companion paper.

FLOW THREADS IN SURFACE RUNOFF: IMPLICATIONS FOR ASSESSMENT OF FLOW PROPERTIES AND FRICTION COEFFICIENTS IN SOIL EROSION AND HYDRAULICS INVESTIGATIONS.

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Though for convenience surface runoff has often been analysed and described as though it were composed of uniform flow, this is not the case. Rather, flow threads or filaments are characteristic of shallow flows across the soil surface, as demonstrated clearly in the classic work of Emmett (1970). Flow threads may follow the lowest track or thalweg across the groundsurface, or a relatively open and unobstructed path along which frictional drag is locally minimised. When using the simplifying assumption of uniform flow, single flow-field mean properties, such as a single effective mean flow speed or flow depth, can be estimated using methods like dye timing and the relation D = Q/WV.

New experiments made on smooth and bare soil surfaces at the Fowlers Gap Arid Zone Research Station in western NSW addressed the issue of how far real flows depart from uniformity. Runoff plots of 2 m x 1 m were fed with trickle flow at controlled rates, and distributed depth and speed observations made. The plots were selected for their evident smoothness and planarity. Any non-uniformity of flow documented on such plots ought to represent a minimal estimate of what might be found where more marked microtopography yields stronger flow concentrations.

Results show that indeed, flow threads did cross these seemingly rather uniform soil surfaces. Flow threads could be identified by their greater depth and faster flow speeds. They were clearly the paths to which injected tracer dye quickly moved. Average thread speeds were shown to average 2.5 x the flow-field mean speed, and to locally reach 6 – 7 x that value. On the other hand, non-thread flow speeds were consistently lower than the flow-field mean, typically only reaching 84% of that value. Thread and non-thread speeds formed statistically distinct populations. Mean depths on threads were 2.4 x the depth in non-thread zones (actual means across 11 runs were 3.29 mm vs 1.45 mm). The flow-field mean was intermediate in value (2.53 mm).

Overall, about 63% of imposed flow was conveyed in flow threads that only occupied about 20% of the plot width. The residual 37% of the flow was conveyed in the shallower and slower-moving 80% of the plot width that forms the non-thread zone.

Statistically distinct estimates of Darcy-Weisbach friction coefficient were derived for thread and non-thread flows. These were f = 2.23 (threads) and f = 16.2 (non-threads). The conventional flow-field mean value was f = 10.3, lying between these two values.

These results have clear implications for studies of surface runoff hydraulics and soil erosion. Since flow threads are relatively deep and fast, they are probably the main avenues for the conveyance of eroded soil particles. When their presence is concealed though a reliance on flow-field mean properties of flow, it would be unsurprising if the explanatory power of the flow data was poor. Much stronger correlations among soil loss from experimental erosion plots and flow properties may result if the flow properties used are those relating to the flow threads.

Many published estimates of friction coefficients for surface runoff, some of which are relied on in distributed hydrological models, are evidently based on field data that subsume thread and non-thread flow properties in proportions that are unknown. Such coefficients seem to be of limited value, and an increasing focus on real flow behaviour (rather than the simplifying uniform flow assumption) appears to have much to recommend it.

MASS MOVEMENT ON THE CENTRAL ELEVATED CORE OF THE MIDDLE MIOCENE CANOBOLAS VOLCANIC COMPLEX, NSW

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The following three mass movement events have been recorded recently in Canobolas State Forest:

1. a major debris slide that involved 1.3 ha on a 28.8° slope in a hillslope hollow of 1969 age class *Pinus radiata* occurred during wet conditions between June and August 1998. It resulted in a subsequent debris flow in the channel downstream of the debris slide. Temporary damming of some of the material eroded by the debris slide in the channel was effected by a series of interlocked pine trees (debris dam). Initiation of renewed movement of some of the debris as a flow was caused by a combination of liquefaction and partial failure of the debris dam soon after formation. The debris flow extended 500 m along two downstream channels.
2. two complex debris flows occurred during the night of 16/17 November 2000 after five consecutive days of prolonged rain and originated in a steep hillslope hollow of 1962 age class pine. The upper slope flow failed first where the slope angle was 33 to 35. There was no well-defined failure plane in the soil regolith. The material eroded by the upper flow was deposited in the small bedrock-confined main channel at the foot of the slope. This sediment and large woody debris caused a temporary dam which subsequently failed by overtopping, initiating a second confined debris flow downstream of the original slope debris flow. The resultant channel debris flow severely eroded the stream margins and transported many pine trees. The main channel slope was about 10 and the lower flow moved about 140 m downstream until it reached a local valley expansion on a bend where the transported pine trees wedged to form a 3.3 m high debris dam which trapped most of the mobilised sediment.
3. repeated translational slides have occurred on part of a steep (33°) cut road batter excavated into Pleistocene diamictons, which are nonsorted sediments consisting of sand and/or larger particles dispersed through a muddy matrix. The diamicton was probably formed by at least two phases of deep-seated rotational sliding of the steep slope above the road cutting.

Field assessment of mass movements in the 1962 age class found evidence of a number of Quaternary mass movements, such as an old diamicton consisting of an irregular hummocky area of cemented angular volcanic gravels; a series of at least four vertically stacked diamictons up to 2.5 m thick in a cut road batter; a very old but poorly exposed diamicton in a road cutting; and a recent (ie within last 20 years) small mass movement which crossed a road and necessitated local road works. Air photograph interpretation was conducted of an area of approximately 80 km and at least another eleven mass movements were identified in areas not hidden under a continuous pine canopy:
Detailed analysis of the Canobolas State Forest (Station No. 063018) rainfall record revealed a poor correlation between monthly rainfall and the occurrence of historical mass movements. Furthermore, rainfall intensities for known mass movements were much less than those reported overseas. A large statistically significant increase in annual rainfall was detected at the Canobolas State Forest station since 1949 and was also associated with a number of very high annual totals. However, no mass movements were recorded during these years. While mass movements do occur infrequently on Mt Canobolas, the risk is minor, even during extended wet periods.

DO DIFFERENT GEOMORPHIC FEATURES CREATED BY THE SAME GLACIATION GIVE THE SAME EXPOSURE AGE?

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The aim of this project is to determine the rate of retreat of the Fennoscandian ice sheet from the Younger Dryas limits in northern Norway to the terminal limits in the northern Swedish mountains. The north to south retreat history is poorly constrained due to a lack of datable material. We are working to provide new constraints on the timing and pattern of deglaciation using cosmogenic nuclide apparent exposure ages.

The work involves mapping and dating depositional and erosional geomorphological features related to the former ice sheet margin. Because the ice sheet initially had warm-based conditions close to its margin, the dominant morphology is one of eskers and aligned lineation systems, such as crag-and-tails. Abundant meltwater eroded bedrock locally to considerable depth and deposited fans or deltas perched above current local base levels. However, subglacial conditions during final deglaciation were generally cold-based, inhibiting the formation of eskers and lineation systems, although there are widespread (lateral) meltwater channel erosional imprints and occasional plucking scars.

Each geomorphological setting was examined for its value in providing deglaciation ages, testing the initial assumption that, (i) abundant erosion on crags of crag-and-tails, across transverse erosional scarps, and in meltwater channels has exposed bedrock surfaces without a prior exposure history and (ii) depositional features contain embedded boulders without a prior exposure history (on the surfaces of eskers and deltas, and erratics). Preliminary results indicate that meltwater channels, transverse erosional scarps, and erratics yield deglaciation ages that are consistent with the limited ages provided by other methods, but that crag-and-tails yield apparent exposure ages that are too old, presumably because of a prior exposure history that was not fully removed by glacial erosion.

TESTING THE VALIDITY OF MINERAL MAGNETIC ENHANCEMENT OF AUSTRALIAN EUCALYPT SOIL AS AN INDICATOR OF BURNING: A CONTROLLED LABORATORY SIMULATION OF DIFFERENT HEATING SCENARIOS

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Mineral magnetic enhancement of soil particles has been viewed as an indicator of burning. The temperature thresholds at which magnetic changes occur, are based on the findings of relatively few studies, conducted largely in Europe. These have shown initial enhancement beginning at temperatures of 100 - 200°C, with additional modifications being apparent around the Curie Point of magnetite (577°C), while peak levels of enhancement have been shown to occur at 950°C. A thorough understanding of temperatures required to change magnetic properties is important for sediment fingerprinting purposes in erosion-based studies and may also allow reconstruction of soil temperatures reached during a fire.

This study examines the effect of heating temperature and duration on the magnetic enhancement of long - unburnt soil from the Lake Burragorang catchment in the Natti Tablelands, NSW, through laboratory-based experiments.
Mineral magnetic susceptibility (χ) was found to be most strongly affected by the different heat treatments. Significant enhancement occurred above 550°C, increasing with higher temperatures. A peak was reached for 20 and 40 minute heating durations at 750°C, followed by some decline. Different heating times caused greatest variation in χ at 650 and 750°C. The changes are thought to be caused by modification of grain sizes and mineral composition, according to the various magnetic parameters measured. Results suggest that for the material examined here, mineral magnetic enhancement can be used to identify soils that had experienced burning, but only where fires have imparted soil temperatures in excess of 550°C. The results also demonstrate that differences in χ may also be caused by differences in heating duration for the same soil temperature.

GEOLOGICAL AND PHYSIOLOGIC CONTROLS ON EROSION AND SEDIMENTATION FOLLOWING THE JANUARY 2003 BUSHFIRES IN NORTHEAST VICTORIA

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Bushfires in January 2003 burnt over 1.1x10 hectares in northeast Victoria, the largest burn in the region since 1939. Intense localised rainfall events in late February 2003 led to widespread erosion and sedimentation, which varied in type primarily as a function of geology and physiology.

Intense thunderstorm cells produced heavy rainfall on February 26 and 27 in the upper Buckland River and Omeo districts, both of which had been extensively and often severely burnt. The upper Buckland River area is composed of Paleozoic metamorphic rocks, forming rugged hill country on a dendritic drainage network, with most slopes between 25-35°. Erosion products are dominantly silt and gravel. The geology of the Omeo region is Paleozoic sediments and granites, forming a series of ranges with steep (20-35°) upper slopes above 5-15° lower slopes and basins. The drainage network fits most closely with the rectangular category. Erosion products from the steep granitic slopes are dominated by sand, with silt and clay sized particles a secondary component.

The upper Buckland River area received heavy rain on 26 February from a single thunderstorm cell. Silt-sized particles were transported by slopewash into streamlines, and gravel, silt and clay were sourced from colluvial deposits in first, second and third order streamlines (Strahler classification). Gullies up to 2.5 m deep and two metres wide were cut into these cohesive streamline colluvial stores, rarely incising to bedrock. The deposits of these events where emplaced in the lower part of second and third order streamlines and the trunk streamlines of the Buckland River and Dingo Creek, a major Buckland River tributary, where the valley floor gradient is less than 15°. Debris flow deposits reached the trunk streams, disrupting the channel course with gravel deposits up to four metres thick. These coarse deposits are being reworked as low flow channels incise the surface of the debris flow deposit. The steep streamline gullies will expand and release gravel and mud-sized sediment. A fine grained sediment slug entered the Buckland River, and took six days to travel down the Ovens River to Wangaratta where it severely impacted the town's water supply.

Intense rainfall fell around Mt Sam north of Omeo town in late February. Sandy soils were readily eroded from the burnt forested upper slopes and sediment was transported into first and second order streamlines and directly downslope onto the 5-15° lower slopes, where sandy floodouts were deposited. Gully floors and sidewalls on steep upper slopes were eroded to bedrock. A fine grained sediment slug filled Livingstone Creek pools. Deposits of well sorted sand were emplaced as sheets on floodplains adjacent to third and fourth order channels, and up to a metre thickness of sand was deposited within these channels. These sand deposits are being reworked by moderate rainfall events.

Lithology is the key control over the type of sediment produced, with granites producing sand in the Omeo region and metamorphic rocks producing gravel and silt. The dendritic drainage network in the Buckland River funnelled sediment from slopewash and gullies on first and second order streamlines to the trunk Buckland River via steep third order streams, producing a limited number of debris flow deposits. In contrast the more rectangular drainage network in the Omeo region has numerous first order catchments that produced floodouts and direct sand contributions to the fourth order Livingstone Creek. Therefore sediment was not only deposited in major streamlines but also in numerous deposits on the lower slopes of the Mt Sam area.

These geological and landscape controls have produced differing types and geomorphic distributions of sedimentary deposit, which need to be managed accordingly. Appreciation of these controls will aid planning responses to reworking and depositional events, which will continue until existing deposits are stabilised.

GEOMORPHOLOGY AND THE BIOTA

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There is a broad acceptance by earth and environmental scientists that the biota are an important factor determining landscape processes. Recent work in the CRC for Landscapes, Environment and Mineral Exploration has led to a focus on the variety of ways that biota interact with regolith and landforms, in fact geomorphology. Biota are both a part of the landscape, and a factor controlling the functioning of that landscape. The functioning of the biota is also critical to the management of landscapes across all timescales from short term human scales to geological timescales. Biota also function across virtually all spatial scales from the microbial to the continental. In fact, biota can be argued to make the earth different from all the other planets, solar systems, galaxies and so on.

Ever since the seminal work of the Russian scientist Dockuchaev in the late 1880's, there has been a recognition in pedology that forests and grasslands have very different weathering and leaching regimes and therefore effects on the soils, regolith and landscape. Similarly, fundamental relationships used in land management such as the USLE include factors which are a combination of biotic effects.

Recent studies into the interactions between biota and the regolith are adding quantitative information to further support our understanding of the processes in landscapes. The soil in which vegetation grows can carry a "signature" from that vegetation for considerable periods of time and different species have different signatures. Soil along a transect between two species of trees, shows markedly different characteristics near each tree bole, in the area affected by stemflow, under the drip zone and in the intervening area. Many of these patterns in soil are strongly related to root growth, leaching and weathering as the result of the selective uptake of elements by the vegetation, the cycling and subsequent deposition in precipitation and litterfall. Trees take part in more obvious bioturbation when uprooted rotating the rootball and bringing subsoil up to the surface.

Studies in forest science suggest that the quantities of material contained in the biota and turned over by vegetation are also of comparable time and spatial scales. Catastrophic events such as fire can then transfer very large quantities of materials within landscapes and become major land forming events

Meso and macro fauna transfer material at rates comparable to weathering and regolith production; and comparable to rates of erosion and deposition. Wombats, kangaroos, wallabies, lyrebirds, and rabbits all can move substantial quantities of material at particular places and times. Collectively they are a major bioturbation factor. Smaller fauna such as earth worms, termites, ants and other insects are also important in bioturbation and again the dominance of one or more groups depends on the environment and timescale. Termites are very important in the seasonal tropics right through to the humid temperate, while earthworms, particularly natives are quite rare in some humid temperate forests such as the dry sclerophyll.
The micro biota are also incredibly important and despite their very small size, sheer numerical dominance makes their weathering and bioturbation effects important in most landscapes.

In summary the biota are critical to landscape processes.

EVOLUTION AND DYNAMICS OF DUNES IN THE LAKE FROME REGION, SOUTH AUSTRALIA

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The timing and dynamics of dune formation remains an unresolved problem in understanding desert regions. The geomorphology of longitudinal and transverse dunes of the Strzelecki Desert northeast of Lake Frome forms the focus of this study. The geomorphic evolution of the area has been interpreted based on the morphology, sedimentology, stratigraphy and optical dating chronology of the dunes.

The Strzelecki dunefield, as with much of the Australian continental dunefield, is a fossil landscape comprising stable dune forms, some with active crests. The longitudinal dunes in the vicinity of Lake Frome have a close spatial relationship to the transverse dune systems (lunettes) observed in the area. This relationship is evident from both high spatial resolution ASTER satellite imagery and observations in the field. Within the study area northeast of Lake Frome, four transverse dune systems are clearly delineated on satellite images and are oriented approximately north-south. Crests become successively more irregular to the east and develop into northeast trending parabolic forms. These forms appear to be a hybrid between transverse and longitudinal dunes, with the longitudinal dunes oriented east-northeast to west-southwest further east, downwind of the lunettes. There is therefore a strong morphologic indication of a genetic relationship between the dune types. Individual longitudinal dunes appear to derive from different crestal lines within the lunette systems, implying different stages of initiation of the longitudinal forms.

Mobile dune crests have diverged northwards from the main fossil dune trend and reflect the current southwesterly direction of sand shifting winds. In addition, modern quartz sands have accumulated on the northern flanks of the longitudinal dunes. These observations confirm a directional difference between dune building winds at the time of formation, and those responsible for sand movement today, since longitudinal dunes are assumed to form parallel to the resultant vector of the sand shifting winds.

The stratigraphy of the dunes was determined from eroded blowouts, which generally occur on the more steeply dipping southern flanks, and from rare section exposures, and gave information about episodes of dune activity and pedogenesis. Dune mineralogy is dominated by the quartz fraction, along with minor fresh feldspars and heavy minerals. Additionally, palaeodune sediments within both the longitudinal and transverse dunes have a significant clay component derived from the clay-rich interdune swales and elongate clay flats. This has important hydrologic implications requiring relatively high water tables to assist in clay deflation.

Optical dating has defined a chronology of the longitudinal and transverse dunes within the field area. The results indicate a temporal as well as spatial relationship between transverse and longitudinal dunes in the region. Three palaeodune horizons were sampled within a transverse dune and yielded ages of approximately >100ka (saturated), 57ka and 22-14.5ka (from base to top of horizon). Ages of approximately 35ka and 11ka were derived from samples within two palaeodune horizons of a longitudinal dune. The 35ka sample represents a palaeosol which was stratigraphically correlated with the middle (57ka) undisturbed horizon of the transverse dune. The horizons dated at approximately 57ka and 20ka have been tentatively correlated with increased aeolian activity elsewhere on the Australian continent, and glacial periods interpreted from ice core data in Antarctica. The last major dune building event around 11ka yielded the most precise dates, and suggests a significant change to arid conditions conducive to dune building. Other regions of Australia have not yet been shown to reflect similar dune building events or aridity around this time; this episode therefore warrants further investigation, and may have significant implications for the understanding of climatic and environmental evolution.

LATE PLEISTOCENE GEOMORPHOLOGICAL INTERPRETATION OF CAVE STRATIGRAPHY FROM NARACOORTE, SOUTH EAST SOUTH AUSTRALIA

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The Naracoorte Caves have acted as pitfall traps accumulating sediments and animal remains for more than 400 k years. The caves contain a unique record of faunal and environmental change during the global climatic oscillations of the late Pleistocene. The entrance configuration as well as landscape position of a cave can bias the faunal accumulation as well as the sediment record. This study compared the sedimentary and stratigraphic record from two caves located 10kms apart on the same limestone ridge.

Our aim was to determine whether the known climatic events that affected south eastern Australia during the Late Pleistocene and Early Holocene could be detected in the stratified sediments filling these two widely separated caves or in other words whether the climate signals were strong enough to overprint any variability in entrapment due to entrance type or location. The outcome is critical to any correlation of faunal stratigraphic differences to climate change.

Pits excavated to a depth of five metres in the sediment fans extending from the base of the sediment cones filling Wet Cave and Robertson Cave are known to span the approximate periods 0.7 ka to 45 ka and 8 ka to 32 ka respectively (14 C dating). Strata at the base of each pit (>25,000 B.P) consisted of sands with a significant silt component indicative of relatively stable surface conditions outside the caves. Moving up-section approaching the Last Glacial Maximum (17,000 B.P) the strata changed to coarser aeolian dominated homogeneous sands. Post the LGM sand, charcoal and organic content of the sediments increased corresponding to the wetter and warmer conditions experienced during the commencement of the Holocene.

δC, δN, Sr87/86, XRF Bulk Rock Chemistry, XRD clay mineralogy and C Nuclear Magnetic Resonance (NMR) analyses were also undertaken on the cave sediments. δC values on soil organic matter become more depleted in C (from -24‰ to –26 to -27‰) heading into the Holocene. This shift is interpreted as a vegetational response to the onset of warmer and wetter conditions that were experienced at this time.

Although the stratigraphic sequence is similar in both caves, the timing does vary somewhat between the two with Robertson Cave producing older ages for similar strata. This may be the result of sporadic inputs of sediment and fossils, a result of different phases of blocking and unblocking of the two entrance shafts or variation in local soil-vegetation conditions

Lower in the Robertson Cave profile at 32,000 B.P, δN values of between 12‰ and 15‰, combined with the presence of phosphorous dominated minerals Whitlockite and Apatite and a decompositional organic matter signature revealed by NMR suggests a faecal origin most likely produced by bats inhabiting the cave during periods of minimal depositional input (ie. better vegetation cover).

Strontium 87/86 isotope ratios were determined in an attempt to trace the source(s) of the fine-grained cave sediments. Variations in Strontium 87/86 ratios varied from 0.7238 at 23,850 ± 1020 to 0.7253 at 14,150 ± 350 for Wet Cave and 0.7255 at 13,650 ± 70 B.P to 0.7225 at 8,080 ± 100 B.P for Robertson Cave suggesting that as the interglacial was reached and passed the source of the aeolian input changed, possibly from a regional to a more localised source.

SEDIMENTARY CASCADES IN AUSTRALIAN RIVER SYSTEMS: USING EXAMPLES FROM THE BEGA AND HUNTER CATCHMENTS TO DEMONSTRATE THE (DIS)CONNECTIVITY OF SEDIMENT MOVEMENT AND ITS IMPLICATIONS FOR GEOMORPHIC RIVER RECOVERY

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The nature and rate of lagged and off-site responses to geomorphic change varies from catchment to catchment, based on the pattern of connectivity of sediment movement within a catchment. To assess sedimentary cascades in a meaningful manner, the connectivity between different landscape compartments must be assessed.

Two primary types of sedimentary linkages occur in landscapes, longitudinal and lateral. Longitudinal linkages include upstream-downstream or reach-to-reach relationships as well as tributary-trunk stream interactions. Lateral linkages are slope-channel and channel-floodplain connections. These linkages can be coupled or decoupled depending on the nature of the landscape in which they operate. At any point in the landscape a series of buffers and/or barriers can disrupt sedimentary linkages. Buffers are defined as landforms that prevent sediment from *entering the channel network* by placing it in storage. Once sediment is in the channel network, barriers can disrupt sediment moving along the *channel network* by placing it in storage.

If barriers and buffers are prevalent in a catchment, they can effectively disconnect or decouple large areas of a catchment from the primary sediment cascade. The degree to which a barrier or buffer has this effect dictates the 'effective catchment area', which is defined as the catchment area that directly contributes to, or transports sediment along, the primary sediment cascade. Effective catchment area describes the degree to which the catchment is longitudinally and laterally connected, and can be assessed both spatial and temporally.

This notion of effective catchment area, whereby only those areas of the catchment that are coupled or connected have a direct impact on the sediment cascades within a catchment, is critical for assessing which parts of catchments are sensitive to change and are most likely to induce off-site geomorphic responses (either positive or negative). This has significant implications for assessing geomorphic river recovery potential. This paper will describe forms of (dis)connectivity and present two catchment-scale assessments of landscape (dis)connectivity as a means for describing the nature of linkages and sediment cascades and their implications for river recovery potential. The Bega and Hunter catchments will be used as examples.

EVALUATION OF NUCLEOGENIC COMPONENT IN COSMOGENIC ^{21}NE SURFACE EXPOSURE DATING

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The cosmogenic nuclide Ne is produced in rocks near the ground surface by reactions with secondary and tertiary cosmic ray neutrons and muons, and it can be used as a chronometer of various geological events, with important implications for geomorphology. In order to accurately determine the amount of cosmogenic Ne (Ne-c) in a sample it is necessary to correct for nucleogenic Ne (Ne-n) potentially present in a sample, which is produced mainly by O(α,n)Ne reaction, where α is generated from U and Th in the crust, and subsequently incorporated into the sample during its crystallisation.

We have analysed three silcrete and six quartzite samples at the surface from the Central Australia for all five noble gases. Most of the samples showed excess Xe (fissiogenic), relative to atmospheric. Because of low U content (<5 ppb) in these samples, the Xe-sf have not been produced in the samples after their crystalisation, but have been incorporated during their formation. The presence of Xe-sf in the samples indicates that the corresponding amounts of crustal Ne-n are also in the samples. We have calculated Ne-n contents from the amounts of Xe-sf in the samples using the crustal production ratio. Subtracting Ne-n from the non-atmospheric Ne yields the amounts of Ne-c. Based on this approach, we estimate as high as 70% of the non-atmospheric Ne in the samples is nucleogenic.

The amounts of Ne-c, after the correction of nucleogenic neon, are compared with cosmogenic Be. Most of the samples showed long exposure ages (>1 Ma) and low erosion rates (<1 m/Ma). Among these results, three data lies below the steady-state erosion curve on a Ne – Be/Ne plot. This implies that the sample may have been experienced a burial event or may show pre-irradiation history.

LATE PLEISTOCENE CALCAREOUS AND SILICEOUS AEOLIAN AND ALLUVIAL FAN DEPOSITS, CAPE LIPTRAP, SOUTHEASTERN VICTORIA (POSTER)

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Cape Liptrap, projecting into the Southern Ocean, lies at the boundary between predominantly siliceous (east) and calcareous (west) dunefields. This location, the well-exposed nature of the dunes along coastal cliffs, and optically stimulated luminescence (OSL) and radiocarbon ages allow for the reconstruction of late Pleistocene palaeoclimates and depositional environments.

Nine overlapping calcareous aeolian units, totalling 40m thick and separated by palaeosols, are exposed in sea cliffs at Arch Rock. The sand fraction contains 31-56% carbonate fossil fragments. Thick (5-15m) tabular cross-beds sets indicate transport by westerly winds. OSL ages range from 89 ka to 68 ka. Immediately to the south, along Morgans Beach, alluvial fan deposits 20m thick are exposed in sea cliffs, and consist of generally horizontally bedded calcarenite sands eroded from the aeolianite beds. These sands coarsen upwards into lenses of angular gravel derived from local bedrock highs, interbedded with and overlain by laterally extensive finely laminated clay. Minor, thin (<1m) tabular cross-beds indicate southerly transport. The alluvial fan unit (4 OSL ages 23-25 ka) is overlain by a prominent palaeosol (C age 5.2 ka) and underlain by a peat (C age 21 ka), which in turn overlies a marine terrace sand (OSL age 122 ka).

Along the eastern side of Cape Liptrap a siliceous dune field caps a flight of marine terraces that extend up to 160m asl. Longitudinal and parabolic dunes indicate transport by westerly winds, with a local sediment source from the marine sand on the exposed terraces. Five OSL ages for the dune field range from 19 to 21 ka.

We propose that calcareous aeolian deposition began during sea level fall after the last interglacial marine highstand (OIS 5e). Temperate westerlies transported calcareous sand from the increasingly exposed continental shelf, especially during sea level rise OIS 5a. Aeolian deposition continued at Arch Rock into early OIS 4. The southeastern coast experienced an increasingly cold, arid, windy climate and flashy surface runoff conditions during OIS 2 (Last Glacial Maximum), that resulted in redeposition of the calcarenites into alluvial fans, and aeolian reworking of the siliceous marine terraces by predominantly westerly winds.

WHAT YOU SEE IS NOT ALWAYS WHAT YOU GET: RIVERBANK EROSION RATES AND PROCESSES ON THE KIEWA RIVER, N.E. VICTORIA

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Little information is available on the rate of riverbank erosion that occurs in Australian streams. Large scale studies, such as the SedNet model, have had to approximate rates based on simple theories and assumptions, such as all riverbanks in a catchment are three metres high. The result is that catchment sediment budgets are left with a very poorly understood component resulting from riverbank erosion. This paper seeks to address this problem by looking at the rates of erosion throughout a largely unregulated river system, the River Kiewa, in order to investigate catchment scaling in rates. Processes of riverbank erosion are also identified, and combined with the rates, giving some indication of magnitude and frequency of erosion events during the 20 month measurement period.

Five actively eroding sites throughout the catchment have been monitored by installing them with over 150 erosion pins. These sites are used to infer the upper end of erosion rates that would occur in the system. These sites have been put into context by kayaking the catchment and observing the size, frequency, and processes at other eroding sites.

Erosion pins have been measured at approximately a monthly interval with erosion epochs resulting containing > 1500 readings. Site average rates of erosion for different epochs have ranged from 0, in the summer months, up to 36.1 m a, during the winter. This highlights the distinct seasonality in erosion rates.

The processes of erosion that have been observed, and monitored, may be classed into three different types: (1) Sub-aerial erosion and preparation caused by desiccation and frost action; (2) Direct fluvial entrainment; and (3) Mass failures including cantilever and slab failures. Generally it is considered that the largest failures must be the most important in terms of sediment delivery to the stream. This stems from the fact they are big and also easily identifiable.

Whilst mass failures appear to contribute large volumes of sediment to the channel the contribution from desiccation may be more significant to the sediment load of the river. During low flow situations the sediment entering the river is derived from in-channel sources, as opposed to sources such hillslope runoff. Thus the small changes in flow during the summer that are sufficient to entrain the friable sub-aerially prepared material are one of the few sources of sediment. The desiccated material is more widely spatial distributed than mass failures, and therefore cumulatively it may be significant, despite being delivered to the channel at lower rates. The supply of desiccated sediment may therefore be an important control on the variability in suspended sediment during low flow scenarios, affecting both instream biota, and the input to drinking water supplies.

ORGANIC MATTER DISTRIBUTION ALONG THE KANGAROO RIVER, NSW

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Understanding organic matter dynamics is fundamental to appreciating ecosystem functioning and is imperative for all river rehabilitation programs. While organic matter dynamics have been researched for decades, there still lacks a comprehensive understanding of the storage, retention and reworking of organic matter and how this relates to the geomorphic structure and function of river systems. A geomorphic approach to river characterisation is used to assess the physical template underlying ecological associations for different River Styles along Kangaroo River, a disturbed coastal river in New South Wales.

Three River Styles were identified; a confined valley setting with occasional floodplain pockets, partly confined valley setting with bedrock controlled discontinuous floodplain pockets; and an alluvial valley setting with a low-moderate sinuosity gravel bed river. Each River Style was found to differ in its geomorphic structure and consequently stored varying amounts of organic matter. The greatest volume retained was in the partly confined River Style with a volume to area ratio of 4.66m/m, followed by the alluvial River Style with 2.51m/m then the confined River Style with 1.71m/m . The bedrock controlled section of the partly confined River Style stored the greatest volume of all reaches with 7.96m/m while the floodplain pocket section of the same River Style retained 4.09 m/m.

A hierarchical set of control determines the distribution of organic matter stores in this system. The degree of organic matter storage and reworking for each River Style is controlled by the energy of the system, reflected in the diversity of geomorphic features that enable trapping and retention. Slope and stream power control the occurrence of geomorphic units and ultimately the type of substrate and availability of flow types. The distributions of aquatic stores are a function of both substrate and flow type while the distribution of terrestrial stores are a function of frequency of inundation and stream power. This work emphasizes the inherent link between geomorphology and ecology in fluvial systems.

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IDENTIFICATION OF CONTRIBUTING AREAS FOR PHOSPHORUS EXPORT

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Eutrophication of rivers and streams caused by excessive nutrients – such as phosphorus (P) – is a widespread problem. In East Germany the situation has improved significantly after the reunification. Many point sources like industrial sites were closed down and sewage plants were modernised. But although nutrient export from point sources has declined, export from non-point source has changed little. In order to take effective measures to reduce nutrient input into rivers, quantification of diffuse sources is required. The EU Water Framework Directive (EU-WFD) further requires a catchment based approach to river basin management. This also necessitates a catchment based approach to assess nutrient dynamics.

In this paper, only phosphorus (P) is considered. P can be transported in dissolved or particulate form, mainly by surface runoff. Surface runoff generation is highly variable in space and time and depends on factors such as rainfall intensity, antecedent moisture condition, infiltration capacity, and slope angle. Most of the available erosion or nutrient transport models work on a small scale (slope, zero order basin). If they describe the transport processes physically, they usually require a large number of parameters. Due to their high demand on data as well as computing time those models are not applicable in meso- or large scale catchments (here: Weiße Elster catchment, 5300 km²). Therefore, a different approach is employed in this study. Based on hydrologic and topographic properties of the catchment areas critical for P export are identified. Those areas linked to a river or streams by water or sediment transport are considered contributing areas.

Besides soil types and land use mainly slope angle is the main controlling factor for overland flow and associated sediment transport. Based on the computer model EROSION 2D using a variety of land uses and rainfall intensities, critical slope angels for sediment export can be determined. Areas with slope angles too low to generate sediment export are considered as sediment sinks of the catchment and the part of the entire catchment draining into these (low gradient) areas is therefore decoupled of the river.

All other areas are contributing areas for P export to rivers and streams. A hydrologic model based on hydrologic response units (HRU) delivers overland flow depths which in turn is required to calculate the amount of sediment transported.

WHAT CONTROLS THE ACTIVITY OF DESERT SAND DUNES IN AUSTRALIA: VEGETATION OR INSUFFICENT WIND?

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Previous studies of the mobility of Australian desert sand dunes have suggested that under modern climatic conditions there is insufficient wind to mobilise the dunes rather than excess vegetation cover. This conclusion has had profound effects on how we understand the degree of climate change (in the past or future) required to mobilise the dunes and on the management of the dunes themselves and how land use may affect wind erosion and sand drift. There is a wealth of anecdotal evidence that in the severe droughts of the 1890s and 1930s-40s 'sand drift' was widespread in parts of the Simpson, Tirari and Strzelecki deserts as well as the more clear cut cases of land degradation in the Murray Mallee dunefields. At least two studies of sand movement on Strzelecki sand dunes have shown high rates of movement under modern climate conditions. The relationship between protective vegetation cover and sand movement on Australian desert dunes, however, does not appear to have been studied in any great detail.

This paper presents the results of a preliminary study of the relationship between vegetation and sand movement on sand dunes in the Simpson and Strzelecki deserts at the end of the 2001-2002 drought. The crests and flanks of clay-poor dunes at three sites along a climatic gradient were examined to sample a range of vegetation densities. All dunes were found to carry a high vegetation cover, above that normally associated with sufficient to stabilise sandy surfaces. However there was strong evidence of sand movement on all sand dunes ranging from ripples to mounds to slip faces. These morphological features, the cover of ripples and the cover of deep loose sand on the surface were found to have a strong linear relationship to the protective plant cover (% of dune surface), without any threshold evident between 100% and 48% cover. Therefore there is a small degree of sand movement when any part of the dune surface is bare, however the volume of mobile sand increases dramatically as the bare area increases (as a power function). The transition to 'active'dunes, with mobile slip faces and substantial reworking to depth, appears to occur at around 50% protective cover.

These results represent the condition of the dunes at one point in time, at the peak of the drought cycle. Over timescales of several years the vegetation cover, and presumably sand movement, is highly variable. The two more arid sites retained little green vegetation, much dead vegetation and evidence of prior nearly complete cover with annuals from the previous wet cycle. In addition, the flanks of the dunes were protected by extensive cyanobacterial mats, which appear to be strong enough to withstand saltation bombardment but are damaged or destroyed by hoofed grazing animals. The true protective cover is much greater than the cover of vascular plants (perennial or annual; living or dead) and the mats are probably responsible for the overall relative stability of most dunes. On the other hand, there are abundant examples of the potential for the wind to mobilise large areas of the desert dunes where the vegetation/surface is disturbed, either by grazing, roads or seismic survey.

There is now, in addition, strong luminescence dating evidence of the widespread late Holocene activity of Simpson Desert dunes; under wind regimes very similar to today. Therefore LGM winds need not have been stronger to activate dunes anywhere in the continental dunefield, but vegetation must have been more sparse, at least for intervals of years or decades.

AEOLIAN-FLUVIAL INTERACTION: LATE QUATERNARY CHANNEL CHANGE AND DUNE FORMATION IN THE SIMPSON DESERT NEAR ALICE SPRINGS, AUSTRALIA

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In central Australia the most easterly extent of the MacDonnell Ranges borders the northwestern Simpson Desert where widely spaced strike ridges intercept and deform the regional linear dunefield. Topographic basins have disrupted regional drainage lines and isolated dune sets from the main dunefield. In the western part of Camel Flat basin large, red-coloured linear dunes of fine sand, with basal ages ~ 74 ka and older, are oriented almost due north. Through gaps in the ranges the Todd River traversed the eastern part of the basin from at least 75 ka until ~25 ka when it apparently avulsed ~25 km eastwards to somewhere near its present position. Subsequently, linear dunes, smaller, lighter in colour and coarser-textured have prograded onto the abandoned floodplain in the basin at rates of about 0.25-0.35 m a and with orientations ~30 west of north. This new alignment suggests a latitudinal shift in Australia's wind patterns by some 160 km or 1.5 since the Last Glacial Maximum (LGM). Ground penetrating radar shows that these younger dunes have shifted slightly eastward off their Pleistocene cores during the Holocene, evidence of a further wind shift. Where dunes free of fluvial interference ramp onto the southern footslopes of the bedrock ridges they yield ages of at least ~65 ka, similar to the large red dunes well away from the palaeofloodplain in the western part of the basin. Recognition of major Late Quaternary channel avulsion in this region supports earlier investigations undertaken nearby by Bourke (1998).

It appears that aeolian dune activity has characterised this part of the Simpson Desert for most of the Late Quaternary, with linear dune orientation a function of both the shifting position of the 'wind whorl' in central Australia and aerodynamic deformation proximal to the ranges. These results highlight the difficulty of separating the impacts of climate change, catastrophic flooding, aerodynamic deformation and river avulsion due to aeolian damming as possible causes of Quaternary landscape change in the ranges of central Australia.

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THE GEOLOGY AND GEOMORPHOLOGY OF ZHARAT ADH DHRA', DEAD SEA PLAIN, JORDAN

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Situated in central west Jordan, the Zahrat adh-Dhra' region is located along the southeastern coast of the Dead Sea, on the Dead Sea Plain, and is bordered to the west by the Lisan Peninsula and to the east by the Jordan Valley margin. Geological investigation of this area was undertaken as part of the 'Archaeology and Environment of the Dead Sea Plain' project, a multidisciplinary study aimed at building on current understandings of the natural and cultural history of the Dead Sea Plain.

Detailed mapping of Zahrat adh-Dhra' identified three major formations, the oldest of which is the Eocene Umm Rijam Chert-Limestone Formation (URC), a foraminifera-rich limestone containing lensoidal beds of chert. Disconformably overlying the URC is the Oligo-Miocene Dana Formation, a series of poorly sorted, chert-limestone conglomerates, carbonate rich sandstones and marls deposited in a lacustrine fan delta environment. Extensive faulting of these beds has produced variously tilted blocks, some of which are capped by the well-lithified chert conglomerate beds to form resistant ridges. In turn the Dana Formation is unconformably overlain by the Pleistocene Lisan Formation, composed of poorly consolidated gravels, sands and laminated marls that accumulated in and around Lake Lisan, the precursor to the Dead Sea. The contact between the base of the Lisan Formation and the top of the Dana Formation is sharp, the gravels of the Lisan Formation mantling the pre-existing topography.

Zahrat adh-Dhra' is divided into three geomorphic regions; the Dhra' Monocline, which is characterised by steeply dipping beds of the Umm Rijam Chert-Limestone Formation and the Dana Formation, the westerly dipping Dhra' Plain composed largely of Lisan Formation gravels overlying the Dana Formation, and the Zahrat adh-Dhra' (ZAD) Triangle, characterised by a badlands topography, displaying flat-topped ridges located between deeply incised wadis (gullies). The dominant drainage direction within Zahrat adh-Dhra' is westerly, towards the Dead Sea, which represents the regional base level.

A contour map of the base of the Lisan Formation shows pre-Pleistocene channels present in the western half of the study area, indicating a period of incision before deposition of the Lisan Formation in the Late Pleistocene. These channels in contrast to the present day drainage, are absent from the eastern half the Zahrat adh-Dhra' region. Faulting has greatly affected the landscape at Zahrat adh-Dhra'; normal movement along pre-Pleistocene faults has produced the tilted blocks of the Dana Formation. Two major offset surfaces located on the southern bank of Wadi Kerak are a result of recent (Holocene) faulting, and have displaced the Lisan Formation and underlying deposits, leaving WNW- and NW-trending escarpments of up to 10m. Post-Pleistocene offset either side of Wadi adh-Dhra' is also recognised.

Located within the ZAD Triangle are two archaeological sites; a Pre-Pottery Neolithic A (PPNA) settlement dated to 9,500 yrs BP (ZAD 2) and 200m to the south, a Middle Bronze Age (~4,000-3,500yrs BP) village (ZAD 1). Both these sites are situated on flat-topped ridges within the ZAD Triangle and have undergone erosion as a result of incision by Wadi adh-Dhra', which follows the strike of a NW-SE trending fault. Erosion of these sites by Wadi adh-Dhra' indicates that the major period of incision within Zahrat adh-Dhra' occurred after 3,500 yrs BP. A comparison of previously interpreted Dead Sea level fluctuation with the geological timing of erosion through ZAD 1 and ZAD 2, combined with other archaeological and geological evidence, suggests that base level changes did not trigger the incision within Zaharat adh-Dhra'. Instead the occurrence of Wadi adh-Dhra' in the vicinity of a major fault, combined with evidence of significant surface displacement either side of Wadi adh-Dhra', points towards tectonically induced incision.

NATURAL HAZARD AND RISK EVOLUTION IN WELLINGTON, NZ – SURVIVAL OF THE FITTEST? -

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Natural processes, such as landslides, are not unusual events. They only become hazards if they adversely affect life, livelihood or other human values. When these values are threatened a condition of risk exists. Consequently, assessing risk associated with natural hazards must integrate aspects of both natural and social science. However, a single-disciplined view still dominates current landslide hazard and risk research. Integrative projects have been suggested from time to time, but these are rarely realised. Furthermore, a static approach is generally pursued that ignores the temporal and spatial development of natural hazard and risk. Commonly, maps of landslide distribution or terrain susceptibility show spatial variability only. These maps serve as basis for regional planning, but do not contain any indication of temporal dynamics within the geosystem. Similarly, maps of the actual risk level do not address the evolution of factors that affect risk and therefore dynamics of the social system are not represented.

The current project proposes to analyse the temporal variability of landslide risk within a given region. Wellington city is chosen as the principal test site to develop and verify the concept. Landslides represent the second most serious hazard in the city. Additional rural sites in the surrounding area will be included. The time period under consideration encompasses several decades.

In natural sciences, the level of risk (R) is calculated by multiplying the three factors natural hazard (H), elements at risk (E) and vulnerability (V): R = H x E x V. Parameters reflecting the sensitivity of the geosystem (natural hazard) and the social system (vulnerability) are identified and extracted from accessible databases. Data on the spatial distribution of the elements at risk and their maximum damage potential are essential.
The estimation of hazard requires several different sources of information, e.g. land use, lithology, digital terrain models (DTMs) and their derivatives (slope, exposition). Furthermore, the extention of already existing landslide databases including historical records is envisaged. Sources of additional landslide information include all kinds of media, research papers and aerial photographs. Aerial photography interpretation is also necessary in order to obtain the spatial distribution of the elements at risk for different dates. The indirect data required to estimate vulnerability and maximum damage potential (income, population density, age, monetary values, etc.) are gathered from census data. Census results are published every five years with parameters and district boundaries remaining constant from 1861 through until the 90ties. The overall period of the risk analysis is split into several time slices. For each slice, the relevant parameters are determined and the level of risk is calculated. The implementation of the method is GIS-based and is carried out by matrix multiplications.

A comprehensive comparison of all time slices should provide an assessment of overall risk evolution. Causes, correlations and interactions between the factors determining risk are identified and analysed. The results will shed light on the way in which the geosystem and the social system evolved. For example, was Charles Darwin right, did the "fittest", i.e. the best adapted, "survive"? Which counter measures could be afforded by whom, and which mitigation strategies resulted in sustainable protection and damage limitation? The study will help to indicate future trends resulting from human landscape modifications. Which adaptation strategies will lead to maximum/minimum damage? The results of the project will support risk-management and serve as a tool to optimise future strategies of damage reduction.

The project is realised within a PhD dissertation, and is a product of the cooperation between the Department of Geography, Bonn, Germany and the Institute of Geography, Wellington, NZ.

LATE QUATERNARY RIVER EVOLUTION OF FLOODPLAIN POCKETS ALONG MULLOON CREEK, NEW SOUTH WALES, AUSTRALIA

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Distinct vertical and down-valley patterns in the alluvial sediment record preserved in four floodplain pockets along Mulloon Creek, in the upper Shoalhaven catchment of southern New South Wales, reveal a dramatic history of late Quaternary river changes. As accommodation space increases beyond points of bedrock confinement, floodplain pockets have developed as a downstream-thinning wedge of vertically accreted deposits atop a basal gravel lag. The transition from a bedload phase to a phase of suspended load deposition occurred some time before 12,500 years ago. In the mid-late Holocene, swamps developed in the middle-lower part of each floodplain pocket. At the time of European settlement of this region (Circa 1820), floodplain pockets comprised discontinuous watercourses. Within a few decades of European settlement, the downstream pocket, and the pocket several kilometres upstream, had incised to produce a low-sinuosity gravel-bed channel. Wedge-shaped units of post incisional alluvium lie atop the downstream part of the floodplain pocket. These vertically accreted deposits thicken downstream and away from the contemporary incision, reflecting the history of incision and down-pocket changes to channel capacity. As incision proceeded to the gravel platform throughout the floodplain pocket, the resulting channel had a much greater capacity in the upper part of the pocket relative to its downstream counterpart. As a consequence, the contemporary channel contains all but the very largest flows in upstream sections, while inundation and rates of overbank sedimentation are much greater downstream. Differing phases of incisional response are evident in each floodplain pocket. The next floodplain pocket upstream contains a 2-3 m headcut that is presently cutting through the swamp, while the furthest most upstream floodplain pocket, just 2 km from the river source, retains an intact swamp.

THE GEOMORPHOLOGY OF VICTORIA: A NEW VIEW OF THE LANDSCAPE

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The remarkable diversity of the landscape of Victoria has been the subject of interest and study for over 150 years. Reports by the early explorers were followed soon after by those of settlers, miners and geological survey mappers. New geomorphological ideas based on the study of the Victorian landscape emerged, e.g. Murray 1887, and between the 1900s and the 1970s books and papers were produced by Gregory, Baragwanath, Fenner, Jutson, Keble, Hills, Gill and others. This early work was summarised and extended by the late Jeff Jenkin in 1976 & 1988, in the first two editions of the Geology of Victoria.

New ideas about the landscape have arisen in the last decade from the application of satellite imagery and airborne geophysics, and from fission track data and luminescence dating. The influence of tectonism, bedrock lithology and sea level change had been recognised in earlier studies, but this is are now known in greater detail though recent investigations of regolith, the mapping and dating of Tertiary strandlines, and recognition of young volcanism and neotectonics.

Joint work by University researchers and state government soil workers, particularly in the Geomorphology Reference Group set up by the Victorian Government eight years ago, has led to a redefinition of the main geomorphological regions of Victoria. The regions have been linked through successive finer divisions to the earlier Statewide Land Systems mapping of Rowan, Martin, Rowe and others. This new work is summarised in the Geomorphology chapter of the 2003 edition of the Geology of Victoria, with its extensive list of contributors, and also in a planned report of the GRG, as well through extensive data sets now available on the state government web site Victorian Resources Online.

Recent interpretations recognise the dynamic evolution of the landsurface of Victoria over the late Neogene and Quaternary. Fission track data confirms that the Western Uplands have been at a low elevation until the last 2 to 3 million years, during which Tertiary strandline ridge deposits on the northern and southern margins have been uplifted some 100 m or more. In contrast, fission track data from the Eastern Uplands presents problems in matching the landscape and landform story. The plains to the north and south of the uplands have surfaces made up of marine sediments, now often overlain by fluvial, aeolian, lacustrine, and in southwestern Victoria, volcanic deposits. Luminescence dating of late Quaternary inland dunes is beginning to provide a more detailed story of the final shaping of these plains. In addition, mapping of the Tertiary strandline ridges on the Western Plains using digital terrain models is highlighting areas of warping and uplift, both around the northern margin of the Otway Ranges, and also around several young volcanic complexes. The formation of the Quaternary coastal dunes of southwestern Victoria is now better known from recent luminescence dating.

The story of the evolution of all these regions is now much richer in detail and better dated, and provides a firm basis for future environmental, groundwater and land management applications.

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DOWNSTREAM HYDRAULIC GEOMETRY OF CONTRACTING, ANABRANCHING RIVER SYSTEMS

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The geometry of alluvial river channels is primarily thought to reflect the influences of hydraulic and sediment characteristics. "Downstream" hydraulic geometry concerns spatial changes in channels with increasing discharge along a river or within a region. Standard hydraulic geometry relationships have normally been applied to rivers in humid regions which feature meandering, bedload streams, but have not been applied systematically to anabranching networks, or to rivers which decrease in size and discharge downstream. Survey and sediment data from 75 stations from 8 alluvial rivers in the Murray-Darling basin, southeastern Australia, was assembled from published and unpublished sources. The Murray-Darling is a large basin, in which discharge generated in the headwaters of the southeast highlands is progressively lost in the drier Riverine Plain. After leaving the highland belt most streams are ephemeral and develop extensive anabranching networks that transport a suspended or mixed sediment load. The effect of sediment parameters (M) on channel shape (w/d) was examined, and channel width, depth and velocity were plotted as a function of bankfull discharge. The resulting relationships differ in detail from most "conventional" rivers, particularly with regard to the exponents found for depth (f) and velocity (m). Normally, relationships are based on rivers that increase in size downstream while both slope and sediment size decrease. Velocity therefore increases (with increasing discharge) while particle size decreases. The Murray-Darling presents a reverse situation, where discharge, slope and sediment size all decrease downstream. An increase in velocity (i.e. in the upstream direction) is accompanied by an *increase* in particle size. Because particle size is believed to affect channel geometry, it is not surprising that hydraulic geometry relationships for these rivers are somewhat different, illustrating the need to develop regional relationships to estimate bankfull discharges for ungauged channels with a given set of characteristics.

SHORE PLATFORM MORPHOLOGY ON A RAPIDLY UPLIFTING COAST, WELLINGTON, NEW ZEALAND

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The rocky coast around Wellington, New Zealand, is tectonically active and contains a series of uplifted shore platforms. These platforms are up to 70 m wide and rise to a height of 3 m above mean sea level where they are buried by anthropogenic structures. A relict sea cliff backs this whole coastline and up to 3 distinct shore platforms can be observed, the lowest modern one at an elevation close to mean sea level. The platforms are composed of highly fractured soft sandstone, which has a low resistance to erosion processes. A series of platforms were surveyed on both the open-ocean and fetch-limited harbour sections of coast. The platforms generally increased in width and height with increased wave exposure, although they all had a similar jagged profile with relief generally ranging around 0.5 m. Several co-seismic uplift events have occurred on the coast with the most recent in 1855 being the most recognisable. Platform development on this coast is rapid; proceeding at a rate of up to 0.15 m/yr. Erosion appears to occur primarily through wave quarrying, especially along joint planes. This occurs at a greater rate than subaerial processes which appear to lower the overall platform height. These results are important in understanding the evolution of these highly mobile coasts and provide a unique setting where shore platform development can be observed over historical timescales.

REGOLITH, LANDFORMS AND SALT IN THE LOWER BALONNE AREA, SOUTHERN QUEENSLAND

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Work undertaken has been part of the ongoing "Lower Balonne Airborne Geophysics Project" which is a collaborative project between the Co-operative Research Centre for Landscapes, Environments and Mineral Exploration (CRC LEME), The Bureau of Rural Sciences, and the Queensland Department of Natural Resources and Mines (QDNR&M).
The study area is in the upper reaches of the Murray Darling Basin and is extensively utilised for agriculture, especially irrigated cotton growing and cattle grazing. Information is needed on the surface geomorphology and landscape evolution of the Lower Balonne to contribute to the interpretation of groundwater flow systems and possible salinity risks in the area.

The Lower Balonne region consists of extensive alluvial deposits from the past and present flow of the Maranoa, the Balonne and Moonie river systems. These deposits are overlying locally variable weathered Cretaceous marine sediments of the Surat Basin.

Surface regolith and landform mapping over the area was undertaken at a 1: 100 000 scale, using a combination of data sources. The largest airborne electromagnetic survey for NRM issues was flown over the area for this project, and this information coupled with gamma-ray radiometric, Landsat-TM, ASTER, aerial photographs, digital elevation models and ground sampling was used to compile a number of geomorphologic maps in a GIS environment.

Nine major geomorphic units were identified in the study area, all but one being former or current alluvial deposits. It was shown that the Lower Balonne River has been progressively moving in an east to west direction and is currently incising and overlying the previous alluvial fan of the Early Quaternary Maranoa River which extends along the Western side of the study area.

The Maranoa fan displays reworking of the surface material in a catena like relationship which for natural resource management issues means that surface distribution of materials are unlikely to be representative of materials at depth.

Geomorphic units identified from the progression of the Lower Balonne River show changes in stream morphology and flow regimes from multiple scale meander systems to the present anastomosing floodplain. The morphology of these deposits is likely to be representative of what is at depth (to a degree) and thus gives insights into the possible groundwater flow systems of the area.

A more detailed regolith landform map of the area identified 22 units within these major geomorphic units. Differentiation of this map relied heavily on Landsat and air photo data for interpretation the more subtle boundaries while for the major geomorphic unit map, the radiometric data coupled with Landsat data was found to be most useful.

The maps produced were useful for interpreting geomorphology and regolith materials within the area and gave insights into the regional landform evolution. This information enables a better understanding of the possible groundwater flow systems and salinity risks in the area, which are of particular importance to the local community.

A HIGH RESOLUTION RECORD OF THE FULL LAST GLACIAL-INTERGLACIAL CYCLE FROM CALEDONIA FEN, VICTORIAN ALPS

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Caledonia Fen is contained within a small enclosed basin eroded into the slopes of the Snowy Range of eastern Victoria and is surrounded by upper montane eucalypt forest. It is remarkable in that it has revealed one of the few high altitude sedimentary records of vegetation and climate extending through at least the last glacial cycle anywhere on the globe. Although the potential of the site has been known for many years, it is only recently that developments in radiometric dating combined with the construction of appropriate coring equipment have made a detailed study of the site feasible. One 20 m sediment core has been pollen analysed at 4 cm intervals and has a chronology for the top 7 m derived predominantly from AMS radiocarbon dating of pollen, plant macrofossils and beetle remains and OSL dating of quartz within the predominantly inorganic sediments. Conventional dating of Holocene peat and U/Th dating of an organic band around 7 m generally support an early MIS 3 age for this part of the sequence. The presence of organic sediment and the nature of the pollen assemblages close to the base of the record, in combination with extrapolation from dated part of the sequence, suggest that the record extends back to the end of MIS 6.

The topmost and basal organic sediment layers, that are equated with the Holocene and Last Interglacial respectively, indicate extensive forest development. The achievement of a similar extent of forest in the organic band dated to early MIS 3, although short-lived, generally supports the evidence from the current dating of Lake Mungo and a recent re-revision of the chronology of Lake Wangoom for marked climatic 'amelioration' at this time within the southeast Australian region. The major part of the record from Caledonia Fen, though, indicates the presence of a shallow, probably predominantly ice covered lake surrounded by alpine grassland-steppe existing under relatively dry and cold conditions.. However, these periods are punctuated by abrupt events that may turn out to be equivalent to short-lived interstadials recorded in other parts of the world. Peaks of grasses are considered to represent warm dry phases of millennial duration while combinations of sharp peaks in eucalypts and short term swamp developments suggest warm and wet, mainly sub-millennial events.

Ongoing studies of grain size analysis and mineral magnetism of the sediments are aimed at understanding the processes responsible for the origin and development of the basin and will hopefully contribute to an elucidation of the nature and causes of recorded climatic variability.

THE RELEVANCE OF LANDSLIDES IN ALPINE FLUVIAL GEOMORPHOLOGY

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Landsliding and fluvial dissection are the dominant erosional agents in the tectonically active alpine South Westland area of New Zealand. The area is characterised by high uplift rates, infrequent large earthquakes, and extreme orographic precipitation. Despite the high density of shallow debris slides and flows, the geomorphic imprints of deep-seated bedrock failures are dominant and more persistent. Over 50 large (>1 km) landslides comprising rock slide/avalanches, complex rotational and rock-block slides, wedge failures, and deep-seated gravitational slope deformation (DSGSD), were detected from air photos and shaded relief images.

Major geomorphic long-term impacts on alpine rivers include (1) forced alluviation upstream of landslide dams, (2) occlusion of gorges and triggering of secondary riparian landslides, and (3) diversion of channels around deposits to form incised meandering gorges. The preservation of large prehistoric (i.e. pre-1840) landslide deposits possibly represents the low-frequency—in terms of total area affected yet dominant—end of the spectrum of mass wasting in the western Southern Alps, and is at odds with high erosion rates in an active erosional landscape.

The regulatory role of landslides in alpine sediment flux ranges from catastrophic input of debris, increasing short-term fluvial yields to >70,000 t/km/yr, to sediment retention due occlusion or long-term stream blockage. The implications of these large-scale landslides are that (1) hillslope processes may control alpine fluvial morphology; (2) previous models of landslide-derived sediment flux need to be re-calibrated; and (3) concepts of catastrophic post-earthquake aggradation may need revision.

WITHIN-REACH VARIABILITY IN CHANNEL ADJUSTMENT ALONG AN 8KM REACH OF THE HUNTER RIVER, NEW SOUTH WALES; IMPLICATIONS FOR ASSESSING FUTURE RIVER REHABILITATION OPTIONS

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Documenting and understanding contemporary channel condition in the context of historical and long-term fluvial adjustment is fundamental and imperative in the design of any river rehabilitation program. As such, the geomorphic history of the Hunter River at Muswellbrook since European settlement has been compiled for the use in such a programme. Sources of information used in this analysis include accounts of the landscape from the first European explorers and settlers of the Upper Hunter Valley, reports and documents relating to channel change, in particular, the changing nature on the impacts of flooding, and in-depth analysis of historical Parish Maps and aerial photography. It was found that since European settlement, the whole system has undergone similar land management practices (eg: riparian vegetation clearance, floods), yet the system has behaved in a non-linear fashion. Some sub-reaches of the river have increased their macro channel width by 400%, whilst others have remained static. It is thought that the radius of curvature at the time of settlement has had a profound effect on the degree of change that has occurred. This information can then be used to assess the future trajectory of the river, given a number of possible hydrologic scenarios.

COMPARING THE EFFECTS IF THE 1939 AND 2003 FIRES ON THE STREAMFLOW OF THE BOGONG HIGH PLAINS

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The Bogong High Plains are a series of high plains plateaux located in north-eastern Victoria. The geomorphic nature of the plateaux makes the area attractive to activities such as summer grazing by cattle, water storages for hydro-electric power generation, and multiple forms of tourism - downhill and cross-country skiing, bushwalking, horse riding, etc. The Bogong High Plains are also an important source of good quality water, and several rivers that drain to the Murray River and the Gippsland region rise on the Bogong High Plains. Bushfires have played an intermittent but important role in shaping the alpine and subalpine environment of the area. Extensive fires burnt the area in 1926, 1932, 1939 and 2003, although the 1939 fire was the most severe of all those fires. This paper focuses on the 1939 and 2003 fires, and compares the climatic conditions that produced the fires, the timing and duration of the fires, the extent of areas affected, fire-fighting procedures, and the impacts of the fires on alpine and subalpine hydrology. The Bogong High Plains has an excellent history of stream gauge operation, as several stream gauges were installed as early as 1925. Although the stream gauges operating in 1939 were different to those operating in 2003, the catchments monitored in 2003 were sub-catchments of those gauged in 1939, and thus largely comparable. The initial response of streams on the Bogong High Plains to fire in 1939 and 2003 are compared via storm hydrographs, flow duration curves and partial flood series.

EFFECTS OF TREES ON REGOLITH & LANDSCAPES

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The interaction between vegetation growth and soil development is poorly understood, but critical to the understanding of evolution of landscapes. Most research has been undertaken in the northern hemisphere, but as Australia's continental history, soils, vegetation and climate are very different, this research is not always relevant here. Also, most research has concentrated on the relationships between agricultural crops and soils, not on long term and relatively undisturbed soil and vegetation relationships where much greater influences may be evident. However, all studies acknowledge that different plant species have different effects on pH and mineral concentrations in the root zone, or rhizosphere, and that this influence decreases with distance away from the root.

This study set out to choose two very different trees in a natural and relatively undisturbed environment, and to examine the soil beneath them. As stated by Gilkes (1998, p124) "roots chemically modify the regolith to maximise plant uptake of many elements". The project site was on a lower slope, characterised by shallow yellow chromosols with little effect of run on or run off from water or sedimentation. An *Eucalyptus mannifera* ssp *maculosa (Brittle Gum)* and an *Acacia faliciformis (Mountain Hickory)* growing ten metres apart were chosen for the study. The Brittle Gum was estimated to be a minimum of 100-150 years old, while the Mountain Hickory was estimated to be 200-300 years old (Banks, pers. comm.). Both species are native to Australia, endemic to the site and well represented in this environment. Soils were sampled at 20 cm intervals both vertically and horizontally along the ten metre costean, from the soil surface to the base of the regolith. These samples were then dried in the laboratory, pH and EC measured, digested with acids and analysed using ICP for Al, Fe, Mn, Ca, Mg, K, Na and other minor elements.

On-site analysis beneath each tree showed quite different soil properties. The root bole of the Mountain Hickory extended 200 mm below the soil surface while the Brittle Gum bole began at the soil surface. Soils were more developed and deeper below the Mountain Hickory than below the Brittle Gum. A comparison of laboratory analysis for pH and EC showed variation along the transect, varying more in the root zones of each tree than in the middle of the transect. The EC was highest with strong variation around the main root zone at the base of the Mountain Hickory, while the Brittle Gum appeared to have little influence on the EC of the soil in the immediate vicinity.

There is a strong concentration of Ca directly below the Mountain Hickory, but not beneath the Brittle Gum; and only low values measured in the area of decomposed bedrock. Magnesium shows high concentration above bedrock, with much lower values in the root zones of both trees and the surface soils. Aluminium and Fe have higher concentrations in the area least affected by tree root growth. There is a concentration of Fe in surface soils close to the Eucalypt that is not reflected by similar concentrations near the acacia. Patterns of distribution of other minerals varied.

The study of the influence of vegetation on soil development has been limited to a preoccupation with the ability of soils to provide nutrients to agricultural crops. There is scope for further analysis of soil nutrient and nutrient transfer through vegetation on this site, and others, and to continue this type of study on different tree species in different climatic zones to determine if the influence of trees on soils is consistent. Further study could consider the influence of different trees to build baseline information with which to compare further studies. This was an undergraduate, summer scholar study, with constraints on resources and time. Further study will enhance the understanding and interpretation of the relationship between vegetation and soil development, and the role plants play in the evolution of the landscape.

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HORIZONTAL AND VERTICAL CONTROLS ON THE CAVES OF THE NARACOORTE EAST RANGE, SOUTH AUSTRALIA

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The Naracoorte East Range is a low ridge of soft Tertiary limestone approximately 30 kilometres long in the south-east of South Australia, adjacent to the Victorian border. More than 100 caves have been found in the range itself with several dozen more to either side of it, and over the past 50 years speleologists have mapped 25 large cave systems along with many of the smaller caves. A number of the larger, decorated caves are located in the Naracoorte Caves National Park and public tours are available to view them. A special feature of one cave is extensive subterranean Pleistocene megafauna deposits, which have earned the Park a World Heritage Listing. To date, most research has focused on the bones, sediments and speleothems in the richly fossiliferous Victoria Fossil Cave.

The aim of this study is to analyse the spatial patterns of cave distribution and passage orientation throughout the Naracoorte East Range in an attempt to understand the processes of development of the cave systems. Three sets of data have been assembled for this study. Firstly, speleological maps of all the larger caves and several smaller ones have been obtained from the Cave Exploration Group of South Australia. In the 1970's, Ian Lewis was one of the key surveyors in the production of these maps. Although the quality of the speleological maps is variable, they generally contain sufficient detail for use in this study and, where necessary, additional fieldwork has been undertaken to supplement existing detail on some maps. Secondly, a detailed GPS-based levelling survey was recently undertaken to accurately coordinate the vertical relationships of all the major caves along the 30 kilometres of the Range. This survey allows an analysis of horizontal and vertical controls on cave entrances and underground features to be made. Thirdly, many local cross-sections of cave passages have been mapped at selected sites, recording particular features related to vertical development processes in detail.

From the cave maps and surface survey, a detailed long section of the whole karst system of the Naracoorte East Range has been generated. This has enabled correlations of the following features to be made between all of the major caves and several minor ones: cave entrance levels, entrance size and overburden depth, bedding plane exposures in cave walls and roofs, concentration of aven zones in cave roofs, distinctive phreatic zones, and sediment infill zones amongst other features. The correlation of these features across 30 kilometres is suggestive of past regional water table fluctuations and phases of cave development, and provides subtle indications of the direction of past groundwater movement. In addition to the long section, a plan view of the distribution of the 25 major caves in the Naracoorte East Range has been compiled which indicates the presence of major and sub-major cave orientation trends, collapse zone distribution patterns, an uneven distribution of phreatic zones, and clustering of lateral flow pathways through the range.

INTER-RELATIONSHIPS BETWEEN SOIL & REGOLITH PATTERNS AND NUTRIENT PROCESSES AT A SUBALPINE INVERTED TREELINE

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The inverted treeline marks the lower limit of tree growth in subalpine and montane valleys as a result of periodic low minimum temperatures. In Australia these woodland-grassland ecotones are especially extensive in response to the gentle topography and the cold intolerance of the dominant subalpine eucalypts. Frost hollows have been present in southeast mainland Australia for thousands of years unaltered by human impacts. However, during the period from 1834 to 1958 grazing, with associated burning practices, dominated and resulted in the fragmentation of the inverted treeline. These boundaries are poorly documented.

This research specifically aimed to test Hedenstroem's (1993) findings of abrupt boundaries in soil calcium (Ca) and manganese (Mn) concentrations across an inverted treeline, this time on a steep slope. Additionally the research aimed to increase the knowledge and understanding of plant-soil interactions and processes that lead to the development of patterns of cation distribution in soil profiles under juxtaposed woodland and grassland ecosystems.

The results clearly show that soil-profile and soil-surface patterns of Ca and Mn concentrations were strongly related to characteristic indicators of the woodland and grassland nutrient cycles. Different patterns of soil Ca and Mn were observed in the adjacent woodland and grassland ecosystems that correlated with litter depth and vegetative composition between two trees of different sizes and ages, and in relation to grass tussocks in the grassland. The greatest variability in ecosystem processes was observed through indicators such as litter depth and its vegetative composition, the cation concentrations in plant roots, and soil profile chemistry. The characteristic differences in the woodland and grassland were especially evident when the surface soil concentrations of Ca and Mn were examined across the inverted treeline. The concentrations of Ca and Mn were strongly related to characteristic nutrient cycling processes despite a steep slope and indicate their value as soil signatures, that may be used to indicate the location of an inverted treeline prior to disturbance.

HEDENSTROEM S. 1993. The influence of trees on site with particular reference to an inverted treeline. Honours Thesis, Forestry Department ANU, Canberra. Unpublished.

LAST GLACIAL MAXIMUM BEETLE FAUNA, LYNDON STREAM, RAKAIA RIVER VALLEY, SOUTH ISLAND, NEW ZEALAND

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An early last glacial maximum (LGM) insect fossil fauna is described from a glacial lake deposit east of the divide in the central South Island of New Zealand. The insect fossil assemblage comprised 25 Coleoptera (beetle) species and an abundance of *Chironomus* (Chironomidae) larval heads. The assemblage represents a montane to subalpine fauna from a lake in an open habitat setting. Chironomidae and predacious diving beetles dominate the assemblage. Subalpine mossy habitat weevils *Curimus* and *Baeosomus* are present. Open tussock vegetation habitats are indicated by the weevils *Rhopalomerus tenuirostris*, *Irenimius* and *Mandolotus* and leaf beetle *Adoxia dilutipes*. Riparian and marsh species include the lake beetle *Limnichus simplex* and the rove beetle *Bledius*, *'Stenomalium' planimarginatum* and *Stenomalium antipodium*. The estimates of paleotemperature derived from beetles' climatic tolerances indicate temperature at this time was relatively warm. Warm conditions are consistent with plant macrofossils data from the site, but are at odds with pollen derived climate reconstructions that suggest very cold conditions from 26,000 yrs BP to 12, 000 yrs BP and expected cooling around 4 – 7 °C. The results indicate considerable climate variability within the LGM.

CHANNEL GEOMETRY OF UPLAND SWAMP STREAMS, BARRINGTON TOPS

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Small, sinuous and narrow channels in the upland swamps of the Barrington Tops area of NSW provide a unique opportunity to study the conditions that control river channel planform and hydraulic geometry. They have extraordinary width to depth ratios of typically 3:1 and hence are very close to offering minimal boundary resistance per unit of flow. Perennial, and with discharges up to 1-2 m/s at bankfull, they have banks that are vertical to undercut, in places almost mimicking efficient pipe flow. The banks are subjected to high shear stresses. Some channels display highly variable bed topography, with deep pools. Meander bends are very tight and show curvature indices (radius of curvature/width) of as low as 1.18. The channels do not appear to transport any significant sediment, the water remaining clear even at bankfull and bedforms remaining exceptionally stable.

The hydraulic geometry of these channels is notably different to those presented in a variety of continuum analyses. In contrast with the findings of Leopold and Wolman (1957), a plot of slope to discharge does not predict channel planform. Nor does the Parker (1976) diagram (based on slope:Froude number and w:d), subsequently modified by Tooth and McCarthy (in press), delineate channel planform. It appears that factors other than slope, discharge and Froude number influence the channel planform and associated cross sectional shape. These streams have very high bank strength relative to their stream energy, with bank strength equated very closely to root strength. Erosional resistance allows channels to form and maintain their cross sections close to that offering an optimum for efficient, bedload-free water transport.

Flow through the meander bends of these channels behaves very differently to that in wider and shallower channels. The maximum velocity filament splits into two vertically stacked flow tubes. This may be the result of the very tight bends that form in these systems combined with very low width:depth ratios. Future work in these systems will be to determine the nature of secondary currents and identify the effects of varying channel curvature and channel cross sectional shape on the location and intensity of secondary currents. An investigation of the unique hydraulic geometry of these streams will greatly add to our understanding of what actually controls channel cross-sectional shape and planform.

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Parker, G. 1976. On the cause and characteristic scales of meandering and braiding in rivers. *Journal of Fluid Mechanics,* **76**: 457-480.

Tooth, S. and McCarthy, T.S. (in press). Controls on the transition from meandering to straight channels in the Okanango Wetlands, Botswana. *Earth Surface Processes and Landforms.*

GEOMORPHOLOGY, TROPICAL CYCLONES, COMMUNITY SAFETY AND GOVERNMENTS

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Coastal natural hazard risk assessments, and local and state policies and legislation in Queensland largely ignore the role that geomorphologists can play in helping to understand the nature of natural hazards and the risks these events pose to coastal communities. Tropical cyclone storm surges, and the rest of the marine inundation (tide, wave set-up, wave action and wave run-up), can result in substantial erosion of coastal dunes allowing the propagation of waves and high velocity currents inland for many hundreds of metres. Only the horizontal, not vertical, erosion of dunes is ever considered in developing risk assessments and coastal management policies by the Qld state and local governments. As a consequence, the assumption is made that these dunes may scarp on the seaward side but will remain intact and provide protection for properties built immediately landward of the dunes during a severe tropical cyclone. Policies outlining set-back distances and minimum habitable floor levels allow buildings, including multi-million dollar tourist developments, to be erected on filled, but otherwise low lying, land (often less than 2 m AHD) within 40 m of the high tide line (not HAT either which maybe only a few metres away).

Recent research on the impacts of intense tropical cyclones on sandy coasts in Western Australia shows that when the marine inundation overtops coastal dunes those dunes erode vertically and the entire dune is removed. Indeed, the surge generated by Severe Tropical Cyclone Vance near Exmouth in 1999, removed three rows of 6-7 m high parallel dunes allowing a high velocity unidirectional flow to extend inland for over 300 metres. The geomorphic and sedimentary evidence left by this flow was considerably more impressive than that left by the 15 m high 1998 Aitape tsunami at Sissano Lagoon in PNG. Other cyclones crossing the WA coast in recent years have shown the same relationship between dune height and the height of the marine inundation. Such observations have also been noted by the USGS following coastal surveys of hurricane landfalls in the U.S, and a V and A zone concept (zones along the coast where waves and currents extend inland after dunes are eroded) has been adopted by the Federal Emergency Management Agency in the US to inform people of the danger of building too close to the sea in hurricane prone areas.

Vertical erosion of dunes is clearly a very real process occurring during cyclone induced marine inundations. The heights of dunes along considerable portions of the northeast Qld coast are relatively low (often less than 3 m AHD) and are lower than the height of the marine inundation during the 1% AEP tropical cyclone. Despite our knowledge of the geomorphic impacts of cyclone induced marine inundations on sandy coasts, the drive for development in tropical Qld results in a complete disregard of the vertical erosion of dunes and consequent danger of building too close to the sea. Indeed, it could be argued that governments in Qld, in this sense, are actually promoting community vulnerability rather than reducing it as is stated so often in their public rhetoric.

URBAN CREEK ASSESSMENT AND PRIORITISATION WITHIN NEWCASTLE LGA

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Natural creeks and their riparian zones within the Newcastle City Council (NCC) area have been severely impacted on by urban development. Historically, these natural systems have not been recognised within Council's asset maintenance program, despite the fact that they form an integral part of the City's stormwater system. In order to "audit" the Newcastle's urban creek system Council has developed a local Creek Assessment Program (CAP) that provides information from both asset and environmental management perspectives. CAP covers a number of different criteria including assessment of creek and floodplain geomorphology, vegetation quality and quantity, engineered structures within the riparian zone and risk. CAP is part of a larger suite of programs called Creeks Alive that also incorporates macroinvertebrates and water quality assessments.

While the River Styles™ (eg Brierley *et al.*, 2002; Fryirs and Brierley, 2000) was readily available as an assessment tool and is being used quite extensively and successfully by DIPNR throughout the state including the Hunter Region, its application to urban creeks in the Newcastle area did not provide sufficient information for decision making purposes.

Within an urban context homogeneous reaches tend to be very short or non-existent because of the dominance of varying anthropogenic inputs and processes, resulting in complex morphology over short distances. The Creeks Alive Programs is focused on reconnecting community to creek reaches that have relevance at the neighbourhood scale. Therefore a number of different mechanisms have been used to identify reaches in the field, rather than just a strict geomorphic identification. NCC also wanted the assessment to include riparian vegetation, infrastructure and risk assessments and have a focus on actual problems and their severity. In addition community groups or individuals needed to be able to undertake assessments where applicable.

Data collected by CAP is stored and analysed using NCC's GIS system. This information provides an outcome that enables prioitisation of resource allocation for creek works based on geomorphic and ecological indicators. In addition, NCC is working towards an additional GIS layer that will prioritise stream rehabilitation works based on utilising social, political and economic factors in addition to those already provided by CAP. A workshop held at NCC in November 2003, involving staff from various Councils and DIPNR offices in NSW has assisted to identify some initial social, political and economic factors and potential data sources for this information that could be utilised to develop a prioritisation model.

DENUDATION RATES AND THE CENOZOIC HISTORY OF THE AUSTRALIAN ALPS IN VICTORIA

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Denudation rates averaged over the last 30 million years are not high in the Australian Alps of Victoria compared to other highland regions, or even to the tablelands regions of the Australian Eastern Highlands. Yet relief here is greater than that of the tablelands, and most of that relief has apparently developed after deposition of Eocene sub-volcanic sediments and Oligocene lava flows.

In the main part of the Australian Alps in Victoria, west of the longitude of the Tambo River (147°50'), river incision below the top of Late Eocene and Oligocene lavas to the present river level can be as low as 9 m Ma, but most rates are in the range 15 – 25 m Ma. River incision in the vicinity of major Cenozoic faults reach rates of 30 m Ma, averaged over a 30 million year period.

However it is apparent from the geomorphology of the region that the erosion did not operate uniformly over that time. Many highland valleys have indications of periodic stream incision in the form of valley-in-valley structures. North of the Great Divide, for instance, the Kiewa River valley had potentially three phases of stream incision; to the south, the Dargo River apparently had four phases. Periods of stability and valley widening between each phase would produce lower apparent rates averaged over a 30 million year period.

Calculations of fluvial denudation rates below incised Pliocene to Pleistocene sediments, at the southern margin with the Gippsland Basin, are not as affected by long periods of stability. These rates are variable, but are commonly in the 40 – 60 m Ma range. Similarly, apatite fission track analyses undertaken in the region indicate the effect of the measured time period on apparent denudation rates. Using the results of O'Sullivan et al. (1999), denudation rates averaged over the last 90 million years at Mt Bogong and Mt McKay are 22 m Ma and 20 m Ma respectively but, at Mt Feathertop, denudation rates averaged over only the last 45 million years are 31 m Ma. Denudation rates calculated over shorter time periods of more rapid change give higher rates, for example 68 m Ma for the period 110 to 90 Ma at Mt Bogong and Mt McKay, and 74 m Ma for the period 65 to 45 Ma at Mt Feathertop.

The results lend credence to the argument that the longer the time period over which denudation rates are measured, the lower the apparent rate (Gardner et al. 1987). Averaged denudation rates may not, as Gardner et al. (1987) suggest, be foolproof indicators of tectonic activity. Both palaeobotanical and geomorphological (in the form of fault block reconstructions) studies found that the Hotham Heights area in the Australian Alps of Victoria has been uplifted from around 800m to its present 1723m elevation after the Eocene period (Greenwood et al. in prep.). Denudation rates in the general area averaged over that time do not clearly indicate tectonic activity, except perhaps in the case of higher erosion rates adjacent to fault fronts. Erosion scaling functions applied to the rates may help address this problem.

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THE EFFECT OF FLOW REGULATION ON THE FREQUENCY OF FLOODPLAIN INUNDATION ON THE MURRUMBIDGEE RIVER, AUSTRALIA

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On meandering rivers with well-developed floodplains, bankfull stage has particular geomorphological and ecological significance because it approximates the threshold of interaction between the channel and the floodplain. Above this stage sediment is deposited on the proximal floodplain, wetlands are progressively inundated and organisms migrate between the channel and floodplain habitats. When floodwaters recede they return organisms, nutrients, organic carbon and other material to the channel.

Like many meandering rivers the lower Murrumbidgee is characterised by a channel that attains bankfull stage with a return period of approximately two years on the annual series. Although it was suspected that the frequency of floodplain inundation had been reduced by reservoir construction in the headwaters, this hypothesis could not be tested until recently when Integrated Quantity Quality Modelling (IQQM) of daily discharges was undertaken by NSW Department of Land and Water Conservation.

A comparison of regulated flows with modelled 'natural' flows for the period 1970 to 1998 showed that there has been a significant reduction in the magnitude of floods with return periods of up to five years on the annual series. The effect of reservoir construction on the frequency of bankfull discharge in the lowland reach has been dramatic. Between Gundagai and Hay the average frequency of bankfull flow has been reduced from once every 0.65 to once every 1.34 years. Downstream, at Balranald, a complex interaction between the channel and low level flood basins resulted in a reduction in average bankfull discharge frequency from once every 1.15 years to once every 2.45 years.

GEOMORPHIC PROCESSES, LANDFORMS AND REGOLITH ON MARS

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A diversity of data are now available for much of the Martian surface, including high resolution imagery, in some cases with pixels as detailed as 1.5m. The Mars Global Surveyor carries a high resolution camera (MOC) and a laser altimeter (MOLA). Mars Odyssey carries a thermal emission imaging system (THEMIS), a gamma ray spectrometer (GRS) and several neutron spectrometers.

These images show clear evidence for processes and landforms familiar to Earth-bound geomorphologists. Sand dunes and other aeolian features are common, as are slopes with cliffs and boulder features. Alluvial forms such as gullies and fans are also present. Apparent lake shores, a recently imaged delta-form, and integrated channel networks suggest the presence of both standing and running water in the Martian past. There are features that have been attributed to ice, perhaps still present on the surface. Mars has a large number of volcanoes, including Olympus Mons, the largest in the Solar System . There is also evidence of a complex history of landscape evolution shown by changing valley morphologies, and many examples of inverted relief.

There are also some forms on the Martian surface that have no obvious Earth analogues. Examples include the "Swiss cheese" features of the south pole, Martian "banyan trees", "fortune cookies" and "spiders", and the "fried egg" terrains of the major valley floors.

Mapping of landform features on Mars has been somewhat inconsistent and largely geologically based. There is a role for systematic regolith-landform mapping of the Martian surface, for at least two reasons. First, such mapping provides consistent data for interpretation of landforms and processes, especially where high resolution information is available. Second, regolith-landform maps provide an indication of the surface conditions likely to be met by landers and rovers. These regolith-landform maps are more functional and have more applications than the current interpretive geology maps. They provide maps of real surface features which have been observed even if we do not know what materials they are composed of or how they formed. Landform maps provide a factual, descriptive base to which new information can be added when it is acquired, and may be interpreted by the observer rather than the map-maker. Such mapping can be carried out at both a regional scale, from orbital imagery, and the site-scale from landers and rovers.

DATING LONGTERM LANDSCAPE EVOLUTION IN AUSTRALIA: HIGHLIGHTS FROM THE CRC LEME GEOCHRONOLOGY PROJECT

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The aim of the CRC LEME geochronology project is to provide reliable numerical ages for Australian regolith materials, and to develop quantitative models of landscape evolution in regions that are important for mineral exploration and land management. The travel and fieldwork are nice too. In this talk I will present three highlights from the LEME geochronology project.

1. Saving Lucas Heights: Construction of the replacement research reactor at Lucas Heights in Sydney was halted last year when faults were discovered in the south wall of the excavation. Paleomagnetic dating of an unfaulted iron oxide layer yielded an age of 9±5 Ma, demonstrating that the seismic risk associated with faults was negligible. Construction continued!

2. Ancient regolith: Parts of the Australian continent have been subaerially exposed for hundreds of millions of years. Ancient weathering profiles at Lancefield (WA), The Granites (NT) and Northparkes (NSW) date back to Permo-Carboniferous times. However, such ancient profiles are unlikely to have been continuously exposed at the surface because long-term erosion rates, though slow, would have long ago removed them. Cosmogneic isotopes do not tell (too many) lies. Burial and exhumation must be the answer, not 42.

3. Dating silcretes: The ages of silcretes in Australia have been much debated. For example, sub-basaltic silcretes may be younger, older or roughly coeval with overlying K/Ar dated basalts, depending on whom you talk to! Miocene and Eocene ages have been inferred from leaf fossil assemblages contained in silcretes in South Australia, but the biostratigraphy is not all that flash. Mostly Cainozoic, and some Mesozoic ages, have been inferred from stratigraphic relationships and landscape position, but these too are often debated. U/Pb dating of anatase (TiO_2), a common accessory mineral in silcretes from western NSW and SA, offers a new way of settling some great arguments, or maybe starting more.

IT ALL DEPENDS.....
IMPLICATIONS OF A NEWLY EMERGING GEOMORPHIC PARADIGM

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Geomorphology has crossed a threshold. In recent decades, concepts and notions have been developed that lead inevitably to the emergence of a new paradigm, and a new way of approaching geomorphic research and application. We compare and contrast the contemporary and emerging geomorphic paradigms in the context of the historical and continuing development of geomorphology as a discipline. The implications of the new paradigm for geomorphic research are discussed.

For much of its history, geomorphology has focused on the notion of equilibrium in one of two ways. Initially, equilibrium was envisaged in the context of an evolutionary endpoint or climax landscape. Subsequently, the notion of geomorphic equilibrium came to mean something quite different, with a focus on the relationship between form and process. These two approaches, which can both be traced back to 19 Century North American geology, appeal to different thermodynamic principles, and discussion of their relative merits characterized much of 20 Century academic geomorphological debate. Both approaches, however, rest on an implicit assumption that there is an equilibrium condition toward which landforms or landscapes will gravitate.

In light of our contemporary understanding of the behaviour of landscapes and energy/matter fluxes, neither of these notions is entirely satisfactory, although they have power at a conceptual level. The notion of equilibrium itself has been all but abandoned. The idea that landforms and landscapes tend toward equilibrium is being supplanted by a realization that non-linear change is an integral aspect of geomorphic systems. Flux, rather than form-process relationships, has become the focus of geomorphic enquiry. The behaviour of geomorphic processes, and the landscapes that are produced as a consequence of those processes, are *contingent* upon a multitude of factors, not least of which are the unique configuration of each landscape and the temporal sequencing of drivers and responses. Thus, the emerging paradigm brings back to geomorphology a new focus on time that was a defining feature of evolutionary geomorphology. However, time is no longer conceived of as a simple index of system development. Rather, system history and event sequencing are recognized as being of profound importance. Static engineering approaches to landform and process are thus replaced by a dynamic focus on flux and change, with parallels in ecological thinking.

There are many implications in this new paradigm for the next phase of geomorphological activity. Rather than developing more sophisticated static models of individual geomorphic processes – although these are by no means obsolete – the focus will shift to developing a hierarchical relationship between these deterministic process models and stochastic models capable of simulating the behaviour of sediment redistribution systems at large spatio-temporal scales. Similarly, a stochastic approach will enable extension of geomorphic understanding into hazard and risk mitigation research. This has long been an area where geomorphic expertise has been applied, but the new approach means that we can move beyond static engineering of individual landforms, and focus on system scale phenomena (e.g. changing flood hazard as a result of the movement of sediment slugs) that are of interest to managers at decadal (or longer) time scales. Perhaps most excitingly, with this approach geomorphology can be cast as the template for interdisciplinary studies, with applications ranging from water quality, to habitat restoration. There are few fields of biophysical research that do not involve elements of sediment movement as a fundamental information layer. Both the nature of substrate (and the way this changes in time and space) and fluxes of material are of fundamental importance. Hence, ecological research can only benefit from incorporation of a geomorphic approach to sediment redistribution.

Geomorphology is thus in a powerful position, with the prospect of playing a central role in many exciting new pieces of research, both theoretical and applied. We are no longer landscape engineers; rather we are landscape ecologists.

SCALES AND MECHANISMS OF CHANNEL BREAKDOWN, LOWER MACQUARIE RIVER AND MACQUARIE MARSHES, N.S.W.

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Australian dryland rivers are often characterised by zones of channel breakdown and floodout. These appear to be Holocene features in many fine-grained alluvial settings with reduced flow discharge. Anabranching and distributary systems tend to lose their ability to effectively transport water and sediment, resulting in adjustments of river pattern and increased alluviation on low-gradient floodplains. Hierarchical patterns of breakdown have been recognised in some dryland fluvial landscapes, with landforms of variable size and longevity representing morphologic responses to combinations of physiographic, hydrologic and geomorphic factors operating through time.

Channel breakdown and floodout occurs on the lower reaches of the Macquarie River in semi-arid, south-eastern Australia, being associated with an area of extensive riverine wetlands known as the Macquarie Marshes. Ancestral alluvial controls determine local base-levels in the system, which, combined with hydrologic regimen, transported sediment and biophysical processes (including vegetation), determine the existing patterns of channel-floodplain dynamics and the distribution of lotic and lentic environments. A nested hierarchy of breakdown has been identified using remotely sensed data and field reconnaissance, and comprises three levels:

Anabranches and primary distributary channels;
Anastomosed reaches and secondary distributary channels;
Wetland feeder channels and floodouts (terminal and non-terminal).

Field measurements indicate that adjustments in river pattern leading to channel breakdown are related to downstream changes in channel morphology, as water loss, slope reduction and sediment deposition cause a reduction in bankfull capacity (decreased width:depth ratios), with an increased likelihood of multiple channels and overbank flooding. The mechanisms of channel breakdown appear to be similar to existing models of avulsion, where continued in- and near-channel alluvial sedimentation occurs until a triggering event forces the system over a stability threshold and creates a gradient advantage for diverted flows. Combinations of avulsion triggers, each associated with relatively high discharge events, also appear to vary over spatial scales in the lower Macquarie:

Flow capture by palaeochannels, existing anabranches or distributary channels;
Flow diversion and distributary formation due to coarse woody debris (log jams) and consolidation via sediment deposition in anastomosed reaches;
Flow diversion, splay development, and wetland feeder channel formation due to vegetative blockage (reed encroachment) and sediment entrapment, thereby influencing episodic wetland growth and abandonment.

EVOLUTION OF A GEOMORPHIC FRAMEWORK FOR VICTORIA-THE ROLE OF THE GEOMORPHOLOGY REFERENCE GROUP (GRG)

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A geomorphological framework for a statewide representation of land systems in Victoria was developed in the mid 1980s (Jenkin 1982, 1991; Jenkin and Rowan 1987). This framework which was based on the work of Hills and Jenkin and was the subject of a review commenced in the mid-1990s. A Working Group of Statewide Land Systems (Rowan 1991, Rees 2000) and associated descriptions of land in Victoria was convened with regular meetings of a group of pedologists and geologists. These specialists with extensive experience in Victoria have prepared an authoritative overview of geomorphological units across Victoria.
Development of the revised Geomorphological Framework is based on the need for a hierarchical approach that will incorporate the Statewide Land Systems, be meaningful at a range of scales and promote an evolutionary approach given the range of information available and spatial representation of these entities. This project has paralleled the preparation of the chapter on Geomorphology in the recently released "geology of Victoria", and both haveincorporated common terminology.

The major aspects of the review are:

(i) the development of three levels (Tiers) of the Geomorphological Framework compared with the previous two levels, comprising greater spatial differentiation, particularly at the finer scale (1:100-500K)
(ii) the reduction and simplification from nine to seven zones at the coarsest level (Tier 1), with the broad numerical hierarchy from the highest to the lowest elevation.
(iii) the dominance of landform rather than structure and process in terms of definition, and
(iv) the challenge of mapping all such entities to the finer scale (Tier3).

Current developments can be viewed on the Department of Primary Industries (DPI) website;
Victorian Resources Online (VRO);
http://www.nre.vic.gov.au/web/root/Domino/vro/vrosite.nsf/pages/landform_geomorphology

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OSL DATING OF SEDIMENTS: A TOOL FOR DEVELOPING MODELS OF FLUVIAL ACTIVITY AND DEPOSITION

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Detailed sedimentological and stratigraphic research by many workers has led to a good understanding of the architecture and depositional mechanisms relating to fluvial sediments. In contrast, determining the age of these sediments, and relating phases of fluvial deposition to local, regional or global climatic or environmental events has been hindered by several limitations in applying C dating. These include i) the poor availability of organic material in some environments, ii) the difficulty of relating organic constituents to the development of the surrounding sedimentary structures, that is reworking of older material, the introduction of younger, intrusive elements such as charcoal, or significant hiatuses between in-situ organic and earlier or later inorganic sedimentation, iii) the method's intrinsic age range limitations of between 250 to around 40,000 years, with additional problems beyond the dendrochronological calibration range and at plateau periods.

Luminescence dating, based on sand-sized grains of quartz or feldspar, dates the time of last daylight exposure prior to burial within the existing sedimentary structures; the material required for dating is almost ubiquitous in fluvial deposits. However, samples may suffer problems of incomplete bleaching of the luminescence signal during periods of high turbidity, short range grain movement, transport at night or during periods of low daylight, and/or significant reworking of older sediments or erosion of bedrock. OSL (Optically Stimulated Luminescence, also called Optical Dating) has a huge advantage over TL (Theroluminescence) dating; the measured signal comes only from the most light-sensitive components. In quartz, the OSL signal is reduced to a few percent by a couple of seconds of direct sunlight, and is still sensitive to the reduced spectrum under deep or turbid water, though effective bleaching times are significantly increased.

The development of the single aliquot regenerative-dose (SAR) OSL protocol for quartz allows an assessment of the degree of internal age consistency between subsamples of an individual sample, and provides a method to screen samples for the effects of severe incomplete zeroing at deposition. The method can be extended to the dating of individual quartz grains, as an improved method to asses the degree of age consistency between grains, and hence provide more reliable age estimates. It may also be used to provide information about different depositional processes. In a similar fashion, the dating of multiple samples from one unit or different units with clear stratigraphic relationships may be used to assess the degree of internal consistency, and hence the reliability of the age estimates. Depending on the timescale being studied, incomplete zeroing at deposition may not be greater than other sources of uncertainty, and probably does not represent a limitation for most Pleistocene fluvial deposits.

As part of several different studies, c. 150 OSL samples from deposits associated with four European rivers have been measured using a multigrain quartz SAR protocol. These samples represent research with a large number of different collaborators, whose input is gratefully acknowledged. Around 60 samples from gravel and sand deposits of the terraces of the Thames in England, spanning the last 4 glacial cycles have been measured. These provide an interesting test of the lithostratigraphic and biostratigraphic models of Bridgland and others. Dating of 60 samples from the well-defined gravel terraces of the rivers Cinca and Gallego in northern Spain, and related glacial deposits of the Pyrenees, spanning 10 to 200 ka provides a useful assessment of the technique, and an opportunity to relate a number of glacial advances and terrace building events to N. Hemisphere climate fluctuations. Finally, around 30 samples from Holocene deposits of the river Culm (a tributary of the Exe) demonstrate an interesting apparent cyclicity to their deposition over the past two millennia.

CHANNEL REDEFINITION AFTER AN ENVIRONMENTAL FLOW RELEASE IN THE SNOWY RIVER

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Flow variability in the Snowy River has been significantly altered by 37 years of damming. Since the impoundment of Jindabyne dam there has been a 95% reduction in flow volume, a complete downward shift in the flow duration and flood frequency curves and a 194% increase in flow constancy compared to the pre-dam period. This has resulted in channel contraction, an ill-defined thalweg from immobile sediments, and a general lack of variability in channel form.

An experiment was set up in July 2002 to measure the short-term response of rock movement after an environmental flow release of 104 MLd in late August 2002, and subsequent flush of 500 MLd from a rainfall event one week later. Between the initiation of the experiment and the environmental flow release, a flush occurred equal in size to the release itself. Answers to the experiment were expected to demonstrate the size of rocks moved and hence the potential for riverbed reformation.

Four sites on the Snowy River and one site on a reference river were initially sampled. Rocks were classified into four Wentworth scale classes: very fine to medium gravels (2-16 mm), coarse to very coarse gravels (16-64 mm), small cobbles (64-128 mm), and large cobbles (128-256 mm). Marked rocks were placed randomly in runs and their position surveyed. Repeated surveying of the rocks was limited to the Blackburn Creek site only. The reference site became anthropogenically disturbed, and the top three Snowy River sites rendered inaccessible because of flow depth and freezing water temperatures. Results from the Blackburn Creek site showed no movement of the substrate under flows of 104 MLd and localised movement of grain sizes <40mm under flows of 500 MLd.

A local rainfall flush piggy backed onto an environmental flow release moved gravels locally at the Blackburn Creek site. This indicates that flows of between 104 and 500 MLd are required to start reforming the channel boundary at this site.

EXAMPLES OF GEOMORPHOLOGICAL INFLUENCES ON SEDIMENT PRODUCTION IN HONG KONG

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Sediment production in Hong Kong is interesting as an indication of geomorphological activity and as a potential impact on aquatic habitats, water supply facilities and drainage service facilities. Pre-Second World War records reported widespread erosion and high rates of reservoir siltation. Post-war changes of landuse in Hong Kong, such as the reforestation of Hong Kong's then largely tree-less hills (Corlett, 1999), have resulted in significant changes in the erosional environment. Lam (1973), for example, showed the importance of natural pine wood regrowth in reducing suspended sediment loads from areas of badland erosion. However, in 2002, nearly 55,000 m of sediment were removed from approximately 3,200 km of managed watercourses, channels and drains (Hong Kong Government, 2002).

This paper reviews recent findings on the sources of stream sediment. These include very low but variable background sediment concentrations in streams (Peart, 1998) and low levels of sheet erosion for grass and fernland when undisturbed by human activity or fire (Hill and Peart, 1998).

Lower frequency, higher magnitude events are important sources of sediment in Hong Kong. Examples are given of monitored channel bank erosion (Peart and Wong, 2002), of a landslide debris fan deposited into the Hok Tau Reservoir, and of the fortuitous recording of a pulse of suspended sediment following a landslide in a monitored catchment.

Geomorphological influences on the contribution of landslides to sediment production have been identified with respect to the location of susceptible areas, the relative entrainment or deposition of material within the debris trail and therefore the ability of the landslide debris to reach the stream (Ruse et al., 2002, Parry et al., 2002). Temporal variations of geomorphological processes that produce sediment within the landslide scar have also been reported (King and Williamson, 2002).

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INFLUENCE OF RIPARIAN VEGETATION ON BANK EROSION RATES IN THE NGARRADJ CATCHMENT AROUND JABILUKA MINE

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Within the Ngarradj (Swift Creek) catchment, a range of different stream types has been developed over time by the movement of water and sediment from the Arnhem Land plateau to the wetlands of Magela Creek. The sandstone valley here progressively widens downstream with sand deposition becoming increasingly active. Another important factor is the prevalence and nature of riparian (stream side) vegetation, which has a significant influence on channel stability in the valley tract between the upper sandstone gorges and the lower floodplain wetlands.

Vegetation exerts an important control on stream dynamics and bank erosion rates which have been measured in Ngarradj over three years by the erosion pin, cross section survey and scour chain techniques. Dense riparian monsoonal forest protects the banks of the larger streams from erosion. Forested meandering reaches have been mapped on extensive lengths of Ngarradj and East Tributary and are dominated by *Allosyncarpia ternata.* Several small streams originate on the lowlands and the sandstone outlier downstream of the headwaters and two of these, Tributaries Central and North, flow close to the Jabiluka minesite. These lowland channels are flanked by open woodland with no distinctive riparian vegetation. Seasonal grasses provide the dominant wet season ground cover.

The aim of this research is to determine the significance of mining-related impacts on stream dynamics in the Ngarradj catchment and to identify factors that should be taken into account in the management of the area.

Up to three years of erosion pin measurements in the Ngarradj catchment have established that:

- channels with dense riparian vegetation did not generate significant amounts of sediment by bank erosion (less than 0.04 t/m/annum);
- substantial bank erosion (up to 0.42 t/m/annum) occurred during the wet season on one of the minesite tributaries (Tributary Central) by rapid lateral migration;
- gully erosion rates on the lower reaches of the other minesite tributary (Tributary North) were always greater than the channels with dense riparian vegetation (up to 0.08 t/m/annum);
- rapid bank erosion (equivalent to a maximum erosion rate of 0.11 t/m/annum) also occurred during the dry season by a combination of desiccation and subsequent loss of cohesion of the sandy sediments, by faunal activity and by dry flow processes.

In addition, the use of scour chains demonstrated that flood scour of stream beds during the wet season was matched by fill on the recessional streamflows during the late wet/early dry season. This natural pattern of scour and fill was not found to have caused bank erosion.

These outcomes highlight the importance of riparian vegetation in reducing erosion in the Ngarradj catchment, including in the impact zone of the mine. Further, it is clear that ongoing management in the area – of mining-related activity and fire –should take account of the importance of the monsoonal forest areas and the higher susceptibility to erosion of the woodland streams where riparian vegetation is not as prevalent.

A MOUNTAIN OF WATER OR A DESERT OF ICE: IMPLICATIONS OF CONTRASTING GLACIAL STYLES IN THE MOUNTAINS OF NEW ZEALAND AND AUSTRALIA AT THE LGM

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The contrasting styles of glaciation in Australia and New Zealand pose both a geomorphic and climatic conundrum. Why do the glacial records present apparently contradictory signals?

A primary feature of glacial deposits and landscapes in New Zealand is the evidence for massive volumes of free water.

1. Lake beds are intercalated with glacial deposits in most of the glacial valleys of New Zealand, though little reported. The scale of these lacustrine systems is enormous and they are not (solely) the product of lake formation during the final stages of glacial retreat. They are the characteristic deposit of New Zealand valley glacier systems.
2. Most of the major glacial systems in New Zealand are associated with large aggradation fans. The individual advances to which these aggradation fans are tied are known to be of short duration.
3. Many New Zealand tills are anomalous. They are highly stratified and show extensive evidence of sorting. They were laid down in relatively warm (> 0°C) conditions with free water flowing through the basal till layers.

The obvious inference from these data are that periods of glacial advances in New Zealand were humid, possibly hyper-humid.

Biological proxies and other data show the LGM in New Zealand to have been c. 4°C colder but some proxies now suggest much less, at least at some sites (Marra, this conference). Closer examination of the evidence suggests that some of the apparent cooling could be explained in terms of landscape disruption rather than cooling. In Australia recent evidence points strongly to the converse. The LGM in South Eastern Australia is now seen as 8-10°C cooler and extremely arid. Even if the 4°C cooling figure for New Zealand is accepted, there is a *minimum* of a 4°C east-west thermal gradient change across the Tasman.

The gradient change can be explained, at least conceptually, by strengthening the zonal wind fields and intensifying and displacing the winter high pressure system over southern Australia. Consequent realignment of the polar jet over the Southern Ocean south and east of Australia would divert marine air masses away from Australia but consistently bring these systems over New Zealand.

WHY AREN'T SEVERE FIRES ALWAYS A TRIGGER FOR 'SERIOUS' HILLSLOPE SOIL EROSION? CASE STUDIES IN EUCALYPT FOREST IN PORTUGAL AND NEW SOUTH WALES

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Researchers have highlighted the sometimes 'disastrous' nature of hillslope soil erosion following severe forest fires. Loss of vegetation and litter cover, breakdown of soil aggregates, a cover of highly erodible ash and the development or intensification of soil water repellency have all been viewed as potential contributing factors. Whilst often the increase in erosion rates amounts to several magnitudes for newly burnt compared with long unburnt forest seems to support this view, rates for the latter can be negligible so that such a comparison can be misleading. Post-fire studies in north-central Portugal and the Nattai Tablelands of New South Wales show that although elevated hillslope erosion rates at these locations are probably hundreds or thousands of times greater than those experienced in mature forest, and their effect on nutrient status and the downstream channel network can be substantial, rates are generally lower than might have been anticipated, despite some intense post-fire rainfall and conducive terrain and soil conditions. Erosion measurements have been based mainly on results obtained from erosion plots (Portugal), repeat ground-level change measurements (Portugal & NSW), radionuclide analysis (NSW) and mineral-magnetic tracing (NSW).

In both the commercial eucalypt forests in Portugal and mature eucalypt forests near Sydney, the character of the soils, their highly repellent surface and/or near-surface condition (depending on fire severity) combined with a largely denuded vegetation and litter cover would be expected to promote less infiltration, more overland flow, enhanced rainsplash detachment of soil and hence potentially large hillslope soil losses. For the Portuguese study sites, however, elevated estimated soil losses are up to an order of magnitude lowerfor the post-fire erosion phase than for erosion following the typical immediate post-fire management response, which involved deep tillage in preparation for planting eucalypt seedlings. At the NSW sites, even intense rainstorms following the Christmas 2001 fires led mainly to localised redistribution of the highly erodible sandy subsurface soil on valley-side slopes. Net soil losses from valley-side slopes were about 30 t haup to *c.*5 months after fire according to radionuclide analysis, which is considerably less than might be expected. Nevertheless, eroded sediment entering the stream system, largely derived from relatively thin organic-rich, ridge top surface soil, may well have had detrimental downstream impacts. Possible reasons for the observed post-fire impacts on the investigated hillslopes are discussed.

GEOMORPHIC FACTORS AND STREAM SALINITY, BEGA, NSW

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There is little documented evidence to date of the extent and level of near coastal stream salinity in NSW, let alone a conceptual model that describes the contributing factors and control mechanisms on its development. A model has been developed by using a case study of the Wolumla and Candelo catchments, with data collection also in Tantawangalo and Sandy Creeks and the Bemboka and Bega River, South Coast, NSW. The landscape and biophysical components and processes that cause stream salinity have been identified using the relative significance of likely sources of salt and by determining the significance of hydrological changes to the geomorphology of valley fills brought about by land use change. The catchments are biophysically representative of near coastal environments of southeastern NSW.

Comprehensive baseline sampling and analysis was carried out for stream water EC, pH and cation concentrations of Na, K, Ca and Mg at 23 sites from May 1994 to May 1995 during drought conditions. The principal sources of salt were found to be geology and rainfall. Rainfall accession was determined from seven sites across the catchments in a transect perpendicular to the coast. Accession was highest closest to the ocean, and the greatest contributions were from single events (probably relating to storm source), rather than constant low level inputs. Sodium dominated the cations found in rainwater.

Geochemical data showed rock types contributed markedly different levels of Na, and ratios of Na to Ca; and these inputs coincided strongly with stream outputs. The geology and geochemistry of the underlying rocks has a profound effect on the supply, storage and release of salts. The effect is twofold. Not only is the lithology underlying a catchment a source of Na, it can also buffer the release of Na by the Ca, K and Mg content. The ratios of Na to Ca + Mg and Na to K can be used to predict salinity levels. The catchments containing rock types high in K, Ca and Mg have buffering processes that allow the leaching of Na from soils and sedimentary fills preferentially, preventing the build of NaCl and subsequent problems of salinity in streams.

These salts are stored in specific parts of the landscape which are governed by the physical structure of the landscape such as the soils, and sedimentary deposits, including valley fill sequences, swamps and chains of ponds. Under the influence of land use changes in the past 200 years, the catchment vegetation has been changed. There are two parts to these changes. The first is the clearing of slopes and crests causing an increase in discharge, resulting in some incision. However the much more important change causing the release of salt has been the destabilisation of the vegetation on the swamps and valley fills – the melaleuca communities. Thus the components of the model are the sources of salt, the landscape stores of salt, and the salt release mechanisms.

Stream geomorphology and sediment stores in valley fills and swamps were found to play the greatest role in defining the development of saline stream conditions. Valley infill sedimentary sequences have been eroded to expose windows into saline ground water. Certain sequences of river geomorphology have been shown to develop more or less severe salinity, with the risk being reduced in the presence of a forested upland headwater catchments and increased by particular underlying geology. The process is driven by the changes in land use since European settlement, so management aims would need to include land use practices that increase rainfall interception, infiltration and decrease runoff to prevent further incision of drainage channels.

CONTROLS ON HISTORIC BEDFORM CHANGES IN A PARTIALLY CONFINED SAND-BED RIVER

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Medium term adjustments in channel form caused by human activities, and in particular land and water resource developments, can occur over periods of decades. Historic channel changes provide a unique opportunity to test models of medium-term and short-term adjustments in channel form in response to changes in environmental controls. Whilst there are many studies of historic adjustment in gross channel dimensions to changes in river hydrology and sedimentology there are few investigations of historical changes in channel bedform and timescales associated with these changes. Bedform change is important in ecological studies and river restoration projects because it influences habitat variability, particularly at low flows, and habitat variability is strongly associated with biological diversity.

This paper examines bedform changes in the lower Snowy River, a partially confined sand-bed river. Historic evidence of channel and bedform changes including survey plans, cross-section plans, air photos and anecdotal accounts is reviewed. Models of bedform change are tested for consistency with historic data. It is apparent that channel bedform has varied considerably over the historic period in response to channel widening and flow variation. Substantial bed scour has occurred at floodplain constrictions during large floods and subsequent infilling can take several years with recovery times a function of the subsequent flow regime. It is clear that management of physical habitats in the lower Snowy River must be compatible with on-going bedform change. Limitations of existing bedform models do not allow explicit predictions of river bedform for particular sequences of flow.

APPLICATION OF REGOLITH-LANDFORM MAPPING TO MARS ANALOGUE RESEARCH AT THE MARS DESERT RESEARCH STATION IN UTAH

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The technique of regolith-landform mapping, developed mainly in Australia, unearths clues to understanding global geological processes and landscape evolution. The application of these techniques to extraterrestrial surfaces presents new challenges. The majority of exploration outside Earth has been via remote means. Mars is a focus for planetary research and has been the target of many unmanned scientific mission over the past 40 years.

The Mars Desert Research Station (MDRS) in Utah was set up as the first of several Mars-analogue research sites around the world. MDRS was designed as a test-bed for geological research, with emphasis on basin architecture, sedimentary geology, and regolith studies. Physical environment analysis and exploration management strategies for Mars analogue landscape investigation were planned as part of a four-week international, multidisciplinary research program in February-March 2003. The research program included testing mapping methods and exploration strategies and was hoped to assess how remotely sensed data could be used in conjunction with field mapping techniques for a wide variety of applications.

Landform maps are easily generated using satellite imagery. On Earth we have a good understanding of landscape processes and materials, however the lack of similar information on Mars, makes regolith materials difficult to study. To simulate a Mars mapping exercise, preliminary landform maps of the topography surrounding MDRS were prepared. To immitate our limited knowledge of the Martian surface, maps were produced using DEM and ASTER images, and no attempt was made to classify regolith materials. Researchers at MDRS were able to use the landform map, as a tool for exploration and investigation of the landscape, and to add more detailed landform units and regolith descriptions to the existing base map. The work showed that remotely sensed data allows regional maps to be made quickly and easily, and form a good basis for more detailed work such as correlating regolith materials and their distribution via ground-truthing studies.

The quality of information acquired demonstrates the diversity of uses to which regolith-landform mapping techniques can be applied, including geomorphological, geophysical and geochemical research; landscape history and evolution; resource identification and extraction; and geotechnical and engineering applications.

REACH MORPHOLOGY IN SE AUSTRALIAN MOUNTAIN-TYPE STREAMS

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Channel response to changes in discharge and sediment supply varies with the magnitude of change and the resistance of the river to such changes. As such, there is enormous variability in the response of river systems to changes in either discharge and/or sediment supply. Such responses range from the destruction of channel form to in-filling of interstitial spaces in the bed framework with potential impacts on habitat diversity. Classification schemes for channel morphology based largely on interactions of power, resistance and sediment supply have been proposed for mountain rivers in the Northern hemisphere that describe bedrock, cascade, step-pool, plane-bed and pool-riffle reach types. The reach types are proposed to exhibit specific form resistance to flow due to channel bed organisation. To test the application and appropriateness of these schemes to SE Australian mountain-type streams, systematic profile surveys and coarse-clast measures were conducted along 30 reaches of high gradient creeks. Sub-catchment lithology (Ordovician metasediments or Devonian granites) and landuse (plantation forests with high roading density or native harvest forests with low roading density) were also introduced as potential factors to explain sediment supply conditions that may affect reach-scale changes in channel bed type. Spatial autocorrelation analysis was applied to the survey data and resulting correlograms were examined for wavelengths, pseudo-oscillatory replication and randomness. Plots of coarse clast measures show lithology dependent modes of sediment size and shape. Most reaches contain bedrock outcrops but the areal extent of bedrock in metasediments appears critical in yielding heterogeneity in channel profile. The high abundance of resistant boulders in granite reaches leads to greater channel bed roughness. Reach types identified differ from Northern hemisphere mountain rivers with core-boulder cascade, forced-bar pool, bar and step-pool and rapid morphologies found as well as bedrock reaches. Findings of this work are discussed within the context of energy-resistance relationships in defining channel types in high-energy streams and the consequence of increased sediment supply to these channel types.

NEOTECTONICS AND GEOMORPHOLOGY OF THE MOUNT LOFTY RANGES, SOUTH AUSTRALIA (POSTER)

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The Mount Lofty Ranges and flanking basins were traditionally considered to be the result of Tertiary compressional tectonics. Our new neotectonic concept involves Tertiary extensional tectonics, but with compression and uplift of the Ranges mainly after the earliest Pleistocene (last million years). Three neotectonic stages are recognised: 1) Extensional Stage (Middle Eocene to Middle Miocene), 2) Transitional Stage (Late Miocene to earliest Pleistocene), and 3) Compressional Stage (Pleistocene to the Present). The most pronounced tectonism such as uplift of the Mount Lofty Ranges is associated with the latest compressional stage, while most of the basin subsidence occurred during the first extensional stage. This model satisfies the observed structural setting and landscape evolution, and fits into the regional lithostratigraphic framework correlated with the global eustatic sea-level curve.

Our model incorporates a pre-Middle Eocene Palaeoplain as the predecessor of the regional neotectonic structure. Remnants of this gently undulating and deeply weathered Palaeoplain are buried beneath the Tertiary sediments in flanking basins and preserved as planation surfaces capped by deep regolith within the Ranges. The global eustatic curve provides evidence that this Palaeoplain was initially >250m above present sea-level. This surface was used as a base for structural reconstructions and to calculate the total amount of neotectonic movements.

Tertiary strain transfer and accommodation zones, tilting and crustal segmentation are fundamental attributes of the extensional tectonics that are recognised within this region. The curved half-graben structures of the St. Vincent Basin embayments were formed as a result of accommodation of strain transfer between non-aligned systems of normal faults. The Mount Lofty Ranges were initially formed as a remnant of the pre-Middle Eocene Palaeoplain between subsiding basins. The Tertiary landscape of the Ranges inherited the landforms of this Palaeoplain that was later modified by regional W-SW tilting and local segmentation following the formation of intramontane basins and incipient river systems.

The Transitional Stage was a time-interval when the extensional style of tectonics did not cease entirely but compressional tectonics did not yet dominate. This was expressed as a regional southern tilting of 1-5 of the pre-Pliocene sedimentary package in the St. Vincent Basin. This deformation was accompanied by basin-wide marine bedload erosion during the marine retreats, resulting in the sub-Pliocene unconformity.

Compressional deformations associated with Pleistocene reverse-fault block movements are recognised on both western and eastern sides of the Mount Lofty Ranges. The highly dissected slopes of the Mount Lofty Ranges including V-shape valleys, river gorges and waterfalls are the result of stream erosional response to major Pleistocene uplift. This uplift is also recorded by a dramatic change of the earlier fine-grained lithologies into coarse fluvial deposits including pebbles and boulders of the Hindmarsh Clay and Pooraka Formations.

MID-MIOCENE ACTIVE UPLIFT OF THE WESTERN MARGIN OF THE SOUTHEASTERN HIGHLANDS OF AUSTRALIA

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Valley-filling Mid Miocene basalts and sediments infilling the Macquarie River valley in the Central-West of New South Wales, have provided evidence for a period of rapid incision in the Mid to Late Miocene – Early Pliocene. This incision is attributed to active highland uplift.

Further evidence to support active uplift has been found by extending investigations to the basalt longprofiles compared to the modern Macquarie River and Cudgegong River (major tributary) longprofiles. Mid Miocene basalts are found over a distance of 90 km along the Macquarie River (Ophir to Mookerawa), as elevated erosional remnants. At Mookerawa, near the confluence of the Macquarie and Cudgegong Rivers, the base of the basalt is around 175 m above the river level. Similar aged basalts are also found in the Gulgong area over a distance of 33 km along the Cudgegong River / Cooyal-Wialdra Creek. Basalts downstream of Gulgong around Yamble are elevated up to 25m above current river level to the basalt base, but merge with the modern river upstream at Beryl, and at Gulgong 40 m thick basalts are buried by up to 10 m of sediment. The longprofile of the basalt-filled Cudgegong valley shows that there has been back-tilting of the valley (i.e. west side up) between Gulgong and Beryl of around 50 m following the flow event(s).

Furthermore, the Mid Miocene valley, indicated by the base of the basalt flow at Mookerawa, located on the Macquarie River 16 km upstream of the Macquarie – Cudgegong River confluence, is now at 484 m.a.s.l. By contrast, the base of the basalt at Yamble, located on the Cudgegong River 70 km upstream of the Macquarie – Cudgegong River confluence, is currently 405 m.a.s.l.. There has been substantial uplift of the downstream site (Mookerawa), relative to the upstream site (Yamble). The total amount of uplift can be determined by the offset in surface elevations (79 m) plus an allowance for the fall of the river (67 m, based on modern river gradients) at 146 m. This is a minimum value, using conservative gradients and neglecting the greater difference in basalt flow upper surface elevations.

The two offsets indicate that Mookerawa has been uplifted relative to Gulgong, something in the order of 200 m. Numerous faults are shown in the Palaeozoic rocks and Permian rocks such as the Mudgee Thrust and Macquarie Fault, however, the geology provides no evidence for post-Permian activation. Instead, active uplift of the highlands west of Gulgong must have been by longwave flexure of the lithosphere (warping). Incision below Mid Miocene basalts on the Macquarie River downstream of Dubbo indicates that uplift extended to the highland margin around Narromine, while valley stratigraphy indicates that there has not been substantial uplift since the Late Miocene. Regional topography and geology suggest that the whole of the central highlands west of the alignment of the Mudgee Thrust were uplifted. We cannot determine the western or southern boundaries of the uplifted block, however uplift appears to have decreased dramatically north of the Talbragar River. This episode of active Neogene uplift has resulted in deeply incised gorges along the western margin of the highlands and an increase in relief, rather than declining relief predicted by models which assume only passive rebound following the initial formation of the highlands in the Late Cretaceous.

A CLASSIFICATION OF IN-CHANNEL BENCHES TO ASSIST IN RELATING RIVER HYDROLOGY AND MORPHOLOGY

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In-channel benches are mostly horizontal, planar features resulting from vertical accretion of suspended sediment within the contemporary river channel. Benches are distinct from bars formed by lateral accretion of bedload material. There is an interest in identifying consistent inundation frequencies for benches within a reach. This has been problematic in previous studies where benches have commonly been classified according to relative elevation in the channel. Where bench types have been identified from inherent characteristics studies have not utilised these types to differentiate results. Based on a review of literature, and an initial investigation on the Buckland and Ovens Rivers northeast Victoria, seven bench types were identified, classified according to causative conditions. This paper aims to explain why a lack of consistency has been found for inundation frequencies and rates of accretion of benches within river systems. Each bench type would be expected to experience different rates of formation and frequency of destruction dominated by local scale influences. It is proposed that an understanding of discrete bench types may improve the consistency of results for bench inundation frequencies and the knowledge of bench distribution and formation.

OSL DATING OF FOWLERS CREEK SILT: A CORRECTION (POSTER)

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Wanaka Meeting (2000)

Work-in-progress results from OSL dating of Fowlers Creek silt were presented to the ANZGG. One aim of the dating was to investigate the effects, if any, of European settlement on fluvial style. An unexpected result was an age of ~2.4 ka for the top silt layer at one sample site (S14). This finely laminated red-brown silt/fine sand, with a sharp lower boundary and basal pebble line, is similar to Post-Settlement Alluvium described by Fanning (1994, 1999) for other areas of western NSW.

Aliquot Size in OSL Dating

OSL dates obtained using large aliquots average together the luminescence of all grains in the aliquot. When only some of a sediment's grains have their luminescence clock re-set (partial bleaching), "old" grains contribute luminescence, leading to an age overestimate. Since only a small fraction of grains luminesce, the fewer grains per aliquot, the greater the chance of some aliquots being uncontaminated by "old" grains. In other studies, minimum ages from small-aliquot OSL have successfully dated partially-bleached sediments. The Wanaka dates were obtained using both large and small aliquots.

Ambiguous Results Resolved In The Nick Of Time – Or Not

For S14's top silt layer, large-aliquot OSL results indicated a stratigraphic reversal. The two possible causes should be resolvable by small-aliquot OSL: if the problem was partial bleaching, the minimum ages would be in correct stratigraphic order; if the problem was sample mislabelling, the ages would continue to be stratigraphically reversed.

Before the Wanaka meeting, small-aliquot dates unambiguously indicated a labelling mixup: the "upper" sample's minimum and mean ages were an order of magnitude greater than those of the "lower" sample. During/after Wanaka, confirmation of the mislabelling was sought by dating two separate sets of spare samples; then the site was revisited and the silt layer resampled. In all cases, the stratigraphic reversal continued to be present. Clearly, the dates were incorrect, and small-aliquot dating was not adequate for this silt.

Single-Grain Dating: Sometimes Useful

Single grain OSL revealed that the upper sample was unusual in three ways: many grains produced usable luminescence, there was a very high degree of partial bleaching, and there was a large number of aberrant "bright" grains. These factors contributed to a gross age overestimate. Although lithologically identical, the lower sample had none of these problems. The silt's age is 100-76 ybp (lower and upper samples respectively).

Single grain OSL dating solved this problem, but resulted in age underestimates when applied to some other Fowlers Creek sediments. The appropriate OSL treatment varies from sample to sample, according to the individual characteristics of each sediment.

Fanning, P.C., 1994. Long-term contemporary erosion rates in an arid rangelands environment in western New South Wales, Australia. *Journal of Arid Environments*, 28: 173-187.

Fanning, P.C., 1999. Recent landscape history in arid western New South Wales, Australia; a model for regional change. *Geomorphology*, 29: 191-209.

FOWLERS CREEK: ONE RIVER, FIVE FLUVIAL STYLES

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Introduction

Fowlers Creek is an ephemeral creek in the Barrier Range of arid western New South Wales. It can be divided into: 1) the hilly Uplands, the source of most of the water and sediment in the river system, where a wide network of small tributaries join to form a substantial channel set into wide floodplains; 2) the Trunk, a zone of water and sediment transport, where the channel is large, but the floodplains are narrow; and 3) the distributary Terminal Floodout, where channel size reduces and overbank/ unchannelised flow becomes increasingly important with distance downstream.

The Uplands

Lower-order tributaries form *discontinuous ephemeral streams* (Bull 1997), with upstream badlands and gullies, central arroyos, and downstream internal floodouts, where the creek channel disappears. Internal floodouts are pinned at tributary confluences and their formation is linked to major floods; groundwater is preferentially retained there, and they are ecologically significant. Downstream, higher-order drainage re-establishes as the main creek's gullies and arroyos, and has some features in common with the lower-order tributaries. However, low valley slope, low bank cohesion, and wide floodplains with irregular topography contribute to an *unstable, threshold-dominated fluvial style*, characterised by a mobile channel, and eroding and vertically aggrading floodplains.

The Trunk

In the Trunk, Fowlers Creek is *anabranching*. Low valley slope and constraining bedrock leave few options for channel adjustment. Channel banks are stable and very cohesive, and water and sediment loads are very high. Under these conditions, an anabranching planform increases fluvial effectiveness by increasing channel depth.

The Trunk anabranches of Fowlers Creek also show *pool-and-riffle* sequences. Semi-regular alternation between broad, shallow, gravelly channels with widely scattered in-channel gum trees, and narrow, deep chutes with dense vegetation lining the banks, may be linked to flood-stage competence reversal, as was demonstrated by Jansen (2001) for nearby Sandy Creek. The combination of down-reach channel variation (pool-and-riffle) with cross-reach variation (anabranching) suggests that fluvial process is likely to be complex, and different at different flood heights.

The Terminal Floodout

The creek channel in the proximal Terminal Floodout is *meandering*, with outer-bank erosion, inner-bank scroll bars, and meander cutoffs. In both the 'Live' (current) and 'Dead' (recently abandoned) branches, large open meanders with riparian gum trees have been replaced by small tight meanders without trees. Increasing sinuousity may result from a decrease in discharge, or increasing slope.

Bull, W.B., 1997. Discontinuous ephemeral streams. *Geomorphology* 19: 227-276.

Jansen, J.J., 2001. *Bedrock channel morphodynamics and landscape evolution in an arid zone gorge: Sandy Creek, northern Barrier Range, south-eastern central Australia.* PhD thesis, Macquarie University, New South Wales.

USE OF TRACER BUDGETS TO ASSESS POST FIRE SEDIMENT REDISTRIBUTION IN A CATCHMENT OF THE NATTAI TABLELANDS, NSW

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The Christmas 2001 wildfires caused widespread loss of vegetation and litter cover in the eucalypt forests surrounding the Lake Burragorang reservoir, the major water supply catchment, for Sydney, NSW, Australia. The fire was then followed by a series of rainfall events which triggered significant redistribution of soils on catchment slopes and delivery of eroded material to downslope locations and river channels (Shakesby et al., 2003). In order to describe and quantify the redistribution of material that occurred after the fires we construct a series of budgets based on measurements of fallout radionuclides; specifically Be (53 days), Cs (~30 years), and Pb_{ex} (~20 years). Measurements of these nuclides are undertaken within various landscape elements (Plateau's, side slopes <11, prior fan, new alluvial fan, and base slope) of an ~80 ha headwater tableland catchment of Blue Gum Creek, a tributary of the Nattai.

As the three radionuclides have different half lives it allows the opportunity to understand sediment redistribution at the study site over different time frames. Specifically the Be budget (53 days) can be used to illustrate the redistribution of sediment that occurred immediately after the fires; the Cs budget may quantify sediment redistribution within the landscape elements over the last 40 years (ie. the time since the deposition of Cs from weapons testing); whilst the Pb_{ex} budget illustrates net sediment redistribution over a time averaged period of ~120 years (ie. 6 x the Pb_{ex} half life of 20 years. The latter time frame allows us to investigate the net effect of multiple bushfires.

These results are discussed within the context of the longer term geomorphic stability of the catchment.

References:

Shakesby, R.A., Chafer, C, Doerr, S.H., Blake, W.H., Wallbrink, P.J., Humphreys, G.S. and Harrington, B.A. 2003. Fire intensity, water repellency characteristics and hydrogeomorphological changes following the Christmas 2001 Sydney forest fires, in press *Aust. Geographer*, 34;2, 147-175.

IRRECONCILABLE DIFFERENCES: APATITE FISSION TRACK ANALYSIS AND THE CONCEPT OF OLD EROSION SURFACES IN THE SOUTHEASTERN HIGHLANDS

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Within the Southeastern Highlands of Australia, the high plains of Victoria comprise small plateaus with a low undulating relief, usually at elevations of >1200 m. The broad open valleys of the high plains have low gradients and contain mineralogically mature sands and gravels. At the edges of the plateaus, streams fall 300–600m into deeply incised valleys at major knickpoints. Development of the high plains has been largely independent of lithology. The Bogong, Cobungra and Dargo high plains appear to have formed part of a single extensive surface before dissection by rivers.

These features have frequently been noted, and used to interpret the high plains as remnants of an uplifted (Early) Mesozoic peneplain/palaeoplain/palaeo-surface. As supporting evidence, the oxygen-isotope signatures of secondary kaolinites from weathering profiles in the highlands of southeastern NSW are believed to have resulted from pre-Late Mesozoic weathering.

Recent apatite fission track studies of the Bogong High Plains (O'Sullivan *et al.*, 1999) conflict strongly with the earlier ideas. The fission track data indicate that rocks presently at the surface on the Bogong High Plains experienced palaeotemperatures of 60–90°C at 110 Ma (Early Cretaceous), and cooled rapidly between 110 Ma and 90 Ma. This has been interpreted to indicate that the Bogong High Plains underwent at least 1.5 km of denudation in the mid-Cretaceous. Thus, far from being in existence since the Early Mesozoic, the Bogong High Plains was apparently being rapidly eroded through the mid-Cretaceous, and the present land surface there was created in the Early Tertiary. The Older Volcanics lavas on the nearby Cobungra High Plains are underlain by sediments with an Early Eocene palynoflora, showing that the high plains' surface had developed by this time.

If the interpretation of the fission track data is correct, then the concept of a Mesozoic palaeoplain, of which the present high plains are now remnants, must be abandoned. Nevertheless, it is difficult to reconcile the fission track results with the geomorphology of the area. According to the fission track data, kilometres of rapid denudation in the mid-Cretaceous over a period of about 20 million years, followed by relative landscape stability for about 40 million years, produced the low-relief surface on which the Early Eocene sediments beneath the Older Volcanics were deposited. By contrast, erosion over the last 30 million years, since eruption of the Oligocene lavas, has apparently formed a steeply dissected landscape.

It has been suggested that the fission track evidence could be explained if the high plains were buried by kilometres of (?Early Cretaceous) sediment and subsequently exhumed during mid-Cretaceous denudation. However, it is most unlikely that there was a thick sedimentary cover across the high plains, as there are no remnants of these sediments in the present landscape, nor is there any evidence of the major Mesozoic subsidence required for them to accumulate. An alternative possibility is that the fission track data, while accurately recording the palaeotemperature record of the strata, cannot always be interpreted in terms of denudation, but may instead identify thermal relaxation following heating, e.g. due to the circulation of hot fluids. If geothermal gradients are temporarily much higher than frequently assumed in fission track studies, the amount of denudation calculated from the fission track data would be an overestimate.

O'SULLIVAN P. B., ORR M., O'SULLIVAN A. J. & GLEADOW A. J. W. 1999. Episodic Late Palaeozoic to Recent denudation of the Eastern Highlands of Australia: evidence from the Bogong High Plains, Victoria. *Australian Journal of Earth Sciences* **46**, 199-216.

SOIL PRODUCTION AND LANDSCAPE EVOLUTION IN THE BLUE MOUNTAINS, NSW, DERIVED FROM COSMOGENIC ^{10}BE AND OSL

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Heath and forest distribution patterns on spurs in the western Blue Mountains, NSW, highlight soil depth contrasts. Forest grows on deeper soil mantles on plateau summits and proximal spur positions while heath occupies spur noses that have shallow and discontinuous soils. The transition from deep to shallow soil mantles is sharp and corresponds with the change in vegetation structure. Other features of the site include two types of rock outcrop which are restricted to spur noses: sandstone towers (known locally as pagodas) 2–15 m high, and near-horizontal rock benches with little relief, which alternate downslope with heath. We established distinct soil depths on either boundary side in our study area, Marrangaroo Ck. (33°S, 150°E), a tributary of Coxs River. Since slope aspect (Wilkinson & Humphreys, in review), soil nutrients levels and lithology do not appear to be major factors controlling these patterns, we turned to soil production models which are examined here.

Local soil production rates have long been thought to be a function of overlying soil thicknesses (Gilbert 1877). Two main models are considered in light of the vegetation-soil depth patterns. Two variants of Gilbert's (1877) 'humped' model are examined, along with the recently derived inverse exponential model of Heimsath *et al.* (1999). Since Gilbert modelled maximum soil production under a non-zero, finite soil depth (d_m), positive feedback exists for sites with a local soil depth between zero and d_m (Carson & Kirkby 1972). This instability is thought to restrict the range of soil thicknesses to $\geq d_m$ or zero (rock outcrop). In light of this model, (a) d_m may equal the forest mantle thickness adjacent to the vegetation boundary, while the spur nose occupies the unstable zone of the model, thereby explaining the sharp soil depth contrasts. Similarly, (b) the soil thickness under the heath bands that alternate with rock benches may equal d_m, while the rock benches results from instability in the model. Alternatively, (c) soil production may be related to soil thickness by a steep inverse exponential function as derived for several sites by Heimsath *et al.* (1999, 2000, 2001).

To estimate the soil production function at Marrangaroo, we took 11 bedrock samples under various soil thicknesses to measure concentrations of cosmogenically produced Be. To test the steady state assumption required to convert nuclide concentrations to production rates, and mindful of nearby aeolian additions to mantles (Hesse *et al.* 2003), bedrock was sampled at a control location, and 7 samples for large aliquot OSL ages were taken from a 70 cm forest pit. Since slope curvature is a proxy for soil production where linear soil transport operates, soil production is balanced by erosion and chemical weathering is minimised (Heimsath *et al.* 1999), we surveyed an area either side of the soil-vegetation boundary as a secondary method to estimate soil production.

Soil production estimates from Be do not approximate an inverse exponential function. Although gaps exist in the data set, and either humped model is possible, the consistency of the production rates with depth suggests otherwise. Slope curvature results are similar. OSL ages increase exponentially with soil depth, suggesting decreasing rates of vertical mixing within the profile with increasing soil depth. Furthermore, no soil addition or stripping is apparent in the last 150 ka. The average soil production rate is 12.5 m/Myr, similar to an estimate for landscape lowering derived from nearby Miocene basalt summits (van der Beek *et al.* 2001). While the 2 m/Myr differential between forest and heath slope segments is enough to produce observed relief over a 50–100 Myr timescale, the basalt summits suggest incision post-dates these flows. This implies a major post-Miocene regolith stripping event, probably similar to that reported by van der Beek *et al.* (2001) for the Grose Valley, to produce relief before the current soil production rates established. The soil depth-vegetation patterns may result from an interaction between soil transport over spurs and plant responses to fire.

GEOMORPHIC EVOLUTION OF THE NILE BASIN

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The Mesozoic and Cainozoic history of the Nile basin is one of episodic reactivation of geological structures (mylonites, shear zones, fractures) generated before and during the 550 Ma Pan-African orogenic event. These ancient structures account for the complexity and variable alignments of the present Nile and of all the major depocentres within the Nile basin. The focus of this paper is on the more recent geomorphic history of the Blue and White Nile tributaries of the Nile. The Nile basin drains about one tenth of the African continent and covers an area of 2.96 million km. It is 6,825 km long, making it the longest river in the world. The Ethiopian and Ugandan headwaters of the Nile attain elevations in excess of 2 km, while the watersheds rise to over 5 km. Despite its impressive catchment area, the annual discharge of the Nile is only 84 kmor 10m/km. The Amazon, in contrast, drains 7,050 km and has an annual discharge of 5,518 km. The Ethiopian tributaries of the Nile (notably the Blue Nile and the Atbara) provide the bulk of the flood discharge and sediment load, but the Ugandan tributaries, via the White Nile, provide the reliable dry season discharge which maintains perennial flow in the main Nile. The hydrological differences between the Blue and White Nile rivers reflect their very different geomorphic histories and are evident also in the ways in which human societies have adapted to these mighty rivers from Neolithic times onwards.

Certain big tropical rivers defy many of our preconceptions relating to floodplain patterns and processes. The White Nile is such a river. Although endowed with a remarkably gentle longitudinal gradient (averaging 1 in 75,000) and a very fine suspension load, the White Nile has many of the characteristics of a braided river system. These include mid-channel bars and a reticulate channel pattern, with no signs of the meander cutoffs and sinuous channels evident in other large tropical suspension load rivers. Landsat 5 TM and Landsat 7 ETM imagery show a series of lake shorelines, palaeochannels and desert dunes in the White Nile valley as far south as latitude 10°N. The highest shoreline (386 m elevation) formed when the White Nile formed a lake up to 70 km wide and over 500 km long over 250ka ago. The recessional stages of the lake are delineated by a series of shallow linear depressions and secondary channels oriented roughly parallel to the flow direction of the present White Nile. Sandy clays and clayey sands were deposited by the White Nile during times of high flow and strong summer monsoons between ≥25ka and ~14ka. The lowest identified shoreline (382 m elevation) is clearly evident in the scalloped margins of desert dunes that were active during the Last Glacial Maximum. Concentrations of freshwater gastropods and occasional Nile perch vertebrae located 1.0-1.4 m beneath the present land surface indicate that the White Nile floods were up to 4.5-5.0 m higher than today and extended up to 20 km from the present channel towards 14-15ka. The stable oxygen and carbon isotopic values of the microcrystalline calcite and dolomite crystals in the fine sandy clays underlying the shell beds indicate a prolonged phase of shallow water sedimentation under saline evaporative conditions. This regime lasted from at least 35,000 years ago until 14-15ka, at which time Lake Victoria in the Ugandan headwaters overflowed once more and a summer monsoon climate was restored. The strontium isotope ratios of modern and sub-fossil gastropod shells from the lake headwaters of the White Nile down to its confluence with the Blue Nile at Khartoum confirm that the present flow regime of the White Nile was re-established by 14-15ka.

While flow in the White Nile waxed and waned during the past 250ka, the Blue Nile continued to construct the large, low-angle alluvial fan known today as the Gezira. Distributary channels of the Blue Nile radiated across the fan and deposited sands and fine gravels derived from the volcanic uplands of Ethiopia. Radiocarbon dates obtained on sub-fossil oyster and gastropod shells within the palaeochannel sediments indicate that they were at least seasonally active between 40ka and 8-5ka. Incision by the main Blue Nile channel from about 8ka onwards effectively beheaded the distributary channels and deprived them progressively of their flood discharge. The abandoned channels show a fining-upwards sequence in which pale sands and fine gravels give way to clays in the upper 2m. Clay deposition in the back-swamps and floodplains of these channels dwindled and finally ceased about 5ka, when the seasonally flooded swampy plains gave way first to acacia-tall grass savanna and finally to semi-desert steppe. The sub-fossil snail fauna within the upper two metres of Gezira clay shows a progressive change from permanent water species to semi-aquatic species with lungs and gills to land snails.

THE EFFECTS OF CLUSTERED AND ISOLATED TREES ON SOIL FERTILITY IN AN AUSTRALIAN BOX WOODLAND

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The once extensive cover of eucalypt woodlands, dominated by Box Woodland communities in the dry temperate regions of eastern Australia has been subject to extensive clearing over the past 150 years. The resulting remnant stands, which are of varying size and quality, are now interspersed amongst grazing and cropping lands. Tree removal has been linked to almost every aspect of land degradation, the effects of which cause further degradation to remaining stands. As a result, those remnants of native vegetation in agricultural areas are currently subject to a range of issues associated with their management and survival.

Paddock and isolated trees are now common occurrences in the south west slopes region of New South Wales. The effects of these trees on soil fertility were examined to determine the benefit in retaining native vegetation to improve soil condition. Whilst numerous studies have been conducted in savanna systems on the effect of trees on soil properties, little data exists on this topic in the highly disturbed areas of the south west slopes region. This study aims to improve the understanding of the impacts of clustered and isolated trees on surrounding soils. Spatial variability of soil properties was assessed along a gradient extending from the tree trunk to open areas, with the consistency in these trends between clustered trees and isolated (living or dead) examined. Changes in soil nutrients with depth within a grove of clustered trees were also assessed.

Trees were found to increase overall soil fertility, with the greatest effects occurring under the clustered trees, and closest to the tree trunk, declining with increasing distance. Nutrients were also highly concentrated on the surface of the profile, and showed a clear trend of decline with increasing depth. Exchangeable Ca and K, organic C and total N and S declined markedly from clustered to dead trees, while soluble Ca and K, and pH increased. Clear trends in soil chemistry were also found with increasing distance from the tree trunk, with available P, and soluble Ca and Mg significantly higher closer to the trunk, while electrical conductivity also declined with distance from the trunk. Nutrient concentrations were highest at the surface and declined markedly with depth, with the greatest declines occurring in the top 10 cm.

These findings highlight the importance of trees in the landscape, particularly in an area of eastern Australia where intact woodlands are rare and scattered trees predominate. Processes such as shedding of bark, stem flow and throughflow increase nutrient and cation concentrations close to trees and at the surface. Nutrient rich soils are further amended through positive feedback processes with trees on more fertile soils producing more nutrient rich litter. Enrichment in the surface horizons was also due to the transportation of nutrients from areas beyond the zone of influence of the tree by stock and other wildlife. Nutrient losses are also decreased by tree canopies through the reduction in leaching and soil erosion in addition to enhancing nutrient levels. Therefore the retention of trees in an agricultural setting has the potential not only to prevent the continuous land degradation associated with traditional agricultural practices, but also improve the overall soil fertility throughout the landscape, with the effects of increased fertility remaining long after their death.

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THE EFFECT OF MIDDLE TO LATE TERTIARY FLUCTUATIONS OF SEA LEVEL ON THE GEOCHEMICAL EVOLUTION OF WEST AUSTRALIAN REGOLITH

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The southeast margin of the Yilgarn Craton, in southwestern Australia, was inundated by marine transgressions during the middle and late Eocene. These transgressions resulted in the deposition of marine sediments in the shallow Eucla Basin and its marginal palaeovalleys, commonly for distances of several hundred kilometres from the palaeo-shoreline.

The Eocene palaeo-shoreline, at the onlap of the Eucla Basin with the Yilgarn Craton, was deeply embayed during this period. Organic and pyrite-rich, fine-grained, non-marine sediments, including locally thick peat accumulations, were deposited in the incised palaeovalleys and coastal plains during the early stages of the middle Eocene transgression. Continued transgression drowned the palaeovalleys, forming estuaries that supported the extensive development of fringing mangrove communities and temperate rainforest. Terrigenous sediments accumulated in most estuaries and embayments during the middle Eocene. The exception was in the Cowan Palaeovalley where reduced terrigenous influx allowed the deposition of shallow-marine, cool-water carbonates

When the sea regressed during the middle Eocene, the estuarine sediments were drained, resulting in oxidation of the pyrite rich profile; generating sulphuric acid and precipitating haematite. The development of acid sulphate soils in reclaimed coastal wetlands is a contemporary analogue for this process. We speculate that acidification of the saline groundwater draining from the estuarine sediments would have resulted in dramatic leaching of the surrounding country rock, generating deep weathering profiles. Silica would have flooded the near-shore marine environment as a consequence of this deep weathering "event", providing key nutrients for the extraordinary proliferation of marine sponges that formed the extensive coastal spiculites and spongolites of the late Eocene transgression. Such abundant and thorough acid sulphate weathering was not available during the otherwise similar middle Eocene transgression–regression sequence because of the absence of widespread sulphidic sediments, explaining the confinement of the sponge facies to the late Eocene. Onshore, metal ions would have been released by weathering of the country rock and may have been fixed with precipitating haematitic iron.

If these speculated changes in the nature of the regolith in environments marginal to the unconformity of the Eucla Basin and the Yilgarn Craton during the mid Tertiary can be substantiated then geochemical exploration models in the Kalgoorlie region will need to be reviewed. Our hypothesis presents new and very different possibilities regarding the timing of deep weathering associated with acid leaching, and the age, style and distribution of metal traps within the regolith; traps which may be the source of anomalies and secondary deposits.

Although this hypothetical model pertains to the southeastern Yilgarn Craton, it is also applicable to other margins of the Eucla Basin. It is especially applicable to the eastern margin, where similar Eocene sediments filled the same type of palaeo-landscape of coastal embayments and drowned estuaries of the Gawler Craton. Thus, we expect similar implications for the development and modification of geochemical signatures of ore bodies, and their supergene expression, in the Gawler Craton.

AN ASSESSMENT OF RUNOFF AND SOIL LOSS UNDER MAJOR LAND USES IN WANALE MICRO-CATCHMENT, MT. ELGON

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Soil erosion is implicated as the driving process in the degradation of natural resources in Uganda and is believed to be an acute problem in highland areas. Yet information about the actual extent and magnitude of the degradation necessary to design remedial action, guide policy makers and reference during monitoring and evaluation was lacking. A study was initiated to quantify runoff soil loss across major land uses on the slopes of Mt. Elgon. 12 runoff plots (150 m) were established in two land uses i.e. annual and perennial on three slope positions i.e. lower, middle and upper slope positions. The annual land use was dominated by corn and beans while the perennials were mainly bananas. Results indicate that runoff and soil loss are occurring at magnitudes beyond tolerable levels (5 t/ha/yr) resulting in significant on-site and offsite damage. Runoff and soil loss were higher in the Annual land use than in Perennial. Runoff in annual and perennial land use was 987 m/ha/yr and 643 m/ha/yr respectively, while soil loss was 45.7 t/ha/yr in annual land use and 25 t/ha/yr in perennial. No significant difference was observed ($P<0.05$). On slope position, more soil loss was registered on lower slopes than on the upper and middle slope positions.