GENERAL INFORMATION

The 2003 conference has been organised by the Otago Branch of the Geological Society of New Zealand. One-day fieldtrips are being held on Monday 1st December, followed by talks and posters on Tuesday 2nd to Thursday 4th December. Multi-day fieldtrips depart at various times from Thursday evening onward.

Venue

Apart from the fieldtrips, activity will centre around the University of Otago campus. Talks and workshops will be in the Castle 1, Castle 2 and Burns 2 Lecture Theatres. Posters, and morning and afternoon teas will be held in the adjacent Union Hall. Conference accommodation is at St. Margaret's College. Social events are being held at St Margaret's and Knox Colleges and at the Otago Museum. See the inside and outside of the back cover for maps.

Scope

At publication time, registration stood at 185 with 110 talk and 55 poster abstracts being presented. Presentations have been grouped into Cretaceous, Paleobotany, Paleoenvironments & Stratigraphy, Quaternary Stratigraphy, Petrology, Neotectonics, Physical Volcanology, Paleontology, and General sessions. Seven 30 minute plenary talks and one public talk have been organised. A one day Quaternary workshop (INTIMATE: Integration of Icecore, Marine and Terrestrial Records) is being held on Thursday. The Association of Australasian Palaeontologists is holding a one day workshop on "The Measurement and Origin of Biodiversity" on Friday.

Registration

Most participants have already registered and paid for the conference and will only need to report to the registration desk to collect their conference packs. At that time, talk presenters will be asked to deposit their Powerpoint CD-ROMs and/or slides.

The registration desk will be open at:

- St. Margaret's College, at the barbecue on Sun 30 Nov, 5.00-7.00pm, and again for fieldtrip departures on Mon 1 Dec 8.30-9.30am.
- Otago Museum Icebreaker on Monday from 6.30-8.00pm.
- In Union Hall, during the rest of the Conference.

Talks

See p. vi-xii for the programme of talks. Speakers should be prepared to deposit their Powerpoint CD-ROMs and/or slides at the registration desk when they first arrive at the conference. Personal laptops cannot be used for presentations.

Oral presentations have been scheduled for a maximum of 20 minutes with 15 minutes for speaking and 5 for questions. Speakers are asked to please get to the point quickly and keep to time. The speaker ready room is “Castle A”, a small seminar room in the basement of the Castle complex.

Public Lecture

A talk on the recent Fiordland Earthquake will be given by Simon Cox in Castle 1 at 5.30pm on Tuesday. This is designed for a general audience; all are welcome to attend.

Posters & Trade Displays

See p. xiv-xvi for a list of poster presentations. Posters and trade displays will be available for viewing in Union Hall throughout the conference; Union Hall is also the venue for morning and afternoon teas. Presenters are asked to put their posters up any time after 8.00am Tuesday and take them down during afternoon tea on Thursday. Presenters are asked to hover by their posters during the scheduled times before morning tea each day.

Refreshments

Morning and afternoon teas are provided, but (except on fieldtrips) not lunches. A number of lunch and dinner venues are either on, or within easy walking distance of, the campus (see map, back cover).

Social Events

BARBECUE & DRINKS

Sun 30 Nov 5.00-7.00pm at St. Margaret’s College. All welcome: cost is included in the general conference registration.

OTAGO BEER & WINE TASTING

Mon 1 Dec 6.30-8.00pm in the “Southern Land, Southern People” Gallery of the Otago Museum (see map). All welcome: cost is included in the general conference registration.

CONFERENCE DINNER & PRESENTATION OF GSNZ AWARDS

Wed 3 Dec at Knox College, Arden Street (see map). Drinks from 7.00pm, Haggis at 7.45pm, Dinner at 8.00pm. To attend you must have prepaid, as indicated by a dot on your name badge. Please wear your name badge to the dinner. Buses will leave St. Margaret's College for Knox from 6.50pm (last approx 7.20pm). Buses will return to St. Margaret's from 10.45 (last approx 11.15pm).

North and Central Dunedin offer a wide range of options for dinner on Monday and Tuesday nights, or for those not attending the conference dinner.

Intra-Conference Meetings

Geological Society NZ Annual General Meeting
Wed 3 Dec, 5.00pm in Castle 1. All GSNZ members are invited to attend.

Geological Society NZ National Committee
Mon 1 Dec, 7.00pm rendezvous at Registration Desk, Otago Museum during Icebreaker
Thu 4 Dec, 7.30am, Green Acorn Café, Cumberland St

HISTORICAL STUDIES GROUP

Wed 3 Dec, 12.30pm in Castle 1 (bring lunch). Details from Mike Johnston.

PALEONTOLOGY SPECIAL INTEREST GROUP

Thu 4 Dec, 12.30pm in Castle 1 (bring lunch). Details from Hamish Campbell.

Quaternary INTIMATE workshop
Thu 4 Dec, 10.40am -12.20pm and 1.20-2.40pm in Burns 2. Details from Jamie Shulmeister.

MULTI-DAY FIELDTRIP PARTICIPANTS

Thu 4 Dec, 2.40pm (start of afternoon tea) in Castle 1.

Association of Australasian Palaeontologists Biodiversity meeting
Fri 5 Dec, 8.50am-5.00pm in Burns 2. Details from Ewan Fordyce, James Crampton and Mike Hannah.

Transport & Parking

From St. Margaret's College it is about 5 minutes walk to Castle Theatre and the Otago Museum, and 20 minutes walk to the Octagon. Bus transport is available to/from St. Margaret's/Knox Colleges for the Conference Dinner, but we recommend the 15 minute walk through the Botanic Gardens if the weather is good (the Gardens close at dusk).

Parking spaces around campus are either metered or commonly reserved for specific cars. Some unrestricted parking is available to the north of campus on Cumberland, Castle, Leith and Dundas Streets and to the south of campus on Albany Street.

Dunedin Taxis 477-7777. Airport shuttle 477-6611. City Taxis (incl. shuttle) 477-1771. Suggested nearby pickup points: St. Margaret's College or entrance to OU Clubs & Societies Building, corner of Ethel Benjamin and Albany Streets.

Allow 40 minutes for direct road travel to Dunedin airport from the university.

Communication

Organising Committee Hotline during conference ph. (027) 249-0439
St. Margaret's College 333 Leith Street, Dunedin North, ph. (03) 479-5544
GNS Dunedin, ph. (03) 477-4050

Messages for registrants will be pinned to the Noticeboard at the Registration Desk.

Web-based email facilities are available at the terminals in the foyer between Castle 1 and Castle 2 Theatres. A username and password will be issued on site.

Ask at the registration desk about photocopying facilities.

Mobile Phones

Cellphones should be switched off in the lecture theatres. If anyone's mobile phone rings, audience heckling is encouraged. The Chairperson will invite that person to make a gold coin donation to charity in the donation boxes provided.

Awards and Grants

Student travel grant cheques may be collected from the Registration Desk. Awards for the best student talks and posters will be made at the closing of the conference at 3.30pm on Thursday.

The announcement and presentation of the 2003 McKay Hammer Award, 2003 Kingma Award and 2004 Hochstetter Lecturer will be made at the Conference Dinner on Wednesday evening.

Fieldtrips

ONE-DAY

Trips 1-4 leave St. Margaret's College at 9.00am Monday 1 Dec, returning in time for the Otago Museum function. Trip 5 leaves St. Margaret's at 1.00pm. Trips 2 and 3 travel via Dunedin airport to pick up 9.50am arrivals.

Fieldtrip 1A. East Otago Gold: Simon Cox, Dave Craw
Fieldtrip 1B. East Otago Gold & Taieri Gorge Railway: Simon Cox, Dave Craw.
Fieldtrip 2. Quaternary Geology of Coastal Otago: Nicola Litchfield, David Barrell
Fieldtrip 3. Otago Schist Structure and Exhumation: Nick Mortimer, Rick Sibson
Fieldtrip 4. Vanished World Trail, North Otago: Ewan Fordyce
Fieldtrip 5. Dunedin Building Stones and Architectural Heritage: Jane Forsyth

MULTI-DAY

Fieldtrip 6. Southern Alps Tectonics and Quaternary Geology: David Barrell, Simon Cox. Leave St. Margaret's 5.30pm Thu 4 Dec, return Dunedin 4pm Sun 7 Dec.
Fieldtrip 7. Median Batholith on the Southland Coast: Michael Palin, Tony Reay, Richard Price. Leave St. Margaret's 8.00am Fri 5 Dec, return Dunedin 5pm Sun 7 Dec.
Fieldtrip 8. Canterbury Basin Paleontology and Stratigraphy: Ewan Fordyce, Philip Maxwell. Leave Geology Department car park opposite St Margaret's College 8.00am Sat 6 Dec, return Dunedin 8pm Sun 7 Dec
Fieldtrip 9. Paleobotany and Sedimentology of Late Cretaceous-Miocene Nonmarine Sequences in Otago and Southland: Daphne Lee, Jon Lindqvist, Barry Douglas. Leave St. Margaret's College 8.30am Sat 6 Dec, return Dunedin 6pm Mon 8 Dec, via airport.

CONFERENCE PROGRAMME FOR TUESDAY 2 DECEMBER

TUESDAY	CASTLE 1	CASTLE 2
	Plenary 1	
	Chair: Phil Glassey	
0830-0845	Opening Ceremony	
0845-0915	Julie Palmer. President's Lecture: A Tale of Two Liquids	-
0915-0945	Chris Uruski. Cretaceous Paleogeography of the Taranaki Basin	-
0945-1010	-	-
1010-1040		
	Neotectonics 1	**Physical Volcanology 1**
	Chair: Russ van Dissen	*Chair: Richard Price*
1040-1100	John Beavan et al. Fault Parameters of Fiordland Mw7.1 Earthquake from GPS Data Modelling	Roger Briggs et al. Silicic Calderas and Volcanic Centres in Coromandel Volcanic Zone
1100-1120	Kelvin Berryman et al. Active Faulting and Strain at the Junction of the Alpine and Hope Faults	Derek Birks. Advances in Understanding Events, SW Flank of Egmont Volcano, Taranaki
1120-1140	Robert Langridge et al. Conway Segment of Hope Fault is a High Slip Rate, Short Recurrence Fault	M.B. Turner. Vulcanian Explosions from Egmont Volcano (Taranaki) 2200-1800 Years B.P.
1140-1200	Dougal P.M. Mason et al. Fault-Segment Junction and Rupturing Behaviour of Awatere Fault, Marlborough	Shane Cronin et al. The June 2003 Eruption of Lopevi Volcano, Vanuatu
1200-1220	Jocelyn Campbell & Jarg Pettinga. Active Fault-Propagation Folding under the Canterbury Plains	Scott Bryan & R.T. Smith. Clastic Dykes in Ignimbrites: Phreatomagmatic Caldera Features?
1220-1320		
	Neotectonics 2	**Physical Volcanology 2**
	Chair: John Beavan	*Chair: Roger Briggs*
1320-1340	J.G. Begg et al. Subsidence Associated with Wellington Fault Earthquakes	Karl Spinks et al. Structural Control of Volcanism in Taupo Volcanic Zone
1340-1400	Sarah Halliday et al. The Patoka Fault: an Incipient Element of the North Island Dextral Fault Belt	D.M. Gravley et al. Eruption and Caldera-Collapse Events in The Central Taupo Volcanic Zone
1400-1420	Ross Nicolls. Quaternary Faulting in Central and East Otago	Graham S. Leonard et al. The Evolution of Maroa Volcanic Centre, Taupo Volcanic Zone
1420-1440	R. Norris et al. Cosmogenic Isotopes, Fault Propagation Rates & Growth of Ranges, Central Otago	Errol Cameron et al. Valid Radiometric Age for Hauhungatahi, Tongariro National Park
1440-1500	Dave Craw et al. Tectonically Driven River Capture Events, northwest Otago	Nicki Stevens. Anticipating Pre-Eruptive Volcanic Deformation in Auckland from Space, using DINSAR
1500-1530		
	Neotectonics 3	**General 1**
	Chair: John Begg	*Chair: Malcolm Laird*
1530-1550	Pilar Villamor & K.R. Berryman. Evolution of the Southern Termination of the Taupo Volcanic Zone	S.C. Cox et al. Pounamu Resource Assessment
1550-1610	Julie Rowland. Normal fault propagation at the Termination of an intra-rift magmatic segment, Main Ethiopian Rift System	Adam J. Vonk et al. Use of GIS for Geological Mapping: Basin Analysis Projects at the University of Waikato
1610-1630	Nicola Litchfield et al. River Terraces and Regional Deformation Patterns along the Hikurangi Subduction Margin	Andrew R. Gorman et al. Velocity Modelling in Southern Guaymas Basin, Mexico
1630-1650	H.R. Grenfell et al. Documenting big events by small things - Holocene earthquake history, eastern BOP	Nick Cozens et al. Resistivity Investigations of Groundwater near Waikanae River Mouth, Kapiti Coast
1650-1710	Russ Van Dissen et al. Mapping Active Faults and Mitigating Surface Rupture Hazard in the Kapiti Coast District	B. Morrison, I. Matcham, M. Edge, J.I. Raine, N. Mortimer, et al. GNS Databases on the web Part 1: PETLAB
	Public Lecture	
	Chair: Phil Glassey	
1730-1830	S.C. Cox et al. Fiordland Shaken and Stirred - the 22 August 2003 M7.1 Earthquake	-

CONFERENCE PROGRAMME FOR TUESDAY 2 DECEMBER

BURNS 2	OTHER VENUE	
		0830-0845
-		0845-0915
-		0915-0945
-	Posters with authors in Union Hall	0945-1010
	Morning Tea in Union Hall	1010-1040
Paleoenvironments & Paleobotany 1		
Chair: Daphne Lee		
Tim Naish. The Andrill Programme		1040-1100
Martin P. Crundwell et al. A New Middle Miocene Time Scale		1100-1120
Cam Nelson et al. Paramoudra Concretions & possible Late Miocene Methane Seep Field, Taranaki		1120-1140
Penelope J. Cooke et al. Carbon Isotopic Events, Hole 593, S Tasman Sea: Regional Palaeoproductivity		1140-1200
Kyle Bland et al. Miocene-Pliocene Onlap Limestone Beds, western Forearc Basin, Hawke's Bay		1200-1220
	Lunch: own arrangements	1220-1320
Paleoenvironments & Paleobotany 2		
Chair: Cam Nelson		
Ian Graham. Fe-Mn Nodules from the SW Pacific: Paleo-Environmental Information for the past 15 m.y.		1320-1340
V. Thorn & R. DeConto. Paleogene Antarctic Palaeoclimate: Proxy Vegetation Records vs GCM		1340-1400
J. Ian Raine. Eocene to Miocene Vegetation History and Climate, Ross Sea Region, Antarctica		1400-1420
Michael Hannah. Miocene Ice Sheet Fluctuations: Site 1165 Palynofloras, Prydz Bay, Antarctica		1420-1440
Elizabeth Kennedy & Brent Alloway. Terrestrial Mid-Pleistocene Lake Deposits near Ormond, Gisborne		1440-1500
	Afternoon Tea in Union Hall	1500-1530
Paleoenvironments & Paleobotany 3		
Chair: Mike Hannah		
Jon K. Lindqvist & Daphne E. Lee. Pikopiko fossil forest and associated leaf remains, (Late Eocene), Southland		1530-1550
Ellen Cieraad & Daphne E. Lee. Fern Macrofossils and Spores, Late Eocene Pikopiko Fossil Forest, Southland		1550-1610
J.M. Bannister et al. Late Eocene Epiphyllous Fungi from Pikopiko, Southland		1610-1630
Tangney D.J & Kennedy D.M. Role of Woody Debris on Sandy Beaches		1630-1650
-		1650-1710
-		1730-1830

CONFERENCE PROGRAMME FOR WEDNESDAY 3 DECEMBER

	CASTLE 1	CASTLE 2
	Plenary 2	
	Chair: Richard Norris	
0840-0845	Daily Notices	
0845-9015	U. Cochran et al. Subduction Earthquake Geology in Northern Hawkes Bay, New Zealand	-
0915-0945	Michael Crozier. Geomorphic Landslide Systems of New Zealand	-
0945-1010	-	-
1010-1040		
	Cretaceous 1	**Quaternary Stratigraphy 1**
	Chair: Nick Mortimer	*Chair: David Barrell*
1040-1100	Hamish Campbell. The Chathams: Emergent Zealandia at its Most Stable	Phil Shane. 70-Kyr Record of Tephra Dispersal Reveals El Niño-Like Wind Patterns over Northern NZ
1100-1120	Andy Tulloch et al. Margin-Parallel Paired Magmatic Belts in Baja-California and NZ at ~ 160-90 Ma	R.S. Marx et al. The Evolution of Lake Rotorua
1120-1140	Tanya Ewing et al. SHRIMP Dating of the Loch Burn Formation, Fiordland: Implications for the MTZ	Vern Manville. Volcanogenic Floods in the Taupo Volcanic Zone
1140-1200	Anekant Wandres & John Bradshaw. Igneous Clasts & Mesozoic Gondwana Margin Configuration	Glenn. R. Hughes & David. M. Kennedy. Late Quaternary Evolution North Horowhenua Coastal Plain
1200-1220	Aaron Stallard & David Shelley. Getting into Shape: Foliation Development Within the Otago Schist	Craig Woodward. Multiproxy investigation of environmental change in Lake Forsyth, last 150 years
1220-1320 1230	Historical Studies Group Meeting	
	Cretaceous 2	**Quaternary Stratigraphy 2**
	Chair: Andy Tulloch	*Chair: Bruce Hayward*
1320-1340	John Stewart. Structure and Stratigraphy, Mount Camel Terrane, Northland	Bruce W. Hayward et al. Foraminiferal record of human impact on estuarine environments, Auckland
1340-1400	N. Mortimer et al. Basement Rocks from Wishbone Ridge and Chatham-Subantarctic Margin	Michael Millar et al. Late Holocene Sea Level Curve from Inter-Tidal Benthic Forams, Whanganui Inlet
1400-1420	Mark S. Rattenbury et al. Structural Grain & Regional Markers, Torlesse of N Canterbury and Marlborough	Ashwaq Sabaa et al. Benthic Foraminiferal Record of the Late Quaternary Bounty Trough
1420-1440	N.G. Powell. Evidence from Matakea Group, Otago, for Windy Arid Conditions in Late Cretaceous NZ	Jamie Wood. Quaternary Geology, Climate and Biota at Mason Bay, Stewart Island
1440-1500	Jon K. Lindqvist. Kspar, Carbonate & Sulphide Cements, Late Cretaceous-Paleocene, South Otago	Maureen Marra. Last Glacial Maximum Beetle Fauna, Lyndon Stream, Rakaia River Valley
1500-1530		
	Petrology 1	**Quaternary Stratigraphy 3**
	Chair: Mark Rattenbury	*Chair: Mike Crozier*
1530-1550	Kari Bassett and Matthias Bernet. Provenance Analysis of Mt Somers Quartz Arenite Using Integrated SEM-CL	Philip Burge. A test of the New Zealand terrestrial glaciation model using beetle fossils
1550-1610	Shaun L.L. Barker & Richard H. Sibson. Earthquake Generated Pseudotachylyte in Central Otago	David Barrell and Jane Forsyth. Holocene Sedimentation Processes, Upper Rangitata Catchment
1610-1630	R.H. Sibson et al. Quartz Vein Systems Hosted by Strike-Slip Faults, Proterozoic Mt Isa Inlier, Australia	Henrik Rother. Late Pleistocene Glacial Geology in the Waiau - Hope Hurunui Valley System
1630-1650	Ruth H. Wightman & Timothy A. Little. Stress Conditions, Fluid Pressure and Embrittlement above the Alpine Fault	Philip Barnes & Richard Pickrill. NZ Fiords: Environmental Changes since the Last Glacial Maximum
1700-1800	**Geol Soc NZ AGM**	
1900 onwards		
2000-2300		

CONFERENCE PROGRAMME FOR WEDNESDAY 3 DECEMBER

BURNS 2	OTHER VENUE	
		0840-0845
-		0845-9015
-		0915-0945
-	Posters with authors in Union Hall	0945-1010
	Morning Tea in Union Hall	1010-1040
-		1040-1100
-		1100-1120
-		1120-1140
-		1140-1200
-		1200-1220
	Lunch: own arrangements	1220-1320 1230
-		1320-1340
-		1340-1400
-		1400-1420
-		1420-1440
-		1440-1500
	Afternoon Tea in Union Hall	1500-1530
-		1530-1550
-		1550-1610
-		1610-1630
-		1630-1650
		1700-1800
	Knox College drinks (prepaid only)	1900 onwards
	Conference Dinner (prepaid only)	2000-2300

CONFERENCE PROGRAMME FOR THURSDAY 4 DECEMBER

	CASTLE 1	CASTLE 2
	Plenary 3	
	Chair: Tim Naish	
0840-0845	Daily Notices	-
0845-9015	R.M. Carter. Marshall Paraconformity: Marker for the Inception of Global Thermohaline Circulation	-
0915-0945	B.V. Alloway et al. Onshore-Offshore Correlation of Pleistocene Rhyolitic Eruptions from NZ	-
0945-1010	-	-
1010-1040		
	Petrology 2	**Paleontology 1**
	Chair: Lorraine Paterson	*Chair: Roger Cooper*
1040-1100	J.M. Palin et al. Zircon chronochemistry of Large Felsic magma bodies: Yellowstone and TVZ	J.B. Waterhouse. Early and Middle Triassic Ammonoids from New Zealand
1100-1120	Victoria C. Smith et al. Geochemical & Mineralogical Evolution Okataina Volcanic Centre, last 45 Kyr	D.C.H. Hikuroa. Diverse Mid - Late Jurassic Marine Fauna from Ellsworth Land, Antarctic Peninsula
1120-1140	B.P. Garden & A. Reay. Kakanui: diamonds or no diamonds? This is the question.	Michael K. Eagle. Cretaceous Crinoidea in Terrane Cover Rocks of New Zealand
1140-1200	Thomas Platz et al. Low-pressure fractionation, Nyiragongo volcanic rocks, Virunga Province, DR Congo	Abigail M. Smith & Marcus M. Key, Jr. From Plate Tectonics to Bryozoan Evolution
1200-1220	Travis Cross. Geochemistry and Morphology of Speleothems, Bulmer Cavern, NW Nelson	Graeme J. Wilson, Poul Schiøler, Norton Hiller, Craig M. Jones. Age and Provenance of Marine Reptile Specimens
1220-1320		
1230	Paleontology Special Interest Meeting	
	Petrology 3	**General 2**
	Chair: Michael Palin	*Chair: Ewan Fordyce*
1320-1340	John A. Gamble et al. Petrology & age of West Antarctic Rift System from peridotite xenoliths in basalts	B. Morrison, I. Matcham, M. Edge, J.I. Raine, N. Mortimer, et al. GNS Databases on the web Part 2: FRED and STRATLEX
1340-1400	Roland Maas & Richard C. Price. Sm/Nd & Rb/Sr Isotopes of gneisses, Windmill Islands, East Antarctica	A.G. Hocken. James Hector before New Zealand
1400-1420	David N.B. Skinner. Geochemistry of Robertson Bay Group (Antarctica) & Correlation with Greenland Group	Murray R. Gregory. Hepworth's Missing Fern Leaf & Voy's Missing Moa Footprints – Revisited and Updated
1420-1440	Richard Jongens. High Grade Rocks of the Bonar Range, Central Westland	John S. Buckeridge. Ethics, Lies and the Earth Sciences
1440-1510		
1440	Multiday fieldtrip participants	
	Plenary 4	
	Chair: Richard Norris	
1510-1540	Rick Sibson. On Fault Structure and the Uses of Earthquakes	-
1540-1600	Student Awards & Closing of Conference	-
1730		

CONFERENCE PROGRAMME FOR THURSDAY 4 DECEMBER

BURNS 2	OTHER VENUE	
-		0840-0845
-		0845-9015
-		0915-0945
-	Posters with authors in Union Hall	0945-1010
	Morning Tea in Union Hall	1010-1040
INTIMATE workshop (no abstracts)		
Convenor: Jamie Shulmeister		
Introduction to the Australasian INTIMATE project		1040-1100
Matt McGlone. Interpretation of the pollen record during the last deglaciation		1100-1120
Maureen Marra. Environmental reconstruction vs paleoclimate from beetles		1120-1140
Phil Shane. Critical deglacial tephra markers and their age models		1140-1200
Barbara Manighetti. The marine record during the deglaciation		1200-1220
	Lunch: own arrangements	1220-1320 1230
INTIMATE workshop		
Convenor: Jamie Shulmeister		
Discussion: Developing the Australasian INTIMATE protocol		1320-1340
Discussion: Time range, key transitions		1340-1400
Discussion: Age model protocols		1400-1420
Discussion: Goals and outputs		1420-1440
	Afternoon Tea in Union Hall	1440-1510 1440
-		1510-1540
-		1540-1600
	Fieldtrip 6 (S Alps) leaves St. Margarets College	1730

CONFERENCE PROGRAMME FOR FRIDAY 5 DECEMBER

	BURNS 2	OTHER VENUE
0800		Fieldtrip 7 (Median Batholith) leaves St. Margarets College
	Association of Australasian Palaeontologists Workshop	
	AAP 1	
0850-0900	Welcome & opening (James Crampton)	
0900-0930	**KEYNOTE** James Maclaurin. Diversity and its Measurement: A Philosophical Overview	
0930-0950	Michael K. Eagle & Daniel Hikuroa. Echinodermata Biodiversity, Latady Formation, Ellsworth Land, Antarctica	
0950-1010	Peter Lockhart. How Old is New Zealand's Extant Biodiversity? Estimates from Plant DNA	
1010-1040		Morning Tea
	AAP 2	
1040-1100	Mary Morgan-Richards et al. How Old is New Zealand's Extant Biodiversity? Invertebrate DNA Estimates	
1100-1120	Margaret A. Harper. A Case Study of Changes in Taxa Lists over Time, Based on Oamaru Diatomite	
1120-1140	Austin J.W. Hendy. Using the Literature to Analyze Ecological Patterns in Biodiversity Change	
1140-1200	Phillip Maxwell et al.. Size Matters in Molluscan Paleobiodiversity Censuses	
1200-1230		Lunch
1230-1300	AAP Business Meeting	
	AAP 3	
1330-1410	**KEYNOTE** Roger Cooper & Peter Sadler. Running Standing Diversity Curve - Estimating Past Biodiversity	
1410-1430	Murray R. Gregory. Terebellina, Torlessia and some other Simple Tubular (Including Trace) Fossils	
1430-1450	Tatsuro Ando. NZ Fossil Penguins: Diversity in the Latest Oligocene/Earliest Miocene	
1450-1520		Afternoon Tea
	AAP 4	
1520-1600	**KEYNOTE** James Crampton et al. A Pail Of Snails And A Can Of Worms! NZ Cenozoic Mollusc Biodiversity	
1600-1620	Craig Jones et al. Spatial Biodiversity of Extant Marine Molluscs in the New Zealand Region	
1620-1640	R. Ewan Fordyce. New Oligocene Dalpiazinids, Waitaki Region: increasing the diversity of platanistoid dolphins	
1640-1700	Closing of workshop (Roger Cooper)	

SATURDAY 6 DECEMBER

	BURNS 2	OTHER VENUE
0800		Fieldtrip 8 (Canterbury) leaves Geology Dept Car Park (opposite St. Mag's)
0830		Fieldtrip 9 (Paleobotany) leaves St. Margarets College

POSTERS

by poster number & theme

Includes Trade Displays

Trade Displays

1	Eagle Technology	ESRI GIS products
2	GNS	Publication sales

Cretaceous & General

3	B. Morrison, I. Matcham, M. Edge, J.I. Raine, N. Mortimer, D. Kelly & J. Crampton	GNS Databases on the web: PETLAB, FRED AND STRATLEX
4	Simon Nathan	Charles Douglas and the Giant Geological Map of South Westland
5	Kyle Bland, Peter J.J. Kamp & Campbell S. Nelson	A new 1:50,000 Scale Geological Map of the Patoka-Te Pohue-Tutira area, Western Hawke's Bay
6	Adam J. Vonk & Peter J.J. Kamp	Geological Map at 1:50,000 Scale of the Eastern Taranaki Peninsula Region
7	Francesca C. Ghisetti , L. Vezzani & A. Festa	The Exhumed Miocene-Pliocene Accretionary Wedge of the Central Apennines (Italy). The new 1:100,000 Geological Map of Molise
8	Michelle Baker, Cathy Rufaut, Carol Smith, Dave Craw & Candace Martin	An interdisciplinary approach to monitoring the rehabilitation of a New Zealand mine site
9	Andy Burgess, Steve Weaver & David Shelley	Emplacement Mechanism and Geochemical Zoning of the Separation Point Batholith, Northwest Nelson
10	Andy Tulloch, Ian Turnbull, Trevor Ireland & Dave Parkinson	Nature of Eastern Campbell Plateau Basement: Age and Character of a Granite Xenolith from a Late Cenozoic Lava Flow on Antipodes Island
11	Witold Fraczek & Oli Helm	Global Undulations
12	J. M. Lee, I.M. Turnbull, D.J.A. Barrell, B. Lukovic & M.S. Rattenbury	Procedures for Upgrading QMAP Digital Data – A Pilot Study
13	Kerry Leith, Jarg Pettinga & Jim McKean	The Relationhip Between Deep-Seated Landsliding and the Geomorphic Evolution of the Esk River Valley, Hawke's Bay
14	V. Mathavan, Mark S. Rattenbury & Nick Mortimer	Geochemical Variation in the Dunedin Region: A Study Combining the QMAP and PETLAB Databases
15	Sarah Milicich, Chris Hendy & Peter Kamp	Helium Isotope Dating: an Application to Antarctic Lacustrine Carbonates
16	Mo Turnbull & Andrew Allibone	Geology of the Murihiku Area: Qmap Sheet 20

Petrology

17	Kari Bassett, Franz Ettmuller & Matthias Bernet	Provenance Analysis of the Paparoa and Brunner Coal Measures using the Integrated SEM-Cathodoluminescence Technique
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ABSTRACTS

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ONSHORE-OFFSHORE CORRELATION OF PLEISTOCENE RHYOLITIC ERUPTIONS FROM NEW ZEALAND: IMPLICATIONS FOR TVZ ERUPTIVE HISTORY & PALEOENVIRONMENTAL RECONSTRUCTION

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Taupo Volcanic Zone (TVZ), in the North Island, New Zealand, is probably the most active Quaternary rhyolitic system in the world. Numerous widespread rhyolitic tephra layers, sourced from the TVZ, form valuable chronostratigraphic markers in onshore and offshore sedimentary sequences. In deep-sea cores from Ocean Drilling Program sites 1123 and 1124, located east of New Zealand, *c*.100 tephra beds are recognised post-dating the Plio-Pleistocene boundary at 1.81 Ma. The tephras have been dated by a combination of magnetostratigraphy, orbitally tuned stable-isotope data and isothermal plateau fission track ages. The widespread occurrence of ash offshore to the east of New Zealand is favoured by the small size of New Zealand, the explosivity of the mainly plinian and ignimbritic eruptions and vigorous prevailing westerly winds.

Though some tephras can be directly attributed to known TVZ eruptions, there are many more tephras represented with the ODP-cores that have yet to be recognised in near-source sequences. This can be attributed to proximal source area erosion and/or deep burial as well as the adverse effect of vapour phase alteration and devitrification within near-source welded ignimbrites. Despite these difficulties, a number of key deep-sea tephras can be reliably correlated to equivalent-aged tephra exposed in uplifted marine back-arc successions of Wanganui Basin where an excellent chronology also exists based on magnetostratigraphy, orbitally tuned stable-isotope data and isothermal plateau fission track ages. Significant Pleistocene tephra markers include: Kawakawa, Rangitawa, Onepuhi, Kupe, Kaukatea, Kidnappers-B, Potaka, Ridge, Pakihikura, Birdgrove, Ototoka, Table Flat and Vinegar Hill Tephras.

The identification of these Pleistocene TVZ-sourced tephras within the ODP-cores, and their correlation to Wanganui Basin is a significant advance for two reasons. Firstly, it provides an even higher-resolution history of the TVZ than can be currently achieved from the near-source record and secondly, it yields a detailed and reliable tephrochronologic framework for future paleoenvironmental reconstructions.

TIDAL ZONATION OF SURFACE BIOTA IN ARAWOA INLET, NW NELSON, AND THEIR UTILITY AS A SEA-LEVEL PROXY

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Awaroa Inlet is the largest estuary in the Abel Tasman National Park at 290 ha, contains an extensive salt marsh community and appears to have been tectonically stable for at least the past 1.7ka. This provides an excellent depositional environment in which to investigate the surface zonation of biota with respect to their elevation above sea level in order to provide a proxy indicator for sea-level variation during the Holocene. A sand spit forms the seaward boundary of the inlet, most of which is exposed at low tide. Coarse sand and gravel dominates the lower part of the estuary, however its upper reaches are composed of fine sand and silt which form extensive flats that are exposed at low tide. The bay is protected from open-ocean waves by the sand spit and is meso-tidal with a mean diurnal range of 4.5 m.

To establish a precise indication of tidal inundation in Awaroa Inlet a tidal gauge was installed and a survey of tidal height undertaken. The tidal cycles corresponded closely with those measured at the Port of Nelson; however a lag in the timing and elevation of the tide was noted between the open ocean and within the inlet due to the friction of the marsh surface at high tide; however there was no significant difference at low tide. A detailed survey of the surface vegetation and biota, mainly foraminifera, was then undertaken to assess the degree of modern tidal zonation across the marsh surface. Three agglutinating foraminiferal associations were found to have moderately to well-constrained vertical ranges, between mean high water neaps and lowest astronomical tide. Two calcareous foraminiferal assemblages were well constrained to below mean high water neaps. These zones provide an excellent basis for estimating paleo sea level heights. These assemblages did however appeared to preserve poorly in the subsurface of the salt marshes which would limit their usefulness to those environments where the preservation potential of foraminifera is higher.

POSTER

NEW ZEALAND FOSSIL PENGUINS: DIVERSITY IN THE LATEST OLIGOCENE/EARLIEST MIOCENE

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Penguins are flightless, wing-propelled sea birds restricted to the Southern Hemisphere with highest diversity in temperate regions. Their fossil extends back to 50-60 Ma, and is also only southern. The distribution and diversity of penguins is assumed to be tightly linked with the environmental changes in the Southern Hemisphere.

In New Zealand, the record of fossil penguins starts in the Paleocene, is patchy in the Eocene, and is relatively dense from Late Eocene to earliest Miocene (~24 Ma). Thereafter, the record is poor until the Late Miocene (5~10 Ma). The morphological disparity of penguin fossils before the Early Miocene is greater than for the Late Miocene-Recent, suggesting perhaps a wider-range of life modes in the past.

Among the range of fossils from New Zealand, two forms from the latest Oligocene/earliest Miocene (~24 Ma) rocks of South Canterbury contrast markedly with such archaic forms as the giant "*Palaeeudyptes*" species. One, the 'Hakataramea bird,' is a tiny species in which the wing bones show mosaic features: the head of the humerus is almost identical with that of modern penguins, but some other wing characters are much more archaic. This tiny bird may be a functional predecessor of modern penguins in terms of ‘under-water flying’, and an ecological equivalent of living Blue penguins, *Eudyptula*. The contemporaneous *Platydyptes* includes middle-sized to large birds. The wing and pectoral elements of *Platydyptes* are distinctly robust, and the proportion of limb elements differs from that of modern penguins. Such differences indicate that *Platydyptes* had some functional/ecological differences from both modern and fossil penguins. The 'Hakataramea bird' and *Platydyptes* represent important stages in the modernisation of penguins. Driving forces, whether biotic - e.g., ecological partitioning - or ultimately physical - e.g. changes in Southern Ocean - are uncertain for now.

At present, one of the most vexing issues in penguin history is the dearth of fossils from much of the Miocene, both in New Zealand and elsewhere. It is in this interval that species close to the modern radiation might be expected. Given that the relevant rocks have not been prospected much, the lack of Miocene fossils from New Zealand is as likely an observer bias as a real absence.

THE LATE QUATERNARY PALEOECOLOGY AND PALEOCLIMATE OF GOLDEN BAY, NORTHWEST NELSON, NEW ZEALAND

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The pollen and climate record for northwest Nelson is of particular importance because the Northwest Nelson Botanical Province is one of the most floristically diverse regions in New Zealand and the region is one of three presumed major plant refugia during glacial periods. Despite this assumption there are no geological records for this refugium, probably because many of the areas investigated for vegetation histories are now known to have been glaciated. As a result a long pollen record is vital to our understanding of Holocene and Late Quaternary palaeoecology, glacial and climate history in New Zealand.

A series of cores have been taken from sites located on the Takaka Hill and the west side of the Takaka valley, and it is possible that these sites may contain pollen records that extend through the (Last Glacial Maximum) LGM. In addition to the pollen record, other data will also be analysed, including Chironomids (which are sensitive to a variety of environmental factors), Loss On Ignition (to give organic content of the sediments), and identification of macrofossils including seeds and leaves. From these data past climatic and environmental conditions and fluctuations will be inferred for Northwest Nelson since the LGM.

Special emphasis will be placed on interpretation of the data with respect to the northwest Nelson Glacial Plant Refugium. A major factor impacting native vegetation in New Zealand during the last 1000 years has been the arrival of humans (both Maori and European) and subsequent land clearance. The effects of human settlement in the Takaka region will also be investigated.

POSTER

A LATE HOLOCENE RECORD OF VEGETATION CHANGE FROM WHANGANUI INLET AND MANGARAKAU SWAMP, NORTHWEST NELSON

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Whanganui Inlet and Mangarakau Swamp have remained tectonically stable throughout the late Holocene, providing a useful record of environmental change for the northwest Nelson area. This research aims to document vegetation change from pollen preserved in both the terrestrial peat sediments of Mangarakau Swamp and the estuarine mud cored from Whanganui Inlet. To this end seven vibracores were extracted from Whanganui Inlet and two peat cores from Mangarakau Swamp. Radiocarbon samples provide an age of up to 7.7 ka in estuarine cores and 6.5 ka in terrestrial samples.

Four zones have been identified from terrestrial peat sub-surface samples; the first is a shrub-land zone dominated by *Coprosma*, *Myrsine* and silver beech, with canopy trees under represented. In zone two a rimu forest dominates, kahikatea, *Ascarina lucida*, tree ferns and manuka type pollen are also common and increase throughout the zone. Red beech does not grow locally (>10%) here until ~5 ka. Zone three is characterised by a mixed beech and rimu forest, red beech type pollen dominates the aboreal pollen assemblage, while rimu and kahikatea percentages decrease correspondingly. A decline in fern taxa and *Ascarina lucida* in this zone identifies a deterioration in climate at approximately 3.5 ka. The fourth zone is defined by the appearance of exotic taxa, notably pine, coinciding with a decline in forest species, this represents the modern pollen rain.

Converse to Mangarakau Swamp, it is assumed that pollen preserved in the sediments of Whanganui Inlet is recruited largely (~95%) from inlet's hinterland. Three zones have been recognised in the estuarine cores; in zone one rimu dominates the canopy cover however, *Ascarina lucida* and red beech type pollen also grow within the catchment area. The second zone is characterised by a mixed more mature forest, red beech dominates the canopy trees but rimu remains a significant component, a decline in ferns and fern allies and *Ascarina lucida* identifies the same deterioration in climate recognised in swamp sediments. Zone three is defined as the modern pollen rain, where forest clearance precedes the introduction of exotic taxa.

Pollen assemblages differ markedly between the two sites. Changes in the pollen from local vegetation (in estuarine sediment) are overwhelmed by the influx of grains collected from the wider catchment area, *Cyathea* pollen is also over-represented. Unlike the estuarine samples wetland and herb taxa are well represented in the samples taken from Mangarakau Swamp. This set of cores provides two distinct records of vegetation change during the late Holocene for NW Nelson.

POSTER

AN INTERDISCIPLINARY APPROACH TO MONITORING THE REHABILITATION OF A NEW ZEALAND MINE SITE

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The Wangaloa opencast coal mine in southeast Otago was closed in 1989. Rehabilitation of the 75 ha of disturbed land and waterways is an essential part of Solid Energy's end of mine life plans (EOML). Consequently, the site is being contoured for stabilisation, pest control plans are in place and an extensive revegetation project using native plant species is near completion. The landowner's goal is to have the site available for public recreational use before the coal mining licence expires in 2007.

However, initial studies reveal low pH values in soil, groundwater, and surface waters as a result of acid rock drainage (ARD). Surface waters contain elevated levels of As, Cu and Zn, the main lake has pH around 4.9, and unexpectedly high levels of boron were measured in needles of *Pinus radiata* planted on overburden deposits. Baseline data arising from Wangaloa suggests that the restoration of structure and function to the site, particularly over short time frames, will be prove to be a challenge.

In recognition of the multifaceted environmental issues occurring at Wangaloa, an interdisciplinary research team at the University of Otago will complete a holistic and comprehensive study that characterises and models restorative processes at the Wangaloa opencast coal mine site. We present an outline of this style of approach to restoration research, and how it interacts alongside inputs from land managers. As an example of this interdisciplinary approach, one study is investigating a small-scale chronosequence on coal mine overburden deposits in relation to underlying soil properties and microarthropod populations.

POSTER

A COMPARATIVE POLLEN ANALYSIS OF PEAT WITH NEIGHBOURING PALAEOSOLS AT THREE SITES IN THE TONGARIRO VOLCANIC CENTRE, NEW ZEALAND

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The usual source of pollen for analysis has been from within deposits of peat from lakes, bogs and mires. Soils have not generally been considered potentially useful as a pollen source. Under some circumstances, however, (such as volcanic eruptions) a soil may be buried so rapidly that the pollen it contains will be more or less completely preserved in the resulting palaeosol.

The purpose of the present investigation was to examine and compare the results of pollen analysis from peats and palaeosols directly beneath the Taupo Ignimbrite. The results indicate that palynomorphs in peat samples were better preserved, and also included a more regional representation of the vegetation. The palaeosol samples contained fewer taxa and were more representative of a localised pollen rain from under a closed canopy. However, in the absence of suitable peats for pollen analysis, palaeosols may preserve palynomorphs in substantial and comparable numbers, and may therefore provide useful evidence for reconstruction of past vegetation assemblages.

POSTER

LATE EOCENE EPIPHYLLOUS FUNGI FROM PIKOPIKO, SOUTHLAND, NEW ZEALAND

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Several different types of leaf surface (phylloplane) fungi have been isolated from 40 million year old carbonaceous leaves from the Pikopiko fossil forest near Tuatapere, Southland. The fungi include species of *Meliolinites*, *Asterina*, *Trichopeltinites*, *Entopeltacites*, *Quillonia*, *Callimothallus* and various other microthyriaceous shields, fungal germlings, and an assortment of spores, setae and hyphae. The fungi are illustrated and compared with those recorded from late Cretaceous and Cenozoic fossil leaves from S.E. Australia. None of these fungi have been reported from fossil leaves in New Zealand previously, although some fructifications and spores have been noted in palynological preparations. This diverse assemblage of fungi is associated with a variety of angiosperm leaves, mainly dicotyledonous, and suggests that climatic conditions in this late Eocene fossil forest were warm temperate and humid.

EARTHQUAKE GENERATED PSEUDOTACHYLYTE IN CENTRAL OTAGO, NEW ZEALAND

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Fault hosted pseudotachylytes have been attributed to friction melting during seismic slip episodes. Near Alexandra, Central Otago, New Zealand, a series of subparallel, NNE-SSW trending, shallow dipping (10-30^{o} E) brittle faults are hosted in TZ III quartzofeldspathic schist. These faults contain numerous (n > 100) black, aphanitic pseudotachylyte veins, which are generally 0.5-2 cm thick and lying subparallel to foliation.

Chill margins, crystallites, embayed lithic clasts, flow banding, and the creation of mineral phases that are absent in the host rock provide unequivocal evidence for melting during formation of the pseudotachylyte. Quartz and lesser plagioclase are present in pseudotachylyte veins as lithic clasts, while potassium feldspar microlites, ultra-fine grained chlorite (probable devitrified glass), and amygdules containing a high-temperature mineral assemblage (quartz, titanite, potassium feldspar, graphite, chlorite) form the bulk of newly crystallised material. Geochemical studies suggest that muscovite was preferentially incorporated in pseudotachylyte, while plagioclase was excluded. Melt temperatures of 900-1100 ^{o}C are inferred. The absence of primary hydrothermal phases in pseudotachylyte veins suggests that pseudotachylyte formation occurred in a 'dry' environment, with no pore fluid present.

Dilational jogs in fault-veins and injection-veins, and fault drag indicate a general top-to-the-north shear sense. Fault veins are traceable along strike for distances of up to 200 m. Fault separations inferred from offset pseudotachylyte veins, dilational jogs and a piercing point analysis suggest the pseudotachylyte was generated by slip increments of < 1 cm to 20 cm, comparable to those believed to occur during small to moderate earthquakes.

Heat-work calculations suggest that the faulting occurred in 'strong', 'dry' crust, at depths of 6-12 km, with shear stress at slip initiation exceeding 200 MPa on pseudotachylyte generating faults. Furthermore, displacement/rupture length ratios on faults imply that relatively high shear stress drops (~ 30 MPa) accompanied pseudotachylyte formation.

A preliminary U-Pb titanite date yields an age of 99 ± 23 Ma for pseudotachylyte formation. It is suggested that the pseudotachylyte-bearing faults were subhorizontal faults, which formed in association with regional extension during the mid-late Cretaceous, and are possibly related to the exhumation and uplift of the Otago Schist Belt.

WHO KILLED BERNICE? THE DEATH AND DISMEMBERMENT OF A CRETACEOUS PLESIOSAUR (PART ONE).

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An elasmosaurid plesiosaur was found preserved in a large concretion in the Late Cretaceous Conway Formation at Waipara River. It has been partially prepared, and is currently stored at Canterbury Museum, Christchurch. The trunk and limb skeleton are disarticulated, and the head, neck, and other bones are absent. The latest sedimentological, paleontological and geochemical data contributing to the taphonomic history of the animal will be presented.

The skeleton is extremely well preserved, and shows little sign of fragmentation. It does have visible scratchmarks and gougemarks that may be attributable to predation and/or scavenging. Results of a long-bone orientation study has shown that ribs, gastralia and limb-bones are aligned, possibly by currents.

The study of taphonomy incorporates death, decay, incorporation into surrounding sediment, and fossil preservation ("the science of dead, rotting things accompanied by a terrific stench" (Martin, 1999)). Numerous taphonomic analyses have been conducted both on terrestrial mammal remains and marine invertebrates, but large marine organisms have received little attention. One experiment conducted into the deep-water taphonomy of a whale skeleton provides the background for this research, and shows that large animals can be transported long distances after death by floating of the carcass by decomposition related gasification. Reptile taphonomy, especially in a marine setting, has received even less attention. Observed differences in the depositional environments and physiology of the subjects will mean that this project will follow a multidisciplinary approach.

Sedimentation rate and grain size analysis is being conducted to determine the environmental setting, and provide constraints on the possibilities for transport of the carcass. Also of interest are components of biological interaction, diagenesis and the timing of concretion growth. Geochemical mapping (using XRF/XRD) will identify geochemical and biological markers related to bioerosion and decay processes, which will be used to determine the dominant decay pathway, rate of burial, environmental conditions, and paleoproductivity.

A combination of sedimentology and physical modelling will provide more data on the bone alignment preserved in the concretion, and determine the influence of current action, biological interaction and decay processes on the disarticulation of the skeleton.

POSTER

THE NEW ZEALAND FIORDS: ENVIRONMENTAL CHANGES SINCE THE LAST GLACIAL MAXIMUM

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From a global perspective, the New Zealand fiords are unique. Their geomorphic and sedimentary evolution since the peak of the last glaciation reflects the tectonic plate boundary setting, the complete deglaciation of relatively small catchments, and the predominantly eustatic signal of rising sea-level. Within this framework, there is a wide variety of present fiord architecture, with several fiords representing different stages in maturity. We present archived and new bathymetric, sedimentary, and geophysical data that allow us to evaluate the sedimentary evolution of the fiords from peak glaciation to present day.

At the peak of the last glaciation (c. 20 ka), tide-water glaciers filled the fiords, excavated existing sedimentary deposits, and extended to the edge of the narrow continental shelf. Vast glacio-marine sedimentary fans swathed across the steep western continental margin and the Alpine Fault, and flooded deep-water sedimentary basins. Rapid glacial recession created freshwater lakes which were entrapped behind entrance sills, and accommodated thick lacustrine sediments between c. 17-10 ka. Eustatic rise of sea-level resulted in transgression of shallow sills about 10-7 kyr ago, and a change to marine fiord environments. As sea-levels stabilised in the Holocene, littoral sediment drift occurred at the open coast during the last 7 kyr, creating barrier spit formations that in some cases returned the fiords to entrapped lakes with estuarine circulation, and in extreme cases, to freshwater lakes. Post-glacial environmental changes in Fiordland have, thus, been complex and astonishingly rapid.

Understanding the evolution and contemporary sedimentation processes in the New Zealand fiords are important for two main reasons. Firstly, they enable generic models of fiord evolution to be developed for mid-latitude, temperate climate, glacio-marine systems on steep, tectonically active margins. Secondly, they provide a framework for evaluation of slip rates on the southern 230 km of the Alpine Fault.

HOLOCENE SEDIMENTATION PROCESSES IN THE UPPER RANGITATA CATCHMENT, CANTERBURY, NEW ZEALAND

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The landscape of the upper Rangitata catchment comprises steep-sided valleys cut in greywacke and broad valley floors occupied by alluvial fans and braided floodplains. The catchment bears the imprint of extensive Late Pleistocene glaciation and although there are Holocene moraines in the headwaters near the Main Divide, the main Holocene depositional process has been alluvial aggradation. At several sites, river or stream erosion has exposed the alluvial deposits, enabling examination of the sediments, the soils formed on or within them, and radiocarbon dating of enclosed organic materials (Forsyth *et al.* 2003).

At Saint Winifred Stream, 5 km east of the Main Divide and within 2 km east of latest Holocene ("Little Ice Age") moraines, a 10 m high river cliff exposes alluvial sediments and buried soil horizons. There was a period of soil formation at about 2,300 calibrated ^{14}C years B.P. Another phase of soil formation between about 300 and 600 cal. ^{14}C years B.P. was followed by the accumulation of at least 5 m of alluvial gravel. At Sandys Basin, 25 km east of the Main Divide, and near the terminal moraines of a probable latest Pleistocene glacial re-advance, a 40 to 50 m high cliff eroded into alluvial fan deposits exposes a soil that formed approximately 14,900 cal. ^{14}C years B.P. This soil is buried by 5 m of alluvial fan gravel which is overlain by a soil with an age of about 9,500 cal. ^{14}C years B.P. This soil is in turn overlain by about 40 m of alluvial fan gravel which is capped by 1 m of loess. The degree of soil development suggests that the loess has been accumulating for at least several thousand years.

At Sandys Basin, sedimentation has involved phases of aggradation interspersed with periods of stability and soil formation on the fan surface. A similar though shorter record of alternating aggradation and stability is seen at Saint Winifred Stream. There is no simple way of interpreting the causes of fan aggradation events because there are many potential variables. Phases of fan aggradation could result from an increased sediment supply due to a general change in climate and/or vegetation cover, or in response to events such as earthquake-generated landslides, non-earthquake-related landslides, or extreme rainstorms. Alternatively, fan aggradation could simply be due to the main river migrating to the other side of the valley and ceasing to entrain and remove the sediment carried by the fan's stream. Similarly, periods of fan stability may reflect decreased sediment supply, or alternatively could be due to fluvial trimming of the fan toe that produces incision of the stream and abandonment of the fan surface. It is important to consider the local context of fluvial landscape processes before identifying climatic or tectonic signals within alluvial fan sedimentary records.

Forsyth, P.J., Barrell, D.J.A., Basher, L.R., Berryman K.R. 2003. Holocene landscape evolution of the Havelock and Upper Rangitata valleys, South Canterbury, New Zealand. *Institute of Geological & Nuclear Sciences science report* 2003/22. 43p.

LANDSCAPE RECONSTRUCTION OVER THE PAST 14,000 YEARS – WAIHO RIVER FLOODPLAIN, SOUTH WESTLAND, NEW ZEALAND

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Floodplain aggradation over the last few decades threatens the township of Franz Josef Glacier, resulting in efforts to define and understand the factors controlling long-term behaviour of the Waiho river system. Field investigations focused on Tartare Stream, the Waiho's northern tributary, which has incised up to 20 m below the general level of the valley floor since breaching the Waiho Loop moraine a few hundred years ago. The Tartare incision exposes a succession of alluvial deposits with organic-rich silt interbeds and occasional tree stumps in position of growth. Several radiocarbon dates were obtained. In addition, we examined the degree of soil development on the Waiho and Tartare aggradation surfaces. The soils range from Fluvial Recent soils on the youngest surfaces to Immature Brown soils on the oldest. From this we infer that the Waiho-Tartare alluvial geomorphic surfaces range in age from a few decades to mid Holocene.

We used these sources of information to compile a geomorphic map of the Waiho valley floor, along with a set of GIS-based landscape reconstruction maps depicting an interpretation of the evolution of the Waiho valley since the end of the Last Glacial Maximum. The landscape reconstructions depict the extent of landforms as they are inferred to have been at the times in question, along with topographic and/or structure contours on the reconstructed landforms and deposits. The units on the maps are drawn in their present location. They have been affected by Alpine Fault displacement but we did not attempt to correct these offsets.

Reconstructions were produced for 14,000, 13,000, 10,500 and 5,000 radiocarbon years BP. Glacier surfaces were reconstructed from the heights of the lateral or terminal moraine crests, although the extent of ice east of the Alpine Fault is speculative. The 14,000 y BP glacier terminus is depicted to lie just west of the modern coastline, based on a widening and northward swing of the westernmost lateral moraine loop. The extent of the post-glacial lake within a deep glacially-scoured trough is inferred from a –260 m a.s.l depth of glacial sediments in the Waiho-1 drillhole, an absence of bedrock in the Waiho River at the Alpine Fault despite an estimated 140 m of uplift in 14,000 years, and the deepest part of Lake Mapourika lying at 4 m a.s.l despite 14,000 years of sedimentation. The 13,000 y BP reconstruction represents a speculative ice-free period following the main LGM glacial retreat, while the 10,500 y BP reconstruction depicts the Waiho Loop glacier advance. The 5,000 y BP reconstruction is framed around the age of buried in-situ tree stumps in Tartare Stream 20 m below the main aggradation surface. The coastline appears to have either stayed in about its present position, or migrated landwards since about 7,000 years BP. Twenty metres of aggradation in a river system whose length is static or decreasing is surprising. It suggests that either there is subsidence west of the Alpine Fault, or that the river gradient is increasing.

POSTER

PROVENANCE ANALYSIS OF THE MOUNT SOMERS QUARTZ ARENITE USING THE INTEGRATED SEM-CL TECHNIQUE

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Quartz arenites contain >95% quartz as framework grains, including mono-, poly- and microcrystalline grains. Overall quartz arenites are regarded as enigmatic with respect to their provenance. In the past many quartz arenites were described as texturally mature, multi-cyclic sediments with high degrees of rounding and sorting; recent studies have found evidence for first-cycle, angular and poorly sorted quartz arenites.

Combined SEM-CL/optical microscopy analysis of single quartz grains is a new provenance analysis tool for quartz rich sediments. SEM-CL allows identification of a variety of characteristics including microcracks, healed fractures, and zoning in certain quartz types, which are not visible with an optical microscope. Optical microscopy provides information on extinction behavior, mono-, poly- or microcrystallinity. By integrating the techniques on the same quartz grains it is possible to distinguish seven categories of quartz grains such as plutonic, deformed plutonic, volcanic, deformed volcanic, metamorphic/recrystallized, microcrystalline and shocked quartz. This approach is simple and fairly inexpensive, provides valuable new information on quartz provenance, and can easily be combined with other provenance techniques such as point counting, geochemical analyses, or isotopic dating of accessory minerals.

A suite of samples was collected from shallow marine quartz arenites of the Eocene Broken River Formation in the Mount Somers area to test this approach. These quartz arenites have been described in the past as derived from local volcanic source rocks, the Mt. Somers rhyolite dome complex, with minor input from metamorphic sources. Using the new integrated SEM-CL/optical microscopy technique we show that only about half of the quartz grains are locally derived from volcanic sources, while ~20% are from metamorphic/recrystallized sources and the other ~30% are from plutonic sources. There are no local plutonic or metamorphic sources suggesting transport from more distal sources by either large fluvial systems or by longshore currents. Recycling of plutonic quartz grains from low-grade metasedimentary rocks is possible but unlikely, given the relatively low temperature range (300-400ºC) that causes the onset of quartz recrystallization.

The Mount Somers quartz arenites were probably formed partially because of intense chemical weathering of the volcanic source material, which is still evident in an underlying >30 m thick kaolinized rhyolite horizon. Van der Lingen (1988) pointed out the Mount Somers rhyolite is particularly strongly kaolinized where overlain by coal measures. Pore waters rich in humic acids could be important in the process of forming quartz arenites, when highly weathered regolith is mobilized.

Because at least 80% of the grains were derived from primary sources this sediment could be described as a first cycle quartz arenite. We found little evidence of recycled sedimentary quartz with inherited quartz overgrowth, nor partially recrystallized grains from metasedimentary sources. Therefore, we think that recycled quartz might only form a minor component.

PROVENANCE ANALYSIS OF THE PAPAROA AND BRUNNER COAL MEASURES USING THE INTEGRATED SEM-CATHODOLUMINESCENCE TECHNIQUE

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An integrated approach using grain-by-grain comparison of SEM-cathodoluminescence (CL) and petrographic characteristics can generate detailed data for quartz, often a relatively uninformative mineral for provenance analysis. SEM-CL shows CL characteristics and features such as homogeneous, patchy, mottled, zoned, dark or light luminescence, microcracks, light or dark linear features and intragrain boundaries. Petrography shows extinction behaviour, polycrystallinity, grain roundness, shape and size. Graphic illustration of grain properties and their combinations helped to discover significant trends.

This integrated approach was used to investigate the provenance of fluvial/lacustrine quartz-rich lithic arenites deposited in the Late Cretaceous extensional Paparoa Trough. Results show that nearly all polycrystalline quartz grains display either an indistinct patchy/mottled or dark CL appearance indicating recrystallization during metamorphism. Grains with straight extinction, light CL appearance, and microcracks typical of plutonic quartz are also present.

Degree of metamorphism and diagenesis can be identified by this method. Quartz grains with weak undulose extinction and light homogeneous CL appearance indicate that many grains were only slightly metamorphosed or deformed. Light linear features, interpreted as unhealed fractures or surface scratches, show the same trend as dark CL and strong undulosity characteristic of metamorphic quartz indicating they were more vulnerable to surface damage. Together, they show a source that has minor metamorphic overprinting of original features. In addition, grains with straight extinction, normally indicating a plutonic or volcanic source, followed the same trend as grains with dark CL appearance indicating that, in this case, straight extinction behaviour is from disaggregation of polycrystalline quartz. Recycled grains are able to be identified by this method. Dark linear features document fracturing and healing during a previous sedimentary cycle, thus identify recycled grains. A common trend, of decrease in frequency up section, of quartz grains showing dark linear features with different extinction behaviour suggested the presence of a higher-grade metamorphic source.

Graphical analysis of the spatial and stratigraphic distribution of quartz types shows that the quartz in the Paparoa Trough was derived from a relatively low-grade metamorphic source increasing in grade upward, most likely recording the unroofing of the Greenland Group off the Charleston metamorphic complex to the northeast. On the west side of the basin about 15% of quartz grains are from a plutonic source, probably the Barrytown Granite pluton. This provenance information, along with the influx of detrital micas, provides the first concrete evidence for sinistral strike-slip fault movement predicted by tectonic reconstructions.

POSTER

FAULT PARAMETERS OF FIORDLAND M_W7.1 EARTHQUAKE FROM DISLOCATION MODELLING OF GPS DATA

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A preliminary solution for the parameters of the fault that ruptured in the 21 August 2003 Fiordland earthquake has been calculated from GPS data. The post-earthquake data were collected between 29 August and 3 September, so include displacements from some of the larger aftershocks as well as the 21 August main shock. The pre-earthquake data were collected largely in February 2001 by a joint Otago University-GNS team. The interseismic displacements between February 2001 and the time of the earthquake were estimated using a recent version of the New Zealand contemporary deformation model, which is derived from campaign GPS observations over the past 10 years.

To model the depth, position and other parameters of the earthquake fault plane we assume uniform slip on a planar rectangular dislocation in an elastic half-space. We invert for the fault parameters using a non-linear least squares algorithm. We omit the observed displacement data from the Secretary Island GPS station as it shows anomalous motion, possibly as a result of strong shaking from the earthquake; it is our only site located directly over the inferred earthquake fault plane.

For the modelling we fixed the strike of the fault to 30° from the Harvard CMT solution. The inversion software was able to solve for all eight of the other fault parameters. We find a fault plane with length 35±5 km, dip 30°±3°, depth range13±3 to 23±3 km, rake 100°±3°, slip 2.4±0.5 m. The surface projection of the fault plane is partially on shore and lies between Doubtful Sound in the south and Caswell Sound in the north. (The software also finds a solution if all parameters are allowed to be free - the result is a fairly similar model but with a strike of 45° and rake of 120°.) The derived moment of 5.8e19 N m corresponds to a moment-magnitude (M_W) of 7.1, and is somewhat lower than the Harvard CMT value of 7.2. The model predicts coastal uplift of up to 0.4-0.5 m along the Tasman Sea coast of Secretary Island.

The maximum horizontal motion observed at a GPS station was 17 cm WNW at the Museum Range GPS site (DF4Q). The maximum vertical motion was 13 cm subsidence at the same site, though the model gives only 9.5 cm subsidence. At most other stations the modelled vertical agrees with the observations to better than 1 to 1.5 cm.

WHAT'S GOING DOWN IN THE LOWER HUTT VALLEY? SUBSIDENCE ASSOCIATED WITH WELLINGTON FAULT EARTHQUAKES

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In 1855, rupture on the Wairarapa Fault resulted in uplift of c. 6 m at Turakirae Head, 1.2-1.5 m in the Lower Hutt Valley, and uplift across a wide swath of the Wellington peninsula. Rightly or wrongly, uplift associated with this event has coloured expectations of what will happen in the next major earthquake that strikes Wellington. However, geological data from the Hutt Valley provides compelling evidence that most major earthquakes in the region generate local subsidence rather than uplift.

The long term record of vertical deformation on the K Surface (probably ≥5 Ma) in the Wellington region is consistent with the intermediate term record of the last c. 350 ka derived from drillhole data, and with the modern high resolution topographic model (the short term record) in requiring subsidence in the Lower Hutt Valley. In contrast to the net uplift associated with the Wairarapa Fault at Turakirae Head (reflected in the beach ridges and marine benches), net vertical deformation in the Lower Hutt Valley, just 25 km away, is subsidence. The presence of the Port Nicholson/Lower Hutt basin is a legacy of that nett local long term subsidence. Drillhole logs record an alternating sequence of cool alluvial and warm marine climatic deposits beneath the Lower Hutt Valley floor. When correlated with the international sea level curve, the elevations of paleoshorelines (which separate non-marine from marine deposits) reveal information on style and rate of medium-term subsidence. Geological features, such as thickness of Quaternary sediments beneath the western valley, upthrow of the scarp to the NW, and NW-dipping basinal strata close to the Wellington Fault (seismic profiles) all link the SE side of the fault with subsidence.

In the medium- to long-term, subsidence associated with the Wellington Fault in the Lower Hutt Valley overwhelms the uplift associated with Wairarapa Fault earthquakes. In other words, the long term nett subsidence in the Lower Hutt Valley equals the sum of uplift associated with ruptures of the Wairarapa Fault and subsidence associated with Wellington Fault ruptures. Using estimates of mean uplift values for Wairarapa Fault events in the Lower Hutt Valley, and the mean recurrence intervals for Wairarapa and Wellington fault ruptures (1668±390 yrs and 635±70 yrs respectively), single event subsidence for a Wellington Fault earthquake is calculated to be c. 1 m.

By spatially modelling subsidence on the basis of calculated nett subsidence from individual drillhole logs, the present day high resolution topography can be deformed to reflect subsidence expected for the next "typical" Wellington Fault rupture. This synthetic "post-Wellington Fault" topo model has specific relevance for evaluating flood hazard and potential infrastructural vulnerability. Although predominantly a dextral strike-slip fault, the Wellington Fault's vertical component of displacement is very important, particularly in areas of low relief.

ACTIVE FAULTING AND STRAIN AT THE JUNCTION OF THE ALPINE AND HOPE FAULTS, NEW ZEALAND

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Recent geological and fault mapping, and repeat GPS survey in north Westland around the junction of the Alpine and Hope faults has provided new insights into the partitioning of strain at this major kinematic junction. Five principal elements are involved in the transfer of motion from the Alpine fault (25±5 mm/yr dextral slip rate) to the Hope fault (15±5 mm/yr dextral slip rate). These are, from north to south: 1) the western-most part of the Hope fault, along the Taramakau River toward Inchbonnie, which is inferred from offset geological boundaries; 2) the Kelly fault (re-defined); 3) Newton fault (new); 4) Hura fault (new); 5) Taipo-Wilberforce fault alignment (new, informal).

We redefine the Kelly fault from a few kilometres west of Harper Pass, to near the headwaters of Kelly Creek to the west of the Arthur's Pass highway. From there the Kelly fault splays west into the Newton and Hura faults, and southwest into the Taipo-Wilberforce fault alignment. The Newton fault is defined by newly mapped bedrock and geomorphic traces across the Taipo Valley to Newton Saddle, where mid-late Holocene deposits are offset, and into the Arahura River. The Hura fault is the southern splay and tracks over Hura Saddle into the Styx River. Poorly constrained offsets of isotect boundaries along the Newton and Hura faults indicate no more than 1-2 km of total dextral motion, compared with c. 5-7 km total dextral motion on the relict strand of the Hope fault along the Taramakau River. The Taipo-Wilberforce fault alignment is not a single continuous fault but forms a series of steep, largely bedding-parallel faults extending from the recent fault trace in Hunts Creek at least to the Browning Pass area. Sub-horizontal striae in soft clay gouge have been observed on one of these faults in the headwaters of the Wilberforce River, suggesting this zone may be important in accommodating plate boundary dextral shear. The structural position of these faults is similar to the Main Divide fault of the Mt Cook region. The faults are within textural zone I (tzI) greywacke near to Arthurs Pass, but to the southwest they coincide with the tz I/IIA boundary.

Repeat GPS surveying of the Arthurs Pass region shows a marked velocity change coincident with the Kelly fault and its Hura fault extension. To the southeast of these faults, velocities range from 12-20 mm/year whereas to the northwest the velocities decrease to 6-8 mm/year. The implications could be that elastic strain is accumulating on these faults, or that the strain gradient may be "seeing" the locked zone of the dipping Alpine fault. There is no apparent velocity change across the Taramakau strand of the Hope fault suggesting this fault is not accumulating strain. The splayed nature of the Hope fault as it approaches the Alpine fault presents challenges in defining the future fault rupture pattern associated with major earthquakes on both the central Alpine and western Hope faults. The central section of the Alpine fault is usually defined by the junction with the Hope fault at Inchbonnie, but this work indicates the present-day boundary is a further 50 km to the SW near the Hokitika River.

ADVANCES IN UNDERSTANDING EVENTS ON THE SOUTH-WESTERN FLANK OF EGMONT VOLCANO, TARANAKI, NEW ZEALAND.

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About 7000 years ago, a large debris avalanche originated from the south-western flank of Egmont Volcano forming a large amphitheatre, with the resulting deposit (Opua Formation) extending to beyond the present coastline in the Opunake district. Since then, an active period of edifice rebuilding has formed the current summit cone and partially infilled the amphitheatre with an array of lava flows and diamictons derived mainly from block-and-ash flows and smaller debris avalanches. This research project was designed to elucidate these deposits, date them principally using the cover-bed stratigraphy, and to interpret the chronology of geological events.

On the upper slopes the array of criss-crossing lava flows that form the upper part of the summit cone has been mapped downslope into the forest below the tree line. The majority of these flows appear to be younger than 3300 years B.P. based on cover-bed stratigraphy, with a progression in the ages of the flows from older flows to the west and younger flows to the east. The petrology of the lavas suggests that the older flows were partially depleted in hornblende, whereas the younger flows have a greater abundance of hornblende, with some having more hornblende than augite.

On the upper slopes, a large Burrell age (1655 A.D.) pyroclastic-flow deposit covers the headwaters of the Punehu and Mangahume Streams and consists of coarse pale brown pumiceous and lithic blocks with jig-saw fracturing throughout both lithics and pumices. Flux gate magnetometer measurements of the pumices show preferred orientation consistent with high temperature emplacement.

Below the tree line, there is a thick (>60m) sequence of Holocene diamictons. At the base is a unit containing megaclasts which is indicative of debris avalanche origin and hence is correlated with the Opua Formation. Above this is a thick sequence of block-and-ash flow and laharic diamictons. Recent work from nearby, outside Egmont National Park, indicate that some of the larger units in this sequence have travelled beyond the margins of the Park. Here they appear as 0.5-1.5m thick block-and-ash flows evidenced by the presence of charcoal either throughout or at the bases of these deposits.

To the east of the Punehu Stream, field work on Fanthams Peak lava flows around the northern Beehive indicates that they were emplaced about 2400 years ago. The bifurcation of these flows suggests the emplacement of the Beehives preceded these lava flows.

A NEW 1:50,000 SCALE GEOLOGICAL MAP OF THE PATOKA-TE POHUE-TUTIRA AREA, WESTERN HAWKE'S BAY

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The western portion of the Hawke's Bay forearc basin contains a Late Miocene-Late Pliocene sedimentary fill up to 2500 m thick. A new geological map has been produced of an area covering approximately 980 km^2 in western Hawke's Bay as part of a basin analysis investigation. The map presented here represents part of a geological database covering a much larger portion of the Hawke's Bay forearc basin (c. 3,500 km^2) being created as part of this study. The geological map has been produced using ArcGIS 8.3 desktop applications, following the procedures established by the QMAP programme at IGNS. Rocks encompassed in this study are of Jurassic to Quaternary age, though emphasis has been placed on determining the distribution of Late Miocene to Early Pleistocene strata. The latter are dominated by siliciclastic rocks that accumulated in a variety of shelf environments. Although subordinate volumetrically, limestone formations are widespread, as are prominent greywacke conglomerate beds restricted to younger strata in the map. Late Pliocene-Pleistocene units display more prominent cyclothemic characters than earlier beds, reflecting an increased influence of relative sea-level changes on the sedimentation of the region.

New units identified on this map are the Te Haroto, Pakaututu (see Bland *et al.* (a), this volume) and the Puketitiri Formations cropping out in the region of the northern Kaweka Range west of the Mohaka Fault. East of the Mohaka Fault the Waitere and Mokonui Formations represent the equivalent stratigraphic interval. The Puketitiri Formation is overlain by the Te Waka Formation. The Mokonui Formation is overlain successively by the Titiokura, Te Waka and Pohue Formations (all part of the Maungaharuru Subgroup of the Mangaheia Group), and the Matahorua, Waipunga, Esk, Tutira, Aropaoanui, Darkys Spur, Mairau, Tangoio, Te Ngaru, Waipatiki, Devils Elbow and Kaiwaka Formations (Petane Group). Towards the western edge of the map sheet thick deposits of undifferentiated Taupo Pumice crop out, and include some primary ignimbrite and abundant reworked alluvium.

The locations of faults in the North Island shear belt (the Kaweka, Ruahine, Mohaka, Patoka and Rukumoana fault zones) have been mapped where possible, constraining the positions of these features more accurately. Some controls on displacement on these structures have been gained. Post-depositional faulting has had a profound influence on the distribution of formations within the basin.

Mass movement events are important through the region, with slumps and landslides of varying scales present throughout. Much of the area is underlain by poorly-cemented sandstone and siltstone beds that are prone to mass movement failure.

POSTER

LATEST MIOCENE-EARLY PLIOCENE ONLAP LIMESTONE BEDS IN THE WESTERN FOREARC BASIN, HAWKE'S BAY

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Geological mapping on the northern end of the Kaweka Range has revealed occurrences of limestone beds onlapping or near Torlesse basement greywackes (see Bland *et al.* poster presentation, this volume). Until now, these rocks have been mapped as undifferentiated siliciclastic beds, or not considered at all. The name **Pakaututu Formation** has been introduced to encompass these beds as part of a wider forearc basin analysis. These beds provide an important link between Late Miocene onlap units near the Napier-Taupo Road and Early Pleistocene onlap units in southern Hawke's Bay. Elevated areas occur in the vicinity of the Mohaka-Ripia River junctions where prominent coarse-grained limestone beds directly overlie greywacke. Towards the Ruahine Fault the limestone is underlain by fossiliferous sandstone, conglomerate and breccia facies that increase in thickness towards the fault trace. The unit is successively overlain by sandstone of the **Puketitiri Formation** and limestone of the **Te Waka Formation.**

The basal limestone beds differ from traditional coarse-grained skeletal "Te Aute" limestone facies of the East Coast Basin in terms of their texture, grain composition and faunal content. The faunal content is dominated by robust, thick-shelled bivalves. Pakaututu Formation contains very abundant large *Tucetona laticostata* valves, many of which are articulated. The oyster *Crassostrea ingens* is common, especially near underlying greywacke. An Opoitian age is inferred from the presence of common small pectens resembling *Phialopecten marwicki* and the Opoitian restricted gastropod *Struthiolaria dolorosea.* Other locally important fauna common or present include *Eucrassitella, Oxyperis, Eumarcia, Dosinia, Purpurocardia, Talochlamys, Zeocolpus, Panopea*, *Mesopeplum*, *Tawera*, *Ostrea* and *Glycymeris*. Irregular sea-floor topography is envisaged during depositional time. Stacks of greywacke up to 2.5 m high commonly protrude into the overlying limestone units. Basal portions of the unit are frequently characterised by breccias and conglomerate facies. No encrusting bryozoans are visible on the surface of the greywacke, although oysters (*Crassostrea* and *Ostrea*) are common in places. The style of onlap is similar to that displayed in younger (Mangapanian-Nukumaruan) limestone beds to the south in the Kuripapango and Kereru districts. Above the onlap zone, however, these younger beds display typical "Te Aute" compositions, rather than the whole-shell, siliciclastic-rich nature of the Pakaututu Formation.

The Pakaututu Formation provides an important paleogeographic constraint on development of the proto-forearc basin, as well as controls on development, timing and offset of the North Island axial fault belt. Vertical displacement on the Kaweka Fault at the northern end of the Kaweka Range can be measured from offset of this limestone unit, and is c. 120 m vertical displacement. The unit has not been recognised east of the Mohaka Fault.

TALK: Paleoenvironments & Paleobotany 1

SILICIC CALDERAS AND VOLCANIC CENTRES IN COROMANDEL VOLCANIC ZONE

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Recent offshore drillcores collected from ODP Leg 181 identified 197 macroscopic tephras of silicic composition (Carter et al. 2003). The frequency and thickness of silicic tephras show that the volcanism was more or less continuous and that the tempo and intensity apparently increased from its initiation at c.12 Ma throughout the late Miocene and Pliocene and then into the Quaternary when the Taupo Volcanic Zone (TVZ) formed (Carter et al. 2003). The pre-TVZ silicic volcanism is considered to have been derived from the Coromandel Volcanic Zone (CVZ). In the CVZ, ten silicic volcanic centres have been identified that span the total age range from c. 10 Ma to 1.9 Ma, but none have been dated as old as 12 Ma as indicated in the offshore tephra record, and there are many gaps in the onshore record. Six of the silicic volcanic centres in CVZ (Mt Hobson, Whitianga, Kapowai, Wharekawa, Tunaiti, Waihi) are also interpreted as calderas or caldera complexes where evidence for collapse has been demonstrated from negative gravity anomalies, thick lake sediments, circular or arcuate structures observed by remote sensing images, and thick intracaldera ignimbrites. The other four volcanic centres in CVZ (Great Mercury, Aldermen, Tauranga, and Kaimai) show no evidence for collapse but have been identified from spatially and temporally associated silicic dome complexes and ignimbrites, and proximal lithic lag breccias. New Ar-Ar age data indicate that silicic volcanism in Tauranga-Kaimai continued until 1.9 Ma, with only a small temporal gap to initiation of TVZ silicic volcanism at c. 1.7 Ma.

The onshore record of CVZ volcanism is incomplete because of poor exposures, burial by a thick pile of younger eruptives, deep weathering, subaerial and marine erosion, hydrothermal alteration, tectonism, and also an inadequate radiometric database. There must be many more unknown buried silicic volcanic centres in CVZ, including the continental shelf off eastern Coromandel Peninsula, and the offshore ODP record will remain a much more complete record of explosive CVZ silicic volcanism than can be recognised onshore. Available whole-rock geochemical data on silicic eruptives of CVZ show that they have similar compositions to those in TVZ, except for the rhyolites of the Whitianga caldera (8.7-7.7 Ma) and the Great Mercury volcanic centre (7.0-5.3 Ma) which are notable for their high-K character, up to 5.2 wt.% K_2O (K_2O contents in glass in derived tephras would be greater) and abundance of sanidine, a rare phenocryst in TVZ lavas. These geochemical differences could be useful for correlating with the ODP tephra record.

CLASTIC DYKES IN IGNIMBRITES: A FEATURE OF PHREATOMAGMATIC CALDERAS?

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We report on examples of clastic dykes from an exhumed intracaldera sequence exposed in the Early Cretaceous Whitsunday Volcanic Province (WVP) of eastern Queensland, and more modern examples from the Coromandel and Taupo Volcanic Zones (TVZ). Some calderas in the WVP were flooded and had phreatomagmatic phases in their eruptive histories, and are thought to represent ancient analogues to modern calderas of the TVZ. Dominantly ash-grade clastic dykes and veins occur extensively within one intracaldera facies rhyolitic welded ignimbrite sheet on Whitsunday Island of the WVP. The underlying stratigraphic sequence, including a rhyolite lava with locally well-developed hyaloclastite margins, and a soft sediment deformed, rhythmically bedded, fine sandstone and siltstone package (~10 m thick), is interpreted to record the existence of a caldera lake prior to the emplacement of the welded ignimbrite sheet. Clastic dykes intruding the ignimbrite are extremely variable in thickness (up to 4 m wide), orientation, internal structure (massive to vertically planar or wavy laminated), grainsize (dominantly fine vitric ash; some with lithic and crystal grains <2 cm), and contact relationships (planar to highly irregular, and locally jig-saw fit domains of ignimbrite). Accretionary lapilli are not present. Where observed in vertical section, the clastic dykes always thin and terminate upwards. Ignimbrite eutaxitic foliation is deformed around one dyke indicating intrusion occurred into hot ignimbrite. Hydrothermal alteration haloes (of variable width) are associated with the clastic dykes and depicted by zones of less indurated ignimbrite (recessive ash matrix). Some hydrothermal alteration zones in the upper part of the ignimbrite sheet occur independently of clastic dykes, and can have pipe- or dyke-like forms. Clastic dykes also feature in a number of non-welded ignimbrites in the Coromandel and TVZ. Clastic dykes observed in a number of ignimbrites in the Whitianga Volcanic Centre, Coromandel show a complex and diverse range of features similar to those in the WVP. The Coromandel clastic dykes are generally curvilinear and typically branch, thin and terminate upwards. Accretionary lapilli (20-50mm) are abundant in clastic dykes cross-cutting the Flaxmill Ignimbrite. However, hydrothermal alteration haloes are not visible, most likely due to the non-welded and more porous character of the Coromandel ignimbrites compared to the WVP deposits.

We interpret the majority of these clastic dykes to record pulverisation and upward injection of host ignimbrite material soon after emplacement (hot rock-water interaction). For the WVP examples, ignimbrite emplacement is interpreted across a caldera lake, locally trapping surface water, causing phreatic explosions to produce the dyke material and concomitant hydrothermal alteration of the ignimbrite ash matrix. This process and style of explosivity represented by the clastic dykes provides insights into modern but short-lived, high-temperature fumarolic activity in ignimbrite sheets (e.g., VTTS ignimbrite) and may be relevant to modern flooded calderas such as in the TVZ.

TALK: Physical Volcanology 1

ETHICS, LIES AND THE EARTH SCIENCES

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Science, from a Western perspective may be perceived as empirical and amoral. In general, the physical earth sciences lend themselves well to empiricism, whilst in palaeontology a more circumspect approach is generally required. None-the-less, the key objective of palaeontology, as in all science, must be the pursuit of truth. The truth however, may be elusive, and many concepts cloaked as facts may subsequently be shown to be lies. The perception of truth may also vary, depending upon an individual's knowledge, intelligence, observational abilities and perhaps values. Ethics is the application of morals in a professional context, and ethical codes are drawn from values, in particular reflecting those values that are currently accepted and held by a particular society. Although "ethics theory" has never been a traditional part of the earth sciences curriculum, it is seen as an essential component of professional degrees such as engineering and medicine. However, without being too cynical, it may be concluded that the incorporation of ethical studies in degrees like engineering is generally a response to potential punitive action for amoral or immoral activities, rather than a reflection of any altruism. Litigation has been shown to be a powerful incentive for action.

Earth science in general, and palaeontology in particular do not have the same public image as disciplines such as engineering. At worst, palaeontologists are perceived as jolly bespectacled folk, wearing white coats and living in the back rooms of museums; at best they are recognized as adventurous outdoor types, digging up dinosaur bones in deserts or mountains. Palaeontologists are more likely to be seen as entertainers, (e.g. of the Attenborough mould) rather than providing essential services for society. A lack of direct professional contact with the general public is often seen as a guide for whether (or not) to include ethics in a curriculum: If the profession is unlikely to effect conditions that are hazardous to human life and/or lead to damage or loss of resources, then the teaching of ethics has a low priority.

Using selected palaeontological case studies from Johann Beringer to Vishwar Gupta, this paper discusses the relevance of ethics in palaeontology – and urges academics, employers and industry alike to ensure that all professional geologists receive exposure to ethical theory – but within a science context.

ESTABLISHING ENVIRONMENTAL CONDITIONS AT THE TIME OF MARINE PLATFORM FORMATION: A TEST OF THE NEW ZEALAND TERRESTRIAL GLACIATION MODEL USING BEETLE FOSSILS

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Flights of uplifted coastal terraces between Westport and Hokitika relate to repeated cycles of glaciation and sea-level change, preserved due to the long-term continuing uplift along this coast. Marine sequences on each terrace are thought to relate to warm phases (interglaciations), while cover gravels and their interbeds represent the intervening cold phases (glaciations or stadials) (Suggate & Waight, 1999). There is, however, a lack of age control to confirm this model.

In theory, it may be possible to examine faunal changes in beetles through several glacial-interglacial cycles providing a high-resolution climatic and environmental reconstruction that will help to clarify the relationships of these marine terraces and their interbeds. If the current model is correct and all the terraces were formed during interglacials then the fossil beetle faunas should all have lowland affinities. If the assemblages do not have lowland affinities then the terraces may have formed during interstadials and uplift rates and glacial chronologies will need to be revised.

Initial samples have been taken to establish the presence of beetle fossils at a number of sites around the West Coast. These include “The Hill”, Wilson’s Lead Road and Gibson’s Beach near Westport; North Beach (Greymouth), Sunday Creek (Chesterfield), and Phelp’s Mine and the Blue Spur Road area (Hokitika). Identifiable beetle fossils have been successfully extracted from “The Hill”, dated within Oxygen Isotope Stage (OIS) 2 (Moar & Suggate, 1979) and Phelp’s Mine, correlated with OIS 5a (Rose, pers. comm. 2003). A smaller number of fossils have also been extracted from Sunday Creek, correlated with OIS 5c moving into OIS 4 (Moar & Suggate, 1996).

A provisional identification to species level of the rove beetle *Aleochara hammondi* has been made from the upper part of the organic horizon at “The Hill”. This species is restricted to the South Island and is found at approximately 850-1500 m in tussock grassland. This site was chosen as an example of a glacial period site and this provisional identification fits with the traditional interpretation of the upper part of the pollen diagram from this site as a primarily open grassland (Moar & Suggate, 1979). Other identifications to family and genus level have been provisionally recorded however additional efforts must be made to identify these to species level.

Work on this project is continuing and will identify further sites for environmental reconstruction using fossil beetles. Potential sites include the Bell Hill sites (correlated with OIS 2 (Moar, 1971), Greens Beach (Kaihinu interglacial, (Moar & McKellar, 2001) and Schultz Creek (early Kaihinu interglacial (Burrows, 1997)) amongst others. In addition, little is currently known about the modern beetle fauna of the West Coast other than a Department of Conservation checklist of the Carabid fauna (Townsend, 1997) and more general surveys of arthropod families occurring in West Coast forests (McColl, 1974). A preliminary sampling regime of a variety of West Coast habitats ranging from coastal to alpine environments will therefore be undertaken to identify ecological associations for common taxa.

TALK: Quaternary Stratigraphy 3

EMPLACEMENT MECHANISM AND GEOCHEMICAL ZONING OF THE SEPARATION POINT BATHOLITH, NORTHWEST NELSON, NEW ZEALAND

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The Early Cretaceous Separation Point Batholith (SPB) of the South Island, New Zealand, is composed of three elongate segments with a total length of ~120 km and an average width of 10 km. It has formed along the northeast-southwest trending margin of the Takaka and Median Tectonic Zone terranes. The elongate nature of the batholith suggests a strong tectonic influence on the mode of emplacement.

The SPB is investigated to determine the origin and ascent of the pluton, and specifically to assess the role of regional tectonics in controlling the emplacement mechanisms and morphology of the batholith. Understanding the emplacement of regional-scale magmatic bodies requires a broad approach, incorporating both structural and petrogenetic data. To achieve this we have used a combination of field-based structural analysis (AMS), microstructural analysis (U-stage and electron back-scatter diffraction), and major/minor element geochemistry. Previous geochemical analyses have been random; we completed a series of east-west geochemical transects across the width of the pluton.

The results of this study will provide an insight into the accretion of the Takaka and MTZ terranes, and will provide a better understanding of terrane amalgamation. Initial results indicate significant geochemical zonation is present throughout the batholith, and emplacement occurred in a transpressional regime, with dextral strike-slip and east-over-west thrusting.

POSTER

ESTABLISHING A VALID RADIOMETRIC AGE FOR HAUHUNGATAHI, TONGARIRO NATIONAL PARK, NORTH ISLAND, NEW ZEALAND

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Results from new argon/argon analyses confirm that Hauhungatahi is approximately 800,000 years old based on analyses from lava samples taken near the summit. This establishes for the first time a valid geological age for the cone and makes it the oldest volcanic complex in the Tongariro Volcanic Centre. The cone is therefore a unique opportunity to study eruptive deposits older than the Whakamaru ignimbrite (>34Ka) event that has buried most of the older TVZ. Andesite lava flows are present at the summit and southern foot of Hauhungatahi; sandwiched between these flows are pyroclastic deposits and lahars. The lavas contain phenocrysts of olivine and clinopyroxene. Plagioclase occurs only as groundmass microlites in most of the cones lavas.

XRF analyses of the lavas indicate they are basaltic andesites ranging in silica from 52-56%. The deposits are low-K, calc-alkaline lavas with 8-9% MgO on average. Multi-element diagrams show enrichments in Large Ion Lithophile Elements (LILE) with a corresponding depletion in High Field Strength Elements (HFSE).

Crystallization temperatures for Hauhungatahi lavas are estimated from 2-pyroxene geothermometry (Brey and Kohler, 1991). They range from 1100-1170°C ± 70°C, these values are typically 100-200°C higher than Ruapehu lavas and typical orogenic andesites (Gill, 1981).

The multi-element pattern of LILE enrichment is typical for arc magmas where fluids from the subducting slab metasomatize the mantle wedge and initiate partial melting. The anomalously high crystallization temperatures and high MgO combined with the relative depletion to N-MORB in the High Field Strength Elements suggest that magmas originated from an already depleted upper mantle source that was later enriched by fluids from the subducting slab. The mafic nature of the Hauhungatahi lavas bears a resemblance to the andesites of Pureora and Titiruapenga volcanoes that are peripheral to the northern margin of TVZ, and to early Te Heranga lavas (~ 300 ka) of Ruapehu Volcano. Hauhungatahi may mark one of the first instances in the Taupo Volcanic Zone of decompressional melting initiated by the extension of the underlying lithosphere. Further Ar/Ar ages are currently being determined from stratigraphically lower samples.

THE CHATHAMS: EMERGENT ZEALANDIA AT ITS MOST STABLE

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The Chatham Islands may be considered as the most stable emergent bit of Zealandia. Located 1,000 kilometres due east of the Alpine Fault, they are well removed from plate boundary deformation, or are they? There is compelling geological evidence that suggests significant tectonism within the last 3-4 million years, probably related to activity of the Hikurangi Plateau (to the north of the Chatham Rise) behaving as an eastward-moving indentor. This idea of rapid uplift of the eastern end of the Chatham Rise, and the Chatham Islands, within the Late Pliocene has prompted a Marsden research project that will commence in early 2004. This project will involve geologists, biologists, molecular biologists, botanists and ecologists.

As a window to the geology of the Chatham Rise, the Chatham Islands are immensely instructive. Most importantly, from a "Cretaceous Zealandia" context, there is a well-exposed mid to Late Cretaceous (Albian to Santonian; Motuan to Teratan) sedimentary sequence (Tupuangi Formation) exposed on Pitt Island. These are the oldest known fossiliferous rocks in the Chathams. The southern mass of Chatham Island (Southern Volcanics) is the remnant of the northern flank of a large Hawaiian-style stratovolcano with a radius of 20-25 kilometres, of Late Cretaceous age (80-70 million years old).

There is therefore, a substantial Cretaceous record in the Chatham Islands and it is highly relevant to any discussions concerning Cretaceous Zealandia. What is perhaps most remarkable, is the absence of any significant or pervasive deformation. In a sense, the Chathams are an exceptionally well-preserved Cretaceous relict, bar a veneer of Cenozoic volcaniclastic and biogenic sediments and a smattering of Cenozoic volcanic vents.

ACTIVE FAULT-PROPAGATION FOLDING UNDER THE CANTERBURY PLAINS

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Although well documented young deformation extends to the boundary of the Canterbury Plains, the question of how much activity is occurring beneath the plains has been debatable. The existence of major structures and strong relief beneath the extensive Pleistocene gravels is known, but demonstrating any late Quaternary activity on these structures is more difficult, due to lack of detailed subsurface data and reliable dating of datum geomorphic surfaces.

The recent availability of both industry seismic reflection data and now a capacity to run shallow, high resolution lines at critical sites, has allowed the subsurface structure beneath subtle and anomalous topographic features to be tested for the presence of structures, and for stratigraphic evidence of deformation in the young gravel deposits. It is now clear that the majority of uplifted surfaces containing remnants of older aggradation gravels are preserved over actively growing fault-propagation folds, and contain evidence of a history of migrating drainage systems controlled by the underlying tectonic activity. In some cases fault traces intersect the surface, in others, the folds are forming over blind thrusts. Preliminary investigations have delineated many of the major structures and some studies of specific targets have been completed.

Current objectives include not only an assessment of these structures with respect to their potential as seismic sources close to population centres, but also to establish the nature of the subsurface structure and linkages to the elements of the plate boundary deformation zone. A variety of structural styles and their interaction with rivers of varying stream power allow for applications of wider interest in the development of process-response models.

Examples drawing on recent University of Canterbury theses, (Sissons, 1999; Evans, 2000; Powell, 2000; Estrada, 2003) illustrate the interplay of fold growth, fault propagation and the chronology provided by the changing pattern of fluvial response such as along the Springbank-Ashley Fault system near Rangiora, and on structures along the inner margin of the Canterbury Plains, will be described.

The Springbank structure is expressed by anticlinal uplift of the Springbank downlands near Cust, where successive late Pleistocene river channels have slipped off to the north, presently marked by the underfit Cust River. These are now warped over a broadly rounded southeast- facing monoclinal fold, shown by seismic reflection data to be formed over a blind thrust. To the north the propagating tip of the Ashley Fault coincides with this structure and may function as a transfer fault. Characteristics of rivers crossing this system suggest that aseismic deformation is currently taking place, and are indicative of the location of the southern extension of the system, planed off by the last late-Pleistocene aggradation of the Waimakariri River.

Emergent structures along the inner plains are west facing, counter to the drainage direction and provide a comparison in the landscape response to the contrasting relative asymmetry.

THE MARSHALL PARACONFORMITY: MARKER FOR THE INCEPTION OF THE GLOBAL THERMOHALINE CIRCULATION

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Rifting between Australia and Antarctica and the creation of a deep-water link between the Indian and Pacific Ocean was completed at the Eocene-Oligocene boundary, ~33.7 Ma. All Southern Ocean drill sites in and east of the Tasmanian gateway record this event as the Marshall Paraconformity, a several million year long, Early-Late Oligocene, sedimentation gap across which occurs a profound change of depositional environment and style.

In both deep- and shallow-water successions, sediments above the Marshall Paraconformity are ubiquitously affected by vigorous current activity consequent upon a restructured ocean circulation. The Marshall Paraconformity represents the start of a fast, cold current around at least part of Antarctica and the production of increased volumes of cold bottom water. It also marks the start of the ENZOSS, the stratigraphy of which records the interplay between an evolving oceanic hydrography - which today includes two major frontal systems - and the supply of biopelagic, terrigenous and volcanogenic sediments around New Zealand.

Erosion and corrosion of the seabed dominated the first 3-10 m.y. of ACC/DWBC activity in the southwest Pacific. At Site 1121, situated beneath the highly energetic combined ACC/DWBC, strong post-Eocene erosion has removed the entire Late Paleocene-Late Eocene top of the Paleogene sediment apron. Sediments above the Marshall Paraconformity at this site comprise only a 15.2-m-thick 'skin drift' of abyssal clay and extensively reworked foraminiferal and quartz sand, with episodic layers of small manganese nodules down to 5.40 mbsf. At Site 1123, a gap of 13 m.y. (33.6-20.5 Ma) separates Late Eocene-Early Oligocene nannofossil chalk from the Early Miocene DWBC drifts above, whereas a shorter gap of 6 m.y. (33-27 Ma) is present at Site 1124. The presence of earliest Oligocene sediment below the Marshall Paraconformity here, and at DSDP Leg 29 Site 277 suggests that the onset of seafloor erosion generally postdated the Oi-1 isotope event by up to ~2 m.y.

Beneath the path of the DWBC, sediments above the Marshall Paraconformity everywhere comprise abyssal biopelagic (~66% carbonate) drifts. The oldest drifts yet sampled are Late Oligocene to Early Miocene (~26.1-16.5 Ma) nannofossil chalks at Site 1124, which exhibit color-banded sedimentary couplets with alternately greater and lesser terrigenous clay and biosiliceous contents. These chalks, and the similar ~21.0-0.0 Ma drift sediments that occur at Site 1123, contain a high-resolution record of 41-k.y. Milankovitch climatic cyclicity and DWBC variability since the Late Oligocene. Grain size analyses and multi-sensor track (MST) logs show that throughout this succession DWBC current speeds were coupled to the climate system at the 41-k.y.

The Marshall Paraconformity represents a regional sedimentary pivot, which separates post-rift transgressive sediments below from platform to abyssal drifts and, in shallow water, from prograding terrigenous shelf sediments, above.

TALK: Plenary 3

FERN MACROFOSSILS AND SPORES FROM THE LATE EOCENE PIKOPIKO FOSSIL FOREST, SOUTHLAND, NEW ZEALAND

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Six types of fern macrofossils, two with *in situ* sporangia, are described and illustrated from the late Eocene Pikopiko fossil forest, near Tuatapere, Southland. They were part of the understorey of a mixed angiosperm forest growing on a well-drained floodplain environment. This record brings the number of fern macrofossils recorded from the Eocene in New Zealand to seven. The Pikopiko fern macroflora is the most diverse recorded from the New Zealand Cenozoic, and one of the richest in the world.

An index of modern fern genera of the world is compiled, incorporating 27 morphological characters that may be present in modern as well as fossil ferns. When systematically analysing the fossil types using this index of differential morphology, two fossil fern types can be identified as species of *Cyclosorus* and *Todea*. For the other four types, many fern families and genera can be excluded as potential nearest living relatives.

Light regimes of several extant fern species are determined and this data, together with palynological data from the site, are used to draw inferences on the ecology of the Pikopiko fern flora.

Additionally a database of published fossil records of modern fern taxa in New Zealand is created. It shows the first occurrence of these taxa and whether or not they have a continuous fossil record in the region. This information suggests that contrary to the views of Brownsey (2001), many modern ferns have been in the New Zealand region since at least Eocene times.

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SUBDUCTION EARTHQUAKE GEOLOGY IN NORTHERN HAWKES BAY, NEW ZEALAND

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Beneath the North Island of New Zealand, the Pacific Plate subducts obliquely beneath the Australian Plate. It is as yet unknown whether great earthquakes occur on the interface between the Pacific and Australian Plates at the Hikurangi Margin. Large subduction zone earthquakes in other parts of the world are known to cause coseismic vertical deformation of the overriding plate, thereby providing a record of past earthquakes in coastal sedimentary sequences. We investigate Holocene coastal sediments of Northern Hawkes Bay for geological evidence of pre-historic rupture of the Hikurangi subduction zone.

Previous work on the coastal plain between Wairoa and Mahia Peninsula established that several metres of net tectonic subsidence occurred in the late Holocene (Ota *et al.,* 1989). Detailed investigation of the sedimentary record of Te Paeroa Lagoon provided evidence for the occurrence of earthquakes involving subsidence at ~6300 and ~4800 years BP (Zachariasen *et al.,* in prep.) and a large tsunami ~6300 years BP (Chague-Goff *et al.,* 2002). Further cores were taken in 2002 at sites 10 km (Opoho) and almost 30 km (Opoutama) east of Te Paeroa to determine the extent of previously identified events and to search for any further events.

Radiocarbon dating, tephrochronology, stratigraphy and microfossil analysis have enabled detailed paleoenvironmental histories to be reconstructed at Opoho and Opoutama. The elevation of paleoenvironments relative to present mean sea level suggests about five metres of subsidence occurred at Opoho in the late Holocene. Subsidence appears to have happened suddenly in two events that created accommodation space at the site. Marine influxes accompanied these events and may provide evidence for tsunami. The ages of these two events coincide well with those identified 10 km away at Te Paeroa Lagoon. Opoutama is thought to lie near the edge of the zone of subsidence as any recent vertical movement at the site is in the order of one or two metres. We conclude that the mechanism for coseismic subsidence is of greater than site-specific significance but further work is required to determine the extent of such events along the coast.

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GEOCHEMICAL DIVERSITY OF JUVENILE BASALTIC PYROCLASTS AT BARRIBALL TUFF RING, SOUTH AUCKLAND, NEW ZEALAND

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The Barriball tuff ring is a volcanic centre in the South Auckland volcanic field, dated at 1.00 ± 0.06 Ma (2_), and characterised by a complex sequence of phreatomagmatic and magmatic activity and abrupt changes in geochemistry. It comprises an initial tuff ring, 2.1 km in diameter, and two late-stage scoria cones. Within the tuff ring, two separate, slightly unconformable phreatomagmatic units have been identified which contain juvenile clasts of contrasting composition: a lower olivine-tholeiitic basalt unit, and an upper basanite unit. Both tuff units occur in a single ring structure, but are considered to have erupted sequentially from separate vents within the tuff ring. Accessory clasts of olivine-tholeiitic basalt are also found within the upper tuff unit, indicating that the basanite magmas erupted through the earlier olivine-tholeiitic basalts of the lower unit. The scoria cones also have contrasting compositions. A basanitic cone is located inside the tuff ring, whereas an olivine-tholeiitic basalt cone, with the same composition as that of the lower tuff, unconformably overlies the rim of the tuff ring.

Mineralogical and geochemical data show that olivine is the sole phenocryst phase in the olivine-tholeiitic basalts and that they have relatively low total alkalis (3.15 - 3.29 wt.%), Nb (9 - 10 ppm), and $(La/Yb)_N$ (3.4). The basanites in the upper tuff unit contain olivine and titaniferous diopside phenocrysts and have high total alkalis (4.01 - 5.22 wt.%), Nb (40 - 71 ppm), and $(La/Yb)_N$ (12.4). Contrasting geochemical trends and incompatible element ratios (e.g., K/Nb and Zr/Nb) suggest that the juvenile pyroclasts in each tuff unit evolved as separate lineages from dissimilar parental magmas derived from distinct subcontinental lithospheric mantle sources. The relatively homogeneous compositions of the olivine-tholeiitic basalts are indicative of the rapid eruption of newly arrived magma at the vent. In contrast, petrogenetic modelling of major- and trace-element abundances suggests that the range of basanite compositions is due principally to fractional crystallisation, which may be indicative of the eruption of a compositionally zoned magma column. Barriball volcano represents an example of the nature of volcanism within the South Auckland volcanic field – the eruption of small magma batches with contrasting compositions derived from distinct mantle sources but related closely in time and space.

POSTER

CARBON ISOTOPIC EVENTS IN HOLE 593, SOUTHERN TASMAN SEA: REGIONAL PALAEOPRODUCTIVITY IMPLICATIONS

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Long-term cooling of climate over the past 19 Ma has impacted on the New Zealand region in various ways. DSDP Site 593 in the southern Tasman Sea is in a prime location to record change in the oceanic system in response to the evolving climate, both geochemically using the stable isotopic composition of marine microfossils, and by way of changes in sediment properties.

The surface and intermediate-depth benthic and planktic $\delta^{18}O$ and $\delta^{13}C$ isotopic records contain most of the globally-recognised extreme glacial zones (Mi) and carbon maxima (CM) events (i.e., Mi1b to Mi7, and CM1 to CM7) (Cooke et al., 2002). The consequences of these global extremes are evident in the stable isotopic records with planktic/benthic covariance indicating that these were full-water column events, affecting the global oceanic system. CM events represent rapid, organic ^{12}C-rich carbon burial occurring after intensive palaeoproductivity episodes. CM1 to CM6 are included in the Monterey Excursion, a time of exceptionally enriched global $\delta^{13}C$ values between 18-14 Ma. If the CM events in the Site 593 record is a result of regional upwelling and increased phytoproduction in the Tasman Sea or Southern Ocean, this should be evident in other regions around New Zealand and in the near-shore sedimentary records. If, however, Site 593 is simply recording the global signal – the result of organic carbon burial (e.g., at Monterey, California) – then it is simply a remote monitor of such events. The planktic and benthic $\delta^{13}C$ records through the Monterey excursion exhibit similar values (often an indicator of upwelling), but the $\delta^{18}O$ records are offset, which does not support the upwelling option. Further investigation of the planktic record from *Zeaglobigerina woodi* used over this interval is needed to establish possible 'vital effect' fractionation by this species.

The Late Miocene to Late Pliocene (11 to 2.5 Ma) $\delta^{13}C$ records are less ambiguous as several planktic species were analysed. The results from both the planktic and benthic records do not support extensive upwelling over this time interval. However, from about 1.5 Ma onwards the planktic and benthic records converge, interpreted as greater vertical mixing of the water column, possibly due to upwelling. This mixing is supported by both the $\delta^{18}O$ and sediment texture records that exhibit greater variability than before, inferred to reflect a more active oceanic system, both globally and within the Tasman Sea.

Cooke, P.J. et al., 2002: Neogene palaeoceanography based on stable isotope stratigraphies from the southern Tasman Sea (Site 593), Southwest Pacific. Abstracts and Programme, GSNZ Annual Conference *"Northland 2002"*. Whangarei. Geological Society of New Zealand Miscellaneous Publication 112A. p. 15.

SEDIMENTARY LITHOFACIES AND DEPOSITIONAL SETTING OF THE MANGAHEWA FORMATION IN THE KAPUNI FIELD, TARANAKI BASIN, NEW ZEALAND

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The Eocene Mangahewa Formation (Kapuni Group) provides the main reservoir units in the Kapuni Field. This study identifies 12 sedimentary lithofacies and their environments of deposition and develops a depositional model for the Mangahewa Formation based on 245m of core and the available digital geophysical logs from seven wells in the field (Kapuni-1, -3, -8, -12, -Deep-1, -14 and -15).

The lithofacies, identified and defined in core on the basis of observed colour, lithology, bedding, texture, trace fossils, and sedimentary structures, are interpreted to represent shallow marine, tidal sandbar, tidal channel, spit platform, tidal-inlet channel, tidal creek, sand flat, meandering tidal channel, tidally-influenced fluvial channels, mud flat, swamp and marsh depositional environments.

Correlation of core lithofacies with geophysical log motifs enabled lithofacies identification where core data were not available. Log motifs representing each of the lithofacies were then extrapolated to uncored sections of the Mangahewa Formation in the Kapuni Field wells.

Based on lithofacies from core and their corresponding log motifs a depositional environment model has been devised. The model demonstrates deposition of the Mangahewa Formation in an estuarine setting in which the relative importance of the physical processes operating changed over time. During initial deposition of the Mangahewa Formation tide-dominated estuarine lithofacies were deposited. A major coal horizon in the field represents a change in the depositional environment as the estuary infilled. Above this coal core and log data indicate a wave-dominated estuary exhibiting a clearly-defined, “tripartite” (coarse-fine-coarse) distribution of lithofacies.

POSTER

A RUNNING STANDING DIVERSITY CURVE - A NEW APPROACH TO ESTIMATING PAST BIODIVERSITY

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In a recent issue of Paleobiology[3], Vermeij and Leighton suggested that the biases inherent in the fossil record are such that estimates of past diversity based on them were meaningless. Needless to say, the majority of those working in the field disagree. However, the biases and distortions do pose formidable problems. We here address one source of bias - the distorting effects of variable time unit duration and species ranges within time units. This can be minimised by applying a correction when converting species ranges to diversity time series (i.e. diversity curves through time). This correction is used for the Cenozoic molluscan data discussed by Crampton et al. (this conference) and gives normalised mean standing diversity values for successive intervals of time. Other partial solutions are discussed by Foote[4].

However, the problem can be circumvented altogether by using the constrained optimisation (CONOP) procedure to effect a precise correlation of stratigraphic sections and build a global composite sequence of species' first and last appearance events. A best-fit rank order of events is derived by trial and error by extending the stratigraphic ranges of individual species in individual sections as necessary to achieve a common order of events among the full set of sections. The best solution is that with the smallest net extension of species ranges across all sections. If the extensions are measured by the number of event levels that they embrace, rather than number of metres, the influence of variable depositional rate is avoided. Event spacing in the composite is based on mean event spacing in the sections after ranges have been extended and after section thicknesses have been normalised according to the number of event levels in the composite that they span. The result is a precise correlation of sections, a scaled composite sequence which gives a proxy timescale, and a precise diversity count at every event level in the composite.

An example from the Ordovician is presented in which graptolite diversity is calculated at 2200 levels from base Ordovician to Early Devonian – essentially an interval-free, or running, standing diversity curve. It spans the entire duration of the graptolite clade.

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[3] *Paleobiology 29(1*), 2003
[4] *Paleobiology 26(4)*: 578-605, 2000.

FIORDLAND SHAKEN AND STIRRED –
THE 22 AUGUST 2003 M7.1 EARTHQUAKE

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A large earthquake with Richter Magnitude M_L 7.1 occurred at 12 minutes past midnight on 22nd August (NZ Standard Time). The epicentre was tentatively located 10 km northwest of Secretary Island at the mouth of Doubtful Sound (45.14ºS, 166.90ºE). Over next three days a "rapid response" team installed 5 portable seismographs and 4 strong motion recorders, and flew over 70% of central Fiordland mapping landslides and looking for signs of ground damage. Over 400 landslides / failures were mapped throughout an area ~3000 km^2. Slides range from small debris flows involving a few trees and a few tens of cubic metres of soil, to large debris slides and rock falls running 1000 m downhill and involving bedrock and regolith. Most initiated on slopes of 60º or greater, with average runout slope angles of 35-50º. The fifteen largest landslides have estimated volumes from 75,000 to 625,000 m^3. Large numbers of trees and vegetation were seen floating in the fiords, particularly Doubtful Sound, making a hazard for boating. Relatively minor, but spectacular, damage occurred to the Te Anau control structure and roads near Manapouri, and a landslide-induced wave damaged a wharf and shorelines around Charles Sound. A tidal gauge at Jacksons Bay recorded a 15cm tsunami that was too late for the main shock and too early for any of the significant aftershocks, possibly induced by a submarine landslide. Other soft sediment deformation was recorded around the shores of Lake Te Anau.

The earthquake ranks amongst the ten biggest earthquakes in the world this year. It occurred where the Indo-Australian plate is obliquely subducted beneath the Pacific plate at 34mm/yr, in one of the more seismically active regions of New Zealand. Three earthquakes greater than M 7 and seven greater than M 6 have occurred in this area during the last 150 years. The main earthquake was followed by a vigorous aftershock sequence including a M_L 6.2 (2.12 am, 22nd Aug), and more than 20 events greater than M_L 5 over the next 4 weeks. The largest peak ground acceleration (PGA) measured during the main shock was 0.17 g at Manapouri Power Station. Horizontal displacements up to 17cm WNW have been recorded by reoccupied geodetic GPS stations. Preliminary models point to a dip-slip thrust event on a NNE striking fault plane, with c. 2-3 m displacement at 10-25 km depth and potential surface uplift of c. 40 cm. Studies to document/confirm the predicted uplift using intertidal organism mortality have been initiated, while electromagnetic experiments will look for possible fluid migration following the event. The landsliding and liquefaction effects appear to be far more significant than occurred during the 1993 M_L 6.8 earthquake in the same area. However, although landslide damage was widespread, the slope failures were mainly superficial. There were no deep-seated very large landslides on the scale of c. 40 very large (~10^7-10^9 m^3) prehistoric (post-glacial) landslides identified in Fiordland. A considerably larger earthquake (~M 7.5 or greater) than that of 22 August 2003 is thought to be required to trigger such very large bedrock collapses. Luckily this is a remote region of New

Zealand, so the Fiordland earthquake caused little damage to infrastructure and no loss of life.

POUNAMU RESOURCE ASSESSMENT

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Pounamu is a M_ori collective term for semi-precious stone scientifically referred to as nephrite, semi-nephrite, jade or bowenite (tangiwai) that is composed predominantly of metamorphic tremolite in a felted, fibrous texture. It is New Zealand's icon mineral material and an important taonga (treasure) that was vested with Te R_nanga o Ng_i Tahu in 1997 as part of the treaty settlement process. Increased demand from the growing tourist industry has placed pressure on the New Zealand resource, leading to imported material masquerading as genuine New Zealand artefacts and concerns over the potential for exploitation/over-use. Most traditional mineral resource assessments are aimed towards defining the total volume/tonnage present, which is generally assumed to be finite. Assessment and management of pounamu is not straightforward because there is not enough intrinsic value to warrant modern exploration methods (e.g. drilling, geophysics), pounamu occurs as both in-situ (hard-rock) and transported (alluvial) deposits, and surface quantities made available for use/extraction has short term variability due to erosion and transport.

A new methodology for assessing New Zealand/Aotearoa pounamu is being trialled on the Wakatipu resource, which is sourced from the Greenstone Melange of the Caples Terrane. The methodology seeks to define (i) the total resource present, (ii) the relative rate of change in the availability of that resource through erosion and other geological processes, (iii) active areas where new material is likely to be exposed (e.g. by erosion), and (iv) appropriate extraction rates for sustainable use. Fieldwork in Sugarloaf Stream-Routeburn and Scott Creek measured the dilution of material downstream from the Greenstone Melange outcrops. Scree observations and streambed transects indicate near-source pounamu proportions of 1% and 3-8% by volume, respectively, that are diluted to <0.5% by 5 km downstream. Similar dilution curves with less uncertainty are duplicated for metavolcanic lithologies sourced from the melange. Field observations were entered into geographic information system (GIS) datasets. GIS calculations indicate Quaternary alluvium, fan and till deposits (127 km^2) have potential to bear 85,000 ± 40,000 t of transported pounamu at surface, compared with 91,000 ± 45,000 t of surface pounamu in situ from 156 km^2 of Greenstone Melange host rocks. Further fieldwork is planned to reduce these uncertainties. A variety of GIS erosion/landslide models were developed to evaluate changes to the surface resource by erosion, including weights of evidence probabilistic models and universal soil loss equations. Modelling is strongly influenced by a SW-NE gradient in mean annual precipitation (from 1-4m/yr) and mountainous topography, and it is felt that field mapping with air photograph interpretation is more reliable than modelling for highlighting actively eroding areas to be monitored. While there are considerable uncertainties within the Wakatipu regional resource model, it is expected that variations between regions will be significant. The methodology will provide a holistic overview of the New Zealand/Aotearoa pounamu resource and may be applicable to other transient

TALK: General 1

natural resources (e.g. supplies of driftwood on beaches) that occur within geologically active environments.

RESISTIVITY INVESTIGATIONS OF GROUNDWATER IN THE VICINITY OF THE WAIKANAE RIVER MOUTH, KAPITI COAST

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The surface and groundwater resources of the Kapiti coast are currently stressed during summer. This situation is likely to get worse with ongoing development, and improving lifestyles that tend to increase water usage. Because of the inherent balances between surface and groundwater conditions, and sea level, any change of the conditions on "the land" are likely to affect the position and dynamics of the river/groundwater and fresh/saline water interfaces. Should the saline interface move inland, or get shallower, then potable water from new supply bores, and the large number of shallow domestic bores, will be threatened. It is therefore necessary to understand the characteristics of the groundwater system, and the way it behaves and interacts with the Waikanae River and the sea.

Geophysical prospecting using resistivity was used to quantify the nature of surface water - groundwater interaction and saline intrusion in the vicinity of the Waikanae River mouth. The bulk electrical resistivity of water bearing rock formations is directly proportional to the resistivity of the groundwater itself. Increased salinity significantly lowers the resistivity below normal values of the order of 100 Ωm. Dc resistivity techniques, which measure the bulk resistivity as a function of depth, were therefore used to determine the sources of water within the saturated zone, to map the extent of salinity within the groundwater reservoir, and to determine the nature and dynamics of these boundaries both in space and through time.

A series of Wenner resistivity transects were made perpendicular to the beach, and normal to the river. These provided 2-dimensional profiles of the variation in resistivity with increasing depth.

Results show little evidence of saline intrusion beyond the beach. Resistivities of 1-3 Ωm characterise the saturated beach sands. Resistivities increase gradually inland to approximately 150 Ωm. The geometry of this resistivity transition is very similar to that predicted by the coastal aquifer interface model proposed by Glover. Resistivity profiles constructed normal to the river show significant groundwater recharge by the highly resistive freshwater (>500Ωm). The effect on resistivity can be detected to a depth of 20 m, and up to 250 m from the river channel.

The electrical signatures of the five resistivity transects clearly demonstrate the inherent balance between surface water, groundwater, and seawater. Decisions regarding the future use of groundwater as a source of potable water need careful consideration to avoid adverse effects on the flow of the Waikanae River, and the equilibrium position of the saline interface.

TALK: General 1

A PAIL OF SNAILS AND A CAN OF WORMS! NEW ZEALAND CENOZOIC MOLLUSC BIODIVERSITY

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Understanding the origin, history and controls of biodiversity remains one of the primary goals of paleontology. Despite 30 years of intense, quantitative research, fundamental questions remain unanswered. For example, has taxonomic diversity increased substantially since the Paleozoic [4], or not [5]?

In order to identify some of the major controls on marine biodiversity, we have compiled data on New Zealand's Cenozoic rock and marine mollusc records, including paleoecological information on mollusc species. New Zealand has a uniquely rich (in the Southern Hemisphere) and extremely well documented Cenozoic mollusc fossil record. New Zealand's geographic isolation, combined with its paleoceanographic and biogeographic setting, make this fossil record all the more valuable.

Before it is possible to use our data to examine the history and controls on marine mollusc biodiversity, it is first necessary to reduce the effects of various highly problematic biases in the record. Foremost amongst these biases are the pervasive influences of sampling effects that may profoundly distort apparent biodiversity patterns. Some of these biases, such as the general lack of rocky shore faunas, can be circumvented simply by framing appropriate questions. Others, such as the sampling effects, require the use of sophisticated numerical approaches borrowed from modern ecology. Even then, patterns of biodiversity history read from the fossil record must be interpreted with great caution.

In this presentation we will examine these issues and reveal our "corrected" mollusc biodiversity curve for the Cenozoic (that is, at the time of writing, still being processed). We will go on to offer some interpretations of this curve in terms of possible drivers of biodiversity, such as paleoclimate and paleoceanographic factors, sea-level and habitat area, and paleoecology and life habits.

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[4] Jablonski *et al.* 2003, Science 300:1133-1135.
[5] Peters & Foote 2001, Paleobiology 27: 583-601.

TECTONICALLY DRIVEN RIVER CAPTURE EVENTS, NW OTAGO

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Major rivers in the outboard zone of the active Southern Alps flow southwards out of the mountains. The orientation of these rivers is controlled by structures that obliquely intersect the Main Divide. Progressive shortening in the Southern Alps orogen results in narrowing of the valleys and migration of valleys towards, and ultimately beyond, the Main Divide. In Otago, several rivers are controlled by the Nevis-Cardrona Fault and its northern extension, which has been active since the Miocene. Drainage directions of these rivers have been disrupted by tectonic processes during development of the Southern Alps. The Landsborough River, currently to the west of the Main Divide, originally flowed southwards into central Otago, transporting greywacke gravels on to schist basement. The upper reaches of the Landsborough River were captured by headward erosion of the west-draining Haast River in the Pliocene. The lower reaches of the paleo-Landsborough River became blocked by the rise of the Pisa Range in late Pliocene, and drainage was reversed to form the north-flowing Cardrona River. Drainage reversal in the Nevis valley occurred in the Pleistocene when two growing antiformal ranges impinged on each other. Galaxiid fish in the north-flowing Nevis River are genetically most closely related to fish in Southland, rather than to any in the Kawarau-Clutha catchment into which the Nevis River now flows. The southeastward drainage that now dominates central Otago developed in the late Pleistocene as glaciers cut across south-trending interfluves between major rivers.

THE JUNE 2003 ERUPTION OF LOPEVI VOLCANO, VANUATU

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On 8 June 2003, exactly one year since its previous outburst, the basaltic-andesite stratovolcano Lopevi erupted explosively. Lopevi is a very steep, 7 km-diameter conical island, reaching 1400 m above sea level, and extending at least 1000 m below sea level. The youngest activity is concentrated along a NW-SE trending fault system that cuts the entire island. Lopevi is one of Vanuatu's most active volcanoes, and was permanently evacuated in 1963. It is an excellent active analogue to volcanism of Ngauruhoe and Egmont/Taranaki. The 2003 eruption began with a large vulcanian blast that was witnessed and photographed by local pilots in clear conditions on the afternoon of 8 June. This blast, from a vent c. 200 m below and to the NW of the 1410 m summit, produced an ash plume to at least 10 km altitude. Pyroclastic flows caused by collapsing outer parts of the plume, cascaded down the NW flanks of the volcano, but stopped short of reaching the sea. Over the next seven days we witnessed a series of further short-lived vulcanian eruptions, producing ash 2-5 km high plumes from the near-summit vent. These were accompanied from the evening of 8 June by a fissure eruption at around 350 m above sea-level on the NW flank, producing an aa lava flow that rapidly descended to the sea. A second en-echelon fissure opened on 11 June, with intense fire-fountaining feeding several lava flows. At least 5 lava flows fed into the sea, with youngest flows from both sources breaking out progressively westward. The impacts of this eruption included severe damage to food crops and open water supplies on the neighbouring Island of Paama, along with some damage to local houses. The style of multi-vent activity observed at Lopevi has apparently characterised its past less-well observed eruptions, and provides us with the opportunity to investigate conduit and eruptive processes in growing stratovolcanoes. We outline plans for further investigation of this volcano and its recent products and the ways in which these data may be highly relevant to understanding periods within the history of Egmont/Taranaki volcano.

THE AD1040 TO PRESENT MAERO ERUPTIVE PERIOD OF EGMONT VOLCANO, TARANAKI, NEW ZEALAND

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The most recent eruptive period of Egmont has involved a summit crater geometry open to the northwest. Since around AD1040 there have been at least six separate episodes, each involving magma of similar high-Si andesitic composition erupted from the summit vent. The types of eruption have varied widely from periods of dome growth, through production of lava flows, and to sub-plinian eruption of voluminous pumiceous tephra. By mapping within and near the National Park, a new stratigraphy of recent events has been developed. Episodes are separated by breaks (c.30-100 years) that are marked by distinct paleosols, but shorter hiatuses occurred within many of the episodes. New radiocarbon dates on charcoal within pyroclastic flow units are used to provide new eruption frequency data for the last 1000 years of activity. All of the last six episodes from Egmont have involved production of pyroclastic flows on the western and northwestern volcano flanks. During two events, pyroclastic flows were also generated on the eastern, northern and southern flanks. The most energetic pyroclastic flows were generated during an episode around AD1400-1500, reaching over 15 km from source. These flows appear to have been generated in association with at least one large vulcanian blast through a summit dome. Surge and fall deposits associated with several events within this AD1400-1500 episode can be found around the entire cone and several of the summit lava flows were probably generated during this time. Another significant event during the Maero Eruptive Period was the production of a series of sub-plinian eruptions at c. AD1655. These events were preceded and possibly interspersed by dome growth, and explosive phases were characterised by column-collapse pyroclastic flows up to 6-8 km from source on at least the southern volcano flanks. By reconstructing the relationship of fall, pyroclastic flow, surge and lava flow events during the Maero Eruptive period, we hope to establish an episode-by-episode history of eruptions at Egmont/Taranaki and thus better predict the course of any future activity from the volcano.

POSTER

GEOCHEMISTRY AND MORPHOLOGY OF SPELEOTHEMS FROM BULMER CAVERN, NORTHWEST NELSON, NEW ZEALAND.

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Bulmer Cavern is located within the Ordovician Arthur Marble karst beneath Mount Owen, Northwest Nelson, New Zealand. Bulmer Cavern is currently New Zealand's longest known cave system, with a length of 51 km, and a 749 m vertical extent. The study area is located in the lower levels of Bulmer Cavern in areas called "Where The Wild Things Are" and "Soupmix 500". Previous work has been restricted because of the isolated locality, difficult access, and ethical constraints which require removal of the smallest possible sample quantities.

Research is focused on six speleothem types, five of which are sulfates and one of carbonate composition. Two speleothems which grow on the cave walls or ceiling are fibrous and are known as "angel hair", and "cave wool" or "beards". Two are floor deposits known as "moonmilk" and "cave crusts". The final two speleothem types are crystals called "needles" and "crystal flowers". The occurrence of these unusual speleothems could be partly attributable to the cave environment, which remains at a constant 4-5 °C, relative humidities varying between 92-98 %, and/or fluctuating airflows created by the chimney effect from multiple entrances.

XRD, XRF, SEM and electron microprobe results showed that the fibrous speleothems are composed of gypsum ($CaSO_4.2H_20$), growing as single crystal fibres up to 1050 mm long and between ~53-500 µm thick, sometimes with secondary surface crystal growths. "Cave wool" is made up of numerous randomly oriented interfingered acicular gypsum crystals typically between ~2-12 µm thick. "Moonmilk" is composed of hydromagnesite ($Mg_4(CO_3)_4(OH)_2.4H_2O$), which blankets a ~50 m length of passage from a thin covering up to ~40 cm thick. "Cave crusts" cover a ~10 m^2 area of passage with a white, broken-up floor encrustation between ~5-30 mm thick. The composition of "cave crusts" is still under investigation but is probably a sulfate. "Needles" are composed of swallowtail twinned gypsum, growing up to ~60 cm in length, at random orientations, from damp, sandy sediments. "Cave flowers" grow from rock fractures, and are thought to be composed of mirabilite ($Na_2SO_4.10H_20$) although qualitative XRF analysis also detected magnesium, suggesting that solid solution substitution could be occurring.

USING MARINE DINOFLAGELLATE CYSTS FOR QUATERNARY PALEOENVIRONMENTAL STUDIES IN THE NEW ZEALAND REGION

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Dinoflagellates are mainly unicellular algae, either heterotrophic or photosynthetic, that occur as motile cells in the surface ocean and are an important part of phytoplankton. Many produce resting organic-walled cysts that are well-preserved in sediments, particularly in environments where calcareous and siliceous plankton are rare or absent due to dissolution, and they can offer a complementary approach to recording Quaternary climate change. Recent studies have used dinocyst assemblages to record detailed oceanic variations in sea-surface temperature, salinity, surface productivity and sea-ice cover. Moreover, analysis of coeval land-derived plant microfossils provides a direct link with changes in non-marine environments, allowing factors such as changes in the source and amount of terrestrial discharge to the oceans to be recognised.

Quaternary dinocyst research in Southern Hemisphere regions is currently limited and more studies, both spatially and temporally, are needed to document trends and variations in distribution patterns. Our current study is aimed at improving paleoenvironmental and paleoceanographic interpretation of fossil dinocyst assemblages by examining the distribution of Recent dinocysts in marine surface sediments off eastern New Zealand, in order to better understand the relationship between dinoflagellates and environmental conditions.

Thirty-eight marine surface sediment samples, obtained by NIWA, have been collected across the Subtropical Front and span a latitudinal transect from ~33º S (Northland) to ~54º S (South Campbell Plateau). The sample sites can be grouped into eight depth transects, extending from outer shelf to abyssal environments. Dinocysts are well-preserved and common to abundant in ~25 samples, along with other types of organic-walled palynomorphs such as spores, pollen, foraminiferal linings and copepod eggs. The absolute abundance of dinocysts, along with land-derived spores and pollen, appears to be highest in the vicinity of the southern North Island and Chatham Rise. A range of initial dinocyst assemblage distribution patterns will be presented.

In addition, results will be presented from a pilot study that examined dinocyst records through a rapid interval of climate change, from glacial Marine Isotope Stage (MIS) 6 to interglacial MIS 5 (~160 to 80 kyr), in ODP Site 1123, eastern New Zealand. Dinocysts are most abundant in MIS 6, and the high concentration of peridinioid and total dinocysts in this interval suggests that there was increased nutrient availability in surface waters during the glacial, relative to MIS 5. A reconstruction of the ratio between dinocysts thought to indicate relatively warm or relatively cool surface oceanic conditions shows a similar pattern to the oxygen isotope record, with cool sea surface temperatures during MIS 6 and the warmest conditions correlating with MIS 5e.

POSTER

GEOMORPHIC LANDSLIDE SYSTEMS OF NEW ZEALAND

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Much of our understanding of landslides has come from geotechnical engineering and engineering geology. The focus has been on mechanics, process behaviour, material properties and site specific hydrology and geometry. Despite some notable exceptions the subject has been case study driven. Geomorphologists have extended landslide study by positioning landslide activity and the occurrence of stability factors in a wider spatial and temporal context. A few studies have attempted to characterise the geomorphic work of landslides while a greater number have concentrated on landslide hazard. Although numerous landslide susceptibility maps have been successfully produced, the identification of frequency–magnitude behaviour has met with less success.

The notion of a landslide geomorphology has remained neglected. This would require the recognition of meaningful landslide geomorphology systems where there is a characteristic recurring interrelationship between landslide activity, geomorphic processes and landform in time and space. Systems might be distinguished on the basis on the extent to which landslide signature dominates the terrain, the temporal persistence of landslide features, episodicity versus chronic occurrence, the frequency –magnitude behaviour and the degree of fluvial coupling (residence time of deposits). Drawing on New Zealand conditions a first attempt is made here to identify landslide geomorphology systems for New Zealand.

It is proposed that five landslide geomorphology systems can account for the spectrum of landslide activity: alpine, stratigraphic, soft rock, edge, and regolith. They are directly controlled by rock properties, relief, and stratigraphy. The factors of climate, vegetation, tectonics and human activity indirectly govern the tempo of activity while seismic activity can also alter the mode of failure. In terms of landform evolution, the five landslide geomorphology systems proposed range in significance from short-term perturbations to long-term relief dominance.

A MIOCENE RECORD OF PRIMARY PRODUCTIVITY: BOLBOFORMS FROM THE SOUTHERN TASMAN SEA

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The late Middle to early Late Miocene section (12 to 8 Ma) of DSDP Site 593, in the southern Tasman Sea, includes a well defined sequence of narrow bolboform subzones. The record is characterized by several features that are not seen in the distribution patterns of planktic foraminifers at the same site: 1) bolboform occurrences are confined to narrow intervals ranging from 1.6 to 5.8 m thick, approximately 50 to 330 k.y. duration; 2) occurrences are often punctuated by intervals without bolboforms; 3) occurrences are often comprised of single species assemblages; 4) distinctive abundance spikes occur within most subzones; and 5) there are no intermediate forms linking distinctive subzonal occurrences. These features appear to be unique to the ecology bolboforms and they provide important insights into this microfossil group, which is thought to be extinct. They also suggest bolboforms did not evolve at the site where they were deposited and that their origin was extra-regional. This is consistent with the general consensus that they are subpolar phytoplanktic organisms and that they were transported into the Tasman Sea by subsurface (intermediate depth) waters generated by subduction of subantarctic surface water along the Antarctic Polar Front and Subantarctic Front. In this respect the punctuated record of bolboform influxes at Site 593 may represent periods of invigorated subsurface flow at intermediate water depths.

Morphological studies of large well preserved bolboform assemblages at Site 593, reveals a relationship between test size and intraspecific morphological variation involving a gradual transformation in test shape and surface ornamentation. In the studied populations, this appears to be an inherent biological feature involving the addition of calcite to the outer surface of the test wall and it is inferred that this occurred while the bolboforms were entrained in subsurface water masses. In this respect, the increased complexity of ornamentation may have been a morphological adaptation to counter the loss of buoyancy as calcite was added to the outer surface of the test wall. This would have presumably contributed to the entrainment and dispersal of bolboforms, and it suggests the calcite shells of bolboforms may represent a disseminal phase in their lifecycle. A similar analogy may be drawn from the disseminal phase of terrestrial plants, where large numbers of seeds are dispersed widely and only a small number germinate and go on to reproduce. While this interpretation of bolboforms is speculative, they have clearly played an important role as primary producers in the Southern Ocean and their contribution to the development of the ecosystem and its biodiversity should be taken into consideration, especially during the Eocene to early Oligocene and middle to late Miocene when bolboforms are most common.

POSTER

A NEW MIDDLE MIOCENE TIME SCALE

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A biochronology is established for Middle Miocene planktic foraminifers and bolboforms, using magnetostratigraphically calibrated age data from ODP Site 1123, on the northeastern flank of Chatham Rise, 1000 km east of New Zealand. The biostratigraphic model is based on dissolution resistant species and morphotypes and is constrained by five bioevents that are also found at DSDP Site 593, on the Challenger Plateau, 400 km west of New Zealand – an important reference site for the correlation of New Zealand stages. These biochronostratigraphic data enable interpolated ages to be assigned to planktic foraminiferal events at Site 593 that are used for the correlation of New Zealand stages, but are poorly constrained or missing at Site 1123 due to dissolution. Although the biostratigraphic construct is based on only two oceanic sites, and assumes constant sedimentation rates with no periods of non-deposition between magnetobiochronologic tie points, it establishes for the first time a robust Middle Miocene biochronostratigraphic framework for the New Zealand region, with bioevents correlated either directly or indirectly with the geomagnetic polarity time scale (CK-95).

Distinctive excursions in planktic foraminiferal oxygen isotope data at Site 593, towards more negative isotopic values, fit closely to the dates of globally isochronous Miller events when calibrated to the new time scale. While the oxygen isotope correlation supports the reliability of the new time scale, the lowest occurrence of *Praeorbulina curva* – an important Middle Miocene marker species – has an interpolated age of 15.94 Ma, which is at least 360 k.y. younger than the age that Berggren *et al.* (1995) assign to the same datum. The disparity of ages brings into question the hitherto assumed evolutionary nature of praeorbuline appearances in New Zealand, or alternatively the reliability of the Berggren et al. (1995) dates for the appearance of praeorbuline species.

TALK: Paleoenvironments & Paleobotany 1

THE OKAREKA & REREWHAKAAITU ERUPTIVE EPISODES; TARAWERA VOLCANIC COMPLEX, NEW ZEALAND

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The Okareka (22 ka) eruptive episode began with a small sub-plinian eruption of basaltic scoria followed by the eruption of plinian rhyolitic pumice deposits, and ended with the extrusion of voluminous lavas. At least two rhyolite magmas were involved – 1) crystal-poor with little or no biotite, and 2) crystal-rich with abundant biotite. Basalt played a major role in the triggering of the rhyolitic eruption, with mixed and mingled pumice clasts found immediately above the basalt. Basalt/rhyolite mingling and mixing is obvious in hand specimens, component analyses and thin sections. The two rhyolite magmas are chemically distinguished by high and low Zr. Several fluctuations in eruption power occurred during the episode, demonstrated by the stratigraphic sequence and the size distribution data. No major pyroclastic flow or surge deposits can be correlated between sites. Lithic populations consist almost entirely of rhyolite, both primary (essential) and accessory, suggesting a magmatic history in the Tarawera area before the Okareka event.

The Rerewhakaaitu (17 ka) episode also involved the eruption of plinian pumice deposits and lavas, with two different rhyolite magma types – 1) crystal rich with abundant biotite and 2) crystal-poor without biotite - being erupted, seemingly simultaneously. A significant mafic component has not been detected. The two different rhyolite magma types are mingled in dome lavas indicating that they were in close proximity before the eruption. Geochemically, the two different rhyolite magmas differ in Rb and Sr. As with the Okareka event, fluctuating eruption column processes throughout the episode are evident at outcrop, and in size distribution data, and no major pyroclastic flow or surge deposits have been recognised. Lithic populations consist almost entirely of primary (essential) and accessory rhyolite.

The Okareka and Rerewhakaaitu episodes represent the earliest of the five recognised stages of the Tarawera Volcanic Complex's 22 kyr evolution. These two episodes were followed by the 13 ka Waiohau; 0.7 ka Kaharoa and 1886 Tarawera episodes. The current focus of research is on the potential hazards that may arise from future eruptions at Tarawera. This research requires better understanding of the whole volcanic history of Tarawera. For the Okareka and Rerewhakaaitu episodes we are establishing eruption dynamics throughout each episode, gathering more geochemical data in order to understand the triggering and sequencing of the two eruptions, and improving the tephra dispersal maps. This will contribute to better understanding of Tarawera history and in turn assist hazard evaluation and mitigation.

POSTER

CRETACEOUS CRINOIDEA IN TERRANE COVER ROCKS OF NEW ZEALAND

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The Echinodermata are an ancient group (Cambrian onward), exclusively marine, and are among the most clearly defined of animal phyla. Crinoids are benthic echinoderms that are either sessile or vagrant, with or without stems. At least 80% of a crinoid's body is a skeleton of calcium carbonate ossicles held together by ligament and muscle that forms the basis for taxonomic classification. The robust skeletal composition has potential to preserve well, but the skeletal mass readily disarticulates post-mortem into many elements. Predation, scavenging, dispersal, abrasion, and leaching, affect preservation. It is often unclear whether dissociated ossicles represent a single taxon or many. Additionally, isocrinids practice regeneration and autotomy; they abscise a distal portion of the stem as an escape strategy when attacked. Shed and abandoned Cretaceous crinoid stems probably contributed to a disproportionate number of columnals per animal. However, even columnals are rare and a general paucity of crinoid fossils exists probably owing to a lack of appropriate facies and a preservation bias. Known and unknown extinction events and possible immigrations and migrations mean that the past biodiversity of New Zealand Cretaceous crinoids can only ever be an incomplete inventory.

Prior to this study, only one Cretaceous crinoid had been described and figured, with fossils remaining uninvestigated or cited as incidental taxa in faunal lists. This study, part of an assessment of the Mesozoic Crinoidea of New Zealand, only found crinoids in Cretaceous rocks from Raukumara Peninsula, Marlborough and Kaipara Harbour areas and Pitt Island. Collected material is mainly single or pluricolumnals. Taxa are from Clarence and Mata Series rocks and are Urutawan, Motuan (Albian), Piripauan and Haumurian (Campanian or Maastrichtian) in age. A collection and fossil preservation bias exists since much of the marine Early Cretaceous period is poorly represented in New Zealand. Crinoids from Cretaceous rocks of New Zealand have been tentatively classified into 4 orders, Isocrinida, Comatulida, Borgetacrinida, and Millericrinida, comprising 11 genera from 39 specimens covering a c. 20 million year period. Isocrinida dominate faunas and include the genera *Austinocrinus*, *Isselicrinus*, *Nielsenicrinus*, *Isocrinus*, *Metacrinus*, and *Doreckicrinus*. Comatulida is represented by a single centrodorsal of *Semiometra*, Bourgeticrinid genera are *Bourgeticrinus*, *Dunnicrinus*, and *Monachocrinus*. A single specimen of *Apiocrinites* represents the Millericrinida. *Semiometra* occurs in the Haumurian and is the earliest comatulid known from New Zealand. All genera are either Cosmopolitan or Tethyan faunas. Diverse isocrinid genera including *Pentacrinites*, *Seirocrinus*, *Isocrinus*, and *Chariocrinus* existed in New Zealand after the Triassic-Jurassic extinction event, but genera appear to have declined throughout the Jurassic and Early/Middle Cretaceous. An apparent influx of exotic stock increased species diversity in the Late Cretaceous. All Late Cretaceous species appear endemic and occur in shallow inner shelf waters (10-50 m) firm bottom sand/grit sediments with the exception of two middle to outer shelf silt paleoenvironments.

TALK: Paleontology 1

ECHINODERMATA BIODIVERSITY OF THE LATADY FORMATION, ELLSWORTH LAND, ANTARCTICA

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It is not known how many species are alive today, or the rate of their extinction. The full picture is never obtained, because the fossil record is prejudiced. Echinoderms are among the most clearly defined of animal phyla, yet a paucity of fossils exists in some orders due to a lack of appropriate facies, preservation and collection biases.

Eight echinoderm taxa were collected from less than 15% of outcropping Latady Formation. Five crinoids, two ophiuroids and one cidarid ranging Late Bajocian-Early Kimmeridgian in age are here recorded from fossil localities in the Behrendt, Wilkins, Latady, and Hauberg Mountains, Ellsworth Land, Antarctica. Scarcity of fossils in the marine metagraywacke sequence of the Latady Formation means that isolated, poorly preserved faunas are important in biostratigraphy, paleoecology, and paleobiogeography. The 'apparent' greater diversity of Cretaceous echinoderms in the Antarctic Peninsula maybe the result of preservation/collection biases attributable to a lack of suitable Jurassic facies and more accessible, less tectonically deformed, Cretaceous outcrops.

Echinoderm populations of the Latady Formation seem hugely disproportionate to those that probably existed and only a brief glimpse of prehistoric biodiversity is encapsulated in known taxa. Middle to Late Jurassic echinoderms of the Latady Formation appear to be cosmopolitan and Tethyan taxa at generic level, but endemic specifically. Migration across or around broad expanses of Tethys Sea and Panthalassan Ocean in the Jurassic culminating in subsequent isolation appears to have had ecologic and evolutionary implications that are barely measurable due to the many biases inherent in the fossil record.

SHRIMP DATING OF THE LOCH BURN FORMATION, FIORDLAND: IMPLICATIONS FOR THE MTZ

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The Loch Burn Formation (LBF) is a dominantly volcaniclastic unit that forms part of the Median Tectonic Zone (MTZ) in eastern Fiordland. Geochemistry and SHRIMP U-Pb dating was used to investigate the provenance of the LBF, and to assess its relationship to the Western Province.

SHRIMP U-Pb dating of a rhyolitic clast from an LBF conglomerate in the Stuart Mountains tops gave a well constrained age of 150.3±1.9Ma, inferred to date igneous crystallisation. No inheritance was detected. A very fine sandstone from the same area is strongly dominated by zircons that gave an age of 147.9±2.1Ma, with minor older material up to 348±5Ma. These ages require that the LBF is <148Ma in this area. Kimbrough *et al.* (1994) reported a U-Pb age of 195^{+3}_{-1} Ma from a lava flow intercalated in LBF metasediments in North Fiord, Lake Te Anau. The new SHRIMP ages therefore suggest that the LBF may be a composite unit with two parts of significantly different ages. It was not, however, possible to detect or map any distinguishing features between the two areas, and volcanic clasts from both areas are indistinguishable in terms of geochemistry. Two informal members within the LBF are therefore proposed, the Mid Lake member (<148Ma) on the Stuart Mountain tops, and the Slip member (c.195Ma) in the North Fiord area. These members were probably both sourced from the same long-lived volcanic arc. Geochemistry indicates that the source of the LBF was probably part of the greater Darran Suite arc system.

LBF conglomerates contain rare tonalite clasts, two of which gave SHRIMP ages of 326.8±3.2Ma and 354.6±2.6Ma. No inheritance significantly older than the magmatic ages was detected in either clast. These ages, together with trace element geochemistry, indicate that the tonalite clasts cannot be sourced from the c.344Ma Lake Roxburgh Tonalite as previously suggested, weakening the case for the postulated unconformable contact between the Lake Roxburgh Tonalite and the LBF. There are no granitoids currently exposed in Fiordland from which the clasts could have been directly derived. However, the c.330Ma Poteriteri pluton could potentially be genetically related to the 327Ma clast on the basis of age and trace element geochemistry. The 355Ma clast is similar in age to the Lake Hankinson Complex, but no trace element geochemistry is available for this unit.

None of the LBF samples dated show any evidence of inherited zircons with ages typical of the Paleozoic Gondwana margin (Western Province). This suggests that the LBF was probably derived entirely from within the MTZ.

Kimbrough, D.L., Tulloch, A.J., Coombs, D.S., Landis, C.A., Johnston, M.R., and Mattinson, J.M., 1994: Uranium-lead zircon ages from the Median Tectonic Zone, South Island, New Zealand. *New Zealand Journal of Geology and Geophysics 37*: 393-419.

TALK: Cretaceous 1

NEW OLIGOCENE DALPIAZINIDS FROM THE WAITAKI REGION: INCREASING THE DIVERSITY OF PLATANISTOID DOLPHINS

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Fossils help to understand the origins of high-rank living groups with low-diversity (e.g. monotypic families). Such living species are usually quite disparate, differing dramatically in structure from their closest extant relatives. Fossils may reveal the origins of disparity, and may reveal past high diversity.

Amongst Cetacea, 1-2 species of *Platanista* (Ganges and Indus River dolphins) are the only living members of the Platanistidae and Platanistoidea. Fossils greatly expand the diversity and disparity of the stem Platanistoidea, with the stem-Platanistidae, Squalodelphinidae, and Squalodontidae including good material from many localities. A single informative specimen is known for the Waipatiidae, while the Dalpiazinidae is based on a single fragmentary dolphin from Italy.

Late Oligocene dolphins from the Waitaki district appear to represent the family Dalpiazinidae. OU 22397 includes the skull, earbones, and a mandible from transitional Kokoamu Greensand-Otekaike Limestone; it has a long flattened upper jaw with projecting, gracile, tusk-like incisors. The maxillary teeth (n = 13) are polydont with diastemata, and have high, flattened triangular crowns with vestigial denticles. The mesorostral groove is open and shallow; there is a prominent vomerine window. The cranium is roughly symmetrical, with an intertemporal constriction but no orbital extensions of pterygoid sinuses. This specimen is the key to identifying earlier-collected dolphins as possible dalpiazinids. OU 22262 is a partial skeleton from transitional Kokoamu Greensand-Otekaike Limestone Sr dated at ~26 Ma. It is closely related to but not conspecific with OU 22397. The skull and mandible are incomplete, but tympanoperiotics are well preserved. Cervical and thoracic vertebrae, ribs, sternal elements, and flipper bones are present. OU 11519 (cranial and other fragments collected ~1940s by B.J. Marples) is probably from lower Kokoamu Greensand. Its teeth appear to represent a species more archaic than OU 22397 and 22262.

OU 22397 and 22262 appear to be close relatives of an un-named enigmatic dolphin, USNM 205491, from Alsea Formation (Early Oligocene) near Yaquina River, Oregon, northeast Pacific. The latter is older and shows more archaic features of the skull and earbones.

It is clear that such fossils will expand knowledge of diversity and ecology of early dolphins. Although dalpiazinids were probably significant in ancient New Zealand ecosystems, there are no modern equivalents anywhere in the world. Is the dalpiazinid niche 1), still present in the oceans, but vacant; 2), occupied by some other organism; or 3), did the niche disappear with the extinction of the group?

GLOBAL UNDULATIONS

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The poster shows a surface of global undulations as represented on the Earth Geodetic Model 96. The term of undulations refers to the discrepancies between mathematically defined WGS 84 ellipsoid and mean sea level of the Geoid 99. Undulations are caused by significant gravitational anomalies within the Earth's outer core, which pull ocean water to reach surface of the gravitational equipotential.

EARLY MIOCENE FORAMINIFERAL MG/CA TEMPERATURES FOR THE MOUNT HARRIS FORMATION, NORTH OTAGO

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Mg/Ca ratios in fossils have potential in paleothermometry to complement signals of oxygen isotopes from fossil carbonate shell ($\delta^{18}O_{calcite}$). Analyses of paired samples of Mg/Ca and $\delta^{18}O_{calcite}$ should reveal the elusive $\delta^{18}O_{paleo-seawater}$, which, for the middle Cenozoic, is considered a proxy for global ice volume. This study reports work on a closely sampled sequence of the Mount Harris Formation (Altonian, Early Miocene) of North Otago.

Mg/Ca paleothermometry will optimally use foraminifera that are living and also have a significant fossil record. Taxa used here are living and fossil *Cibicides* and *Notorotalia*. We established correlation curves for Mg/Ca ratio vs water temperature using modern samples of foraminifera from around New Zealand. The resulting correlations are: *Notorotalia*, Mg/Ca (mmol/mol) = $0.123e^{0.293T}$; and *Cibicides*, Mg/Ca (mmol/mol) = $1.23e^{0.126T}$. The latter result for *Cibicides* accords closely with published correlation curves for the genus.

We collected and analysed 12 samples at 33 cm intervals from mudstone of the Mt Harris Formation near Pukeuri. Samples represent the Altonian stage, around 18 Ma; sedimentation rate is uncertain but is presumed to be high (>50 m/Ma). Samples were cleaned to remove secondary (diagenetic) carbonates, and several specimens of each foraminiferan were analysed at each horizon. Mg/Ca paleotemperature estimates agree well for different foraminifera: 11.2 ± 0.3 ºC for *Notorotalia* and 11.4 ± 2.0 ºC for *Cibicides*. For *Notorotalia*, the 12 samples show almost uniform paleotemperatures, while *Cibicides* results are more scattered; however, the mean values for *Notorotalia* and *Cibicides* are concordant. These results imply that the main factor influencing Mg/Ca ratios is environmental temperature. A temperature around 11 ºC is lower than some suggested previously for the New Zealand early Miocene. Paired oxygen isotope results for *Notorotalia* provide an estimate of $\delta^{18}O_{paleo-seawater}$ for the 12 samples. $\delta^{18}O_{paleo-seawater}$ fluctuates, with values in the range –0.45 to –1.03 per mil. These are consistent with little or no global ice.

POSTER

THE PETROLOGY AND AGE OF THE LITHOSPHERE OF THE WEST ANTARCTIC RIFT SYSTEM (WARS) FROM PERIDOTITE XENOLITHS IN BASALTS

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The West Antarctic Rift System (WARS) that extends for over 2500 km along the eastern margin of the Antarctic continent from Cape Adare to the base of the Antarctic Peninsula has been a focus for intraplate volcanism dating back 30 Ma. Basalt scoria cones peripheral to the major strato volcanoes associated with WARS have sampled diverse suites of upper-crustal (granitoids and metamorphic rocks), lower-crustal (mafic and felsic granulites) and mantle (spinel facies peridotites) xenoliths, thereby offering a unique window into the lithosphere in this largely ice-covered wilderness.

Here we report major (EMPA), trace element (LAICPMS) and isotopic (TIMS) measurements on spinel facies lherzolite xenoliths from the WARS. Samples range in texture from coarse protogranular to porphyroclastic rocks. All are dominated by olivine (>60 modal %) that ranges between Fo_{90} – Fo_{93}. Orthopyroxene varies between 10 and 40 modal %, with 100Mg/Mg + Fe^{2+} = 90 – 92. Clinopyroxene is bright green in hand specimen, ranging in abundance from negligible (harzburgites) to ~ 10 modal %. Compositions range in Mg/Mg + Fe^{2+} from 91 – 93 with between 0.5 and 1.6% Cr_2O_3. In all analysed samples clinopyroxene is the major trace element bearing phase. Chondrite normalised REE patterns vary from slightly LREE enriched (Ce/Yb_n ~ 2 - 3) to LREE depleted (Ce/Yb_n ~ 0.6 – 0.3). Rare samples have clinopyroxene displaying unusual U-shaped LREE patterns (La – Sm), that are mirrored, at lower concentrations, in the orthopyroxene and olivine analyses. In clinopyroxene Sr ranges from 42 – 63 ppm, Sc from 47 – 66 ppm, with elements such as Zr, Hf and Y varying by factors of 400x, 80x and 5x respectively. Highly incompatible elements such as Ba and Rb are strongly depleted in all analysed samples.

Sr and Nd isotopes were determined on a sub set of these samples and broadly reflect the measured REE patterns. Depleted peridotites from the USAS Escarpment (Mt Aldas) and Mt Hampton on the Executive Committee Range (ECR) having depleted MORB mantle-like Nd (ε Nd = +6 - +10) and one sample ε Nd = +23, provides a T_{DM} of ~ 490 Ma. Os isotopes have also been determined for samples from the ECR, the USAS Escarpment and Fosdick Mountains and these provide new age constraints on lithosphere stabilisation in Marie Byrd Land. On-going analyses of samples from the Ross Sea Embayment and Trans Antarctic Mountains have yielded minimum Os T_{RD} ages from mid Phanerozoic to late Proterozoic and, overall, the WARS lithospheric mantle ages are consistent with a model of late Proterozoic lithospheric stabilisation along the Gondwana margin of West Antarctica. This is broadly consistent with a model of accumulation of voluminous basement-forming Phanerozoic sandstone – argillite deposits on oceanic crust along the length of the Palaeo-Pacific Gondwana margin, not only in West Antarctica, but also New Zealand and eastern Australia.

TALK: Petrology 3

KAKANUI: DIAMONDS OR NO DIAMONDS? THIS IS THE QUESTION

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The Kakanui Mineral Breccia, southeast Otago is one of only two known garnet bearing volcanics in New Zealand and has been the site of intensive geochemical investigation and scrutiny for over one hundred years. In the early twentieth century Thompson (1906) postulated the presence of diamonds and noted the similarity between Kakanui and kimberlitic diatremes, suggesting Kakanui as a potential diamond prospect. Recent renewed interest in Kakanui as a diamond prospect spurred on by recent unconventional finds may be unfounded as Kakanui has no true diamond indicators, and does not lie in a favorable tectonic setting or geotherm, where all these unconventional finds did.

Kakanui contains a diverse variety of mantle derived xenoliths (spinel peridotites, garnet pyroxenites & quenched pyroxenites) and megacrysts (kaersutite, augite, pyrope, anorthoclase, apatite, ilmenite, phlogopite and zircon) but none of these mantle xenoliths or megacrysts display the necessary geochemical signature for the presence of diamond. For example, the most common diamond indicator mineral (DIM) is a chrome rich pyrope garnet (G10), Kakanui contains pyrope rich garnets but they contain no chrome (<0.1 wt%) whilst G10 garnets contain between 4-12wt % and are sub-calcic (>4wt% CaO). In addition, Kakanui pyropes are megacrysts and not disaggregated garnets from peridotites, confirmed by major and REE element chemistry, in direct contrast to a G10 garnet. Similarly the pyroxenitic garnets do not display the elevated sodium contents displayed by true kimberlitic eclogitic garnets, ruling them out as a DIM. Ilmenite is another potential DIM but this mineral is used for determining the oxidation state of the magma to determine if diamonds would be preserved during transportation to the surface so the presence of ilmenite alone does not mean there will be diamonds present if they could survive the transportation process.

Diamonds are only stable in cool Archean cratons at depths >150km, well within the garnet facies; no garnet peridotites have been found at Kakanui to date. All experimental data illustrates that the megacrysts (pyrope garnets) and garnet pryoxenites formed at depths <80km (Merrill & Wylie 1975, Garden 2001) and geothermobarometry suggests that the geotherm under Kakanui is too hot to support the presence of diamonds. In addition there is no evidence that Kakanui, or New Zealand for that matter, is underlain by a cold stable Archean craton, which is needed to preserve diamonds for billions of years before transportation to the surface as a accidental passenger in a host magma.

In essence, the source region for the mantle xenoliths beneath Kakanui is not within the diamond stability field, does not lie on or near a cratonic margin and its mantle xenoliths do not display any geochemical signatures suggestive of diamond formation beneath Kakanui. Kakanui has a very complex petrogenesis involving at least three different magmatic bodies, none of which should be diamond bearing. All evidence suggests that the Kakanui Mineral Breccia should be barren and contain no diamonds.

TALK: Petrology 2

Re-Os SYSTEMATICS: SUMMARY AND APPLICATIONS TO IGNEOUS PETROLOGY - AN EXAMPLE FROM SOUTHERN AFRICA

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Rhenium-osmium systematics (Re-Os) provides a powerful tool in igneous petrology. Re & Os are siderophile elements; Re behaves incompatibly during partial melting whilst Os is mildly compatible, meaning that Os is concentrated in the residual while Re goes into the melt. This partitioning makes the Re-Os system an excellent tracer of melt depletion and is less susceptible to the metasomatism that plagues other isotopic systems (i.e. Sm-Nd & Rb-Sr).The Re-Os system can be applied in a number of ways as a petrogenetic tracer to determine depletion ages and histories. An example from the Bellsbank kimberlite (Group II, 120Ma), Kaapvaal craton, South Africa, is given below.

The Bellsbank group kimberlite lies west of Kimberley and the Colesburg Lineament (proposed suture zone where the eastern Kaapvaal was being subducted underneath the western Kaapvaal at 2.88-2.94 Ga) and contains a diverse variety of mantle xenoliths (eclogites and rare peridotites) and diamonds.

Bellsbank peridotites are split into three groups based on Re-Os systematics and petrography: spinel peridotites, garnet peridotites and garnet peridotites with garnet exsolution necklace texture (opx+gnt assemblages). Spinel peridotites are characterised by extremely low rhenium concentrations and tightly clustered model ages (average T_{RD} = 2.85 Ga ± 0.06, T_{ma} = 3.01 Ga ± 0.09). Garnet peridotites show more variation in Re and Os concentration and model ages that is interpreted as reflecting a higher degree of mantle metasomatism, kimberlite contamination or melting out of the sulfide component lowering Os concentration enhancing the effect of kimberlite interaction and metasomatism. Three peridotites have old T_{RD} model ages (>3.2 Ga). Compared to the other samples, these three peridotites contain lower mineral Mg numbers, illustrating that they are less depleted than the majority of the Bellsbank suite. The higher Mg numbers seen in the majority of samples may reflect multiple episodes of melt removal associated with fluxing of the lithospheric mantle with volatiles/melts from a subducting slab associated with the ca. 2.9 Ga Kimberley block accretion and subduction of the eastern Kaapvaal beneath the western domain.

Bellsbank eclogites define a 2.9 Ga isochron and their Re-Os concentrations suggest a protolith of a subducted slab which has undergone partial melting, so in essence the Bellsbank peridotites represent the residual of the Kimberley accretion slab at 2.9 Ga underneath the Kaapvaal craton.

The Bellsbank example illustrates the variety of uses the Re-Os system has in igneous petrology (melt depletion tracer & geochronometer) and its importance in unraveling the complex melt history of some igneous products and petrogenetic histories.

POSTER

THE EXHUMED MIOCENE-PLIOCENE ACCRETIONARY WEDGE OF THE CENTRAL APENNINES (ITALY)
THE NEW 1:100,000 GEOLOGICAL MAP OF MOLISE

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The Apennines of central Italy result from convergence between the European plate and the westward-subducted Adriatic lithosphere. From the Oligocene to early Pleistocene, shortening at the collisional margin involved progressive folding and thrusting of Mesozoic-Tertiary units and of late Miocene-late Pliocene clastic sequences deposited in the eastward-migrating Adriatic foredeep.

The new Geological Map of Molise at scale 1:100,000 (in print, early 2004) completes two decades of field research in the central Apennines. This project has led to new cartographic coverage over an area of 25,000 km^2 comprising the outermost domains of the thrust belt. The Geological Map of Molise embraces a representative portion of the accretionary wedge of the central Apennines, preserved in a structural low. This area is dominated by low-competence sequences of the far-travelled Sicilide thrust sheet (Cretaceous-middle Miocene), thrust over Mesozoic-Tertiary carbonate units and over late Miocene siliciclastic deposits telescoped with the carbonate substratum of the Adriatic margin. Internal deformation of individual units is heterogenous, reflecting competence contrasts between sedimentary packages, large-scale rotation of units during tectonic transport, and out-of-sequence propagation of thrust fronts. This system of tectonic units is largely allochthonous above the buried Pliocene foredeep and Adriatic foreland, as testified by boreholes, seismic profiles and gravimetry.

Along the Adriatic coastline, frontal thrusting above the undeformed late Pliocene-early Pleistocene foredeep is marked by a 10-15 km wide belt of chaotic and disrupted rock assemblages. Imbrication on low-angle NW-SE thrust faults involves the Mesozoic-Tertiary units and early Pliocene to early Pleistocene siliciclastic sequences. This tectonic mélange incorporates innumerable olistoliths of different size and provenance, derived from strong fragmentation of rocks of different ages and mixing into younger, poorly consolidated sequences. This setting is consistent with slope failure and debris avalanches at the frontal thrust, highly analogous in style and scale to current deformation and mass flow along the Hikurangi thrust front.

The Adriatic foredeep hosts the largest number of gas fields in Italy. To date, gas production in the Molise region is significant, but not the highest. South of the mapped area important stratigraphic traps (oil and gas) have been discovered in middle-upper Pliocene sands sealed by the outermost olistostromes that were derived from the eastern slope of the southern Apennines. Cross sections of the map reveal the hidden potential of the overthrust turbiditic reservoirs sealed by the tectonic mélange.

POSTER

VELOCITY MODELLING IN THE SOUTHERN GUAYMAS BASIN, MEXICO – RESULTS FROM THE GULF OF CALIFORNIA SEISMIC SURVEY 2002

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The Gulf of California, a focus site for the Continental Rifting component of the US National Science Foundation's MARGINS Program, is an ideal and unique location to study rifting processes. Rifting is young and ongoing and the style of rifting varies along the length of the gulf. The Guaymas Basin, located approximately halfway along the length of the Gulf of California, contains the northernmost examples of distinctly orthogonal ridge segments and transform faults along this boundary between the North American and Pacific plates.

In September – November 2002, a controlled-source seismic experiment, including extensive multi-channel seismic acquisition, was conducted in and around the gulf. As part of this survey, 480-channel seismic reflection transects were acquired across two ridge segments in the Guaymas Basin by the R/V *Maurice Ewing*. Whereas the northern of these two transects was instrumented with ocean bottom seismometers suitable for wide-angle crustal velocity analyses, the southern transect was not. On the southern transect, structural imaging and velocity control has been initially constrained by prestack depth migration. In addition, the velocity structure of apparent shallow sills within syn-rift sediments west of the ridge is tested using one-dimensional waveform inversions.

Fe-Mn NODULES FROM THE SW PACIFIC ARE ARCHIVES OF KEY PALEO-ENVIRONMENTAL INFORMATION FOR THE PAST 15 m.y.

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An extensive ferromanganese nodule field south of New Zealand (Campbell Nodule Field) has formed in ca. 4500 m water depth beneath the flow of the Deep Western Boundary Current (DWBC) and Antarctic Circumpolar Current (ACC). Recovered nodules yield $^{10}Be/^{9}Be$ ages ranging from 6.4 to 14.9 Ma, which correspond to growth rates of 3.5-7 mm $m.y.^{-1}$. $^{10}Be/^{9}Be$ ratios of the nodule rims, 1.34±0.05 atom $atom^{-1}$, are typical of ferromanganese nodules and crusts elsewhere in the Pacific Ocean. Smooth surface textures, relatively slow growth rates, and low Mn, Ni and Cu contents indicate dominantly hydrogenetic formation in conditions of very low net sedimentation.

ODP 181, Site 1121 sediment core was drilled through the 'Campbell Skin Drift' on the mid-western margin of the Campbell Nodule Field. This core lacks a definitive biostratigraphy, so a $^{10}Be/^{9}Be$-based chronology was derived from ferromanganese nodules entrapped in its upper part. The entrapped nodules, which are similar morphologically and chemically to nearby sea floor nodules, show a systematic decrease in measured $^{10}Be/^{9}Be$ rim ratios with depth in the sediment core, in accord with radioactive decay. Given that the nodules are in situ, and have remained intact physically and isotopically since cessation of growth, and assuming that the rim ratios reflect initial $^{10}Be/^{9}Be$ ratios equivalent to contemporary seawater, the age of the sediment core to 4m depth is 10.5 Ma. This is consistent with diatom biostratrigraphy indicating an age of 2-4 Ma at 1m depth. Calculated net sedimentation rates range from 8 to 95 cm m.y.-1, with a mean of 39 cm m.y.-1. The lowest rates generally coincide with the occurrence of entrapped nodules, and possibly reflect periods of increased bottom current flow causing net sediment loss.

There is an overall decrease in growth rate of the individual entrapped nodules towards the top of the sediment core, which corresponds to the observed decrease in growth rate from core to rim for their sea floor nodule counterparts. These decreases in growth rate, together with increases in Mn, Ni and Cu contents, and decreases in detrital element contents, Ce anomalies and heavy isotope concentrations from nodule core to rim are interpreted to reflect gradually intensifying DWBC/ACC flow since ca. 10 Ma and a changing water and bed-load composition since ca. 6 Ma.

THE GIANT DUNE BED LITHOFACIES OF THE OHAKURI PYROCLASTICS (TAUPO VOLCANIC ZONE, NEW ZEALAND), AS REVEALED BY GROUND PENETRATING RADAR

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Ground Penetrating Radar (GPR) has been successfully utilised worldwide to image shallow subsurface bedforms in a variety of volcaniclastic deposits. Here we present results from a GPR survey of a dune-bedded lithofacies of the ~ 240 ka Ohakuri pyroclastics in the Taupo Volcanic Zone, New Zealand. The study area is a ~ 2 km stretch of highway where 5-20-m-high benched roadcuts were established, but have subsequently been obscured by grass. GPR profiles were established on the tops of roadcut benches and are subparallel to the south-to-north transport direction of the parental pyroclastic density currents. A 400 MHz frequency antenna was used to provide optimum resolution and depth penetration in these conditions. A very high sampling density of 100 scans per metre was used to enable high image resolution and assist in the interpretation of smaller scale features. The profiles clarify and extend to the subsurface the previously visible bedforms, revealing giant dune structures with wavelengths up to 42 metres and amplitudes > 5 metres. Onlap relationships between successive dunes are consistent with the transport directions of the pyroclastic density current. In addition the profiles reveal internal structures within the mega dunes that provide insights into the depositional mechanisms of these deposits.

The giant dune-bedded deposits represent an aerially-confined lithofacies of Ohakuri ignimbrite deposits and are correlated with more-conventional massive ignimbrite that was being coevally deposited in other sectors at similar distances from source. The dune forms show low angles of deposition on both stoss and lee sides, and the deposits are fines-rich and lack any indication for the presence of liquid water on deposition. Grain size characteristics of laminae within the dunes change mostly with variable amounts of lapilli-grade material and, overall, grainsize distributions for the dune beds are very similar to those in the massive ignimbrite lithofacies. We conclude that the parental currents for the dune-bedded lithofacies were highly turbulent, but heavily loaded with material. Their closest analogues are some of the dune-bedded proximal deposits in the 1.8 ka Taupo ignimbrite, except that the Ohakuri examples are not simply a proximal variant but occur in a particular geographic sector.

POSTER

TEMPORALLY- AND TECTONICALLY-LINKED ERUPTION AND CALDERA-COLLAPSE EVENTS IN THE CENTRAL TAUPO VOLCANIC ZONE, NEW ZEALAND

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Central Taupo Volcanic Zone is remarkable for its silicic volcanism, including caldera-forming eruptions. On average, such events occur every 40-50,000 years, and include > 17 examples of > 100 km^3 magma. A particularly intensive period of large eruptions occurred between ~ 340 and ~ 220 ka, with > 6 events, the youngest two of which (Mamaku ignimbrite and Ohakuri pyroclastics) are discussed here. The Mamaku is > 145 km^3 magma and was associated with collapse of Rotorua caldera in the northern part of the central TVZ (Milner et al., 2003, *JVGR* **122**: 243-264). The Ohakuri pyroclastics represent > 100 km^3 magma, and were sourced from an ill-defined collapse structure ~ 25 km to the SSW of Rotorua (Gravley, Ph.D. thesis in progress). New fieldwork shows the following succession in areas between the sources of these two ignimbrites.

1. A small, poorly sorted fall deposit, rich in dense juvenile ejecta (dome-related?), that was partly reworked prior to deposition of
2. A small fall deposit consisting of a lapilli-rich base, and a fines-rich top. This is overlain with no reworking by
3. The basal plinian pumice fall deposit that underlies
4. The Mamaku ignimbrite. This ignimbrite is conformably capped by
5. An extremely fine-grained vitric (co-ignimbrite?) ash fall deposit. This shows minor water-reworking, but no deep gullying or weathering prior to burial by
6. The Ohakuri pyroclastics.

Field relationships show that the first two deposits, above, come from sources in the southerly part of the area, close to or possibly subsequently engulfed by the vent(s) for the Ohakuri pyroclastics. Units 3 and 4 come from a northerly source, Rotorua caldera. Unit 5 is inferred to be ash fall-out after emplacement of the Mamaku ignimbrite followed by the eruption of unit 6, the Ohakuri pyroclastics, from a southerly caldera source. All field evidence points towards only short time gaps in the whole sequence; months to years between units 1 and 2, days to weeks between 5 and 6, and no discernible gaps between units 2 through 5.

The Mamaku ignimbrite and Ohakuri pyroclastics share similar pumice chemistries and may share a common magma source, though this source could either have been a single geographically extensive zone, or two petrologically identical zones separated in space. However, field evidence rules out the Ohakuri pyroclastics from being simply an unusual lithofacies of the Mamaku. We infer that these two major eruptions and their two preceding minor eruptions occurred in rapid succession from geographically separated areas. The most feasible way to do this is by linkage through tectonic events, such as rifting (which is presently active at ~7-8 mm/yr in central TVZ). Contemporaneous faulting seems the most feasible means that could have allowed successive triggering of events over distances of ~ 25 km.

HEPWORTH'S MISSING FERN LEAF, AND VOY'S MISSING MOA FOOTPRINTS – REVISITED AND UPDATED

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Hepworth:- For much of the 1960's, the noted St Ives, Cornwall, based sculptor Barbara Hepworth worked extensively with slate. Her first experience with this medium [*Carving*(*Mylor*)] was probably a slab of Welsh slate taken from the bed of a discarded billiard table (Gale and Stephens, 1999). This lithology proved rather soft and most of her later works in this material utilised harder Devonian slate sourced from nearby Delabole Quarry. Four years ago I drew attention to Hepworth's misidentification of a "gorgeous fern fossil" that was revealed on the surface of one of her more substantive works [*Two figures* (*Menhirs*)] (Gregory, 1999). On inspection this had proven to be a trace fossil (probably *Scolicia*). At the time it was also suggested that trace fossils may be present in some of her other works in slate. This has proven to be correct and will be substantiated with views of two pieces – *Four rectangles with four oblique circles* and *Rhomboid 1.* In these bioturbation is intense and somewhat deformed with particular ichnotaxa difficult to indentify. The bioturbate textures or fabrics of this kind are often termed "lam-scram". These are also reminiscent of dark mud/light silt couplets recognisable in the current working face of Delabole Quarry. It has been claimed that fossils similar to the "fern leaf" ripped hacksaw teeth when stone was being cut. This is improbable – it is more likely that the saw had encountered shell material such as the well-known Delabole butterfly (a spiriferid brachiopod).

Gregory, M.R. 1999 Barbara Hepworth's missing leaf. *Geological Society of New Zealand, Miscellaneous Publication, 107A*: 53.
Gale, M. and Stephens, C. 1999 Barbara Hepworth. Tate Gallery Publishing, London. 296p.

Voy:- Moa footprints and trackways have been largely ignored by local paleontologists since the pioneering studies of the late 1800's and early 1900's. Specimens housed in local and overseas collections are mostly in the form of dismembered individual footprints. Many of these are preserved within wooden frames for protection. Work in progress (Gill et al., in prep.) suggests there may be less than eight specimens of moa trackways with more than two footprints. Of these, one described by Voy in 1880 appeared to have been long lost (Gregory and Lockley, in press). Recently, I examined and photographed a specimen (AMNH 55) in the American Museum of Natural History. There can be little question that this slab with four complete prints, and part of another, and which is preserved in a white tephric substrate, is the specimen figured by Voy.

Gill, B.J., Gregory, M.R., Lockley, M., Lovis, P.M. and Tennyson, A.J.D. (in prep) Fossilised footprints of Moas (Aves: Dinornithformes): History of research, ichnotaxonomy and palaeobiological implications
Gregory, M.R. and Lockley, M.G., (in press) Voy's missing moa footprints. *Newsletter, Historical Studies Group, Geological Society of New Zealand*

TEREBELLINA, TORLESSIA AND SOME OTHER SIMPLE TUBULAR (INCLUDING TRACE) FOSSILS – VENDOBIONT RELICS!!??

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There are a number of long lasting taxa that many consider "living fossils". Examples include, *Lingula* (brachiopod), *Limulus* (horseshoe crab) and *Sphenodon* (tuatara). Even some Precambrian trace fossils have a record that extends to the recent (e.g. *Skolithos* and *Planolites*), but not necessarily with the same progenitor. This being so, is it not possible that some vendobionts could have similarly persisted from Archean times to the present?

There are numerous simple and often similar tubular fossils whose taxonomic affinities and relationships are uncertain. Typical local examples include the variously identified *Terebellina, Torlessia, Titahia* and *Schaubcylindrichnus.* Today, it is widely accepted that *Terebellina* (and probably *Torlessia*) should be placed in synonymy with the foraminiferid, *Bathysiphon.* On the other hand, *Schaubcylindrichnus,* which may exist either as single (*Terebellina*-like) tubes, or with a clumped and colonial habit, which in some instances is suggestive of branching, remains an ichnofossil. Possibilities will be explored through the conspicuous black core of many *Terebellina.* Similarities can be drawn with the back-stuffed fecal matter in some vendobionts, and which probably provides some "skeletal stiffening" to organism structure.

DOCUMENTING BIG EVENTS BY SMALL THINGS - THE HOLOCENE EARTHQUAKE HISTORY OF THE EASTERN BAY OF PLENTY

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Fossil foraminifera and diatoms are used to identify sudden, probably earthquake-related, elevational changes in three Holocene sedimentary sequences from Ohiwa Harbour, eastern Bay of Plenty. Modern analogue calibration sets of faunal and floral census data are used to estimate paleosalinities and paleotidal elevations that help quantify seismic-generated, vertical displacements. Skeletal age models for the three vibrocored sequences are built on a combination of tephrostratigraphy and radiocarbon dating.

A new index, the Land elevation record (LER) is introduced to graphically portray earthquake related vertical land displacements on a time-depth diagram. Also plotted are elements used to calculate LER, such as the indicative depth estimated from microfossils, inferred sediment compaction, and the New Zealand Holocene paleo-sea-level curve.

All three Ohiwa cores, spread over 3 km of coast, contain both freshwater and intertidal sediments. A prominent erosional contact between freshwater peat or soil and overlying intertidal mud, records a major subsidence event in each core of c. 2 m, dated at c. 2600 cal years BP. The deepest core (7.4 m) indicates that this is the only substantial vertical displacement event to have occurred in the last 8 kyrs. A small subsidence event (c. 0.3-0.7 m) is indicated close to the top of one core, but is not present in the other two sites. This may be the result of a local land subsidence during the poorly known Taneatua Earthquake of 1866.

There is no historic human record of earthquake displacements around Ohiwa, but our study provides conclusive evidence of at least 2m of earthquake-related, subsidence during the Holocene, with a recurrence time of major earthquakes of c. 5000 + yrs.

TALK: Neotectonics 3

CONTROLS ON DEPOSITION OF THE WAIKATO COAL MEASURES

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The primary controls on peat accumulation during deposition of the Waikato Coal Measures have been inferred to be syn-depositional normal faulting, pre-depositional paleotopography, and regional subsidence. The data presented in support of these models are typically equivocal and which, if any, of these processes provide the principal control on the geometry and spatial distribution of coal seams in the Waikato Coal Region is uncertain.

Here we utilise a large database of drill-logs, seismic-reflection lines and mine exposures in four areas (Huntly, Maramarua, Rotowaro and North Huntly/ Waikare Coalfields) to test whether faulting, paleotopography, subsidence or a combination of these factors control coal seam architecture. These data offer information on the relative timing of faulting and coal measure deposition, together with information on the spatial relations between seam thicknesses, faulting and paleotopography.

In three of the four areas examined (Huntly, Maramarua, and North Huntly/ Waikare), basement topography seems to have been the most dominant control on coal seam distribution and geometry, position and number of splits, and thickness and number of partings. In these areas, coal measure deposition is unlikely to have been influenced by faulting. Coal seams invariably thicken over paleolows and thin over highs.

We suggest that the deepest and best developed of the paleolows were occupied by drainage systems at the time of coal measure deposition. These lows, when occupied by paleo-drainage, experienced locally elevated sedimentation rates which reduced peat accumulation, producing thin (< 1.5m) or non-existent seams within the depression. Alternatively, in cases where the paleolow was not occupied by drainage at the time of peat accumulation, coal thickness increases into the depression.

In contrast, fault processes were found to be the most important control in Callaghans Sector of Rotowaro Coalfield. The data produced shows that the Mangakotuku Fault appears to have accrued displacement between deposition of the Taupiri and Kupakupa Seams. A thick coal measure sequence developed adjacent to the downthrown side of the fault, with coal seams thinning and splitting towards the deepening trough. This structural depression provided the focus for sedimentation, which inhibited peat accumulation.

A key factor in the formation of coal seams in the Waikato Coal Region is therefore sediment supply. Both faulting and paleotopography provide mechanisms, which focus sedimentation into conduits, and significantly reduce its impact on peat accumulation outside these restricted areas. This process controlled the deposition of the thick, low ash Waikato coals.

POSTER

THE PATOKA FAULT: AN INCIPIENT ELEMENT OF THE NORTH ISLAND DEXTRAL FAULT BELT, NEW ZEALAND

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The Patoka Fault is a previously unstudied, northeast-striking active fault that lies within the western strand of the North Island Dextral Fault Belt, approximately 30 km west of Napier, 12 km east of the Ruahine Fault and 5 km east of the Mohaka Fault in central Hawkes Bay.

The Patoka Fault was examined to determine its length, surface expression, kinematics and paleoseismic history. Displaced landforms define the length of the Patoka Fault at the surface to be at least 15 km including a bifurcation at its northeast end and a series of short (200m long) traces near its southwest end. Holocene spurs and streams have dextral and vertical offsets of up to c. 13 m and c. 1 m respectively. No offsets greater than this were observed anywhere along the fault length. Two trenches at one site indicate that at least three paleoearthquakes have occurred on the Patoka Fault during the last c.5300 years, including at least one since the eruption of the Taupo tephra c. 1820 years B.P.

These new data indicate that the fault is predominantly dextral strike-slip in character with a secondary normal component that is upthrown to the northwest. We infer maximum horizontal and vertical slip rates of 2.6 mm/yr and 0.21 mm/yr respectively, based on the oldest available radiocarbon age of sediment that was deposited behind a shutter ridge at the trench site. The trench data imply a mean recurrence interval of c. 1600 years during the last c. 5300 years. The smallest observed displacement was c. 4m, which is consistent with a single event moment magnitude of M 7.3.

Based on its Holocene activity, location and proximity to the Mohaka Fault, the Patoka Fault is considered to be a splay of the Mohaka Fault. The discontinuity and shortness of its surface trace implies that it is at an early stage of its development. The Patoka Fault projects northeast along strike toward the Rangiora Fault. It is possible that the Patoka Fault is only c 5300 years old, in which case the maximum estimated slip rate may be close to the actual rate in the Holocene.

MIOCENE FLUCTUATIONS OF THE ANTARCTIC ICE SHEET INFERRED FROM PALYNOFLORAS IN SITE 1165, PRYDZ BAY, ANTARCTICA

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ODP Site 1165 was drilled into the Wild Drift, constructed from terrigenous sand and mud reworked by contour currents in 2000 m of water on the continental rise off Prydz Bay, Antarctica. The strata were cored to a depth of about 1000m with between about 60 to 80% recovery and span the period from 22 to 7 Ma.

The palynomorph assemblages recovered are complex, dominated by members of the acritarch genus *Leiosphaeridia* and reworked terrestrial spores and pollen of Permian to Eocene age. The rest of the assemblage is composed of dinocysts - both reworked and *in situ,* prasinophyte algae and other acritarchs. What little work that has been carried out from around Antarctica suggests that these complex assemblages are not typical of the modern sea floor. However such assemblages have been routinely recorded from the Arctic Ocean, providing some useful environmental analogues.

Detailed counts of the palynomorphs allow the hole to be subdivided into four distinct intervals based on distinct assemblages. Each interval is dominated by either:

- Reworked terrestrial palynomorphs – taken as indicating times when the Antarctic ice sheet expanded and covered the shelf
  or
- Leiospheres which are interpreted as indicating periods when the ice sheet retreated exposing the shelf again.

The overall pattern implies shorter term climate fluctuations from glacial to warmer conditions, superimposed on an overall deterioration. The youngest shift from warmer to glacial conditions appears to be the most extreme and is dated at about 15Ma, corresponding to the well known oxygen isotope shift generally linked to the build up of the permanent Antarctic ice sheet.

A CASE STUDY OF CHANGES IN TAXA LISTS OVER TIME, BASED ON THE OAMARU DIATOMITE

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Biodiversity is often based on listing taxa. Diatomists have been finding taxa in the Oamaru diatomite since diatoms were first noted in samples of "Kaolin" in 1886. Nineteenth century diatomists found hundreds of mainly undescribed taxa. Further records were made at a generally decreasing rate through the twentieth century. Meanwhile many taxa were reclassified, being separated, amalgamated and renamed. Both Schrader (1969) and Desikachary and Sreelatha (1989) have added several taxa. Schrader specialised in looking for pennate diatoms, which are less common in the material. Desikachary and Sreelatha looked for all the taxa known to occur, and also others likely to be present in Eocene to Oligocene times. Most recently Ross and Sims of the British Museum have examined the fine structure of some taxa and have reclassified some of them.

Measurement of biodiversity normally depends on species lists. The Oamaru diatomite has a long list of over 500 taxa, but it was originally intensively studied as a source of many new taxa. Biodiversity measurements are far too influenced by taxonomic effort!

TALK: AAP 2

FORAMINIFERAL RECORD OF HUMAN IMPACT ON INTERTIDAL ESTUARINE ENVIRONMENTS IN AUCKLAND

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Four short cores (0.8-0.9 m) of low-tidal, estuarine sediment on the fringes of the Waitemata Harbour (Panmure Basin, Rangitopuni Estuary) provide a multi-proxy record of the physical and ecological impacts of the growth of Auckland city. The cores have been dated using radiocarbon, palynology, caesium-137, and lead-210, and correlated using their profiles of historic heavy metal contamination. All cores record similar dramatic changes in their fossil content since the arrival of humans (c. 1300AD), with faunal changes continuing through to the 1970s. Molluscs have disappeared from all cores, and the foraminiferal faunas have switched from dominantly calcareous (*Ammonia* association) to dominantly agglutinated (*Textularia-Schlerochorella*, *Miliammina-Haplophragmoides* associations). A two-step change is evident, with an intermediate mixed calcareous-agglutinated faunal zone (1950s-1970s), characterised by peak abundances (13-20%) of *Elphidium gunteri* and *E. excavatum.*

The faunal changes replicate the zonation in a low tidal transect of surface samples going up the Rangitopuni Estuary at the head of the Waitemata Harbour. Canonical Correspondence Analyses of the foraminiferal and environmental proxy data from the cores and the modern estuary transect, indicate that faunal changes can be largely attributed to decreasing salinity; and additionally lowered pH (causing carbonate dissolution) in the more brackish Rangitopuni Estuary core locality. There may be a weak correlation with increased nutrients (TOC, N, P), but sediment grain size and increasing heavy metal concentrations played no part in producing the foraminiferal changes. The absence of deformed foraminiferal shells suggests that neither natural environmental stress nor heavy metal concentrations (Pb 40-100 ppm; Zn 130-250 ppm) were sufficient for these to be generated.

All cores contain a hiatus between the pre-human and late European (post 1950) periods, coincident with cockle layers and the first major change in foraminiferal faunas. The onset of decreasing salinity through increased freshwater runoff, probably began with forest clearance in Polynesian (c. 1300-1840) and early European (1840-1900) times. Faunal changes were more dramatic because of more severe salinity decreases in Rangitopuni Estuary cores with its large catchment. Sedimentation has increased throughout the harbour since the 1950s, as a result of land disturbance associated with accelerating urban subdivisions. More faunal changes linked to further decreased salinity, occurred in the 1970s, probably attributable in Panmure Basin to an increase in impervious surfaces (roofs and paved areas) as its small catchment was rapidly urbanised.

READING THE FOSSIL RECORD: USING THE LITERATURE TO ANALYZE ECOLOGICAL PATTERNS IN BIODIVERSITY CHANGE

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The use of literature-sourced data in paleontological investigations has become standard practice in recent decades, particularly for the construction of diversity curves at a variety of temporal and spatial scales. These data are also useful for analyzing paleoecological trends of importance in macroevolutionary investigations. The advantages of compiling these data are clear; in particular, they are readily available, often in extensive faunal lists. However, the construction and use of large databases is not a straightforward task because of difficulties with data management and, perhaps more importantly, the need to standardize both taxonomic and temporal frameworks for the data entered.

A literature-based dataset has been compiled for marine macroinvertebrate faunas from the late Cenozoic of New Zealand, to investigate macroevolutionary and paleoecological trends in relation to regional changes in biodiversity. These data include macrofaunal assemblage lists spanning the Oligocene to Pleistocene (Whaingaroan through Haweran NZ stages). The genus-level database contains c. 25,000 occurrences of bivalves, gastropods, scaphopods, and articulated brachiopods from 2150 localities, representing 583 unique genera in all. Overall, raw diversity patterns derived from these data are consistent with those of the more comprehensive dataset of Crampton et al. (2003), suggesting that this new database has adequately sampled New Zealand's late Cenozoic biodiversity. As a test of the quality of this dataset, a number of diversity indices were analyzed with respect to geography and a range of paleoenvironmental controls, including water depth and sedimentary facies. Two important features are apparent: (1) the data are not distributed evenly with regard to geographic and paleoenvironmental settings through time; and (2) measures of alpha diversity within these settings are highly variable. These observations point to the need to account for such variability when assessing regional diversity trends throughout the Cenozoic. Exploratory multivariate statistical techniques applied to this dataset have also allowed the measurement of similarity between faunas of successive biostratigraphic stages, and throughout the entire interval, elucidating patterns of both taxonomic and ecological change beyond what are apparent from studying general diversity trends.

Moreover, construction of the present database has highlighted a range of problems inherent to assemblies of literature-sourced data in biodiversity and paleoecological investigations. These include the highly variable quality of taxonomic data (both accuracy and nomenclatural issues), and the uneven availability and quality of subsidiary data (e.g., information on stratigraphy, sedimentology, and paleoecology). I will present a summary of these issues, their potential influence on diversity and paleoecological analyses, and the use of numerical procedures developed to resolve them.

Crampton J.S. et al. (2003), Estimating the Rock Volume Bias in Paleobiodiversity Studies: Science, v. 301 (5631), p. 358-360.

TALK: AAP 2

SHELF TAPHOFACIES FROM THE MIOCENE-PLIOCENE OF NEW ZEALAND – PALEOENVIRONMENTAL RELATIONSHIPS AND APPLICATIONS TO SEQUENCE STRATIGRAPHIC ANALYSIS

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Condensed shell beds are used commonly to highlight the internal stratal geometry of fifth and sixth-order glacio-eustatic sequences in late Neogene sedimentary basins of New Zealand. Condensed shell beds, together with associated disconformities provide stratigraphic guides for the subdivision of sequences into their component systems tracts. In addition, shell bed facies contain important taphonomic data that adds to, and complements, the palette of paleoenvironmental indicators (including sedimentologic and paleoecological data) available to the field geologist. Such beds also provide valuable information on rates of environmental change during sequence deposition.

An investigation of the taphonomy, paleoecology, and stratigraphy of skeletal concentrations of the Matemateaonga Formation (Late Miocene-Early Pliocene) of the Wanganui Basin, New Zealand, has provided a basis for the classification of taphofacies, which are assigned to either transgressive or highstand/regressive systems tracts. Two taphofacies are described from transgressive systems tracts, the amalgamated shell bed and sediment starved shell bed taphofacies, which represent concentration by wave and current agitation, and sediment starvation (respectively). Five additional taphofacies described from highstand and regressive systems tracts, exhibit a gradient of sedimentologic, taphonomic, and paleoecological properties that result from responses to variations in storm event intensity across the paleo-shelf bathymetric gradient.

Comparisons are made between these examples and those of shell bed and carbonate facies described from other Plio-Pleistocene cyclothemic lithostratigraphic units in New Zealand. Many analogues to Matemateaonga Formation taphofacies are identified from the literature, although variation exists in their taphonomic properties because of temporal and spatial variation in basinal depositional environments (e.g. sedimentary regimes, hydrodynamic conditions). It is acknowledged, however, that while shell beds associated with disconformities have direct sequence stratigraphic utility as marker beds, the taphofacies they contain are not consistently reliable indicators of systems tract position, and should be considered in association with other sedimentologic and paleoecological information. In addition, the taphofacies, that characterize the siliciclastic-dominated portions of sequences (HST/RST) possess little direct relevance to sequence stratigraphic analyses, but do provide valuable information on environmental conditions, in particular, depth relative to storm and fair-weather wave base, and proximity to shoreline.

POSTER

A DIVERSE MID - LATE JURASSIC MARINE FAUNA FROM ELLSWORTH LAND, ANTARCTIC PENINSULA

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The Latady Formation, situated on the south-eastern edge of the Antarctic Peninsula (Fig. 1), is in places abundantly fossiliferous. Substantial collections were made during a deep field British Antarctic Survey expedition in the 1999/2000 field season. The fauna is entirely marine and comprises c.170 species (93 genera), dominated by marine invertebrates, predominantly bivalves, but also cephalopods (ammonites and belemnites), brachiopods, echinoderms, annelids, an arthropod, and a solitary coral. Of note is the relatively diverse echinoderm fauna that consists of 5 crinoids , 2 ophiuroids, and a cidaroid. Vertebrates constitute a minor component (4 specimens), consisting of at least two, possibly three, species of fish and the second Jurassic record of marine reptiles from the Antarctic Peninsula.

Fig. 1. Map of Antarctica showing location of the Latady Formation.

Initial studies demonstrated cosmopolitan faunal affinities for the Middle Jurassic, in contrast to the Late Jurassic strata, where strong affinities exist with the coeval New Zealand (Murihiku Supergroup), and South American faunas. Faunal similarities are such that early workers applied local New Zealand bivalve-based biostratigraphic stages to Late Jurassic strata in the Latady Formation. Scarce, poorly preserved belemnites are inconclusive. Ammonites are rare, and usually poorly preserved. Those from the Bajocian, Oxfordian, Kimmeridgian, and Tithonian are well documented, but ammonites from supposed Callovian strata are indeterminate.

A concise account of the fauna, paleoecologic interpretations, and key index species used for biostratigraphic analysis will be presented.

MICROSTRUCTURAL EVIDENCE FOR MULTIPLE QUARTZ DEFORMATION MECHANISMS OPERATING IN DEEP BRITTLE-DUCTILE SHEARS NEAR FOX GLACIER, NEW ZEALAND

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Microstructural research carried out on an exhumed brittle-ductile transition zone (BDTZ) in the central Southern Alps of New Zealand has been found to show an unusually broad range of deformation mechanisms occurring in brittle-ductile shear zones. The shearing occurred at transient brittle conditions c. 20 km beneath the Southern Alps and is associated with back shearing on a frontal ramp in the oblique convergence zone. These steeply dipping dextral reverse shear zones are the youngest ductile fabric in the quartzofeldspathic Alpine Schist. Organised arrays of the structures striking sub-parallel to the Alpine Fault are exposed on a 2 km wide glaciated exposure above Fox Glacier in biotite zone rocks c. 7 km structurally above the Alpine Fault.

Field observations of offsets and measurement of crystallographic preferred orientation (CPO) of quartz c-axes in veins deformed by these shears allows us to calculate ductile shear strain and slip directions. Field based strain-rate estimates range from 10^{-7} to 10^{-9} sec^{-1}. Steeply pitching stretching directions measured from CPO of quartz c-axes suggest near pure dip-slip shear during ductile deformation in the shear zone.

Brittle faulting of quartzofeldspathic schist occurs synchronously with ductile deformation of centimetre thick quartz veins. During accumulation of offset, deformation and attenuation of sheared quartz veins was accommodated by further ductile deformation and crack-tip propagation along the schist vein margins. Brittle deformation was achieved when shear-related thinning allowed the propagating crack-tip to penetrate through the vein. Crack-seal infilling of faulted quartzofeldspathic schist by quartz carbonate veins was followed by ductile creeping and finally by static late stage annealing of the deformed quartz veins and the syntectonic infilling veins.

Microstructural observations and the CPO of quartz c-axes have been used to determine three groups of deformation mechanisms in the sheared quartz veins. First, semi-brittle deformation associated with initial brittle failure is observed in quartz crystals which have healed microcracks and in crystals with internal dislocations that have not been able to recover by dislocation climb at high differential stress. Second, dislocation creep, accommodated by grain boundary migration and subgrain rotation recovery mechanisms, similar to the experimental regime 3 of Hirth and Tullis (1992), was active during deformation of quartz veins. Corresponding CPO fabric patterns show variable activity of rhomb and basal crystallographic slip systems. Third, grain boundary sliding has been interpreted in some ductile shear zones from the progressive evolution of a strong CPO fabric outside of the shear zone to a randomised fabric within the zone. This range of deformation mechanisms suggests that sheared quartz under these conditions is highly sensitive to controlling factors such as changes in strain-rate, stress, temperature, carbonate and mica impurities and the effects of fluid pressure in the BDTZ.

POSTER

ARE THERE MORE MARINE MONSTERS OUT THERE?

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During the course of research on New Zealand Late Cretaceous plesiosaurs, we have become aware that, in addition to three named taxa of elasmosaurs and one cryptoclidid, bones of creatures that cannot easily be attributed to these forms are present in the collections of several institutions. This leads us to ask just what other marine monsters were out there.

From the time of the first discovery of fossil marine reptile bones in the Waipara River in 1859, some unusual specimens were encountered. Previous authors tended to place much of this generally indeterminate material within the Pliosauroidea. Welles & Gregg (1971) wrote that among the bones was a growth series belonging to a giant polycotylid (at the time, polycotylids were included among the pliosaurs), although there was insufficient material to diagnose the genus or species. In addition, they claimed there was at least one other polycotylid represented only by fragments. Wiffen & Moisley (1986) also listed a number of indeterminate pliosaurid specimens from Hawke's Bay.

Isolated bones in the collections of Canterbury Museum indicate the presence of a plesiosaur of exceptionally large proportions. Included among these are two fragments of a very large skull that were recovered separately from the Waipara River area in the late 19th century. Although the specimens would have been available to Welles and Gregg, they apparently chose to ignore them. The preserved portions of the skull resemble similar parts of skull material attributed to the elasmosaurs *Mauisaurus* and *Tuarangisaurus* but the dimensions are approximately three times larger. If the skull does belong to an elasmosaur then the owner would have been much bigger than any previously described member of that family.

A further specimen, a partial skeleton from the Waipara River, also shows differences from elasmosaurid and cryptoclidid skeletons and cannot be readily placed in either family. However, in the absence of skull material, we are unable to say whether it might belong in the Polycotylidae or in some pliosaur family. Available evidence, therefore, suggests that plesiosaurs other than elasmosaurs and cryptoclidids were, indeed, part of the New Zealand Late Cretaceous marine reptile fauna, but their true nature cannot yet be determined.

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POSTER

JAMES HECTOR BEFORE NEW ZEALAND

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James Hector (1834-1907) was a scientist of major importance to New Zealand for over forty years. His principal focus was geology but his contribution to natural history was catholic and influential. He was born and educated in Edinburgh, although the family roots had been in Aberdeen, in the Highlands. Educated nominally in medicine, he informally studied natural history, geology and botany in particular, such that his abilities in those fields became obvious, before he graduated MD, Edinburgh, in 1856. This heritage and education bore the thread of commonality between him and Sir Roderick Murchison, the prominent generator of 19th Century British imperial geology, whose several offices of influence in Britain culminated in his Directorship of that Geological Survey. Although the ultimate details are not clear, it is apparent that it was the Scottish links which led to Murchison's recommendation of Hector as geologist and naturalist to the British North American Expedition of 1857-1860, led by Captain John Palliser. In this Hector participated with unqualified success as a geologist, natural historian, social philosopher and medical practitioner. That his contribution played such a major part in the scientific success and the safety of the whole expedition, directly led to his appointment, *via* Murchison, as Otago Provincial Geologist in 1862. The explorations of the Palliser Expedition made a considerable contribution to the establishment of communication and thus settlement of the area from Lake Superior to Vancouver Island in British North America. Hector's legacy is only in part his contribution to the official account of the two and a half year expedition. It also lies in his own published account of the geology, illustrated by maps of geology and geography and more than fifty sectional drawings covering a transect of the continent of more than 1150 miles. Thus, although the history of the Expedition has been published, edited and exhaustively resourced, Hector's inclusion and role in it are so pivotal to his future in New Zealand geology and natural history, that its reconsideration in presenting any biography of Hector is essential.

LATE QUATERNARY EVOLUTION OF THE NORTH HOROWHENUA COASTAL PLAIN, SOUTHWEST NORTH ISLAND, NEW ZEALAND

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The southwestern coastal region of the North Island, New Zealand contains a near continuous stratigraphic record of Late Quaternary climate change. Along the eastern rim of the South Wanganui Basin, subsurface faulting has produced small sedimentary basins that have allowed the formation of thick (~600m) sedimentary sequences. The Horowhenua coastal plain is one example. This area has built up by progressive progradational-retrogradational stacking of alternating facies successions that reflect regressive-transgressive cycles of sea level and climate change associated with local tectonism.

The current research aims to use sediment samples collected from a borehole being drilled south of Levin, near Ohau, to test the marine-terrestrial components of the coastal plain using the concepts of sequence stratigraphy. In general, each stratigraphic sequence is about 10-15m thick and contains four recurring sedimentary units that begin with basal marine silts, which are successively overlaid by marine sand and gravel, marine sand, and terrestrial sand, silt and clay.

Preliminary interpretations suggest marine silts are characteristic of shallow marine or estuarine facies that were deposited during postglacial transgressions, possibly behind the Poroutawhao High that was an exposed greywacke basement high during glacial lowstands. Marine sand and gravel deposits are possibly from a mixed sand-gravel beach system that infilled the lagoonal-estuary as accommodation space reduced in association with a slowing and stabilisation of sea level. Following infill, when accommodation space had disappeared, existing nearshore strata gave way to late highstand progradational strata characteristic of strand plain development, and wide spread fluvial and swamp deposition that deposited dune sands, and fine terrestrial sand, silt and clay. The age and number of these sequences preserved beneath the coastal plain is the focus of this study.

SPATIAL BIODIVERSITY OF EXTANT MARINE MOLLUSCS IN THE NEW ZEALAND REGION

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Constructing and interpreting fossil biodiversity in great part relies on extrapolating ecological and geographic distributions from living relatives. However the biogeographical and ecological distribution of many modern groups is still poorly understood.

As part of a larger study of New Zealand Cenozoic molluscan biodiversity, an integrated GIS-relational database has been developed to improve our understanding of the ecology and biogeography of marine bivalves, gastropods and scaphopods in the New Zealand region. The data were extracted from the Te Papa Collections Management Database "Te Kahui" and are based on their collection of living molluscs, the most comprehensive in the country.

The database catalogues approximately 3490 locations throughout the New Zealand region with a list of taxa collected at each site. The species lists comprise 1771 mollusc taxa representing 142 families. In addition approximately 1000 of these species have detailed ecological and size data. This type of dataset is ideally suited to the application of GIS (Geographic Information Systems) tools to help interpret biological patterns.

An initial study has examined the spatial distribution of modern species diversity and compared this with sampling location distribution. Diversity, represented by number of species recorded at each location was mapped as a density surface. Sample locations were also mapped as a density surface and compared with diversity.
The areas of highest diversity are the Three Kings Islands, Bay of Islands, Wellington/Wanganui region, Fiordland, Stewart Island and canyons along the east coast of the South Island. Some areas with high sampling density show surprisingly low diversity, notably east coast of the North Island south of East Cape and much of the Chatham Rise. The data also reveal data gaps in the Canterbury Bight and parts of the west coasts of both islands.

Future work will examine the degree of endemism in areas of high diversity as well as broader distribution patterns of specific families.

HIGH GRADE ROCKS OF THE BONAR RANGE, CENTRAL WESTLAND

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Basement rocks of the Bonar Range consist predominantly of amphibolite-grade orthogneiss and gneissic granitoids. Sillimanite-bearing paragneiss, schist, mylonite-series rocks, weakly-deformed granitoids, and pegmatites make up the remainder of basement rocks. In central Westland (south of the Grey River), the Bonar Range is unique in that it is the only occurrence of high-grade rocks that outcrop west of the Fraser Fault.

The gneissic granitoids and orthogneisses can be subdivided into southern and northern mapping units based on accessory mineralogy. The southern part of the Bonar Range consists of highly-deformed biotite-garnet±sillimanite±muscovite granite/granodiorite (occasionally tonalite) or orthogneiss equivalent. The northern part of the Bonar Range is a highly deformed biotite-muscovite granite/granodiorite or orthogneiss equivalent; sillimanite and garnet are absent. Metasedimentary enclaves occur throughout both mapping units. The presence of metasedimentary enclaves, red-brown biotite, muscovite, Al-rich minerals (in the southern part of the range), and low magnetic susceptibility in the rocks are characteristic of S-type granitoids. Based on the S-type character and a probable intrusive relationship with a Late Devonian granitoid, the gneissic granitoids and orthogneiss are correlated with the Karamea Suite.

Tectonic foliation is mainly E-W striking, dipping to the north, and probably relates to Devonian metamorphism. Overprinting the foliation are late-stage thin mylonitic zones of similar orientation. The mylonitisation occurred under greenschist conditions with stretching lineations and shear-sense indicators indicating a top to the NE-E sense of shear. The late-stage mylonitisation may relate to Early Cretaceous extension seen elsewhere in the Paparoa Range and Fiordland. Close to the Fraser Fault, tectonic foliation is NNE-SSW striking, dipping to the SE, and is consistent with a Cenozoic foliation found in the adjacent Fraser Complex.

Low-grade Greenland Group rocks and undeformed granites in the nearby Rangitoto Range clearly represent a higher crustal level than the Bonar Range gneissic rocks. The rapid change in crustal level is most easily explained by an inferred NNW striking fault between the two ranges.

THE EASTERN SOUTH ISLAND SEDIMENTARY SYSTEM: CHARACTERIZATION OF SOURCES OF SEDIMENT TO THE BOUNTY FAN

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The Bounty Fan is located approximately 830 km east of Dunedin in the seaward axial deep of the Bounty Trough. The abyssal fan represents the terminus of the Eastern South Island Sediment System (ESISS) and consists of interbedded contourites and turbidites deposited from the Early Miocene (~16 Ma) to present. A ~900 km long network of submarine canyons forms the link between eastern South Island river systems and the deep sea fan. While ESISS represents the main input to the Bounty Fan, deposition has occurred directly in the path of the South Pacific deep western boundary current (DWBC). The DWBC represents a vigorous sediment transport system that has reworked and added/removed sediment from the fan system. Additional inputs to the fan include ash fall and rhyolitic tephra from arc magmatism in the Taupo Volcanic Zone and local biopelagic deposition.

This work seeks to take advantage of the major and trace element composition of different sediment sources in an attempt to track the influences of each through the ~16 Ma depositional history of the Bounty Fan. Similar studies have been used to help establish the erosive evolution of the Western Himalaya and constrain sediment provenance and erosion process in the Congo and Amazon river basins. High standing islands in the South Pacific contribute a large portion of global sediment flux to the ocean but little geochemical data exists for the suspended sediment of these fluvial systems. Thus, this work will also focus on the analysis of fluvial suspended sediment and its relation to global solid-phase geochemical fluxes to the ocean.

XRD analysis suggests that there is little mineralogical distinction between the bedload sediments of three major ESISS rivers that contribute to the Bounty Fan (Clutha, Waitaki, and Rangitata). Fine sand and silt size fractions are dominated by quartz, plagioclase, chlorite and muscovite; these minerals directly correspond to the mineralogy of unweathered parent rocks in each river catchment. Downstream attenuation of plagioclase peaks at 3.21-3.18 Å may represent the preferential dissolution of feldspar. XRD data indicate no fractionation of minerals between 355-63 μm, 63-45 μm, and < 45 μm sample splits. Initial XRF data suggests that river bedload chemistry differs very little from average bedrock lithologies. A downstream decrease in all trace element concentrations in the fine sand fraction (355-63μm) of the Clutha river is not paralleled by trace element signatures of the 63-45 μm and <45 μm fractions. This distinction is likely the result different transport mechanisms as sand-size grains weather or are diluted by quartz during bed load saltation and silt size grains are conserved in the suspended load.

POSTER

LAKE DEPOSITS NEAR ORMOND, GISBORNE: A RICH TERRESTRIAL MID-PLEISTOCENE RESOURCE

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Lacustrine sediments exposed in Ormond Valley Road (OVRd) near Gisborne have been well-known since collections of well-preserved fossil leaf, fish, bivalve and feather impressions were made by Hill, Ongley and Oliver in the early 1900's. Unfortunately, the stratigraphy and age of these fossil-bearing lake sediments was essentially unknown. Using these leaf impressions, the principal objective of this study was to assess, for the first time in New Zealand (NZ), the application of leaf morphology-based paleoclimate methods to floral assemblages of Quaternary age.

The OVRd fossil-bearing localities were revisited in early 2003. A c.10 m-thick sedimentary succession was described in detail and sub-divided into a lower and upper section. The lower section is dominantly comprised of inorganic to highly carbonaceous muds and silts, whereas the upper section (~4 metres) predominantly comprises very finely laminated diatomite. Nineteen mm- to cm-thick tephra beds and five dcm-thick hyperconcentrated flow deposits of dacite to rhyolitic composition were also identified within the 10 m-thick succession. None of these dacitic to rhyolitic layers could be correlated to proximal TVZ-source areas. However, one geochemically distinctive OVRd tephra bed (AT-568) was tentatively correlated on the basis of its glass shard chemistry to a tephra layer (1124C 3H 3W 54-56; 28.37 mcd) with an astronomically tuned age of 0.7136 Ma occurring in a deep-sea core retrieved east of North Island. Further age control is likely to be made from three OVRd tephras that are in the process of being directly dated through application of the isothermal plateau fission-track (ITPFT) technique.

New collections of leaf, fish and bivalve impressions were made from the OVRd succession but the richly fossiliferous horizons of the original collections were unable to be relocated. Only scattered plant and faunal remains were found. In applying leaf macro-morphological methods of paleoclimate analysis only dicotyledonous angiosperm leaves are known to be suitable. The original collection studied by Oliver, and later re-assessed by McQueen, contains 20 different dicotyledonous plant forms. An initial temperature analysis using a multivariate method, and based on the 18 dicotyledonous leaf forms suitable for analysis in the published collection, suggests the Ormond flora grew under cool temperate conditions. Discrepancies in estimates from the multivariate method and the more widely used Leaf Margin Analysis method support the pilot study hypothesis that, like the modern NZ vegetation, NZ Quaternary vegetation exhibits a different leaf morphology/temperature relationship than is seen in other regions of the globe, particularly in the Northern Hemisphere.

PALEOSEISMIC STUDIES CONFIRM THE CONWAY SEGMENT OF THE HOPE FAULT IS A HIGH SLIP RATE, SHORT RECURRENCE FAULT

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The Conway segment of the Hope Fault is considered one of the fastest slipping onshore faults along New Zealand's plate boundary, but has not ruptured in the historic period and little paleoseismic data exists to constrain its earthquake record. In 2001, two paleoseismic trenches were opened adjacent to Greenburn Stream, near Kaikoura (NZMS 260 O31/423678). Both trenches were excavated into deposits laid against an uphill-facing scarp developed by a shutter ridge.

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

Trench 2, dug ~50 m to the west, has an expanded sequence of similar aged cover deposits. Three recent paleoseismic event horizons have been recognised from the combined evidence of offset units, upward-terminating faults, sandblow, and abrupt landscape change. Two paleosols underlying the modern soil are clearly faulted by two rupture events. The age of the MRE is constrained by a surface age on the cobbles to be 1780 A.D. ± 60 yr, which overlaps with lichenometric estimates and the historic period. The second event horizon (Paleosol II) is overlain by a dome of sand interpreted as a liquefaction sandblow. Both paleosol I and II are overlain by metre-thick debris deposits, interpreted as rock avalanches that cascaded off the hillslope following M >7 earthquakes. A radiocarbon date (548 ± 60 C-14 yr BP) below the Paleosol II constrains the duration of time in which the last two events occurred in. Another date from within the source of the liquefaction sand, discovered after Trench 2 was deepened, constrains the timing of the last 3 events to since 2212 ± 45 C-14 yr BP.

In concert with Pope's estimate of single event displacement (5-6 m), these results show that the Conway segment of the Hope Fault is fast-slipping (22 ± 3 mm/yr) and has ruptured (i.e. M 7+) twice in the last ~650 to 160 years ago, with an average recurrence of only 180-310 years.

THE WELLINGTON – MOHAKA FAULT SYSTEM: NEW SEGMENTATION, SLIP RATE AND PALEOSEISMIC DATA

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It has been hypothesized that the slip rate on upper plate faults of the Hikurangi margin in eastern North Island decreases from south to north along strike due to a decrease in locking between the Pacific and Australian plates beneath North Island (Beanland, 1995). This appears to be the case for the eastern North Island Shear Belt (NISB) faults, but is relatively untested for the western NISB, i.e. the Wellington–Mohaka–Ruahine-Whakatane faults. We present new work outlining a preliminary geomorphic fault segmentation pattern and new slip rate data for the southernmost 250 km of the Wellington – Mohaka Fault System, as well as new paleoseismic results from the southernmost Mohaka Fault.

The Wellington Fault extends ~170 km from Cook Strait to just south of the Manawatu gorge, where it continues north as the Mohaka and Whakatane faults for a further ~290 km to the Bay of Plenty. No historical earthquakes of M >6 have occurred on this fault system. Previous studies show that the Wellington Fault consists of three geomorphic segments. From south to north these are the 75 km long Wellington-Hutt Valley segment; the 53 km long Tararua Ranges segment and the 43 km long Pahiatua segment. In this paper the southern Mohaka Fault has been included and arbitrarily divided into two ~40 km sections: the Dannevirke and Norsewood sections.

Two new slip rate determinations, aided by GPS-RTK surveys, have been made for the Dannevirke section at Mangapukakakahu Stream (T23/ 624077) and Trotter Farm (T23/ 608058). At the former, trimmed Porewan terraces have been dextrally offset 127-156 m. The dextral slip rate determined at this site is 2.5-5.2 mm/yr. At Trotter Farm, the dextral slip rate comes from the re-assessment of an offset Holocene riser (38-42 m) and the adjacent graben fill dated from trenches. This site yields a maximum slip rate of 4.9-5.6 mm/yr. These data are consistent with slip rate estimates to the north and south along this fault system and appear to confirm the hypothesis expressed above. However, it is important to recognize that other faults, e.g. Ruahine Fault, may be accommodating upper plate motion north of the Manawatu gorge.

Two new trenches excavated at Trotter Farm display evidence for multiple surface-rupturing paleo-earthquakes, which occurred at similar times to those on the Pahiatua section of the Wellington Fault over the last c. 3000 yr. Paleoearthquake results from the four southernmost fault segments of this system yield similar (overlapping) and perhaps younging to the north, event ranges for the last 2-4 events. These results have significant implications for the treatment of seismic hazard from future surface-rupturing earthquakes of M>7 in southern North Island.

POSTER

PROCEDURES FOR UPGRADING QMAP DIGITAL DATA – A PILOT STUDY

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One of the aims of the QMAP 1:250 000 scale digital database is to provide an up-to-date seamless geological map of New Zealand that will eventually be available over the Internet. Users of geological information, including researchers, engineers, regional councils, and petroleum and mining companies will benefit from easy access to this dataset. Currently the focus of QMAP is to complete the first-time digital map coverage of New Zealand, but the future relevance and usefulness of the QMAP database depends largely on there being a mechanism for maintaining and updating the database as new geological information becomes available. A pilot study was undertaken to develop and test procedures for upgrading QMAP digital data, and explore options for revising the database on an ongoing basis.

QMAP Dunedin was chosen for this pilot study. It was the first QMAP produced, published in 1996. Since then, geological investigations and research have provided a substantial body of new data, particularly in the Dunedin urban area and in relation to Quaternary geology. There were also a number of edge-matching issues with neighbouring sheets, the recently published QMAP Waitaki and soon-to-be published QMAP Murihiku. The net effect is that only 7 years after its original publication, a number of interpretations on the 1996 QMAP Dunedin have been superseded.

Upgrading QMAP Dunedin digital data involved several stages:

1. Definition of the scope and methodologies for the upgrade
2. Collection and compilation of new data.
3. Digitising of new data, including revised polygons and linework attributes
4. Print-out of the draft revised map data for checking and review
5. Amendments and fine-tuning of the new map database
6. Final checking.

Only the onshore digital geological information was updated. The map, text, data record sheets, legend and cross sections were not redrafted or reprinted. The original 1996 QMAP Dunedin database was archived and the updated information stored separately.
The pilot study highlighted that there is no simple means of automatic upgrades to the QMAP database. The procedure for updates will continue to depend on manual collation and assessment of new data, re-evaluation and revision of interpretations by specialist regional mapping geologists, and revised digitising, peer review and reissue of the digital database.

The accuracy and relevance of QMAP data to end users depends on the continued maintenance of QMAP digital data. This will require a funding source that continues after the initial compilation and completion of each QMAP sheet. A survey will be conducted at the poster session to assess demand for both the updated and previously published information.

POSTER

THE RELATIONHIP BETWEEN DEEP-SEATED LANDSLIDING AND THE GEOMORPHIC EVOLUTION OF THE ESK RIVER VALLEY, HAWKE'S BAY, NEW ZEALAND

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An engineering geomorphological investigation of the Esk River Valley has been undertaken to quantify the relationship between the valley's geomorphic evolution and the many 1-10km^2 deep-seated landslides present within the catchment. The identification of key mechanical and geomorphic controls enabled the development of a generalised model of landsliding, assessment of stability, and the delineation of a pre-disposed zone of instability.

The region lies within the forearc basin of the obliquely convergent Hikurangi Margin, and is underlain by soft, gently eastward dipping Pliocene marine strata. Structurally it is dominated by its close proximity to the Mohaka Fault, as well as two westward-dipping blind thrusts within the valley identified in this study; the Wakarara Fault – Trelinnoe Sector, and the Eastern Patoka Fault. Evidence from seismic reflection surveys indicates these have both been active since the early Mangapanian (2-8 – 3.2 Ma), and an analysis of stream longitudinal profiles and plan form suggests limited displacement may have taken place within the last 10,000 years.

A survey of rock mass defects within a sample area in the centre of the valley highlights four sub-vertical joint sets; conjugate sets strike sub-parallel to the folding and another – perpendicular to bedding. These defects correlate well with lineaments identified in aerial and satellite photographs and are attributed to extension of the sediments across the top of fault-propagated folds. The generally low power streams have exploited these defects and highly incised channels now run almost exclusively along them.

Deep-seated landslides occur generally within the area of folding and their extents are defined by major lineaments inferred to correspond to persistent joints in the rock mass. The slides are translational and are facilitated by up to 80m of incision initiated since the abandonment of an extensive terrace inferred to be Ohakean (18-10ka) in age. Basal failure surfaces commonly dip at angles as low as 6°, and a combination of tectonically induced flexural shears sub-parallel to bedding and very low shear strength tuffaceous horizons are inferred to provide planes of sufficiently low shear strength to facilitate failure. While most appear active, there is no evidence to suggest they were substantially affected by recent major tectonic (e.g. 1931 M_W 7.6 Hawke's Bay earthquake) or climatic events (e.g. 1938 1:500yr+ Esk Valley storm).

POSTER

THE EVOLUTION OF MAROA VOLCANIC CENTRE, TAUPO VOLCANIC ZONE, NEW ZEALAND

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Maroa Volcanic Centre (Maroa) is located within the older Whakamaru caldera, central Taupo Volcanic Zone (TVZ), New Zealand. Dome lavas make up the majority of Maroa volume, with the large Maroa West and East Complexes erupted mostly over a short 29 kyr period starting at 251 ± 17 ka. The five mappable Maroa pyroclastics deposits (each <3 km^3) range in age from 283 ± 11 ka to 196 ka. The ages of the nearby Mamaku, Ohakuri and Mokai pyroclastics are equivocal. The Mamaku and Ohakuri pyroclastics appear to be older (~ 240 ka) than the age previously accepted for the Mamaku pyroclastics. From 230 to 64 ka there was a hiatus in caldera-forming eruptions in TVZ. Maroa and the Western Dome Belt (WDB) constitute the largest concentrated volume of eruptions (as relatively gentle lava extrusion) during this period. The rate of Maroa volcanism has decreased exponentially from a maximum prior to 200 ka. In contrast volcanism at Taupo and Okataina has increased from ~ 64 ka to present. The oldest Maroa dome highlights the extraordinarily high rate of infilling of Whakamaru caldera (Leonard et al., this volume). The WDB and Maroa are petrologically distinct from one another, despite eruption over a similar period. Magma sources for Maroa and the WDB may have been partly or wholly derived from the Whakamaru caldera magma system(s), but petrological distinctions among all three mean that Maroa and the WDB cannot be considered as simple magmatic resurgence of the Whakamaru caldera.

Based on spatial, chronological and petrological similarities, six magma associations account for almost all Maroa deposits. The distinction between Maroa and Taupo Volcanic Centres is somewhat arbitrary and is best considered to be the easting directly north of Ben Lomond, north of which most volcanism is older than 100 ka and south of which most volcanism is younger than 100 ka and petrologically distinct.

Maroa's distinct Thorpe Road Fault is in fact a fossil feature which hasn't been active in as much as 200 kyr. In addition, the graben across Tuahu Dome was likely created by shallow blind diking. Several recent studies across TVZ show structural features with some associated dike intrusion/eruption. Such volcano tectonic interaction is not highlighted in TVZ but may be relatively common and lie on a continuum between dike-induced faulting and dikes following structural features. Although rates of volcanism are now low in Maroa, magmatic intrusion appears to remain high. This raises the possibility of a causative link between faulting and volcanism in contrast to traditional views of volcanism controlled by rates of magmatic ascent. Probable future eruptions from Maroa are likely to be of similar scale (< 0.1 km^3) and frequency (every ~ 14,000 years) to most of those over the last 100 ka. Several towns lie in a range of zones of Maroa volcanic hazard from total destruction to possible ash fall. However, the probability of a future eruption is only ~ 0.6 % in an 80 year lifetime.

RAPID POST-COLLAPSE INFILLING OF CALDERAS: EVIDENCE FROM TAUPO VOLCANIC ZONE, NEW ZEALAND

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Caldera collapse events represent the climax of evolution of many large silicic systems. Models (e.g. Smith & Bailey, 1968, GSA Memoir 116, 613-662) propose post-collapse episodes of _pre-resurgence volcanism and sedimentation_ and _resurgent doming_. The Taupo Volcanic Zone (TVZ) in New Zealand contains numerous examples of caldera-forming events. New radiometric-age and geological data (Leonard et al., this volume) shed light on the timing and presence of the post-collapse processes after formation of two calderas, Whakamaru (340-320 ka) and Oruanui (26.5 ka).

The Whakamaru caldera is ~40x25 km, and displacement of the top surface of the associated ignimbrites is >500-1000 m. However, surface-exposed domes and pyroclastics in the Maroa volcanic centre, which overlies the northern half of the Whakamaru caldera footprint, range in age from 220 to 305 ka, indicating that ~450 km^3 infill of the earlier caldera was mostly accomplished within 35 kyr and entirely within 100 kyr. The infill, where proven from drillholes is a mixture of primary and reworked volcaniclastics and numerous lavas. The Oruanui caldera is of complex shape, centred around a 140 km^2 structural core (Davy & Caldwell, 1998, J. Volcanol. Geotherm. Res. 81, 69-89). Since the eruption, ~130 km^3 of reworked Oruanui debris and >100 km^3 of primary and reworked post-Oruanui pyroclastic material has accumulated.

Both calderas were largely (Oruanui) to completely (Whakamaru) refilled within a few tens of thousands of years, yielding average infill rates (from all processes) of 8.5 (Oruanui) and 9 (Whakamaru) km^3/kyr. The examples cited by Smith & Bailey also show similar rapid rates of infilling. For example, at Long Valley, the caldera-related 760 ka Bishop Tuff is buried to depths of 300-700 m, yet the oldest surface post-caldera lava is only ~10 kyr younger (Heumann et al., 2002, Geochim. Cosmochim. Acta 66, 1821-1837). However, neither New Zealand caldera shows evidence for structural resurgence, and available chemical and isotopic data show that post-collapse volcanism involves wholly new magmatic systems, not a resurgence of residual magma from the climactic event.

 POSTER

AUTHIGENIC POTASSIUM FELDSPAR, CARBONATE AND SULPHIDE CEMENTS IN TARATU AND WANGALOA FORMATIONS (LATE CRETACEOUS—PALEOCENE) SOUTH OTAGO, NEW ZEALAND

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The transgressive succession of alluvial coal-bearing strata (Taratu Formation) and overlying shallow marine sandstone (Wangaloa Formation) in the Kaitangata area has undergone syndepositional and moderate burial-related diagenesis.

Sandstone in lower Taratu Formation is locally cemented with radial-spherulitic magnesian calcite. In upper Taratu Formation the Barclay sand-dominated clastic interval is extensively dolomite-cemented. Coarse crystalline pyrite forms spherical concretions and dispersed euhedra. Syndepositional and early diagenetic pyrite cements are strongly developed in the upper Taratu ~130 m thick transitional interval where estuarine channels of quartzose granule conglomerate and sandstone interfinger with transgressive shoreface sandstone bodies. Pyrite accumulation reflects the flux of Fe^{2+} in acid groundwater and microbial reduction of seawater-derived sulphate associated with organic-rich substrates in a 'mixing zone' setting. Transported wood in channel facies is commonly pyrite-filled. Pyrite-cemented chimney structures and *Rhizocorallium* burrows in transgressive sands are evidence of submarine groundwater discharge from buried alluvial-estuarine channels. Associated growth of 1-3 m diameter Fe-dolomite concretions is related to microbial oxidation of methane in the sediment column.

Overgrowth of orthoclase and microcline by almost-pure K-feldspar in otherwise weakly cemented sandstone and concretionary shellbeds in Wangaloa Formation (Figs. 1 & 2) appears to have been a relatively early and widespread diagenetic process, followed by localised magnesian calcite cementation in concretions and generally pervasive precipitation of siderite.

TALK: Cretaceous 2

PIKOPIKO FOSSIL FOREST AND ASSOCIATED LEAF REMAINS, BEAUMONT FORMATION (LATE EOCENE), WAIAU BASIN, SOUTHLAND, NEW ZEALAND

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Beaumont Formation alluvial sediments of probable Kaiatan age exposed on the east bank of Waiau River near Pikopiko, 6 km north of Tuatapere, include diverse forest remains. *In situ* tree stumps spaced 2-6 m apart and distributed over a 25 x 120 m area are represented by ~100 calcite-cemented columnar concretions up to 60 cm diameter and 80 cm high. The concretions grew in fine-grained arkosic sandstone deposited in a south-flowing trunk river or splay channel that appears to have overwhelmed the growing forest. Some small upright tree stumps near the base of the sandstone bed are pyrite-cemented. Other trees are preserved as uncemented sand-filled and coalified 'hulls' that represent the outer few cm of their original stumps.

Forest litter preserved in mudstone and coal underlying the sandstone contains a well-preserved diverse macroflora that includes several ferns, a palm, araucarian bark, and leaves of *Nothofagus* and ?*Metrosideros*, as well as leaves and stems of a probable liane (?*Smilax*). Leaves were hosts to a variety of epiphyllous fungi. Moderately well preserved wood associated with concretions in the overlying sandstone includes angiosperms of uncertain affinity (cf. extant *Ixerba*).

Calcite cementation of the tree stumps is inferred to have been an early diagenetic process involving the localised reaction of Ca^{2+} in groundwater with HCO_3^- generated during wood decay. The Pikopiko fossil forest is the first *in situ* forest of Late Eocene age to be described from the New Zealand region.

RIVER TERRACES AND REGIONAL DEFORMATION PATTERNS ALONG THE HIKURANGI SUBDUCTION MARGIN, EASTERN NORTH ISLAND.

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Flights of river terraces in the eastern North Island record uplift of the Hikurangi Margin driven by subduction processes at depth. Aggradation river terraces formed during glacial periods provide marker surfaces from which river incision rates can be calculated, of which tectonic uplift rates form a significant component. This study focuses on the Last Glacial Maximum river terrace, the Ohakea Terrace (c. 30-18 ka), which is well preserved along the trunk rivers of the 9 major catchments draining the axial and coastal ranges.

Post-glacial (c. 18 ka) river incision rates have been calculated from longitudinal profiles constructed using RTK GPS measurements, Regional Council cross-channel survey data, and detailed topographic maps. Results from some catchments are still preliminary as we await OSL ages. Broad river incision rate patterns show low values in the south (1-2 mm/yr, Wairarapa and central Hawke's Bay) and more variable values to the north. Two patterns are evident in the north: increasing incision rates upstream (Ngaruroro, Waiau, Waipaoa Rivers), and two areas of locally high values (Mohaka and Waiapu Rivers). Comparison of incision rate patterns with hydrological controls such as catchment area, gradient, mean annual flow rates, and rainfall, and geological controls such as lithology and rock strength, show no consistent patterns that fully explain the variation in river incision rates, indicating tectonic uplift is the major driver.

Numerical models are being used to test the location and magnitudes of regional uplift of the Hikurangi Margin in response to subduction processes. Two-dimensional finite element models will be presented of processes such as seamount subduction, sediment subduction, and factors such as variations in upper plate crustal thickness and mantle properties. Preliminary results from seamount subduction models show a transient shortening of the accretionary wedge and uplift particularly focused at the landward edge of the wedge.

HOW OLD IS NEW ZEALAND'S EXTANT BIODIVERSITY? ESTIMATES FROM PLANT DNA

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A surprising finding from DNA sequence analyses is that many plant groups arrived in New Zealand by long distance dispersal during the Tertiary and Quaternary. Once here they radiated and dispersed into other Southern Hemisphere lands. This talk outlines recent DNA studies that support these conclusions. It also describes future work to explore more precisely the timing of NZ plant species radiations, and how they may relate to tectonic and climatic change.

Sm/Nd & Rb/Sr ISOTOPE GEOCHEMISTRY AND GEOCHRONOLOGY FOR GNEISSES OF THE WINDMILL ISLANDS, EAST ANTARCTICA.

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The Windmill Islands in east Antarctica provide excellent exposures of a metamorphic transition from upper amphibolite to granulite facies. Multiply deformed schists, ortho- and para-gneisses and migmatites are intruded by granites and charnockites (Blight & Oliver, 1977). The gneisses were originally interpreted to represent a metamorphosed sequence of volcanic and sedimentary rocks but there is convincing field evidence to suggest that the orthogneisses are intrusive rocks that were emplaced into a sedimentary sequence now represented by the paragneisses.

Existing Rb-Sr and K-Ar ages range from 950-1400 Ma (Williams et al. 1983 and references therein). Rb-Sr and Sm-Nd whole rock and SHRIMP zircon age data were used by Williams et al. (1983) to argue that the protoliths for the Windmill Island orthogneisses are less than 1470 Ma old. It was further noted that although paragneisses contain an Archaean component, the major metamorphism affecting these rocks coincided with the 1470 Ma event that emplaced the orthogneisses.

Sm-Nd garnet ages for an orthogneiss and a granite from the Casey area yield garnet formation or high-temperature cooling ages between 1180-1130 Ma while biotite Rb-Sr dating for the same rocks gives a 1020 Ma low-temperature cooling age. These dates are in the lower portion of the age range established by Williams et al. (1983). However, they fit quite accurately into a more recent chronological sequence based on SHRIMP zircon-monazite data by Post et al. (1996), who suggest 2 high-grade metamorphic events (M1, upper amphibolite, 1400-1310 Ma; M2 granulite, 1210-1180 Ma, 700±50^{o}), followed by continuing deep emplacement of charnockitic granites (to 1160 Ma) and aplite dikes (1138 Ma). The Casey garnet Sm-Nd ages (1189 & 1185 Ma) appear to mark late-M2 conditions while the biotite Rb-Sr ages record post-M2 cooling below 300^{o} at 1020 Ma. A 1260±26 Ma, 6-point Rb-Sr isochron obtained for amphibolites, orthogneisses and granites is presumably an artifact of the polymetamorphic history.

Nd model ages for the orthogneisses and granites of ~2.5-2.0 Ga, imply crustal protoliths older than 1470 Ma age (see above). Nd-Sr isotope data for granitic gneiss, granitoids and amphibolite, calculated at 1.15 Ga, define a typical crust-mantle mixing array which indicates that precursor magmas were generated at around 1100-1200 Ma as partial melts from the ortho-/para-gneiss terrane.

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TALK: Petrology 3

DIVERSITY AND ITS MEASUREMENT: A PHILOSOPHICAL OVERVIEW

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The idea of biological diversity is indispensable to the life sciences. Surely, evolutionary biology, systematics, developmental biology and a host of other disciplines would all be incomplete were they to shun reference to this fundamental facet of biotic systems. That said, biological diversity is difficult to characterise and is measurable using an astounding variety of methodologies. As with 'fitness' and 'species', this leads to philosophical speculation as to the underlying nature of this property upon which the aforementioned methodologies supposedly converge. This paper examines the philosophical issues and attempts to place them within a wider theoretical context.

TANGIWAI 50 YEARS ON: PALEOFLOOD ANALYSIS OF THE 1953 LAHAR

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New Zealand's second worst volcanic disaster occurred on Christmas Eve, 1953, when the summit Crater Lake of Mount Ruapehu breached an unstable barrier of volcanic material deposited during the 1945 eruption sequence, and snow and ice of the Crater Basin Glacier. Approximately 1.8 million cubic metres of water was released into the Whangaehu River (O'Shea 1954; Stilwell et al. 1954), where it rapidly bulked by entraining particulate material to form a lahar that swept away a pier of the Tangiwai railway bridge 38 km downstream. Tragically this occurred moments before the passage of the Wellington-Auckland express: unable to stop in time the train fell into the lahar-swollen stream and was swept away with the loss of 151 lives. Advances in our understanding of volcano-hydrologic lahars and flows in ice tunnels made over the past 50 years, coupled with the high probability of a similar break-out flood occurring sometime in 2005-2007 as a result of the refilling of Crater Lake in the aftermath of the 1995-96 eruptions suggest that it is time for a re-analysis of the 1953 lahar using modern techniques. Key questions that need to be answered include:

1. What was the mechanism of failure of the tephra barrier at the lake outlet?
2. How fast did the water escape?
3. What role, if any, did the ice tunnel (or tunnels) beneath the (now absent) Crater Basin and Whangaehu glaciers play in moderating the outflow?
4. How did the lahar hydrograph evolve downstream through attenuation and the effects of volumetric bulking (through the erosion and incorporation of particulate material) and debulking (i.e. sedimentation)?
5. How does the 1953 lahar compare with other (pre-)historic lahars at Ruapehu?

This poster seeks to address some of these questions through numerical modeling, re-analysis of data from the 1953 event, and comparisons with historic lahars, in particular the 1995-96 lahar sequence. Current work suggests that the Crater Basin Glacier did not impede the outflow of 26 ^{o}C lake water, enlargement of the ice tunnel keeping pace with growth of a trapezoidal breach at the outlet to generate a peak discharge in the 400-600 m^3/s range. By 9 km downstream, flow bulking through the entrainment of particulate material had increased this to c. 2000 m^3/s, as estimated from a contemporary flow cross-section and an historical lahar velocity (Cronin et al. 1997). Much of the subsequent decrease to the c. 647 m^3/s estimated at Tangiwai (38 km) occurred by hydrologic attenuation on the Whangaehu fan rather than debulking, since the lahar arrived at the railway bridge as a debris- to hyperconcentrated flow. The 1953 event is not unusual in either scale or mechanism in the Ruapehu lahar catalogue.

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VOLCANOGENIC FLOODS IN THE TAUPO VOLCANIC ZONE, NEW ZEALAND

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The Taupo Volcanic Zone (TVZ) in the central North Island of New Zealand is a region of intense Quaternary volcanism and extensional tectonics, characterized by frequent caldera-forming explosive eruptions from multiple short-lived, nested, and/or overlapping volcanic centres. Its geography and geomorphology are dominated by thick ignimbrite plateaux, volcano-tectonic collapse structures, half-grabens, and resurgent lava dome complexes, while lakes and rivers periodically shift their positions in response to volcanic activity. In numerous instances, intrabasin sequences provide evidence for brief-to-prolonged lake highstand intervals terminated by sudden falls in level that can often be correlated with evidence for large magnitude floods downstream. Such fill-and-spill couplets appear to be a recurrent feature of volcanism in New Zealand, spanning a range of settings as diverse as the modern Crater Lake of Ruapehu, to the largest intracaldera lake in the North Island.

Lakes Taupo and Rotorua, the largest extant bodies of water in the TVZ, are fringed by extensive terrace and shoreline deposits formed following the major eruptions that either created or modified the depressions that they occupy. Lake Taupo (616 km^2) was created in essentially its modern configuration by the 26.5 ka Oruanui eruption, and initially refilled to ~ 500 metres above sea level (mASL). The highstand lake initially spilled via a semi-stable outlet controlled by a sill of 340 ka welded ignimbrite, but headward erosion through thick Oruanui pyroclastics 20 km further east established a new, lower outlet at ~ 405 mASL some time prior to 22.5 ka, releasing an estimated 60 km^3 of water. Dimensions of transported boulders indicate peak discharges in the 100000 m^3/s range 80 km downstream. Eruption of the Taupo ignimbrite at the climax of the 1800a Taupo eruption again blocked the lake outlet, resulting in a 34 m rise in lake level that was followed by break-out flood which peaked at 17 000 – 30 000 m^3/s and released 5 years of normal outflow in 3 weeks. The geomorphic expression of this flood is found in boulder deposits, erosion surfaces, and overbank aggradation deposits and buried forests that can be traced for over 200 km downstream along the Waikato River.

Lake Rotorua also shows evidence for multiple highstands dating back to its formation at c. 220 ka, and possible break-outs in three completely different directions, its complex history being influenced by volcanic activity at the adjacent Okataina Volcanic Centre. The latter has itself has been the locus of at least two floods from Lake Tarawera, including an historic flood in 1904 A.D., following the 1886 Tarawera eruption, which inundated much of the Rangitaiki Plains and triggered long-term alluviation as a tertiary hazard. Although such historical break-outs are tiny in comparison with prehistoric floods (some of which rank in global terms), the 1953 Tangiwai lahar still tragically resulted in 151 deaths, highlighting the currently under-recognised hazards associated with this kind of event.

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

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

PLATINUM GROUP ELEMENT GEOCHEMISTRY OF SEDIMENTS IN THE GULF OF PAPUA

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The elemental concentration pattern for the platinum group elements (PGEs) in modern seawater is highly fractionated relative to the upper continental crust (UCC), mantle and meteorites. This may be due to a combination of factors, including fractionation during weathering and transport to the open ocean. However, as yet little is known about the geochemical behaviours of the PGEs in estuaries. The Gulf of Papua and its drainage basin are a good type location in which to investigate estuarine PGE fractionations that take place in the wet tropics. The Fly River is one of the largest rivers draining into the Gulf of Papua and is among the world's top rivers in terms of discharge and sediment yield. We have measured PGE concentrations in suspended sediment from the Fly River and surface sediments from the Fly Delta and Gulf of Papua.

Sediment from near the headwaters of the Fly River has an Os/Ir of ~4. This value is high in comparison to the UCC, mantle and meteorites, all of which have Os/Ir of ~1. This may reflect a fractionation of Os from Ir during rock weathering or a dominance of sedimentary source rocks that have inherited a high Os/Ir ratio. Sediments in the Fly River Delta and Gulf of Papua have Os/Ir ratios ranging between 1.4 and 3.2. Two samples from the central Gulf region would be expected to have less of a Fly River sediment signature due to their proximity to the Purari and Kikori Rivers, both of which have ultramafic rocks mapped in their headwater regions. The Os/Ir ratios of those two samples approach the mantle value of 1, indicating a predominance of mantle derived ultramafic detrital sources. The other sediments in the Gulf of Papua have Os/Ir ratios that are intermediate between the Fly River and ultramafic endmember values. These ratios could be interpreted as being due to variable physical mixtures of detritus from the different sources (ultramafic and sediment dominated). However, a marked decrease in Os/Ir in Fly Delta sediments (Os/Ir ~2.5) relative to the river sediment, accompanied by a higher Ir concentration, suggests that Ir is preferentially scavenged in the oxic sediments that are typical of the Gulf of Papua. Although a correlation between organic carbon and Os burial was previously indicated, the Ir concentrations do not appear to be correlated with organic carbon. The Os/Ir ratio of seawater is approximately 110, much higher than any of the sediments. Our results may indicate that preferential removal of Ir to sediments in the estuarine environment might contribute to the extremely elevated Os/Ir of seawater. Although the fractionations observed for Pt/Pd are smaller than for Os/Ir, there is evidence of preferential incorporation or retention of Pd relative to Pt in the estuarine and marginal marine sediments. The relatively high Pt/Pd in seawater (~3) compared to the UCC (~1) or ultramafic rocks (~2) may thus also be explained by oxic scavenging of Pd in sediments such as those in the Gulf of Papua.

POSTER

THE EVOLUTION OF LAKE ROTORUA

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The aim of this project was to determine the drainage history of the Rotorua Volcanic Centre, and the evolution of its principal lake, prior to the Oruanui eruption at ≈ 22.6 ka, from the nearby (≈70 km) Taupo Volcanic Centre.
Fieldwork involved mapping the spatial distribution of high stand lake terraces by collecting spot height data in the Rotorua basin, and examination of 36 separate outcrop locations. Field relationships indicate a complex lake history, involving at least three high stands since the formation of the Rotorua Caldera. These followed the voluminous eruption of the (≈275 km^3) Mamaku Ignimbrite at 220 ka.

1. Post Mamaku Ignimbrite (≈220 ka), level at ≈387m – 414m A.S.L.
2. Post Rotoiti Tephra (≈64 ka), level at ≈370m – 380m A.S.L.
3. Post Hauparu Tephra (≈ 36 ka), level at ≈348m – 353m A.S.L.

Other lake terraces were identified at lower levels.

- ≈335m A.S.L. Erosional terrace
- ≈320m A.S.L. Constructional terrace
- ≈310m A.S.L.
- ≈300m A.S.L.

The present water level of Lake Rotorua, at 279m A.S.L. is determined by the height of a Mamaku Ignimbrite sill, and maintained at this level by control gates at the mouth of the Kaituna River, Lake Rotoiti.
The southern end of the Rotorua Basin is bisected by the Hemo Gorge, which early aerial photographs indicate to be a typical trapezoidal shaped natural dam breach. Lakebeds and terraces are also found throughout the Ngakuru basin, south of the Hemo Gorge. Successive tephra and lake deposits have covered up the floor and lower walls of the breach, so it isn't possible to tell if this structure is inclined northward or southward, and hence whether it was carved by a breakout to the south from Rotorua basin, or a break-in to the north from Ngakuru.
The focus of ongoing lab work is to

- Map the spatial distribution of lake terraces.
- Constrain the timing of lake high stands and their longevity.
- Correlate the lakebeds by chronology, lithofacies and componentry.
- Compare volcanic glass geochemistry and clay composition between lake terraces.
- Interpret paleoenvironments, based on lithofacies, and microfossils where present.
- Determine changes in sand provenance between high stand deposits.
- Determine the drainage history of the lake and the relationship of possible breach points to different terrace levels.

INFLUENCE OF A FAULT-SEGMENT JUNCTION ON THE RUPTURING BEHAVIOUR OF THE AWATERE FAULT, MARLBOROUGH

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The Awatere Fault comprises 2 geometric sections (the eastern and Molesworth sections; see figure 1), which differ by 15-20º in strike and are separated by a conspicuous junction near the Molesworth Station homestead in the upper Awatere Valley. The fault last ruptured in the October 16, 1848 M_w ~7.5 Marlborough earthquake. Historical accounts of this earthquake, well-preserved geomorphic displacements, and paleoseismic data for the eastern and Molesworth sections, including well-constrained timing for the last two surface-rupturing events, provide important new data on the rupturing behaviour of the Awatere fault.

Previous work suggests that the 1848 earthquake, observed to have ruptured the eastern section, bypassed the Molesworth section, propagating west toward Barefell Pass. This was based on historical accounts and the apparent non-correlation of paleoearthquakes inferred from existing trenching studies. The fresh-looking scarps of the Molesworth section, however, imply a recent surface-rupturing event there. New fieldwork shows the junction to be a much lower-angle, more smoothly curved fault transition than originally mapped, with the two fault strands striking approximately parallel for >5km. This may allow ruptures to propagate along both sub-parallel sections simultaneously. New paleoseismic data for the most recent (1848 A.D.) and penultimate (1000 ±200 cal. yrs B.P.) events show well-constrained overlaps in the timing of these events on both the eastern and Molesworth sections. This suggests either these earthquakes involved simultaneous rupture of both geometric sections, or stress-loading of the rupture end-point on one section triggered rupture on the adjacent section.

The distribution of smallest geomorphic displacements suggest the fault junction region was the location of a maximum in slip during the most recent event, which favours the simultaneous-rupture model as the junction region would be near the rupture end-points for the stress-triggering model. Cumulative slip in the junction region during the 1848 event may have reached <10m, in contrast to a maximum of <7m on the eastern section near Lake Jasper. This implies the epicentre for this event was near the fault junction, and that the previously calculated paleomagnitude of M=7.5 may be too low. These observations revise our view of the rupturing behaviour of the Awatere Fault, and suggest that the fault junction may act as a nucleation site of large earthquakes which rupture both sections simultaneously, as has been suggested for these and other types of discontinuities, such as fault bends and stepovers.

Figure 1: Location map with main components of the Marlborough fault system. This study focuses on the segment boundary between the eastern and Molesworth sections of the Awatere fault.

GEOCHEMICAL VARIATION IN THE DUNEDIN REGION: A STUDY COMBINING THE QMAP AND PETLAB DATABASES

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Geographic information systems (GIS) contain powerful tools for archiving, manipulating, analysing, and visualizing diverse and large geological data sets. GIS techniques are extensively used in geological mapping, mineral exploration, engineering geological applications and environmental studies. In this study the geochemical variation in the Dunedin region is investigated based using GIS techniques applied to the PETLAB and QMAP databases maintained by GNS. The PETLAB database currently holds about 125 major and trace element analyses from the area of interest in the Dunedin region. The data come mainly from the Torlesse, Caples, and Murihiku terranes. Over 375 major and trace element data sets are being added from published and unpublished papers and university theses. They include well-represented data sets for the different phases of the Dunedin Volcanic Group and the Onekakara, Otakou and Kekenodon groups.

The second phase of the project involves assessing the geochemical variability within and between specific geological units defined by the QMAP geological map database. The GIS-mapped extent of these units will allow extrapolation of geochemical data and provide a first order geochemical background assessment of the Dunedin region. Maps showing variation of selected major and trace elements together with their significance and environmental implications will be discussed.

POSTER

SIZE MATTERS IN MOLLUSCAN PALEOBIODIVERSITY CENSUSES

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When estimating fossil biodiversity it is imperative to identify and try to compensate for any potential biases. One of these is the way the size of a fossil determines whether or not it is collected. This is particularly important for molluscs, as they have an exceptionally wide size range: New Zealand Cenozoic gastropods run the gamut from c. 0.6 mm to >190 mm, bivalves from c.1 mm to at least 300 mm in maximum dimension. It is clearly not enough to rely on what can be collected from the face of an outcrop, and it is therefore necessary to use techniques borrowed from micropaleontology if we want reasonably representative collections. Early workers on New Zealand Cenozoic molluscs focussed on the larger species and described few species < 5mm. H.J. Finlay was the first to advocate processing of fossiliferous matrix, but it was C.R. Laws who did this on a systematic basis, and described numerous "micromolluscs" from such localities as Pakaurangi and Kaawa. Despite this, the list of named Cenozoic species is weighted towards the larger forms (>15 mm), particularly Pectinidae, Veneridae, Turritellidae, Struthiolariidae, Naticidae, Muricidae, Buccinidae, Volutidae and Conoidea. Later workers have processed bulk samples from numerous additional localities throughout New Zealand, and greatly increased the number of species in groups dominated by micromolluscs; e.g. Nuculidae, Galeommatoidea, Skeneidae, Rissooidea, Vitrinellidae, Triphoroidea, Eulimidae and Pyramidelloidea. Even so, the mean size of fossil molluscs ranges from 24.0 to 33.0 mm, depending on habitat and substrate. If the modern fauna is any guide, micromolluscs are under-represented in the fossil record.

Taphonomic/diagenetic processes almost certainly account for some of this shortfall, particularly in shallow-water and hard substrate assemblages, but a bigger contributing factor is that relatively few localities have been adequately sampled. Little or nothing is known of micromolluscs in the Paleocene, Early Oligocene or Late Miocene. This is partly because some lithologies are difficult to disaggregate, or fossils are so sparse that bulk sampling is impractical (particularly if the site is a long way from a road).

Size distributions have been calculated for several well-studied faunules, ranging in age from Early Paleocene (Wangaloan) to Middle Pleistocene (Haweran), and show that compensating for such complications is not straightforward. Two shallow-water assemblages, one Early Eocene, the other Middle Pliocene, are quite similar to each other, but otherwise there is a wide range in size distributions, particularly in the number of very small species (< 5 mm). Factors such as water depth and bottom temperature are probably as important as diagenesis and collection failure in accounting for this variation.

OXYGEN ISOTOPES FROM FOSSIL PENGUIN BONE, AND EOCENE/OLIGOCENE PALEOCLIMATE

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Fossil penguin bones from the Waitaki region offer new scope to elucidate Cenozoic climates. Oxygen isotope measurements ($\delta^{18}O_{shell}$) from invertebrate carbonate are used widely in paleoclimatology. For example, an increase of ~1.7‰ in $\delta^{18}O_{shell}$ indicates major climate change at the Eocene/ Oligocene (E/O) boundary (~34 Ma), involving cooling, increased seasonality and stronger latitudinal temperature gradients. Changes in Antarctic ice are also implicated, but the relative contribution of temperature change and ice-sheet growth cannot be resolved from $\delta^{18}O_{shell}$ and is still widely debated.

Penguins are active warm-blooded marine birds that precipitate bone (and oxygen isotopes) at known constant temperature. Isotope budgets for penguins can be modeled using isotope fluxes for living species, to show that oxygen isotopes in penguin bone are independent of ambient water temperature. Instead, $\delta^{18}O$ reflects mainly the isotopic composition of sea-water ($\delta^{18}O_{seawater}$), in turn an index of global ice volume.

Measurements of oxygen isotopes from penguin bone have potential as a tool to determine the isotope composition of ancient seawater. The latter is fundamental in interpreting the carbonate isotope record. In such applications, a key issue is how the signal from penguin bone relates to environmental water.

Laboratory results and modeling identify significant gaps in the understanding of ancient penguin physiology. For now, measurements from penguin fossils do not seem to truly indicate the absolute value of $\delta^{18}O_{seawater}$. However, relative values may be used if we assume that penguin physiology did not change significantly over the sampled time. Results from penguins sampled across the E/O boundary indicate that the environmental (ocean) water composition changed by ~1.7‰. This implies that the major change at the E/O transition represents *only* rapid ice-sheet growth and *no* cooling effect.

We conclude that: 1), $\delta^{18}O$ of penguin bone is directly related to environmental water with an off-set dependant on physiological parameters. 2), The physiology of fossil penguins is not understood well enough to use oxygen isotopes to determine the isotope composition of ancient seawater. 3), Changes occur over intervals that are short relative to evolutionary timescales. 4), Change across E/O boundary of $\delta^{18}O$ ~1.7‰ implies that the widely reported invertebrate carbonate record is due to rapid ice volume changes. 5), $\delta^{18}O$ from penguin bone should answer questions of penguin physiology, especially thermoregulation.

STRATIGRAPHY, PETROLOGY AND FIELD CHARACTERISTICS OF MANGAKINO-DERIVED IGNIMBRITES IN THE SOUTH WAIKATO REGION

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The Mangakino volcanic centre is a rhyolitic caldera complex situated in the western part of Taupo Volcanic Zone. Eruptive units ascribed to Mangakino volcanic centre have produced a sequence of voluminous (>1,100 km^3), widespread welded and non-welded ignimbrites, phreatomagmatic fall deposits, and minor lava domes, mostly erupted in two concentrated periods of caldera-forming eruptions from 1.68 to 1.53 Ma, and 1.21 to 0.95 Ma. The stratigraphy, petrology and field characteristics are presented for two Mangakino ignimbrites (Ongatiti and Ahuroa) within the study area near Wharepapa South, South Waikato region.

The 1.21 ± 0.04 Ma Ongatiti Ignimbrite represents the start of the second phase of caldera-forming activity at the Mangakino volcanic centre. At around 300 km^3 in volume it is the most widespread and voluminous Mangakino ignimbrite and one of the largest ignimbrites known in the Taupo Volcanic Zone. In the South Waikato region, it has constructed a broad gently sloping plateau that dips at 1-2º to the northwest, and has flowed around upstanding Mesozoic basement highs. In some cases the basement highs have formed a barrier to the advancing flows. The plateau has been deeply incised and the Ongatiti Ignimbrite is now the major bluff-forming unit in the study area, with cliffs up to 40 m high. The Ongatiti Ignimbrite displays no clear flow unit boundaries and varies from weakly to partially welded. It is crystal and pumice rich and contains a suite of lithologically diverse lithic fragments. The crystal assemblage is dominated by plagioclase with lower abundances of quartz, orthopyroxene, hornblende and opaque oxides.

The 1.18 ± 0.02 Ma Ahuroa Ignimbrite lies unconformably on the Ongatiti Ignimbrite, and is characterized by a reverse welding zonation pattern, varying from unwelded at the base to densely welded at the top. This results in the formation of flat-topped mesas perched on Ongatiti Ignimbrite and bordered by vertical bluffs that feature prominently in the landscape. The matrix of the unwelded base of the ignimbrite displays a distinctive 'sandy black' appearance and contains pumices ranging from black/dark grey highly vesicular dacitic pumice to pale buff/orange fibrous and creamy/white dense high-silica rhyolitic pumice. The unit grades into a densely welded light grey lenticulite with high aspect-ratio fiamme and a hackly, fractured appearance. Lithic clasts are mainly rhyolite lava. Quartz is absent and the crystal assemblage is dominated by plagioclase with lower proportions of orthopyroxene, hornblende, and opaque oxides.

POSTER

HELIUM ISOTOPE DATING: AN APPLICATION TO ANTARCTIC LACUSTRINE CARBONATES

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Helium-4 is the end product of alpha decay processes and is produced mainly from the decay of ^{238}U and ^{232}Th and their daughters. Due to the helium atoms being much smaller than ^{40}Ar, the decay product of ^{40}K, they are much more mobile and are able to diffuse through crystal lattices more readily. For many minerals, helium stops diffusing at temperatures below 40^{o}C. This "closure" temperature varies with mineral lattice space, grain size and shape. Unlike argon, helium can also be lost from the mineral through the kinetic energy of the alpha particle (recoil). Options for estimating ages since closure based on the ratio of recovered helium-4 to uranium and thorium content involve calculation of the likely helium loss from grain size and shape measurements.

University of Waikato have built a Helium extraction line and mass spectrometer to carry out (U-Th)/He dating. Amongst the dating projects to be undertaken are attempts to date mid Pleistocene glacial sediments.

POSTER

LATE HOLOCENE SEA LEVEL CURVE FROM INTER-TIDAL BENTHIC FORAMINIFERA, WHANGANUI INLET, NORTHWEST NELSON

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Sea level changes in New Zealand over the last ten thousand years have been inferred using paleo-indicators, such as dated beach terraces, cheniers and tidal flats. These have provided plausible estimates of sea level change for New Zealand. A sea level curve by Gibb (1986) shows a rapid rise in sea level of ~43m from ~10000 BP to ~7000 BP followed by a period of general stability. However, several low amplitude fluctuations of approx 1m are inferred to have occurred throughout the last 7000 years. None of the sea level curves constructed for New Zealand are particularly high resolution especially within this period.

Several studies have recognised foraminiferal assemblages characteristic of narrow inter-tidal zones, for example an accumulation of species Haplofragmoides wilberti is only found in high abundance between mean high water and extreme high water spring in some modern sheltered brackish water environments in New Zealand (Hayward et al., 1999). Foraminiferal assemblages, if preserved and identified in the sediment record, will be useful for determining previous sea level heights.

Whanganui Inlet, Northwest Nelson is New Zealand's second largest estuary (2744 hectares). At low tide the inlet divides into two main channels exposing broad mudflats. The inlet is located in the Pakawau Sub-basin which has remained tectonically stable for the last 690ka (Williams, 1991). Cores up to five metres in length were recovered and radiocarbon dated, providing a useful sediment record for foraminiferal assemblage analysis to infer sea levels in Whanganui Inlet for the last 8000 years.

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Hayward, B.W., Grenfell, H.R., and Scott, D.B., 1999, Tidal range of marsh foraminifera for determining former sea-level heights in New Zealand: New Zealand Journal of Geology and Geophysics, v. 42, p. 395-413.

Williams, P.W., 1991, Tectonic Geomorphology, Uplift rates and Geomorphic response in New Zealand: CANTENA, v. 18, p. 439-452.

HOW OLD IS NEW ZEALAND'S EXTANT BIODIVERSITY? ESTIMATES FROM INVERTEBRATE DNA

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Studies of New Zealand's endemic fauna using DNA sequences have allowed us to test hypothesis about the processes that have led to the current distribution and abundance of extant species and given us estimates of the approximate age of that diversity. Species radiations can be linked with geological events and era. Recent mountain building and Pliocene Islands have apparently had a major role in the origin of new insect species. Most invertebrate studies have found that many species in New Zealand are older than the Pleistocene but younger than the Miocene. In contrast, the New Zealand weta have multiple lineages that data back to the Oligocene and provide evidence of speciation during the Miocene, Pliocene and Pleistocene.

GNS DATABASES ON THE WEB: PETLAB, FRED AND STRATLEX

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In recent years, GNS has put considerable effort into upgrading its databases. Three GNS databases can now be accessed at the web addresses shown in the above figure or from <http://www.gns.cri.nz/store/databases/index.html>

PETLAB contains sample and analytical records for rocks and minerals, mainly from GNS's National Petrology Reference Collection. FRED (Fossil Record Electronic Database) is a database of fossil localities in the New Zealand region. STRATLEX, the New Zealand Straigraphic Lexicon is a database of formally named New Zealand rock units.

Further improvements to the web interfaces are planned, but even now all New Zealand geologists can benefit by using these research tools in their work.

TALKS: General 1, 2 & POSTER

BASEMENT ROCKS FROM THE WISHBONE RIDGE, EASTERNMOST CHATHAM RISE AND CHATHAM-SUBANTARCTIC MARGIN

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With *in situ* rock obtained from 77 of 95 attempted dredges, the major goals of the *Sonne* 168 cruise (Dec 2002-Jan 2003), to recover basalts from the Hikurangi Plateau, Chatham Rise and adjacent Pacific ocean crust seamounts, were achieved. Interestingly, and somewhat unexpectedly, non-basaltic rocks were obtained from three deep water areas.

WISHBONE (DR54-56; 2600-3700 m water depth; 80 kg rock recovered): three dredges on the faulted scarp of the Wishbone Ridge, a major intraoceanic gravity feature, consisted entirely of altered dacitic lavas and feldspathic sandstones.
TAKAHE (DR62; 2400-3100 m; 1000 kg): a dredge on this 20 x 10 km plateau-like feature at the extreme eastern end of the Chatham Rise gave variably cataclastic, altered hypabyssal granodioritic-granitic rocks. No other rock types were present.
STUTTGART (DR71; 3600-4200 m; 20 kg): this seamount is isolated from the Chatham Rise by abyssal Southern Ocean floor; swath mapping revealed it to be of non-volcanic, fault-block origin. Garnet amphibolite, garnet-biotite schist, green phyllitic schist and pink phosphatised limestone were the only rocks in the dredge.

Dating and petrologic work on the (Haast?) schist and (Cretaceous?) siliceous igneous rocks is underway. This will enable correlations with South Island and Antarctic rock units and provide important new constraints on the nature and timing of the change from subduction to rifting in eastern Zealandia.

TALK: Cretaceous 2

ALONG STRIKE CHANGES IN SLIP PATTERN OF STRIKE-SLIP FAULTS: PRELIMINARY OBSERVATIONS FROM THE NORTHERN NORTH ISLAND DEXTRAL FAULT BELT

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The North Island Dextral Fault Belt (NIDFB) and the North Anatolian Fault System (NAFS) appear to change along strike from mainly strike-slip to principally dip-slip as they approach regions of active extension (Taupo Volcanic Zone and Aegean Sea respectively). How and why such active fault systems change their kinematics along strike is poorly understood; this is especially so for individual earthquakes or cycles of earthquakes. The western prolongation of the NAFS into the Aegean Sea provides a good analogue for the northern NIDFB. Along the NIDFB in the North Island of New Zealand, we wish to provide new insights into the following poorly understood aspects of active deformation.

1. How does the ratio of strike-slip to dip-slip change along the northern NIDFB?
2. How are the changing fault kinematics manifest in the population of large magnitude earthquakes within the NIDFB (e.g. how does fault segmentation and changing slip kinematics, affect rupture dimensions and propagation during earthquakes)?
3. What is the long-term (>100 kyr) tectonic evolution of the transition zone from strike-slip to extension dominated deformation in the NIDFB? Do extensional basins in the Northern part of the NIDFB, including those in Minginui, Ruatahuna, Galatea, Waiohau regions, provide information on the long-term growth of the system?

POSTER

THE ANDRILL PROGRAMME: A NEW MULTINATIONAL INITIATIVE TO INVESTIGATE ANTARCTICA'S CLIMATIC AND TECTONIC HISTORY FROM STRATIGRAPHIC DRILLING

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ANDRILL is a multinational initiative to investigate Antarctica's role in Cenozoic-Recent (65 million years ago to the present) climatic, glacial and tectonic change through the recovery of stratigraphic records from and around the Antarctic margin. The ANDRILL programme was initially conceived and promoted by scientists who led the successful Cape Roberts Project (CRP) and other interested parties. A key motivation of ANDRILL is that the role of the Antarctic cryosphere (ice sheets, ice shelves & sea ice) in the climate system is complex and very poorly understood. While, high-quality sedimentary archives of past ice sheet behaviour have recently become available from projects such as the Cape Roberts Project and the Ocean Drilling Program (Leg 188, Prydz Bay), unfortunately they are too few in number to allow a comprehensive understanding of the continents influence on global climate. ANDRILL will address this issue through drilling a targeted portfolio of sites initially in the McMurdo Sound region. Here the dynamic behaviour of the East and West Antarctic ice sheets, and the Ross Ice Shelf have left their signature in the thick Cenozoic sedimentary fills of the West Antarctic Rift system and flexural moat basins. The ANDRILL McMurdo Sound Portfolio, is an 8 to 9 year programme spanning from 2001 to 2010 of which geophysical and site survey scientific investigations are nearing completion and the drilling phase will soon begin. An ANDRILL consortium has been established comprising five countries – USA, Italy, Germany, UK and NZ. This paper will present the scientific objectives of the programme, discuss the current status and future plans.

CHARLES DOUGLAS AND THE GIANT GEOLOGICAL MAP OF SOUTH WESTLAND

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Charles Edward Douglas explored and mapped the remoter parts of Westland for almost 40 years (1868-1906). He often worked alone or with only one companion as well as a dog. In 1897 he was awarded the Gill Memorial Prize by the Royal Geographical Society, and about that time the Lands and Survey Department gave him the designation of "Explorer".

Douglas was always interested in minerals and geology. In 1868 he accompanied Haast on a trip to South Westland, and they spent nine days trapped by high seas at Arnott Point. Douglas undoubtedly picked up some basic geology and knowledge of rock identification from Haast. Throughout his career he collected samples and commented on geological features and mineral prospects in his reports.

The Lands and Survey Department recognised that Douglas had a unique knowledge of South Westland, and he was encouraged to record his observations. In the later part of his life he often spent the winter months in Hokitika working on two huge maps of Westland that showed topography and geology. Sheet One covered the area from Hokitika to Okarito; Sheet Two covered the area from Okarito to Big Bay. These maps were displayed by the Mines Department in the 1906-07 Christchurch Exhibition (although Douglas received no credit).

The maps were stored for many years at the Lands and Survey Department, Hokitika. They are now held in the National Archives, Wellington (LS W1388). A copy of the second (southern) map will be on display at the conference.

Many geologists and prospectors have examined these maps over the years. Harold Wellman and Dick Willett spend a day in Hokitika noting the geology before travelling to South Westland in 1941. The observations made by Douglas undoubtedly contributed to their discovery of the Alpine Fault.

An account of Douglas' life and explorations is given by John Pascoe in his book "Mr Explorer Douglas". An updated second edition has recently been published.

POSTER

PARAMOUDRA CONCRETIONS MARK A POSSIBLE LATE MIOCENE METHANE SEEP FIELD, NORTH TARANAKI

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The Late Miocene (late Tongaporutuan) Urenui Formation in North Taranaki is an upper slope mudstone with occasional channel-fill units. The mudstone is massive or weakly bedded, bioturbated, weakly calcareous, and locally concretionary. In coastal outcrops north of Urenui the mudstone includes a concentration of a variety of concretionary structures, including pipes, tubes, slabs, pockmark-like rings, and more conventional subspherical types. The pipes and tubes resemble “paramoudra” concretions, formerly interpreted to be concreted trace fossil burrows. However, our preliminary investigations suggest the paramoudra are carbonate vent structures that mark sites of focussed fluid/methane gas escape from below, analogous to modern seafloor cold seeps, and so they have implications for active petroleum system evolution in eastern Taranaki Basin.

The paramoudra are mainly oriented (sub)vertically, range in length from 0.5-5.0 m, and in diameter from about 10 to a few 10s of centimetres. They may taper upwards or downwards, branch, anastomose and bend over, sometimes developing slab-like forms. Most support an internal, near-central tube, 2-4 cm across, now filled with host sediment or cement(s); others contain many central tubelets each up to a few millimetres across. While there is much variation, two main morphological varieties occur: cylindrical paramoudra, and larger, more irregular bulbous paramoudra.

The carbonate content of the paramoudra ranges from c. 30-75% (cf. <5% in the host mudstone) and is due to micrite or microsparite that cements the host sediment, indicating the structures formed below the seabed. In the cylindrical paramoudra the cement is calcite, but in the bulbous paramoudra it is dolomite, suggesting they originated in different sub-seafloor environments or have different times of formation. Contrasting stable isotope values for the carbonates support this distinction, with cylindrical types, _^{13}C -30 to -40‰, _^{18}O -2 to 0‰ versus bulbous paramoudra, _^{13}C -10 to +10‰, _^{18}O 2 to 4‰. These isotope characteristics suggest calcite precipitation in the cylindrical paramoudra occurred in the zone of microbial sulphate reduction near below the seafloor, while dolomite precipitation in the bulbous paramoudra was in the underlying zone of methanogenesis, and was possibly later. The actual carbon sources involved, among other contributions, were probably a mixture of deep thermogenic hydrocarbons and shallow biogenic methane. We suspect the paramoudra are delineating a shallow sub-seafloor plumbing system that focussed the upwards ascent of methane gas/fluid flow towards the Urenui seabed in the Late Miocene.

TALK: Paleoenvironments & Paleobotany 1

QUATERNARY FAULTING IN CENTRAL AND EAST OTAGO

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Late Quaternary dip-slip rates on the Alpine Fault reach a maximum in the central South Island but south of Haast, reduce to near zero. Here, the c. 9 mm/yr fault- normal component of convergence must be accommodated on other structures. Part is distributed eastward across a c. 200 km zone of Otago Schist. The Late Cretaceous- Miocene low-relief erosion surface is now deformed into c. NE-striking asymmetric anticline-syncline pairs of 10-25 km wavelength and <1700 m amplitude. The uplifted schist anticlines forming the sub-parallel ranges have been stripped of their mainly terrestrial Tertiary sediments to reveal a basement whose schistosity roughly mimics topography. Intervening basin fill consists of basal Tertiary sediment remnants overlain by a wide range of Quaternary alluvial, fluvial, glacial, and aeolian sediments. Distortion of these sediments provides an informative record of on-going tectonic activity.

These ranges are traditionally shown as uplifted on major reverse faults mostly on the steeper southeast range-fronts. These master faults are often mapped coincident with the unconformity between emergent range and intervening basin fill. Field evidence of these major structures is nonexistent. A low historical seismicity, abundance of precariously balanced rocks (especially on tors), and consistency of textural grade between summits and valleys all point to anomalously low activity on any single major structure deemed responsible for range-scale uplift.

Investigations along the southeast margins of the Dunstan, Blackstone-Raggedy, Rough Ridge Group, Rock and Pillar, and Taieri Ranges show small-scale range- parallel faulting both within the exposed basement and intervening basins. Widely distributed brittle deformation occurs on many small-offset sub-parallel faults giving the impression of a fold train. This has clear implications for seismic hazard assessment within Otago. Deformation within basin sediments occurs as tilted surfaces, disrupted, offset and anomalously dipping beds, and fault planes cutting across bedding. Occasional overturned beds are found, especially in older sediments close to the range-fronts. Anomalous drainage patterns, especially straight range- parallel stream segments, are common.

Twelve samples of disrupted Quaternary sediments from the basins adjacent to five southeast range-fronts are currently being processed for OSL dating. The sites were selected to extract as much information as possible on the tectonic development of Otago. The ages of surfaces will help constrain the timing of many tectonic events, allow growth rates to be assessed, and may uncover temporal clustering of seismicity.

Re-occupation of two high-precision GPS sites spanning Otago allow current strain rates to be assessed. Sufficient time has elapsed since initial occupation for likely displacements to be outside error ellipses.

USE OF COSMOGENIC ISOTOPES TO PLACE CONSTRAINTS ON FAULT PROPAGATION RATES AND THE GROWTH OF RANGES, CENTRAL OTAGO.

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The Quaternary structure and geomorphology of Central Otago are dominated by anticlines which form above blind reverse faults. Where these faults reach the surface on the flanks of ranges, offset features and trenching studies demonstrate their late Quaternary activity. Earlier work on drainage patterns in the area provided information about the style, relative timing and growth of these anticlines. In particular, drainage diversion and asymmetry of catchment areas indicated that, within one system of parallel ridges, the frontal South Rough Ridge formed later than the higher Rough Ridge and propagated northwards. Near its northern tip, two major creeks that now cut through the ridge, Dingo Creek and Oliverburn, have been deflected around, and eventually across, the growing structure. During their deflection, they have cut a series of terraces that reduce in height progressively northeastwards as far as the present Oliverburn. These terraces are warped and offset over South Rough Ridge and track the growth of the range northwards. The terraces are cut into weathered schist that underlies the Tertiary Manuherikia Group sedimentary cover. Quartzites formed in the lower few metres of the sediments have been left resting on the terrace surfaces and on the summit of the ridge. Exposure of the quartzites occurred during the removal of the overlying sediments that would coincide with, or possibly predate, terrace cutting. ^{10}Be ages obtained from these quartzites on terraces and ridge crest formed during migration of the Oliverburn, range from c. 500 ka to 80 ka and are consistent with the sequence of terraces and northward propagation of the ridge. From these, we obtain an uplift rate of 0.10-0.15 mm yr^{-1} and a lateral propagation rate of 1.0-2.0 mm yr^{-1} averaged over the last 450 ka. Growth of the range may, however, have been episodic leading to the development of the distinct strath terraces.

Ages obtained from quartzites on top of Rough Ridge, the higher older ridge immediately to the west, are c. 800 ka. These ages are also consistent with the geomorphology. The maximum possible rates of quartzite erosion derived from these samples are extremely low and support the interpretation of the ages from South Rough Ridge as representing exposure ages. We conclude that the relationship between $^{10-}$Be ages and geomorphology supports the use of cosmogenic isotopes in placing constraints on the growth of these ranges. Ages from several ranges in the region show a broad correlation with the relative ages inferred from drainage patterns, adding further support to this conclusion, and indicating that much of the range growth has occurred in the last 1 Ma.

ZIRCON CHRONOCHEMISTRY OF LARGE FELSIC MAGMA BODIES: RESULTS FROM THE YELLOWSTONE AND TAUPO VOLCANIC ZONES

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The accessory mineral zircon ($ZrSiO_4$) contains a wealth of petrogenetic information for igneous rocks of intermediate to felsic composition. Excimer laser ablation (ELA) provides access to these data via *in situ* (≥15 micrometer spot) sampling for elemental and isotopic analysis by inductively coupled plasma quadrupole mass spectrometry (ICP-QMS). The reproducible ablation characteristics of the ArF (193 nm) excimer laser enables corrections for instrumental mass bias and ablation-related elemental fractionation to be made using zircon and glass standards run in series with samples. Accuracy and precision of U-Th-Pb ages determined by ELA-ICP-QMS are comparable to those obtained with the SHRIMP (sensitive high-resolution ion microprobe) for Phanerozoic zircons. Rapid scanning of a wide mass range by ICP-QMS permits the simultaneous collection of trace element data. Integration of age and compositional data forms the basis of zircon chronochemistry.

In order to better understand the temporal and chemical evolution of felsic magma bodies within the Yellowstone and Taupo volcanic zones, we are examining zircons in pumice from large-volume caldera-forming ignimbrites. Results have been obtained for the Mesa Falls Tuff (MFT, 1.29 Ma, 300km^3) and Lava Creek Tuff (LCT, 0.64 Ma, 1000 km^3) from Yellowstone, and work is in progress on the Ngaroma (1.55 Ma), Ongatiti, (1.21 Ma), Ahuroa (1.18 Ma), and Rocky Hill (1.00 Ma) ignimbrites from the Mangakino caldera in the TVZ.

Three populations of zircons can be distinguished in the MFT based on combined age and trace element criteria. Population 1 is oldest (1.35 ± 0.03 Ma) and has very high U and P concentrations and negative Eu anomalies. Population 2 has an intermediate age (1.30 ± 0.03 Ma) and chemical characteristics. Population 3 is youngest (1.19 ± 0.07 Ma) and has the lowest U and P concentrations and least negative Eu anomalies. The trace element data preclude physical mixing between populations as an explanation for chemical variations within populations and imply the existence of temporally and spatially distinct magma bodies. The extreme chemical characteristics of population 1 (and 2) zircons indicate they may have crystallised from low degree partial melts of wall rock during early stages in the accumulation of the MFT magma body. Zircons in the volumetrically larger LCT exhibit similar trace element systematics, but over a shorter time interval.

A TALE OF TWO LIQUIDS

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Planet Earth is the only known planet in our solar system where water and hydrocarbons are stable in liquid, solid and gaseous phase. Modern society is more dependent upon water and hydrocarbons than ever before. Our lifestyles are based upon the premise that New Zealand has a plentiful supply of indigenous water and natural gas.

On a worldwide scale New Zealand appears to have plenty of freshwater, but is that freshwater resource as plentiful as it first appears? Certainly climatic and hydrological extremes and the resultant unpredictable distribution challenge the management of this resource.

Through the 1970s and 80s the Maui gas field was the answer to our energy woes. But as the Maui Field nears the end of its producing life New Zealanders are faced with the harsh realities of the true cost of energy.

Rarely do people question their use of resources, except perhaps when they are under threat. As the occupants of a south west Pacific archipelago remote from the major population centres of the world we need to treasure our resources more than most because the cost of "buying" more will soar as world demand increases.

PALEOSEISMOLOGY OF THE KEREPEHI FAULT, HAURAKI GRABEN

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The Kerepehi fault is one of the closest large active faults to Auckland City. It is the active central graben normal fault within the Hauraki graben, in the back-arc of the old Hikurangi subduction zone. The graben is bounded by the Hauraki fault on the eastern margin and the Thames fault at its western edge which are not considered to be active today. The Kerepehi fault trends NNW and dips to the west. Onshore, the fault's surface expression comprises simple, stepped and double scarps, and broad warps. The fault continues offshore into the Firth of Thames and the Hauraki Gulf to as far north as Bream Head (e.g. Rawson 1983 and references therein). In the Hauraki Plains, three segments have been identified by Foster & Berryman (1991) between Elstow and Te Poi. These are from south to north, the Te Poi segment (from Te Poi to Hungahunga), the Waitoa segment (from Hungahunga to Elstow) and the Elstow segment (from 2 km south of Elstow to Elstow). The segments are separated by side-steps to the east of about 3 to 3.5 km. Together these three segments have a 50 km long surface trace. North of Elstow, this paper presents new parts of the fault trace which are more discontinuous but can be followed as far north as Ngatea. We suggest that the Elstow segment extends northward into the Kopouatai bog. Another side-step just south of Tirohia could indicate a fourth segment that stretches between Tirohia and Ngatea which we propose to call the Ngatea segment. Including these new fault traces the total onshore surface trace is now 80 km long.

The fault mainly offsets the 19.4 ka old pumice-rich fluvial sediments of the Hinuera Formation. Scarp heights on all segments range from 1 to 8 m vertically with little or no evidence for strike-slip movement. This would result in an average slip rate of 0.4 to 1.3 mm/a. The total throw on the fault as determined by geophysical methods is 1–3.5 km (Tearney, 1980; Beanland & Berryman, 1986). The smallest scarps (1–1.8 m) are found on the youngest river terraces (degraded Hinuera 2 surfaces) and are likely to represent single event displacements. Based on the length, area and the slip of the Te Poi segment, the possible MCEs for this segment are M_W = 6.36 – 7.29 and for the whole fault, including the new segments, the possible MCE ranges from M_W = 7.00 – 7.77.

Previously, two trenches were dug on the Te Poi and the Waitoa segments (Foster & Berryman 1991) suggesting that these segments did not rupture in the same events. The last event along the Te Poi segment occurred at 450 to 900 yrs BP with an estimated recurrence interval of 4500 to 9000 yrs. On the Waitoa segment, the last rupture took place 1800 – 4787 yrs BP with a recurrence interval of 6000 – 9000 yrs.

Paleoseismological data are not yet available for the Elstow and the Tirohia segments but will be collected in the near future, possibly together with high resolution reflection seismic data. We also plan to expand on the reconnaissance level information currently available on the southern segments.

POSTER

LOW-PRESSURE FRACTIONATION OF NYIRAGONGO VOLCANIC ROCKS, VIRUNGA PROVINCE, DR CONGO

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The Nyiragongo volcano is one of the most active volcanoes in Africa and is one of the few volcanoes in the world containing an active lava lake. The last eruption in January 2002 was triggered tectonically; fissures opened on the S flank of Nyiragongo causing the drainage of the lava lake. The potential for volcanic hazards in this densely populated area comes from fast spreading, low viscosity lava flows and the release of large quantities of carbon dioxide and methane.

Geographically, Nyiragongo is located close to the borders between DR Congo, Rwanda and Uganda, approximately 18 km north of Goma on the N shore of Lake Kivu. The stratovolcano consists of a main cone and two satellite craters, Shaheru and Baruta to the south and north, respectively. The main cone is 3469 m high with a near circular crater of 1200 m in diameter which is up to 900 m deep. The Nyiragongo lava plain is marked by more than 100 radially arranged parasitic volcanic cones.

Geologically, the Nyiragongo volcano belongs to the Virunga Volcanic Province in the Western branch of the East African Rift System. The province is located where the active N-trending Albert rift intersects with the NW-trending Kamatembe Rift to the west and the NE-trending Bay of Bufumbira to the east. Volcanism started at about 12 Ma, producing eight major volcanic edifices. Historical volcanic activity is confined to the active rift floor with Nyamuragira (3058 m) and Nyiragongo as the main volcanic structures.

Petrologically, the Nyiragongo volcano and its surrounding lava plain is known for its variety of rare rock types such as melilitites, leucitites, olivine melilitites, picrites, and ankaratrites. Representative samples of the main cone have been chosen for detailed studies from the Nyiragongo rock collection stored at the Museum of Central Africa in Tervuren, Belgium. Petrography, bulk geochemistry, and mineral chemistry revealed a complete fractionation series of melilitite - melilite nephelinite - pyroxene nephelinite - leucite nephelinite - leucitite - leucite tephrite. An initial pyroxene nephelinitic melt has evolved towards melilite nephelinite and melilitite mainly by leucite fractionation with cumulates represented by leucite nephelinite to leucite tephrites. Leucite fractionation is demonstrated by both major elements and Rb and K.

Known lava lake temperatures and geobarometer calculations using clinopyroxene show that leucite crystallisation takes place at very low pressures, mostly within the volcanic edifice. The parental melt of the main suite is suggested to be olivine melilitites exposed at the Rushayo chain, SW of Nyiragongo. These low degree partial melts form pyroxene nephelinitic melt compositions by fractionation of olivine and melilite.

Rare alkaline olivine basalts exposed at the Nyiragongo edifice have a different petrogenetic origin. Comparison with Nyamuragira volcanics suggests a co-magmatic origin, which is supported by NW-trending faults linking Nyamuragira and Nyiragongo.

TALK: Petrology 2

EVIDENCE FROM THE MATAKEA GROUP, OTAGO, FOR WINDY ARID CONDITIONS IN LATE CRETACEOUS NEW ZEALAND

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The Kyeburn Formation of the Matakea Group (Cretaceous) comprises >4 km of non-marine sandstone, conglomerate and coarse breccia resting unconformably on Otago Schist basement. The top of the Kyeburn Formation is truncated by the regionally extensive Waipounamu erosion surface, the origin of which is controversial. The Kyeburn Formation is down-faulted into basement and is currently interpreted as rift infill, with boulder breccias representing talus shed from nearby fault scarps and finer fluvial and lacustrine sediments representing distal equivalents. This interpretation is problematic, however, partly because it requires lithofacies units to be bounded by abrupt facies changes, and also because some units of distal aspect have a different provenance to their putative proximal equivalents. Geometry of Kyeburn Formation lithofacies units can instead be interpreted in terms of sandstones and conglomerates low in the sequence giving way up-section to laterally extensive breccias.

Kyeburn Formation breccias contain angular clasts up to 1 m across; some contain faceted boulders, and many have a red hematitic matrix. The transition to breccia-dominated sedimentation can be interpreted in terms of a pluvial climatic regime being superseded by an episode of windy aridity contemporaneously with an influx of coarse detritus into the depocentre. Transitions to breccia-dominated sedimentation similar to that in the Kyeburn Formation are evident in the Henley Breccia of the Matakea Group and in the Pororari Group of Westland and Nelson. These mid to Late Cretaceous units include the youngest sediments beneath the Waipounamu erosion surface, and the regionally expressed transition to boulder breccia sedimentation preserved within these units records a marked Late Cretaceous environmental change that took place soon before the brief (~10^7 year) erosional event that formed the enigmatic Waipounamu erosion surface.

At the time of Matakea and Pororari Group sedimentation, New Zealand was part of a continental margin undergoing rifting to form a high latitude archipelago. While rifting-related mechanisms can account for the influx of coarse angular detritus into Matakea and Pororari depocentres, onset of aridity is an unanticipated consequence of a transition from a continental margin to a maritime setting. Influx of coarse debris contemporaneously with onset of aridity can however be accounted for by the operation of glacial and periglacial processes, with small perennial ice accumulations transporting angular debris, and periglacial katabatic winds suppressing fluvial processes by evaporating surface waters. Coalescing of small dry-based ice caps into a voluminous wet-based or polythermal ice sheet provides a mechanism to account for the rapid development of the Waipounamu erosion surface, which is otherwise difficult to explain. Whatever the origin of the Waipounamu erosion surface, the Pororari and Matakea Groups, which were deposited not long before it developed, archive evidence for an episode of marked paleoenvironmental change that can be explained in terms of ice cap nucleation and growth.

TALK: Cretaceous 2

STEPS TOWARDS RETRIEVING A HIGH-RESOLUTION RECORD OF PAST CLIMATE CHANGE FROM BENEATH LAKE PUKAKI, SOUTH ISLAND, NEW ZEALAND

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Lake Pukaki is one of three large post-glacial lakes occupying formerly glaciated troughs at the head of the Waitaki River. Much of the Pukaki catchment lies in Mount Cook National Park and is New Zealand's most glaciated catchment, with glaciers presently covering more than 210 km^2. Dammed behind moraines formed during the Last Glacial Maximum (LGM), the Pukaki glacial trough (Pukaki Basin) has been a very effective sediment trap that contains a near-complete record of sediment delivery from the catchment and information on climate change over the past c.17,000 calendar years since the last main retreat of ice.

To determine the climatic history of the Pukaki Basin, a multi-disciplinary scientific team proposes to retrieve a long sedimentary core from beneath Lake Pukaki and use an integrated analytical approach that has been highly successful for reconstructing past environments from ocean drilling programmes. Continuous down-core sediment, pollen, diatom, inter-regional quartz flux, stable carbon/oxygen and organic carbon/nitrogen isotopes and environmental magnetism profiles will be determined and reconciled against equivalent-age terrestrial and marine records. A robust age framework will also be developed using a combination of ^{210}Pb, ^{137}Cs, ^{14}C and ^{32}Si, and OSL techniques that can be reconciled against climate proxies.

To date, our collective efforts have focused on assessing the feasibility of retrieving a long sedimentary record beneath Lake Pukaki in order to assess past climate characteristics (rainfall, temperature and windiness) and determine rates of change. Seismic data were recently acquired, showing fine parallel reflections of lake sediment up to 400 m thickness overlying basement in the southern central portions of Lake Pukaki under c.90-100 m of water. This reflection character suggests a relatively undisturbed sedimentary sequence implying potential preservation of a fine-scale record. A 2.2 m thick piston core (L1395) retrieved by NIWA from nearby Lake Tekapo at 120 m water depth, is also being used to help develop and refine biotic, abiotic and chronologic methodologies that can be applied to the proposed Pukaki core.

Ultimately, we intend to form a multi-institutional research consortium to retrieve a sensitive high-resolution sedimentary record from beneath Lake Pukaki and document sub-decadal (annual?) scale biotic and abiotic signatures of climate history. Variations in climate proxies will assist us to construct and compare regional and inter-regional paleoclimatic signatures and rates of change. Aside from being of considerable interest to the international paleoclimate research community, such a high resolution and long-term climate history will be of great relevance to hydroelectricity stakeholders, especially in light of recent episodes of poor seasonal recharge to storage lakes, and flow-on effects resulting in reduced electricity generation capacity.

POSTER

EOCENE TO MIOCENE VEGETATION HISTORY AND CLIMATE, ROSS SEA REGION, ANTARCTICA

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Terrestrial palynomorphs from the recent Cape Roberts Project (CRP) drillholes (Raine & Askin 2001) supplement palynofloras from glacial erratics (Askin 2000) and CIROS-1 drillhole (Mildenhall 1989) to provide an emerging picture of vegetation history and climate for coastal Victoria Land from the mid-Eocene to early Miocene. Palynological evidence suggests diversity reduction through this period, consistent with increasing glaciation recorded in the sediments. Sparse recovery, and recycling by glacial processes remain continuing problems in interpretation.

Assemblages of middle to late Eocene age from the McMurdo Sound glacial erratics, dated by associated dinoflagellate cysts, are characterized by diverse and common *Nothofagus* pollen, along with that of podocarps, diverse (though uncommon) Proteaceae and other angiosperms, and rare cryptogam spores. Similar assemblages, which reflect a cool temperate *Nothofagus*-broadleaf-podocarp forest, occur in the late Eocene part of CIROS-1.

Early Oligocene palynomorph assemblages, known from erratics, CIROS-1, and CRP drillholes, are much reduced in diversity compared to those of the Eocene, with loss of most ferns, some previously important podocarpaceous conifers, the previously diverse Proteaceae, the *brassii* group of *Nothofagus*, and other angiosperms. The Early Oligocene vegetation may have resembled present-day Magellanic *Nothofagus* woodland. Climatic conditions were likely cold temperate-periglacial, with warmest month mean daily temperatures at sea level about 10-12°C.

In the youngest part of the CIROS-1 and CRP succession, late Oligocene and early Miocene assemblages are similar to those of the Sirius Group in the Beardmore Glacier area, of questionable Pliocene age. They reflect low diversity mossy tundra vegetation, with a few dwarf woody plants (one or more species of *Nothofagus* and podocarp conifers) in more protected locations. Mean summer temperatures for this sparse periglacial vegetation were in the range 2-7^0 C, similar to present-day temperatures in Subantarctic islands.

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TALK: Paleoenvironments & Paleobotany 2

THE STRUCTURAL GRAIN AND REGIONAL MARKERS WITHIN TORLESSE ROCKS OF NORTH CANTERBURY AND MARLBOROUGH

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Regional geological fieldwork and compilation for QMAP sheets Greymouth and Kaikoura have resulted in a dense coverage of structural measurement data of greywacke rocks in the Rakaia and Pahau terranes in northern Canterbury, inland Kaikoura and southern Marlborough. The data, complemented by lineaments derived from air photo interpretation and field observation, have been generalised into form lines that portray the dominant structural grain of the Torlesse rocks. In most cases the form lines represent primary stratification (bedding) or transposed or sheared bedding (broken formation and melange). The form lines are locally supported by thin marker units, such as prominent sandstone beds or distinctive coloured mudstones.

The form lines trend from north to NNW in Canterbury (south of the Hope Fault) to NNE to northeast in Marlborough. There are distinct changes in orientation across the major strike-slip faults of the Marlborough Fault System suggesting movement of the faults have influenced the trend. This could result from rigid body rotation or distributed internal shear of the blocks enclosed by the faults. Alternatively localised fault drag of bedding may have accentuated pre-existing orientation differences.

Deformation zones of broken formation and melange persist across the area. Locally these zones change in thickness, and deformation style according to the proportion of thick-bedded sandstone versus mudstone. The Esk Head Melange has been mapped from its type locality through blocks displaced by the Hope, Clarence and Awatere faults to the Alpine Fault in Wairau valley. Another significant regional marker occurs west of the Esk Head Melange. This band of red and green altered mudstone and volcanic rocks, including limestone and basalt, has been mapped for 115 km from southwest of Harper Pass and across the aforementioned faults to Lake Tennyson. This band however, although locally sheared, is not as deformed as typical melange and may represent a primary interstratified lithological unit. The band converges with the Esk Head Melange to the northeast and is probably truncated by the melange north of Lake Tennyson.

Several other deformation zones have been identified within the Pahau terrane. These broken formation (and locally melange) zones appear to be concordant with adjacent form lines. Correlation of individual zones in adjacent faults blocks is not always clear. This in part reflects lithological contrasts but also reflects the relatively weakly developed shear fabric. One prominent melange zone extends from the Alpine Fault through the Waihopai valley to the Awatere Fault and may correlate with another melange zone west of Cheviot in North Canterbury.

A STUDY OF THE NEOTECTONICS AND STRUCTURAL GEOLOGY OF THE WELLINGTON FAULT, NORTH ISLAND, NEW ZEALAND

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Three displaced Holocene fluvial terraces in Harcourt Park, Upper Hutt are used as geomorphic markers to estimate late Quaternary finite and incremental displacements on the Wellington Fault. Net dextral displacements of terrace risers of 27 m, 21 m and 10 m were estimated, and corresponding vertical offsets, all up-thrown to the northwest, of 5.5 m, 3 m and 2.8 m. These data correspond to incremental displacements of 6 m, 10 m, and 10 m (oldest to youngest). Incremental displacements indicate a consistent sense of throw that is up to the northwest. Vertical:horizontal ratios for slip on these terrace risers are estimated from oldest to youngest: 1:5, 1:7, 1:4. Based on single-event displacements previously measured in Te Marua of 3.7-4.5 m (Berryman, 1990), we infer that approximately 7 events are represented in the offset of the oldest measured riser (R3-4); that ~5 events affected the next youngest terrace riser R2-3, and that 2 contributed to offset of the youngest riser.

Also examined is the structural geology of outcrop scale faults and fault rocks in the bedrock damage zone of the Wellington Fault at Mains Rock, Upper Hutt. This outcrop exposes a major abandoned fault plane that strikes sub-parallel to the current active trace of the Wellington Fault, which is located several metres to the southeast. Secondary dextral-slip faults with small-offsets cross-cut the major fault plane at Mains Rock at angles between ~36° and ~66° clockwise. These faults make a higher angle to the main fault than typical Riedel shears. They are clearly younger and may have occasioned the deactivation of that major fault. Their attitudes have been used to constrain paleo-orientations of the maximum principal stresses at the time of their formation. Orientations of _$_1$, at the time of this brittle deformation is inferred to have been nearly perpendicular to the Wellington Fault, a situation that would have been associated with significant frictional resistance on that structure. This stress disposition may be explained by elastic stress perturbations near the tip of a coseismically ruptured slip patch, and it is possible that the crosscutting faults represent aftershock events related to coseismic slip on the Wellington Fault.

Ultracataclasites at Mains Rock contain veins of heulandite, a zeolite mineral that typically forms at temperatures ranging between 170°C and 250°C. Assuming a geothermal gradient of 20-30°C/km for the Wellington region implies that the currently exposed fault rocks formed at an original depth of between ~5.6 and ~12.5 km. Using an inferred vertical rate of uplift on the Wellington Fault of ~0.5-1 mm/yr (Berryman, 1990), the time taken for exhumation from this depth would be 5.7-16.6 Ma, implying that the presently active Wellington Fault is at least this old.

EXPLOSIVE VOLCANISM AT TAUHARA VOLCANIC COMPLEX: IMPLICATIONS FOR THE EMPLACEMENT OF HIPAUA DOME

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Tauhara Volcano is a complex of six coalesced dacite lava domes/cryptodomes and their associated lava flows and pyroclastic deposits. Buried or partially buried rhyolite lava bodies adjacent to the main edifice may be genetically related.

Hipaua is a small volume dacite lava dome located in the northeast of the Tauhara Complex. It probably formed prior to extrusion of the largest dome (Main Dome), but at ~190 ka (Tanaka et al. 1996) is not the oldest lava. The lava exposed in the quarry at Hipaua is columnar-jointed, blocky, or brecciated and is mantled by post-26.5 cal. ka. tephra and tephric loess. However, in one quarry exposure near the top of the quarry, dacite tephra conformably covers lava flow breccia. In another exposure, brecciated lava is directly overlain by thinly bedded, siliciclastic, lacustrine Huka Falls Formation sediments.

Recent earthworks at the quarry exposed ~4m of well-bedded, dacite ash and lapilli. Angular and variably dense clasts, vesiculated ash tuff beds, mud-coated clasts, and liquified fine ash indicate that the tephra was generated by a phreatomagmatic eruption. In the initial-phase deposits, we found Huka Falls Formation sandstone and dacite lava lithics. The sandstone clasts indicate that dacite magma erupted through saturated lake sediments. This style of activity has not previously been recognised at Tauhara.

In addition to the lithic blocks in the tephra at ~600m asl, we recorded Huka sediments at two lower elevations in the quarry: 1) baked and enclosed by blocky lava at ~580m asl and 2) in direct contact with brecciated lava in the lower face at ~540m asl. At the lowest elevation, the Huka sediments are at least 150m above the elevation of equivalent strata encountered in wells at Wairakei and Tauhara geothermal fields. Taking into account fault displacements and ground subsidence, we suggest that the difference can be explained if Hipaua Dome growth started as a cryptodome that upthrust the Huka sediments. Explosive interaction of fresh dacite magma and saturated Huka sediments was probably contemporaneous with subaerial emergence of the dome.

Based on tephrostratigraphy, Worthington (1992) estimated Hipaua Dome to be between 19-22.6 ka. The age of Huka Falls Formation is between ~330ka (Whakamaru Group ignimbrite) and 22.6ka (Oruanui ignimbrite), so the presence of Huka sediments in conformable contact with Hipaua dacite indicates that the dacite is older than 22.6 14C years BP. We favour an $^{40}Ar/^{39}Ar$ age of 190ka obtained on Hipaua lava by Tanaka et al. (1996), above an earlier K/Ar age of 31ka (Stipp, 1968). The latter has been suggested as unreliable due to excess radiogenic argon.

POSTER

LATE PLEISTOCENE GLACIAL GEOLOGY OF THE WAIAU - HOPE HURUNUI VALLEY SYSTEM IN NORTH CANTERBURY, NEW ZEALAND

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The primary objective of this ongoing research project (Ph.D.) is a re-evaluation of the extent, timing and nature of Late Pleistocene glacial fluctuations in a large valley system in North Canterbury. Detailed field mapping of glacial sequences accompanied by an extensive dating campaign (cosmogenic-, OSL-, and ^{14}C dating) will form the basis for a revised glacial chronology for North Canterbury and its correlation to global marine Oxygen Isotope Stages (OIS). Further investigations will focus on the reconstruction of paleo-climatic conditions during past glacial/interglacial periods using pollen, beetles and chironomids.

Current field work is concentrating on the understanding of climatically induced fluvial processes in response to Late Pleistocene climate changes. Characteristic feature of the valley morphology upstream from Hanmer Basin (lower Waiau- and lower Hope Valleys) is a repeated sucession of narrow bedrock gorges and connecting wider valley segments. Accordingly, the fluvial pattern is diverse with rapid changes from straight to meandering to intense braiding. Despite the presence of several bedrock gorges in the main valley the longitudinal profile is remarkably "smooth" and lacks distinct knickpoints. A large number of fluvial terraces represent massive multi-phased aggradation prior and during the LGM as well as rapid postglacial degradation. Maximum vertical incision into the valley fill has occurred in the lower Hope Valley (at the Hope-Boyle River Jct.) where the present Hope River is located 170m below the aggradational Glynn Wye Terrace surface.

Geophysical investigations with Ground Penetrating Radar (GPR) at river level in the basin-like lower Hope Valley indicate a sediment fill of at least 15m (max. depth of signal penetration). Furthermore, the radar profiles clearly show an erosional unconformity between the upper 2m of close to horizontally bedded gravel (active channel deposits) and the underlying distinctively dipping gravel units. Additionally, low degradational terraces (2-5m above the present river) and the absence of bedrock at river level suggest that postglacial valley excavation in the lower Hope Valley is an ongoing process. At the same time, the sediment fill in the wider valley segments is also responsible for maintaining the 'smooth' longitudinal valley profile as it is effectively burying and therefore masking the original bedrock valley floor which is expected to exhibit much greater changes in valley floor gradient.

Geological mapping in the lower Hope Valley found evidence of at least one large (glacial?) lake/s which occupied the valley prior to the LGM advance. Up to 90m of intensely deformed lake and fluvial deposits best exposed in a gully at Poplars Station are currently logged in detail for facies analysis (luminescence age determination in progress). The relation to other thick lacustrine deposits including a large delta foreset on the south side of the lower Hope Valley is uncertain but it is indicated that the deposits represent several distinct lakes phases during the Late Pleistocene.

NORMAL FAULT PROPAGATION AT THE TERMINATION OF AN INTRA-RIFT MAGMATIC SEGMENT, MAIN ETHIOPIAN RIFT SYSTEM

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Where do normal faults nucleate? The intra-rift structural fabric of the Main Ethiopian Rift System (MER) provides constraints on normal fault growth models, with a recent interpretation arguing for nucleation in the near-surface consequent on the downward propagation of surface fissures. ESE-trending extension (3-5 mm/yr) across the MER is oblique to the trend defined by border-fault segments, which formed early in the evolution of the rift but are no longer the principal loci of extension. Currently, over 80% of the strain across the rift is focussed within an axial zone defined by the en echelon arrangement of ~ 20-km-wide by ~ 60-km-long discrete magmatic segments, which strike orthogonal to the current extension direction and appear to be soft-linked to the border faults. Examples of genetically related fissures and normal faults occur within the Koka Magmatic Segment near its southern termination against the Asela Border Fault. Considerable along-strike variations in displacement are evident, resulting in flexure of the rift floor. Ramps, breached ramps, hanging wall anticlines and footwall synclines indicate that normal faults have grown by segment linkage. Fault spacing, throw, and back tilting decrease toward the intra-rift axial zone, which comprises subparallel grabens separated by narrow, occasionally synclinal, horsts. Fissures on the order of 1 to several meters wide occur within these grabens and have similar length scales to primary segment lengths revealed by linkage structures along the normal faults. Commonly, fissures are located at the top of narrow monoclinal flexures, which trend parallel to the axial graben. Where a throw (<1-2m) occurs across the fissure, the associated flexure is more subdued. Monoclinal flexures continue for some distance (generally < a few 10s of meters) beyond the lateral tips of the associated fissure, though their curvature reduces significantly. Partially filled fissures of similar width occur at the foot of steep normal fault scarps with throws of > 20m. Thus, there appears to be an evolution from small-offset fissure to larger-offset fault. The top-down fault nucleation model invokes fault drag as a consequence of higher friction at the fissure-fault transformation depth to explain the observed surface flexure. However, examples of monoclines without fissures or with small poorly connected fissures occur both along the graben floor and within hanging walls of large normal fault splays. Therefore, in some cases flexure development precedes that of fissures. This may arise as a consequence of upward propagation of a blind normal fault nucleated at depth, which induces warping and associated fissuring in cover materials; or alternatively, as a consequence of localised sub-surface mass transport into or out of the axial zone.

BENTHIC FORAMINIFERAL RECORD OF THE LATE QUATERNARY (LAST 150 ka) PALEOCEANOGRAPHIC HISTORY OF THE BOUNTY TROUGH, EAST OF NEW ZEALAND

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The Bounty Trough, east of New Zealand, lies along the southern edge of the present-day Subtropical Front, and is a major conduit via the Bounty Channel, for terrigenous sediment supply from the uplifted Southern Alps to the abyssal Bounty Fan. Census data on benthic foraminiferal faunas (>63 _m) from upper bathyal (ODP 1119), and lower bathyal (DSDP594) sequences, provide additional information on the paleoceanographic history of the trough through the last 150 ka (marine isotope stages, MIS 6-1).

R-mode cluster analysis using Pearson's product-moment correlation coefficient allows the recognition of six species groups whose abundances correlate strongly with proxies for food supply (organic carbon flux), sea surface temperature (SST), and sediment type: *Cassidulina carinata-Trifarina angulosa* - sandy, calcareous substrates, warm SSTs, moderately low food supply; *Nonionellina flemingi-Cibicides dispars* - dominantly upper bathyal, strong bottom currents, moderately low food supply, moderately warm SSTs; *Globocassidulina canalisuturata-Bolivina seminuda* - mostly upper bathyal, cold SSTs, moderately high, sustained food supply, terrigenous mud; *Cassidulina nørvangi-Eilohedra levicula* - dominantly lower bathyal, cold SSTs, high sustained food supply, carbonate corrosive waters; *Alabaminella weddellensis- Nonionella auris* - lower bathyal, high, sustained food supply, cold SSTs, terrigenous mud; *Epistominella exigua-Abditodentrix pseudothalmanni* - lower bathyal, moderately low, pulsed food supply, warm SSTs, sandy calcareous substrates.

Faunal changes most strongly correlate with the climate cycles and associated increased glacial productivity, attributed to increased upwelling and inflow of cold, nutrient-rich, Antarctic Intermediate Water. Observed interglacial-glacial faunal changes at bathyal depths are not a result of associations migrating up and down the slope, as the glacial faunas (dominated by *E. levicula* and *G. canalisuturata*) are markedly different from those currently living in the Bounty Trough. SST estimates based on planktic foraminifera confirm previous conclusions that the Subtropical Front sat above the Chatham Rise, on the north side of the Bounty Trough, throughout most of this interval, with a short southward migration during the warm peak of MIS 5.5.

70-KYR RECORD OF TEPHRA DISPERSAL REVEALS EL NIÑO-LIKE WIND PATTERNS OVER NORTHERN NEW ZEALAND

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A 70-kyr record of andesitic tephra fallout in northern New Zealand from the continually active Taranaki volcano reveals the prominence of southerly and south-south-westerly atmospheric circulation. This is most pronounced during stadials, and reduced during the Holocene. Winter southerlies are a feature of historic El Niño years, and provide a mechanism to explain the tephra dispersal, whereas prevailing zonal westerlies cannot. El Niño-like conditions may have been enhanced during stadials. This provides high latitude teleconnection support for the concept of millennial-scale super ENSO cycles. The atmospheric influence on tephra dispersal requires volcanic hazard assessments to consider ENSO cycles, both past and future.

BIOTITE COMPOSITIONS AS A TRACER IN ERUPTION DYNAMICS AND A TOOL IN CORRELATION OF RHYOLITIC PYROCLASTIC DEPOSITS

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Quaternary rhyolitic pyroclastic deposits erupted from the Okataina and Taupo volcanic centres in New Zealand can be geochemically characterised using the FeO and MgO contents of their biotite phenocrysts. This enables pyroclastic deposits with similar glass compositions to be discriminated by their different biotite compositions. Deposits from some eruptive episodes display sequential changes in biotite composition that allow separate phases of the eruption to be identified, greatly increasing the precision for correlation of eruptives. In addition, devitrified lavas that are unsuitable for glass analysis can be correlated to coeval tephra deposits by their biotite compositions. The FeO/MgO ratio in biotite does not correlate with FeO/MgO in the co-existing glass phase, suggesting melt composition is not the main control on biotite compositions. Instead, melt temperature and oxygen fugacity are likely to be important influences. Preliminary trace element studies show that V, Ni, Sc and Co are also useful in chemically fingerprinting biotite. Biotite is common in high-K_2O (>4 wt %), low temperature (<760°C) rhyolite pyroclastic deposits and lava, and is widely dispersed in ash plumes because of its platy form, thus making it important in correlation studies.

POSTER

ON FAULT STRUCTURE AND THE USES OF EARTHQUAKES

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Primary effects from crustal earthquakes - incremental fault slip, wave propagation and ground shaking, and changes in stress-state - contribute to a broad spectrum of geological processes. Rocks derived from these effects record information on earthquake actions. In particular, fault rocks exhumed from depth in ancient and still active fault zones provide information on crustal rupturing which complements that obtained from classical seismological techniques, geodetic studies of strain accumulation and release, and mapped surface rupture traces.

Rheological strength profiles of crustal fault zones based on fault rock studies account for the depth distribution of seismicity and the nucleation of larger ruptures towards the base of the seismogenic zone. In continental crust, maximum seismogenic depth is controlled by the transition from a pressure-sensitive frictional regime to temperature-dependent ductile flow at temperatures of c. 350-450°C, corresponding to the onset of quartz and feldspar plasticity, respectively. While there are problems reconciling the inferred strength profiles with the apparent weakness of major crustal fault zones, fault rocks also provide information on fluid-pressure levels and power dissipation during seismic slip as well as fault-healing processes, all related to this critical question. Thermal pressurisation of fault fluids during slip is a possibly widespread mechanism contributing to high-efficiency rupturing and near-total stress release.

Seismic style (including characteristic earthquake behavior) is affected both by fault structural geometry and by conditions affecting fault zone rheology (especially fluid-pressure level). It is now clear that in some instances rupturing is occurring in strongly fluid-overpressured crust. Rupturing enhances fracture permeability which, coupled to stress changes, may induce redistribution of crustal fluids, contributing to hydrothermal mineralization at specific structural sites and aiding oil/gas migration. Cycling of fluid-pressure tied to the earthquake stress cycle must therefore play an important role in both the nucleation and recurrence of ruptures.

The extent to which earthquakes are integral to a spectrum of fundamental earth processes (e.g. mountain building, sedimentation, mineralisation) is just beginning to be appreciated. Our country *'crumpled like an unmade bed'* is shaped by earthquake activity. New Zealanders are thus well placed to advance 'Earthquake Science' embracing geological as well as more traditional information on the earthquake source.

STRESS FIELD CYCLING COUPLED TO FLUID FLOW RECORDED IN QUARTZ VEIN SYSTEMS HOSTED BY STRIKE-SLIP FAULTS, PROTEROZOIC MT ISA INLIER, AUSTRALIA

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The Proterozoic Mt Isa inlier (~50,000 km^2) in NW Queensland, Australia, underwent a complex tectonothermal history involving multiple episodes of intracontinental rifting, sedimentation, and magmatism that culminated in the Isan Orogeny (1590-1500 Ma) where strong E-W shortening led to compressional inversion of former rift basins. Brittle, late-orogenic (1500-1450 Ma?) strike-slip faults disrupt the metamorphic complex of subgreenschist to amphibolite facies assemblages. A dominant set of dextral strike-slip faults striking NE-SW to NNE-SSW with offsets <25 km, is apparently conjugate to a set of sinistral faults striking NW-SE to NNW-SSE, consistent with continued ~E-W shortening.

The faults commonly outcrop as blade-like ridges extending linearly across the semi-arid terrain for many kilometres. Transects across the dextral NE-SW Fountain Range and Overlander Faults (which crosscut granites and amphibolite facies metasediments and metavolcanics) have shown that the fault zones are about 100 m thick with a composite brittle fabric comprising: (1) subvertical silicified cataclastic shear zones (cataclasites plus microbreccias containing vein fragments); (2) innumerable subvertical quartz-veins (cm to m thickness) lying subparallel to the principal shear zones (some retain purely dilational textures; others are multiply recemented fault-breccias with wallrock fragments); (3) highly irregular non-systematic veins; and (4) a systematic set of predominantly extensional, steep planar quartz veins oriented 080-120° at moderate angles to the main faults. Mutual cross-cutting relationships occur between all structural components, indicating broad contemporaneity. Recorded dextral separations along shear fracture components are commonly of the order of 1-10 cm, consistent with small-moderate seismic slip increments.

A preliminary interpretation is that the different systematic vein-sets reflect changing orientations of the local stress field at different stages of the earthquake stress cycle. Minimum compressional stress oblique to the fault through the interseismic interval alternates with minimum compression oriented subperpendicular to the fault immediately postfailure, suggesting that each slip episode was accompanied by near-total relief of shear stress along the fault. Amethystine quartz, open-space filling textures, and calcite-quartz intergrowths in the veins are consistent with hydrothermal precipitation occurring within 1-2 km of the former ground surface. The source of the hydrothermal fluids responsible for these extensive vein systems is not yet clear, nor whether they developed under hydrostatic or overpressured fluid conditions.

GEOCHEMICAL VARIATION IN ROBERTSON BAY GROUP (NORTH VICTORIA LAND, ANTARCTICA) AND CORRELATION WITH GREENLAND GROUP OF WEST COAST, SOUTH ISLAND

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On the western side of the South Island of New Zealand, the latest Cambrian-Ordovician Buller Terrane is represented by a widespread and uniform turbidite succession, the Greenland Group. On the basis largely of age and lithological similarity, Greenland Group has been correlated with the Robertson Bay Group of North Victoria Land, Antarctica, the two forming parts of an extensive turbidite apron along the Pacific Australian-Antarctic Gondwana margin (Cooper & Tulloch 1992; Nathan 1976).

Both Greenland Group (GG) and Robertson Bay Group (RBG) typically consist of alternating beds of quartzose, greenish-grey sandstone and mudstone; calcareous concretions and lenses are a common minor lithology in the southern part of Greenland Group and throughout Robertson Bay Group. The sandstones contain abundant quartz of several varieties (GG-30-40%; RBG-28-40%), sodic plagioclase (GG-<15%; RBG-<13.5%), metasedimentary and minor volcanic rock fragments (GG-<25%; RBG-<22%), and up to 50% (GG) & 66% (RBG) matrix. Detrital muscovite intergrown with chlorite after biotite (<5%) is a constant component (Christie & Brathwaite 2003; Roser et al. 1996; Wright 1981).

Within Greenland Group, there is a spatial chemical variation defining three sub-sets, southern, central and northern (Roser et al. 1996). Compared to the central and northern sets, the southern sandstones are markedly enriched in CaO and Sr. SiO_2-K_2O/Na_2O signatures cluster across the divide between passive margin (PM) and active continental margin (ACM) fields, the southern set lying mostly within the ACM field.

All Robertson Bay Group samples lie within the field of Greenland Group on a SiO_2-K_2O/Na_2O diagram, and like the southern set, mostly within the ACM field. However, several geochemical parameters differentiate samples from east of the Rennick Glacier (ER) from those of the Morozumi Range to the west (Mz). Compared to ER rocks, Mz samples have lower SiO_2/Al_2O_3, and Ca, but higher Sr, Rb, Al_2O_3, Na_2O, and Ba. For RBG as a whole, K_2O/Na_2O ratios are 0.5-1.7; Rb/Sr ratios are 0.3-1.3; FeO/Fe_2O_3 ratios are 1.7-5.6, averaging 3.6. Plots of SiO_2-Al_2O_3 and Ba–K form sublinear clusters, with Mz corresponding to the central GG set and ER to the southern GG set. Sr-Ca (for ER) and Rb-K plots are linear as for Greenland Group, but Mz samples cluster at higher Sr values. Discriminant function analysis places the ER samples within a recycled quartzose provenance in the precise position of Greenland Group, but the Mz samples lie in the felsic field trending from a quartzose to an intermediate igneous provenance, and in the CA-ACM fields discrete from the ER samples. (Fe_2O_3+MgO)-TiO_2 provenance plots also cluster in the CA field, trending into the ACM field.

In general, the eastern samples closely correspond to the southern set of Greenland Group, whereas the Morozumi Range samples are significantly different.

FROM PLATE TECTONICS TO BRYOZOAN EVOLUTION

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Paleobiologists and paleoecologists often focus on biotic interactions as they can play important roles in evolution. Often less obvious are abiotic evolutionary forcing mechanisms, particularly large-scale global geochemical cycles. Stanley and Hardie (1998) synthesized a theory of secular geochemical variation over the Phanerozoic, describing oscillations in the mineralogy of marine inorganic and biogenic carbonates, with periods dominated by aragonite/high-Mg calcite (aragonite seas) and low-Mg calcite (calcite seas). They argued that temporal variations in the Mg/Ca ratio of sea water were driven by changes in plate tectonic spreading rates at mid-ocean ridges. Their supporting data included marine cements, ooids, evaporites, and tropical hypercalcifying organisms (e.g., calcareous algae, forams, and corals).

If chemical changes in sea water are global in scope, then geochemical signals should be expressed beyond the dominantly-tropical evidence used to date. Temperate bryozoans, with their wide mineralogical and stratigraphic ranges (Smith et al., 1998), offer the opportunity to ascertain the extent of the mineralogical influence of sea water on biogenic carbonate production.

Here we report on the results of a literature review of bryozoan skeletal mineralogy over the Phanerozoic, comprising over 1100 geochemical measurements of Recent bryozoans, and over 40 fossil bryozoans since the Ordovician. The phylum Bryozoa occupies a very wide range of the possible carbonate mineralogies available to marine organisms. How has it changed over time? Do bryozoans exhibit more aragonite/high-Mg calcite skeletons during times of aragonite seas and more low-Mg calcite skeletons during times of calcite seas? Do bryozoans have the potential to delineate and refine the global model of secular variations in marine chemistry? And has bryozoan evolution itself been constrained by sea water chemistry?

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GEOCHEMICAL AND MINERALOGICAL EVOLUTION OF OKATAINA VOLCANIC CENTRE DURING THE LAST 45 KYR.

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The Taupo Volcanic Zone (TVZ) is the most frequently active rhyolitic centre on Earth, erupting at a millennial scale frequency. Okataina Volcanic Centre (OVC) is one of the two calderas still considered active. It has been active since *c.* 250 ka and frequently active since the large Rotoiti caldera-forming event at ~ 44.6 ka. Since the Rotoiti event, there have been two distinct phases of activity. That from ~ 44.6 ka – 25 ka was characterised by large pyroclastic events, collectively referred to as the Mangaone Subgroup. Post-25 ka eruptions have occurred along linear chains of vents up to 20 km long and involve the extrusion of large volume lava domes and flows (commonly >2 km^3 d.r.e.). These distinct phases in activity are accompanied by differences in geochemistry and mineralogy, indicating fundamental changes in processes governing where the magma was sourced and how they were triggered.

The 14 Mangaone Subgroup eruptions were homogenous and the magmas began to crystallise at greater depths (>6 km). The older Mangaone Subgroup eruptions (~44-36 ka) are clinopyroxene bearing, high temperature (850-940^{o}C) rhyodacites. Whereas, the younger Mangaone Subgroup eruptions (post-36 ka) are orthopyroxene dominated, medium temperature (~720-800^{o}C) rhyolites. In contrast, post-25 ka magmas crystallised at shallow depths (< 6 km). These are low temperature, hydrous magmas and contain biotite and cummingtonite. Of the 9 eruptions in the past 25 kyr, only 2 are homogeneous. We suggest that the heterogeneity in these less frequent eruptions is associated with the tapping of multiple magma batches that have interacted at depth. Often hotter, volatile rich magmas collide with and reactivate stagnant magmas prior to eruption.

There have been 3 major changes in activity and geochemistry at OVC in the last 45 kyr. These changes occurred after the Rotioti event (~45 ka), the Hauparu event (~36 ka), and the Omataroa & Unit L event (~31 ka). This suggests that large-scale events exhaust the magma source.

TALK: Petrology 2

CALDERA GEOMETRY AND EVOLUTION IN TAUPO VOLCANIC ZONE

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Caldera centres of the Taupo Volcanic Zone (TVZ) vary widely in their geometry and eruptive history. A study of the structure of modern TVZ (<300 ka) and the four youngest caldera centres has led to simple observations regarding the relationship between regional structure and caldera geometry. In this study, the structure and geometry of calderas is characterized using Digital Elevation Model (DEM) derived imagery.

Okataina and Taupo volcanic centres, located within the axial zone of intense rift faulting (Taupo Fault Belt) in TVZ, comprise multiple collapse structures with complex eruptive histories responsible for two or more ignimbrites. Poorly defined individual collapse geometries are overprinted by younger volcanism and faulting. Caldera centres are elongate normal to rift faults and preferential caldera collapse along volcano-tectonic faults parallel to the regional fault trend defines calderas with rectilinear collapse margins.

Okataina Volcanic Centre (OVC) comprises a rectangular caldera complex (28 km x 22 km) located at a major bend in the Taupo Fault Belt where fault-segment axes to the northeast and southwest of the caldera centre are offset by almost 25 km. This bend is interpreted as a releasing step-over in a transtensional tectonic setting. The evolution of OVC as a N-S elongate caldera complex, normal to the local rift axis, is attributed to the interaction between offset fault segments.

In contrast, two calderas outside the main zone of faulting in TVZ match typical caldera models of circular to semi-circular collapse structures. Both Rotorua and Reporoa calderas are monogenetic calderas and each is associated with one large ignimbrite with only minor post-collapse volcanism. Their simple morphology and evolution is a function of their location peripheral to the axial faulting.

The influence of regional structure on caldera geometry and evolution is evidenced by the clear differences between calderas inside and outside the zone of faulting and deformation. The architecture of TVZ is such that regional structure has had a strong influence on both the location and form of volcanic features.

POSTER

STRUCTURAL CONTROL OF VOLCANISM IN TAUPO VOLCANIC ZONE

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The geometry and structure of Taupo Volcanic Zone (TVZ) is investigated to define the relationship between regional structure and volcanism. To achieve this we combine remote sensing and structural data with previously published geological and geophysical data for modern TVZ (< 300ka).

Rhyolite volcanism dominates the central zone of modern TVZ, and is responsible for the eruption of large volumes of pyroclastics and lavas from four main caldera sources. The extremities of TVZ comprise andesitic composite volcanoes with a conspicuous lack of rhyolitic volcanism. The origin of this segmentation remains largely unresolved, however the geometry and structure of TVZ provides some insight into this broad segmentation, and specifically accounts for the location and eruptive histories of individual volcanic centres.

The results indicate that overall TVZ comprises a number of segments characterised by varying degrees of extension, and that the amount of extension corresponds to the volume of erupted magma in each segment. Segments with the highest degrees of extension correspond to the currently active Okataina and Taupo volcanic centres in the central zone, while a higher degree of dextral transtension corresponds to the volumetrically subordinate extremities of TVZ.

An increased component of extension at Okataina and Taupo has provided a suitable structural setting for the accumulation of rhyolitic magma and eventual caldera collapse and voluminous ignimbrite eruptions. Further structural control of these two centres is evidenced by their location at bends or offsets in the regional fault belt.

GETTING INTO SHAPE: PROCESSES OF FOLIATION DEVELOPMENT WITHIN THE OTAGO SCHIST

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Metamorphic foliation such as schistosity is commonly defined by mineral shape preferred orientation (SPO), yet there exist few if any studies that document the changing 3D size, shape and orientation of individual grains with increasing metamorphic grade from sedimentary protolith to metamorphic equivalent. In this study we present shape and SPO data for white mica and quartz along two transects of increasing metamorphic grade in the Otago Schist, New Zealand.

The progressive development of metamorphic foliation, from non-metamorphic Torlesse protolith to chlorite zone equivalents, can be described in terms of three continuous stages:

(i) Under sub-greenschist facies conditions, and early in the deformation history, poorly oriented and coarse clastic white mica was rapidly eliminated in favour of newly crystallised smaller and well-oriented mica microporphyroblasts. Sedimentary compaction contributed little to forming the SPO. Metamorphic micas are blade-shaped with long axes defining the linear aspect of the foliation, and intermediate and long axes the planar aspect of the foliation. Intermediate axes form a partial girdle about the lineation. In hand specimen, the schists can be described as S-L tectonites, reflecting the shape and orientation characteristics of the constituent mineral grains, which in turn results from strain intermediate between pure flattening and pure extension. Quartz grains are generally detrital grains modified by pervasive pressure solution. The mica and quartz SPOs are subparallel to bedding to form a composite structure parallel to theaxial planes of F_1 folds.

(ii) With continued deformation, the foliation progressively intensified by an increase in the aspect ratios, size and alignment of grains. The long axes of the blade-shaped micas continue to define a prominent lineation parallel to fold axes (F_2), and intermediate and long axes the planar aspect of the foliation.

(iii) The third stage of foliation development is accompanied by formation of segregation layering, enabled by crenulation, pressure solution, and the reorientation of veins. In the Otago Schist, this occurs in the chlorite zone of the greenschist facies. The intensity of SPO is reduced from that in stage (ii): mica and quartz grains record a decrease in aspect ratio and alignment, though the grains continued to increase in size.

We interpret the mica SPO as resulting from competitive anisotropic growth. The growth of stably oriented mica during progressive strain allowed preferential growth of mica along the mica cleavage parallel to the extension direction so that blade shapes developed. Competitive growth processes are indicated by the reduction in the number of grains with increasing grade of metamorphism. The origin of the quartz SPO is more complex and resulted from pressure solution modification of grain shape probably accompanied by a component of plastic deformation and oriented growth.

TALK: Cretaceous 1

ANTICIPATING PRE-ERUPTIVE VOLCANIC DEFORMATION IN AUCKLAND FROM SPACE, USING DIFFERENTIAL RADAR INTERFEROMETRY (DINSAR)

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The urban area of Auckland and surrounds, with a population exceeding one million, is built directly on top of an active monogenetic volcanic field, which last erupted several hundred years ago. Hence, it is important to have effective and robust monitoring systems already in place to ensure that precursors of future volcanic activity are detected well in advance, with the aim of providing early warning to emergency management professionals.

Surface deformation often precedes eruptive activity, as magma moves up within the system, and has been detected at similar monogenetic fields, e.g. the 1989 eruption in Isu Peninsular, Japan, where 3 cm of onshore uplift was recorded during the six months preceding the eruption of a new offshore volcano. Although field-based techniques, such as levelling and GPS, have been used successfully for measuring pre-eruptive deformation at volcanoes elsewhere, the use of such techniques for surveying the entire Auckland monogenetic volcanic field would be impractical. The manpower and resources needed to obtain an adequate frequency and spatial density of measurements for volcano monitoring preclude field-based techniques as an effective solution.

Satellite measurements of surface deformation provide a potential solution to this problem. During the last decade, following the launch of a number of satellites carrying radar sensors, the differential radar interferometry (DInSAR) technique was developed. At C-band radar wavelengths, the technique allows measurement of surface deformation to within a centimetre from pairs of radar acquisitions, at a spatial resolution of a few tens of metres. However, the best results are obtained in arid, flat, unvegetated environments, and the technique does not perform optimally in the New Zealand environment.

In this paper, I examine and demonstrate the feasibility of DInSAR in Auckland, using data acquired by the ERS satellites during the late 1990s. Having ascertained that the technique works for urban Auckland, the feasibility of developing a near-real-time monitoring capability using data provided by existing and future satellites, such as Envisat ASAR, will be discussed.

A NEW LOOK AT THE STRUCTURE AND STRATIGRAPHY OF THE MOUNT CAMEL TERRANE, SOUTH COAST KARIKARI PENINSULA, NORTHLAND

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The Mount Camel Terrane in the area consists of four distinct packages of rock. The first, and stratigraphically lowest, includes Early Cretaceous sandstone and mudstone of the **Tokerau Formation**. This Tokerau Formation is much less deformed than that at Henderson Point near Mount Camel. The sediments are intruded and overlain by a basic igneous unit including spilitic pillow lavas of yet unknown affinity. The second package comprises the **Rangiawhia Volcanics** ranging from spilite to keratophyre intruded by amygdaloidal porphyries. Rangiawhia intrudes (already deformed?) Tokerau Formation. The third package, the **Whatuwhiwhi Formation** lies on a Rangiawhia Volcanics unconformity surface. Whatuwhiwhi Formation fines upwards from conglomerate to sandstone to mudstone. The conglomerates contain horizons of large well-rounded exotic? granitoid boulders of possible continental derivation. This could involve the collapse of coarse shoreline deposits in steep topography. The process by which these large boulders were emplaced in the fine-grained matrix is yet unknown. Renewed uplift during Latest Cretaceous-Early Paleocene caused an angular unconformity at the base of the fourth package, siliceous mudstones and cherts of the **Waiari Formation**.

There were three major tectonic upheavals recorded by the contacts between the four packages: Broken Formation structures may have been formed simultaneous with the Rangiawhia/Whatuwhiwhi unconformity. Significant westward tilting and folding occurred at the time of the Whatuwhiwhi/Waiari unconformity. A phase of E-W trending, south verging folds postdate all formations and may be synchronous with the emplacement of the Northland Allochthon, but predate emplacement of Miocene Karikari dikes. These facts need to be considered in any reconstructions of the tectonics of northernmost New Zealand.

With outcrops at only several localities in New Zealand and possible correlatives from the Three Kings Ridge to New Caledonia, the stratigraphic and structural relationships within the Mount Camel Terrane are thus significant in developing tectonic models for the SW Pacific.

THE PALAEOECOLOGY OF THE WILKIES SHELLBED (*Crassostrea ingens*), ON THE WANGANUI RIVER VALLEY ROAD

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A bioherm composed almost exclusively of *Crassostrea ingens* is exposed along the Wanganui River Valley road. This study aims to document both the palaeoenvironment of the bioherm and the biology of *Crassostrea ingens* through a comparison of other extinct and extant *Crassostrea*.

Grainsize analysis compared sediments within the bioherm and the Makokako Sands beneath as well as the Cable Siltstone above. A count of foraminiferal species and documentation of macrofossils established the palaeoenvironment of the bioherm as inner to mid shelf. This is supported by a fining upward grainsize from the Makokako Sands through the bioherm into the Cable Siltstone, and a subtle change in foram species. The absence of estuarine mollusc species was noted along with a reasonably diverse fauna within the bioherm with slightly higher diversity in the Cable Siltstone which also suggests a deepening marine environment. *Crassostrea ingens* is considered to have lived in a marine environment due to the evidence of its rapid growth and very thick shell along with its large size, and by its close association with *Chlamys gemmulata* which likes deeper waters (17-35 m). The deepening conditions suggest that the bioherm was growing at the beginning of a transgressive part of a cyclothem related to glacio eustatic sea level changes.

The allometry of *Crassostrea ingens*, with regard to correlation coefficients for the variables of length versus width, depth and volume were not significant at the 5% confidence level, therefore they vary independently of each other. In comparison *Crassostrea virginica* and *Crassostrea gigas* did show significant results at the 5% confidence level. Data compiled from length frequency to establish age cohorts for *Crassostrea ingens* was used in von Bertalanffy and Gompertz non-linear and von Bertalanffy linear growth function models. All models have very high R^2 values but give different K and L_∞ values. Comparison in growth rates between *Crassostrea titan*, (Miocene extinct) *Crassostrea virginica*, (Pleistocene extinct, and Recent extant) *Crassostrea rhizophorae* (Recent extant) and *Crassostrea ingens* (Pliocene extinct) showed *Crassostrea ingens* along with *Crassostrea titan* grew faster and were larger than other *Crassostrea*.

POSTER

ROLE OF WOODY DEBRIS ON SANDY BEACHES

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Woody debris is a broad term that encompasses accumulations of tree branches, logs, and other organic material on the coast. It is a common occurrence on beaches generally being located above the upper limit of storm wash. Large accumulations occur on many New Zealand beaches, in some cases forming large berms metres in height. While the debris tends not to be preserved in the sedimentary record, it is often assumed to play an important role in dune development and beach stability. The processes of sediment deposition associated with woody debris are well known in the fluvial environment, however, there has been little direct evidence of its geomorphic role on the coast.

In general woody debris plays a geomorphic role, by reducing fluid velocity through diverting flow path within a channel. This is particularly the case when wood is wedged against the channel bank where it also provides storage for sediment.

This research aimed to transfer the established geomorphic role of woody debris from the fluvial zone to the coast, and investigate a relationship between the wood and dune face scarping. Foxton and Waikawa beach were chosen as field sites as each beach has an abundant supply of driftwood, and established dune network and high-energy wind and wave environment. The data suggest there is a morphological relationship between wood at the base of the dune and erosion of its face. Wood is most effective in the post storm recovery as it can trap sand and vegetation and aid the rebuilding of the dune. Survey results identified those dunes with no wood at their base cut back 7-10m from the mean high tide mark, while on those wooded profiles the toe was cut back only 4-6m from the mean high tide mark. As woody debris is placed on beaches during storm events it did not appear to protect the dunes during the high energy events.

PHYTOLITH PRODUCTION AND SOIL ASSEMBLAGES ON SUBANTARCTIC CAMPBELL ISLAND

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Phytolith (plant opal) production, and its preservation within the soil surface, is described for the first time in the subantarctic region from Campbell Island, c. 600 km south of New Zealand, forming the basis for a new modern reference collection for the region. Plant samples (many from species endemic to the island and vegetation community dominants) were sourced from Campbell Island and from gardens in New Zealand.

Short and long cell phytoliths are described from four graminoids (*Chionochloa antarctica, Poa litorosa, Poa* sp., *Carex trifida*), four forbs (*Acaena minor* var. *antarctica, A. anserinifolia, Myosotis capitata, Anaphalioides bellioides*) and a shrub (*Hebe elliptica*) from 23 analysed taxa. The remainder were found to be non-phytolith producers, including the distinctive macrophyllous forbs ('megaherbs'). Soil surface samples collected with 11 of the plants from Campbell Island contain abundant, predominantly graminoid-type phytoliths.

Two-sample Kolmogorov-Smirnov tests indicate the soil surface assemblages beneath different vegetation community types are similar to each other. This is interpreted to be a direct result of widespread grasses in the island's vegetation that produce abundant phytoliths of robust morphology. The over-representation of grass phytoliths in the soils may also be explained by the absence of other non-grass phytolith producer taxa in the vicinity of the collection locality, or the dissolution or fragmentation in the soil of fragile forms. Localised concentrations of sedge 'hat-shaped' phytoliths in two soil surface samples suggest that despite the high proportion of grass-type phytoliths overall, there is still potential for differentiating vegetation community types on Campbell Island on the basis of the dispersed soil surface assemblages. With further knowledge about modem phytolith production in the subantarctic, this technique may then be applied to regional fossil assemblages.

The predominantly grass-type phytoliths described during this pilot study differ significantly from the Oligocene and Miocene tree/shrub-dominated assemblage of the Cape Roberts Project cores from the Ross Sea region of Antarctica, interpreted to have been sourced from a vegetation growing in similar, but less oceanic, climatic conditions. The reasons for this disparity remain unclear, but may involve differences in the growing environment or different continental origins of elements of the vegetation.

POSTER

ANTARCTIC PALAEOCLIMATE DURING THE PALAEOGENE: PROXY VEGETATION RECORDS VS GLOBAL CLIMATE MODEL OUTPUT

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With the advent of palaeoclimate earth system modelling using sophisticated Global Climate Models (GCMs) in conjunction with increased understanding of vegetation-climate feedbacks, it has become important to characterise vegetation type and distribution because of its influence on climate model output. For computer efficiency, many model runs are initiated with a relatively simple 'fixed' vegetation, which remains constant as the modelled climate evolves. Novel applications for palaeobotany have arisen when using GCMs to develop palaeoclimate scenarios. Knowledge of regional fossil plant deposits can be used to assess the realism of the 'best guess' initial vegetation boundary conditions. Further, by extrapolating the present-day ecology of 'nearest modem relatives' of known fossil taxa into the geological past, selected GCM outputs can be validated. Although some assumptions must still be made, more detailed information on past vegetation enhances the validity of GCM results for specific time slices.

In the past two decades a key Antarctic research theme has been to investigate and understand earth system processes involved in the initiation and persistence of ice sheets on the Antarctic continent, from latest Eocene times on. Recent coupled atmosphere-ice sheet modelling suggests that declining levels of atmospheric CO_2 set the scene for the initiation and subsequent behaviour of the East Antarctic Ice Sheet, triggered by specific orbital parameters.

Antarctic terrestrial vegetation records for the Palaeogene are reviewed, including leaves, wood and terrestrial palynomorphs from glacial erratics, outcrop and near- offshore sediment cores. Vegetation across the continent changed, reflecting a cooling climate from evergreen mixed broad-leaved and needleleaf forests (dominated by *Nothofagus* spp.) to tundra/low shrub vegetation from late Palaeocene to earliest Miocene. A fixed vegetation of tundra (covering Antarctica and Greenland) and a mixed forest (the remainder of the terrestrial regions) was supplied as a boundary condition for coupled GENESIS v2.1 GCM runs for 34 Ma. GCM output mean annual temperatures (10 year averages) using different orbital scenarios at both 2x and 3x pre-industrial levels of atmospheric CO_2, and suggested that the modelled climates were cooler than that suggested by 'nearest modern relative' analysis of the fossil flora. Subsequent model runs using a more realistic blanket needleleaf evergreen forest in place of high latitude tundra are ongoing, but already suggest dramatic seasonal changes in mean annual temperature in the Antarctic region resulting in an overall annual warming of between -1-4°C south of 60°S latitude, with the notable exception of up to -1.5°C cooling in Wilkes Land. Such changes may be the result of lower albedo, different sea ice fractional cover and thickness and altered surface sensible and latent heat fluxes.

HOW MUCH INFO'S IN AN EARTHQUAKE? QUANTIFYING SEISMOLOGICAL CONSTRAINTS ON TECTONIC STRESS

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Earthquakes are clear manifestations of tectonic stress, but the nonlinear physical relationships between tractions on a fault plane, frictional slip, and the ensuing radiation pattern are such that individual earthquakes provide little information about the ambient stress tensor.

McKenzie (1969) demonstrated that a single focal mechanism imposes only minimal constraints on the orientation of the causative stress tensor. Specifically, in the absence of any prior information about the relative magnitudes of the principal stresses, all that can be deduced regarding the tectonic stress tensor from a single focal mechanism observation is that the axes of maximum and minimum compressive stress lie within the dilatational (P) and compressional (T) quadrants, respectively. Existing stress estimation algorithms produce smaller posterior stress uncertainties than McKenzie's analysis suggests are intrinsically reasonable. This issue is particularly problematic when fault strength and the orientation of the crustal stress tensor with respect to major faults are being considered, since identifying whether apparent differences in stress orientation are physically significant depends critically on a realistic estimate of the uncertainties in each measurement.

What is therefore required is a method of stress determination that more robustly acknowledges the minimal information regarding the principal stress orientations that each individual focal mechanism contributes. Our approach here is to treat this information in a probabilistic (Bayesian) sense, in which $p(\sigma \mid \mathrm{FM}) \propto p(\sigma) \times p(\mathrm{FM} \mid \sigma)$, where σ and FM represent stress and focal mechanism parameters respectively. We first quantify the constraints on the four determinable stress tensor parameters imposed by a single focal mechanism in terms of a joint probability density function, and then formalise the process of estimating stress tensor parameters from a number of such mechanisms by combining the corresponding probability density functions. We explicitly include the limitation that, in general, the two nodal planes of a given focal mechanism cannot be unambiguously distinguished and are invariably subject to uncertainty.

Our approach combines small but reliable increments of constraint rather than larger but more subjective constraints provided by arbitrary objective functions or linearised stress/fault slip relationships. We are working towards providing reliable tectonic stress estimates that can be confidently compared to other tectonic parameters, such as a geodetic strain rates, and to detailed studies of the stresses acting on major faults.

POSTER

MARGIN-PARALLEL PAIRED MAGMATIC BELTS IN BAJA-CALIFORNIA AND NEW ZEALAND AT ~ 160-90 Ma.

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Cretaceous plutons of the eastern Peninsular Ranges Batholith (PRB) and the Separation Point Suite of New Zealand represent major fluxes of relatively high Na, Sr and low Y, HREE magmas. They have similarities to Archean Tonalite-Trondhjemite-Granodiorite (TTG) granitoids and Cenozoic adakites, but their genesis in Phanerozoic subduction zone settings is controversial.

The terms *adakite* and *TTG* are inappropriate to describe the Phanerozoic plutonic rocks discussed here because of differences in lithology and chemistry, and genetic connotations. We use a non-genetic terminology based on the single most distinctive parameter, Sr/Y (Sr/Y > 40 boundary adopted from Drummond and Defant, 1990):

HiSY for High-Sr/Y, Na, Al, Sr, low Y rocks
LoSY for the complementary Low Sr/Y etc, rocks.

LoSY rocks cannot be distinguished by use of terms such as *calc alkaline*, *Cordilleran* etc., because HiSY and LoSY suites in any given convergent margin have similar or identical alkali-lime indices, and both varieties form Cordilleran batholiths.

Comparisons between the PRB of Baja-California and the Median Batholith of New Zealand reveal the following similarities that require accomodation in any general model for the origin of these batholiths. In both convergent margins HiSY magmatism is mostly younger than, and lies inboard of, a LoSY magmatic belt. In both areas the major burst of HiSY magmatism forms the end point of subduction-related magmatism within the batholiths. The two belts are commonly separated by ocean-verging contractional faults, and the inboard belt has undergone rapid uplift following magmatism.

Chemical and isotopic links between HiSY and LoSY belts indicate genetic relationships between the paired belts within each area. Comparative features from both margins support a model that involves underthrusting of the outboard LoSY arc base during shallowing subduction to a deeper, more continent-ward position. The mafic arc base is then partially melted under high pressure conditions resulting in plagioclase-poor or absent, garnet-bearing residual mineral assemblages that produce high Sr/Y partial melts. Such pairing could be used as an indicator of subduction polarity in ancient arcs.

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NATURE OF EASTERN CAMPBELL PLATEAU BASEMENT: AGE AND CHARACTER OF A GRANITE XENOLITH FROM A LATE CENOZOIC LAVA FLOW ON ANTIPODES ISLAND

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An 8x4x4 cm partially melted granite xenolith recovered from late Cenozoic basaltic lavas which form Antipodes Island, is believed to have been derived from subjacent continental basement. U-Pb dating of zircon by single crystal TIMS and ion microprobe yields an age of ~130 Ma, considered to record the original emplacement age of the granite. TIMS analyses indicate major U-Pb reverse discordance in some grains, likely related to partial melting of the rock. Rocks of this age form a major component of the 340-100 Ma Median Batholith in New Zealand. Chemical analyses are slightly ambiguous at the high SiO_2 level of this granite (72.84%), but elevated Sr/Y, Sr and Nd-isotopic composition, and absence of a Eu anomally suggest correlation with the inboard Separation Point Suite component of the batholith, rather than with the outboard Median Suite.

No Early Cretaceous plutonic rocks have been recorded from the Eastern Province of New Zealand. If the correlation with the Median Batholith is correct, the location of the Antipodes Islands on the projected extension of this batholithic belt in onshore and near-onshore NZ may not support the existence of a major dextral fault previously postulated to trend NE across the Campbell Plateau. The NE-trending Campbell Magnetic Anomaly System parallels mid-Cretaceous extensional features and may be largely related to mafic magmatic rocks associated with the Late Cretaceous rifting of the Campbell Plateau from Marie Byrd Land, rather than the (offset) Median Batholith.

This sample (P51539) is one of only ten effectively *in situ* basement sample locations (five islands; four oil exploration wells in the Great South Basin; a set of dredge sites on the Bounty Rise) on the c. 10^6 km^2 Campbell Plateau, and one of only three such sites in the eastern two thirds of the plateau. Many previously dredged rock samples have been rafted by icebergs from Antarctica.

GEOLOGY OF THE MURIHIKU AREA: QMAP SHEET 20

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Murihiku, Sheet 20 of the 1:250 000 QMAP series, is shortly to be published. The sheet extends over Central, Western and Northern Southland, South Otago, and Stewart Island (Rakiura). The map synthesises 35 years worth of both published and unpublished data, including a significant amount of University research. Results of additional field work on the mainland, and seven seasons of mapping on Stewart Island, are also incorporated. Major geological units are, from southwest to east: Takaka terrane; Median Batholith; Brook Street terrane; Murihiku terrane; Dun Mountain - Maitai terrane; and Caples terrane. Cretaceous to Cenozoic sediments extend from the Waiau Basin to the Winton Basin beneath the Southland Plains, and underlie the Waimea Plains and much of the offshore area. Extensive Quaternary gravels typify the Southland and Waimea plains.

The major advance over previous geological maps lies in the detailed mapping of intrusive and metamorphic rocks on Stewart Island, where 38 separate plutons or intrusive complexes within the Median Batholith are recognised, together with two major fault systems. Regional syntheses of the Median Batholith, Brook Street Volcanic Group, Productus Creek Group, and Murihiku Supergroup, have rationalised previous mapping but highlighted some inconsistencies and the need for further research. In particular, the internal structure of the Takitimu Mountains, and the relationships between Greenhills Group and Takitimu rocks need to be investigated. Unconformities, thinning sequences, volcanic rocks and folding within the Murihiku Supergroup east of Invercargill suggest that this area may be close to the southwestern limit of the Murihiku depositional system.

Cretaceous and Eocene to Pliocene sedimentary rocks of the Ohai, Nightcaps, Waiau and East Southland groups have a complicated lithostratigraphic nomenclature, which should be redefined in some areas. The stratigraphic relationships of Pliocene to Early Quaternary auriferous quartz gravels of eastern Southland and the Waikaka area are also problematical.

Quaternary deposits in the Waiau Valley represent down-valley limits of extensive Fiordland-sourced glacial systems. Quaternary cirque and valley glaciation in the Takitimu Mountains has been widespread. Cirque glaciers probably occurred in the Longwood Range and Black Umbrella Mountains, and affected Mt Anglem and the Tin Range on Stewart Island. Quaternary gravels in the Southland Plains were deposited by numerous rivers which have had several phases of channel switching, perhaps influenced by tectonics. The Murihiku map area is subject to a more severe seismic hazard than previously realised, following the mapping of numerous active faults.

POSTER

VULCANIAN EXPLOSIONS FROM EGMONT VOLCANO (TARANAKI) BETWEEN 2200 AND 1800 YEARS B.P.

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Between c. 2200 and 1800 years B.P. Egmont volcano (Mt Taranaki) produced a series of eruptions recorded in the cover bed sequence to the east of the edifice. The activity at this time appears to have been cyclic with three known episodes of ballistic, vulcanian eruptives, shortly followed by lava extrusion. The series of eruptions appears to have ended with a basaltic andesite flank eruption to the north east of Rangitoto flat, and possibly a period of extensive lava extrusion, creating the Staircase lava flows.

Each vulcanian eruption was of a different magnitude, creating deposits which reflect a wide spectrum of pyroclastic density current emplacement. The largest of the ballistic, vulcanian eruptions experienced subsequent column collapse, analogous to the 1997 Soufrière Hills eruptions.

Petrological and geochemical studies on lithics and pumices from the deposits indicate a complex history of magma intrusion, mixing and the evolution of the magma produced within a stratified magma chamber. These studies reveal that it is likely that at least some of the eruptives were triggered by the intrusion of a hot mafic magma into a high level, more evolved magma chamber.

The periodic intrusion of a mafic magma body from a subsidiary dike into a larger, more evolved magma chamber has been proposed to explain the cyclical eruptions at the Soufrière Hills volcano, Montserrat. A similar model may also apply to the broader eruption sequences from Egmont volcano with respect to at least the last 3500 years, perhaps even the last 7000 years B.P. following the Opua debris avalanche event.

The ballistic, vulcanian eruptions between c. 2200 and 1800 years B.P. with their associated spectrum of pyroclastic density currents represent the possible violent hazardous processes that can occur as the result of the proposed mafic intrusion model. Hence these processes need to be taken into account as important, possibly frequent, events at Egmont volcano.

CRETACEOUS PALEOGEOGRAPHY OF THE TARANAKI BASIN

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The New Caledonia Trough is a bathymetric depression that extends from the Taranaki shelf edge, nearly 3000 km northwestwards to the Coral Sea and it may have continued to the southeast through what is now the Bounty Trough. Although a Cretaceous or earlier origin for the New Caledonia Trough has been repeatedly suggested (e.g. Uruski and Wood, 1991) little supporting hard data have been available until recently. The discovery of a major, and older continuation of the Taranaki Basin into the head of the New Caledonia Trough (Uruski and Baillie, 2002) shows that a trough has been present, at least since the Early Cretaceous and it may have had its origin in the Jurassic or earlier.

Initial reconnaissance of the region was by low-fold industry seismic profiling in the early 1970s, followed by low power research seismic in the 1980s. The ruling by the United Nation Commission on Law of the Sea (UNCLOS) that maritime nations could claim "Legal Continental Shelf" that extends beyond the Exclusive Economic Zone (EEZ) gave impetus to an initial joint survey by Australia and New Zealand in the Tasman Sea. The final line of this 1996 programme was TL-1, a 1000 km long, good quality multi-channel transit line from Taranaki along the axis of the New Caledonia Trough. This single line showed that as much as 10 km of sedimentary rocks underlie the head of the Trough.

Recognition of petroleum potential of the deepwater Taranaki depocentre resulted in "Astrolabe" a 6000 km, high-quality 2D speculative seismic survey across the region in 2001. This paper presents some of the results of this survey and discusses Cretaceous paleogeography of Taranaki and its affect on evolution of sedimentary systems of northwest New Zealand

Uruski, C.I. and Wood, R.A. (1991) A new look at the New Caledonia Basin, an extension of the Taranaki Basin, offshore North Island, New Zealand. Marine and Petroleum Geology. V.8(4) pp. 379-391.

Uruski, C.I. and Baillie, P. (2002) Petroleum systems of the deepwater Taranaki Basin. In: Proceedings of the 2002 New Zealand Petroleum Conference. Ministry of Economic Development, Wellington. Pp. 402-407.

TALK: Plenary 1

AN INTERIM CLASSIFICATION OF NEW ZEALAND'S ACTIVE FAULTS FOR THE MITIGATION OF SURFACE RUPTURE HAZARD

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The Ministry for the Environment (MfE), New Zealand, recently published Interim Guidelines (IGs) for mitigating the impacts of building on, or near, active faults (copies of the IGs are available at the MfE and Quality Planning websites, www.mfe.govt.nz and www.qp.org.nz). The aims of the IGs are to a) provide information about active faults, specifically fault rupture hazard, b) promote a risk-based approach when dealing with development in areas subject to such hazard, and c) assist resource management planners tasked with developing land use policy and making decisions about development of land on, or near, active faults.

In the MfE IGs, the surface rupture hazard of an active fault is characterised by two parameters: 1) the location/complexity of surface rupture of the fault, and 2) the activity of the fault, as measured by its average recurrence interval of surface rupture. The IGs classify active faults according to Recurrence Interval Class (RIC), such that the most hazardous faults, i.e. those with the shortest recurrence intervals, are grouped within RIC I (average recurrence interval ≤2000 yrs). The next most active faults are grouped within RIC II (recurrence interval >2000 to ≤3500 yrs), and so on – RIC III (>3500 to ≤5000 yrs); RIC IV (>5000 to ≤10,000 yrs); RIC V (>10,000 to ≤20,000 yrs); RIC VI (>20,000 to ≤125,000 yrs). The Interim Guidelines also advance a hierarchical relationship between fault recurrence interval and building importance, such that the greater the importance of a structure, with respect to life safety, the longer the recurrence interval required for fault avoidance.

To facilitate the use and application of the MfE IGs, we have undertaken an interim classification of most of New Zealand's on-land active faults based on the Recurrence Interval Classes defined in the IGs. In assigning faults to a specific RIC, we give preference to fault-specific recurrence interval data which, in general, are most complete for the principal faults in New Zealand. For the remainder, and majority, of active faults, where recurrence interval data are generally either less constrained or non-existent, we assign RIC, though with less confidence, based on an iterative combination of available fault-specific data, the use of fault-scaling relationships, and comparisons with similar better studied faults. For each fault we also note the level of confidence with which the fault is assigned to a particular RIC. This indicates the precision (or lack thereof) with which active faults can presently be classified according to the recurrence interval criteria defined in the MfE IGs. It also highlights those faults where better constrained recurrence interval data would have the most benefit towards mitigating surface rupture hazard. Currently there are about 50 faults each within RIC I and RIC II, and 40 faults each within RIC III and RIC IV. In addition, there is a similar number of active faults/traces that have yet to be classified; however, we suspect that most of these have long recurrence intervals and will eventually be grouped within RIC V or RIC VI.

POSTER

MAPPING ACTIVE FAULTS AND MITIGATING SURFACE RUPTURE HAZARD IN THE KAPITI COAST DISTRICT, NEW ZEALAND

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The Kapiti Coast District is the fastest growing area in the Wellington region, and is traversed by several active faults (e.g. Ohariu, Northern Ohariu, Gibbs, Otaki Forks faults). In recognition of the surface rupture hazard, Kapiti Coast District Council and Greater Wellington commissioned GNS to: a) more accurately define the location of the active faults in the district, and b) present the fault location results in GIS format wholly compatible with the Interim Guidelines recently published by the Ministry for the Environment (MfE) on planning for development of land on, or near, active faults (copies of the Interim Guidelines are available at the MfE and Quality Planning websites, www.mfe.govt.nz and www.qp.org.nz). Ultimately, Kapiti Coast District Council's goal is to formulate and implement appropriate, risk-based controls within the District Plan pertaining to development in areas on, or near, active faults.

In the MfE Interim Guidelines, the surface rupture hazard of an active fault is characterised by: 1) the location/complexity of surface rupture of the fault, and 2) the activity of the fault, as measured by its average recurrence interval of surface rupture. Surrounding all parts of all known active faults in the Kapiti Coast District, Fault Avoidance Zones (FAZs) have been defined based on the rupture complexity of the fault, and the precision to which its location can be constrained. FAZs are attributed as *well defined*, *distributed*, *uncertain - constrained*, or *uncertain - poorly constrained* in the GIS database, and range in width from about 40 m to greater than 300 m. Also, each active fault has been placed into a specific Recurrence Interval Class (RIC) based on existing data relevant to its recurrence interval: Ohariu & Northern Ohariu faults – RIC II (>2000 to ≤3500 yrs); Gibbs & Otaki Forks faults – RIC III (>3500 to ≤5000 yrs); SE Reikorangi fault – RIC IV (>5000 to ≤10,000 yrs).

The risk of fault rupture at a site is a function not only of the location and activity of a fault, but also on the type of structure/building that may be impacted by rupture of the fault. Building Importance Category is used here, and in the MfE Interim Guidelines, to characterise building type with respect of life safety, and a hierarchical relationship is established between Building Importance Category and RIC, such that the greater the importance of a structure, the longer the fault avoidance recurrence interval. By linking Building Importance Category, with fault rupture hazard parameters (i.e. RIC, and FAZ), and with development status of a site (i.e. previously developed site, or undeveloped "greenfield" site) a matrix of appropriate, risk-based Resource Consent Categories (e.g. *permitted*, *discretionary*, *non-complying*) is defined to facilitate the mitigation of surface rupture hazard and assist in the responsible development of land on, or close to the active faults in the Kapiti Coast District. For example, in a "greenfield" setting, a resource consent application for the construction of a single-story timber framed house (Building Importance Category 2a structure) within a *well defined* FAZ of a RIC I or II active fault (i.e. a fault with an average recurrence interval ≤3500 yrs) would be classified as a *non-complying* activity. Whereas, it would be classified as a *permitted* activity if the fault has a longer recurrence interval (i.e. RIC III of greater) and the FAZ is less well defined (i.e. *distributed* or *uncertain*).

TALK: Neotectonics 3 & POSTER

EVOLUTION OF THE SOUTHERN TERMINATION OF THE TAUPO VOLCANIC ZONE, NEW ZEALAND

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Two independent lines of investigation suggest the southern, Tongariro-Ruapehu sector of the Taupo Volcanic Zone (TVZ) is principally younger than c. 380 ka. Firstly, recent dating of magmatic activity at Ruapehu volcano suggest inception of volcanism at Tongario Volcanic Centre at c. 340ka (Gamble et al. 2003). Secondly, structural and fault mapping in the southern sector of the Taupo Volcanic Zone (this study) indicate much faster late Quaternary fault slip rates than those derived by averaging over the age of the displaced Pliocene formations. Extrapolating the late Quaternary rates back into the past suggests initiation of normal faulting around 380ka. Faulting also appears to be less evolved in the southern sector of the TVZ than in the central parts, with less subsidence of the graben, thicker seismogenic crust, and wider fault spacing.

The estimated initiation time of faulting and volcanism in the southern sector of the TVZ is coincident with the timing of mid-Pleistocene catastrophic volcanism in the central TVZ associated with emplacement of the Whakamaru Ignimbrite group. We suggest that the eruption of c. 1000 km^3 of material in that episode induced a major strain perturbation in the whole of the Hikurangi Subduction Margin, enlarging the region of extensional strain in the backarc, and assisting the initiation of volcanism further south.

At the present-day southern limit of TVZ volcanism there is a sharp transition from extension in the TVZ to contraction in the northern Wanganui basin. This strain field is not conducive to continued propagation of the TVZ, and suggests the southern termination is pinned until there is a major perturbation of the strain field brought about by a major volcanic episode or possibly a great earthquake on the subduction interface.

TEMPORAL VARIABILITY OF SLIP RATE: A CASE STUDY ON THE RANGIPO FAULT, TAUPO VOLCANIC ZONE, NEW ZEALAND

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The Rangipo Fault (a.k.a. Desert Road Fault) is a prominent NNE striking, W dipping, normal fault that defines the eastern boundary of the Taupo Fault Belt (or Taupo Rift) at the southern termination of the Taupo Volcanic Zone. Active fault traces can be mapped for at least 25 km with its closest trace occurring c. 15 km distant from the crater lake of Ruapehu volcano.

Detailed mapping of offset geomorphic features and excavation of four trenches across the fault just south of the Whangaehu River escarpment, and its intersection with State Highway 1, has revealed a detailed history of the fault slip rate over the last c. 17 ka and evidence for extensive erosion during the Last Glacial Maximum (LGM). Evidence of erosion during the LGM is identified by the occurrence of erosional unconformities within the cover-bed successions at the trenches and identification of abandoned terraces higher in the mountain in the Karioi Forest. The height of the Whangaehu River escarpment appears to have been accentuated on the downthrown side by erosion/incision of the ring plain during the LGM, impeding estimates of fault slip rate.

About 5 km south of the Whangaehu River escarpment, the total vertical displacement of the ring plain surface is c. 27 m. The age of the surface at this location is constrained between 17.3 to 26.5 ka, based upon the occurrence of Rerewhakaaitu (c.17. 3 ka) and Kawakawa (26.5 ka) Tephras enveloping the laharic units that comprise the ring plain surface. The average slip rate of the Rangipo fault at this locality, since laharic and alluvial sedimentation ceased, is thus 1– 1.6 mm/yr. In contrast, exposed in the trenches was a total offset since deposition of the Waiohau Tephra (c. 13.4 ka) of only c. 3 m. Collectively, these data indicate significant variability in slip rate on the fault over the last 17.3-26.5 ka ago. Over the last c. 13.4 ka, the fault has accumulated only c. 3 m of vertical slip, yielding an average vertical slip rate of approximately 0.2 mm/yr. However, the scarp height on the ring plain is c. 27 m which means that about 24 m of vertical slip accumulated on the fault before deposition of the Waiohau Tephra (13.4 ka) and after alluvial and laharic sedimentation ceased on the part of the ring plain displaced by the fault (17.3 – 26.5 ka). This implies an incremental slip rate of 1.8 to 6.1 mm/yr for the time period pre 13.4 ka and post 17.3-26.5 ka. The change from high fault slip rate (1.8-6.1 mm/yr) to low slip rate (0.2 mm/year) around c.13.4 ka years ago could be explained by complex association of faulting and eruptive activity at nearby Mt Ruapehu or simply by pure tectonic processes such as earthquake clustering in time.

A similar drastic reduction in slip rate, over the same time period, has been observed on the Shawcroft Road Fault immediately adjacent to the Rangipo Fault.

POSTER

THE USE OF GIS TECHNOLOGY FOR GEOLOGICAL MAPPING IN BASIN ANALYSIS PROJECTS AT THE UNIVERSITY OF WAIKATO

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A GIS is required to manage the volume of geographically related data typically acquired in our basin analysis projects. Key factors that have influenced the development of our University of Waikato, Department of Earth Sciences GIS mapping routines include: 1) the release of ESRI's ArcGIS 8.x desktop applications; 2) inexpensive GPS unit availability and the removal of the selective availability which introduced a 100 m error to civilian GPS coordinates; 3) removal of the royalty on the LINZ NZMS 260 1:50,000 topographic vector dataset; 4) the existence of the QMAP programme at GNS and the availability of the QMAP data model; 5) speed and performance improvements in personal computer hardware; 6) investment in physical resources and training; 7) advances in digital photography.

During the past 5 years, we have migrated our mapping methodologies from traditional cartography using illustration software such as Macromedia Freehand and Corel Draw, to GIS desktop systems, where geological features with multiple attributes are stored in spatially enabled databases, and map symbolization is based on database feature attributes. Data compilation involves the acquiring, manipulation, and integration of a variety of data sources grouped in logical thematic groups in the geodatabase. Datasets used in our projects include: 1) LINZ NZMS 260 1:50,000 topographic vector and raster datasets; 2) digital orthorectified aerial photos; 3) georeferenced historical geological maps; 4) gravity data; 5) fossil record file data; 6) petroleum exploration data (exploration wells, seismic line locations, permit areas); 7) denudation maps generated from bulk density measurements. Data incorporated from field work includes GPS waypoints which locate various information such as stratigraphic columns, geological contacts, sample sites, paleomagnetic drill hole locations, and digital camera photos.

We will illustrate our approaches in this talk, and how these have changed over the past few years, by reference to Eastern Taranaki Peninsula, where extensive mapping has been undertaken of the Late Miocene – Early Pliocene cyclothemic Matemateaonga Formation and associated strata (see also Vonk and Kamp, poster presentation, this volume). Another example of a University of Waikato application of GIS technology in Basin Analysis is shown for the Hawke's Bay Basin by Bland et al. (oral presentation), and Bland et al. (poster presentation).

GEOLOGICAL MAP AT 1:50,000 SCALE OF THE EASTERN TARANAKI PENINSULA REGION

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An 1100 km^2 area of part of the eastern Taranaki Peninsula region has been geologically mapped at a 1:50 000 scale as part of a basin analysis programme. A combination of lithostratigraphic, sequence stratigraphic and chronostratigraphic surface (i.e. marine/river terrace) mapping methods are used to subdivide the succession into map units. The geological map units are of Late Miocene to Pleistocene age and include the **Kiore** and **Matemateaonga Formations** of the **Whangamomona Group**; **Tangahoe Mudstone (Formation)** and **Whenuakura Subgroup** of the **Rangitikei Supergroup**, Late Pleistocene marine terraces, Patea River terraces; undifferentiated alluvium and Egmont Volcano ring plain deposits.

The primary focus has been to document the stratigraphic detail in the Matemateaonga Formation, which is an ~1100 m thick succession of cyclothemic, unconformity bounded shelfal strata of Late Miocene-Early Pliocene (Late Kapitean to Early Opoitian) age (c.5.5-4.7 Ma). This succession formed as a result of the interplay between climatically-driven 6th-order (41 k.y.) eustatic sea-level changes, high rates of basin subsidence and a substantial southerly-derived sediment flux. Individual sequences or groups of sequences are the fundamental mapping entities. Sequences are typically 10-90 m thick and comprise vertically stacked shellbed, siltstone and sandstone facies, which are ascribed to transgressive (TST), highstand (HST) and regressive (RST) systems tracts, respectively. The geometry of these sequences is remarkably tabular and continuous although some lateral variations are evident.

The mapping area sits astride the southward-plunging Whangamomona Anticline, which has deformed the Neogene succession, producing a regional dip on its western flank of 2 to 4 degrees to the southwest. The anticline axis is located between the Patea and Whenuakura Rivers. Northeast-southwest trending normal faults are relatively common and offset Matemateaonga Formation strata with throws of 2-50 m. Most faults have little or no surface expression. Rather, they are identified by offset on shellbed marker horizons. This combined with the similar thickness of the cyclothems compounds the correlation problem.

The basal sequences of the Matemateaonga Formation are of particular interest. A 280 m thick sandstone-dominated interval, which crops out in the Huiroa-Te Popo-Kupe region, is a correlative unit, both chronologically and lithologically, of the “Manutahi Sands” and/or “Waiouru Sandstone” named in exploration well reports for sites south of the mapping area (i.e. Manutahi-1; Kauri and Rimu wells). These sequences become increasingly finer-grained in eastern outcrop areas of the western Matemateaonga Range, suggesting a localised depositional gradient from west to east.

THE GEOPHYSICAL EXPLORATION OF THE OHURA FAULT, NORTH WANGANUI BASIN, NEW ZEALAND

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The Waimiha Region of the North Wanganui Basin is the site of a c. 25 mgal residual gravity anomaly. The anomaly can be distinguished on the 1:1,000,000 North Island Bouguer Anomaly Map as the gradient here is as high (c. 10 mgal/km) as on many of the larger structures found in the Taupo Volcanic Zone to the east. The Ohura fault, as shown in the 1:250,000 Geological Map Series, appears to flank the sharp northwest extent of the anomaly, and it is expected that normal slip on the fault is the primary reason for its existence. A 200 m high, steep (30-40^o), southeast-facing scarp suggests that the Ohura fault has moved during the Quaternary. To investigate the relationship between the gravity anomaly and the Ohura fault, seismic and gravity techniques were employed. Seismic reflection and refraction measurements were made on the edge of the Waimiha Basin, perpendicular to and crossing the Ohura fault. These measurements of velocities and depths of layers produced a two-dimensional structural section through the sediments. Quaternary ignimbrite overlying Tertiary sediments is expected below the surface. Strong reverse moveout events are seen on the shot records suggesting a steeply (~50^o) southeast dipping structure associated with the subsurface extent of the Ohura fault. This information will be used to determine a history of movement on the fault. A dense spread of gravity measurements were taken in and around the Waimiha Region and across the Ohura fault. The Bouguer gravity field calculated from these measurements clearly delineates the Ohura fault, coinciding with its prominent scarp in the Waimiha area. Quantifying extensional movement and timing will allow us to learn about the link between Quaternary extension in the Taupo Volcanic Zone and more distributed extension to the west.

POSTER

USING IGNEOUS CLASTS TO CONSTRAIN THE MESOZOIC PANTHALASSAN GONDWANA MARGIN CONFIGURATION

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The field of provenance analysis has undergone a revolution with the development of single-crystal isotope dating techniques using mainly silt to sand sized single minerals. Coarser-grained rocks, notably conglomerates, involve much shorter transport distances and are therefore useful to trace proximal sources. Igneous conglomerate clasts are capable of placing exceptionally tight constraints on the Pahau and Rakaia terrane provenance and on their Mesozoic tectonic setting within the Southwest Pacific margin of Gondwana. A detailed rock sampling program and geochronological, geochemical and Sr-Nd isotope analysis of igneous clasts from seven South Island Torlesse conglomerates have broadly characterised the igneous source for the two terranes. Geochronology, geochemistry and Sr-Nd isotopes of Pahau terrane igneous conglomerate clasts identify the Median Tectonic Zone/Amundsen Province as a major contributor of detritus to the Pahau depositional basin. Geochronology, geochemistry and Sr-Nd isotopes of Rakaia igneous clasts correlate with those of plutons and volcanics from the Amundsen and Ross provinces of Marie Byrd Land.

115 Ma

220 Ma

EARLY AND MIDDLE TRIASSIC AMMONOIDS FROM NEW ZEALAND

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The Murihiku and Dun Mountain terranes each have Anisian (mid-Triassic) ammonoids: the Murihiku referred to the Etalian Stage, with Arctic affinities, the Maitai to the Nelsonian Stage, with Himalayan affinities. Both assemblages look very different. The Etalian includes *Simplicites marshalli* (Browne), *Beaumontaria grebneffi* Waterhouse, *Beaumontites* spp., *Gangadharites cultrata* (Browne) and *Longobardites*. The upper Greville Maitai assemblage is dominated by *Durvilleoceras woodmani* Waterhouse, defined as marking the base of the Nelsonian Stage, and *Phukungia* sp. New Caledonia shares both assemblages, with the lower Moindou Formation containing *Durvilleoceras, Phukungia*, *Beaumontaria* and *Longobardites*. All are of upper Anisian, or Illyrian age, and in New Zealand differ because of different provincial affinities and basinal settings, not age or succession. In short, ammonoids, on which the stages are founded, suggest that the Nelsonian Stage is redundant.

The middle Anisian (Bithynian) Malakovian Stage, lying below Etalian, contains *Tardoria*, *Acerlecanites*, *Stenopopanoceras* and *Ussurites* cf *arthaberi* (Welter). In the Countess Range, the Malakovian fossil *Permophorus obovata* Waterhouse appears to overlie Greville beds with *Durvilleoceras*, pointing to intervening tectonic contact as between Murihiku and Maitai at Nelson, Arthurton-Gore, and Wairaki Downs, Southland.

Pre-Malakovian, pre-Nelsonian ammonoids are represented by *Stenopopanoceras* aff. *mirabile* Popov in the lower Greville beds of basal Anisian age in Nelson, and by Early Triassic Scythian ammonoids at Wairaki Downs, and Wairoa Gorge, Nelson. The Southland fossils include *Pseudoflemingites* and *Eophyllites*, of late Scythian age, and the Nelson ammonoids come from cemetery accumulations involving several different zones and reworked as olistoliths, mixed with *Durvilleoceras – Phukungia* (late Anisian) and Permian blocks. Their ages and identifications may be pin-pointed, and referred to lower and upper middle, and late Scythian. The various ammonoids might be better included as an extended Malakovian Stage, rather than added on to the Permian Wairakian Stage (ie. Makarewan Substage).

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Waterhouse, J. B. 2002b: The stratigraphic succession and structure of Wairaki Downs, New Zealand, and its implications for Permian biostratigraphy of New Zealand, marine mid-Permian of east Australia and Gondwana. *Earthwise 4*: 1-260.

LIFE AT THE BASE OF A MAJOR CONTINENTAL FAULT RAMP: STRESS CONDITIONS, FLUID PRESSURE AND TRANSIENT DEEP EMBRITTLEMENT ABOVE THE ALPINE FAULT, NEW ZEALAND

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A combination of transiently high pore fluid pressures and strain rates triggered deep brittle failure of the lower crust beneath the central Southern Alps, New Zealand. This brittle yielding initiated the development of near-vertical shear zones that are organised into an evenly spaced, systematic array that lies ~7 km structurally above the Alpine Fault in the Franz Josef and Fox Glacier areas. The dextral-oblique shear zones cross-cut all other ductile fabrics in the Alpine Schist, strike sub-parallel to the Alpine Fault but are uniformly upthrown to the north-west, antithetic to that structure. Offset along the shear zones averages ~15 cm, varying from brittle where they cut quartzofeldspathic schist to totally ductile where the shear zones intersect pre-existing quartz veins >2 cm thick. Deformation mechanisms thus varied from brittle to ductile depending on lithology. We infer that the shears were sequentially activated, like the steps of an escalator, to accommodate tilting of the delaminated Pacific Plate rocks onto the SE-dipping Alpine Fault ramp during late Cenozoic oblique convergence.

After their initiation, the shears were infilled by quartz-calcite veins that evolved as hybrid shear-extensional structures. Stable isotope thermometry of these veins indicate they were emplaced at temperatures of 450 ± 50°C, as is consistent with new $^{40}Ar/^{39}Ar$ data on white mica in the host schist. Cooling ages of ~3-4 Ma indicate that the rocks were exhumed in the late Cenozoic from temperatures >400 ± 50°C (inferred mica closure temperature). Based on the central Alpine Fault's dip-slip rate of ~10 mm/yr, the shears appear to have been exhumed from depths of at least 20 km. Isotope analyses yield metamorphic signatures for these shear-infilling veins, implying an upward flux of hot metamorphic fluids from rocks being sheared across the base of the Alpine Fault ramp at depth.

Based on frictional failure criteria we infer that fluid pressures close to lithostatic (λ= ~0.95) and high strain rates allowed transient embrittlement to initiate the shears as brittle structures at ~20 km depths in the quartzofeldpathic schist. Simultaneously, the thick quartz veins underwent dislocation creep at differential stress values of ~100 MPa. Using experimentally determined flow laws for wet quartz, this implies high strain rates (1×10^{-9} - 10^{-10} s^{-1}) were active during shearing of the quartz veins. Fluid inclusions trapped in the infilling veins record a post-failure fluid pressure of ~310 MPa (λ= ~ 0.6), suggesting a large and transient drop in fluid pressure that extended well below the base of the seismogenic zone (estimated at 10-12 km for the Southern Alps orogen). These data provide new insight into deformation and crustal rheology of the Southern Alps orogen, and confirm that the up-ramped lower crust was subject to transient conditions of high strain rate, fluid flow, and deep embrittlement.

DINOS AND DRAGONS – DETERMINING THE AGE AND PROVENANCE OF MARINE REPTILE SPECIMENS

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The development in recent years of a refined biostratigraphy for the New Zealand Upper Cretaceous, based on dinoflagellate cysts, has provided the opportunity to assign more accurate dates to many marine reptile fossils. It has also permitted the localisation of specimens whose provenance was previously in doubt. In this paper we outline the results obtained for South Island and Chatham Island specimens.

Dinoflagellate analyses of marine reptile sites in southeastern Marlborough, North Canterbury, North Otago and on Chatham Island, indicate that the localities range from Lower to uppermost Haumurian (Middle Campanian to Upper Maastrichtian) in age, spanning a period of about 15 million years. Sites in the Waipara River area are principally Upper Haumurian and range from the *Alterbidinium acutulum* Dinoflagellate Zone to the *Manumiella druggii* Zone. Sites in the Haumuri Bluff-NgaromaStation-Cheviot/Jed River area are Lower Haumurian to lower Upper Haumurian and range from the *Satyrodinium haumuriense* Zone to the *Isabelidinium pellucidum* Zone. The Shag Point locality is Upper Haumurian (*Alterbidinium acutulum* Zone) indicating a general correlation with the Waipara localities. The Chatham Island locality is Lower Haumurian (*S. haumuriense* Zone) indicating a similar age to the oldest Haumuri Bluff sites. Material from two unknown sites appears to be from the Waipara River area, based on the associated dinoflagellate assemblages. The results of this study have permitted us to consider whether more than one reptile fauna is represented in the New Zealand Upper Cretaceous.

STUDYING THE MECHANISMS OF UPLIFT FOR RAISED COASTAL TERRACES ON THE HIKURANGI MARGIN, NEW ZEALAND, AND IMPLICATIONS FOR SUBDUCTION PROCESSES

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Many have argued that the dynamics of the Hikurangi subduction margin vary along strike from the southwest to the northeast of the East Coast, North Island. This is manifestED by changes in the pattern of active faulting, seismicity and geodetically documented surface deformation. These changes in geodynamic signature occur despite only a small change in the plate convergence azimuth and rate along the margin. One feature of the margin that seems ubiquitous are flights of elevated Holocene coastal terraces. This project seeks to resolve the pattern and tempo of uplift of these terraces and to relate these to plate boundary processes.

Focus is placed on theories of changing plate coupling along the margin, particularly resolution of how previous work has defined coupling: whether it is seismic, kinematic or dynamic coupling or simply the downdip length of the elastically locked portion of the interface. For example, evidence from earthquake seismology suggests that if the plate coupling is measured by the length of the locked part of the subduction interface then it decreases markedly along the margin from the southwest to the northeast (Reyners, 1998). By implication the hazard of large subduction earthquakes probably decreases to the northeast. It is here that a contradiction arises between the geophysical and geological models of how plate motion is accommodated along the Hikurangi margin. To date, all studies on the Holocene coastal terraces along the East Coast, including the northeastern part, have indicated that they were uplifted in a punctuated fashion during large earthquakes (Berryman *et al.*, 1989; Ota *et al.*, 1992). This project seeks to compare and contrast three sites with similarly high uplift rates along the Hikurangi margin where marine terraces co-exist with uplifted estuarine sediments to determine if the mechanism of coastal uplift varies along the margin.

During the Holocene, sea level rose eustatically from 10 - 6.5 ka and at the locations selected for the study incised river valleys were gradually back-filled by estuarine mud. Our reconnaissance work indicates that these sediments contain a high-resolution and dateable record of relative sea level changes and uplift events. Tools, such as micropaleontology, palynology, radiocarbon dating and tephrochronology will be used to determine whether uplift events were sudden or gradual. The results will be related to the pattern of on and offshore faulting, regional uplift and crustal structure to infer the mechanisms of coastal uplift along the margin.

The poster will summarize existing knowledge about the active tectonics of the Hikurangi margin, especially along strike changes in plate convergence and crustal thickening processes and their possible implications for styles of coastal uplift.

QUATERNARY GEOLOGY, CLIMATE AND BIOTA AT MASON BAY, STEWART ISLAND, NEW ZEALAND

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Two distinct Pleistocene cyclothems occur at Mason Bay on the west coast of Stewart Island. They rest unconformably on the Mesozoic basement, and each consists of sand overlain by a coarse angular breccia. Sands are laminated tidal rhythmites deposited at interglacial high sea level stands, while breccias represent felsenmeer (block fields) formed by periglacial processes during the last two glacial maxima. The inferred age range of these sediments is c. oxygen isotope stage 7 to c. oxygen isotope stage 2. Late Pleistocene - early Holocene dunes, common on the Island Hill Flats east of Mason Bay, are uncommon in outcrop at the bay, but provided the substrates for the forests forming the peat horizons at Mason Bay.

Three distinct peat horizons occur at Mason Bay, a coarse, sandy peat (latest Pleistocene-earliest Holocene), remnants of a drowned coastal forest (c. 7000 B.P.), and a modern flax-dominated peat. A diverse assemblage of subfossil invertebrates was found in the c. 7000 B.P. peat, including beetles from the families Carabidae, Curculionidae, Hydrophilidae, Chrysomelidae, Scirtidae, and Scarabidae, and possible fragments of *Peripatus*, which if verified, would be the first record of this taxon from Stewart Island.

The active Holocene dunes at Mason Bay form one of the most extensive dune systems in New Zealand. During fieldwork, 2632 disarticulated bird bones were collected from the active dunes. The majority are from South Georgian diving petrels (*Pelecanoides georgicus*), which formerly bred at Mason Bay, but became extinct at this site between 1475 A.D. and 1650 A.D. (Holdaway et al. 2003). Twenty-seven other bird species were represented in the dune assemblage, including the first subfossil records of yellow-eyed penguin, New Zealand falcon, pied oystercatcher, New Zealand pigeon and tui at Mason Bay, as well as the second record of piopio from Stewart Island. Bones of forest bird species were found a mean distance of 75 m from the edge of forest, significantly closer than bones of non-forest species (X = 290 m), and may be a useful indicator of dune proximity to forest habitat during pre-European times. Dunes fixed by forest near the southern end of Mason Bay do not contain bone or shell, possibly due to the presence of humic acid. The influence of pH and sand abrasion on bird bone preservation was examined experimentally, and found to significantly affect the condition of bone. The dissolution of bone by groundwater with low pH may explain the lack of (bird) bones in the New Zealand terrestrial fossil record.

Holdaway, R.N., Jones, M.D., Beavan Athfield, N.R. (2003). Establishment and extinction of South Georgian diving petrel (*Pelecanoides georgicus*) at Mason Bay, Stewart Island, New Zealand, during the late Holocene. *Journal of the Royal Society of New Zealand 33:3*, 601-622.

A MULTIPROXY INVESTIGATION OF ENVIRONMENTAL CHANGE IN LAKE FORSYTH OVER THE LAST 150 YEARS

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Lake Forsyth (Te Wairewa) is a shallow, hypertrophic, slightly brackish lake situated to the south of Banks Peninsula. This lake is presently isolated from the Pacific Ocean by a narrow gravel bar, but there is documentary and cartographic evidence that it was permanently open to the Pacific Ocean until the middle of last century. A short (1.2m) sediment core, extracted from the deepest point of Kaitoreti Basin was examined for pollen, chironomid (midge) remains, forams, and macrofossils to determine both environmental changes and human impact on the catchment.

Pollen counts were dominated by tree ferns (*Cyathea* & *Dicksonia*) which contributed 95- 40% of the total pollen count for the entire core, reflecting a dominance of stream/river derived pollen to the pollen record in this lake. The pollen record was divided into two main zones, based on a count which excluded trilete fern spores, and swamp elements (Cyperaceae etc.). **Zone I** (120-50 cm) was dominated by Podocarpaceae (*Primnopitys taxifolia* & *Podocarpus totara*), 80%; Shrubland taxa (*Aristotelia serrata*, *Melicytus ramiflorus* and *Coprosma sp.*), 15%; and is interpreted to represent the pre- European vegetation in the region. **Zone II** (50-0 cm) is marked by the sudden decrease in native canopy tree species from 80% to 10% of the pollen count. This is punctuated by a peak in bracken (*Pteridium esculentum*) spores at 52 cm, the increase of herb and grass derived pollen from 10% to 60% of the pollen count, and the appearance of the exotic *Pinus radiata* at 29 cm depth. **Zone II** is interpreted to represent deforestation by European settlers, followed by the increase in pastoralism and tree planting recorded in the late 19th to early 20th century. There is no clear evidence of Polynesian disturbance in the pollen record. As no carbon dating has been performed on this core, tentative dates were attributed to the beginning of deforestation (1840) and the appearance of *Pinus radiata* in the record (1930), based on historical records.

Brackish foraminifera (*Ammonia parkinsonian*, *Elphidium excavatum*, and *Zeaflorius parri*) indicate saline conditions at the base of the core. A massive peak of the phytoplankton *Pediastrum sp.* At 40 cm possibly represents the stabilisation of the lake basin as a fresh water system.

Chironomid remains are dominated for the entire core by *Chironomus zealandicus* (>90%) a ubiquitous New Zealand taxa that is tolerant of both highly saline conditions and low levels of dissolved oxygen. Minor contributions (< 5 %) by a predatory chironomid subfamily Tanypodinae correspond to the *Pediastrum sp.* peak at 40 cm (possibly early 1900s). Unlike *Chironomus zealandicus* the Tanypodinae are intolerant of low levels of dissolved oxygen and may be indicative of better water quality at this time. Abundant Larval caddis (Trichoptera) larval cases (*Oecetis unicolour*) also appear about the time of the *Pediastrum sp.* peak and disappear about 25 cm from the top of the core. The absence of caddis larval cases higher in the core lends support to the argument for a decline in water quality in the mid to late 1900s due to human disturbance. Carbon and Pb^{210} dating will provide a better constraint on the chronology of events in this core.

FORMATION OF QUARTZ PEBBLE CONGLOMERATE PLACERS THROUGH TIME IN SOUTHERN NEW ZEALAND

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Numerous auriferous fluvial quartz pebble conglomerates (QPCs) are present within the Late Cretaceous–Recent sedimentary sequence in southern New Zealand. The QPCs formed before, during, and after regional marine transgression, in alluvial fan and a variety of fluvial and near-shore depositional settings. QPC characteristics are complex and vary with transport and recycling history, stratigraphic proximity to the Waipounamu Erosion Surface (WES) cut during marine transgression, and the amount of first-cycle detritus incorporated during recycling. The latter varies, in turn, with tectonic intensity and geographic proximity to remnant Cretaceous topography for pre-marine QPCs, and with tectonic intensity and geographic proximity to Late Cenozoic uplift of basement ranges for post-marine QPCs.

Reduced and/or oxidized groundwater alteration (kaolinisation) of labile minerals in pre-existing sediment and the upper part of underlying basement is fundamental in raising the compositional maturity of QPCs. Altered material disaggregates easily upon erosion, and alteration clays are winnowed to leave quartz-rich residues containing detrital sulphide and resistant heavy minerals such as zircon and gold. Incorporation of these residues during sediment recycling increases compositional maturity of QPCs, provided that recycling is not accompanied by excessive erosion of fresh basement rock. Uplift of many parts of the Otago Schist belt since late Miocene-Pliocene has raised rocks above the water table, increased erosion rates, and interrupted the alteration and associated authigenic sulphide precipitation processes in many areas. However, these processes are highly efficient in Southland, where water tables are high and sediments are saturated, uplift and erosion rate, topography, and fluvial gradients are all low, and winnowing of clays and accumulation of residual quartz-rich gravels has been the dominant sorting mechanism since the Miocene. Consequently, QPCs are still forming in Southland.

Textural maturity generally increases with transport distance in first cycle sediments, but depositional environment and recycling history are the principal controls on the textural maturity of QPCs: they are dominantly sub-mature in incised paleovalleys on the schist belt, due to incorporation of immature quartz during recycling, mature in significant degradational lags within these channels, and in coastal delta plain strata close to, and beyond the margins of the schist belt, and super-mature in wave-reworked beds immediately below the WES.

QPCs formation processes essentially represent physical and geochemical lagging of precursor strata, and accumulation of detrital gold, resistant heavy minerals and, in some cases, detrital sulphides, is an inevitable consequence.

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