PROGRAMME, ABSTRACTS AND PARTICIPANTS

geomorphology
wanaka 2000

9TH AUSTRALIA NEW ZEALAND GEOMORPHOLOGY GROUP (ANZGG) CONFERENCE

Monday 11/12	Tuesday	Wednesday	Thursday	Friday 15/12
0830-0900 **Opening address**	0830-1030 **Evolution-1**	***Fieldtrip Day***		
0900-1030 **Hillslopes-1**			0900-1030 **Evolution-3**	0900-1115 **Coastal**
1030-1100 ***Morning tea***	1030-1115 ***Morning tea***		1030-1100 ***Morning tea***	1115-1145 ***Morning tea***
1100-1200 **Hillslopes-2**	1115-1215 **Tectonic-Geol –1**		1100-1230 **Evolution-4**	1145-1300 **Evolution-5**
1200-1315 ***Lunch***	*1215-1315* ***Lunch***		*1230-1330* ***Lunch***	*1300-1400* ***Lunch***
1315-1445 **Fluvial-1**	1315-1445 **Evolution-2**		1330-1500 **Fluvial-3**	1400-1530 **Tectonic-Geol-2**
1445-1515 ***Afternoon tea***	1445-1515 ***Afternoon tea***		1500-1530 ***Afternoon tea***	
1515-1700 **Glacial-Aeolian**	1515-1615 **Fluvial-2**		1530-1700 **Fluvial-4**	
	1615- **Margins Project Discussion**			

9TH AUSTRALIA NEW ZEALAND GEOMORPHOLOGY GROUP (ANZGG) CONFERENCE

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Monday 11 December

0830-0900 **Opening Address** *Mike Crozier*

Hillslopes-1 Chair: *Worrall, L*

0900-0915 **Dunkerley, D.:**
WATER REDISTRIBUTION BY RUNOFF AND RUNON IN SEMI-ARID MOSAIC LANDSCAPES - HOW DOES IT WORK?

0915-0930 **Humphreys, G.:**
ANTICIPATING THE SPACING BETWEEN VEGETATION ARCS AND LITTER DAMS

0930-0945 **Cleverly, R. and Crozier, M.:**
SOIL PIPEFLOW: CONTROLS AND MECHANISMS

0945-1000 **Dunkerley, D.:**
FLOW HYDRAULICS IN LAMINAR FLOWS, THE STARTING POINT FOR INTERRILL SEDIMENT EROSION AND TRANSPORT

1000-1015 **Roering, J.J., Kirchner, J.W., Sklar,L.S. and Dietrich, W.E.:**
THE EVOLUTION OF SOIL-MANTLED HILLSOPES: TOPOGRAPHIC AND EXPERIMENTAL EVIDENCE FOR NON-LINEAR SEDIMENT TRANSPORT

1015-1030 **Hawke, R.M.** and McConchie, J.A.:
FREQUENCY AND MAGNITUDE OF PORE PRESSURE FLUCTUATIONS WITHIN UNSTABLE SLOPES

1030-1100 *MORNING TEA*

Hillslopes-2 Chair: *Hawke, R*

1100-1115 **Worrall, L.:**
THE CAUSE OF VARIABILTY IN THE TOPOGRAPHY OF THE WEATHERING FRONT IN THE GRANT'S PATCH AREA, EASTERN GOLDFIELDS REGION, WESTERN AUSTRALIA

1115-1130 **Wilkinson, M.** and Humphreys, G.:
EXPOSURE, SOIL PRODUCTION AND LANDSCAPE EVOLUTION ON TREED AND TREELESS PARTS OF THE NEWNES PLATEAU, BLUE MOUNTAINS

1130-1145 **Hennrich, K.:**
PROBABILISTIC DETERMINATION OF LANDSLIDE FREQUENCY IN HAWKE'S BAY

1145-1200 **Schmidt, J.**, Alteköster, C., Fabian, M. and Dikau, R.:
MONITORING AND MODELLING OF LANDSLIDE ACTIVITY IN THE BONN AREA: AN INTERDISCIPLINARY RESEARCH APPROACH

1200-1315 *LUNCH*

Fluvial-1: RECENT Chair: *Dunkerley, D.*

1315-1330	**Haschenburger, J.K.**: CHANGES IN BED MATERIAL TEXTURE IN A GRAVEL-BED CHANNEL
1330-1345	**Toleman, I.E.J.** and McConchie, J.A.: PLACING EXTREME EVENTS IN GEOMORPHIC CONTEXT, WAIPAWA RIVER, RUAHINE RANGE
1345-1400	**Saynor, M.J.**, W.D. Erskine, W.D. and Evans, K.G.: CHANNEL STABILITY AND EROSION IN THE SWIFT CREEK CATCHMENT, JABILUKA MINE SITE, NORTHERN TERRITORY, AUSTRALIA
1400-1415	**Lawrence, R.E.**, Wegener, J.E. and Newman, L.A.: RECENT EROSION AND SEDIMENTATION HISTORY OF TWO CATCHMENTS IN THE WILLUNGA BASIN, SOUTH AUSTRALIA
1415-1430	**Swabey, S.E.J.**: FLUVIAL GEOMORPHOLOGY OF GARDNERS GUT CAVE, WAITOMO
1430-1445	**Terry, J.P.**, Kostaschuk, R.A. and Motilal, S.: RIVER MEANDER MIGRATION AND PLANFORM CHANGES IN RESPONSE TO LARGE FLOODS ON A TROPICAL PACIFIC ISLAND
1445-1515	***AFTERNOON TEA***

Glacial-Aeolian Chair: *McConchie, J.*

1515-1530	**Fabel,D.**, Harbor, J., Dahms, D., James, J., Elmore, D., Daley, K. and Steele, C.: SPATIAL PATTERNS OF GLACIAL EROSION AT A VALLEY SCALE DERIVED USING COSMOGENIC ISOTOPE CONCENTRATIONS IN QUARTZ
1530-1545	**Fabel,D.**, Harbor, J. and Stroeven, A.: COSMOGENIC ISOTOPE EVIDENCE OF LANDSCAPE PRESERVATION UNDER ICE SHEETS
1545-1600	**Augustinus, P.** and Fink, D.: GLACIAL SEQUENCE FROM WESTERN TASMANIA
1600-1615	**Fitzsimons, S.J.**, Lorrain, R.D. and Vandergoes, M.J.: BEHAVIOUR OF SUBGLACIAL SEDIMENT BASAL ICE IN A COLD GLACIER
1615-1630	**Campbell, J.** and Hesse, P. THE USE OF AIRBORNE RADIOMETRICS FOR MAPPING AEOLIAN DEPOSITS IN THE CENTRAL HIGHLANDS OF NEW SOUTH WALES
1630-1645	**Xiu-Ming Liu**: PRELIMINARY STUDY ON MAGNETIC PROPERTIES OF AEOLIAN DEPOSITS IN NEW ZEALAND
1645-1700	**Marx, S. and McGowan, H.**: TRANS-TASMAN DUST TRANSPORT 1900-2000

Tuesday 12 December

Evolution-1: LONG TERM Chair: *Brown, K.*

0830-0845	**Brown, M.C.**: LONG TERM EROSION RATES IN SOUTHEAST N.S.W. - HAVE THEY BEEN SERIOUSLY UNDERESTIMATED?
0845-0900	**Chan, R.** and Gibson, D.: ASPECTS OF LONGTERM LANDSCAPE EVOLUTION IN CENTRAL NEW SOUTH WALES, AUSTRALIA: THE GILMORE STUDY
0900-0915	**Chappell, J.**: COSMOGENIC EROSION RATES AND EVOLUTION OF THE AUSTRALIAN LANDSCAPE
0915-0930	**Fisher, A.G.** , Chappell, J. and Melville, M.D.: A PRELIMINARY TRIAL OF *IN-SITU*-PRODUCED COSMOGENIC ISOTOPE ANALYSIS FOR INVESTIGATING STONE PAVEMENT FORMATION IN WESTERN NEW SOUTH WALES.
0930-0945	**Wakelin-King, G.A.**, Roberts, R. and Webb, J.: LANDSCAPE HISTORY OF THE FOWLER'S CREEK SYSTEM
0945-1000	**Pillans, B.**: ON THE SURVIVAL OF PRE-TERTIARY LANDFORMS AND REGOLITH IN AUSTRALIA: CONTINUOUS EXPOSURE OR BURIAL AND EXHUMATION?
1000-1015	**Price, D.M.**: THE DISCOVERY OF THE GREAT SOUTHERN LAND THERMOLUMINESCENCE THROWS LIGHT UPON THE MYSTERY?
1015-1030	**Pain, C.** and O'Sullivan, P.: SOUTH EASTERN AUSTRALIA: GEOMORPHOLOGY AND FISSION TRACKS
1030-1115	*MORNING TEA*

Tectonic-Geology-1 Chair: Gostin, V.

1115-1130	**Gibson, D.L.**, O'Sullivan, P.B. and Chan, R.A. CRETACEOUS DENUDATION IN SOUTHEAST AUSTRALIA: FISSION TRACK AND GEOMORPHOLOGICAL RECONCILIATION
1130-1145	**O'Sullivan, P.B.**, Gibson, D.L. and Kohn, B.P.: MESOZOIC TO RECENT LANDSCAPE EVOLUTION OF THE MURRAY BASIN REGION: NOT AS SIMPLE A STORY AS PREVIOUSLY PROPOSED
1145-1200	**Nemeth, K.**: LONG-TERM EROSION RATE CALCULATION BASED ON REMNANTS OF CONTINENTAL MONOGENETIC VOLCANIC LANDFORMS OF THE MIOCENE DUNEDIN VOLCANIC GROUP, NEW ZEALAND
1200-1215	**Webb, J.A.**, Grimes, K.G., Maas, R. and Drysdale, R.: ORIGIN OF CENOTES NEAR MT GAMBIER, SOUTH AUSTRALIA
1215-1315	*LUNCH*

Evolution-2: HOLOCENE Chair: *Soons, J.*

1315-1330 **Williams, M.**, Adamson, D., Talbot, M. and Aharon, P.:
QUATERNARY LAKES, PALAEOCHANNELS AND DUNES IN THE WHITE NILE VALLEY

1330-1345 **Roman, C.**, van Oploo, P., Chappell, J. and Melville, M.:
THE HOLOCENE INFILL OF "LAKE TWEED" IN NORTHERN NEW SOUTH WALES

1345-1400 **Shimeld, P.** and McNab, C.:
A HOLOCENE RECORD OF ENVIRONMENTAL CHANGE FROM A HUNTER VALLEY LAKE, NEW SOUTH WALES, AUSTRALIA

1400-1415 **Taylor, M.P.** and Brierley, G.J.:
DEBUNKING THE HUMAN-CLIMATE PARADIGM OF HOLOCENE ALLUVIAL BEHAVIOUR

1415-1430 **Shulmeister, J.**, Grapes, R. and Eade, R.:
GRAVEL AGGRADATION DURING INTERGLACIATIONS: A CASE STUDY FROM PALLISER BAY, SOUTHERN NORTH ISLAND, NEW ZEALAND.

1430-1445 **Trustrum, N.**, Page, M., Gomez, B., Marden, M., Berryman, K. and Hicks, M.:
LANDSCAPE EVOLUTION AND CONTROLS ON SEDIMENT AND SOIL CARBON FLUXES

1445-1515 *AFTERNOON TEA*

Fluvial-2: LONG TERM Chair: *Fryirs, K.*

1515-1530 **Brown, K.**:
ASSESSING THE USE OF THE CAESIUM-137 EXCESS LEAD-210 RATIO TECHNIQUE IN AN ARID AUSTRALIAN ENVIRONMENT

1530-1545 **Coleman, M.**, Nanson, G.C., Jones, B.G. and Price, D.M.:
CLIMATE AND FLOW REGIME CHANGES OVER THE LAST 250 KA FOR COOPER CREEK IN NORTHEASTERN SOUTH AUSTRALIA

1545-1600 **Nanson, G.C.** and Jones, B.G.:
LITHIFICATION OF LATE QUATERNARY ALLUVIUM; THE FORMATION OF ANABRANCHED ROCK-CONFINED CHANNELS IN MONSOON-TROPICAL AUSTRALIA

1600-1615 **Webb, A.A.**, Erskine, W.D. and Dragovich, D.:
VEGETATION AND THE LATE HOLOCENE CHANNEL AND FLOODPLAIN STABILITY OF SAND-BED, FOREST STREAMS

1615--- **Trustrum, N., Tonkin, P.**
Margins Project Discussion

Wednesday 13 December

FIELDTRIP

Thursday 14 December

Evolution-3: REGOLITH Chair: *Pain, C.*

0900-0915 **Craig, M.** and Wilford, J.:
UNDERSTANDING GAWLER CRATON REGOLITH, AND ITS SIGNIFICANCE TO THE AUSTRALIAN MINERAL EXPLORATION INDUSTRY

0915-0930 **Killick, M.F.**, Churchward, H.M. and Anand, R.R.:
WEATHERING AND EROSION: LANDSCAPE EVOLUTION OF THE HAMERSLEY IRON PROVINCE OF WESTERN AUSTRALIA

0930-0945 **McMahon, A.P.**, Leah Moore, C.L. and Muller.:
REGOLITH MAPPING AND DRYLAND SALINITY HAZARD MITIGATION AT MEMAGONG, CENTRAL WESTERN NSW, AUSTRALIA.

0945-1000 **Spry, M.J.**:
REGOLITH-LANDFORM MAPS AND THE LANDSCAPE HISTORY OF THE COBAR REGION, NSW: DEVELOPING A LANDSCAPE EVOLUTION MODEL

1000-1015 **De Souza Kovacs, N.**, Moore, C. L., Reilly, N. S. and Lawrie, K. C.
THREE-DIMENSIONAL REGOLITH MODELLING, A NEW APPROACH: APPLICATIONS FOR ENVIRONMENTAL AND ORE DEPOSIT STUDIES.

1015-1030 **Wilford, J.** and Pain, C.:
EXPOSING BURIED LANDSCAPES

1030-1100 ***MORNING TEA***

Evolution-4: SOIL Chair: *Tonkin, P.*

1100-1115 **Hill, R.**, Tonkin, P. and Almond, P.:
A SOIL-STRATIGRAPHIC INTERPRETATION OF THE LATE QUATERNARY GEOMORPHOLOGY AND EROSION HISTORY OF THE SOUTHERN MAMAKU PLATEAU, CENTRAL NORTH ISLAND, NEW ZEALAND

1115-1130 **Jones, P.**:
AN EXAMINATION OF THE SUITABILITY OF CAESIUM-137 FOR SOIL EROSION ESTIMATES IN THE AUSTRALIAN SEMI-ARID ZONE

1130-1145 **Keene, A.F.**:
SOIL POTASSIUM AVAILABILITY IN THE GEOMORPHOLOGIC DYNAMICS AND EVOLUTION OF THE SOUTH ALLIGATOR RIVER FLOODPLAIN, NORTHERN AUSTRALIA

1145-1200 **Macdonald, B.C.T.**:
WHAT CAN CHENOPOD PATTERNED GROUNDREVEAL ABOUT THE RECENT GEOMORPHIC EVOLUTION OF ARID ZONE PEDIMONTS?

1200-1215 **Page, M.**, Trustrum, N. and Brackley, H.:
EROSION-RELATED SOIL CARBON LOSSES IN THE TUTIRA CATCHMENT SINCE EUROPEAN SETTLEMENT

1215-1230 **Pulford,,A.**, Davies, R. and Stern, T.:
EXTRACTION OF GEOMORPHOLOGICAL INFORMATION FROM DEMS, EXAMPLES FROM THE MANAWATU REGION, NORTH ISLAND, NEW ZEALAND

1230-1330 ***LUNCH***

Fluvial-3: BIG PICTURE Chair: *Nanson, G.*

1330-1345 **Habberfield-Short, J.**, Boyd, W.E., Higham, C.F.W., Thosarat, R., and McGrath, R.J.:

THE CHANGING MORPHOLOGY OF MOATED IRON AGE SITES IN THE UPPER MUN RIVER FLOODPLAIN, NE THAILAND

1345-1400 **M^cGrath, R.J. and Boyd, W.E.:**

THE CONSTRUCTION OF THE MOATS OF NORTHEAST THAILAND

1400-1415 **Reinfelds, I.**, Cohen, T., Batten, P., Jansen, J. and Brierley, G.:

BASIN-WIDE MODELLING OF STREAM POWER: EXAMPLES FROM

BELLINGER RIVER CATCHMENT, NSW, AUSTRALIA

1415-1430 **Rustomji, P., Prosser, I. And Young, W.:**

LARGE SCALE ASSESSMENT OF RIVER SEDIMENT REGIME - THE MURRUMBIDGEE RIVER AS AN EXAMPLE

1430-1445 **Frazier, P.**, Page, K., Livingston, B., Briggs, S., Louis, J. and Robertson, A.

REMOTE SENSING OF FLOODPLAIN INUNDATION: A CASE STUDY ON THE MURRUMBIDGEE RIVER, NSW

1445-1500 **Korup, O.:**

DIFFERENTIATING FLUVIAL GEOMORPHIC RESPONSE TO CHANGES IN EXTERNAL CONTROLS: A CONCEPTUAL APPROACH ON THE DRAINAGE BASIN SCALE

1500-1530 *AFTERNOON TEA*

Fluvial-4: ASSESSMENT Chair: *Williams, P.*

1530-1545 **Young, W.J., Olley, J.M., Prosser, I.P. and Warner, R.F.:**

THE RELATIVE CHANGES IN SEDIMENT SUPPLY AND SEDIMENT TRANSPORT CAPACITY IN A BEDROCK-CONTROLLED RIVER AS A RESULT OF LAND DEGRADATION, HISTORICAL CLIMATE CHANGE AND DAM CLOSURE

1545-1600 **Yonge,D.**, Hesse,P. and Pearce,B.:

FLUVIAL BEHAVIOR AND EVOLUTION OF THE LOWER MACQUARIE RIVER, NORTH-WESTERN NEW SOUTH WALES

1600-1615 **Gippel, C.J.:**

CAN CHANNEL STABILITY BE RAPIDLY ASSESSED BY NON-EXPERTS (OR EXPERTS FOR THAT MATTER)?

1615-1630 **Brierley, G.**, Fryirs, K., Outhet, D. and Massey, C.:

RIVER STYLES (TM): APPLICATION OF A BIOPHYSICAL FRAMEWORK FOR RIVER MANAGEMENT IN NEW SOUTH WALES.

1630-1645 **Fryirs, K.:**

A GEOMORPHIC APPROACH TO IDENTIFICATION OF RIVER RECOVERY POTENTIAL: APPLICATION IN BEGA CATCHMENT, SOUTH COAST, NSW, AUSTRALIA

1645-1700 **Brierley, G.J.**, Thomson, J., Taylor, M.P. and Fryirs, K.A.:

A GEOMORPHIC FRAMEWORK FOR RIVER CHARACTERISATION AND HABITAT ASSESSMENT

Friday 15 December

Coastal Chair: *Shulmeister, J*

0900-0915 **Kennedy, D.M.**:
HOLOCENE REEF GROWTH IN THE TORRES STRAIT

0915-0930 **Bush, R.T.** , Melville, M. D. , Macdonald, B., Sullivan, L.A. and Smith, J.:
DRAINAGE INDUCED ESTUARINE FLOODPLAIN SUBSIDENCE AND ITS MEASUREMENT BY MAGNETO-STATIGRAPHY

0930-0945 **Smith, J.** and Melville, M.D.:
GEOMORPHIC CONTROLS ON ACTUAL ACIDITY IN AN ACID SULFATE SOIL ENVIRONMENT

0945-1000 **Dickson, M.**:
ROCK COAST GEOMORPHOLOGY OF LORD HOWE ISLAND

1000-1015 **McLean, E.J.** and Hinwood, J.B.:
ENTRANCE RESISTANCE AND MORPHODYNAMIC PROGRESSION IN ESTUARIES

1015-1030 **Panayotou. K.**:
SEDIMENTATION IN MINNAMURRA RIVER ESTUARY, SOUTH COAST NEW SOUTH WALES

1030-1045 **Hemmingsen, M.**:
WHERE DOES THE SEDIMENT GO? THE ROLE OF ABRASION IN A COASTAL SEDIMENT BUDGET

1045-1100 **Ruxton, B.P.**:
SEAWATER, WAVES AND PLATFORMS A CONTINUUM IN ENERGY

1100-1115 **Jennings, R.**:
GRAIN SIZE AND BEACH SLOPE ON GRAVEL BEACHES

1115-1145 ***MORNING TEA***

Evolution-5 Chair: *Chan, R.*

1145-1200 **Webb, E.** and Baynes, A.:
THE LANDBRIDGE FILTER EFFECT AND THE PATTERN OF COLONISATION OF THE BRITISH ISLES BY THERMOPHILOUS TERRESTRIAL MAMMALS SINCE THE CROMERIAN (~0.5Ma)

1200-1215 **Marra, M.**:
FOSSIL BEETLES AS INDICATORS OF PALEOENVIRONMENTS: TEST CASE FROM BANKS PENINSULA (CANTERBURY, NEW ZEALAND)

1215-1230 **Carter, J.A.** and Lian, O.B.:
PALEOENVIRONMENTAL RECONSTRUCTION FROM THE LAST INTERGLACIAL PHYTOLITH ANALYSIS, SOUTH EASTERN NORTH ISLAND, NEW ZEALAND

1230-1245 **Williams, M., Prescott, J., Chappell, J, Adamson, D., Cock, B., Lawson, E., Walker, K., Symonds, R. and Gell, P.:**
LATE PLEISTOCENE WETLANDS IN THE SEMI-ARID FLINDERS RANGES, SOUTH AUSTRALIA

1245-1300 **Williams, P.:**
SPELEOTHEM DATA ON QUATERNARY ENVIRONMENTAL CHANGE IN
NEW ZEALAND

1300-1400 ***LUNCH***

Tectonic-Geology-2 Chair: *Trustrum, N.*

1400-1415	**Berryman, K.**: ALPINE FAULT RUPTURE AND LANDSCAPE EVOLUTION IN WESTLAND
1415-1430	**Almond, P.**, Duncan, R., Tonkin, P., Alloway, B., Barrell, D., Berryman, K., McSaveney, M., and Read, S. CATASTROPHIC AGGRADATION FOLLOWING THE LAST ALPINE FAULT EARTHQUAKE: PRELIMINARY RESULTS FROM THE WHATAROA FLOODPLAIN, SOUTH WESTLAND, NEW ZEALAND
1430-1445	**D. Sutherland, D.**, Van Dissen, R., Redwine, J. and Bowers, R.: MILLER STREAM FOREST BURIAL AT 1530-1810 CAL BP, AND POSSIBLE TRIGGERED RUPTURE OF THE CLARENCE FAULT AND JORDAN THRUST, SOUTH ISLAND, NEW ZEALAND
1445-1500	**Berryman, K.**,Marden, M., Eden, D., Mazengarb, C., Yokoota. and Moriya, I.: TECTONIC AND PALEOCLIMATIC SIGNIFICANCE OF QUATERNARY RIVER TERRACES OF THE WAIPAOA RIVER, EAST COAST, NORTH ISLAND, NEW ZEALAND
1500-1515	**Brackley, H.**: AGE AND DEVELOPMENT OF THE POHANGINA ANTICLINE, NORTHEASTERN MANAWATU, NEW ZEALAND
1515-1530	**Litchfield, N.**: GEOMORPHOLOGICAL EVOLUTION OF ACTIVELY RISING REVERSE FAULT BLOCKS, COASTAL OTAGO

CATASTROPHIC AGGRADATION FOLLOWING THE LAST ALPINE FAULT EARTHQUAKE: PRELIMINARY RESULTS FROM THE WHATAROA FLOODPLAIN, SOUTH WESTLAND, NEW ZEALAND

[1]Peter Almond, [1]Richard Duncan, [1]Philip Tonkin, [2]Brent Alloway, [2]David Barrell, [2]Kelvin Berryman, [2]Mauri McSaveney, and [2]Stuart Read

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[2]Institute of Geological and Nuclear Sciences Limited, Wairakei, Dunedin and Lower Hutt

Introduction: The Alpine Fault, the transform between the Pacific and Australian Plates, forms the western boundary of the Southern Alps. Paleoseismic evidence indicates movements on a 300+ km section in AD 1717, ca. 1630 and 1460 (Wells et al., 1999). Widespread disturbance-initiated forest establishment followed these earthquakes (Wells et al., 1998). Mountains east of the fault are formed by rapid tectonic uplift in a region of extreme rainfall (4 to 10 m yr-1) resulting in rapid denudation (c. 10 000 t km^{-2} yr^{-1}). The Westland piedmont comprises a number of valley fills separated by lateral moraines and hills. Extending from the mountain front, braided fans grade laterally into flood plains, marginal swamps and lakes. Soil maps indicate young Fluvial Recent Soils (Hokitika and Harihari series) are dominant. In a two week reconnaissance of the Whataroa floodplain we selectively examined soils, documented the soil stratigraphy and radiocarbon chronology of some fan and flood plain sediment packages, and measured tree ages by ring counting. The results reported here are part of a wider programme tracking landscape change in Westland. In this paper we consider the evidence for aggradation following Alpine Fault earthquakes.

The Whataroa Study, results to date: On the south side of the Whataroa fan head a c. 5 m incision exposes bouldery alluvium with no indication of a buried geomorphic surface. No soils showed development beyond Recent Soils. In light of the high rate of soil development in Westland this is strong evidence for a young age for the entire valley floor. Tree rings were counted from cores and discs. Six complete chronologies gave an average of 246 ± 25 years (1). Taking into account establishment time, this age is consistent with forest regenerating on an aggradation surface formed after the AD 1717 earthquake. Along the eastern margin of the basin, smaller fans from the mountain front interfinger with the larger Whataroa fan. Here there is evidence for multiple episodes of coarse to fine sedimentation, separated by short hiatuses as indicated by buried soils with A/C or O/C profiles. In two sections woody debris in buried soils toward the base of each section gave ^{14}C ages of 996 ± 55 BP (NZA 11608) and 1239± 60 BP (NZA 11607). In both sections four episodes of deposition were inferred, the youngest post dates a ^{14}C date on wood of 220 ± 50 BP (Wk 8337). Midway between the mountain front and the coastline a buried forest is exposed at river level. At this site shrub wood in growth position in a buried peat soil at a depth of 1.7 m dated at 270 ± 50 BP (Wk 8335), and outermost rings from a matai stump from the buried forest, at c. 5 m, dated at 1110 ± 50 BP (Wk 8336). In the lower half of the basin, sandy and silty alluvium is inter-bedded with sedge and forest peats.

Conclusions: Surface soil development, tree ages across the Whataroa valley and radiocarbon ages from underlying sediment packages are consistent with widespread aggradation in the Whataroa valley following the AD 1717 Alpine Fault earthquake. Establishing the recent history of aggradation episodes and whether or not they relate to Alpine Fault earthquakes, is important for assessing the risk posed by future events of a similar magnitude to Westland communities.

References:

Wells, A., Stewart, G.H., Duncan, R.P. 1998. Evidence of widespread, synchronous, disturbance-initiated forest establishment in Westland, New Zealand. Journal of the Royal Society of New Zealand, 28. 333-345.

Wells, A., Yetton, M.D., Duncan, P.D., Stewart, G.H. 1999. Prehistoric dates of the most recent Alpine fault earthquakes, New Zealand. Geology, 27. 995-998.

COSMOGENIC ^{10}Be AND ^{26}Al EXPOSURE AGE DATING OF A PLEISTOCENE GLACIAL SEQUENCE FROM WESTERN TASMANIA

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Cosmogenic nuclide (CN) exposure age dating of quartzite erratics on moraines from the early to late Pleistocene glacial sequence preserved in the Pieman River basin western Tasmania, has forced a re-evaluation of the established chronology of glacial events. Application of the CN pairs ^{10}Be and ^{26}Al allowed the identification of boulders that had undergone complex exposure histories such as burial and exhumation since the $^{26}Al/^{10}Be$ ratios plot below the 'steady-state erosion island' in this case. Conversely, where the model of a single stage of exposure since deposition was applicable, the $^{26}Al/^{10}Be$ ratios were indistinguishable from the isotope production ratio of 6.0 for late Pleistocene moraine boulders, although middle-early Pleistocene samples produced lower $^{26}Al/^{10}Be$ ratios due to the relatively higher rate of decay of ^{26}Al. Despite the complex boulder exposure histories apparent at many sites, the ^{10}Be and ^{26}Al ages obtained from the erratic boulders were usually able to be interpreted as at least minimum ages for the depositional events, and demonstrated that glacial drifts previously attributed to MIS 6 and 8 in the Pieman River basin are most likely considerably older. Furthermore, there was no CN evidence for MIS 4 advances in the West Coast Ranges, whilst MIS 6 and 2 advances were restricted to the higher parts of the range, and much less extensive than envisaged previously.

LATE PLEISTOCENE EQUILIBRIUM LINE ALTITUDES FROM GLACIAL FEATURES IN THE INLAND KAIKOURA RANGE, NEW ZEALAND

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A reconnaissance investigation of glacial features in the Inland Kaikoura Range, New Zealand, confirms that the range, encompassing the summits of Mt Tapuae-o-Uenuku (2885 m) and Mt Alarm (2877 m), has been extensively glaciated in the past, in contrast to previous investigations. Identified glacial features include cirques, lateral and terminal moraines, and rock glaciers. Lateral moraines appear to be of mid to late Otiran age (oxygen isotope stages 2 to 3) with the possibility that some are of early Otiran age (oxygen isotope stage 4). The lack of preservation of older glacial landforms is attributed to the high erosion rate related to the relatively high uplift rate (c. 5 mm/yr) of the Inland Kaikoura Range, located in the hanging wall of the Clarence Fault. During the last glacial maximum, valley glaciers in the Inland Kaikoura Range had lengths up to c. 6 km, and average maximum and minimum elevation ranges of c. 2750 m and c. 1250 m, respectively.

A maximum paleo-equilibrium line altitude (ELA) of c. 2320 m is derived from 24 cirque floor elevations within the study area. A minimum paleo-ELA of c. 1650 m is calculated using the upper elevations of five prominent lateral moraines in the Branch Stream catchment. A paleo-ELA of c. 2000 m, intermediate between the above two values, is estimated using the median altitudes of reconstructed outlines of past glaciers. We thus consider that the ELA in the Inland Kaikoura Range during the last glacial maximum probably lay somewhere in the range of 1650-2000 m. To further refine this elevation range, additional research is needed to test key assumptions made in the ELA estimations.

The paleo-ELA estimate of c. 1650-2000 m for the Inland Kaikoura Range, and corresponding paleo-ELA depression of c. 880-530 m, using a modern snowline of 2530 m, are similar to values calculated elsewhere in both the South and North Islands. Correcting for accrued uplift over the past c. 18 ka provides an additional c. 90 m of paleo-ELA depression, suggesting a total ELA depression of as much as c. 970-620 m during the last glacial maximum. The presence of active rock glaciers in the Inland Kaikoura Range provides evidence that the peaks currently rise into the permafrost zone in an arid climate. Evidence of glacial features in the range suggests that the region was affected not only by westerly airflow patterns, as current paleoclimate models imply, but presumably also by southeasterly airflow patterns to the degree necessary to provide enough precipitation to form prominent valley glaciers.

ALPINE FAULT RUPTURE AND LANDSCAPE EVOLUTION IN WESTLAND

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Results from recent paleoseismic studies at a number of sites along the Alpine Fault from near Milford Sound in the south to Haupiri in the north have identified either three or four major surface rupture events in the past 1000 years. In the south, and extending north at least to Haast, the events occurred around 1720 AD, c. 1400 AD, and c. 1200 AD. These were large earthquakes with 8±1 m of displacement in each event. There are few paleoseismic data from the central section of the fault in the vicinity of the glaciers, but there is a possible single event, 3 m-high, scarp at Franz Josef township that may represent the vertical component of the last event. Farther north, from the Waitaha River to Haupiri, the available data indicate ruptures of 4-6 m at 1720 AD, c. 1620 AD, c. 1445 AD, and an earlier event that may or may not coincide with the c. 1200 AD event in the south. Thus, within the limits of radiocarbon and other dating control the events of 1720, 1400-1445, and 1200 AD may have involved very long ruptures of c. 400 km, characterised by 8 m of slip in the south decreasing to 4-6 m in the north. Alternatively there may have been smaller events closely spaced in time that broke 100-300 km-long sections of the fault.

Single event surface displacement of 8 m suggest, using empirical relationships derived from observations of historical earthquakes, magnitudes of M 7.6-8.3 and rupture lengths of 145-600 km. Smaller displacements of around 5 m characterised by the northern section of the Alpine Fault are consistent with magnitudes in the range M 7.3-8.0 and rupture length of 90-330 km. Earthquakes in the range M 7.3-8.3 are associated with very strong ground motions, approaching or exceeding 1 g, particularly on ridge-tops, steep slopes, and bluffs. Thus, there is a expectation that with recurrence times of 100-300 years much of the Southern Alps within 10 km of the Alpine Fault will be subject to ground acceleration at or above the gravitational force. The effects of such earthquakes can be expected to be catastrophic on the landscape. The elapsed time since the last such event is about 280 years, so we may assume the Southern Alps and adjacent coastal lowlands are in their most stable condition at present.

TECTONIC AND PALEOCLIMATIC SIGNIFICANCE OF QUATERNARY RIVER TERRACES OF THE WAIPAOA RIVER, EAST COAST, NORTH ISLAND, NEW ZEALAND

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Remnants of four aggradational terraces in the lower 45 km of the main branch of the Waipaoa River have been correlated with cold/cool climate episodes of the Otiran glaciation. The youngest of the aggradational levels - the Waipaoa-1 terrace - has the c. 14.7 ka Rerewhakaaitu Tephra as the oldest part of the coverbed sequence, indicating cessation of aggradation about 16 ka BP. This terrace is broadly correlated with Ohakean-aged terraces in other parts of the North Island. The second most recent episode of aggradation - the Waipaoa-2 terrace - is slightly older than the c. 28 ka Mangaone Tephra, and is broadly correlated with the Rata terrace. The third most recent aggradation episode - the Waipaoa-3 terrace - is slightly older than the c. 55-57 ka Rotoehu Tephra (age estimate based on stratigraphic relationships in this study), indicating cessation of aggradation at c. 65 ka BP, and correlative with the Porewa terrace. The fourth, and oldest, aggradation episode we identify in the present landscape - the Waipaoa-4 terrace - has poor age constraints but is probably related to the cool period of late oxygen isotope stage 5 at c. 90 ka BP or the glacial period of oxygen isotope stage 6 at c. 140 ka BP.

Tectonic deformation in the middle reaches of the Waipaoa catchment is deduced from the elevation difference of pairs of aggradation terraces, and takes the form of broad regional uplift in the range of 0.5-1.1 mm/yr. Uplift is probably driven by subduction processes in the middle part of the catchment and by a combination of deep-seated subduction processes and local deformation associated with active active faults and folds in the lower valley area. Downcutting rates of up to 7 mm/yr occur in upper reaches of the river. In the middle reaches of the valley, where there are both uplift and downcutting data, we find that downcutting is about four times faster than tectonic uplift. Thus, climate fluctuations are interpreted to be the primary control on formation of fluvial terrace landscapes in the region.

Keywords: Quaternary; fluvial terraces; aggradation; downcutting; paleoclimate; uplift; tectonic deformation; tephra; Waipaoa River; Poverty Bay; Raukumara Peninsula

AGE AND DEVELOPMENT OF THE POHANGINA ANTICLINE, NORTHEASTERN MANAWATU, NEW ZEALAND

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The stratigraphy and sedimentology of the Pohangina Anticline has been established, and the characteristics of the sediments used to determine the depositional environments and paleogeography of the area. As a subsidiary to this study, the age and development of the Pohangina Anticline itself has also been determined.

The Pohangina Anticline is one of several growing structures on the northeastern Manawatu Plains. The axis of this asymmetrical anticline lies within the valley of the Pohangina River, with the strata on the western limb dipping gently 2–3° to the west, and those on the eastern limb dipping at up to 70° to the east. The axis of the anticline plunges at 1–2° to the south.

The sediments are ca. 1.3–0.6 Ma, with age control being provided by several coarse pumiceous tuffs within the sediments. The Rewa Pumice (1.29±0.12 Ma), Potaka Pumice (1.05±0.05 Ma), Kaukatea Pumice (0.87±0.05 Ma) and Kupe pumice (0.63±0.08 Ma) are all present within the stratigraphy.

Formation of the Pohangina anticline appears to have occurred since the deposition of the Kaukatea pumice, or possibly even the Kupe pumice. The rate of deformation is calculated as being at least 7°/100,000 years, and possibly as much as 10°/100,000 years if the deformation has occurred since deposition of the Kupe pumice.

RIVER STYLES (TM): APPLICATION OF A BIOPHYSICAL FRAMEWORK FOR RIVER MANAGEMENT IN NEW SOUTH WALES

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Effective strategies in natural resource management must 'work with nature'. To achieve this, reliable biophysical baseline data on the structure and function of ecosystems are required. These must be framed within a catchment context, highlighting spatial and temporal linkages in landscapes. In many ways, rivers can be viewed as barometers of landscape condition or health. A geomorphic template provides the critical basis upon which relationships between river and landscape processes can be assessed. The River Styles framework developed at Macquarie University by Gary Brierley and Kirstie Fryirs provides a basis by which these relationships have been assessed for river systems in New South Wales.

River Styles are assessed within a nested hierarchical framework, focussing initially on the landscape units that make up a catchment. Topographic controls dictate the range of River Styles formed along river courses, largely through the control on valley-setting (width and planform configuration) and slope. Geomorphic units are the building blocks of River Styles and are used to interpret form-process associations or behaviour along river courses. This link to geomorphic process, tied to reach linkages and analysis of river evolution, provide the basis for assessments of river condition and recovery potential for each reach of each River Style in a catchment. The range and diversity of River Styles across the landscape are assessed and process connections determined (upstream-downstream, off-site, tributary-trunk, slope-valley floor). To date, 21 River Styles have been identified in coastal New South Wales. Analysis of River Styles is presently underway in numerous catchments in western NSW. Given the open-ended nature of the procedure, the range of River Styles is not prescriptive and can be added to as new variants arise.

Management issues differ for different types of rivers. In New South Wales, the River Styles™ framework is being used as a basis for:

1) Within-catchment prioritorisation of conservation and rehabilitation strategies to achieve appropriate target conditions for different types of river based on their particular character, behaviour and present condition.
2) The design of rehabilitation actions compatible with the recovery potential and behaviour of each River Style.
3) A state and national level template for better assessment of the severity and causes of biophysical "stress" for certain rivers and patterns of rivers in different parts of the landscape.
4) A consistent biophysical baseline upon which additional layers of management information can be added, such as habitat assessment, riparian vegetation surveys, river rehabilitation/conservation plans, benchmarking/biomonitoring, etc.

Further uses of the framework are being developed. These include the identification of rare or unusual River Styles, licensing/policy arrangements for environmental flows, water use allocation, sand and gravel extraction, etc.

Through the use of the River Styles™ framework, it is intended that all these various management programs are viewed in terms of an integrative catchment-framed context so that principles of sustainable use of natural resources and maintenance of biodiversity are not compromised.

A GEOMORPHIC FRAMEWORK FOR RIVER CHARACTERISATION AND HABITAT ASSESSMENT

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Methods for assessing the physical habitat available to aquatic organisms provide important tools for many aspects of river management, including river health monitoring, river restoration/rehabilitation, setting and evaluating environmental flows, and as surrogates for assessing biodiversity and conservation value. Methods of assessing physical habitat need to be ecologically and geomorphologically meaningful, as well as logistically practical. The range of physical habitats varies naturally within and between river systems, such that "good" habitat at one location may be inappropriate at another. Therefore a physical classification of rivers is required to enable setting of appropriate reference conditions against which the quality and quantity of habitat along a given reach can be assessed, for the same type of river.

River Styles is an hierarchical framework for characterising river reaches on the basis of geomorphology that provides a useful baseline for habitat assessment. Because River Styles are identified on the basis of valley setting and the assemblage of geomorphic units, intact reaches of a particular River Style should have similar assemblages of instream and floodplain habitat. Thus the River Styles methodology may provide a basis for comparing like with like, setting reference conditions for habitat assessment.

Geomorphic units are the fundamental building blocks of river and floodplain systems, and analysis of the assemblages of geomorphic units along a reach provides an understanding of process-form relationships, allowing interpretation of river behaviour. However, to be meaningful, instream habitat assessments need to incorporate smaller scale physical and hydraulic features. We present a method with which instream habitat is assessed at a practical scale that links flow hydraulics and geomorphology. Hydraulic units are patches of relatively homogenous surface flow type and substrate composition, nested within geomorphic units. Attributes that affect microhabitat diversity, such as aquatic vegetation, woody debris, leaf litter, and algae, are assessed within each hydraulic unit, allowing differentiation between patches of vegetation or organic matter in different flow environments.

Research is presently underway to determine whether individual River Styles have characteristic assemblages of instream habitat - and consequently biota, and to test the application of hydraulic units in habitat assessment.

ASSESSING THE USE OF THE CAESIUM-137 EXCESS LEAD-210 RATIO TECHNIQUE IN AN ARID AUSTRALIAN ENVIRONMENT

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A major problem in geomorphology is undertaking sufficiently long sediment transport investigations to adequately represent a range of expected storm event sizes. Such monitoring methods are costly owing to the intensive nature of sediment collection programmes and the long time periods required. However, net rates of sediment transport over periods of several decades may be obtained almost instantaneously through the use of radio-isotopes; two of these are caesium-137 and lead-210. The presence of caesium-137 in the environment results from atmospheric weapons testing which largely occurred during the 1950s and 1960s. In contrast lead-210 occurs naturally in the environment and forms as a breakdown product of radon gas; a part of the uranium decay series. Of importance, however, is the fact that radon can diffuse into the atmosphere, decay to lead-210, and return to the surface by the same processes as caesium-137. This type of lead-210 is called excess lead-210.

On reaching the surface, both isotopes bind strongly with silt and clay sized soil particles in the surface soils. Caesium-137 concentrations tend to decrease to approximately half within 30 to 50 mm of the surface, while excess lead-210 has typical half penetration depths of 10 to 30 mm. Using these differences in penetration depth, Wallbrink and Murray (1996) have developed a technique for determining soil loss by assessing the ratio of excess lead-210 to caesium-137. A major strength of the new ratio technique is that as the areal concentration of the two isotopes is spatially correlated, some of the variability in the spatial distribution of the isotopes is removed. This means that fewer samples are required, and the cost of the sampling programme is reduced. Wallbrink and Murray argue that by using a ratio of two environmental tracers, the random variability is reduced and thus a more sensitive technique is available for assessing net erosion rates.

This paper discusses the caesium-137 excess lead-210 ratio technique, and outlines its application to an arid environment where spatial heterogeneity in both landscape features and rainfall tend to result in a highly variable sediment transport environment.

References:

Wallbrink, P.J. and Murray, A.S. 1996. Determining soil loss using the inventory ratio of excess lead-210 to cesium-137. *Journal of the Soil Science Society of America*, 60: 1201-1208

LONG TERM EROSION RATES IN SOUTHEAST N.S.W. - HAVE THEY BEEN SERIOUSLY UNDERESTIMATED?

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Studies of longterm geomorphological evolution in the highlands and coastal zone of southeast N.S.W. have been facilitated by the presence of areas of datable Cenozoic basalts and sediments which overlie the Palaeozoic to early Mesozoic bedrock. Many estimates of longterm erosion rates in the region use evidence from basalts and Cenozoic sediments; and in general they indicate very low rates of longterm erosion. They include rates of valley widening of 0.3 to 28 m/Ma, headward erosion of canyons of 0.05 to 2.5 Km/Ma, valley deepening of 0.17 to 13.3 m/Ma, and escarpment retreat as low as 170 m/Ma.

There are three main reasons for questioning the validity of many of these estimates. Firstly, they come mostly from areas which are not representative of the region as a whole, in that they are areas of preservation of Cenozoic basalt and sediments where erosion rates are likely to have been lower than average. Secondly, and more seriously, most of the estimates ignore the question of the possible former extent and thickness of the basalt. Thirdly, some of the estimates are based on an unwarranted assumption of longterm tectonic stability.

The estimate of only 0.3 m/Ma for valley widening is based on an observation that the 2.5 Km wide valley of the Shoalhaven at Tallong is very little wider than a former Oligocene palaeovalley; but the calculation does not take into account that this palaeovalley was formerly completely full of Oligocene basalt, which dammed the river to form a lake upstream. Taking into account the erosion of this basalt, the valley widening since the Oligocene is the full 2.5km width of the present valley; an average rate of about 80 m/Ma.

The estimate of only 0.05 Km/Ma for headward erosion is based on the Towamba River. A major knick point near the head of the river exposes a section through several thin flows of Palaeocene basalt filling a palaeovalley, with a total thickness of 200 m. A small area of basalt occurs in the valley floor about 3 Km downstream. The above estimate is based on the assumption that the basalt never extended further downstream than 3 Km from the knick point. However, in view of the mobility of basalt magmas, it is much more likely that the basalt originally extended tens of kilometres downstream of the knick point, and a more realistic estimate of the mean rate of headward erosion since the Palaeocene is around 1 Km/Ma.

The highest published estimate of headward erosion rate, 2.5 Km/Ma, is a minimum estimate for the Shoalhaven River, based on an observation that the river has cut back 75 Km from a hypothetical knick point near the present plateau margin at Tallong since the Oligocene. However, the headward erosion could have been initiated by late Cenozoic tectonic lowering of the coastal zone, starting near the coast 50 Km further downstream; a rate of 125 Km in 15 million years or less, about 8.5 Km/Ma or more.

DRAINAGE INDUCED ESTUARINE FLOODPLAIN SUBSIDENCE AND ITS MEASUREMENT BY MAGNETO-STATIGRAPHY.

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Coastal floodplain drainage and reclamation causes land surface subsidence. This can increase the threat of prolonged flooding and cause infrastructure to fail. The lower reaches of most eastern Australian coastal floodplains were formed during the Holocene by sedimentation of estuarine 'muds', mainly of marine origin. Thin layers of fluviatile sediments buried the muds in the late stages of floodplain evolution, often in the form of river levees. The buried estuarine muds occur to within 1m from the ground surface and are typically 50-80 % water by volume, have a gel-like consistency, and contain appreciable concentrations of iron sulfide (as pyrite). Drainage enables air to infiltrate the muds, causing sulfide mineral oxidation and the release of ferrous sulfate and acidity. This acidity causes weathering of clay minerals in the host sediments and the release of elevated concentrations of Aluminium and Silica. The physical and chemical changes associated with the drainage and oxidation of these estuarine 'muds' causes irreversible shrinkage of up to 60%. After the initial drainage, the land surfaces of floodplains are often level-graded for agricultural systems and further drainage, making it difficult to identify changes in elevation relating to subsidence. Sedimentary markers are usually hidden by the substantial geochemical and physical changes associated with the sulfide oxidation. However, the detrital ferrimagnetic iron oxides including magnetite and titanomagnetite are resilient to acidic weathering, and may provide stable magnetic stratigraphic markers. We examine the application of magneto-stratigraphy to accurately measure subsidence, by comparing adjacent drained/undrained sites at two locations on the Tweed River floodplain where drainage of a mangrove swamp in 1979 was not followed by any further activity and significant subsidence is obvious. The implications of subsidence to geomorphology and land management are discussed.

THE USE OF AIRBORNE RADIOMETRICS FOR MAPPING AEOLIAN DEPOSITS IN THE CENTRAL HIGHLANDS OF NEW SOUTH WALES

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Particle size analysis, soil morphology and airborne radiometric surveys indicate extensive aeolian dust additions (modal size 30 μm) to the soils of the Blayney region in the Central Highlands of NSW. These aeolian deposits range from near 'loess' on some basalt or phyllite substrates to substantial additions to local soils on coarser lithologies. Some of these deposits occur on gentle crests and summits and others as reworked colluvial mantles at the base of gentle slopes.

Airborne radiometric data have been used to identify an aeolian component with a common Thorium content on many lithologies. In combination with DEM topographic data, the radiometrics show slope controlled preservation of aeolian materials and identify geomorphic situations in which aeolian material will be preserved. The highest concentrations of aeolian material occur on slopes less than 10% with low curvature, an easterly aspect and in catchments with low erosion rates. This distribution and its incorporation in in-situ weathering mantles illustrates that aeolian materials are extensively reworked in the landscape following deposition.

The presence of a log slope - Thorium content relationship for mixtures of aeolian and local soil material shoes potential for enhancing radiometric images for geological exploration and regolith mapping. As a direct mapping tool for soils radiometrics are poor. The high error and presence of signals and effects unrelated to soil radiometric content means that readiometric images are too noisy for spatial classification or correlation. Instead, the non-spatial approach allows identification of likely sites of aeolian deposits but the radiometric data is unable to identify them definitively.

PALEOENVIRONMENTAL RECONSTRUCTION FROM THE LAST INTERGLACIAL PHYTOLITH ANALYSIS, SOUTH EASTERN NORTH ISLAND, NEW ZEALAND

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Phytoliths extracted from loess resting conformably on lacustrine sediments in south-eastern North Island, New Zealand, provide a nearly continuous vegetation-climate record spanning the time period from the last interglacial (oxygen isotope stage 5) to the present. Phytoliths reveal changes in vegetation patterns following changes in climate. Correlation between tree/shrub phytolith fluctuations and the SPECMAP oxygen isotope curve, between oxygen isotope stages 1 and 5, suggest that changes in the ratio of arboreal to non-arboreal phytoliths directly result from changes in climate. These data generally support the existing pollen and diatom record.

This study confirms the usefulness of phytolith fossils for providing environmental and climate information from the Quaternary sedimentary record, especially in cases where the deposits contain no fossil pollen or diatoms.

ASPECTS OF LONGTERM LANDSCAPE EVOLUTION IN CENTRAL NEW SOUTH WALES, AUSTRALIA: THE GILMORE STUDY

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The Gilmore study area is in central New South Wales, straddling the Lachlan-Murrumbidgee drainage divide. To the north of the divide are extensive alluvial plains associated with the Lachlan River. A prime aim of the Gilmore study is to define the 3 dimensional regolith architecture as a basis for renewed mineral exploration and resolution of dryland salinity. An associated outcome is the elucidation of the regional regolith and landscape evolution. For further details of regolith landforms of the Gilmore study area, refer to Chan & Gibson, (2000).

Today, much of the study area is subdued and clogged with sediment, and deposition has been ongoing for a long time. Sediments including sheetwash up to 48m thick in the south, mask a sub-sediment palaeo-topography steeper than the present topography, with present drainage frequently offset from palaeodrainage. Residual materials from collapsed granitic saprolite are a major source for some of these sediments. Extensive depositional plains north of the Lachlan-Murrumbidgee drainage divide have sediments up to 120m thick overlying a ridge and vale topography eroded in the Early Tertiary (Chan, 1999). Coalescing very low gradient alluvial fans are still barely active, and almost overtop a saddle on the divide. Stagnant alluvial plains further indicate that geomorphic activity has all but ceased at the present stage of a major depositional event that probably commenced in the Miocene (Chan, 1999).

Drilling, and down-hole and airborne geophysics, indicate lacustrine and channel sediments beneath the extensive depositional plains north of the divide. High-resolution magnetics depict magnetic channel deposits both within depositional and erosional areas. The Wyalong palaeochannel (Lawrie et al. 1999) is eroded into granite saprolite and its magnetic channel deposits, which are covered by sheetwash and aeolian sediments, are partially inverted in places. Lags of abundant magnetic iron pisoliths overlying and derived from mottled granitic saprolite indicate the likely source of the magnetic palaeochannel sediments. A series of three buried catchments, ridges and hills beneath the depositional plains have been identified by electromagnetic and drilling data.

Some alluvial fans south of the Lachlan-Murrumbidgee drainage divide are now being eroded to form erosional plains, whereas other fans are presently forming The clasts in these palaeofans are often angular and reflect surrounding lithologies. Remnant clayey alluvium on top of a rise at Gidginbung Mine, standing above the northern depositional plains, indicates a much older geomorphic event than the Tertiary erosion and deposition associated with the Bland palaeovalley. In the far south of the study area, remnant pebble-conglomerate with iron pisoliths and rounded quartz and lithic pebbles on a residual rise also indicate an older event. Ubiquitous rounded quartz granules to small pebbles, occurring on tops of rises and drainage divides, do not reflect local provenance, and may be the last vestiges of a Jurassic sediment cover (Gibson & Chan, 1999).

References:

CHAN R.A., 1999. Palaeodrainage and its significance to mineral exploration in the Bathurst region, NSW. Proceedings from Regolith 1998 conference, Kalgoorlie, May 1998. CRC LEME, Perth.

CHAN R.A. & GIBSON D.L., 2000. Regolith landforms of the Gilmore study area, central New South Wales. CRC LEME Report No. 142, Perth.

GIBSON D.L. & CHAN R.A., 1999. Aspects of palaeodrainage of the north Lachlan Fold Belt region. Proceedings from Regolith 1998 conference, Kalgoorlie, May 1998. CRC LEME, Perth.

LAWRIE K.C., CHAN R.A., GIBSON D.L., & DE SOUZA KOVACS N. 1999. Alluvial gold potential in buried palaeochannels in the Wyalong district, Lachlan Fold Belt, New South Wales. AGSO Research Newsletter. May, 1999; No. 30, pp.1-5.

COSMOGENIC EROSION RATES AND EVOLUTION OF THE AUSTRALIAN LANDSCAPE

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Amongst the world's continents, Australia has the lowest relief and, setting Antarctica aside, the lowest precipitation. Landscape evolution generally is held to be slow to very slow but divergent opinions are held about landscape ages, the degree of denudation, and the timing and role of tectonic factors.

Reported here are over 100 new determinations of natural rates of erosion and, locally, soil production, derived from accelerator mass spectrometric measurements of *in situ* cosmogenic ^{10}Be, from sites throughout Australia including the Flinders Ranges, MacDonnell ranges and central desert regions. As well as these new measurements, the data set includes over 60 previously-reported measurements from detailed study sites from the southeastern escarpment and highlands.

Results show that erosion (denudation) rates on weathering-limited terrain are substantially slower (1-8 m my^{-1}) than on soil-mantled landscapes (15-50 my^{-1}) and the the diffencs are not related to rock type, nor directly to rainfall. Results also indicate that in some regions the relief is increasing (valley incision rates exceed ridge lowering rates: e.g. the Flinders Ranges) but is in steady-state in other regions. In all cases, the natural rates of soil production and/or denudation are very much slower than the high local rates that have occurred since European colonisation.

INTERACTIONS OF RIVER, LAKE AND DUNE: LANDFORM EVOLUTION OF LAKES MENINDEE AND CAWNDILLA,NSW

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Introduction

Although located closely to the well-studied Willandra Lakes, Lakes Menindee and Cawndilla differ significantly from the latter by: 1) receiving their water from a catchment area in the subtropical Queensland, and, 2) deposition of their lunette dunes lasting from Late Pleistocene to almost present time. This study of the two lakes has revealed their sedimentation sequences and landform evolution, based on the data of stratigraphy, particle size features, thin section studies, 16 TL dates and 4 ^{14}C dates.

Results

Lakes Menindee and Cawndilla, connected with both of the Darling River and the anabranching system, have incised into the saline (up to 0.8% salts) Blanchetown Clay, which ceased deposition about 500 ka (An et al. 1986). Since then, highly calcareous sand-plain deposits and sand dunes formed which give TL ages >100 ka.

The lunette dunes of the two lakes consist of a major sand sequence (37.7 to 22.4 ka), an overlying clayey layer (16 to 4.6 ka) which is saline (up to 0.5% salts) and a non-saline clayey layer (<1000 years) at foot-slope of the lunettes which contains abundant aboriginal artifacts. The 3 units are separated by two paleosols in the sequences. Aeolian activity of the area is also shown by pale linear dunes (15.8 ka) extending from the sandy lunettes and a red dune (4 ka) which has advanced into the basin of Menindee Lake.

Discussions and conclusions

All the 3 major lunette facies recognised by Bowler (1976) are present in the studied lunettes: a) sand lunette representing high water levels in the lake basins, b) clayey lunette representing fluctuated low water levels in the lake basins and c) soils indicating dry lake basins with low watertable. However, the distinctive saline and non-saline clayey layers in the studied lunettes may indicate different regimes of regional watertable. A high regional watertable may have driven salty water from the Blanchetown Clay into the lake basins if the water level in the basins was low and a low regional watertable could not do so. This also gives a warning that the wide distribution of the saline Blanchetown Clay in the region may cause severe salinity in low-lying areas if a regional high watertable occurs.

The water level in the lake basins changed from generally high to fluctuating and low since the period 22 -16 ka. The dry glacial climate may be one of the relevant causes but this transition may be mainly due to an incision of the river channel, which reduced the water supply to the lake basins significantly. This is similar to the present situation, ie. before the water regulation from 1960 , the lake basins were filled naturally by major floods only.

References

An, Zhisheng, Bowler, J.M., Opdyke, N.D., Macumber, P.G., and Firman, J.B. (1986), Palaeomagnetic stratigraphy of Lake Bungunnia: Plio-Pleistocene precursor of aridity in the Murray Basin, southeastern Australia. Palaeogeogragpy, Palaeoclimatology, Palaeoecology, 54:219-239.

Bowler, J.M. (1976), Aridity in Australia: age, origins and expression in aeolian landforms and sediments. Earth-Science Reviews, 12:279-310.

SOIL PIPEFLOW: CONTROLS AND MECHANISMS

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Soil pipeflow is an important geomorphic and hydrological process on many New Zealand hillslopes. It is a factor in soil erosion, gully development, and slope instability. Its hydrological significance is less well understood, particularly in the areas of pipeflow behaviour, solute transport, and contribution to streamflow. An appreciation of pipeflow behaviour and its controlling factors can provide an indication of the mechanisms involved in pipeflow generation and its significance as a hillslope process.

This study examines flow from one of a number of pipes occurring within an upper hillslope facet within the Lake Tutira catchment, Hawke's Bay. The pipes vary in diameter from 90 – 250 mm and are located at a depth of about 40-50 cm within a relatively coarse horizon of a sandy loam. The slope facet has been instrumented to record automatically climatic and soil hydrological parameters, including soil moisture, soil suction and positive porewater pressure. Measurements are taken below the ground surface at depths of 25, 50, and 100 cm at five locations on the slope facet. Flow measurements are made at the downslope pipe outlet using a pressure transducer stage and a 20 degree 'V" notch weir.

Hydrograph and regression analyses indicate that pipeflow is closely related to rainfall characteristics, particularly rainstorm total, duration, and intensity. Pipeflow appears to be little modified by antecedent soil hydrological conditions. Lag times which are bimodally distributed, appear to be unaffected by antecedent soil moisture conditions. These observations, together with a comparison of lag times with hydraulic conductivities suggest that pipeflow response is too quick to be generated by diffuse matrix flow.

CLIMATE AND FLOW REGIME CHANGES OVER THE LAST 250 KA FOR COOPER CREEK IN NORTHEASTERN SOUTH AUSTRALIA

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Alluvial, aeolian and lacustrine sediments from Cooper Creek within and downstream of the Innamincka Dome provide evidence of climate and flow regime changes over the past 250 ka within the Lake Eyre basin of central Australia. Nearly 70 thermoluminescence (TL) dates have been obtained from quartz sand in three depositional settings; 41 from fluvial sediments (channel and overbank facies), 25 from aeolian sediments (source-bordering and longitudinal dunes) and three from a lunette on the river-terminus Coongie Lakes have enabled an interpretation of the Quaternary history of Cooper Creek in this region.

Palaeoenvironmental evidence has been interpreted from sedimentological data including particle size analyses, mineralogy, petrography and SEM analyses. It appears to have been wet at around 250 ka to 230 ka, but this phase is based here on only two dates. There is gap in the TL chronology between 230 ka and 170 ka with no alluvial or aeolian units dated. From about 170 ka to 146 ka there is a prominent wet phase corresponding to the middle of OI Stage 6, followed by another gap in fluvial deposition between 146 ka and 120 ka, a period that corresponds to the probably dry penultimate glacial maximum. Following this there commenced a period of pronounced fluvial activity associated with the formation of source-bordering dunes and lunettes between 116 ka and 109 ka. While fluvial activity continued near Innamincka from 120 ka to about 6 ka, the region became increasingly drier after about 60 ka. With this drying, fluvial activity was limited to the immediate confinement of the Dome and to parts of Strzelecki Creek, with source-bordering dunes downstream of the Dome supplying sand for longitudinal dune formation from about 16 ka to the present. Similarly, lacustrine lunettes were reworked from about 11 ka to 4 ka.

The chronostratigraphy and sedimentological evidence from this study reveals that there was a wet phase during mid Stage 6, probably an arid penultimate glacial maximum during late Stage 6, and ongoing fluvial activity between mid Stage 5 and the Holocene. The Stage 5 wet phase was associated with the development of source-bordering dunes and lunettes, with the formation of an extensive field of longitudinal dunes starting around 16 ka. Other research on Cooper Creek suggests distinct wet and dry phases during the last full glacial cycle; however, results from the Innamincka region suggest a more continuous period of fluvial activity continuing through to the Holocene. This protracted activity is probably the result of enhanced stream energy and alluvial reworking, even during relatively dry episodes, due to flow confinement within and immediately below the Dome. Despite this, there is clear regional evidence for increasing aridity following Stage 4.

UNDERSTANDING GAWLER CRATON REGOLITH, AND ITS SIGNIFICANCE TO THE AUSTRALIAN MINERAL EXPLORATION INDUSTRY.

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Gold was first discovered at Challenger (Gawler Craton, South Australia) in 1995. Although earlier work had been done in the region, detailed investigation of the regolith and geochemistry did not begin until 1997. This detailed work was carried out on behalf of the Gawler Joint Venture (GJV), as a collaborative project between the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME) and Primary Industries and Resources South Australia (PIRSA). Preliminary geochemical investigations were based on research methods that have been successfully applied to the deeply weathered environments in Western Australia and Queensland but were later adjusted to suit the local South Australian regolith environment.

A range of detailed regolith landform maps and thematic maps incorporating remotely sensed datasets have been generated. More detailed observations reveal that this region is especially characterised by a subtle landscape with an overall low relief, where saprolite is rarely exposed at the surface because of the extensive, often thick concealing colluvial and alluvial sediment cover. Ferruginous and siliceous lags, and duricrusts are common but not always extensive. Calcareous soils, calcrete nodules and calcrete sheets are however much more extensive than the ubiquitous ferruginous weathering products of Western Australia. One the one hand the difference in the nature of Gawler Craton weathering products confirms the general need for geochemical exploration strategies to move away from the traditional lateritic-based geochemical sampling media common in Western Australia. However, on the other hand the alternatives-calcrete and perhaps even silcrete, hold a much more cryptic message.

The value and limitations of using sampling media, and the interpretation of geochemical anomalies defined by the regolith materials more common in the Gawler Craton is now a matter of more detailed on-going research. A new project is now in progress that looks at the specific relationships between regolith materials, processes and geochemical signatures already defined.

CHARACTERISATION OF REGOLITH MATERIALS AT MANDAMAH PROSPECT, CENTRAL WESTERN NEW SOUTH WALES, AUSTRALIA: IMPLICATIONS FOR THE DISTRIBUTION OF GOLD AND BASE METALS

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Semi-quantitative observations have been used to define the spatial distribution of regolith materials above the concealed Mandamah porphyry-related Au-Cu deposit in Central West NSW, and to constrain the distribution of secondary mineralisation more precisely. Parameters used include down hole distribution and nature of mottled zones, sediment grain size, presence and morphology of quartz, presence and nature of iron concretions, magnetic susceptibility, and recognised retention of primary texture. A Portable Infrared Mineral Analyser (PIMA) and X-ray diffractometer were used to identify minerals and to detect changes in degree of disorder of kaolinite. PIMA analysis was used to delimit the down hole relative proportion of bound water in regolith materials.

The transported unit lies on an irregular erosional unconformity in pallid saprolite, about 45 m below the land surface. Sandy sediment dominates from 0 m to 18 m, gravel from 18 m to 25 m, sandy material from 25 m to 31.8 m, and clay-rich sediment below 31.8 m. The transported unit is characterised by two mottled zones, one from 3.7 m to 18 m, and a second 31.8 m to 45 m. Magnetic susceptibility measurements were taken on very small samples of drillcore, and were used for comparative analysis downhole only. Susceptibility readings are variable, but generally very low, from 0.0002 to 0.0012 SI units down to 31.8 m, zero to 0.0001 SI units in the region of the contact, and increase from 0.0001 to 0.0012 SI units down hole from 52.1 m. Iron concretions are concentrated in a horizon 31.8 m to 36.1 m below surface, above the base of transported regolith, and along fractures in the interval 79.9 m to 89.2 m. The degree of disorder of the kaolinite is variable, but is low at the base of the transported material and high in the *in situ* pallid saprolite.

Regional metamorphism (up to greenschist facies) of hydrothermally altered host rock resulted in formation of a chlorite-silica-sulphide dominant mineral assemblage. This altered and metamorphosed bedrock was subsequently weathered to a chlorite-sericite-kaolinite-illite-rich saprolite greater than 40-m thick. Primary porphyritic rock texture is preserved in the lower saprolite.

Copper anomalies (up to 6400 ppm) increase with depth, and are higher in the saprock (>85 m depth), than in the lower saprolite (56.3 m to 84.5 m). Gold anomalies are irregularly distributed down hole. Gold anomalies up to 5 ppm occur at the base of transported regolith, at the top of the pallid saprolite zone, in the saprock and in the bedrock. In places the lower saprolite contains Au values of 5 to 10 ppm and Cu values of 1700-2000 ppm.

Anomalous gold and base metal values are associated with dispersion along the base of the transported unit, with residual metal concentration in saprolite, and supergene enrichment at the interface between saprolite and saprock. Concentration of gold, copper, lead and zinc in the saprolite and saprock appears to result from weathering of fractured-rock and vein hosted mineralisation.

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REGOLITH CHARACTERISATION OF THE MAGNETIC WYALONG PALAEOCHANNEL, CENTRAL WESTERN NEW SOUTH WALES, AUSTRALIA

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Sinuous features with a high magnetic response were recognised on aeromagnetic images from the Wyalong area, central-western New South Wales, Australia. The area is well known for mining of vein-hosted and porphyry-related gold and base metals from *in situ* saprolite material, that is developed over variably altered bedrock. Historic workings have also exploited deep leads for tin and gold. Bedrock is dominantly an Ordovician volcanic succession, and Siluro-Devonian granitic intrusions, with much younger cover and channel fills.

Comparison of the spatial distribution of regolith materials from regional regolith-landform maps, with a high-resolution aerial magnetic survey image showed little correlation between surficial regolith and the sinuous magnetic features recognised at depth. Closer analysis of the aerial magnetic image revealed curved elongate features up to a few hundred metres wide that formed a dendritic pattern closing to the north-east. These were interpreted as palaeochannels draining north-eastward into the major north-south trending Bland Palaeochannel system (Lawrie *et al.* 1999).

A costine excavated near West Wyalong enabled examination of shallow subsurface features in an area of high magnetic response (de Souza Kovacs 2000). The costine exposed near surface palaeochannels confirming the aeromagnetic image interpretation. The magnetic signature of the palaeochannel deposits is due to the presence of detrital maghemite-bearing ferruginous nodules in the sediments. They occur as 0.5 mm to 15 mm round nodules, in 4 cm thick to 40 cm thick bands and lenses. Internally the maghemite nodules are not concentrically zoned and contain randomly distributed subangular quartz grains. Highly magnetic channel-fill successions occur at depths between 3 m and 4.5 m below the present land surface.

Quantitative X-ray diffraction (XRD) of regolith materials from the Wyalong costine indicate that there are a greater abundance of X-ray amorphous (poorly crystalline) minerals in the palaeochannel layers compared with the underlying *in situ* material. Algorithms for kaolinite crystallinity and bound water generated from Portable Infrared Mineral Analyser (PIMA) data also show variations between transported and *in situ* regolith materials. Typically, transported material has high bound water and low kaolinite crystallinity values and *in situ* regolith has low bound water and high kaolinite crystallinity values.

A three-dimensional model of the distribution of regolith materials in the Wyalong area indicates that the palaeochannels originate from granitic erosional areas in the west and flow north-east across the northern-most extent of mineralised Ordovician volcanic rocks, into the broad north-south trending Bland alluvial system. Palaeochannels nested within the cover sequence are not readily recognised at the land surface. The most effective approach for regolith description in this geological setting is to combine geophysical information with descriptions from excavated sections and drill holes.

This work illustrates that aeromagnetic images can be used to delineate palaeochannels, but palaeochannels either have to be near surface (e.g. 40 cm thick maghemite-nodule-bearing lenses at 4.5 m, this study) or contain large concentrations of magnetic nodules or minerals. It follows that deep channels or channels with few or dispersed magnetic sediments are invisible when using this technique.

Observations made in the Wyalong costine indicate that use of high-resolution magnetic imagery to define palaeochannels is a valid regolith-mapping tool. It also illustrates that the features recognised in the images are multiple nested channels rather than discrete channels. The preferred model for maghemite nodule formation in this area is that non-magnetic ferruginous nodules were exposed to high temperatures at the land surface, and subsequently reworked into alluvial channels.

The use of one or a combination of quantitative XRD, kaolinite crystallinity and proportions of bound water can be applied in other locations to define a contact between transported and *in situ* regolith materials. However, it is strongly recommended that these methods be used together with semi-quantitative descriptions of regolith materials before decisions are made about the location of contacts within the regolith mantle.

The most effective approach for regolith description in locations where surficial landforms do not reflect subsurface variations in regolith is to combine geophysical information (e.g. aerial magnetic images) with descriptions from excavated sections and drill holes, to develop a three-dimensional model of regolith distribution.

References:

De Souza Kovacs N. (2000) Regolith stratigraphy and landform architecture, Barmedman District, central western NSW: influence of mineral systems. Unpublished BAppSci Honours Thesis, University of Canberra, pp166.

Lawrie K.C., Chan R.A., Gibson D.L. and de Souza Kovacs N. (1999) Alluvial gold potential in buried palaeochannels in the Wyalong District, Lachlan Fold Belt, New South Wales. *Australian Geological Survey Research Newsletter* 30, p1-5.

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THREE-DIMENSIONAL REGOLITH MODELLING, A NEW APPROACH: APPLICATIONS FOR ENVIRONMENTAL AND ORE DEPOSIT STUDIES.

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A new approach to three-dimensional modelling correlates subsurface regolith materials to geophysical datasets. This methodology was developed to establish a procedure for three-dimensional regolith interpretation in the Temora region of central western New South Wales, Australia.

Initially, regolith-landform maps are combined with magnetic and airborne electromagnetic induction (AEM) images to define polygons depicting the regolith, the underlying geology and related geophysical characteristics. Representative drillholes are chosen from each of these polygons based on data availability. For areas with large datasets this step reduces the sampling density of drillholes to an effective minimum. In areas with limited drillhole coverage this approach defines target areas for three-dimensional characterisation.

Physical and chemical characteristics including: mineralogy, colour, soil texture, degree of induration, magnetic susceptibility, sedimentary parameters, carbonate and manganese oxide presence, and pH, are systematically measured for the regolith materials. These data are complemented by Portable Infrared Mineral Analysis (PIMA) and quantitative X-ray Diffraction (XRD) techniques, used to define mineralogy and pinpoint transitions in the profile. The framework established provides a context for the interpretation of geochemical data.

This method is an effective way to examine large and geologically complex areas. It allows determination of facies change at depth and laterally in transported regolith units, as well as, mineralogical and thickness variations in the saprolite over primary and altered rock. The technique has been used in studies of salt storage, and flow of solutes through the landscape. It has been directly applied in the development of mineral exploration strategies in weathered- and altered-rock terrains, and has broader applications.

ROCK COAST GEOMORPHOLOGY OF LORD HOWE ISLAND

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Lord Howe Island (33°30'S, 159°05'E) is a small oceanic island, located in the Tasman Sea approximately 600 km off the eastern coast of Australia. Geologically, the island consists of Tertiary basalts with Pleistocene calcarenite dunes at lower elevations. The island is small, approximately 11 km long and 2 km wide, having been reduced by erosion to less than 3% of its original area.

Lord Howe Island lies at the southern limit to coral growth and features a fringing reef on only the western side of the island. The reef attenuates wave energy along the western coastline, but the remainder of the island is exposed to waves of unlimited fetch. In addition to this varied wave-exposure setting, there are considerable variations in rock strength around the island. The variations in erosion parameters support deduction as to the extent to which subaerial processes and wave erosion have contributed to the development of coastal landforms around Lord Howe Island.

Rock strength was examined through Schmidt Hammer testing and studies of rock weathering and jointing. Wave power was modelled from wind and bathymetric data. These results were correlated with coastal form (field inspection, surveying, aerial photograph analysis). At the broadest scale, a simple contrast is presented between the highly cliffed exposed coastline and the undulating vegetated hillslopes of the reef-sheltered coastline. Contrast was also drawn between shore platforms on each coastline: contemporary calcarenite and basalt platforms were shown to be more than twice the width on the exposed coastline than on the sheltered coastline. This confirms that wave erosion contributes to shore platform development at Lord Howe Island. Further, basalt platforms were always narrower and at relatively higher elevation than calcarenite platforms confirming that basalt is more resistant to both wave erosion and subaerial weathering.

Within similar wave-erosion settings, morphological variations reflect the resistance of different rock types. In basalt shore platforms, rock pools up to 4 m deep have been preferentially excavated in breccia: the lateral dimensions of these pools are controlled by harder outcrops of basalt and dykes. The pools are permanently saturated indicating that wave erosion must be responsible for much of their development. Sea caves, gulches and an arch are present along much of Lord Howe's coastline; most often they have been eroded along the line of dykes. Whilst dykes are generally shown to be harder than adjacent lithologies, they are highly fractured, and this has allowed differential erosion by waves. In the southern portion of the island, dykes are very rare, and sea caves, gulches and arches are absent. Here cliffs of more than 500 m plunge into deep water or else they have very large talus slopes at their foot. Shore platforms are absent except where cliff height drops below about 200 m. In addition to these examples, Lord Howe presents many other intriguing relationships between coastal process and form. The analysis to date highlights the importance of wave erosion in the development of many of these forms. Weathering processes are also shown to be important, especially with respect to calcarenite and breccia lithologies, but also as regards the enlargement and weakening of joints. A combination of these processes can account for much of the variety in coastal scenery at Lord Howe Island.

FLOW HYDRAULICS IN LAMINAR FLOWS, THE STARTING POINT FOR INTERRILL SEDIMENT EROSION AND TRANSPORT.

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Runoff from the land mostly begins in the interrill zone, and where soils are relatively bare, may involve at least some infiltration-excess (Hortonian) flows. The initial stages of soil particle entrainment and transport begin in relatively shallow and slow moving flows, which may become deeper and faster along the runoff pathways leading to rills, small channels, and streams. Whilst a considerable body of evidence is available on the hydraulics and erosion processes that take place in rills and other channels, there are substantial gaps in our understanding of events in thin and slow-moving overland flows.

Flow experiments made both in the field and the laboratory have been carried out to explore some aspects of these shallow flows. In terms of conventional Reynolds numbers, shallow flows are commonly laminar, but during rain are disturbed by raindrop impacts. To analyse flow hydraulics, known discharges were passed along small plots or flumes, within which grids of flow depth measurements were collected by an automated travelling needle-gauge system. Resulting data allowed mean flow speeds and depths to be derived, and friction factors calculated. In the experiments, these data were collected on natural soil surfaces in the field, and on glued-sand boards in the laboratory. Additionally, surfaces modified by the addition of plant litter and small stones (both augmenting the sources of frictional retardation on the test surface) were examined in the same way.

Results show that in the laminar range, shallow flows exhibit Darcy-Weisbach roughness coefficients that fall monotonically with increasing discharge. This happens even in the presence of obstacles such as litter or non-submerged stones. Quite different behaviour is known from turbulent flows, where the dominant view is that non-submerged roughness elements trigger rising roughness as they become increasingly submerged. Roughness reaches a maximum as the obstacles are just overtopped, and then declines as they become more deeply submerged. Thus, in terms of the co-variation of flow speeds with discharge, laminar flows demonstrate a response quite distinct from that of turbulent flows. Clearly, these differing behaviours suggest that there might be quite distinct trends in sediment transport capacity with rising discharge in the two flow regimes.

The laminar flow results also show unexpected effects from large non-submerged obstacles in the flow. These tests were made with natural stones added randomly to a bare desert soil in order to achieve 5%, 10% and 20% surface cover. On desert surfaces, in particular, the interrill zone is often mantled by loose stones of this kind. In the laboratory, square ceramic tiles were used to generate the same surface cover fractions. Flow depths, speeds, and friction factors were determined. Results show that roughness is not always increased by obstacles in the flow. Instead, obstructed flow in some cases showed lower flow roughness than flow over the identical surface, but with the obstacles removed. It is inferred that the upward displacement of flow depths that is caused by the volume occupied by the obstacles more than compensates for the obstruction of flow paths and the greater resulting tortuosity of these paths. No consistent trends were evident however as the cover was increased from 5% to 20%, and the effect on flow roughness may depend on the geometric arrangement of the obstacles as well as their surface cover fraction.

Finally, plant litter experiments (using litter loadings of 20 g/m^2, 40 g/m^2 and 100 g/m^2) showed that a much greater increase in friction factors is contributed by litter than by stones, for the same cover fraction. Thus, organic properties of the flow surface warrant greater attention in studies of overland flow hydraulics than they appear to have been given in work done to date.

WATER REDISTRIBUTION BY RUNOFF AND RUNON IN SEMI-ARID MOSAIC LANDSCAPES - HOW DOES IT WORK?

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Mosaic patterns are widely-described from the plant communities of semi-arid landscapes. These mosaics consist of relatively dense groves of plants with intervening bare or more sparsely-vegetated zones. These two primary mosaic components may take the form of irregular patches, or complex stripe and band formations that are mostly contour-parallel. In general, it has been deduced that these mosaics operate as runoff - runon systems, in which plant growth in groves is supported by water shed from the bare intergroves.

Field observations of soil moisture and infiltration rate were collected from two different dryland mosaic landscapes. The first is a contour-banded shrubland near Menindee in arid New South Wales, Australia, and the second a groved mulga (*Acacia aneura*) woodland north of Alice Springs in central Australia. Soil moisture was determined *in situ* using a dielectric constant probe, and infiltration rates were determined from static ponding using miniature cylinder infiltrometers.

Results in both landscapes show greater complexity in the distribution of water than the simple runoff - runon conception would suggest. Intergroves in the Menindee landscape show systematic internal variation in infiltration rates. Rates are high in the upslope parts, reach a minimum in the totally bare lower intergrove, and then rise once more as the grove is approached. This variation relates to changes in soil texture, surface crust type, and the cover fraction of surface stones. As a result, runoff is not shed in equal amounts from different parts of an intergrove. In particular, the upper parts of intergroves show infiltration rates as high as the lowermost parts of groves. Thus, some of the vegetation boundaries that mark out the mosaic community do not coincide with changes in soil hydraulic properties.

Groves in the mulga landscape exhibit a different kind of systematic internal variation in infiltration rates. Transects running radially outward from mulga stems show that infiltration rates are highest near the stem, and decline steadily with increasing distance. The decline extends to soils located well beyond the limits of the plant canopy, and soils well away from stems show infiltration rates indistinguishable from intergrove rates. Thus, water absorption does not characterise grove soils as a whole, but rather only those soils lying within the 'zone of influence' of the mulga trees. Radiating root systems and associated soil macroporosity probably account for the observed patterns. This pattern of radially changing infiltration rates has also been reported from groves in a patchy chenopod shrubland located north of Broken Hill is western NSW.

Runoff passing downslope across intergroves tends to pond near the bottom of the intergrove, from where some at least infiltrates, and some trickles into the grove. The field soil moisture data from the mulga landscape show that as a result, lower intergrove soils can be as wet as upper grove soils. Indeed, this band of adjacent soils was the wettest part of the entire landscape. It is therefore not entirely clear why there is a distinct plant cover boundary between intergrove and grove, when the soils on either side of this boundary are equally moist. It may be that the position of plant cover boundaries is set in years of more severe moisture stress, when intergroves are especially bare, and less water is absorbed into the soils of the lower intergrove.

The distribution of soil moisture in both the Menindee and central Australian landscapes revealed that groves become drier in the downslope direction, even after antecedent months of record rainfall. Surprisingly, projected foliar cover shows no evident parallel decline downslope. Thus, plants in the downslope parts of groves may tap soil moisture reserves in the deeper subsoil that are more uniform because of water redistribution by percolation and lateral seepage.

SPATIAL PATTERNS OF GLACIAL EROSION AT A VALLEY SCALE DERIVED USING COSMOGENIC ISOTOPE CONCENTRATIONS IN QUARTZ

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Our understanding of landscape change and landform development is based on quantitative and qualitative models of geomorphic processes combined with knowledge of spatial and temporal variations in controlling variables. A lack of ways to test process models on time and space scales that are relevant for large-scale landform development has limited our ability to refine process models and advance our understanding of form development. Thus there is considerable need for approaches that provide quantitative data on large-scale patterns of erosion.

Cosmogenic isotopes are produced in the upper several meters of rock surfaces. Concentrations of these isotopes can be used to determine total time of near surface exposure and in some cases the amount of rock lost by erosion. To test the potential use of the cosmogenic isotope technique in determining patterns of glacial erosion on a valley scale, rock samples were taken along valley side transects in Sinks Canyon, Wind River Range, Wyoming, and the South Yuba River, Sierra Nevada, California. These valleys have each experienced at least two glacial advances that produced erosion. In both cases up-valley transects recorded erosion that exceeded 1.73 m throughout, and down-valley samples recorded erosion that decreased towards the lateral limit of ice extent. These results demonstrate that cosmogenic radionuclides provide useful insight into the spatial pattern of glacial erosion, and suggest more extensive sampling in areas with limited erosional loss would provide detailed records of erosion patterns with which to test predictions generated by models of ice dynamics and erosion processes.

COSMOGENIC ISOTOPE EVIDENCE OF LANDSCAPE PRESERVATION UNDER ICE SHEETS

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The typical geomorphology of high latitude Northern Hemisphere mountains is a patchwork of glaciated terrain and preglacial relict upland surfaces. Glacial terrain is characterised by U-shaped valleys, cirques, horns, arrêtes, valley- and mountain truncation, mountain asymmetry and the ubiquitous presence of lakes. Relict upland surfaces, on the other hand, are characterised by sinuous V-shaped fluvial valleys, tors, weathering mantles and the absence of (water-filled) rock basins. In many cases there is very strong evidence that these relict surfaces were covered by ice sheets. This patchwork occurrence of glacially scoured and preglacial relict surfaces indicates that Plio-Pleistocene subglacial erosion was aerially restricted. The most prominent valleys of the preglacial landscape were probably exploited by early ice sheets as primary routes of ice drainage, and hence became locations for subglacial bedrock erosion and valley deepening. These deepened valleys provided more efficient ice drainage and were presumably exploited during each subsequent glaciation. The implication is that adjacent highlands were covered by relatively stagnant ice with subglacial freezing allowing landscape preservation. The most visible alteration of the preglacial upland landscapes since commencement of glaciation in this region has been deepening of the V-shaped valleys that terminate in glacial troughs. This is because in interglacial times these rivers adjusted their profiles to the new base-level conditions produced by trough deepening during previous glaciation(s).

We have begun to test this model of mountain development through the application of cosmogenic nuclide analysis of exposed bedrock surfaces in the northern Swedish mountains. Preliminary ^{10}Be data from quartz separates demonstrate that preglacial surface samples have survived at least one Fennoscandian ice-sheet overriding event, providing clear evidence of subglacial landscape preservation. Patterns of ^{10}Be apparent ages from adjacent sites corroborate our inference of areally restricted glacial erosion formerly inferred from boundaries based on geomorphological observations. Cosmogenic nuclide concentrations in bedrock surfaces in the northern Swedish mountains provide a powerful tool to help constrain the rate of glacial and fluvial erosion and shed light on the numerical age of preglacial landscape surfaces.

relicts of pre-glacial landscape - 52'000 dates.
exposure age
- meandering valleys
- weathering mantles
((deglacial age - 9000)
- "tear offs".

THE EPISODIC NATURE OF ARID ZONE EROSION AND SEDIMENTATION: EVIDENCE FROM SELECTIVE PRESERVATION OF ABORIGINAL CAMP SITES IN WESTERN NSW, AUSTRALIA.

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Archaeological evidence that demonstrates the episodic, and often very localised, nature of erosion and sedimentation resulting from storm events in arid environments, will be presented in this paper.

In June 1999, clusters of Aboriginal heat-retainer hearths adjacent to Fowlers Creek on Fowlers Gap Arid Zone Research Station, 110 km north of Broken Hill, NSW, were surveyed and documented. This formed part of a larger study of Aboriginal stone artefacts being conducted under the auspices of the Western NSW Archaeological Program, a Large-ARC funded research program conducted jointly by the GSE at Macquarie University in Sydney and the Department of Anthropology at the University of Auckland. In February 2000, a major rainfall event occurred, reported from many places in the region as the largest on record, which partially destroyed some hearth clusters. At other sites on Fowlers Gap Station, stone artefact scatters surveyed in 1999 were still largely intact after this event, while others had been buried by localised sedimentation. Similar patterns of selective burial and erosion were observed on the adjacent Sturts Meadows Station.

The geomorphic factors controlling this selective erosion and deposition will be explored, and the implications for understanding of both ephemeral stream erosion and Aboriginal occupation of the arid zone will be discussed. Such events demonstrate that the processes that transform both the geomorphological and the archaeological record in this region are episodic and often catastrophic, not slow and steady. Further, it demonstrates that preservation of long records of occupation are unlikely in this environment.

A PRELIMINARY TRIAL OF *IN-SITU*-PRODUCED COSMOGENIC ISOTOPE ANALYSIS FOR INVESTIGATING STONE PAVEMENT FORMATION IN WESTERN NEW SOUTH WALES.

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Fowlers Gap Arid Zone Research Station is located 110km north of Broken Hill, in the northern Barrier Ranges of western N.S.W. Over the ranges are mantled desert loam soils (aeolian derived, yellowish-red silts and clays) which contain layers of buried stones, and whose surface is covered by a stone pavement of identifiable local outcrop source. The objective of this preliminary study was to determine the exposure ages of the surface and buried stones through measuring the cosmogenic isotope ^{10}Be within quartz grains of the stones. This should allow a better understanding of how stone pavements form, and may also allow an approximate deposition time for the aeolian sediments to be determined. The three main published theories of how the stone pavements formed in the area are cumulic pedogenesis, upward displacement of stone, or slopewash.

Three samples were used in this small preliminary study. Sample FG1 is from a silcrete outcrop that caps the foothill of the range. Sample FG2 is taken from the surface silcrete stones lying approximately 100 m downslope from the outcrop. Sample FG3 is taken from buried silcrete stones at 1.6 m depth below sample FG2. The rock samples were crushed, ground, sieved and then cleaned using the chemical isolation of quartz technique of Kohl and Nishiizumi (1992). ^{10}Be was then separated from the quartz, and measured using accelerated mass spectrometry. The amount of ^{10}Be produced in each sample is controlled by the altitude, latitude, shielding and exposure age of the sample, and Lal (1991) has established equations for these relationships. This allows an approximate exposure age for each sample to be determined from the amount of ^{10}Be that has accumulated within the quartz grains of the rocks.

With only one isotope being measured, the results can only be interpreted if it is assumed that the samples have not had complex exposure/burial histories. Knowing these limitations and knowing that each of the three theories will result in different exposure histories, the relative concentrations of ^{10}Be in the samples will show which of the theories is most likely correct. Cumulic pedogenesis will have kept the FG2 stones being continuously exposed at the surface while FG3 was buried. Upward displacement of the stone will have buried and shielded sample FG2, before re-exposing it at the surface through the shrink/swell of the clay. While erosion of the outcrop and slopewash (after deposition of aeolian clays and burial of FG3) will mean that sample FG2 is younger than FG3.

The process of stone pavement formation in Australia's arid zone has been discussed in the literature without direct measurement. Analysing the stones for *in-situ*-produced cosmogenic isotopes should allow the theories to be tested. Future work will investigate the area further, by examining more samples from more sites, and by measuring both ^{10}Be and ^{26}Al. Using this multiple isotope approach will greatly reduce uncertainty and allow fewer assumptions to be made.

References:

Kohl, C.P. and Nishiizumi, K., (1992), Chemical isolation of quartz for measurement of in-situ produced cosmogenic nuclides. *Geochemica Cosmochima Acta*, 56, 3583.

Lal, D., (1991), Cosmic ray labelling of erosional surfaces in situ production rates and erosion models. *Earth and Planetary Science Letters*, 104, 424-439.

BEHAVIOUR OF SUBGLACIAL SEDIMENT BASAL ICE IN A COLD GLACIER

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Tunnels in glaciers offer unique opportunities for examining processes acting at the bed. At Suess Glacier in the Taylor Valley, Antarctica, a 25 m tunnel excavated into the bed of the glacier provides access to a 3.2 m-thick basal zone and the ice-substrate contact. Measurements of ice velocity over 2 years together with glaciotectonic structures show that there are distinct flow separations at several locations in the basal zone. The flow separations provide evidence of narrow shear planes and sliding of ice over boulders, blocks of frozen debris and other bodies of ice at -17°C. Comparison of debris concentrations and the shear strength of basal ice samples demonstrate that strength is at least partly controlled by debris concentration. The substrate and blocks of the substrate within basal ice are characterised by brittle and slow ductile deformation whereas ice with low debris concentrations behaves in a ductile manner. The range of structures observed in the basal ice suggests that deformation occurs in a self-enhancing system. As debris begins to deform, debris and ice are mixed resulting in decreased debris concentrations. Subsequent deformation becomes more rapid and increasingly ductile as the debris and sedimentary structures within the debris are attenuated by glacier flow. The structural complexity and thickness of the resulting basal ice are considerably greater than previous descriptions of cold glaciers and demonstrate that the glacier is or was closely coupled to its bed.

REMOTE SENSING OF FLOODPLAIN INUNDATION: A CASE STUDY ON THE MURRUMBIDGEE RIVER, NSW

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River regulation has altered the hydrological regimes of many of the world's major river systems. One effect of regulation has been to alter the frequency of floodplain inundation. The nature of the relationship between river stage and floodplain inundation is often difficult to determine in the field. Large floods occur infrequently and the flood wave may move quickly downstream. Fieldwork in flooded areas can also be hazardous. This project demonstrates the values of using satellite imagery to determine the relationship between river discharge and floodplain wetland inundation.

Data from the Landsat satellites have been available since the early 1970's and from SPOT satellites since the early 1990's. These data are synoptic and repetitive with extensive archives making them useful for the analysis of historical river flows. This study compared the accuracy of using Landsat MSS, Landsat TM and SPOT data to map river floodplain water bodies on the Murrumbidgee River near Wagga Wagga, Australia.

Once the accuracy of using these data to map water bodies was assessed a sequence of Landsat TM satellite data was used to assess the current relationship between river stage and floodplain wetland inundation. Landsat TM data, purchased before and after a flood event are being used to determine which of the wetlands in a given reach received water during that flood. Using this technique with a range of flood events from within channel freshes to larger overbank floods the commence to fill stage for each of the wetlands was determined. These data were then analysed to indicate the inundation frequency of all wetlands in a given reach for any given gauging period.

A GEOMORPHIC APPROACH TO IDENTIFICATION OF RIVER RECOVERY POTENTIAL: APPLICATION IN BEGA CATCHMENT, SOUTH COAST, NSW, AUSTRALIA

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Geomorphic recovery occurs naturally as rivers adjust to disturbance. While many studies of river character and behaviour have documented pathways of degradation, little emphasis has been placed on the character, capacity and stages of river recovery. A generic procedure to analyse river recovery potential has been developed and applied in Bega catchment, on the south coast of New South Wales (NSW), Australia. The approach uses the River Stylesä framework and directly links river forms and processes at various stages of recovery.

Different reaches of the same River Style can display different conditions. Based on a number of geomorphic principles including the assemblage of geomorphic units, sedimentary characteristics, hydraulic character, vegetation composition and coverage etc., each reach is assigned a good, moderate or poor condition. **Good condition** reaches operate in a self-adjusting manner, whereby processes maintain the pre-disturbance or near-intact geomorphic character of the reach. **Poor condition** reaches are often still adjusting to disturbance and form-process associations are out-of-balance. **Moderate condition** reaches sit between these two extremes. Once the condition has been assessed, predictions are made about the direction of change a reach will take.

At any stage along the condition continuum the processes of recovery may begin and the reach may adjust onto one of two recovery pathways. If processes in a reach maintain and enhance the 'natural' geomorphic structure of the reach for that particular River Style, the reach is adjusting towards a **restored (or intact) condition**. Alternatively, if the reach is adjusting towards a new, or **creation condition**, the river character and behaviour has been irreversibly altered, a number of thresholds breached and a shift to a new River Style has resulted. Ultimately, this reach may also attain a self-adjusting character and behaviour, but it now operates under altered catchment boundary conditions (in terms of water and sediment transfer and riparian vegetation associations).

Whether or not these reaches attain their respective recovery endpoints will depend on limiting factors operating in the catchment. Reach position and the condition of reaches upstream and downstream determine the potential for geomorphic recovery. Detailed analysis of vegetation cover and distribution, and water and sediment budgets, give further insight into the potential for geomorphic recovery of a reach.

Assessments of geomorphic condition and recovery potential of River Styles provides a solid basis to identify appropriate target conditions for river rehabilitation based on the natural variability of river character and behaviour in equivalent landscape settings. In addition, it provides a geomorphic platform to assess ecological recovery potential within an entire system.

CRETACEOUS DENUDATION IN SOUTHEAST AUSTRALIA: FISSION TRACK AND GEOMORPHOLOGICAL RECONCILIATION

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Apatite fission track (AFT) data indicate that Lachlan Fold Belt (LFB) rocks in many locations within the highlands of southeast Australia resided at elevated paleotemperatures prior to ~95±5 Ma, at which time they underwent rapid cooling. Sydney Basin thermal data also suggest a significant degree of cooling since this time. The thermal signature of this mid-Cretaceous event becomes weaker westward from the highlands: AFT data from the central LFB record a major Permo/Triassic cooling event, followed by reheating in the late Mesozoic, and widespread latest Cretaceous to early Tertiary cooling. Tertiary erosion rates measured by geomorphologists in the highlands (up to a few tens of m/my) contrast with middle Cretaceous rates of up to ~400 m/my suggested by AFT data. Thus, geomorphologists have tended to discount interpretations of AFT data.

The preserved Cretaceous basins in eastern Australia have been eroded since close of sedimentation. Rocks near the southern margin of the Surat Basin have undergone cooling equivalent to removal of one or more km of sediment. Vitrinite reflectance data from erosional outliers in the Parkes/Orange area south of the main basin margin suggest a considerable eroded section. The contrast in interpreted erosion rates, combined with these data have lead us to propose that most, if not all, of what is now the southeast highlands were part of a Mesozoic basin connecting the extant Surat and Gippsland Basins. It was rapid erosion of newly deposited sediment, rather than well indurated rocks of the LFB, that gave rise to the rapid cooling recorded at ~95 my. Some of the eroded sediment was re-deposited across the central and western LFB, prior to further erosion in those areas (O'Sullivan, *et al.*, this volume). The "Highlands" Basin may have been a tectonic viscous coupled downwarp parallel to a west-subducting convergent margin to the east. If this was so, the amount of initial downwarp would balance downward viscous coupling force, and upward isostatic force. As sediment was trapped in the downwarped area (first terriginous clastics, and then marine volcanolithic muds and sands sourced from a Mesozoic island arc to the east), isostatic sinking continued, allowing the deposition of several kilometres of sediment.

The initiation of cooling during the middle Cretaceous is consistent with a major change in plate motion, which included "switching off" the viscous coupling initially responsible for the downwarp. Without the downward force from viscous coupling, the basin began to rise by isostacy, forming an arched upland of poorly consolidated sediment, which was rapidly eroded by newly formed and modified rivers draining roughly normal to the uplift axis. Some of the eroded sediment was deposited on the shoulders of the uplift, as the youngest rock units in the Eromanga Basin, and now completely eroded sediment in the west LFB. There is no record of sedimentation in the east, as it mostly occurred on Pacifica, which subsequently separated from Australia at 80-65 Ma. As sediment was removed, isostatic rebound continued as upwarp, ensuring continued erosion. When the rivers eroding the upwarped area eroded through the sediment and into the underlying LFB rocks, rates of incision slowed, due to the well-cemented nature of the older rocks, and waning isostatic rebound. This resulted in the approximate exhumation, in isostatic balance, of the pre-sedimentation landscape. The courses of modern rivers were superimposed onto LFB rocks at this time. This landscape was probably further affected by tectonically driven shifts in isostatic balance during the subsequent breakup of eastern Gondwana, such as underplating, crustal thinning, etc, to form the basis of the modern highlands.

The model, although containing tenuous assumptions about tectonic conditions and mechanisms, accounts for the following:

1) High temperatures prior to ~95 my in LFB rocks, due to burial during the Jurassic-Cretaceous.
2) Rapid cooling due to rapid denudation of poorly cemented sediment after upwarp at ~ 95 Ma.
3) Relatively slow erosion of LFB rocks since exhumation in the Late Cretaceous.
4) The apparent superimposed courses of rivers draining west from the highlands.

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CAN CHANNEL STABILITY BE RAPIDLY ASSESSED BY NON-EXPERTS (OR EXPERTS FOR THAT MATTER)?

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There are numerous ways to assess stability of channels. Erosion rates can be expressed in absolute terms (e.g. metres of lateral migration per year), but this is a difficult task that requires detailed survey data collected through time. Even aerial photographs at a scale of 1:10,000 to 1:50,000 can detect channel erosion only at a fairly coarse scale (in the order of 10s of metres). The more common approach to erosion (stability/instability) assessment is to make a visual evaluation using relative terms (e.g. a site is judged more unstable than another), or with respect to a classification scale (e.g. severe, moderate, slight, none). The visual observation-based approach to geomorphic assessment is a central component of most stream condition survey methodologies. Stream condition surveys are currently receiving widespread application across Australia, and are generally being performed by non-geomorphologists. This paper argues that the survey methodology is fundamentally flawed and could lead to misleading results.

Channel form assessment is couched in the simple notion that channels that have the appearance of being stable are desirable, while channels with bed material or banks that move are undesirable. Even natural processes such as channel avulsion are regarded as undesirable. The classification of bank stability based largely on bank angle can be misleading. It is sometimes the case that vertical banks are an indicator of stability rather than instability, simply because the bank material requires cohesiveness to be able to maintain this steep angle of repose. Some vertical banks have been that way for many years. For example, incised streams have vertical banks, but they may be undergoing a post-disturbance recovery phase.

Visually assessed channel stability indices were developed within the paradigm that stable streams are desirable from a management perspective, because such streams do not require expenditure in order to prevent inconvenient events, such as changes to property boundaries, loss of cultural assets, delivery of sediment downstream, or alteration of local flooding patterns. This is essentially the river engineer's view of stream management. The extreme categories of stability (eg. incised/aggraded) also have implications for stream ecology (diversity and abundance are usually lower in these cases), but the relationship between geomorphic stability and ecological value in moderately stable streams is uncertain and probably not linear. Thus, the indices provide only a superficial evaluation of a complex process, and coming from an engineering perspective, are likely to maintain the artificial control-approach to managing streams for absolute stability.

The results of a major visual channel erosion survey conducted on the Maribyrnong River in 1990 were used to justify expenditure of $1M on major stability works. In this paper, several geomorphic and hydraulic variables were measured and analysed using principal components analysis to determine the factors most closely associated with the original erosion ratings. Two variables, stream power, and bank angle, explained most of the variance. It appears that bank angle (easily visually assessable) was influencing the evaluation (although this does not necessarily indicate erosion rate), and operators were somehow also sensitive to bankfull stream power variations, even though this variable cannot be directly visually assessed.

Geomorphologists are familiar with the difficulty of interpreting channel features, viewed at low-flow, in terms of flood event processes, so it is unlikely that untrained technicians will be able to provide consistent or useful data for geomorphic understanding. It is important that the data from these surveys are interpreted only within the limitations of the methodology.

THE CHANGING MORPHOLOGY OF MOATED IRON AGE SITES IN THE UPPER MUN RIVER FLOODPLAIN, NE THAILAND

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This paper presents data from the first geoarchaeological investigation of the on-site morphology of moated Iron Age archaeological sites in Northeast Thailand. It focuses on the lithostratigraphy and chronostratigraphy of two archaeological sites at Noen U-Loke and Non Muang Kao. The sedimentological analyses suggest that these sites were characterised by temporally and spatially distinct cultural and physical geomorphic processes. At Noen U-Loke initial occupation was located in a swampy context while the basal sediments at Non Muang Kao suggest a slightly elevated position. However at both sites radiocarbon dating and sedimentary data suggest there is a clear transition from a natural landsurface to one of rapid anthropogenic induced mound accretion. Furthermore, data suggests that mound accretion underwent cycles of development and abandonment. Spatially, the surface morphology of both mounds also indicate two distinct areas of occupation. The concept of changing on-site morphology can now be built into discussions centering around the dynamics of complex society in this area of Southeast Asia c. 500 BC - 500 AD.

CHANGES IN BED MATERIAL TEXTURE IN A GRAVEL-BED CHANNEL

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In gravel-bed channels, the characteristics of bed material texture at a given location depend on the amount and caliber of sediment supply and the sediment exchange between bedload and the streambed. The existence of a coarse surface layer creates two populations of bed sediment, the surface and subsurface. Prediction of bedload transport depends on knowledge of these two bed sediments. The grain size distribution of surface sediment controls the onset of sediment movement and defines the upper limit of the bedload size distribution when the surface is the only source of sediment. When sediment exchange occurs at deeper depths, the grain size distribution of subsurface sediment must also be known. The purpose of this paper is to evaluate temporal changes in both surface and subsurface grain size distributions derived from a single gravel-bed stream.

Observations are drawn from Carnation Creek, which is located on Vancouver Island, Canada. In the study reach, channel width and bankfull depth average 15 m and 0.8 m, respectively. Over the 0.9% gradient the bed morphology is that of pool-riffle-bar units. The median diameter of surface and subsurface sediment is 47 and 29 mm, respectively. Large woody debris is present in the channel. Multiple floods are experienced each year. During the field program, the largest flood peaked at 48.8 cubic meters per second, 1.5 times the mean annual flood.

Seven gravel bars were sampled in 1991-1993, 1996 and 1998. Sampling sites were positioned on exposed bar heads at the transition between pool tails and riffles to reduce variation between sampling sites. Using the Wolman method, 100 count surface samples were collected. The amount of sediment excavated for subsurface samples ranged between 500 and 800 kg, giving an average accuracy of 1.8%. Sediment was sieved into 0.5 phi grain size classes.

Surface sediment at four of the seven bars exhibit significant differences in grain size distributions over time. At some sites grain size distributions of subsurface sediment vary widely. Evaluation of the armor ratio indicates that the adjustment of both surface and subsurface grain size distributions contributes to the temporal fluctuation of this index.

FREQUENCY AND MAGNITUDE OF PORE PRESSURE FLUCTUATIONS WITHIN UNSTABLE SLOPES

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The immediate cost of shallow regolith landslides in New Zealand has been estimated to exceed US$33M annually. Since the majority of these landslides occur during wet conditions, or intense rainfall, moisture conditions must be a major control. While still the subject of considerable international debate, one model of failure suggests that instability is controlled by the rise of positive pore water pressures. This model argues that the resistance of the regolith is largely frictional and a function of the stresses "pushing" the particles together, i.e., the weight of the material. If this weight, and therefore resistance, is reduced by upthrust from positive pore water pressures when the regolith saturates, failure may occur.

The development and persistence of pore water pressures have been recorded in an "incipient" landslide on pastoral hill country within the Lake Tutira catchment in northern Hawkes Bay. This study site is typical of extensive areas of the east coast of the North Island which are periodically affected by numerous shallow regolith failures.

Field measurements show that both the soil moisture and piezometric response within the regolith are highly storm and site specific. The development of pore pressures occur infrequently, are generally limited to intense rainstorms, and are of short duration. Short-duration high intensity storms generate rapid macropore flow through the soil which percolates rapidly to the bedrock interface. The permeability discontinuity at the bedrock promotes the formation of a perched water table and positive pore water pressures within the regolith. This reduces the frictional strength of the regolith proportional to the thickness of the saturated zone. The presence of pipes and layers of friable tephra within the regolith provide preferential flow paths which, while draining the slope in some situations, can also concentrate water flow.

The piezometric rise is larger towards the top of the slope even though these sites would be expected to be more stable. While the rise appears to be related to rainfall intensity the persistence is more a function of rainfall duration. The slopes are steep and numerous macropores provide preferential flow paths ensuring the rapid dissipation of pore pressures unless the rainstorm is prolonged.

Various frequency analysis techniques are available to provide return periods for different amounts of piezometric rise and hence stability reduction. The site specific nature of any response, and the effect of antecedent conditions, however, reduce the usefulness of such approaches. In fact, the highly specific nature of the response perhaps highlights the need for, and advantages of, more general and robust models of instability triggering rather than highly intensive and detailed monitoring and modelling. The results of these general models are also likely to be more cost effective.

WHERE DOES THE SEDIMENT GO?
THE ROLE OF ABRASION IN A COASTAL SEDIMENT BUDGET.

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Several large, braided rivers drain from the rapidly eroding Southern Alps into the Canterbury Bight transporting indurated sandstone of the Torlesse Super Group (or greywacke) to the coast. Griffiths (1981) states that catchment-specific sediment yields average 1856 261t km^2yr^{-1} compared with the world average of 182t km^2yr^{-1} and are among the highest known specific sediment yields. However, the large sediment loads from these Canterbury rivers are comprised of predominantly fine sediments in suspended load (more than 90%) and only a small amount of coarse bedload (less than 10%). This is reflected in the nature of the mixed sand and gravel beaches.

Paradoxically, the coastline of the Canterbury Bight between Timaru and the southern end of Kaitorete Barrier at Taumutu is in a state of long term erosion. The 29 km long Kaitorete Barrier is stable, or only mildly accretional, yet longshore sediment transport is strongly net northward from the 100 km of eroding unconsolidated alluvial fan interface at the coast that makes up most of the bay.

The coast is apparently abundantly supplied with sediment which is subsequently transported northward at rates around 40,000m^3yr^{-1} (Flatman 1997) ultimately forming Kaitorete Barrier. Yet since the 1950's there has been very little accumulation of sediment against Banks Peninsula at the downdrift end. This raises the question - where does the sediment go?

Kirk (1995), Flatman (1997) and others including Marshall (1927), Adams (1978) and Hicks (1998) suggested that sediment is lost from the beaches by abrasion of coarse material into fine sands, silt and mud. For the Canterbury Bight a range of abrasion values have been stated as the possible percentages of the total losses, by volume of sediment to the coastal system, that might be attributable to abrasion. These abrasion rates range from 4.8 % per km for the whole of the Canterbury Bight (Adams, 1978) to 76.8% per year by volume for 26 kms adjacent to the Ashburton River (Flatman, 1997) However, the question of the role of abrasion in coastal sediment budgets of mixed sand and gravel beaches remains.

PROBABILISTIC DETERMINATION OF LANDSLIDE FREQUENCY IN HAWKE'S BAY

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Shallow translational landslides can have a major impact on the productivity of a region, if they occur frequently and affect large areas. Therefore, the frequency and magnitude of events of a certain size are an important prerequisite for sustainable land management. This study presents a probabilistic approach to establish the frequency of landslides based on climatic triggering conditions.

In order to analyse this, an undisturbed test site within a landslide prone catchment in northern Hawke's Bay has been chosen. On the site, a monitoring network has been installed to record all changes in soil water content, soil suction, and positive pore water pressure, and the climatic inputs and outputs (precipitation, air temperature, solar radiation etc.).

The landslides in question always occur in association with rainstorms. So, the first and most important step is to investigate the role of water within the soil in terms of slope stability. It becomes clear, that soil water can lead to slope failure by either decreasing cohesion through reducing suction, or by building up positive pore water pressure and decreasing the effective stress. Therefore, the critical water content has to be determined, which is the maximum water content allowed to just maintain stability. This critical water content depends in the shear stress - shear strain relationship, which is specific for each point in the catchment. As a result, the critical water content is spatially highly variable. Because it is impossible to assess all parameters necessary at such a high spatial resolution, frequency distributions of all variables relevant to calculate the factor of safety are used to compute the probability of failure for each point at different water contents.

For the next step of analysis, rainstorm size and characteristics leading to this critical water content are determined using data recorded with the monitoring network. The return period for certain rainstorms can be determined from climatic records.

The result shows, that only slope angles steeper than 20 degrees appear to be critical to slope failure. Furthermore, for soils of less than 0.75m depth, the factor of safety was always larger than 1. Given the topography of the catchment, about 30% of the area is likely to be affected by landslides if the soils are saturated. This condition has a return period of about 1.5 - 6 years.

A SOIL-STRATIGRAPHIC INTERPRETATION OF THE LATE QUATERNARY GEOMORPHOLOGY AND EROSION HISTORY OF THE SOUTHERN MAMAKU PLATEAU, CENTRAL NORTH ISLAND, NEW ZEALAND.

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The Mamaku Plateau is located on the northern edge of the Taupo Volcanic Zone, east of Tokoroa in central North Island. It rises from 200 mASL along its western margin to 700 mASL in the south east. The southern Mamaku Plateau consists of five superimposed late Quaternary ignimbrites (Lynch-Blosse, 1998) with the Mamaku Ignimbrite (220 ± 10 ka) and the Whakamaru Ignimbrite (320 ± 20 ka) being the uppermost and lowermost exposed. Deposition of thick ignimbrite units in valleys and thin units on interfluves has resulted in inversion of relief. Four episodes of strath cutting and valley incision into ignimbrite are recognised from the soil stratigraphy of overlying cover beds. The coverbeds comprise distal tephra accumulations, regional loess and key tephra marker beds. Valley widening occurs by processes such as toppling (Bakker, 1997). The basal loess and/or tephra on the erosion surfaces denoting the cessation of each episode of erosion and down cutting are; (a) pre Rotoehu loess, (b) pre KawaKawa loess, (c) Rotorua Tephra, and (d) Taupo Ignimbrite. The distribution of the coverbed soil stratigraphic units have been mapped in relation to the different land components within the southern Mamaku Plateau.

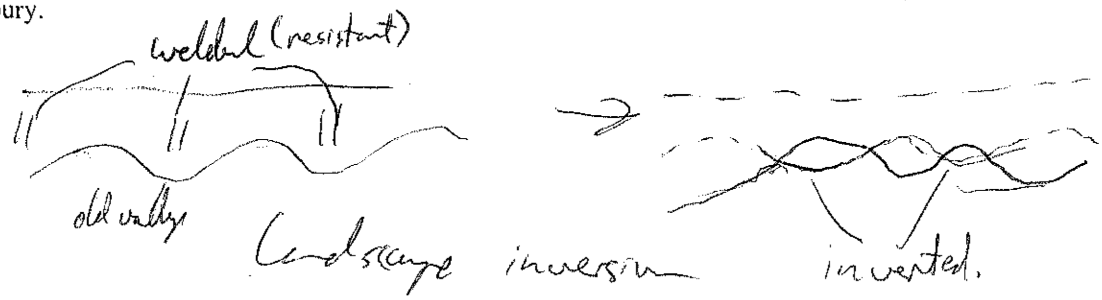
The four episodes of strath cutting and valley incision can be synthesised into five topographically recognised stages of landform evolution. Stage 1 occurs in the softer upper and welded middle parts of the Mamaku Ignimbrite where erosion episodes (a) and (c) are recognised. Stage 2 represents valley incision through the welded Pokai Ignimbrite unit, forming vertical freefaces, and extends into the underlying less welded Pokai and Waihou ignimbrites. Erosion surfaces (a) and (b) are recognised. Stages 3 and 4 are characterised by incision and widening of valleys into the Waihou, Waimakariri and Whakamaru ignimbrites. A thin capping of Mamaku Ignimbrite and Pokai Ignimbrite occurs on the interfluves between the valleys. Stages 3 and 4 are distinguished by plannar and convex interfluves respectively. Erosion surfaces (a), (b), (c) and (d) are recognised. In Stage 5 the removal of the capping Pokai Ignimbrite has resulted in a concavo-convex hilly topography in the underlying Waihou and Waimakariri ignimbrites. Erosion surfaces (a), (b), (c) and (d) are recognised. The erosion history of the southern Mamaku Plateau prior to the deposition of the pre Rotoehu loess can not be inferred. This interpretation substantially modifies the earlier interpretation of Kennedy (1994).

This study provided a stratification of the soil landscape to be used for the effective application of site specific forest management practices in the 35 000 ha of Kinleith Forest on the southern Mamaku Plateau. The coverbed stratigraphy together with its soil stratigraphic interpretation and soil landform relationships have been used to map nine land sytems.

References:

Bakker, L., 1997. Towards a model of valley-side development on ignimbrite terrain, Mamaku Plateau, New Zealand. Unpublished Ph.D. Thesis, University of Waikato, Hamilton.

Hill, R.B. 1999. Applying a landsystems approach to describe and partition soil and forestry variability, southern Mamaku Plateau, part of the Kinleith Forest New Zealand. Unpublished Ph.D. Thesis, Lincoln University, Canterbury.



ANTICIPATING THE SPACING BETWEEN VEGETATION ARCS AND LITTER DAMS

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Vegetation arcs are groves of vegetation aligned approximately perpendicular to topographic slope and separated by a comparatively bare area. The groves occur as sets spaced every 30-120 m or sometimes more. They are particularly common on gentle slopes in rangelands and have been reported from Africa, Australia, the Middle East and North/Central America. In contrast litter dams are 1-2 orders of magnitude smaller in both spacing and height and may be found on steeper slopes and in more humid settings. There is no generally accepted explanation for the formation of vegetation arcs. Early interpretations identified wind and/or runoff as important formative agents. More recent explanations have also included individual plant and community dynamics. In the case of litter dams runoff is the main agent. The spacing between vegetation arcs and litter dams is strongly associated with hillslope gradient and this relationship is consistent with a runoff-based explanation (Eddy et al 1999). In detail the arcs and dams plot on separate but parallel lines. The potential role of runoff has been explored further using a runoff version of Manning's equation expressed to solve for slope length (L) as:

$$L = v^{5/2}\, n^{3/2}/r\, \sin^{3/4}\theta\, \cos\theta$$

where v = maximum velocity at which time excessive erosion occurs, n is Manning's roughness value, r is peak rainfall excess (= rainfall intensity – infiltration) and θ is slope angle. This yields results that parallel the statistical relationships. The most acceptable results involve comparatively low v values of 0.3-0.5 m/s, n values of 0.02-0.04 with r values equivalent to 5 minute rainfall events of 100-200 mm but with no infiltration. Increasing v generates unacceptable r values but increasing n allows both v to increase but curtails r. The results indicate that the spacing of arcs and dams can be predicted from a standard flow equation which clearly implies that runoff is a key agent in their spacing and hence formation. The results also imply that the formation of dams and arcs do not require a high magnitude runoff event.

References:

Eddy, J. Humphreys, G.S., Hart, D.M., Mitchell, P.B., Fanning, P.C. (1999) Vegetation arcs and litter dams: similarities and differences. *Catena* **37**,57-73

GRAIN SIZE AND BEACH SLOPE ON GRAVEL BEACHES.

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Gravel beaches in New Zealand make up a significant part of the coastline and can be found in both high and low energy environments. In the literature three main types of gravel beach have been recognised; pure gravel, composite and mixed sand and gravel. Mixed sand and gravel beaches have dominated research in New Zealand and are typically classified as being distinctly different to other types of gravel beach. A question still remains as to whether different types of gravel beach are unique, or part of a continuum.

Previous research has shown that mixed sand and gravel beaches in New Zealand do not fit into the classic linear grain size-slope relationship that is accepted for sandy beaches, due to sediment source effects. In this research field data has been collected to test the empirical grain size-slope relationship developed for sandy beaches on the three main gravel beach types.

When all gravel beaches are compared together a breakdown in the classic linear relationship occurs. A stronger relationship emerges when beaches of specific regions are plotted separately, reaffirming the importance of the intensity of wave action. Variability in the relationship between grain size and slope on gravel beaches primarily occurs between different types, rather than within. Contrary to expectation, mixed sand and gravel beaches have the most significant linear grain size-slope relationship.

A conceptual model will be proposed which places the three gravel beaches within a continuum, and where mixed sand and gravel beaches are more dynamic than other types due to the presence of sand within the beachface.

AN EXAMINATION OF THE SUITABILITY OF CAESIUM-137 FOR SOIL EROSION ESTIMATES IN THE AUSTRALIAN SEMI-ARID ZONE

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Caesium-137 is a radioisotope derived from atmospheric nuclear tests that occurred during the 1950s to 1970s and is commonly used as a tracer for water erosion and sedimentation studies. The use of this isotope in semi-arid regions has been limited and a number of potential difficulties have been identified including the lack of an appropriate calibration model. To examine the accuracy of the calibration models used to convert caesium-137 measurements to soil loss, an alternative estimation of soil erosion is required. This research investigates the suitability of the caesium-137 technique in the semi-arid zone and uses other established techniques to derive independent measures of soil erosion.

The study site encompasses Tank Creek Catchment, which is 12.5 ha in size and located north west of Broken Hill in semi-arid western New South Wales. Located at the outlet of this catchment is a small water reservoir almost completely full of sediment. The reservoir was constructed around 1875 when the area was settled by Europeans. The reservoir offers an opportunity to estimate soil erosion and to evaluate, independently, the appropriateness of the existing caesium-137 models in a semi-arid environment.

A survey of the reservoir sediments indicates that its initial capacity has been reduced by 89%. Following dating of these sediments and a correction for the reservoir trap efficiency, results indicate that the highest sedimentation rates have occurred following the construction of the reservoir (1875 –1885) and more recently, the period from 1958 to present. Rainfall records for this latter period indicate that there has been an increasing frequency of high magnitude events, especially during the 1970s.

Application of the calibration models widely used in temperate regions, to this study, has resulted in over estimates of soil loss compared to those obtained from the reservoir estimates. There is a clear need for a suitable caesium-137 calibration model for the semi-arid zone.

SOIL POTASSIUM AVAILABILITY IN THE GEOMORPHOLOGIC DYNAMICS AND EVOLUTION OF THE SOUTH ALLIGATOR RIVER FLOODPLAIN, NORTHERN AUSTRALIA.

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This study was undertaken to determine the potassium (K) status and adsorption behaviour of Holocene-age sulfidic sediments from the deltaic-estuarine plain of the South Alligator River, northern Australia. Characterised by both estuarine and fluvial processes, the geomorphic evolution of the South Alligator River involves depositional sequences that may be related to the availability of soil potassium. Development and decay of mangrove forests in the South Alligator River floodplain appears to be concurrent with geomorphic evolution. Following the development of extensive mid-Holocene mangrove forests 6800-5300 years BP, a phase termed the 'big swamp', vertical accretion under these forests allowed the deposition of potassium-rich clays and the initial formation of the floodplain. Changes in soil mineralogy from the natural sulfide oxidation / acidification of acid sulfate soils (ASS) during pedological development are involved with inducing potassium deficiency. At the geological time scale, the annual export of potassium in estuaries depletes potassium from ASS of the estuarine floodplain and transports it in tidal waters to offshore storages.

The role of potassium in soils is fundamental, with the plant nutrient – soil mineral relationship of major significance. The potassium potential is a free energy measure of the soil nutrient availability. Employing K-(Ca+Mg) exchange equilibria in soils, classical thermodynamics can be related to soil exchangeable K^+, Ca^{2+} and Mg^{2+} release to the soil solution. The use of the potassium potential to describe the potassium status of soils is based on the conclusions that soil potassium availability to plants can be characterised with reference to that of both calcium and magnesium as

$$DG_{K, Ca+Mg} = RT \ln [a_K/(a_{Ca+Mg})^{½}]$$

where the function $a_K/(a_{Ca+Mg})^{½}$ is the activity ratio (AR) or intensity (I) of K^+ in the soil.

Much of the floodplain morphology of the South Alligator River is characterised by a surface layer of black organic freshwater cracking clays, heavily marked and modified by oxidation, that overlies a freshwater-marine transitional zone and blue-grey, estuarine saline mangrove muds at depth. The transition from estuarine mud deposited intertidally beneath mangroves and freshwater clays deposited under grasses and sedges occurs within the oxidation zone. There exists little information on soil potassium availability to plants and potassium adsorption behaviour of estuarine sediments in relation to their geomorphic and pedological development. An understanding of these relationships is important in determining the relative depletion of soil potassium from the estuarine floodplain through oxidation processes. This study attempts to show that the potassium potential is a significant means of examining nutrient availability in Holocene stratigraphy and morphodynamics of the South Alligator river floodplain and relates potassium status to depositional sequences in the evolution of the floodplain.

HOLOCENE REEF GROWTH IN THE TORRES STRAIT

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The platform and fringing reefs of Torres Strait are morphologically similar to reefs of the Great Barrier Reef to the south, except that several are elongated in the direction of the strong tidal currents between the Coral Sea and the Gulf of Carpentaria. Surface mapping and drilling investigations on Yam, Warraber and Hammond Island reveal that the initiation of the reefs and their mode of growth was influenced by the pre-Holocene antecedent topography and sea-level history. On the granitic Yam Island fringing reefs have in places established over a Pleistocene limestone around 7000 years BP. Emergent Holocene *Porites* sp. on the reef flat indicate the reef flats have prograded seawards while sea level has fallen from at least 0.8 m above present about 5800 years BP. On Warraber Island, a platform reef, the reef established around 6700 years BP over a Pleistocene limestone. Reef growth lagged behind Yam Island, and emergent microatolls on the reef flat and adjacent to the sandy reef island indicate that the reef reached sea level around 5300 years BP, when the sea was elevated 0.8 – 1.0 m above present. The reef on Hammond Island established over terrigenous mud with the granitic basement being encountered at 7 – 8 m depth. The reef is only 1 – 2 m thick and has prograded over these muds over the past 5800 years as sea level has gradually fallen. Reef-flat progradation on these reefs occurred as a series of stepwise buildouts marked by lines of microatolls parallel to the reef crest. Detrital infill has occurred between these. Their growth has also been strongly influenced by a relative sea-level fall in the Strait.

WEATHERING AND EROSION: LANDSCAPE EVOLUTION OF THE HAMERSLEY IRON PROVINCE OF WESTERN AUSTRALIA

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This research was carried out for Hamersley Iron Pty. Ltd. for the purpose of examining the evidence supporting various theories proposed to explain the origin and distribution of detrital hematite in the Hamersley Iron Province, central Pilbara Craton. The landscape model presented here is based on observations made at 144 locations and on numerous traverses over a 4125 km^2 area. The rocks of the area comprise late Archaean metasediments and metavolcanics of the Fortescue Group, unconformably overlain by Early Proterozoic metasediments of the Hamersley Group. In the northern part of the study area (Mt Sheila, Mt Margaret), Hamersley Group rocks are essentially (sub)horizontally bedded. In the southern part of the study area (Mt Brockman), the Hamersley Group has been faulted and folded into a ~10 km wide anticline, plunging to the east. The northern and southern areas are separated by the Nammuldi Plain, a broad low valley of Fortescue Group outcrop.

Hamersley Group banded iron Formations (BIF) are highly resistant to erosion, and are the dominant lithology at high levels of the landscape. The less resistant Hamersley Group Formations, and the Fortescue Group are typically exposed on valley flanks and floors. Where the Hamersley Group is (sub)horizontally bedded, the landscape is characterised by flat topped hills and plateaux, typically bounded by scarps and incised by deep dendritic valleys and gorges. Depressions in the plateaux commonly preserve weathered horizons. In the folded areas, valleys have developed where the more easily eroded lithologies have been removed. The resultant curvi-linear ridges and valleys follow strike. Weathered materials are rare, being mostly in situ in fractures and faults, and pockets of trapped residual pisoliths.

Alluvial fans of goethite cemented hematite clasts (canga) typically mantle the lower slopes of valley margins, more rarely extending to upper levels. Valley floor sediments typically comprise a lower unit dominated by hematite clasts overlain by an upper unit of siliceous BIF clasts. Both canga and valley floor sediments invariably overlie weathered *in situ* rocks of the Hamersley Group. Mesas on the Nammuldi plain are capped by ferruginised clasts, dominantly comprising fossilised wood fragments. These "channel iron deposits" (CID) overlie bleached saprolite developed in the Fortescue Group. Weathering profiles developed in BIF typically have two zones: an upper 2-3m thick (dehydrated) hematite-rich zone overlying several metres of (hydrated) goethitic and more siliceous rock. Palynological evidence gives a maximum age range of latest Cretaceous to middle Miocene for the ferruginous deposits.

The gross morphology of the modern Hamersley Iron Province landscape is essentially pre-Tertiary. By Early Tertiary times, a hematite/goethite weathered mantle blanketed the Pilbara land surface at all levels. This probably developed in response to the warm-humid Cretaceous- Early Tertiary climatic conditions. Since then, the climate has become more arid, and erosion has outpaced weathering. The weathered materials at high levels in the landscape were preferentially eroded, and were deposited on the flanks and floors of the valleys. These deposits preserve the low-level *in situ* weathered material, and record an inverted stratigraphy (siliceous over ferruginous material) of the high level weathered zones (ferruginous over siliceous).

This model, based on the demonstrable presence of the majority of the oldest (weathered) parts of the landscape in the valley floors, and fresh rock on the high hills, differs fundamentally from earlier "Hamersley Surface" models. No evidence is found for the presence of a hypothetical eroded high level regional peneplain. Conversely, the nature and disposition of weathered and detrital materials suggests the existing landscape is essentially Cretaceous or older. (This research was sponsored and supported by Hamersley Iron Pty. Ltd.)

DIFFERENTIATING FLUVIAL GEOMORPHIC RESPONSE TO CHANGES IN EXTERNAL CONTROLS: A CONCEPTUAL APPROACH ON THE DRAINAGE BASIN SCALE

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Channel morphology at a given place and time is generally governed by a set of internal and external controls. Internal parameters such as discharge and sediment yield are primarily affecting channel three-dimensional channel shape on a range of time scales; however the effect of external parameters such as climatic, tectonic, or anthropogenic inputs, can be modifying or even overriding initial expressions of fluvial forms and processes. In addition, the exceedance of internal geomorphic thresholds might also contribute to increasing the complexity of response of the channel system to a change in any of the controlling variables. This project focuses on testing a series of hypotheses of fluvial response mainly to (neo-)tectonic forcing and base-level changes with differing climatic boundary conditions. The theoretical framework is provided by a mountain catchment dominated by both long-term tectonic uplift and discrete event-type (seismic) impacts. The latter would exhibit a more or less established recurrence interval, capable of episodically triggering both sediment generation by coseismic colluvial mass movement and channel gradient disruption and/or promotion of stream piracy by vertical and lateral displacement, respectively.

The following three basic hypothetical cases will be investigated:

Overload Model: Sediment generation by coseismic landsliding by far outweighs the potential for fluvial evacuation of the material made available within the recurrence interval of the seismic event. This takes into account that subsequent base-level adjustments would play an important role in stream transport capacity. The result would be a catchment (or reach) largely characterised by supply-dominated colluvial sediment input.

Underload Model: Fluvial erosion and transport is high enough to evacuate any hillslope-derived material produced by seismic events (and even rainstorm-triggered material). The drainage basin would thus be largely dominated by fluvial activity (downcutting, lateral migration, etc.).

Dynamic Equilibrium: Stream erosion and transport is just sufficient enough to evacuate all the sediment generated by coseismic landsliding within the recurrence interval of the tectonic impulse, regardless of base-level adjustments. The fluvial system would thus be in a state of transport equilibrium. Any change in boundary conditions (e.g. climatic, human-made) could however result in shifting towards one of the above cases.

This simple framework based on a catchment-scale sediment budget approach does not only allow quantification of response to external forcing, but also integrative perspectives on the often-neglected interaction between channels, floodplains, and hillslopes. Since both fluvial and hillslope systems represent two extensive and traditional, yet mostly separate areas of geomorphologic research, this approach might be a step towards (a) a better appreciation of the alluvial-colluvial interface and (b) handling the questions whether hillslope processes represent internal or external controls on fluvial systems. The approach also allows testing of theories of geomorphic equilibrium and thresholds on a drainage basin scale.

To test and verify these objectives, several catchments with well-established boundary conditions, such as timing and nature of tectonic events, displacement rates, coseismic landslide activity, base-level changes etc., have been selected in the South Wellington and Westland areas of New Zealand. Identification and interpretation of the geomorphic imprint of tectonic controls in these areas is most important and desirable in terms of land use and natural hazard management in affected river catchments.

COMPLEX RESPONSE TO HISTORIC FLOOD IMPACT ON A SMALL SAND-BED STREAM, WELLUMS CREEK, NSW, AUSTRALIA

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There is an increasing awareness that many fluvial systems in Australia have undergone substantial changes, if not transformation, since commencement of European Settlement on the continent more than 200 years ago. Several studies have described river metamorphosis, i.e. the complete transformation of three-dimensional channel geometry due to a change in flow regime, in catchments with sand-bed streams in the Sydney Basin. Most of this previous work has been carried out on reach- or catchment scale, whereas small drainage basins had received relatively little attention. The aim of this project is to test various models of fluvial geomorphic response to changes in external controls, such as short-term hydroclimatologic oscillations and anthropogenic impact, in an ungauged low-order catchment.

Wellums Creek is a small sand-bed tributary of the Macdonald River with a catchment area of some 43 km, and is situated some 80 km NNW of Sydney, in coastal New South Wales. Documented evidence shows that the Macdonald River has undergone substantial channel metamorphosis since the late 1940's (e.g. HENRY 1977, ERSKINE 1986). The channel switched from a meandering mixed-load to a more straight and more bed-load dominated system, due to a distinct upward shift of the whole flood frequency curve. The initial trigger mechanism was inferred to be a transition from a Drought-Dominated Regime (DDR) to a Flood-Dominated Regime (FDR), causing extensive channel widening by bank erosion, increasing transport capacity, mobilization of bed-load waves (sand slugs), and ponding of tributaries. The latter process formed the backstow pond of Wellums Lake in 1949, which has since served as the temporary base level for Wellums Creek. Analysis of multitemporal air photography suggests significant channel widening by bank erosion and substantial downstream conveyance of mobilized sandy bed-material load in the Wellums Creek sub-catchment since the early 1950s at least. These flood impacts were most evident in reach-scale formation of splays and chute bars within a distinctive levee-backswamp architecture counteracted by local floodplain scour and chute cuttings.

Both quantitative and qualitative geomorphologic mapping have revealed, that though floodplain recovery and revegetation is well underway, the same is not applicable for the channel. The latter displays a multitude of both channel patterns and cross-sectional geometry, which suggests that neither channel recovery nor adaptation to any discrete flow regime have been established as yet. This type of complex response is superimposed by transient sand slug and floodout deposits in the creeks lower reaches. However, various elements of in-channel accumulation forms such as vegetated benches, bars and streamlined sediment piles hint at recent minor scour process and general low-stage fluvial activity. It is argued that the channel not only has failed to establish any stable equilibrium but also deviates from the model of fluvial geomorphic response to proposed alternating hydrologic regimes (ERSKINE & WARNER 1988). Though the channel promotes transient form, several up- and downstream sections simultaneously display characteristics usually assigned to either one of the two regimes only. In the case of Wellums Creek, exceedance of internal geomorphic thresholds such as ephemeral base level fluctuations (Wellums Lake) combined with episodic backflooding from the main trunk of the Macdonald River seem to outweigh the geomorphic imprint of any external control. It is proposed that this channel metamorphosis had been superimposed on an earlier drainage pattern, which is still evident from several slightly more sinuous meander cut-offs and palaeochannel segments, which had been heavily backfilled by suspended overbank load. Focus points for further research will be determination of a more exact timing of the river metamorphosis inherent to the increase in bed-material load competence, the role of anthropogenic impact, and the role of evident lateral sediment input from hillslopes. The latter may have been underestimated in previous studies, and will have to involve quantification of sediment pulses through and storage within the catchment.

RECENT EROSION AND SEDIMENTATION HISTORY OF TWO CATCHMENTS IN THE WILLUNGA BASIN, SOUTH AUSTRALIA

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The Willunga Basin is located about 40 kilometres south of Adelaide on the Fleurieu Peninsula. The Basin is bounded to the southeast by the Sellicks Hill Range, which is comprised of folded basement rocks such as slate, sandstone, limestone and shale, which have been uplifted along the Willunga Fault. To the west of the Range is the Aldinga Plain that gently dips from the base of the Sellicks Hill Range to Gulf St Vincent, and is comprised of about 300 metres of sands and clays. The Washpool and Sellicks Creeks rise in the Sellicks Hill Range at about 350 metres above sea level and flow westerly across the Range and the Plains to the sea. The areas of the Washpool and Sellicks Creek catchments are 42.7 and 7.7 km^2 respectively. Today, both creeks occupy incised gullies in the Sellicks Hill Range and well-defined creeks or gullies on the Aldinga Plains. However, a map of the area drawn in 1840 does not depict the present-day drainage pattern but rather portrays waterways emanating from the Sellicks Hill Range and terminating a short distance onto the Plain. It appears that in 1840, surface runoff from the Sellicks Hill Range recharged the aquifers comprising the Aldinga Plains, and discharged as springs along the Gulf St Vincent coastline.

The purpose of this paper is twofold. The first aim is trace the spatial and temporal development of drainage lines of the Washpool and Sellicks creeks. The history of stream channel development and gully erosion of the two catchments since 1840 will thus be determined. The second aim is to examine the sediment erosion and deposition history of the two creeks between 1840 and the present.

In order to trace the spatial and temporal development of drainage lines of the Washpool and Sellicks creeks, a suite of historical maps depicting selected environmental facets in the two catchments was obtained. These were survey maps of the Hundreds and Sections of the Willunga Basin that detailed the extent of surface drainage lines on individual Sections. These maps were compiled by surveyors in 1840, 1873, 1883, 1896, 1915 and 1926, and were complimented by other maps drawn in 1959, 1963 and 1992 and recent aerial photography. The migration of the Washpool and Sellicks creeks across the Aldinga Plain could thus be traced in space and time.

The sediment balance of the Washpool and Sellicks creeks was determined by examining volumes of material eroded and deposited within the catchments. A calculation of the volume of material eroded was determined by categorising all drainage lines according to a width and depth dimension class and multiplying that dimension class by the length of drainage line in each class. In this way, it was found that about 73 000 m^3 and 30 000 m^3 of sediment had been removed from the Washpool and Sellicks creek catchments respectively. To determine the depositional status of the catchments, a sediment core was taken from the Washpool catchment at Washpool Lagoon. Washpool Lagoon is located at the seaward end of the catchment and has served as an effective trap for eroded sediment material. The sediment core was ^{210}Pb dated and indicated a deposition rate 0.9 mm per year for about 120 years. This rate translated to 43 000 m^3 of material deposited in the Lagoon over 120 years. Thus, about 60% of the sediment eroded from the Washpool Creek catchment was deposited in the Washpool Lagoon.

An attempt was made to relate the sedimentation history of the Washpool and Sellicks creek catchments to other environmental factors operating within the catchments. Europeans settled the Willunga Basin in the 1840s and subsequent land uses included grazing, cropping, mining and urbanisation. Grazing and cropping practices led to the removal of native vegetation: firstly on the Aldinga Plains during the 1850s, and later on the Sellicks Hill Range. Most of the eucalypt forests originally growing on the Sellicks Hill Range were cleared between the 1860s and '80s. It is not coincidental that the timing of major vegetation clearance relates to the onset of erosion and deposition in the Washpool and Sellicks creek catchments.

GEOMORPHOLOGICAL EVOLUTION OF ACTIVELY RISING REVERSE FAULT BLOCKS, COASTAL OTAGO

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The coastal range, south of Dunedin, is composed of two fault blocks, actively being uplifted by the reverse Titri Fault System and the Akatore Fault. The Akatore block rides piggy-back on the east side of the Titri block. Much of the surface of the coastal range is characterised by the re-exposed late Cretaceous erosion surface on Haast Schist and Henley Breccia basement (Otago Peneplain or Waipounamu Erosion Surface). This surface shows no evidence for large scale folding, which is characteristic of many other ranges in the Otago range and basin province.

Drainage patterns have clearly been affected by uplift of the fault blocks. The largest river in the area, the Taieri River, undergoes a major left-step between the Taieri basin and the antecedent gorge through the Titri block. Both the Taieri River and Tokomairiro River antecedent gorges are situated within structural depressions within the Titri block. Using the basement erosion surface as a marker, a graph of total throw across the Titri Fault System indicates that the structural depressions probably define fault segment boundaries.

Sub-parallel, consequent, drainage on the Titri block is locally disrupted by the Akatore Fault/block, indicating that the drainage pattern, and consequently uplift of the Titri block is older than that on the Akatore block. Only the largest streams (3rd order or greater) have managed to maintain antecedent gorges through the Akatore block, and new consequent drainage have developed on the Akatore block. The catchments for these antecedent streams is generally asymmetric away from the centre of the Akatore block, which may indicate lateral propagation of the Akatore block with time.

Flights of marine terraces up to 160 m above sea level are preserved on the seaward edge of the Akatore and Titri blocks and record emergence of the blocks above sea level with time. Marine terraces on the Akatore block are more numerous, and more closely spaced than those on the Titri block, indicating differential uplift across the Akatore Fault. The pattern of terraces on the Akatore block is relatively symmetrical about the centre of the block, which, like the antecedent stream catchments, probably indicates elongation of the block with time.

PRELIMINARY STUDY ON MAGNETIC PROPERTIES OF AEOLIAN DEPOSITS IN NEW ZEALAND

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Over the last two decades aeolian loess and paleosol sequences from continents played an important role in understanding paleoenvironmental evolution. Especially long magnetic susceptibility records from the Loess Plateau of China provide a detailed insight of climatic change history for the last 2.6 Ma. The loess record from New Zealand, Southern Hemisphere, however, represents its unique characteristics in many respects. More than 40 topsoil samples was collected from both north and south islands and Dashing Rock section in Timaru was also sampled in ~10 cm intervals. Detail magnetic measurements, such as high- and low frequency susceptibility, ARM, IRM, low- and high-temperature dependent susceptibility, low- and high-temperature dependent magnetization, and particle size analysis were made for these samples. These results have been compared with previous studies and that of Chinese loess and paleosols.

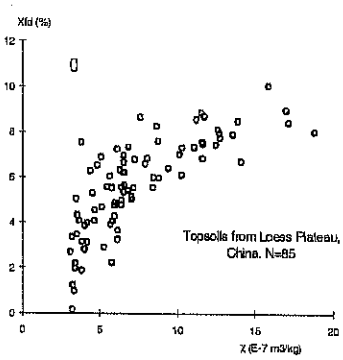
The soil magnetism in Chinese loess generally shows a positive relation with degree of pedogenic development (or paleoclimate). The pedogenic generated extra fine magnetic component in Chinese loess shows a proportional to the susceptibility (Fig. 1a), to the extra fine fraction of particle size but inverse to the mean grain size values. New Zealand loess, however, is complicated. It almost shows no relations between them. As shown in Fig. 1b, the New Zealand loess at least has two different sources. Those high susceptibility (>20 10^{-7} m^3/kg) samples with low frequency dependent susceptibility (Xfd <3%), much higher susceptibility than normal loess and soils over the world, are identified to the locations near volcano. Those therefore were inferred to be dominant volcanic andesitic origin (Pillans and Wright, 1990; Palmer and Pillans, 1996). The susceptibility record from the Wanganui area, North Island revealed such high susceptibility variation to already continue for the last 500ka. Such high susceptibility records are likely controlled by both volcanism (Pillans and wright, 1990) and paleoclimate. On the opposite, the susceptibility record from Timaru section, South Island, demonstrates very low values (<1 10^{-7} m^3/kg, except for the top 3 samples). No matter high or low susceptibility over various regions in New Zealand, the peaks and troughs of the susceptibility records do not match very well with those of marine oxygen isotope. This indicates very likely that pedogenic development in New Zealand mostly occurs under conditions which oscillate between ferrimagnet formation and destruction (Liu et al., 1999), resulting difficult to find a positive or negative correlation between the susceptibility and paleoclimate.

References:

Liu X.M. Hesse P., Rolph T. and Begét J.E., 1999, Properties of magnetic mineralogy of Alaskan loess: evidence for pedogenesis. Quaternary International, 62, 93-102.

Palmer A.S. and Pillands B.J., 1996, Record of climatic fluctuations from ca. 500 ka loess deposits and paleosol near Wanganui, New Zealand. Quaternary International, 34, 155-162.

Pillands B and Wright I., 1990, 500,00-year paleomagnetic record from New Zealand loess. Quaternary Research, 33, 178-187.



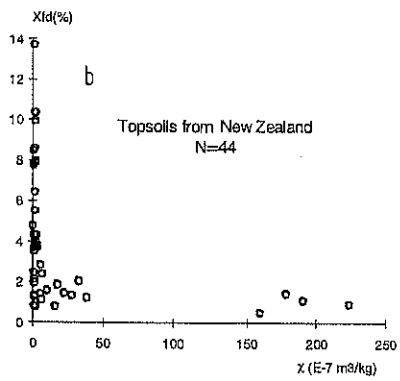


Fig. 1. The magnetic susceptibility X plot against the frequency dependent susceptibility Xfd for the topsoil from Loess Plateau of China (a) and from New Zealand (b). Chinese loess shows a gradual systematic change whereas magnetic behaviours of the New Zealand loess imply that there are at least two different aeolian input sources.

WHAT CAN CHENOPOD PATTERNED GROUNDREVEAL ABOUT THE RECENT GEOMORPHIC EVOLUTION OF ARID ZONE PEDIMONTS?

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Patterned ground is a landscape feature where the spatial variation of vegetated and bare areas is rhythmically repeated. The vegetation usually appears as arcs, stripes, or whorls, with the main axis parallel to the contour and separated by bare areas. The vegetated areas may form approximately continuous lines over a kilometre or more, and from the air, patterned ground looks like the stripes on a tiger skin and is known as "brousse tigrée". There are three main forms of chenopod patterned ground, which are "linear", "sorted-step" and an intermediate form "weakly sorted step". The different forms of chenopod patterned ground can occur individually, but commonly they occur as a group and the location of the each form is controlled by slope gradient.

A pediment of the Barrier Range at UNSW Fowler's Gap Arid Zone Research Station, covered by 4 forms of patterned ground, was investigated. These forms bear a similarity to gelifluction deposits of the Polar Regions. It is believed that the polar deposits were formed by processes that produced downward movement of soil either by mass flows or by soil creep. The formation of chenopod patterned ground is unclear, but due to the similarities with gelifluction deposits it is possible that it was formed by similar processes of mass flows and shrinking and swelling of the soil matrix. It appears that the location of the different forms of patterned ground upon the pediment is due to topography and the geomorphic history of the pediment.

The formation of chenopod patterned ground within this area of Australia has been shaped by Quaternary climatic variations and associated aeolian deposition and fluvial reworking of the sediments. An analogous dust system also occurred during the Quaternary in western Africa, which deposited clay dust over extensive areas. Within parts of western Africa patterned ground systems occur upon these clay mantles. The occurrence of the patterned ground system within arid Australia and Africa could be caused by the combination of an alternating aeolian and fluvial system during the Quaternary, which deposited and reworked aeolian clay materials.

FOSSIL BEETLES AS INDICATORS OF PALEOENVIRONMENTS: TEST CASE FROM BANKS PENINSULA (CANTERBURY, NEW ZEALAND).

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The technique of examining fossil insect assemblages for information about past environments is a well-established methodology in the Northern Hemisphere. This is particularly so in UK and US where fossil beetles have not only been used to detect short-term climatic oscillations and to track climate changes over time, but also to precisely calculate the rates and degrees of Quaternary climatic fluctuations. This method is long overdue in New Zealand as a Quaternary reconstruction tool and may provide the quantification of elusive paleoclimatic parameters here.

A core record from Gebbies Valley, Banks Peninsula, was chosen to test this method of research in New Zealand. This offers two significant advantages for evaluating the insect fossil assemblage. Firstly, the arthropods in the area are well documented. Secondly, the 75 m core providing detailed age control and independent environmental information from pollen, phytolyths and diatoms for the past 200 ka was available.

Insect fossils were extracted from an organic silt unit within the core at a depth of 41.10 - 40.70 m above mean sea level. The depositional environment for this unit is identified as a backbarrier, freshwater environment. Luminescence dating places the age of the deposit around 136 $\pm$ 10 ka and in Marine Isotope Stage (MIS) 6 – the penultimate glaciation. Pollen data indicates a cool phase at the time of deposition.

Seventeen beetle species belonging to six families were identified from the fossils. They included; *Pachyurinus metallicus*, a canopy weevil associated with *Podocarpus* and *Dacrydium*; *Cecyropa modesta,* a sand dune weevil that lives on dune plants; *Baeosmus* sp., a weevil that lives on mosses, particularly *Polytrichaceae* mosses; bush floor species including *Scelodolichus* sp., *Mandalotus* sp., and several *Cryptorhynchini* species associated with dead wood habitats and *Eucossonus setiger*, a weevil strictly associated with *Cordyline* species. Other species included *Carabidae* sp., *Epichorius* sp., *Bledius* sp., *Sphindoteles* sp. The habitat of the fossil assemblage was a coastal freshwater environment surrounded by Podocarp forest probably fringed with *Cordyline* sp. The forest floor was probably dryish and contained a significant amount of dry, dead wood.

Only two of the fossil species occur as modern species in the Banks Peninsula region. Although most species identified have a wide distribution in New Zealand, at least three of the species represent an assemblage associated with cooler regions. Of particular interest, the *Epichorius* sp identifed is now found in Old Man's Range at 1300 m, and the *Sphindoteles* sp is now found in the Dunedin area. The indications of cooler than present day temperatures fit what is already known for the area at MIS 6.

As a test study, this site has shown that beetle fossils have potential to be successful indicators of past environments.

TRANS-TASMAN DUST TRANSPORT 1900-2000

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Atmospheric dust is an important control on radiative energy exchanges. Dust scatters and absorbs incoming solar radiation and absorbs outgoing terrestrial longwave radiation, while dust grains act as principal condensation nuclei affecting formation of cloud. Consequently, atmospheric dust can modify the thermal structure of the troposphere affecting the formation of synoptic circulation systems and precipitation, while also significantly modifying local climates in proximity to major dust sources. Dust affects air quality and has been linked to respiratory diseases, while it may also influence both nitrogen and sulfur photochemical cycles and tropospheric ozone concentrations. As a result, knowledge of atmospheric dust transport such as tropospheric dust load and plume pathways is considered essential with regard to weather forecasting, air quality management and modeling both past and future climatic conditions.

Several major sources of atmospheric dust exist in the semi-arid subtropics, of which Australia is arguably the most important in the Southern Hemisphere. Two major west - east dust transport pathways have been identified from principal source areas in eastern Australia. These pathways display seasonal and interannual variability (Sprigg, 1982; McTanish & Pitblado, 1987; McTanish *et. al*, 1998) and have been linked to nineteen reported Australian dust 'events' in New Zealand since 1900, identified by both wet and dry deposition of dust, including red snow events in the Southern Alps, mud rains, dust haze, 'yellow light', and spectacular sunsets. During a particularly large event in October 1928, the deposition of Australian dust was reported from Kaitaia to Southland, where dust coated houses and cars to depths of 5 mm (Marshall & Kidson, 1929). Conservative estimates of the amount of material deposited during the event were put at 200,000 tons (Kidson & Gregory, 1930).

In May of this year samples of red dust were collected from the lower Fox Glacier on New Zealand's West Coast. Comparisons between this dust, locally sourced material and aeolian dusts collected from eastern Australia have been made on the basis of colour, particle size distributions, biogenic content and mineralogy. The Fox Glacier samples were found to consist of well rounded grains which displayed a leptokurtic particle size distribution and mean grain sizes of 17 to 20 μm. Such characteristics are indicative of aeolian transport and compare favourably with observations made by Kidson & Gregory (1930). Charcoal counts preformed on the samples showed that the red dust from Fox Glacier contained a comparatively high abundance of charcoal with a mean particle size of approximately 11 μm, thereby supporting an association with long distance atmospheric transport such as from Australia to New Zealand.

References:

Kindon, E, Gregory, J.W, 1930: Australian origin of red rain in New Zealand, *Nature*, No. 3150, Vol. 125, P. 410-411.

Marshall, P, Kindon, E, 1929: The dust storm of October 1928, *New Zealand Journal of Science and Technology*, Vol. 10, P. 291-299.

McTainsh, G.H, Pitblado, J.R, 1987: Dust storms and related phenomena measured from meteorological records in Australia, *Earth surface processes and Landforms*, V. 12, P. 415-424.

McTainsh, G.H, Lynch, A.W, Tews, E.K, 1998: Climatic controls upon dust storm occurance in eastern Australia, *Journal of Arid Environments*, Vol. 39, P. 457-466.

Sprigg, R.C, 1982: Alternating wind cycles of the Quaternary era and their influence on aeolian sedimentation in and around the dune deserts of south eastern Australia. In Wasson, R.J (ed): Quaternary mantels of China, New Zealand, and Australia, *Proceedings of the INQUA loess commission workshop*, INQUA, Canberra, 1980, P. 211-240.

THE CONSTRUCTION OF THE MOATS OF NORTHEAST THAILAND

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For the first time excavations designed to uncover the full buried morphological features of the moats surrounding Iron Aged sites in northeast Thailand have been carried. These sites are prominent geomorphic features in the otherwise, level floodplain landscape, and are significant archaeological sites. Accelerator Mass Spectrometry (AMS) dating indicates their construction occurred during the Mid to Late Iron Age, , and was confined to short periods at each site. The buried morphology of the moats we propose, provides strong evidence for their construction by simple ditch and bank formation, which could be quickly and effectively achieved by a small group of people. This type of construction requires the excavation of only small quantities of material, but could form reasonably wide, shallow moats. Such moats would be prone to rapid infilling by fluvial material during monsoonal inundation.

ENTRANCE RESISTANCE AND MORPHODYNAMIC PROGRESSION IN ESTUARIES

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Entrance resistance at the mouths of small estuaries provides a controlling factor in the tidal exchange with the ocean. Restriction of the estuary entrance modifies the tidal characteristics within the estuary, attenuating the tide, reducing amplitude and increasing phase lag. This is especially critical in the case of intermittently closed estuaries where the influx of nearshore sand through the entrance produces an increased resistance to flows and ultimately closure to marine influences.

Regime formulae which have been developed for the design of stable estuary entrances (reviewed in Hume and Herdendorf, 1993) assume a steady state entrance condition as the design state. This state has been referred to as the "regime" state with implication that it is the product of the range of forcing conditions experienced but neglecting the responses to extremes in the forcing conditions. While this may be appropriate for inherently stable estuarine systems, it does not necessarily apply to intermittently opening estuaries where the system switches from open to closed states. The use of steady-state models to characterise conditions for entrance stability will identify average or ideal conditions but usually will neglect the fluctuations associated with the main forcing processes. Entrance conditions for small barrier estuaries on the SE Australian coast are quite sensitive to low frequency coastal storm and/or fluvial events (McLean and Hinwood, 1999) with tidal flows providing the background energy and processes producing gradual entrance change following these larger perturbations.

Water levels in Lake Conjola, a small barrier estuary on the NSW south coast have been examined to illustrate entrance response to coastal storms and catchment flows. A progressive harmonic analysis over 10 months of water level record is used to identify changes in entrance resistance and these are coupled to observations of morphodynamic state.

A model which simulates the response of a simple basin to tidal forcing and fluvial inflow has been developed to assist in the identification of these changes. Outputs of the model include diagrams of tidal attenuation and entrance velocities as functions of entrance resistance and fluvial inflow. Fluvial, tidal and morphological data for periods following a major fluvial event, with subsequent entrance scour in Lake Conjola, have been examined to provide data on the progression of entrance conditions from partly closed, through scoured and through partial closure by an overwash event. Various morphodynamic states have been identified and may be located on the model output diagram.

Management tools, including analysis of available water level and meteorological records and a simulation model illustrating their interactions with the estuarine morphology may be used to identify conditions likely to lead to restriction of tidal exchange through the estuary entrance. Such tools are important for estuaries where tidal regime conditions are rarely achieved and the entrance exhibits a range of responses to fluvial and wave forcing.

References:

Hume, T.M. and Herdendorf, C.E. 1993. On the Use of Empirical Stability Relationships for Characterising Estuaries. *J. of Coastal Research*, Vol.9, No.2.

McLean, E.J. and Hinwood J.B., 1999. The impact of a major storm event on entrance conditions of four NSW South Coast estuaries. Proceedings 14th Australasian Conference on Coastal and Ocean Engineering, Perth, April 1999, pp.426-431.

REGOLITH MAPPING AND DRYLAND SALINITY HAZARD MITIGATION AT MEMAGONG, CENTRAL WESTERN NSW, AUSTRALIA.

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An emerging dryland salinity problem is recognised in regolith developed on the Young Granodiorite, Memagong catchment, central western New South Wales, Australia. Indicators of rising water tables and introduced salt include: dead trees; clear standing water; increased presence of salt and water tolerant vegetation (e.g. cumbungi and spike rush); new areas of salt scalded ground; reduction in crop yield; extensive road degradation; and, the presence of waterlogged soils and hummocky ground.

Sixteen regolith-landform units were defined during the compilation of a 1:10,000 scale map. Alluvial channels range from narrow, incised (2 m to 5 m deep) ephemeral streams, to broad, shallow (<0.5 m deep) streams with permanent water. A large alluvial plain extends for 5 km along Bundilla Creek and is up to 500 m wide. Smaller alluvial plains are defined by anastomosing channels in the upper part of the catchment. Bedrock crops out as tors and has been subdivided into domains with large (>2 m high), small tors (<2 m high) and sub-cropping granodiorite with less than 1 m of colluvial cover. The remaining units refer to the erosional and depositional colluvial landforms that dominate the catchment.

Regolith-landform mapping has assisted the development of a landscape evolution model for the Memagong catchment. The Young Granodiorite intruded Goobarragandra Volcanics, and subsequent uplift and erosion exposed these lithologies. In the Quaternary, topographic highs were draped with an aeolian mantle (parna) originating from southern central Australia. Weathering, erosion and anthropogenic modification have shaped the present landscape.

A ground electromagnetic (EM) induction survey was conducted to assess the magnitude of the dryland salinity problem. Electrically conductive materials within the regolith include pore water, (fresh and saline) and charged clay minerals. Characterisation of regolith-landform units has allowed for a clearer understanding of the porosity and primary permeability of regolith materials, factors that control shallow fluid flow. Mapping provides evidence of the spatial distribution of regolith-landform units and this facilitates interpretation of the EM survey results. The original source of salt in the Young district is believed to be cyclic salt from marine aerosols or in windblown dust (parna) introduced to the area over an extended period of time. It appears that near surface fluid flow mobilises salt throughout the regolith zone.

The most intensely salt affected areas are located in valleys associated with the modern drainage systems. A problem with ponding of water occurs where a road partially dams drainage in an area where there is a pre-existing bedrock constriction. Smaller salt affected areas relate to perched water that has ponded due to anthropogenic interference with natural streams. The inappropriate location of an agricultural dam on the main alluvial channel contributes to waterlogging and salinity problems covering an area in excess of 2.5 km^2 upstream.

Regolith mapping is an essential part of a multi-disciplinary approach to dryland salinity hazard mitigation in this area. Effective interpretation of EM surveys in the Young district directly contributes to modification of land management practices.

LATE QUATERNARY GLACIAL AND SEA LEVEL HISTORY OF WEST-CENTRAL AXEL HEIBERG ISLAND, HIGH ARCTIC CANADA.

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This poster documents the reconstruction of the glacial and sea level history of west-central Axel Heiberg Island based upon the interpretation of surficial geology, geomorphology and raised marine deposits. Radiocarbon dates on marine fauna provide a preliminary chronology for ice advance and deglaciation.

The last glaciation was characterised by the northward and westward expansion of the Steacie Ice Cap. Ice inundated the mountains of west-central Axel Heiberg Island and extended an unknown distance offshore. An AMS date of 46.8 ka BP on an individual valve of *Hiatella arctica* from a fossiliferous till may provide a maximum age estimate for ice advance. Deglaciation was underway by 8.8 ka BP and involved the thinning of fiord-based trunk glaciers and the concomitant retreat of terrestrial margins towards the highland interior.

The pattern of differential postglacial emergence is indicated by the 8.5 ka BP isobases across west-central Axel Heiberg Island which reach ~115m asl over the study area. The revised isobases show a NE-SW orientation which is in alignment with a previously documented uplift centre of the Innuitian Ice Sheet to the northwest of Devon Island to the south.

LITHIFICATION OF LATE QUATERNARY ALLUVIUM; THE FORMATION OF ANABRANCHED ROCK-CONFINED CHANNELS IN MONSOON-TROPICAL AUSTRALIA

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Ferruginous and calcrete profiles are evidence of periods of intense weathering, commonly regarded as having occurred in the Tertiary or before. In the monsoon tropics of northern Australia are alluvial sequences that have become lithified during the late Quaternary, mostly during the last 70ka. On the Gilbert River fan delta in the Gulf of Carpentaria, a combination of TL dates of alluvial sediment and U series dates of pedogenic minerals shows alluviation to have been closely followed by induration from both calcrete and ferrocrete, a process that appears to be continuing today. The present river is now confined between banks of its own irregularly lithified deposits. Dating reveals iron and manganese oxyhydroxides and calcite precipitation to have been essentially contemporaneous under this wet-dry climate, in some cases with nodules of all three minerals intertwined. As a result, the present Gilbert River in places runs within rock gorges up to 10m deep and over 4-6m high waterfalls that extend across the entire channel The latter show evidence of nickpoint retreat with collapsed and tilted blocks downstream of the falls. Flow over these lithified sediments has formed scalloped and fluted forms similar to those eroded by high velocity flow over harder rock types. Clearly, some tropical river systems are not free to adjust their geometry as truly alluvial channels, but instead they are subjected to partial confinement within their own lithified alluvium. As occurs in other bedrock or cohesive-alluvial settings, these channels relocate by avulsion, and the resulting planform of these rivers is commonly anabranched or distributary.

LONG-TERM EROSION RATE CALCULATION BASED ON REMNANTS OF CONTINENTAL MONOGENETIC VOLCANIC LANDFORMS OF THE MIOCENE DUNEDIN VOLCANIC GROUP, NEW ZEALAND

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Long-term erosion rate calculation is presented using general identification of lithofacies association distribution of erosion remnants of terrestrial monogenetic volcanic landforms of the Miocene Dunedin Volcanic Group (DVG). Three areas have been studied:

1) "The Crater", named for its circular tuff ramparts surrounded by schist, is a 1 km wide depression, partially filled with ~ 12 My old pyroclastic rocks and cross cutting dykes, on the Otago schist peneplain. Pyroclastic rocks of "The Crater" have been interpreted to be deposited by pyroclastic density currents and formed a former tuff ring around a possible maar. Subsequently large blocks of the former tuff ring collapsed into the vent. Pyroclastic rocks of "The Crater" contain large amount of sedimentary clasts are not known in the surface recently and indicate that those sedimentary units must have been existed during volcanism. The estimation of the possible thickness of formerly presented, but today already eroded units allow ~400 m erosion of a sedimentary cover and a ~ 30 m/My long-term erosion rate.

2) Black Rock is a pyroclastic rock filled small butte with a same age than "The Crater" on the Otago schist peneplain. There is no any Cenozoic pre-volcanic unit on the surface in nearby. The pyroclastic rocks of the Black Rock extremely rich in clasts derived from Cenozoic sedimentary units which are not exist recently in the area, but must have been formed the former conduit wall was cut through by vent of Black Rock volcano. The smaller than "The Crater" size of the pyroclastic butte of Black Rock suggests a deeper exposure of a diatreme than "The Crater", thus slightly larger thickness of eroded units, but still probably in the same range (>30 m/My).

3) Swinburn plateau is a ~16 My old volcanic area in the northern side of the DVG and exhibit at least 4 eruptive centers and an adjacent extended lava field. A westward dip of pre-volcanic and volcanic units suggest significant post-volcanic tilting processes of the area which tilting must be accounted during total erosion calculation. There are two possible calculation method: A) tilting significantly post-date the erosion. In this case ~60 m of total erosion has been calculated with a speed of 5m/My. B) tilting was shortly after volcanism, thus the area eroded in a tilted mode. In this case a total of 250 m of erosion has been calculated with a speed of 21 m/My.

The three long-term erosion rate calculations based on erosional remnants of monogenetic terrestrial volcanic landforms of the DVG gave similar values in a few tens of meter per My, which value is consistent to values have been calculated from other Miocene volcanic fields in a continental, temperate climate.

MESOZOIC TO RECENT LANDSCAPE EVOLUTION OF THE MURRAY BASIN REGION: NOT AS SIMPLE A STORY AS PREVIOUSLY PROPOSED

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We report the results of an apatite fission track (AFT) and vitrinite reflectance (VR) study designed to address the apparent difference between: 1) the proposed simple thermal and depositional history of Mesozoic and Cenozoic deposits associated with the Murray Basin (i.e., Brown & Stephenson, 1991), and 2) a complicated Mesozoic and Cenozoic thermal history proposed for the western Lachlan Fold Belt east of the basin, as suggested by AFT results (i.e., O'Sullivan et al., 1998, 2000).

The Murray Basin represents an extensive intracratonic basin covering an area of over 300,000 km^2 of southeastern Australia. This low-lying saucer-shaped basin contains relatively thin deposits of Cenozoic sediments (<600 m), which unconformably overlie older basement rocks of the Adelaide, Kanmantoo and Lachlan fold belts, and disconformably to paraconformably overlie rocks of Cretaceous, Middle Triassic, Late Permian and Permo-Carboniferous infrabasins. Importantly, the disconformable relationship between the Cenozoic sediments and the immediately underlying Lower Cretaceous sedimentary rocks has been best described as representing an extensive period (~40 m.y.) of non-deposition rather than one during which any extensive erosion might have occurred (Brown & Stephenson, 1991).

However, AFT results from the western Lachlan Fold Belt (O'Sullivan et al., 1998, 2000), suggest that basement rocks exposed along the eastern flank of the Murray Basin experienced a much more complicated thermotectonic history than that proposed for the basin itself. In particular, the AFT data suggest that during the middle to Late Cretaceous, while the basin region was supposedly experiencing a prolonged period of non-deposition, the rocks just to the east of the basin experienced a period of significant reheating followed by a period of rapid cooling at sometime during the Late Cretaceous to Early Tertiary.

To address the apparent different thermal histories proposed for the region, new AFT analyses were carried out on drilhole samples of granitic material in basement rocks beneath the Cenozoic sediments, and VR analyses from sediments collected immediately above and below the Late Cretaceous unconformity. The AFT results indicate that rocks beneath the basin experienced a significant period of reheating during the Cretaceous prior to a period of cooling at some time during the Late Cretaceous to Early Tertiary. Furthermore, the VR results, assuming a constant geothermal gradient of ~25°C/km, suggest that up to 1 km of additional Early to Late Cretaceous section is missing across the Late Cretaceous unconformity.

These new results indicate that the thermotectonic history of basement rocks and sediments associated with the Murray Basin must be re-evaluated. Clearly, a significant section of Early to Late Cretaceous material was deposited and then removed prior to subsequent deposition of the overlying Cenozoic sediments. Furthermore, this missing section may have originally been sourced from the uplifting southeastern highlands at ~95 Ma. If correct, the region of the western Lachlan Fold Belt and the Murray Basin acted as a catchment for detritus eroded from the highlands to the east as they were being denuded during the middle to Late Cretaceous. Denudation during the Late Cretaceous to Early Tertiary subsequently removed all evidence of these deposits prior to the initiation of Cenozoic deposition in the Murray Basin.

References:

Brown C.M. & Stephenson A.E. 1991. Geology of the Murray Basin, Southeastern Australia. *Bureau of Mineral Resources Australia*, Bulletin 235, 430 pp.

O'Sullivan P.B., Kohn B.P. & Mitchell M.M. 1998. Phanerozoic reactivation along a fundamental Proterozoic crustal fault, the Darling River Lineament, Australia: constraint from apatite fission track thermochronology. *Earth and Planetary Science Letters* 164, 451-465.

O'Sullivan P.B., Gibson D.L., Kohn B.P., Pillans B. & Pain C.F. 2000. Long-term landscape evolution of the Northparkes region of the Lachlan Fold Belt, New South Wales: constraints from apatite fission track and paleomagnetic data. *Journal of Geology* 108, 1-16.

EROSION-RELATED SOIL CARBON LOSSES IN THE TUTIRA CATCHMENT SINCE EUROPEAN SETTLEMENT

Mike Page, Noel Trustrum, Hannah Brackley

Landcare Research NZ

Lake Tutira, on the East Coast of the North Island, has been the focus of erosion research for over a decade, initially by Landcare Reseach and more recently by Victoria University of Wellington. This research has yielded a wealth of empirical data, and understanding of geomorphic processes.

Current work by Landcare Research is focused on constructing a carbon budget for the catchment, to identify soil carbon losses associated with landsliding and other erosion processes. Interest in national carbon budgets has increased following the signing of the Kyoto Protocol, as countries begin to develop national carbon inventories. New Zealand intends to meet its target of a 15% reduction in greenhouse gas emissions by 2012, through carbon uptake and storage in exotic plantation forests.

To identify the amount of forestry required, the sources, sinks and transfers of carbon need to be understood. While vegetation contains ~2420 Mt C, soil is New Zealand's major store of carbon with ~4260 Mt (to 1m depth). However, an estimated 387 Mt of sediment are delivered to the ocean annually. The loss of carbon through erosion, and the impact on New Zealand's carbon budget are therefore likely to be significant and need quantification. It is also clear that the benefit of forest planting and scrub reversion to NZ's carbon budget will be increased if it is targeted at erodible terrain.

A methodology is outlined which uses the knowledge gained from the research at Tutira to link erosion and soil carbon transfers and provide estimates of carbon losses from landslide and sheet erosion since European settlement. These estimates are compared with estimates of carbon accumulated in lake sediments. Results indicate that ~1 t C/ha/yr is lost from erosion-prone land. This provides a basis for a regional scale estimate of soil carbon losses from erodible East Coast hill country, and contributes to the goal of a national scale carbon budget.

LEGACY OF A CENTURY OF EROSION FOR FUTURE LAND USE IN EASTLAND

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The East Coast of the North Island of New Zealand is renowned for its severe erosion, flooding and sedimentation. Extensive deforestation between 1880-1920 initiated this period of dramatic landscape transformation, and today reforestation is seen as the panacea. However, a century of pastoral farming has left a legacy of a highly degraded landscape, which is currently redistributing the products of this erosion. The rate and level of landscape recovery will influence the ability of communities to carry out future land use.

This poster uses the results of a decade of geomorphic research into the controls and processes of landscape change to illustrate some of the past and likely future impacts on the landscape and its land use, and to identify some still unanswered questions. This increasing understanding, together with changing community attitudes, provides the opportunity to maximise the benefits of reforestation and other management strategies through better targeting of the landscape.

SOUTH EASTERN AUSTRALIA: GEOMORPHOLOGY AND FISSION TRACKS

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The main point of contention between geomorphologists and fission track analysts is the amount of denudation that each group considers to have taken place (Hill 1999). Kilometre-scale erosion since 100 Ma as implied by apatite fission track thermochronology (AFTT) for various regions is difficult to reconcile with the nature of the landscapes during the Palaeocene (60 Ma) and erosion rates since. If only 250 m has been eroded from valleys in 60 Ma how is it possible to erode 1000 m+ in the preceding 40 Ma as well as forming and preserving deep weathering profiles on these erosional surfaces? This paper looks at possible answers to this question.

The palaeoplain is a surface of low relief, and is also of considerable age. The present topography in some places is higher than the Eocene topography in the same area - just the opposite of general surface lowering. The palaeoplain is thus a surface of very little change, with Palaeocene, Eocene and Miocene deposits showing a small range in elevation over a large lateral extent. The palaeoplain also retains an ancient and deep weathering profile.

The bedrock parts of the southern New South Wales coastal plains also contain many examples of ancient landscapes ranging from sediments and weathering profiles to volcanics, of at least Cretaceous age. AFTT data suggest that ~2 km of denudation has occurred across the Sydney Basin since rifting and opening of the Tasman Sea, and ~3-4 km of denudation has occurred within large areas of the highlands since the initiation of extension in the Tasman Sea. The majority of this denudation occurred rapidly and during the middle Cretaceous. This appears inconsistent with the geomorphic evidence. The plains themselves, the weathering profiles, and dated sediments all point to small amounts of lowering - perhaps a few hundred metres at most.

A blanket figure of regional erosion thickness allows a simple estimate of rates of erosion. If 3 km is to be removed in, say, 60 million years, then 3000 m / 60 Ma = 500 m/Ma. This is approximately the average rate of erosion in mountainous country, not on plains. These figures don't include chemical erosion, which may not translate directly into landscape lowering rates. Even if a figure of 1.5 km of lowering is used, the erosion rate is still 250 m/Ma, or ten times the rate of lowering calculated by other methods. All estimates of erosion rates in the eastern highlands are considerably less, mostly <10 m/Ma. This is low even when compared with the average erosion rate on plains, which is about 50 m/Ma.

Given the AFTT data, simple extrapolation of erosion rates does not work. One solution appears to lie in Mesozoic burial, and subsequent rapid exhumation, of an ancient landscape. This is consistent with some geomorphic evidence. For example, bevelled quartzite ridges with superimposed drainage, west of Parkes, can only have formed when the general elevation was higher than it is now. In other areas, major drainage lines cross bedrock structures, suggesting they were superimposed from a higher level.

So what can we make of this? The issue is not easily resolved. First, the resolution of amounts of denudation derived from AFTT data is coarse, in the order of ±500-1000m. Second, reliable dating of surfaces and weathering profiles does not yet extend back far enough to allow direct comparison of denudation rates derived from geomorphic evidence on the one hand and AFTT data on the other. For example, recent work in the Parkes area of NSW shows no inconsistencies between the timing of stability and weathering on the one hand, and denudation on the other (O'Sullivan et al. 2000).

There are obvious areas that could benefit from joint research. AFTT studies have to make assumptions about thermal gradients. However, the assumption that isotherms are parallel to the mean surface of the Earth may not be valid, and the slope of apparent apatite fission track ages in an elevation-age plot may be a topography-induced overestimate of the erosion rate. One approach is to locate sites where it may be possible to establish palaeo-geothermal gradients using geological and landscape data. Another approach is detailed plotting of AFTT data in relation to geomorphic features. This has not yet been done, but AFTT results may follow geomorphic irregularities, rather than marking simple zones parallel to the coast. For example, it may be that depth of dissection is a controlling factor.

References:

Hill, S.M. 1999: Australian Journal of Earth Sciences, 46(2): 217-232.

O'Sullivan P.B., Gibson D.L., Kohn B.P., Pillans B. & Pain C.F. 2000: Journal of Geology, 108(1): 1-16.

SEDIMENTATION IN MINNAMURRA RIVER ESTUARY, SOUTH COAST NEW SOUTH WALES

Kate Panayotou

Minnamurra River is an unusual barrier estuary on the New South Wales coast, draining a moderately sized catchment with both urban and rural development. This river-dominated barrier estuary is in its mature stage of evolutionary history and thus provides insight into spatial and temporal sedimentation changes of similar estuaries on the southern New South Wales coast. In a recent management study of Minnamurra estuary, sedimentation and erosion issues were identified. The investigation and quantification of these patterns and rates of past and present sedimentation will ensure then, that future management of this estuary and similar southeastern Australian estuaries is based upon understanding of natural morphostratigraphic changes. This study is focused on integrating the sedimentation changes and estuarine evolution of Minnamurra River over both geological and engineering timescales.

Estuaries and their alluvial deposits consist of various depositional environments whose nature and development depend on estuary size, estuary type and maturity. These depositional environments are characterised by particular substrate conditions and hydrological regimes, and constitute discrete sedimentation patterns and rates whose distribution can be mapped and quantified. The focus of this study then is to identify sources of sediment input, describe sediment characteristics and their variation throughout the estuary, determine sedimentation rates and patterns in major habitats and identify regions susceptible to erosion. This is being done through:

- development of the broad pattern of Holocene infill by a drilling program combined with radiocarbon and/or thermoluminescence dating of sediments
- establishment of the history of recent morphological changes through interpretation of surveys, surface-sediment sampling and aerial photographs
- integration of the changes in sedimentation over the medium timescale by relating modern changes into the broad context of infill using Lead-210 analysis

Preliminary findings have shown sedimentation at one point in the estuary to be at a rate of 0.3 +/- 0.05 cm/year through Lead-210 analyses. Stratigraphic results from the drilling program have identified the geological zones relating to palaeo-estuary size and degree of sediment infilling. Mapping the distribution of these zones during Holocene evolution will help account for present day and future estuary morphology.

The challenge for this research is to develop a model that integrates understanding of the pattern of Holocene geomorphological development and monitoring at the "event" timescale with the more complex dynamics of estuaries over engineering timescales. This will provide meaningful insight into how more complex New South Wales river-dominated estuarine systems are evolving and the effects of estuary management.

ON THE SURVIVAL OF PRE-TERTIARY LANDFORMS AND REGOLITH IN AUSTRALIA: CONTINUOUS EXPOSURE OR BURIAL AND EXHUMATION?

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Parts of the Australian continent have been subaerially exposed for hundreds of millions of years. The survival of pre-Tertiary regolith is confirmed by dating methods including stratigraphy, paleomagnetism and oxygen isotopes. Pre-Tertiary ages for landforms in Australia have been postulated on geological evidence. Examples include Cambrian river terraces in the Davenport Range (Stewart *et al.* 1986), pre-Cretaceous plateaux in Arnhem Land (Nott 1995), and a Precambrian age for the Kimberley High Plateau (Ollier *et al.* 1988).

The survival of such ancient landforms and weathering profiles in Australia is usually rationalised as being a consequence of prolonged tectonic stability and postulated low rates of weathering and erosion (e.g. Gale 1992). In contrast, the evidence from apatite fission track thermochronology (AFTT) generally indicates kilometre-scale denudation over much of the continent during the Phanerozoic (e.g. O'Sullivan *et al.* 1996; Belton *et al.* 2000; Kohn *et al.* 2000). Using a combination of paleomagnetic and AFTT data, O'Sullivan *et al.* (2000) deduced a Late Paleozoic to Cainozoic landscape history of the Northparkes region, N.S.W., which included episodes of kilometre scale denudation and burial, resulting in re-exhumation of a Carboniferous weathering profile. AFTT and cosmogenic isotope data from the Davenport Range (Belton *et al.* 2000) also imply that the Cambrian river terraces cannot have been continuously subaerially exposed, as claimed by Stewart *et al.* (1986), but rather must have been exhumed from beneath a cover of some 2 km of strata during the Mesozoic.

While measured rates of long-term weathering (e.g. Pillans 1997; Heimsath *et al.* in press) and bedrock erosion (e.g. Bierman & Turner 1995) in Australia may indeed be low by world standards, they are not low enough to explain the continuous subaerial survival of pre-Tertiary landforms and weathering profiles. Burial and exhumation must therefore be significant contributing factors in the preservation of ancient features in the Australian landscape.

References:

Bierman, P. & Turner, J. 1995. *Quaternary Research*, 44, 378-382.

Belton, D.X. *et al.* 2000. 9th International Conference on Fission Track Dating & Thermochronology, Lorne 2000. Geological Society of Australia Abstracts, 58, 19-21.

Gale, S.J. 1992. *Earth Surface Processes & Landforms*, 17, 323-343.

Heimsath, A.M. *et al.* in press. *Geology*.

Kohn, B.P. *et al.* 2000. *9th International Conference on Fission Track Dating and Thermochronology*, Lorne 2000. Geological Society of Australia Abstracts, 58, 213-215.

Nott 1995. *Journal of Geology*, 103, 19-32.

Ollier, C.D. *et al.* 1988. *Zeitschrift fur Geomorphologie*, 32, 239-246.

O'Sullivan, P.B. *et al.* 2000. *Journal of Geology*, 108, 1-16.

Pillans, B. 1997. *Geoderma*, 80, 117-128.

Stewart, A.J. *et al.* 1986. *Science.*, 233, 758-761.

THE DISCOVERY OF THE GREAT SOUTHERN LAND THERMOLUMINESCENCE THROWS LIGHT UPON THE MYSTERY?

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The controversy as to who were the first Europeans to explore the south coast of Australia has been, and remains, a much debated topic. Over the years there have been reports of sightings of various objects which suggest early Portuguese presence in the area. Amongst these one of the more mysterious sightings is that of a solidly constructed timber ship buried in the sand dunes midway between Warrnambool and Port Fairy. Because of the colour of the timber this has become known as the Mahogany Ship. This was first sighted by white settlers in 1836 and there are reports of sightings throughout the next four of five decades. It was in a state of disrepair when first sighted and local aboriginals indicated that the ship was there long before their own personal knowledge or tribal legends and was part of the dreamtime. Since 1880, when the ship was finally buried by drift sand, there have been numerous unsuccessful attempts to relocate the vessel. Such is the interest that the Victorian Government recently offered a large reward for the discovery of the ship.

There are numerous additional clues suggesting early Portuguese presence around the coastline of Australia. Reports of a battle between aboriginals and enemy invaders carrying swords and wearing armour were made by Captain Cumberlege of the royal navy. It seems that this battle took place in Napier Broome Bay on the north-west coast in around 1560, long before Captain Cook entered Australian waters. Captain Cumberlege in fact witnessed a re-enactment of the battle which ensued and two, apparently captured, bronze carronades were found upon a nearby island. The discovery of the Geelong Keys in Corio Bay was reported by none the less than Governor La Trobe who, apart from being a fine administrator, was also a keen naturalist and geologist. There are various theories as to the origin of the ruins at Bittangabee Bay just south of Eden one of these being that these are the remains of an ancient a Portuguese block house. The origin of this theory and a more likely explanation is provided in this presentation.

Much more evidence supporting early Portuguese presence around the shores of southern Australia can be found in map form. The interpretation of these maps is difficult but of great interest as it involves early politics, navigation and map making skills. It is, however, a matter of history that the first Portuguese colonial presence of East Timor occurred around 1509 which is testament to their seamanship and early navigational abilities. The so-called Dauphin map of 1536 provides ample evidence of this.

Whilst it is not surprising to find evidence of early Portuguese presence around the northern shores of Australia, the question as to when they may have rounded the southern coastline is perhaps more open to debate. This presentation seeks to throw light upon a few of these mysteries and perhaps to provide possible solutions to some. The research area stretches south from the Illawarra area but is mainly centred around the Eden Twofold Bay region. This area is particularly hazardous to present day shipping and there have been many recorded shipwrecks off this coast. It would not therefore prove surprising if this was also the case 500 years ago. Indeed there is thermoluminescence evidence to suggest that this was indeed the case.

EXTRACTION OF GEOMORPHOLOGICAL INFORMATION FROM DEMS, EXAMPLES FROM THE MANAWATU REGION, NORTH ISLAND, NEW ZEALAND

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The use of digital elevation models (DEMs) has become increasingly popular for solving geomorphological problems, especially when studying large regions. Recently the Crown lifted the copyright fees from the digital New Zealand Infomap 260 Series 1:50,000, making the data more affordable. We have interpolated this contour data into a regular grid DEM using the Generic Mapping Tool (GMT) surface program. Here we use DEMs of 50 and 25m resolution to investigate tectonic deformation in the Manawatu region, calculate erosion in the Manawatu/Taranaki Region and also identify lineations and faults using illumination angles.

Within the onshore portion of the Wanganui Basin, Te Punga (1952) was the first to record the progressive increase of seaward tilt of fluvial terraces along the Rangitikei River. Since then various authors have investigated tilting of surfaces and structures within this region, identifying a tilt rate of $3\text{-}4X10^{-8}$ rad/year in a SSW direction (Jackson et al. 1998). Investigation of topography has demonstrated that the direction of tilt has rotated from a south west direction to south south west. Rotation of the land surface is likely to be in response to movement of the depocentre of the Wanganui Basin as well as the formation of the Ruahine Ranges and associated anticlines to the west.

Summit Height accordance has been speculated for the inland part of the Manawatu/ Taranaki region (Molloy 1988). Using the assumption that this accordance of peaks represents an initially planar dissected surface, a plane fitted through the main peaks of this region will give an approximation of an old marine or fluvial surface. The difference in volume between this reconstructed palaeosurface and the present day topography gives an estimate of amount of erosion since the area was submersed.

Rotating the angle of illumination of the DEM is undertaken to help identify lineations across the land surface. Through this rotation, both bedding planes and faults are able to be identified. Such a method is of considerable advantage for preliminary investigation of a region prior to the undertaking of field study.

References:

Jackson, J., van Dissen, R., Berryman, K., (1998) Tilting of Active Folds and Faults in the Manawatu Region, New Zealand: Evidence from Surface Drainage Patterns. New Zealand Journal of Geology and Geophysics. 41 p377-385.

Molloy, L. (1988) Soils in the New Zealand Landscape: The Living Mantle. New Zealand Society of Soil Science. Pub: Mallinson Rendel Publishers Ltd. Wellington. pp239.

CORRELATION OF ALLUVIAL TERRACES IN THE WAITAKI VALLEY

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A chronology of river terraces in the Waitaki valley, South Canterbury, has been defined from field inspection of terrace surfaces and deposits, aerial photo interpretation of landforms, topographic profiling, and dating by thermoluminescence and radiocarbon.

The Waitaki valley passes through a series of tectonic basins separated by short gorges. Quaternary alluvial surfaces are preserved most continuously in the Mackenzie basin and on the coastal plain. Elsewhere, terrace remnants are generally discontinuous. Maps and profiles compiled at 1:50 000 scale extend from moraines at Lakes Pukaki and Ohau in the Mackenzie basin, 150 km down-valley to the coast near Glenavy.

The terrace correlation is based on a "best-fit" consideration of:

- terrace height/position relative to the present-day river;
- terrace surface morphologies;
- weathering of alluvial deposits;
- nature and thickness of cover beds;
- radiometric dates

A best-fit method is needed because no one criterion, by itself, is reliable as a correlation tool. For example, terrace position is affected by tectonics; degree of weathering is influenced by lithology, grain-size, and situation; cover-bed thickness is affected by situation and aspect; and radiometric dates obtained from cover-beds represent only minimum ages of alluvial deposition.

The sequence is differentiated into seven groups, collectively representing several, or many, glacial-interglacial cycles. Only the Late Otiran (Oxygen Isotope Stage 2) alluvial terraces, extending from moraines, can be traced with reasonable confidence through the valley and provide a reference "timeplane" within the terrace sequence.

The OI Stage 2 glacial aggradation terraces of the upper and middle valley are linked with a series of cut terraces nested within an extensive aggradation deposit forming the coastal plain. This raises a key question: does the aggradation/incision behaviour of the river near the coast relate to glacial events in the headwaters or to coastal events (e.g. sea level change)? Comparison of Waitaki river and terrace gradients with geometry/gradients of the adjacent continental shelf suggests that sea level falls of up to –80 m below present would expose a shallow gradient inner to mid shelf, and cause widespread alluvial aggradation of the lower river valley. At sea levels below –80 m, steeper outer shelf gradients would encourage fluvial incision of the coastal plain. We infer that the extensive gravel aggradation of the coastal plain is a result of moderately low sea levels during OI Stages 4 and 3, while the cut terraces are a consequence of very low sea levels during OI Stage 2.

BASIN-WIDE MODELLING OF STREAM POWER: EXAMPLES FROM BELLINGER RIVER CATCHMENT, NSW, AUSTRALIA.

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The morphological form and behavioural characteristics of rivers are controlled by the interplay between numerous variables, including channel gradient, catchment hydrology, degree of channel confinement, stream power, sediment character and supply, riparian vegetation and human impacts. In general terms, the first three of these variables change systematically downstream along any river system. Gradients decrease, discharges increase (in humid environments) and channels generally become less confined as they enter their distal coastal or alluvial plains, although geological controls induce significant local discontinuity to downstream trends in gradient and confinement. It is the downstream change in these variables that produce the striking differences in river geomorphology that are evident along all river systems (Knighton, 1999).

A recent approach by which downstream morphological change in river systems can be investigated was outlined by Knighton (1999), who modelled downstream variations in stream power in the Trent River basin, UK. Knighton used both a theoretical approach, whereby the longitudinal profile and channel gradients were modelled by a power function and quantified at regular downstream intervals of 0.5 km, and an empirical method that entailed manually measuring channel gradient from 1:25,000 scale topographic maps between each contour interval. A well established relationship between discharge and link magnitude (a measure similar to stream order) was used to determine mean annual discharge in the Trent basin to combine with the gradient data for calculating stream power.

In this paper, we outline a simpler and more accurate method by which downstream changes in channel gradient and total stream power can be modelled in exquisite detail for any river basin from Digital Elevation Model (DEM) data and regional discharge estimation equations, using the Bellinger River catchment on the north coast of New South Wales, Australia, as our example basin. We also provide examples from the Bellinger catchment where downstream changes in gradient and stream power exert a demonstrable control on channel morphology and behaviour. Finally, we contribute to the ongoing debate as to the location of theoretical and actual stream power maxima in river systems by investigating controls inherent in local, regional and global hydrological datasets.

Reference:

Knighton, A. D. (1999). Downstream variation in stream power. Geomorphology, 29, 293-306.

LUMINESCENCE DATING: A REVIEW OF NEW TECHNIQUES FRO NON-SPECIALISTS

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Recent progress in luminescence dating has led to the realization of a long-standing wish of geoscientists, namely, the ability to directly date a wide range of sediments. Using luminescence dating, one is able to determine the moment when mineral grains were last exposed to light. In most terrestrial sedimentary environments the grains are exposed to light during erosion, transportation, and deposition. After they are buried the grains are shielded from light, and the luminescence 'clock' starts running.

The speed of development of new techniques and the wide range of independent techniques subsumed by the title 'luminescence dating' means that it is harder and harder for geoscientists to make an informed decision about the best dating choice for their samples. This has been compounded by technical debates over advantages and disadvantages of different measurement protocols and it has led to widespread confusion amongst non-specialists.

The poster will explain technical terms like optically or thermally stimulated luminescence, additive and regenerative methods, different single and multiple aliquot protocols, single grain dating, coarse or fine grain technique for quartz and feldspars, the use of different spectral bands to obtain ages, ..., to name only a few major variants from the ever increasing field. The intention of this up-to-date review is to guide non-specialists to find the *best* answers for their application needs.

LUMINESCENCE DATING OF LAKE WAIPORI CORE, OTAGO: TECHNIQUES AND RESULTS

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As part of the 'Regional Paleoclimates and Climate Modelling PGSF Programme' Lake Waipori, Otago, was cored to a depth of 154.3 metres in early 1999. Before useful climatic and tectonic interpretations of this record could be undertaken, a detailed chronology was required. There are few organics in the core but radiocarbon dating secured the top 22 m (the Holocene). Ages rapidly exceeded the range of C-14 beyond this depth. One U/Th age on a lignite (at 64 m depth) provided the only age control for lower parts of the record.

16 samples were taken from the top 120 m of the core and dated by Optically Stimulated Luminescence, using both by the routine 'Multiple Aliquot' and the new 'Single Aliquot' technique. These samples were recovered from a variety of environments including estuarine muds, lake silts, and river sands. Despite the variety of target materials the ages provide a stratigraphically consistent result which is compatible with available proxy data (e.g. pollen). These results have significant implications for the tectonic evolution of the basin and highlight recent ecological changes in the basin. The poster gives a detailed presentation of the luminescence measurement protocols used and shows both the potential and limitations of these dating techniques for long sedimentary records.

THE EVOLUTION OF SOIL-MANTLED HILLSOPES: TOPOGRAPHIC AND EXPERIMENTAL EVIDENCE FOR NON-LINEAR SEDIMENT TRANSPORT

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Landscape evolution models are widely used to explore linkages between tectonics, climate, and hillslope morphology, yet mechanisms of hillslope erosion remain poorly understood. Most landscape evolution models represent hillslope transport by linear diffusion, in which rates of sediment transport are proportional to slope, such that equilibrium hillslopes should have constant curvature between divides and channels. However, on real hillslopes curvature varies systematically, such that slopes are typically convex near the divide and become increasingly planar downslope. Nonlinear transport models (which indicate that sediment flux increases rapidly as gradient approaches a critical value) help to explain the observed variation in hillslope curvature. We calibrated and tested a nonlinear transport model using high-resolution topographic data from the Oregon Coast Range. These data, obtained by airborne laser altimetry, allow us to characterize hillslope morphology at 2m scale. At our study site, hillslope curvature approaches zero continuously with increasing gradient, consistent with our proposed non-linear diffusive transport law. Hillslope gradients tend to cluster near values for which sediment flux increases rapidly with slope, such that large changes in erosion rate will correspond to small changes in gradient. Therefore, average hillslope gradient is unlikely to be a reliable indicator of rates of tectonic forcing or baselevel lowering.

We further tested our proposed nonlinear model using a laboratory hillslope of granular material. In our experimental hillslope, sediment transport rates increase nonlinearly with slope due to granular creep, and become increasingly episodic at steep slope angles as creep gives way to periodic landsliding. We use spectral analysis to quantify the variability of sediment flux and to define the slope threshold that separates creep and landsliding. The power spectrum of sediment flux steepens with hillslope gradient, exhibiting fractal 1/*f* scaling just below the creep-landsliding transition. By evolving the experimental hillslope under fixed baselevel boundary conditions, we demonstrate how disturbance-driven transport generates hillslope convexity. The transient evolution is consistent with numerical predictions derived from a recently proposed nonlinear transport model, as initially steep hillslopes are lowered rapidly by landsliding before slopes decay slowly by creep-dominated transport.

THE HOLOCENE INFILL OF "LAKE TWEED" IN NORTHERN NEW SOUTH WALES

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An understanding of the nature and distribution of Holocene-age, coastal sulfidic deposits, that form acid sulfate soil (ASS), is required to assist the application of best land management practices with theseproblematic materials. An important element of this understanding has been provided from geomorphic models of the Holocene infilling of bedrock valleys behind barrier dune systems in eastern Australia. The Tweed River is the most northerly estuary in New South Wales and recent mapping of ASS has shown that almost the entire floodplain is underlain by potential acid sulfate soil (PASS). There have also been significant episodes of river acidification and fishkills after flood rains displace into the estuary, acidic porewater from the floodplain ASS.

Classification of the Tweed River estuary embayment according to Roy (1984) and Thom (1984) represents infilling of a mudbasin behind a low, stationary barrier. Further classification according to Chappell (1993), based on marine/catchment sediment and discharge volumes, shows the system as a sediment-starved, mesotidal system

Three transects of drill holes across the Tweed River floodplain have been completed and a range of sample analyses undertaken (^{14}C, pollen, forams, particle size and sand grain micromorphology, XRD, chemical analyses). These analyses have confirmed that deeper sulfidic PASS materials were deposited in a shallow estuarine lake that was established when present sealevel was reached, with much of the sediment supply from marine sources. The subsequent infilling of Lake Tweed was at a decreasing rate but with an increasingly greater proportion of fluviatile discharge and sediment deltaic features. Recognition of the existence and role that natural fluviatile levees can play in isolating the floodplain backswamp from continual saturation by tidal inundation is important for predicting the degree of non-anthropogenic acidification that has occurred and therefore the amount of naturally-formed acidity that exists in the ASS landscape. Other work by our group is indicating that the main problem now faced with agricultural landuse of ASS floodplains is the best management of this existing acidity in the floodplain.

DOWNSTREAM FINING IN A RAPIDLY AGGRADING, GRAVEL-BED RIVER

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The 104 km long Waipaoa River drains into Poverty Bay near Gisborne, East Cape, New Zealand. Rapid aggradation in the historic period was triggered by the conversion of indigenous forest to pasture. The channel system aggraded in response to the influx of bed material load supplied by mass movements and gullies. For the period 1948 to 1988, the amount of aggradation in the upper reaches was > 5 m, and in the lower reaches ~0.5 m.

Most sediment enters the river system in the upper reaches of the Waipaoa and Mangatu rivers. In its upper reaches (0 – 12 km) the Waipaoa River exhibits a braided configuration and mass movements generate significant lateral sediment inputs. At the downstream end of the braided reach the river enters a narrow gorge. Downstream from the gorge the river develops a single thread meandering channel with a gravel-sand bed and cohesive banks. The gravel-sand transition occurs at approximately 96 km, 2.5 km downstream from the tidal limit, though gravel is transported to the coast during large magnitude flood events.

Downstream changes in particle size, shape and lithology that occur in the Waipaoa River are presented. The work is distinguished from previous field studies by the spatial and temporal resolution of the sampling program, as well as by its focus on a rapidly aggrading river system and the provision of particle size data for both proximal and distal reaches. Downstream fining occurred in all particle size fractions, but the rate of downstream fining was greater for the coarser fractions. No downstream change in the proportion of each main lithology was observed, and each lithology exhibited a similar rate of particle size decline. Similarly, downstream alteration in particle shape was minimal, although roundness did increase downstream. Downstream fining in the Waipaoa river appears to be a response to changes in flow hydraulics that are regulated by the concave configuration of the long profile. Despite the variability induced by lateral sediment inputs, the pattern of downstream fining is essentially continuous along the length of the river. The rate of downstream fining did not appear to be related to the rate of sediment supply to the channel, and was consistent for the period 1948 to 1996.

LARGE SCALE ASSESSMENT OF RIVER SEDIMENT REGIME - THE MURRUMBIDGEE RIVER AS AN EXAMPLE

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An assessment of river sediment regime for the Murrumbidgee River, South Eastern Australia is presented here, as one component of an Australia wide program currently underway to predict river condition and ecological health.

The rate of both sediment loading to, fluvial transport within, and out of a river reach, determines the sediment regime of that river reach. That is, whether or not a river reach has excess stream power relative to that required to transport the supplied load and is actively eroding, or whether the channel is stable with respect to supplied and transported load, or is subject to sediment deposition where loading exceeds transport capacity. As the sediment regime of a river is a strong determinant of the ecological habitat diversity, this information is of value for assessing a river's ecological health.

A model has been established to predict a river's sediment regime. It comprises four components:

1) A drainage network extracted from the national nine second resolution digital elevation model. The drainage network is split into discrete links. River sediment regime calculations are predicted for each river link.

2) A prediction of the mean annual sediment transport capacity for each of the stream links. Sediment transport capacity is predicted using Yang's (1972) equation, in which sediment transport capacity can be expressed as a function of channel width, discharge and slope.

3) Predictions of sediment delivery. It is recognised that subsurface sources of sediment (gullied material) is the dominant source of bedload in the Murrumbidgee Catchment. Observed gully density data for the catchment were utilised in the model, along with predictions of hillslope erosion based on a USLE type model.

4) A model to compute the balances between sediment delivery and transport capacity. This model is a simple model accounting for mass delivery from the two diffuse sediment source terms and any delivery from upstream links, and compares the net delivery to a stream link to the calculated transport capacity of that link. Load excess to capacity is deposited, load less than capacity passed to the downstream link.

input parameters - cf. Jean Braun's model inputs.

SEAWATER, WAVES AND PLATFORMS A CONTINUUM IN ENERGY

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Coastal sea water may contain abundant particles of both dead and alive organisms especially adjacent to river mouths. The water encapsulates these particles in hydrophobic fashion restricting the content of free water. The "ordered" water may be polymerised to the hexamer or above. Sea water has a tough skin. Spill curtains of large waves appear similar to open polymer foams. Some of the high energy release of breaking waves is probably due to the mechanical action changing the water hexamer to lower polymer forms.

With high swells in shoaling conditions plunging waves are common (Ruxton, 1996). Orbital motions of water particles become elliptical, straight, and then give way to shear in the upper part of the rotating wave. In the early stages of wave formation undertow from the previous wave folds under the accelerating upper part of the advancing wave often to form a log spiral shaped (near vertical) face. This is a near wave break condition with much of the momentum about to be concentrated into a two dimensional jet.

Oblique surf beat can give rise to a cuspate wave front in plan where one dimensional jets shoot forward from the horns of the cusps. A venturi shaped flow form causes the high concentration of energy. Sometimes shock waves may emanate from the cusps. Near parallel surf beat is probably responsible for wave fronts that throw up to form an arch. Jets from singular surfaces have been described recently (Brenner, 2000).

On a primary hilly coast with weathering profile over rock and water table graded to sea level (Bartrum, 1926) wave action cuts into the weathered rocks at both storm level and mean sea level. As tools are released to corrade, cutting of these levels will continue into bedrock to form incipient platforms. Cutting at two levels at once is controversial. Sea level has been constant for about 6000 years and early on much windier conditions prevailed that may have caused high swells and the cutting of the storm platforms.

References:

Bartrum, J.A. 1926. "Abnormal" shore platforms. Journal of Geology, 34, 793-806.

Brenner, M.P. 2000. Jets from a singular surface. Nature, 403, 377-378.

Ruxton, B.P. 1996. Plunging Waves. Bulletin of the Australian Meteorological and Oceanographic Society, 9(2), 32-33.

CHANNEL STABILITY AND EROSION IN THE SWIFT CREEK CATCHMENT, JABILUKA MINE SITE, NORTHERN TERRITORY, AUSTRALIA.

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The Swift Creek catchment in the Northern Territory, Australia contains the recently constructed Jabiluka Minesite. Various projects have been implemented to determine the geomorphic baseline conditions of the Swift creek catchment. One of these projects investigates channel stability of Swift Creek and its various tributaries.

Tributary North is a left bank tributary of Swift Creek, has a discontinuous channel with gully knick points on the channel closest to the main channel of Swift Creek. A small part of the headwater section of this creek has been relocated allow the construction of the minesite to Various methods have been employed to investigate the stability of the channel including;

- Cross sectional survey
- Erosion pins
- Planform survey using theodilite and also differential GPS
- Scour chains

During the period in which the research program was been implemented, a new track was formed in the vicinity of Tributary North to move people away from the site. This track was mapped and the impact of the 2 wet seasons, fire and vegetation is discussed with regard to erosion.

MONITORING AND MODELLING OF LANDSLIDE ACTIVITY IN THE BONN AREA: AN INTERDISCIPLINARY RESEARCH APPROACH

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The occurrence of landslides in the Bonn area is dependent on site specific geomorphometric, tectonic and geologic boundary conditions. Recent and historic mass movements have lead to damage to roads and buildings. It is the purpose of an interdisciplinary research programme at the University of Bonn to derive basic parameters for the triggering factors and to gain an understanding of the sensitivity of slope systems in the Bonn area, in order to identify the role of landslide processes as a part of the slope system.

Therefore, in an initial project phase, detailed monitoring and modelling of slope stability and slope movement for well-known field sites, as well as regional mapping and modelling has been carried out. This involved an intensive measurement programme for several specific landslides in the Bonn area, incorporating a variety of methodologies. Therefore a series of typical landslides were selected, that potentially show seasonal activity on pre-existing failure planes. The aim is to provide detailed specific knowledge of typical landslides, leading to a more fundamental understanding of the controlling factors of landslide occurrence for the Bonn area in space and time.

A series of core drillings have been carried out delivering detailed information about lithologic layers. Geophysical monitoring techniques are used to increase information about the subsurface structure. An intensive laboratory programme lead to an estimation of the basic material properties. Slope hydrology is monitored via a series of groundwater tubes. Movements are measured with inclinometers and with high temporal resolution tiltmeters. Geomorphic, geologic and pedologic mapping and geomorphometric analysis has been carried out to provide additional spatial information for the research areas.

The application of different techniques provides comparatively detailed knowledge of the subsurface structure of the specific sites. However it also points out strengths and weaknesses of the different investigation methodologies. The results show, despite a large complexity in the underlying geologic structure, that the occurrence of mass movements is associated with sensitive material of Tertiary and Devonian sedimentary and tuff layers. The application of slope stability models with the derived data gives some indication of the effective factors triggering landslide activity. These findings contribute to a more fundamental understanding of landslide processes and their contribution to slope evolution in the Bonn area.

A HOLOCENE RECORD OF ENVIRONMENTAL CHANGE FROM A HUNTER VALLEY LAKE, NEW SOUTH WALES, AUSTRALIA.

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Ellalong Lagoon is situated in the lower Hunter Valley 45 km south west of Newcastle in New South Wales, Australia. The Ellalong and Paxton faults have dammed Quorrobolong Creek immediately upstream from the confluence with Congewoi Creek. During floods Congewoi Creek sometimes flows back into the lagoon. The Quorrobolong catchment is bounded to the south by the Myall Range that forms the drainage divide with Congewoi Creek. Broken Back Range bounds the northern and eastern sides of the catchment. The catchment is mostly Permian mudstones, sandstones and conglomerates with Triassic sandstones at higher altitudes on the Myall Ranges

The small townships of Ellalong and Paxton are situated adjacent to Ellalong Lagoon, to the east and north west respectively, and the catchment has been extensively farmed since the early 1800s. In recent years, a road easement has altered the water levels. At present water covers an area of 65 hectares and is less than 1 metre deep when full.

A 1998 study of the sediments in Ellalong Lagoon determined sedimentation rates for recent and pre-European periods using heavy metals and ^{137}Cs analyses. A limited pollen analysis was undertaken and used as an independent chronological marker to identify the European occupation period. The lagoon was considered to be a less than ideal site for pollen based vegetation and climate reconstructions, however some interesting signals were present and the need for further study was indicated.

Three AMS radiocarbon assays were obtained with the oldest taken near the base of a 1.8 metre sediment core returning an age of 6080 ± 50 years bp. The radiocarbon dates, together with the ^{137}Cs and heavy metal results, indicate sedimentation rates for the pre-European period averaged 0.25 mm yr^{-1}, and a twenty fold increase for the ^{137}Cs (post 1958) period with rates of around 5 mm yr^{-1}. The absence of reworked Permian and Tertiary pollen in the core suggests old carbon has not contaminated the samples, a situation which would have lead to overly old dates and an underestimation of the pre-European sedimentation rates.

The pollen history of the site has provided information on water level changes, climate change, the effects of European occupation in the catchment and a possible period of intensification in Aboriginal occupation (which appears to coincide with the period of increase in valley fill rates in eastern Australia). The chronology and pollen record show that there were large and significant changes in the environment in the pre-European period, changes that appear to have had little effect on sedimentation rates, which remained low and stable.

GRAVEL AGGRADATION DURING INTERGLACIATIONS: A CASE STUDY FROM PALLISER BAY, SOUTHERN NORTH ISLAND, NEW ZEALAND.

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Sedimentological and geomorphological investigations supported by microfossil analyses and luminescence dating of a coastal outcrop in western Palliser Bay, North Island, New Zealand, demonstrate the presence of two major phases of gravel aggradation, since the last Interglaciation. The earlier phase of gravel aggradation dates to the end of isotope stage 5 (c.80 ka). The absence of glacial age aggradation surfaces indicate that the glaciation was either a period of active degradation or, at the very least, insignificant aggradation. A second major phase of aggradation occurred between c. 14 and 8 ka. The early mid-Holocene was a period of rapid degradation with three flights of degradation terraces preserved within the deglacial aggradation surface, while the in last few thousand years river base-levels have been relatively stable.

These findings run counter to the traditional interpretation of aggradation surfaces coinciding with cooling events but are consistent with best estimates for the age of the most recent regional aggradation surface (the Waiohine Surface at 11+/- 1 ka). Instead aggradation events appear to reflect the release of long term sediment stores. In the case of the terminal interglaciation aggradation at c. 80 ka we invoke release of sediments from upland storage as slopes became less vegetated with climatic decline. For the deglaciation aggradation we envision the rapid transfer of frost shattered material from upland slopes to the lowland when river flow increased at the end of the glaciation.

These findings require a substantial modification of our understanding of landscape evolution of non-glaciated, normally mesic areas, during glacial times. They also provide an explanation for the anomalously young age for the apparent deglaciation of the Wairarapa region, New Zealand at the end of the last ice age.

GEOMORPHIC CONTROLS ON ACTUAL ACIDITY IN AN ACID SULFATE SOIL ENVIRONMENT

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Large areas of the Australian coastline are characterised by acid sulfate soils. These soils are caused by the oxidation of pyrite (FeS_2) and are characterised by low pH values and elevated sulfuric acid, iron and aluminium concentrations. These elevated concentrations pose a hazard for the surrounding waterways and aquatic organisms and have caused massive fish kills in rivers.

Pyritic sediments accumulated in estuarine embayments following the last glacial maximum. The rapid and consistent rise in sea level during the Holocene period was approximately balanced by sediment supply, encroaching on many estuarine embayments and resulting in laterally and vertically extensive deposits of pyritic sediments.

The backswamp area of the Tweed River estuarine embayment in northeastern New South Wales is a typical acid sulfate soil environment. The analysis of deep cores in the Tweed River backswamp have shown a relatively uniform sulfide concentration throughout the unoxidised estuarine profile. The backswamp consists of fairly flat topography with natural levee deposits associated with the contemporary and paleo-channels of the Tweed River.

Traditionally, management of acid sulfate soils involved applying one management technique to an entire area. Despite uniform sulfide concentrations in the Tweed River backswamp, significant spatial variations in the amount of actual acidity exist across a relatively small area.

The natural drainage system that existed prior to the development, straightening and widening of the existing drainage channels consisted of wide, shallow depressions in the low-lying areas of the backswamp. Natural levees formed adjacent to these depressions. The land has since been reworked for agriculture and much of the area has been laser leveled. The spatial variations in actual acidity are correlated with natural drainage features. In particular, the largest actual acidity values were found to occur where natural drainage lines drained into low-lying depressions. The large actual acidity values have resulted from the movement of acidity from the higher elevated areas to low-lying areas via the drains or subsurface water movement created by the drains. The smallest actual acidity values were found on the levee of the Tweed River.

Re-pyritisation, if any, is limited so it can be concluded that the spatial patterns of actual acidity in the acid sulfate soil landscape are actually a reflection of the geomorphology and drainage patterns of the site before it was modified for present landuses whereby low-lying areas contain greater actual acidity.

Further research is required to provide a thorough understanding of the relationship between geomorphic features and spatial variations in actual acidity. The development of models based on this relationship can be used in the management of acid sulfate soils.

REGOLITH-LANDFORM MAPS AND THE LANDSCAPE HISTORY OF THE COBAR REGION, NSW: DEVELOPING A LANDSCAPE EVOLUTION MODEL

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Regolith-landform maps classify and map the distribution of regolith materials and in this way, can be of great assistance in constructing landscape evolution models. At Cobar, in central NSW, evidence of landscape development dating back to at least the Cretaceous is apparent in the wide variety of *in situ* and transported materials preserved. Regolith-landform maps at 1:100,000 scale have been constructed over the Cobar block to assist in the interpretation of the complex landscape history, and as a basis from which to build a landscape evolution model. Both *in situ* and transported regolith materials are widespread at Cobar. *In situ* materials vary from slightly weathered to deeply weathered on all landforms and are commonly covered by a veneer of transported materials, including alluvial, aeolian, lacustrine and colluvial units. Both *in situ* and transported materials occur in all landscape positions, most commonly on plains of low relief (less than 5 metres).

The alluvial deposits of the Cobar area show evidence of multiple phases of deposition and soil formation. They have been grouped into at least 4 types of drainage systems, including the modern drainage, deeply incised maghemite bearing palaeochannels of low relief, as well as quartzose deposits both at low and higher elevation in the topography. These inverted alluvial deposits have frequently been silicified and appear to represent the oldest alluvial deposits of the Cobar area.

Colluvial materials are widespread but typically of shallow depth (less than 1 metre). The majority are sheetwash deposits overlying weathered bedrock, and are composed of coarse angular lithic fragments which are locally derived. Grainsize typically decreases downslope with a corresponding increase in silty loam and maghemite gravels. Other types of colluvial deposits include fan deposits flanking the higher ranges of the area.

Aeolian deposits include longitudinal dunefields as well as smaller areas of isolated sand dunes. Source bordering dunes occur adjacent to some drainage systems, particularly distributary systems in the western half of the Cobar block. Aeolian materials are also incorporated into soils, and may contribute to the widespread occurrence of secondary carbonates on hilltops for example. Lacustrine deposits are most common in the western part of the Cobar area and have associated lunettes up to several metres height preserved on the southeastern margins. These lunettes contain truncated soil profiles, which are overprinted by later soil development.

The regolith-landform units of the Cobar area provide information on aspects of the landscape evolution of the Cobar region, including drainage history, landsurface development and neotectonics. The Cobar area is commonly referred to as the "Cobar pediplain" or "Cobar peneplain" (see Spry 1998), following the early work of David (1911 cited in Dury & Langford-Smith 1964) and Taylor (1940). Evidence from recent work indicates that these models require review. The Cobar landscape is a plain of generally low relief however the landscape has been continuously evolving throughout the course of landscape history, as suggested by the wide variety of alluvial deposits. Importantly regolith materials indicate an absence of recent tectonic movement, suggesting that previous models of peneplanation and pediplanation, and the associated "Kosciusko uplift" do not adequately account for the landscape history of the Cobar area.

References:

Dury G. H. & Langford-Smith T. 1964. The use of the term *Peneplain* in descriptions of Australian landscapes. *Australian Journal of Science* **27 (6)**, 171-175.

Spry M.J. 1998. Examining the landscape evolution models of the Cobar region, New South Wales, evidence from regolith-landform features. Regolith '98. Proceedings, 251-263.

Taylor G. 1940. *Australia.* 1st edition. Dutton & Co. Inc, New York, 455 pp.

MILLER STREAM FOREST BURIAL AT 1530-1810 CAL BP, AND POSSIBLE TRIGGERED RUPTURE OF THE CLARENCE FAULT AND JORDAN THRUST, SOUTH ISLAND, NEW ZEALAND

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An exhumed forest that was killed at 1530-1810 cal BP, and comprises over 40 trees in growth position with circumferences up to 2.5 m, is preserved over several hundred meters along the modern channel on Miller Stream, Marlborough, New Zealand (grid ref. NZMS 260-P30 761955). A local landslide was not the cause of the forest's burial, as a sample from its base is less than several hundred years old. Just over 2 km downstream, sub-horizontal trees with the same age as the exhumed forest are buried by more than 10 m of a fining upward, high energy ("debris flow") deposit containing clasts to 2 m which is, in turn, capped by another 10 m of thickly bedded alluvial channel deposits. The 1530-1810 cal BP aggradation event inundated the South and Middle Branches of Miller Stream with at least 4.4 ´ 10^6 m^3 of material, equating to a sediment yield (300,000 to 600,000 m^3/km^2) almost identical to that of the most affected catchments impacted by the 1929 M 7.7 Murchison earthquake (Pearce & Watson, 1986). Over the last 200-400 years, Miller Stream has incised down to nearly the pre-disturbance elevation, and is, in several places, flowing on bedrock.

Although the triggering mechanism for the 1530-1810 cal BP aggradation event in Miller Stream could have been an intense local storm, the extent and magnitude of aggradation, and the close proximity of the site to at least five major active faults suggest that an earthquake trigger should also be considered. Timing of the Miller Stream aggradation event overlaps with the timing of the most recent surface rupture of the Middle Clarence Valley section of the Clarence fault (1630-1880 cal BP; Van Dissen & Nicol, 1999), located c. 15 km NW from the buried forest. However, the closest active fault to the site (only 2 km distant) is the Jordan thrust that directly underlies the steep source area of the Miller Stream aggradation material. We consider it plausible that rupture of the Jordan thrust triggered the Miller Stream aggradation event. Modeling of Coulomb failure stresses for various permissible rupture scenarios of the Clarence fault and Jordan thrust show that rupture of either fault enhances the likelihood of rupture of the other. Could the most recent rupture on the Clarence fault have triggered rupture of the Jordan thrust? (or visa versa?).

References:

Pearce, A.J., Watson, A.J., 1986, Effects of earthquake-induced landslides on sediment budget and transport over a 50-yr period. *Geology* 14: 52-55.

Van Dissen, R.J., & Nicol, A., 1999, Paleoseismicity of the Middle Clarence Valley section of the Clarence fault, Marlborough, New Zealand: *Geological Society of New Zealand Miscellaneous Publication 107A*. Geological Society of New Zealand Annual Conference, Palmerston North, 1999, p. 162.

FLUVIAL GEOMORPHOLOGY OF GARDNERS GUT CAVE, WAITOMO

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Gardners Gut cave in Waitomo, is the longest and most heavily visited 'wild' cave in the North Island, with 2400 caver movements recorded in the year April 1999-April 2000. It drains both karstic limestone and non-limestone rocks including mudstones and sandstones. A mantle of volcanic ash up to 3 m deep covers shallow gradient slopes on the surface. The total enterable passage length is over 13 km and includes approximately 6 km of stream passage. The predominantly karst catchment has imprecise hydrological boundaries, but is approximately 4 km^2.

This work examined the total sediment budget for the cave through a complete annual cycle by observation of dissolved load, suspended load and bedload transport both within the cave and at the resurgence. The water balance of the local area has been calculated using a surface weather station, gauging weir and cave climate records. The nature of observation in caves means continuous records of these parameters are difficult to obtain. To provide a continuous data set, the cave data has been trained to neighbouring gauging and weather stations.

Sediment supplied to the cave enters through several dolines. Allogenic material is predominantly weathered volcanic ashes, but boulders of mudstone are also found in several upstream entrances (Cleft of the Orcs, Helm's Deep). These larger boulders decrease in size from several metres in diameter in the entrance shaft to 0.5 m in the cave stream. The nominal diameter and maximum projection sphericity both decrease rapidly in the first 350 m downstream of Cleft of the Orcs. These parameters decrease at a slower rate from the passage junction between Cleft of the Orcs and Helm's Deep probably because of the increased energy available for transport from this point.

Maximum discharge of the cave stream recorded (October 1999) was 1.4 cumecs, with an average Q of 0.05 cumecs. Sequences of backwater deposits are found in vertically abandoned levels of the cave. Speleothems on these deposits are being U-Th dated for information on downcutting rates.

Mainly mudstone bedload of varying sizes shows a maximum travel distance of 51 m over 5 flood events during the period February-July 1999. Some sections of the alluvial streambed are armoured. Cavers walking in the stream break up this armouring, exposing the underlying layers of the streambed to the stream. This is likely to increase rates of bedload entrainment, and increase marginally the transport of bedload. Cavers' feet also increase the entrainment of finer sediments normally protected by the armoured layer. In low flow conditions, suspended sediment entrained by cavers' feet may increase by 400% 3 m downstream of the disturbance. Elevated suspended sediment load is experienced up to 800m from the site of the disturbance.

LARGE SCALE OVERWASH SEDIMENTATION AND THE QUATERNARY STRATIGRAPHY OF A SHELTERED COASTAL EMBAYMENT AT DUNMORE, SOUTHEASTERN NEW SOUTH WALES, AUSTRALIA.

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The Quaternary evolution of an infilled coastal embayment at Dunmore, New South Wales is presented. The embayment was cut into porphyritic basalt by fluvial action during the last glacial low stand of sea-level. This period of subaerial exposure is recorded by a slightly mottled basal mud unit that is overlain by a thin grey uniform mud probably laid down in a stranded lake. The overlying massive marine sand unit and associated small beach ridge containing Aboriginal midden material was laid down during the post-glacial marine transgression and is of mid Holocene age. The massive sand of the coastal embayment is overlain by a muddy shell-rich sand unit most likely of estuarine origin. The relative reduction in energy is probably the result of the development of the present beach barrier blocking the embayment to the southeast. A large flat-lying sand sheet overlies the estuarine unit. Large amounts of organic matter, including Spinifex sp. and broken shell, found in the upper sand unit, suggest that the seaward barrier was subject to significant overwash, capable of stripping vegetation, and incorporating the estuarine macrofauna into this sand sheet. Vibracoring into the upper sand unit reveals chaotic bedding, containing six varied facies, including a number of graded, massive and muddy sand layers incorporationg a number of erosional structures, such as rip-up clasts and organic-rich sand. These units appear characteristic of deposits emplaced by tsunami waves.

DEBUNKING THE HUMAN-CLIMATE PARADIGM OF HOLOCENE ALLUVIAL BEHAVIOUR

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The Holocene alluvial record is being increasing examined to ascertain the relative importance of human and climate impacts on river response. Despite numerous studies, there remains considerable debate surrounding the arguments for the principal agents of change, leading to Macklin and Lewin's (1993) phrase that Holocene river alluviation in the United Kingdom is "climatically driven but culturally blurred". Since the late 1980s, several authors in the USA, Australia and Europe have argued strongly for a causal regional relationship between climate change and fluvial response. While it can be clearly demonstrated that certain UK geographically separated river systems experienced major alterations to their sediment load during the Little Ice Age, thus showing a direct correlation between climate change and river response, the arguments surrounding synchronous response of river systems on a regional scale is much weaker. Indeed, numerous regional studies have been able to show that adjacent rivers did not respond in a synchronous manner to the same environmental impacts. Young *et al.* (1986) compared several coastal draining rivers in southeast Australia and were able to show that at around 7000 BP, a period of apparent alluviation, was coeval with higher rainfall and runoff, whereas between 12,000 and 10,000 BP, also a time of increased rainfall and runoff, alluvial systems were characterised by a phase of minimal deposition. In a similar study of river systems of the southern Highlands, NSW, Prosser (1987) was also able to demonstrate that there was no causal relationship between known Holocene hydro-climatic variations and alluvial behaviour, results that are contradictory to the paradigm emanating from northern hemisphere Holocene fluvial studies.

While major shifts in climate such as those experienced at the Pleistocene-Holocene boundary in the northern Hemisphere can trigger changes in hydrological regime, reach-scale geomorphic controls such as intrinsic thresholds (*cf.* Schumm, 1977) and lagged response, sequencing of major flood and fire events, bedrock outcrops, glacial inheritance, sediment supply, valley morphology and vegetation cover may be more dominant than hitherto argued. If rivers do not respond in a synchronous manner to known environmental impacts (human and climate induced) then this has serious implications for the determination of broad environmental change from individual sites, irrespective of however complete the alluvial record may appear to be.

Reference:

Macklin, M.G. and Lewin, J. 1993. Holocene river alluviation in Britain. *Zeitschrift für Geomorphology (Supplement)*, 88, 109-122.

Prosser, I.P. 1987. The history of Holocene alluviation in the southeastern highlands of Australia. *Search*, 18, (4), 201-202.

Schumm, S.A. 1977. *The fluvial system*. John Wiley and Sons Ltd., New York, pp 338.

Young, R.W., Nanson, G.C. and Bryant, E.A. 1986. Alluvial chronology for coastal New South Wales – climatic control or random erosional events? *Search*, 17, (10-12), 270-272.

RIVER MEANDER MIGRATION AND PLANFORM CHANGES IN RESPONSE TO LARGE FLOODS ON A TROPICAL PACIFIC ISLAND

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The Wainimala is a major tributary of the Rewa River, the largest river system on the main Fiji island of Viti Levu. The mountainous volcanic landscape is vegetated by rainforest and has a wet tropical climate due to the predominant moist south east trade winds and orographic effects. The fluvial system is a flood-dominated regime because of the average biennial occurrence of extreme flows caused by tropical cyclones.

The channel of the lower Wainimala meanders across an alluvial terraced floodplain. Air photograph records over the last c.50 years show large changes in meander position and geometry. In a chosen study reach, changes in meander wavelength and amplitude have been influenced by local controls such as river marginal forest and bank composition. Maximum rates of meander down-valley migration are 18 m per year or 35 m per flood event. This high rate of channel shifting causes problems for rural Fijian communities because rivers demarcate traditional land boundaries on floodplains between adjacent clans. Some villages have lost much valuable farmland needed for growing subsistence crops and cattle pasturing. Understanding meander behaviour in the region in relation to high magnitude floods is important for future land use planning, especially if tropical cyclone frequency or intensity increases in the tropical south west Pacific with global warming, as some climate models predict.

PLACING EXTREME EVENTS IN GEOMORPHIC CONTEXT, WAIPAWA RIVER, RUAHINE RANGE

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In the 1970s the trend throughout the Ruahine Range in southern Hawkes Bay was one of accelerated denudation, erosion, aggradation, and bed load transport rates. Several major storms since the 1950s, including Cyclone Alison in March 1975, had resulted in major channel changes. Increasing active bed width (ABW) and rising mean bed level (MBL) were dominant throughout the upper Waipawa River. Concern was expressed over the future integrity of the flood protection works on the intensively used Ruataniwha plains as the large pulse of coarse sediment in the upper catchment moved through the system.

As a result of this concern 80 cross-sections were established, in a series of characteristic reaches, along the river so that future changes could be monitored and quantified. These cross-sections were surveyed regularly over the first couple of years, but with Government restructuring and a change in priorities, they were not surveyed again until 1996-97. They now provide a record of channel changes over the past 20 years.

Since 1977 there has been a significant reduction in the ABW within each reach: up to 80% but an average of about 40%. This trend has been significant even in the steep tributary streams that delivered the bulk of the sediment during Cyclone Alison. Reduced activity of the streams over the once extensive "floodplain" has allowed the revegetation and stabilisation of the 'Alison' sediment. In fact over 60% of this sediment is still in storage where it was deposited during the event back in 1975. It will probably remain there for the short to medium term, at least under the current flow regime.

The ABWs increase significantly downstream with increasing discharge and a reduction in the degree of confinement of the valley. This trend is apparent in both the 1977 and 1997 surveys. The degree of change between the surveys, however, appears related to specific controls within the individual reaches rather than distance from source or discharge.

The reduction in ABWs, and the concentration of available energy within a more restricted channel, has seen significant local degradation: by up to 4m. As a result MBLs have reduced significantly within the upper catchment but the amount of change in MBLs decreases downstream and in some lower valley reaches slight increases have been recorded. This is probably a result of deposition of reworked sediment from upstream. While the reductions in overall MBLs are significant, the changes are even more dramatic when it is remembered that the majority of the change has occurred within a relatively limited part of each cross-section.

The bulk of the coarse sediment that moved into the Waipawa River channel during Cyclone Alison has therefore stabilised to form vegetated terraces over the past 20 years. The anticipated threat posed by this sediment to human occupation and landuse activities of the lower valley has been largely unrealised.

LANDSCAPE EVOLUTION AND CONTROLS ON SEDIMENT AND SOIL CARBON FLUXES

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We report on a research programme designed to improve our ability to predict the relative importance of climatic, tectonic and anthropogenic disturbances on controlling the stability of the late Quaternary landscape of the Waipaoa River basin, on the East Coast of the North Island. Dramatic landscape transformations have occurred in the erodible hill country in the last 150 years, but there is still considerable uncertainty about how much on-going human disturbance influences the rate, time scales and the level to which the landscape will recover from this cycle of erosion, sedimentation and the export of soil carbon. In collaboration with NIWA, GNS, Massey and Victoria Universities and Indiana State University, we are using landscape geomorphology, sediment budgets and high resolution land and marine sediment archives to begin to discriminate between natural and anthropogenic controls on sediment and carbon fluxes.

Mapping of the distribution, age and elevation of flights of river terraces has demonstrated that the Waipaoa catchment is undergoing extremely rapid rates and processes of landscape evolution. In the last 15 ka years the high rates of river downcutting (~6 mm yr^{-1}) appear to be much higher than uplift rates (~1-2mm yr^{-1}). This suggests that the high rates of river incision and associated sediment delivery may be primarily controlled by climatic changes rather than by rapid tectonic uplift.

The extent to which floodplains might buffer signals of climatically and tectonically induced sediment delivery is being ascertained from the paleoenvironmental histories contained in the floodplain and marine sediment cores. Stratigraphic analysis and cross-sectional measurements of floodplain sediments has shown that although the average rate of current sediment accretion is very high by world standards, the volume of sediment stored on the floodplain only accounts for 5% of the total suspended sediment load, and 16% of suspended sediment transport during events where river banks overflowed. Linking this result with the analysis of the upper portions of a floodplain and marine sediment core show that the C contents of the cores had doubled over the last 80 years since deforestation. Overall the losses of C from erosion of the terrestrial ecosystem are large, with only 15% stored in floodplain sediments and the rest lost to the marine environment.

Complementary research with two international programmes should significantly accelerate our ability to predict the effects of changing climate and associated nutrient and sediment fluxes. Participation in the IGBP-LUCIFS project (Land Use and Climate Change in Fluvial Systems) provides access to experiences from 22 international research projects on the effects of land-use and climate change. At least ten geomorphologists and marine geologists from New Zealand are involved in the US National Science Foundation programme (MARGINS Source-to-Sink) where the Waipaoa sub-area will be part of a ten year study of the impact of global processes on sediment and nutrient delivery.

LANDSCAPE HISTORY OF THE FOWLER'S CREEK SYSTEM

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Fowler's Creek extends for 55km through the subdued topography of the arid zone of far western NSW. The creek has a fall of only ~120m along its length. It can be divided into three sections. In the **uplands**, the source of the great majority of the creek's water and sediment load, the creek flows across floodplains of alluvial sediment, between low rolling hills. Within the **trunk**, mostly an area of sediment and water transport, the creek is confined by strongly outcropping lithologies. In the **terminal fan**, the creek diminishes and gradually disappears as it flows across the flat plains away from the hills. The creek channel is often entrenched as a straight-sided, flat-floored arroyo, however it displays a variety of forms including anabranching, meandering, and unconfined shallow braiding or anastomosing.

Geomorphology, bank stratigraphy, and Optically-Stimulated Luminescence dating have been used during this study to investigate the landscape history of the area, and to determine the degree of equilibrium between existing geomorphology and current fluvial process. In particular, how much effect has European settlement of the area had in terms of proposed rapid erosion of colluvium from hillslopes onto floodplain, and subsequent channel entrenchment?

Bank stratigraphy in the uplands and in the terminal fan generally shows a basal gravel or sand, deposited by a previous higher-energy fluvial regime ~2-8ka ago. Previous valley fill has been removed, possibly by megaflood/s (~10-20ka). The sandy sediments are overlain by orange-brown silt that in places shows signs of very rapid deposition. The base of the silt is often an abrupt or erosive contact. At one site, the silt is clearly of post-European age, as shown by buried artifatcs. Similar units elsewhere have been regarded by other workers as Post-Settlement Alluvium. However, the fluvial process resulting in the deposition of the orange-brown silt over all other units was diachronous. The silt is not the same age wherever it is seen, dates of deposition ranging from >5ka to modern; and silts are accumulating at present. There has been continuing erosion of colluvium from hillslope to floodplain, from at least 3ka.

The timing of channel entrenchment dates back to ~4ka when at least one arroyo was formed. Modern entrenchment continues in the present in the distal parts of the terminal fan. The cause of channel downcutting cannot, therefore, be due entirely to sudden post-European changes in hydrodynamic conditions. There has been episodic & incomplete sediment transport through the creek system, resulting in stable accumulations of sediment at tributary confluences for the last ~1-2ka, and this can cause entrenchment by drainage concentration and exceedance of slope thresholds. Other non-anthropogenic causes include increase in floodplain erodability by intra-sedimentary evaporite precipitation, and entrenchment as part of the development of anabranches. All these processes are currently occurring in the Fowlers Creek system.

This work is still in progress, and dates given above are subject to further refinment. Please note that these dates were obtained using a protocol that was specifically designed to deal with the problem of partial bleaching.

VEGETATION AND THE LATE HOLOCENE CHANNEL AND FLOODPLAIN STABILITY OF SAND-BED, FOREST STREAMS

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The morphology of stream channels and their floodplains has long been investigated in relation to valley slope, bedrock confinement, discharge, sediment load and boundary sediment characteristics. However, the complex interactions between riparian vegetation, large woody debris and fluvial landforms remain largely unknown in Australia where hydrologic regimes, sediment loads and vegetation types differ from those in most parts of the world. Our research investigates the fluvial geomorphic significance of riparian vegetation and large woody debris on four undisturbed sand-bed, forest streams in southeastern Australia. Two of the study sites are sinuous channels continuously flanked by floodplain and colonised by a *Tristaniopsis laurina* (Water Gum) dominated riparian vegetation community. The other two sites are straight, bedrock-confined channels with discontinuous pockets of vertically accreted floodplain and a series of in-channel benches. Riparian vegetation on these streams has a *T. laurina* component nearer the channel but the floodplains are predominantly colonised by eucalypts such as *Eucalyptus saligna* (Sydney Blue Gum).

Detailed channel cross section, longitudinal profile and floodplain surface surveys have been conducted at each site using a total station. These results have been used to construct digital terrain models (DTMs) that accurately depict the morphology of forest streams. Riparian vegetation surveys and complete inventories of large woody debris in each study reach have provided an insight into large woody debris recruitment processes and loadings in different channel environments colonised by different riparian vegetation species. Within channels we have established the roles of different vegetation species and large woody debris as nuclei for bar formation and also in providing slow-water habitat by the formation of step-pools, scour-pools and debris dams. Probing of the bed has indicated the amount of sediment stored in each channel reach as a result of large woody debris. On floodplains sedimentological and topographical surveys have shown the importance of vegetation in the formation of small-scale landforms, such as hummocks on the leeward side of rushes and swirl pits at the base of tree trunks, and larger landforms such as chutes, cutoffs, avulsions and benches. Radiocarbon dates from channels and floodplains provide an insight into large woody debris residence times and rates of channel migration, vertical accretion and possible alluvial stripping. The combined results allow conclusions to be drawn regarding the importance of different vegetation communities in controlling the stability of different stream environments in southeastern Australia during the late Holocene.

THE LANDBRIDGE FILTER EFFECT AND THE PATTERN OF COLONISATION OF THE BRITISH ISLES BY THERMOPHILOUS TERRESTRIAL MAMMALS SINCE THE CROMERIAN (~0.5Ma)

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During past glacial cycles Britain was joined to continental Europe by a landbridge that moved north over time. Non-volant mammals, including humans, would have been able then to colonise the islands unaided. However, the environment would have been unsuitable for many thermophilous species, because most of Britain was covered by ice. Conversely, during interglacials the British Isles were isolated from continental Europe by the sea, inhibiting colonisation by non-volant mammals. There was, therefore, probably only a brief period towards the end of each glaciation when unaided immigration to the British Isles was possible for thermophilous terrestrial mammals before rising sea level flooded the landbridge. Whether or not a particular species managed to establish itself in a given interglacial would depend on the distance of its refuge from Britain, its migration rate, the barriers it encountered en route and the competition it faced on arrival.

Distinctive thermophilous faunas have been identified in Britain from deposits attributed, mainly on stratigraphic grounds because few sites yet have radiometric dates, to successive interglacials. While it is clear that these faunas span the Middle and Upper Pleistocene, the precise number of interglacials they represent and how, or even whether, they can be correlated to the deep sea oxygen isotope record or to each other, is more controversial. It is generally agreed that the most extensive glaciation to cover Britain, the Anglian, deflected the Thames into its present valley, opened the Dover Strait and correlates to OI stage 12. Faunas of the preceding Cromerian interglacial complex are well known, but evidence for even earlier interglacials is too fragmentary to analyse. Therefore, beginning with the Cromerian ss, the known interglacial faunas are described in sequence to see whether the same or descendant species of non-volant thermophilous mammals established themselves in Britain during successive warm periods. Changes in the composition and diversity of the known faunas might illuminate the effect of the northward migration of the landbridge. The Recent pre-Neolithic Irish fauna is also compared with that from the early Flandrian of Britain, of which it is a sub-set. The notoriously depauperate nature of the Irish fauna well illustrates the effect of landbridge accessibility on terrestrial migrants.

Species numbers are also examined via the species/area relationship to determine whether successive faunas were in equilibrium; depauperate because they are either inadequately known or do not represent fully interglacial conditions; or 'super-saturated' because they represent more than one interglacial, or equilibrium had not been reached between warmth loving immigrants and cold-tolerant residents, or the landbridge remained open throughout the interglacial.

Given the amount and possible unfamiliarity of the data to be presented, the verbal presentation of this paper will be supported by a poster displaying the details of the interglacial faunas to be discussed.

ORIGIN OF CENOTES NEAR MT GAMBIER, SOUTH AUSTRALIA

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The Southeast Karst Province of South Australia is notable for its cenotes, collapse dolines containing water-table lakes up to 50m wide at the surface and extending down to 95m below the land surface. They are developed in the flat-lying Oligocene - Early Miocene Gambier Limestone, which is exposed at the surface over much of the province. The cenotes are all characterized by collapse; they have vertical and overhanging sides and are floored by large cones of rubble, which may be overlain by finer grained sediment. Exploration and diving have revealed no major phreatic passages extending off any of the cenotes, despite the fact that typical shallow phreatic joint maze caves, both dry and water-filled, are common in the Gambier Limestone throughout the Southeast Karst Province. Collapse dolines are associated with some of these phreatic caves, but are shallower than the cenotes in that they do not have deep lakes.

The distribution of the cenotes is uneven; they are concentrated in two small areas, each ~3km in diameter, located 5km W and 10km NW of Mt Schank (a few other cenotes are scattered through the province). Within these areas they are distributed along two joint sets, a dominant set trending 320° and a subsidiary one at right angles. These are the dominant regional joint directions.

The depth of the cenotes indicates that they represent collapse into large caverns dissolved at or close to the base of the Gambier Limestone; the boundary between the Gambier Limestone and the underlying Tertiary siliciclastics lies at about 100m below ground surface around the cenotes west of Mt Schank. It has been suggested that the caverns were dissolved by acidified groundwater containing large amounts of volcanogenic CO_2, which had ascended up fractures from deep-seated reservoirs related to the magma chambers that fed the Quaternary volcanoes Mt Schank and Mt Gambier. Approximately 10km east of Mt Schank is a CO_2-producing well (Caroline); the isotopic composition of the CO_2 identifies it as magmatic in origin, and it is probably related to the Quaternary volcanics in the area.

Evidence for the influence of volcanogenic fluids on the cenotes comes from strontium isotope analyses of a stromatolite collected at ~8m depth from Black Hole, one of the larger cenotes. Stromatolites grow on the walls of many of the cenote lakes, and are large structures up to 4m long formed of calcite precipitated by the microbial communities growing on their surfaces. In cross-section the calcite of the Black Hole stromatolite shows submillimeter-scale laminations, which may be annual. Detailed sampling of one section of this stromatolite showed that overall it has a $^{87}Sr/^{86}Sr$ ratio of around 0.7088, but one sample has a lower ratio (0.7079), probably due to an input at this time of volcanic fluids, which have a much lower Sr isotopic ratio (0.7037-0.7058 for the Quaternary volcanics of the region). The layer with the anomalous $^{87}Sr/^{86}Sr$ ratio has an age of ~6000 BP, from C_{14} dates on the stromatolite either side of the layer, and assuming a uniform rate of growth. This age corresponds closely to that of the eruption at Mt Schank (6000 BP, based on recent thermoluminescent dating).

Thus the Sr isotope data show the apparent influence of volcanogenic fluids within the cenote lakes during a time of eruption; additional work is currently being carried out to confirm this influence, by obtaining rare earth element concentrations and additional Sr isotope analyses. Larger amounts of fluid, including volcanogenic CO_2, could have been injected during previous eruptions, dissolving the caves that collapsed to form the cenotes.

EXPOSING BURIED LANDSCAPES

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Regolith is particularly well developed in Australia with over 80% of the continents surface characterised by highly weathered bedrock and transported materials. The formation of an extensive blanket of transported regolith and weathered bedrock in Australia is largely due to:

1.Long exposure of most of the land surface to subaerial weathering;

2.reservation due to the overall low relief and recent arid climate with associated low geomorphic process rates; and,

3.he tectonic stability of the Australian landmass.

Regolith-landform mapping is a critical step in understanding the relationships between landscapes, past and present geomorphic processes, and regolith materials. Once these relationships are understood regolith-landform evolution models can be developed and used to generate or refine models for geochemical mineral exploration and in environmental management. To date most regolith mapping has used airphotos, gamma-ray spectrometry and Landsat TM imagery. These datasets have been excellent in describing surface process and materials but are limited in buried landscapes where present day topography in many cases bears little correlation to surface and materials at depth.

3D visualisation techniques are now being used in conjunction with 2D regolith maps and images to improve the way we map, analyse, and visualise the regolith. This integration has helped develop more accurate, effective and predicative models for mineral exploration in highly weathered or covered terrains. Geophysics constrained by ground checking, and 3D visualisations are being used to map surfaces between major units of regolith. The 3D models are a direct aid to understanding metal dispersion, and salt movement and storage, in deeply weathered and buried landscapes. Data sources for this work include regolith maps, drill hole logs and down-hole geophysics, aeromagnetics, airborne electromagnetics, and ground geophysics including ground-penetrating radar.

An important spin off from this work is the application of the data and methods to the reassessment of models of landscape evolution. For example, in the West Wyalong area of NSW, aeromagnetics, airborne EM and drill hole data reveal a landscape, now buried, that consists of deep gorges, upper catchment basins, and broad erosional surfaces (Chan and Gibson, this conference). The data also reveal a considerable thickness of saprolite beneath the transported materials, and a complex depositional structure within the sediments. This knowledge allows much better assessment of the nature of the processes that formed the buried landscape.

EXPOSURE, SOIL PRODUCTION AND LANDSCAPE EVOLUTION ON TREED AND TREELESS PARTS OF THE NEWNES PLATEAU, BLUE MOUNTAINS.

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In order to investigate the distribution of dry shrublands (treeless vegetation) and open-forested/woodland (treed vegetation) on the Newnes Plateau in the upper Blue Mountains, NSW, we tested site exposure and dismissed this as a major control. Since the treed and treeless vegetation communities correspond with relatively deep and shallow soils respectively and occur on upper and lower parts of slopes respectively, we examined models of soil production for the Plateau. Furthermore, as soil depth at a site depends upon the balance between soil production and soil loss it follows that bimodal rates of landscape lowering must also correspond to these spatial patterns. The humped model of Gilbert (1877) predicts a slope morphology that has not been observed on the Newnes Plateau, whereas Heimsath *et al.*'s (1997) exponential decay model generally forecasts the *status quo*.

If the exponential decay model is applicable as hypothesised high rates of erosion must be taking place in the areas of shallow-treeless soils. The use of slope length to predict treed and treeless vegetation furthers the idea that more dissected areas of the Plateau (areas with high frequencies of short slopes) are less likely to be treed because they are losing too much soil material. We found that slopes less than approximately 110 m are always treeless. Hence the presence of trees is considered to be a proxy for soil retention. The reasons for low rates of soil retention adjacent to cliffs and other places of incision require further testing. However, exposure to wind may be more significant than previously considered and modification of this parameter may lead to a major development in our aspect based exposure model.

References:

Gilbert, G.K. (1877) *Report on the geology of the Henry Mountains.* US Geol. Surv.

Heimsath, A.M., Dietrich, W.E., Nishiizumi, K. and Finkel, R.C. (1997). The soil production function and landscape evolution. *Nature* **388**,358-361

Lake Victoria dry at 18 ka.

QUATERNARY LAKES, PALAEOCHANNELS AND DUNES IN THE WHITE NILE VALLEY

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Using Landsat 5 TM and Landsat 7 ETM satellite imagery, we have recently mapped a series of hitherto unknown lake shorelines, palaeochannels and desert dunes in the White Nile valley as far south as latitude 12°S. The highest shoreline (386 metres elevation) was eroded when the White Nile formed a lake up to 70 km wide and over 600 km long at some stage prior to about 40 000 years ago. The recessional stages of this 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. The lowest identified shoreline (382 metres 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 11 500-11 000 radiocarbon years ago. The stable oxygen and carbon isotopic values of the microcrystalline calcite and dolomite crystals in the fine sandy clays underlying the shell beds to a depth of at least six metres beneath the surface indicate a prolonged phase of shallow water sedimentation under saline evaporative conditions. This regime lasted from at least 35 000 years ago until 11 500 years ago, at which time Lake Victoria in the Ugandan headwaters overflowed once more and a summer monsoon climate was restored. We have analysed the strontium isotope ratios of modern and sub-fossil freshwater gastropod shells from the lake headwaters of the White Nile down to its confluence with the Blue Nile at Khartoum. The results confirm that the present flow regime of the White Nile regime was re-established by 11 500 years ago, contrary to some recent work claiming no continuity of flow until 7 200 years ago.

Lake Victoria dry at 18ka.

LATE PLEISTOCENE WETLANDS IN THE SEMI-ARID FLINDERS RANGES, SOUTH AUSTRALIA

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Laminated clays and fine sands dated by OSL and AMS radiocarbon to 30 000- 15 000 years BP are exposed immediately upstream of Brachina Gorge in 10-12 m high bank sections in the presently semi-arid central Flinders Ranges of South Australia. Individual laminations can be traced laterally for several hundred metres. The laminae are of variable thickness, but usually range from a minimum of 1-2 cm to a maximum of 10-15 cm. The laminae range from nearly horizontal to gently sloping to slightly undulating with a maximum vertical wave amplitude of 10-15 cm. The associated ostracod and shell fauna are consistent with sluggish, shallow water flow under freshwater to saline conditions, as is the diatom assemblage. Both we and the Geological Survey of South Australia had considered that these fine laminated sediments had been laid down in a shallow late Pleistocene lake. In July 2000 we completed a theodolite survey of the present Brachina Creek and of all the main exposures of the putative grey lacustrine clay within and upstream of Brachina Gorge, using bench marks surveyed in 1970. The gradient of the present Brachina Creek bed within the gorge is roughly 1 in 87. The upper surface of the grey clays parallels the channel floor at an elevation of about 15 metres above channel bed level and has a similar longitudinal gradient to the modern channel. We therefore reject the lake hypothesis proposed by Cock, Williams and Adamson (1999) and interpret the laminated grey clays and fine sands as part of a steeply sloping but well vegetated wetland comparable to the Button Grass plains of western Tasmania. The most likely modern analogues for these late Pleistocene wetlands are the present-day swamps of southern Patagonia.

Reference:

Cock, B.J., Williams, M.A.J. and Adamson, D.A. (1999). Pleistocene Lake Brachina: a preliminary stratigraphy and chronology of lacustrine sediments from the central Flinders Ranges, South Australia. *Australian Journal of Earth Sciences* **46**, 61-69.

SPELEOTHEM DATA ON QUATERNARY ENVIRONMENTAL CHANGE IN NEW ZEALAND.

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Speleothems from New Zealand caves yield information on uplift rates and climatic change. Earliest records are from beyond the Brunhes/Matuyama boundary in Wet Neck and Nettlebed Caves. A histogram of speleothems dated by uranium series shows variation over time with most growing during relatively warm intervals, although beyond glacier limits speleothems still grew during cold periods. Within the limits of glaciation speleothems only grew during the absence of glaciers, and their ages have helped to define interstadial intervals between glacial advances.

Speleothem stable isotope records have been most intensively investigated from ca. 15 ka BP until the present. One record from the Westland coast near Punakaiki provides evidence for cooling at about the same time as the Younger Dryas from the North Atlantic. Other records help to define the period of postglacial climatic optimum, which was less obvious in Westland than in parts of the North Island. Various relatively cool intervals are also now being defined in the Holocene record.

THE CAUSE OF VARIBILTY IN THE TOPOGRAPHY OF THE WEATHERING FRONT IN THE GRANT'S PATCH AREA, EASTERN GOLDFIELDS REGION, WESTERN AUSTRALIA.

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Mineral exploration companies working in regolith dominated terrains are using airborne geophysical technologies to map the regolith rock interface (the weathering front). Variability in the topography of this surface is being used to infer the presence of mineralised structures. Whist the association is demonstrably valid, the casual factors are poorly understood.

This presentation considers the cause of variability in the topography of the weathering front in an 8 by 8km area in the vicinity of the Grant's Patch Mine, north west of Kalgoorlie in the Eastern Goldfields Region of Western Australia. This surface has been mapped using airborne electromagnetics. The regolith consists of a complex suite of materials developed *in situ*, as well as a variably thick cover of materials that have been transported. The bedrock includes mafic extrusive and intrusive lithologies, as well as felsic volcanic, volcaniclastic and epiclastic sequences. There is considerable relief in the topography of the regolith rock interface, and this relief is at variance with relief in the contemporary landsurface. The development of relief in the weathering front is considered against the nature of contemporary geomorphic process, palaeo-geomorphic process, hydro-geological process and the character of the parent rock.

THE RELATIVE CHANGES IN SEDIMENT SUPPLY AND SEDIMENT TRANSPORT CAPACITY IN A BEDROCK-CONTROLLED RIVER AS A RESULT OF LAND DEGRADATION, HISTORICAL CLIMATE CHANGE AND DAM CLOSURE

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River sediment regimes are affected by multiple natural and human-induced changes to sediment supply and to sediment transport capacity. Assessments of the relative importance of these different changes enable appropriate management responses to river degradation. Here, an assessment is made of the relative changes in sediment supply and sediment transport capacity of an 83 km section of the bedrock-controlled Coxs River, New South Wales, Australia. These relative changes are estimated in turn for land degradation, historical climate change, and dam closure. The Coxs River does not have a smooth graded long profile. Bedrock outcrops have produced cascades in the mid-reaches which are far steeper than upstream or downstream reaches. Sediment transport capacity varies down the river section by two orders of magnitude, largely because of these slope variations rather than because of downstream discharge increases. Following European settlement, erosion rates increased due to forest clearing and the introduction of rabbits, sheep and cattle. Measurements of gully erosion extent from aerial photographs suggest sediment supply to the river was increased by a factor of over 30. Rainfall records and flow gauging records show a climate shift in the mid-1940s. The increased runoff and stream flow (including flood magnitudes) in the period since the mid-1940s led to an almost three-fold increase in sediment transport capacity. Dam closure in the early 1980s stopped sediment supply from the upper catchment, and flow regulation and abstraction at the dam caused a 15% reduction in the long term sediment transport capacity. The current sediment transport capacity after the climate shift and dam closure is 2.5 times higher that in the first half of this century. In spite of this net increase in sediment transport capacity, the huge volume of sediment delivered to the channel from land degradation has meant that sand deposition is widespread along much of the river. Much of the river bed that was previously dominated by bedrock is now alluvial in character. Only the steepest reaches remain bedrock-dominated.

FLUVIAL BEHAVIOR AND EVOLUTION OF THE LOWER MACQUARIE RIVER, NORTH-WESTERN NEW SOUTH WALES

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The lower Macquarie river of north-western New South Wales occupies a portion of an extensive coalescing alluvial plain sequence to which the Castlereagh and Bogan rivers also contribute. In its lower reaches the Macquarie becomes a complex network of discontinuous anabranching and distributary channels and associated wetlands, known as the Macquarie Marshes. Relics of large meandering mixed-load channels are evident across the surface of the plain indicating a dramatic change in fluvial character within the Macquarie system in recent geological time. This paper will investigate the nature of the contemporary fluvial system, chronology and causes of initiation of the marshes system.

The lower Macquarie is highly avulsive and multiple stages of channel initiation and abandonment are identified on the contemporary floodplain surface. In-channel vegetation plays an important role in the avulsion process. Terminal distributaries branch from the trunk channel and disperse available discharge over a wide area of the alluvial plain. Stratigraphic drilling data indicate the modern system is dominated by a suspended load, and channel and floodplain sediment sequences consist entirely of muds to a depth of 2.5 metres. Accumulation rates are believed to be relatively low, however a relatively recent age for the development of this style of deposition is probable.

Sedimentological evidence shows the change in fluvial style was dramatic. The palaeochannel systems are higher in elevation, and laterally confine the contemporary multi-channeled network. Evidence suggests a period of floodplain degradation preceded the development of the modern drainage form. Timing and causes for this transition are currently being investigated.

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