JOINT GEOLOGICAL SOCIETY OF NEW ZEALAND &
NEW ZEALAND GEOPHYSICAL SOCIETY CONFERENCE
LAUNCHING INTERNATIONAL YEAR OF PLANET EARTH

PROGRAMME & ABSTRACTS

New Zealand Geophysical Society (Inc)

TAURANGA
26-29 NOVEMBER
2007

Geological Society of New Zealand Miscellaneous Publication 123A

ISBN No. 0-908678-08-8

GEOLOGICAL SOCIETY OF NEW ZEALAND & NEW ZEALAND GEOPHYSICAL SOCIETY JOINT ANNUAL CONFERENCE

Launching International Year of Planet Earth
26-29 November 2007
Baycourt Community and Arts Centre, Tauranga

New Zealand
Geophysical Society Inc.

Programme and Abstracts

Edited by Nick Mortimer and Laura Wallace

ORGANISING COMMITTEE
Keith Lewis, Susan Ellis (Convenors), Janet Simes, David Skinner, Dan Barker, Annie Cervelli, Ursula Cochran, Bryan Davy, Nick Mortimer, Laura Wallace

WITH ASSISTANCE FROM
Tauranga Locals
David and Joan Kear, David Milner and Kathrin Otrel-Cass

Symposium Organisers
Joel Baker, Willem de Lange, Geoffroy Lamarche, Graham Leonard, Kathrin Otrel-Cass, Martin Reyners, Julie Rowland, Wendy Saunders, Marcus Vandergoes, Pilar Villamor, Richard Wysoczanski

Fieldtrip Leaders
Willem de Lange, Geoff Kilgour, Mauri McSaveney, David Milner, Ian Nairn, Mike Rosenberg, Brad Scott, Hannu Seebeck, Pilar Villamor, Colin Wilson

Technical Support
Kate Bodger, Daniel Clarke, John Creech, Claudine Curran, Sharryn Duggan, Sara Ewan, Alison Graettinger, Janine Krippner, Rochelle Hanson, Fiona Sanders, Tom Whittaker

Geological Society of New Zealand Miscellaneous Publication 123A
ISBN 0-908678-08-8

CONFERENCE SPONSORS

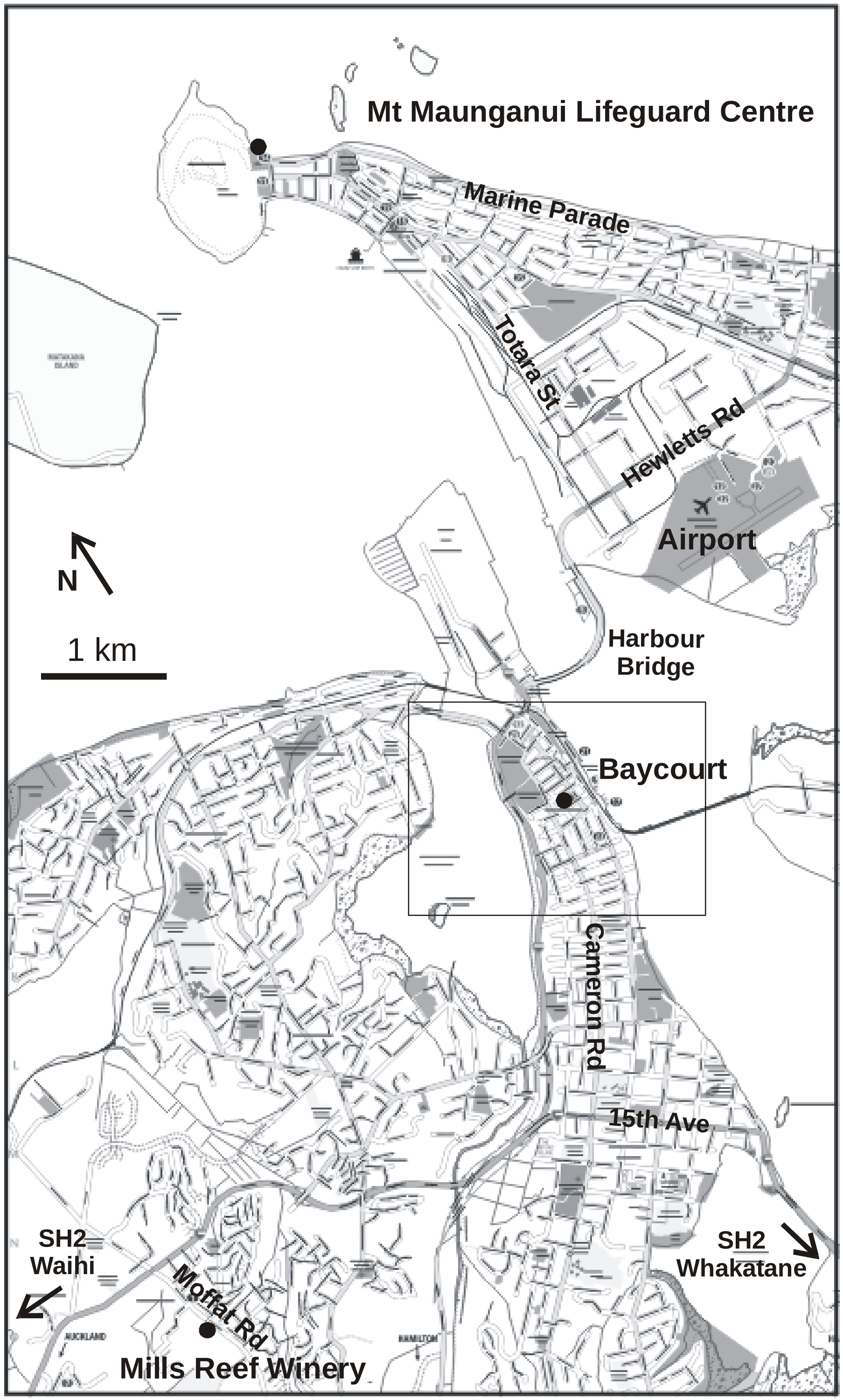
Platinum

Gold Plus

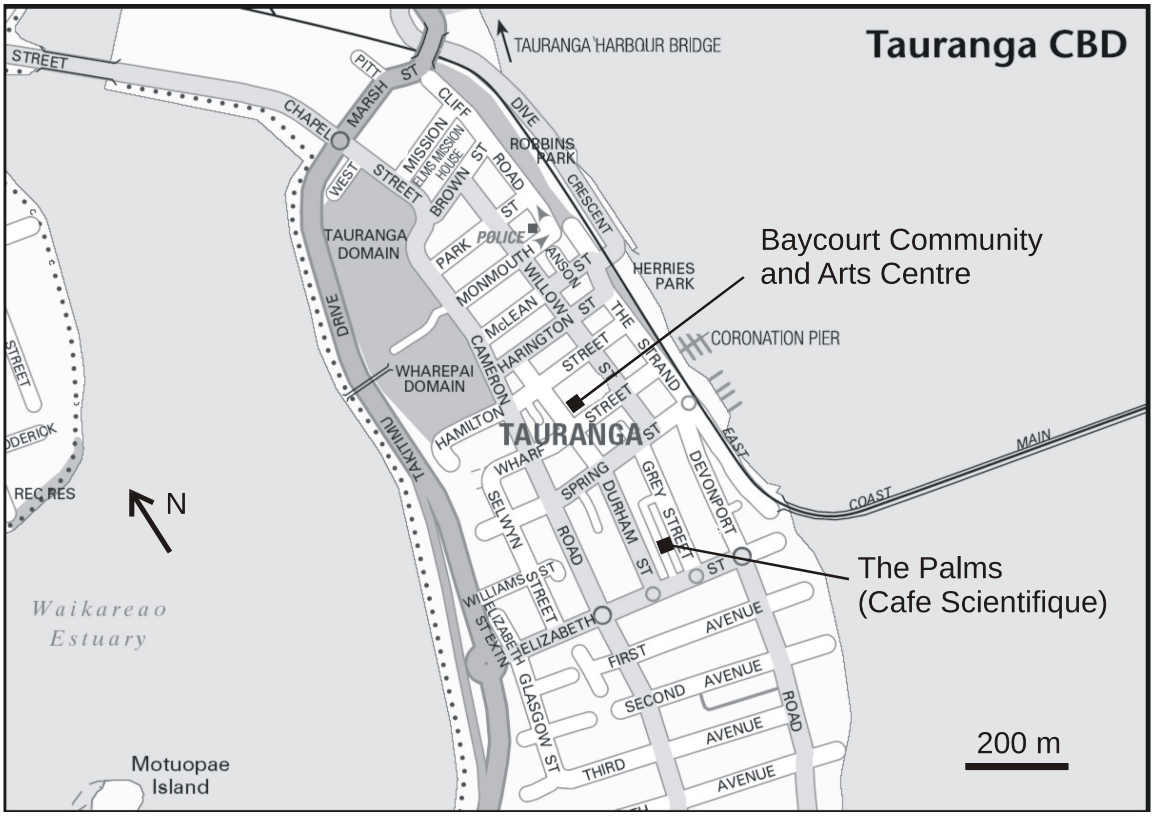
Gold

Silver

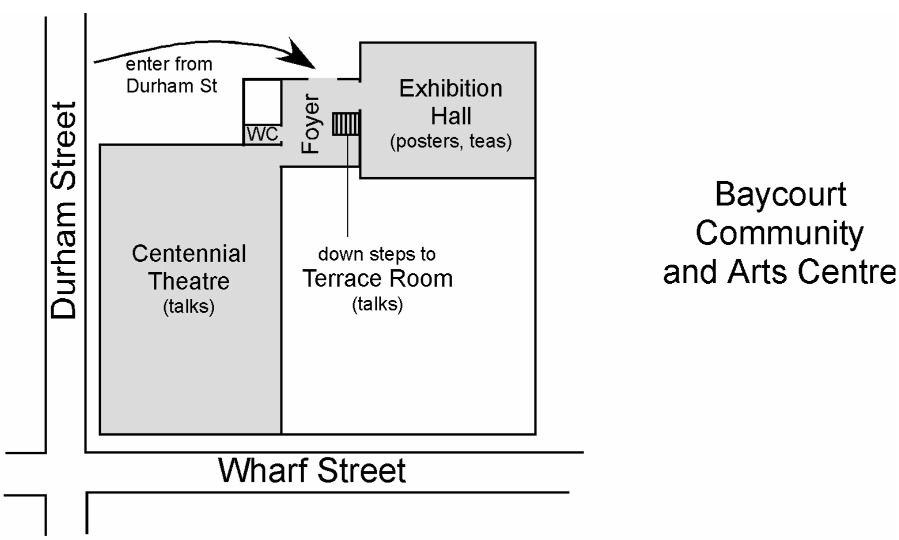
Bronze Plus



Central Tauranga and environs



Tauranga CBD
TAURANGA HARBOUR BRIDGE
Baycourt Community
and Arts Centre
The Palms
(Cafe Scientifique)
ROBBINS PARK
HERRIES PARK
CORONATION PIER
TAURANGA DOMAIN
WHAREPAI DOMAIN
ELMS MISSION HOUSE
POLICE
TAURANGA
REC RES
N
Waikareao
Estuary
Motuopae
Island
200 m
CHAPEL STREET
MARSH ST
PITT ST
CLIFF ROAD
DIVE CRESCENT
MISSION STREET
BROWN ST
WEST DRIVE
PARK ST
MONMOUTH ST
ANSON ST
WILLOW ST
McLEAN STREET
HARINGTON STREET
CAMERON ROAD
THE STRAND
HAMILTON ST
WHARF STREET
SPRING ST
GREY STREET
DURHAM ST
DEVONPORT ROAD
SELWYN ST
WILLIAMS ST
ELIZABETH STREET
ELIZABETH ST EXTN
GLASGOW ST
TAKITIMU DRIVE
FIRST AVENUE
SECOND AVENUE
THIRD AVENUE
EAST
MAIN COAST ROAD



enter from
Durham St
WC
Foyer
Exhibition
Hall
(posters, teas)
Centennial
Theatre
(talks)
down steps to
Terrace Room
(talks)
Durham Street
Wharf Street
Baycourt
Community
and Arts Centre

GENERAL INFORMATION

Welcome to the 2007 Joint Annual Conference of the Geological Society of New Zealand and the New Zealand Geophysical Society. One-day fieldtrips and an evening icebreaker are being held on Monday 26 November. Talks and posters form the core of the conference from Tuesday 27 to Thursday 29 November. Further one-day fieldtrips depart on the morning of Friday 30 November.

Venues

Apart from the fieldtrips, conference activity will be based at the Baycourt Community and Arts Centre on Durham Street (between Wharf and Hamilton Streets), downtown Tauranga. During the conference there will be two concurrent sessions of talks in the Centennial Theatre and Terrace Room. Posters, trade displays and morning and afternoon teas will be held in the Foyer and Exhibition Hall. Conference attendees should have arranged their own accommodation. Conference-related events are being held at the Baycourt Centre, Palms Restaurant and Bar, Mount Maunganui Lifeguard Centre and Mills Reef Winery and Restaurant.

Science Programme

At publication time, 250 people had registered and 123 talk and 63 poster abstracts had been submitted. Presentations have been grouped into half a dozen symposia: (1) Arc volcanism at SW Pacific convergent margins: a symposium honouring Professor John Gamble, (2) Tearing the arcs apart – Rifting in the TVZ and Havre Trough, (3) Paleoclimate and paleoenvironments in the southwest Pacific, (4) Geohazards in New Zealand, (5) New challenges for geoscience education and (6) Tectonics and Basins. Four 30 minute plenary talks and one public talk have been organised.

Registration and Help Desk

The registration desk will be open in the Baycourt Foyer between

- 4.30pm - 7.30pm on Monday 26 November
- 8.00am - 3.15pm on Tuesday, Wednesday & Thursday 27-29 November

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, speakers will be asked to download their Powerpoint files to the conference laptops.

Talks

See p. xiii-xv for the programme of talks. Speakers should be prepared to upload and check their Powerpoint presentations at the registration desk when they first arrive at the Baycourt. Personal laptops cannot be used for presentations. Please make sure your presentation is Office XP/Powerpoint 2002 compatible. Projector resolution is XGA (1024 pixels wide by 768 high). We recommend that complex characters be embedded as bitmaps rather than using a symbol font. We cannot guarantee that movies will display correctly. We suggest that those wishing to incorporate avi movies in their presentations also bring a static version of their talk along, just in case. Alternatively they can embed each frame into their presentation and advance frames automatically. There is no speaker-ready room, but a laptop is available for checking slides at the Registration Desk.

Unless you are a keynote or plenary speaker, all oral presentations have now been scheduled in 15 minute slots (12 minutes for speaking, 2 minutes for questions and 1 minute for changeover). Note this differs from the slightly longer times mentioned in the Conference Circular; the extremely well-subscribed programme has led to the reduction in talk time. Speakers are asked to please keep slides to a minimum, get to the point quickly, rehearse their talks and keep to schedule. Session chairs will enforce timekeeping by giving a verbal warning when two minutes (of the 12) remain for speaking, and stand up when the talking time is finished and questions should start. Keynote speakers have 20 (=15+4+1) minute and plenary speakers 30 (=25+4+1) minute slots.

Public Lecture

A 45 minute public talk "Understanding and Dealing with a Warmer World" will be given by Lionel Carter, Professor of Marine Geology at Victoria University, at 12.15pm on Wednesday 28 November in the Centennial Theatre. This is designed for a general audience and as a casual "brown bag" style of event; all are welcome to attend. It is suggested that conference delegates bring lunch with them on Wednesday as there is very little time between close of the morning session and start of the public talk.

Café Scientifique

Planet Earth in our hands?

On Monday, 26 November at 8.00pm after the conference Icebreaker, Lionel Carter and Hamish Campbell will be the panelists at the Tauranga *Café Scientifique* discussing the 'big issues' of Planet Earth from their perspective, and what can be learned from looking at the past in order to understand complex interactions within the Earth system.

Café Scientifique is a forum where, for the price of a cup of coffee or a glass of wine, anyone can come to explore the latest ideas in science and technology. The *Café* is a forum for debating science issues and is committed to promoting public engagement with science and to making science accessible.

The venue of this *Café Scientifique* is The Palms Restaurant and Bar, 107 Grey Street, Tauranga, which is an easy 10 minute walk from the Baycourt Centre (see map).

Posters and Trade Displays

See p. xvi-xvii for a list of poster presentations which are grouped by Symposium. Posters and trade displays will be available for viewing in the Foyer and Exhibition Hall throughout the entire conference. These are also the venues for morning and afternoon teas. Presenters are asked to put up their posters on the specified 1.2m wide by 1.8m high boards any time after 4.30pm Monday and take them down during afternoon tea on Thursday. Both velcro and/or pin attachments will work (bring your own). Presenters are asked to stand near their posters during tea and lunch breaks of their symposia.

Refreshments

Morning and afternoon teas are provided, but (except on fieldtrips) not lunches. A number of lunch and dinner venues are within easy walking distance of Baycourt. Note that the 12.15pm start time of the Public Lecture on Wednesday makes it a good day to bring a sandwich with you in the morning.

Social Events

Icebreaker

Drinks and finger food will be available from 5.30-7.30pm, Monday 26 November at Baycourt Community and Arts Centre on Durham Street near the corner of Wharf Street, downtown Tauranga. Cost is included in registration. Afterwards, a number of restaurants are within easy walk of the Baycourt. See also Café Scientifique above.

Beach Barbecue

A barbecue will be held at the Mount Maunganui Lifeguard Centre, 21 Adams Avenue, Mount Maunganui (west end of Marine Parade) starting at 7.00pm Tuesday 27 November. Beach volleyball will be on offer, enjoy the sunset or go for a walk up the Mount. The venue is about 6 km north of the Baycourt, across the Tauranga Harbour Bridge. Entry to this function is by pre-purchased ticket ($35 per person), and includes a complimentary drink voucher. Transport to and from the venue will be provided. Buses will leave at 6:30pm from Durham Street outside the Baycourt Centre. Buses leave after the event from 9:30 - 10.00pm. A cash bar will be available at the venue.

Conference Dinner & Presentation of Annual Awards

This event starts at 7.00pm, Wednesday 28 November at Mills Reef Winery, 143 Moffat Road, Bethlehem, Tauranga. The venue is about 6 km from the Baycourt (head west on SH2 towards Waihi, turn south on Moffat). Entry is by pre-purchased ticket and includes a complimentary drink voucher. Note, this function is full and no further tickets are available. The theme of the dinner is "*Oh I do like to be beside the seaside*". Dressing up is encouraged and prizes will be awarded by an anonymous jury to the best costumes spotted during the evening. Buses will leave Durham Street outside Baycourt Centre for Mills Reef at 6.30pm and will depart Mills Reef for the Baycourt at about 10.30pm (second bus approx 11.00pm).

Intra-Conference Meetings

Geological Society of New Zealand Annual General Meeting

Tuesday 27 November, 5.00pm in the Centennial Theatre. The agenda is publised in GSNZ Newsletter 144. There will certainly be discussion of future subscription increases. All GSNZ members are requested to attend.

Geological Society of New Zealand National Committee

Monday 26 November, rendezvous at Baycourt Registration Desk at 7.30pm (end of Icebreaker) for a Working Dinner.
Thursday 29 November, 7.45am, Breakfast Meeting. Venue TBA.

Check the Message Board at the Registration Desk for notice of any additional intraconference meetings.

Marsden Workshop

The Marsden Fund supports research excellence in science, technology, engineering, mathematics, social sciences and the humanities. Each year, Government provides funding for projects that will foster scholarly research of the highest calibre. This work is not subject to government priorities but enhances New Zealand's ability to participate in, and benefit from, research of an international standard.

A 35 minute workshop (Tuesday 27 November, 4.15-4.50pm, Terrace Room) will be presented by Tasha Black of the Marsden Fund, RSNZ. Come and get a general outline of the Marsden Process, including how it is administered, Marsden Fund Council and Panels, the 2008 timetable and any changes for the new round. We will also have a look at the Fund's objectives and how to optimise your chances when applying. The focus will be on applying to the Earth Sciences and Astronomy panel, but the information applies equally as well to any of the other disciplines. Past and present Marsden Panel members have been invited to this presentation to add to the discussion. More information at <http://marsden.rsnz.org/>.

Transport and Parking

Bay Hopper (public transport) www.baybus.co.nz ph 0800 422928
Tauranga Airport Shuttles ph (07) 574 6177, 0800 574 617
Taxis: Tauranga Mount Taxis ph 0800 829477, Bay Citicabs, ph (07) 577 0999
Allow at least half an hour travel time between downtown Tauranga and the airport and Mt Maunganui - traffic can be heavy on the harbour bridge, especially during rush hours.

Parking in downtown Tauranga is typically metered Monday to Friday 9.00am to 4.00pm. Some all day pay-parking is available on the east side of the Railway tracks along The Strand, and in multi-storey parking buildings at Elizabeth Street (access from Elizabeth Street or 1st Ave) and Spring Street (corner of Durham Street, vehicle access from Durham only).

Communication

There are no Internet or photocopying facilities available at the Baycourt. So enjoy an email-free conference. Or, if you must, the nearest Internet cafe is at Tauranga Central Backpackers (corner Willow and Harington Streets).

Organising Committee Hotlines during conference: phone or txt Janet on 027 452 6001, Keith on 021 767 441 or Nick on 027 688 2720

Please turn cellphones off, and do not use laptops, in the lecture theatres.

Awards and Grants

The announcement and presentation of the Geological Society's 2007 McKay Hammer Award, 2007 Kingma Award and 2008 Hochstetter Lecturer will be made at the Conference Dinner on Wednesday evening, as will the Geophysical Society's New Zealand Geophysics Prize.

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

Fieldtrips

Pre-conference: Monday 26 November

Fieldtrip 2 *Earthquakes and Eruptions at Okataina Volcanic Centre:* Pilar Villamor, Ian Nairn, Hannu Seebeck. Departs from the conference venue at 08:00, returns at 18:00 in time for most of the Icebreaker.

Fieldtrip 3 *An Introduction to Sunny Matata and Its Great Debris Flows:* Mauri McSaveney. Departs from the conference venue at 08:30, returns at 16:30 in time for the Icebreaker.

Post-conference: Friday 30 November

Fieldtrip 5 *Coastal Hazards of Western Bay of Plenty:* Willem de Lange. Departs from the conference venue at 08:30, returns at 17:30 to Tauranga.

Fieldtrip 6 *Exploring Mayor Island:* Colin Wilson, David Milner. Departs at 07:30 from Coronation Pier, Port of Tauranga, returns at 19:30 at the latest.

Fieldtrip 7 *White Island Tour:* Brad Scott, Mike Rosenberg, Geoff Kilgour. Departs from the conference venue at 07:00, returns to Whakatane at 15.30 and Tauranga at 17:00.

CONFERENCE PROGRAMME

The Science Programme for the conference is set out over the following pages. Presenting authors are underlined, * = GSNZ student, ** = NZGS student. There are two concurrent oral sessions, with four plenary and 15 keynote talks. Abstracts are listed alphabetically by first author.

The Convenors of the six symposia, and their additional recruited session chairs, are:

Gamble: Joel Baker, Richard Wysoczanski (convenors), Jon Davidson, John Gamble, Monica Handler, Janet Hergt, Adam Kent, Colin Wilson.

TVZ Rifting: Julie Rowland, Pilar Vilamor, Geoffroy Lamarche (convenors).

Paleoclimate: Marcus Vandergoes (convenor) Helen Bostock, Martin Crundwell.

Geohazards: Willem de Lange, Graham Leonard, Wendy Saunders (convenors), Art Jolly, Laura Wallace.

Geoeducation & General: Kathrin Otrel-Cass and Jenny Pollock (convenors).

Tectonics and Basins: Nick Mortimer, Martin Reyners (convenors), John Beavan, Paul Denys, Rick Herzer.

CONFERENCE PROGRAMME FOR TUESDAY 27 NOVEMBER

	Centennial Theatre	Terrace Room
0800 registration		
0825	OPENING AND WELCOME. Keith Lewis, John Townend & Vince Neall	<-- Opening and Welcome in Centennial Theatre
	Gamble - 1	Paleoclimate - 1
0845	Davidson. New perspectives on differentiation processes at arc volcanoes (PLENARY)	<-- Plenary in Centennial Theatre
0915	Gamble. 35 years of geochemical research on the Tonga–Kermadec-NZ system (KEYNOTE)	*Whittaker et al. New high-resolution climate record for New Zealand, 11-73 kyr BP (KEYNOTE)
0935	Mortimer et al. Miocene-Quaternary evolution of SW Pacific arcs and backarc basins	Bostock & Opdyke. Using carbon isotopes to trace intermediate South Pacific waters, past and present
0950	Graham et al. Towards a better understanding of petrogenesis of Kermadec arc volcanic rocks	Marra. Forest refugia during the last glaciation
1005 tea & posters		
	Gamble - 2	Paleoclimate - 2
1030	Davy et al. Magnetic surveying of Brothers Volcano, Kermadec Arc	Vandergoes et al. Climate variability in South Westland from 30,000 to 15,000 cal yr BP
1045	Wysoczanski et al. Constructional volcanism and back-arc rifting in the southern Havre Trough	Crundwell et al. Glacial–interglacial ocean climate variability at ODP 1123 during the mid-Pleistocene transition
1100	Hergt et al. Magmatism in the Havre Trough: new insights from new samples	Wilson et al. Paleomagnetic research at Otago - looking beyond the geomagnetic polarity time scale
1115	*Todd et al. Cross-arc isotopic and trace element heterogeneity, southern Havre Trough	*McKay et al. Neogene sedimentation and history of the West Antarctic Ice Sheet - initial results from ANDRILL
1130	Handler et al. Re–Os systematics in subduction zones: constraints from southern Kermadec Arc	*Bolton et al. Laser ablation foraminferal Mg/Ca and ocean temperatures
1145	*Booden et al. Geochemistry of volcanism in the Miocene-Pliocene Hauraki Volcanic Region	Eggins et al. Deconvolving temperature and carbonate ion effects on Mg/Ca in planktic foraminifera
1200 lunch & posters		
	Gamble - 3	Paleoclimate - 3
1300	Woodhead et al. Subduction zone trace element systematics: when are anomalies normal? (KEYNOTE)	Neil et al. What has been the variability in climate over the last 100-1000 years? (KEYNOTE)
1320	Price et al. Mantle source compositions for basaltic component in North Island andesitic volcanoes	Gehrels et al. (Hayward). 20th century acceleration of sea-level rise in New Zealand
1335	*Turner et al. Cyclic magma evolution of andesite strato-volcanoes: a case study from Mt Taranaki	Grenfell & Hayward. Microfossil record of human impacts – progress report on New Zealand studies
1350	Shane et al. Incremental growth of rhyolite magma systems: insights from Tarawera Volcano	Hendy et al. Diagenesis and methane in Lake Rotorua
1405	*Deering & J Cole. Distinct magma types of the TVZ: implications for rhyolite petrogenesis	*Payne et al. Sedimentation on the north Kaipara continental margin: some interim results
1420	*Saunders et al. Petrogenesis of large-volume silicic magmatism in TVZ and southern Kermadec Arc	White & Weeber. Chronology of Holocene Springston Formation gravel deposition under Christchurch
1435	*Allan et al. Trace element characterisation of Quaternary silicic tephras from ODP 1123	Gorman et al. Quaternary structure, morphology, and stratigraphy of Otago and South Canterbury shelves
1450 tea & posters		
	Gamble - 4	Paleontology
1515	Hochstein & Sudarman. Geothermal systems along volcanic arcs in Indonesia	Bland K et al. Late Neogene biofacies in central Hawkes Bay: sequence stratigraphy and paleogeography
1530	Nemeth et al. Volcanic evolution and oral traditions of Western Samoa: volcanic hazard implications	*Eagle. Tracking vagrants - known New Zealand comatulids
1545	Stewart et al. Large-scale, near-sea level, silicic caldera-forming eruption in Efate, Vanuatu	Gregory & Raine. Guilielmites – a trace fossil it ain't
1600	*Zernack et al. Revised stratigraphy of the Mt. Taranaki ring-plain succession	Morrison et al. Update on paleontological database development
1615	*Moebis et al. Tephras in fine ashes of an arc volcanic complex: Mangatawai Tephra, Tongariro	Marsden Workshop - Tasha Black
1630	Kent & Rowe. Li variations in minerals and melt inclusions: Oct 2004 Mt St Helens eruption (KEYNOTE)	' '
1700	GSNZ AGM	<-- GSNZ AGM in Centennial Theatre
1830 buses to BBQ		

CONFERENCE PROGRAMME FOR WEDNESDAY 28 NOVEMBER

	Centennial Theatre	Terrace Room
	Geohazards - 1	Geoeducation and General - 1
0825	NOTICES	NOTICES
0830	De Lange et al. Palaeotsunami sources for the Bay of Plenty (KEYNOTE)	Sibson. Hubbert's Peak for global oil production: over the hill, or do Alps on Alps arise? (KEYNOTE)
0850	Gibb. Thresholds for coastal erosion from sea-level rise along open-exposed sandy coasts	McKenzie & Lindsay. Virtual earth science field trips in NZ: enthusing school children in earth science
0905	Pondard et al. Active faulting and seismic hazard in Cook Strait using high-resolution seismic data	"
0920	Van Dissen et al. "It's our fault": better defining the earthquake risk in Wellington	Otrel-Cass et al. Earth science in context on the Science Learning Hub website
0935	Langridge et al. Statistical assessments of earthquake recurrence for the Wellington Fault	"
0950	*Duffy et al. Multi-channel analysis of surface waves and the internal structure of active fault zones	Black et al. Fe-rich clinkers from spontaneous combustion and industrial burning of Rotowaro coal
1005 tea & posters		
	Geohazards - 2	Geoeducation and General - 2
1030	Sibson. Rupturing in fluid-overpressured crust: recent compressional inversion earthquakes in Japan	Nathan. Seeking James Hector (1834-1907)
1045	McCaffrey et al. Automated detection of slow slip events, Hikurangi subduction zone, with continuous GPS	Campbell A. The creep of creationism – is it relevant to teaching earth sciences?
1100	Delahaye et al. (Townend). Seismic phenomena associated with slow slip near Gisborne in 2004	Hume et al. Shifting sands, shifting paradigms
1115	Cervelli et al. Challenges in growing applications for GEONET's CGPS network	Pollock. The place of earth science in the new science curriculum
1130	Ristau. Implementation of routine regional moment tensor analysis in New Zealand	"
1145	Matcham et al. Riskscape – designing a multihazard modelling tool	free
1200 lunch		
1215	Carter L. Understanding and Living with a Warmer World (PUBLIC LECTURE, 45 mins)	<-- Public Lecture in Centennial Theatre
	Geohazards - 3	Tectonics - North Island
1315	Manville et al. 18 March 2007 break-out lahar from Crater Lake, Ruapehu: an overview (KEYNOTE)	Beavan et al. Continuous deformation map of New Zealand from active faulting (KEYNOTE)
1335	Cronin et al. Lahar-streamflow interactions: new data from 18 March 2007 Ruapehu lahar	Salmon et al. (Stern). The tectonic significance of the Taranaki-Ruapehu line
1350	*Cole S et al. Geophysical tools and internal dynamics of moving lahars: 18 March 2007 Ruapehu lahar	Savage et al. Seismic anisotropy across the Taranaki-Ruapehu line
1405	*Graettinger et al. Depositional record of historic lahars within the upper Whangaehu Valley, Mt Ruapehu	**Behr et al. Ambient noise imaging of New Zealand's geological roots
1420	Lindsay & Leonard. Volcanic hazard assessment for the Auckland volcanic field: state of play	**Ewig & Stern. Subsidence style in the south-eastern Wanganui Basin
1435	*Molloy & Shane. Volcanic ash fall frequencies and hazards from new Auckland maar sediment records	Reyners. What do small earthquakes tell us about plate coupling in the southern North Island?
1450 tea & posters		
	Geohazards - 4	Tectonics - South Island
1515	Pittari et al. Catastrophic Abrigo eruption, Tenerife and its relevance to volcanic hazards in NZ	*Jugum et al. The Dun Mountain Ophiolite Belt and Permian to Jurassic Gondwanan accretion
1530	Lube & Cronin. Avulsion of pyroclastic flows from channels: 2006 Gunung Merapi eruption, Indonesia	*Fagereng & Sibson. Chrystalls Beach Complex: analogue to the active Hikurangi margin subduction channel?
1545	Hikuroa et al. Matata 2005-2007: lessons learnt and assumptions tested	**Bourguignon et al. Southern South Island crust-mantle structure from teleseismic receiver functions
1600	*Mueller et al. Round Top rock avalanche, West Coast, New Zealand	Cooper & Norris. Plagioclase and garnet compositions reveal structure of Alpine Fault mylonite zone
1615	Milner. Landsliding in Otumoetai, 2005	Sutherland. Age of glacial landscapes offset by the Alpine Fault, and precise slip rate determination
1630	Lecointre. Managing volcanic risk in densely populated coastal areas: an international perspective (KEYNOTE)	Denys et al. The Central Otago deformation (COD) network (KEYNOTE)
1650	Miller, Jolly et al. 25 Sept 2007 Mt Ruapehu phreatic eruption: GeoNet response and preliminary scientific results (PLENARY)	<-- Plenary in Centennial Theatre
1720 end of day		
1830 buses to dinner		

CONFERENCE PROGRAMME FOR THURSDAY 29 NOVEMBER

	Centennial Theatre	Terrace Room
	TVZ Rifting - 1	Tectonics - General
0825	NOTICES	<-- Notices in Centennial Theatre
0830	Berryman. Quarter century of tectonics in the Taupo Rift (TVZ): a personal view (TVZ PLENARY)	<-- Plenary in Centennial Theatre
0900	Bannister et al. Crustal imaging from the 2005-2007 Matata (BOP) earthquake sequence (KEYNOTE)	Herzer et al. Miocene stratigraphy and structure of the Northland Plateau (KEYNOTE)
0920	**Clarke et al. Seismicity in TVZ geothermal systems: earthquake clustering and focal mechanisms	Upton et al. Numerical modelling of auriferous quartz vein formation in a thrust zone, Macraes Mine
0935	**Greve & Savage. Modeling seismic anisotropy across the Central Volcanic Region	*Grigull et al. A method for extracting rheological information for quartz from naturally deformed rocks
0950	**Benson et al. Lower crust – upper mantle structure and bright reflectors under TVZ	Reyes. Water-rock interaction in South Island mineral spring systems, New Zealand
1005 tea & posters		
	TVZ Rifting - 2	Tectonics and Sedimentology
1030	Lamarche & Barnes. Active continental rift transfer zone between Whakatane Graben and southern Havre Trough	Nodder et al. New sea-floor features discovered on the Chatham Rise and Challenger Plateau
1045	Rowland et al. Along-axis variations in the rifting process, TVZ	*Hansen et al. Relationships between discontinuity features and silica content in limestone, Te Kuiti
1100	Begg & Mouslopoulou. Rangitaiki Plains: new LiDAR data lift another veil	**Shears et al. Geophysical constraints on the sediment budget of Otago Harbour
1115	Sepulveda et al. Relationship between structures and geothermal activity of the TVZ: Wairakei case study	*Mountjoy et al. Tectonically forced slope-failures in offshore Hikurangi subduction-collision transition zone
1130	**Seward et al. Upper mantle properties beneath the central North Island	**Bodger et al. Submarine landscape evolution in response to subduction processes, northern Hikurangi margin
1145	Oliver et al. Does fluid flow in the TVZ control the position of the brittle-ductile transition?	Strachan. How do subaqueous slumps transform into turbidity currents?
1200 lunch & posters		
	TVZ Rifting - 3	Gas Hydrates and Basins
1300	Bull J. Constraining active fault behaviour in rift zones (KEYNOTE)	Orpin et al. Worms, clams and donuts: new methane seeps along the East Coast margin (KEYNOTE)
1320	*Seebeck et al. Relationships between extension and volcanism in Okataina Volcanic Complex	*Nyman et al. Controls on the distribution of concretionary seep carbonates, East Cape, North Island
1335	Gravley et al. How normal are normal faults in volcanic rifts?	Roncaglia et al. Seismically driven facies characterization, Kupe Field, Taranaki Basin
1350	Villamor et al. Prehistoric Okataina eruptions and surface rupture of nearby active faults	Ghisetti et al. Active fault-propagation folding and gas hydrates in the Hikurangi margin
1405	Cole J et al. Subvolcanic plumbing systems beneath caldera volcanoes: importance of crustal structure	Barnes et al. Tectonics, subduction processes and gas hydrates, Hikurangi margin, cruise SO-191
1420	Wallace et al. Crustal deformation in the rift: focus on southern TVZ kinematics	Geddes. Understanding risk assessment and geological processes through time with basin modelling
1435	Nicol & Stagpoole. Taranaki Fault structure and kinematic history; implications for North Island subduction (TECTONICS PLENARY)	<-- Plenary in Centennial Theatre
1505	CLOSING & PRESENTATION OF STUDENT AWARDS	<-- Closing & Student Awards in Centennial Theatre
1530 tea		
1600 end conference		

Presenting author is underlined, * = GSNZ student, ** = NZGS student.

CONFERENCE POSTERS LISTED BY BOARD NUMBER
Foyer and Exhibition Hall

Trade Displays

A	GSNZ	Pre-publication display of GSNZ Book "A Continent on the Move" Ian Graham (ed.)
B	GNS Science	Publications
C	EQC	
D	NIWA	
E	Hoare Research Software	
F	datatran	

Gamble Symposium (talks on Tuesday)

1	Della Pasqua et al.	Breakdown of quartzite xenoliths in Ngauruhoe lava: interaction with host andesite melt
2	Lee et al.	Structural controls on changing differentiation pathways at Mt. Ruapehu
3	*Marx et al.	Miocene tephra deposits at the Gable End foreland, East Coast Basin, North Island
4	*McCoy-West & Baker	Origin and evolution of mid-Cretaceous volcanism, Marlborough
5	Nemeth et al. (Charley)	Post-caldera volcanism, Yenkahe Caldera, Tanna Island, Vanuatu
6	Nicholson et al.	Igneous geochemistry of the Noumea Basin, New Caledonia
7	*Andrews et al.	Ni isotope measurements of Fe-Ni metal in meteorites from the cores of asteroids
8	*Schiller & Baker	26Al - 26Mg isotope dating of planetary differentiation in the young solar system
9	*Town et al.	26Al - 26Mg dating of the solar system's oldest solids
10	*Schipper et al.	Primary volcaniclastic deposits at Loihi seamount, Hawaii: submarine explosive activity?
11	Wright et al.	Tonga - Kermadec arc calderas: review of caldera morphology and structure

TVZ Rifting (talks on Thursday)

12	Davey, F.	Crustal seismic reflection measurements across the Bay of Plenty
13	Ellis et al.	Controls on the termination of the Taupo Rift; results from 3D analogue & numerical models
14	Stern et al. (Henderson)	Possible role of mantle instabilities in initiating back-arc spreading

Paleoclimate, Paleoenvironment & Paleontology (talks on Tuesday)

15	Hayward et al. (Sabaa)	Last deep sea global extinction – benthic foraminiferal populations prior to disappearance
16	Hill J & Grant-Mackie	Eocene marine turtle from the Whangarei area
17	*Holt	Quaternary geology and uplift rates on Chatham Island
18	*Marr et al.	NZ ocean temperatures, last glacial maximum-present: insights from foram Mg/Ca ratios
19	Mylroie et al. (C Nelson)	Flank margin caves in New Zealand Tertiary limestones
20	**Nelson F et al.	Preliminary palaeomagnetic record from Hokitika Canyon levee
21	Northcote & Neil	Foraminiferal morphological oddities: evidence of asexual budding?
22	**Ohneiser & Wilson	Middle Miocene ocean record from W Southland: eccentricity-obliquity paced glaciations
23	*Pearson L et al.	The sediments of Lake Rotorua, New Zealand
24	*Pickett et al.	High resolution Holocene record of sediments from Lake Rotorua
25	*Rust	Fossil bryozoans from the Wanganui Basin: a survey of colony growth forms
26	*Ryan et al.	Oxygen isotope stratigraphy of the Hokitika and Cook submarine canyons

Geohazards (talks on Wednesday)

27	*Arthurs et al.	Slope failure and erosion in the coastal escarpment west of Matata
28	Bland L & Tresch	GEONET: monitoring New Zealand's natural hazards
29	**Johnson J et al.	Seismic anisotropy as an eruption forecasting tool at Mt Ruapehu
30	Kilgour et al.	The October 2006 eruption of Ruapehu crater lake
31	Lentfer	Engineering geology of the Northland Allochthon, Silverdale
32	**O'Keefe et al.	Microseismicity survey of the central Alpine Fault
33	Patterson et al.	Tsunami monitoring in real-time
34	Power	Response of Wellington Harbour to the 2007 Solomon Islands and Peru tsunamis
35	*Procter et al.	Simulation of the anticipated "breakout lahar" at Ruapehu using Titan 2D
36	*Robertson C & Glavovic	Integrating science into land use planning for volcanic hazards
37	**Robertson E de J et al.	Centroid moment tensor inversions from GEONET: local moment magnitude scale for NZ
38	Rosenberg et al.	Insights into 2006 Raoul Island eruption from deposit characteristics and eruption effects
39	**Walsh et al.	Bayesian methods of focal mechanism estimation

Geoeducation and General (talks on Wednesday)

40	Coomer & Johnston D	Emergency management in schools
41	Machin	Geophysical exploration

Tectonics and Basins (talks on Wednesday and Thursday)

42	Adams et al.	Kaweka Terrane: status and extent within the North Island basement
43	*Bassett D et al.	Geophysical analysis of the crustal transition from East Cape to offshore Raukumara Basin.
44	**Brikke & Stern	Seismic velocity structure of shallow Alpine Fault and gravity study of Whataroa flood plain
45	*Carne et al.	Refined history of surface rupturing earthquakes and slip rates on southern Wairarapa Fault
46	Edbrooke & Brook	QMAP Whangarei: the new 1:250 000 geological map of central Northland
47	Hill, M & Little	3D deformation history of quartz veins exhumed from deep brittle-ductile shear zones
48	Jung & Jang	Shallow subsurface S wave velocity structures of the Korean Peninsula
49	Kear	Whakatane – astride north island geological movement for 25 million years
50	Kenny	JAFfA – just another fault for Auckland – a preliminary investigation of block faulting
51	*Murphy et al.	U-Pb dating of overgrowths on zircon from the Otago Schist
52	**Rajasekhar et al.	Seismic and petrofabric studies from Red Mountain, South Island
53, 54	Rattenbury et al.	QMAP 1:250 000 geological map of New Zealand: linking Cape Reinga to Stewart Island.
55	*Robertson J et al.	Shear zones and boundary layers: modelling of Alpine Fault mylonites
56	Samsonov et al.	Integration of GPS and differential INSAR data for derivation of high-res 3D velocity maps
57	Schioler & Roncaglia	Great South and E Coast Basins: Tartan and Waipawa formations as equivalent source rocks
58	**Scholz & Smith	Application of a spatio-temporal seismicity model to the Vrancea seismic zone, Romania
59	Toy et al. (Norris)	Rheological evolution of fault rocks along a retrograde PT path – the Alpine Fault mylonites
60	Verdier et al.	Quantitative analysis of backscatter data characterise Cook Strait seafloor physical properties
61	Wada et al.	Modeling the thermal regime of the Hikurangi subduction zone
62	*Ewen et al.	Miocene cold-seep limestones, Raukumara Peninsula: evidence for past seabed hydrocarbon seepage
63	Hood et al.	Towards paragenesis of Miocene cold-seep carbonate deposits, southern Hawkes Bay
64	Pearson, M et al.	Lipids in tubular concretions from NZ petroliferous basins: involvement of anaerobic methane oxidation

Presenting author is underlined, * = GSNZ student, ** = NZGS student.

ABSTRACTS

in alphabetical order by first author

The bibliographic reference for abstracts is:

Author, A.N. (2007). Title of abstract.
Geological Society of New Zealand Miscellaneous Publication 123A: p.

THE KAWEKA TERRANE: STATUS AND EXTENT WITHIN THE NORTH ISLAND BASEMENT

Chris Adams, Hamish Campbell, Nick Mortimer
GNS Science, n.mortimer@gns.cri.nz

A revised terrane map is presented here showing the Kaweka terrane, a newly recognised unit in the Torlesse composite terrane. Kaweka terrane is made up of greywacke dominated sedimentary rocks, with complex structures and no recognisable stratigraphic formations. The main basis for its establishment are (i) areal extent; (ii) characteristic zircon age patterns that are different from other terranes; (iii) uniformity of petrofacies and Sr isotopic character; (iv) observed and/or inferred fault/melange bounded nature. Kaweka terrane lies along the entire eastern side of Taupo Volcanic Zone and underlies the Ikawhenua, Ahimanawa, Kaimanawa and Kaweka Ranges, and much of the Ruahine Range. Parts of it were formerly regarded as being part of the Rakaia and Pahau terranes.

It is remarkable for being unfossiliferous. However, higher grade metamorphic correlatives (Kaimanawa Schist) have ages that set an Early Cretaceous minimum for deposition. Detrital zircon U/Pb ages indicate maximum ages of Early and Middle Jurassic, thus it cannot be regarded as part of the Pahau (Cretaceous) or Rakaia (Permian and Triassic) terranes. Petrographic and geochemical characters suggest a provenance similar to the rest of the Torlesse composite terrane. The Kaweka terrane rocks thus appear to fill an apparent biostratigraphic gap, i.e. Early to Middle Jurassic, previously recognised within the Torlesse Supergoup (Torlesse composite terrrane). However, the Sr isotope patterns are relatively unradiogenic and quite similar to those of the southern part of the Waipapa terrane west of Lake Taupo.

The identification of the Early-Middle Jurassic Kaweka terrane in the North Island raises the possibility that similar rocks yet remain to be discovered in the Torlesse composite terrane of the South Island. New research is at present investigating some possible correlatives in north Canterbury.

TRACE ELEMENT CHARACTERISATION OF QUATERNARY SILICIC TEPHRAS FROM ODP SITE 1123: CHRONOSTRATIGRAPHIC AND PETROGENETIC IMPLICATIONS

Aidan Allan[1], Joel Baker[1], Lionel Carter[2] & Richard Wysoczanski[1]
[1,2] School of Geography, Environment and Earth Sciences and Antarctic Research Centre, Victoria University of Wellington (Aidan.Allan@vuw.ac.nz)

Ocean Drilling Program Site 1123, situated *ca*. 1000 km east of New Zealand, recovered a near complete history of large-volume rhyolitic eruptions sourced from the Taupo Volcanic Zone (TVZ). Tephras preserved in well dated sediments from Site 1123 can potentially be correlated to onland deposits and also pre-date the exposed volcanic record in the TVZ, allowing a more complete history of large-volume, explosive, silicic volcanism to be reconstructed and linked to high resolution climatic records. Chronostratigraphic correlations of widely dispersed tephras are typically made using major element chemistry, but such correlations are hindered by a lack of major element variability in many silicic magmas, meaning that unequivocal correlations can be difficult to establish. However, trace element concentrations in silicic magmas can vary greatly as a result of varying degrees of crustal assimilation and fractional crystallisation, and offer greater potential for unambiguous correlations to be made. Microanalytical techniques such as wavelength-dispersive electron microprobe analysis and laser ablation inductively coupled plasma mass spectrometry applied to individual glass shards as small as 40 µm in size allow a full range of major and trace element data to be obtained on multiple shards from individual tephras. These data can be used for both chronostratigraphic purposes and also to examine the heterogeneity of magmas erupted during single and related eruptive events in order to elucidate the processes responsible for silicic magma generation.

Here, we present preliminary major and trace element data for Quaternary tephra deposits at Site 1123. Results show that the geochemical fingerprints of individual tephras can be used to critically evaluate the stratigraphy of the Site 1123 composite core. Incompatible trace element ratios (e.g., Sr/Y, Zr/Th) and chondrite-normalised REE diagrams are powerful discriminators of tephras, even for tephras that exhibit similar major element chemistry. The trace element record shows that some individual tephras have previously been included in the composite record more than once. In particular, where the composite benthic oxygen isotope curve for Site 1123 shows a poor correlation between *ca*. 1.2 to 1.4 Ma with other Southern Hemisphere records, the trace element chemistry of several tephras indicate that this is due to a previously unrecognised repeated section of ~ 4 m in the 1123A and 1123C cores. The petrogenetic origin of TVZ rhyolites is still a matter of debate, with fractional crystallisation from a mafic parent and partial melting of meta-sedimentary crustal rocks being the end-member models. Strong negative correlations between fractionation indices such as Rb/Sr and compatible trace elements observed in some individual tephras illustrate the dominance of crystal fractionation processes during magma evolution. However, many tephras exhibit strong positive correlations between compatible and incompatible trace elements (e.g. Sr vs Pb) which cannot be generated solely by fractional crystallisation and require mixing between two or more discrete batches of magma that have experienced differing amounts of crustal assimilation and/or a crustal melt.

TALK – Tue pm

HIGH PRECISION NICKEL ISOTOPE MEASUREMENTS OF FE-NI METAL IN METEORITES FROM THE CORES OF ASTEROIDS

Kim T. Andrews, Martin Schiller and Joel A. Baker
School of Geography, Environment and Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand (kimtandrews@gmail.com)

Nickel has five isotopes (58, 60, 61, 62 & 64) and is potentially a powerful early Solar System chronometer and tool to identify the astrophysical setting in which our Solar System formed. Variations of ^{60}Ni abundances in meteorites might result from the decay of short-lived ^{60}Fe ($t_{1/2}$ = 1.49 Myr), if ^{60}Fe was injected by a supernova into the proto-Solar System shortly before or during Solar System fomation. Furthermore, variations in the abundances of the two neutron-rich Ni isotopes, ^{62}Ni and ^{64}Ni, in meteorites may also be a powerful tracer for different stellar nucleosynthetic inputs into the proto-Solar System and time-scales of mixing of different nucleosynthetic components in the proto-planetary disc. Recently published Ni isotope data for meteorites has produced conflicting results [1,2,3]. [1] and [2] found no evidence for measurable Ni isotopic anomalies in the Fe-Ni metal of iron and pallasite meteorites, which represent the metal cores and core-mantle boundaries of the Solar System's oldest planetesimals. In contrast, [3] reported deficits in ε^{60}Ni and ε^{62}Ni of 0.24 and 0.69 epsilon units, respectively, and concluded that ^{60}Fe was injected into the Solar System just after its formation, and that ε^{62}Ni deficits reflect preservation of Ni nucleosynthetic anomalies on a planetary scale in the Solar System. These results suggest that stellar winds from a massive Wolf Rayet star caused collapse of the cloud of dust and gas from which our SS formed and that 1 Myr after Solar System formation this star underwent a supernova which injected ^{60}Fe into the Solar System.

We have developed methods for separation of Ni from Fe-Ni metal and high-precision Ni isotopic analysis by multiple-collector inductively coupled plasma mass spectrometry at VUW. Fe-Ni metal from the pallasites Esquel and Brenham was digested and subjected to a 2-step column chemistry following the methods of [3]. Ni cuts for iron meteorites Esquel, Arispe and Mundrabilla that were analysed and reported in [3] were also analysed. Some analyses were carried out in pseudo-high resolution allowing complete resolution of all interferences with the exception of Ni-Fe hydrides. ε^{60}Ni ranges from +0.030 to -0.089 although the analyses of the 4 pallasites and irons are barely statistically resolvable from one another. ε^{62}Ni ranges from +0.107 to -0.042, although ε^{62}Ni for all 4 irons and pallasites are identical within analytical uncertainty, yielding an average for all samples of ε^{62}Ni = +0.060 ± 0.073. However, the two irons may have ε^{62}Ni values that are marginally higher (0.100 ε units) than the terrestrial standard. The preliminary results of this study differ markedly from those of [3], which reported a significant deficit for ε^{60}Ni and large negative ε^{62}Ni values for irons and pallasites. Thus, the data produced in this study does not clearly reveal significant deficits in ^{60}Ni that might be attributed to a late (or early) supernova ^{60}Fe input into the young Solar System, or large ^{62}Ni variations in irons and pallasites that are significantly different from Earth that might represent preservation of Ni nucleosynthetic variability on a planetary scale in the Solar System.

References: [1] Quitte G. et al. (2006) *Earth Planet. Sci. Lett. 242*, 16-25. [2] Cook D.L. et al. (2006) *Anal. Chem. 78*, 8477-8484. [3] Bizzarro M. et al. (2007) *Science 316*, 1178-1181.

POSTER 7

CONTROLS ON SLOPE FAILURE AND EROSION IN WEAK ROCK TO STRONG SOIL IN THE COASTAL ESCARPMENT WEST OF MATATA, NEW ZEALAND

James M. Arthurs[1], Warwick M. Prebble[1], & Colin J.N. Wilson[1]
Inst. of Earth Science and Engineering, and Geology Prog., SGGES, Univ. of Auckland
j.arthurs@auckland.ac.nz

Landslides and high rates of erosion along cliffs of the coastal escarpment west of Matata, New Zealand, have frequently affected a major transportation corridor, which includes Highway 2, the railway from Kawerau to Mt. Maunganui, and properties. The cliffs are primarily composed of marine and terrestrial fluvial sediments (silts, sands, and gravels) and pyroclastic deposits (tephras and ignimbrites). In engineering terms these are described as stiff clayey silts, compact sands and gravels, and loose to compact pumice gravels. These weak and erodible deposits are highly susceptible to failure during intense and prolonged rainfall events, such as those of May 2005, which caused rock fall, debris avalanches, piping, and rilling. Each of these failure mechanisms is caused by different combinations of material properties and exposure, and each process in turn promotes specific hazard conditions.

Rockfall occurs when a stiff clayey silt (or very weak siltstone) is present above a highly erodible sand, especially where this sand is subjected to stream flow. This can also occur in locations where the sand is exposed to intermittent flow such as road side drainage channels. This failure style requires a relatively strong stratum to be exposed above a relatively weak stratum.

Debris avalanches occur in unconsolidated and weakly to nonwelded pyroclastic deposits exposed near the top of the cliff section. Initial failures near the top of the cliff occur in response to heavy precipitation. The flow moves down the slope and entrains further soil and plant debris. Finally, the debris avalanche stops moving as the slope gradient flattens.

Piping failures occur in locations with highly permeable (unconsolidated, nonwelded) pyroclastic material overlying low permeability paleosols and other clay-rich deposits. When paleotopography concentrates groundwater flow, excess pore pressures can develop during intense precipitation events. Once the pore pressures exceed the material strength, failure occurs.

The final type of failure is rilling. This occurs in locations where overland flow of intermittent streams is concentrated onto a narrow band of unconsolidated pyroclastic material. The material is easily entrained by flow causing the formation of a deeply incised rill. While this is not a catastrophic failure, the higher rate of erosion could threaten properties above these landforms.

POSTER 27

CRUSTAL IMAGING USING EARTHQUAKE WAVEFORMS FROM THE 2005-2007 MATATA (BAY OF PLENTY) EARTHQUAKE SEQUENCE.

Stephen Bannister[1], Martin Reyners[1], John Louie[2], Brad Scott[3] & John Ristau[1].

[1]GNS Science, Avalon
[2]Seismological Laboratory 174, University of Nevada, Reno
[3]GNS Science, Wairakei
s.bannister@gns.cri.nz

Our ability to accurately locate crustal earthquakes has markedly improved with improvements in the density of the Geonet seismograph network, and with new approaches for relative earthquake location, using cross-correlation analysis and double-difference location techniques. If these approaches are applied to earthquake swarms, such as often occur in the Taupo Volcanic Zone, waveforms from closely-related earthquakes can be subsequently used for crustal imaging, once errors in relative locations are much less than the shortest seismic wavelength. Here we examine waveforms from more than 700 earthquakes (2 < ML < 4) in the 2005-2007 Matata (Bay of Plenty) earthquake sequence to image nearby crustal structure. We relocate the sequence using both absolute and waveform-based differential time measurements, simultaneously inverting for local velocity structure using double-difference tomography. The relocated events are clearly aligned c.NE-SW (strike 35 degrees) on several sub-parallel planes, with events clustered at 2-6 kms depth, just northwest of the rupture area of the 1987 Mag 6.2 Edgecumbe earthquake and southwest of deep 'bright spot' seismic reflections observed at 10-11 km depth. Super-receiver gathers of the earthquake waveforms, processed using coherency and frequency filtering, show secondary phases out to 110 km+. Coherent phases are observed in the S-wave coda, 2-4 seconds after direct S, especially at offsets between 23 and 52 km. These phases may relate to lower crustal changes in S-wave reflectivity associated with intrusions, or to surface reflections. Possible interpretations are being investigated using elastic wave finite difference synthetics and observed 3-component data.

KEYNOTE TALK – Thu am

REGIONAL THRUST TECTONICS, SUBDUCTION PROCESSES, AND GAS HYDRATES IN THE CENTRAL HIKURANGI MARGIN: PRELIMINARY RESULTS OF RV SONNE CRUISE SO-191 LEG 1 2007

Philip Barnes[1], Geoffroy Lamarche[1], Jeorg Bialas[2], Ingo Pecher[3], Gareth Crutchley[4], Stuart Henrys[5], Jens Greinert[5]

[1] National Institute of Water and Atmospheric Research (NIWA), PO Box 14901, Kilbirnie, Wellington, New Zealand
[2] IFM-GEOMAR, Leibniz-Institut fuer Meereswissenschaften, Wischoftsr. 1-3, 24148 Keil, Germany
[3] Heriot-Watt University, Edinburgh, EH14 4AS, United Kingdom
[4] University of Otago, PO Box 56, Dunedin 9015, New Zealand
[5] GNS Science, PO Box 30-368, Lower Hutt
(p.barnes@niwa.co.nz)

The central part of the Hikurangi subduction margin is a wide imbricate thrust wedge undergoing frontal accretion. Bottom simulating reflectors indicative of gas hydrates are widespread, as is evidence of fluid seepage and associated biological communities. In January to March 2007, three legs of the German voyage *Sonne* SO-191 were completed as part of a multi-national, multi-disciplinary programme to study the tectonic structure, fluid flow, methane transport and flux, and the geological and biological characterisation of cold vents and gas hydrate deposits along the margin. The survey programme focused on four key sites, from offshore Mahia to southern Wairarapa. The geophysical leg (Leg 1) of the survey, also provided an opportunity to acquire eight new regional multichannel seismic reflection profiles across the central margin. These profiles were planned to integrate with recent seismic data acquired by GNS Science and the Ministry of Economic Development. Preliminary interpretations of the regional lines will be presented here.

The seismic reflection profiles are of good quality, particularly across the accreted trench-fill sequence, and typically image c. 3.5 s two-way travel (c. 4-5 km) beneath the seafloor. The main interplate thrust is imaged as a décollement between the subducted sequence and the accretionary wedge, to about 35-40 km down the dip of the subduction zone. A significant tectonic buttress is identified beneath the mid-slope, separating the deforming upper margin from a young accretionary wedge. The major structures include forward- and back-verging thrusts, and a spectacular zone of incipient protothrust deformation up to 25 km wide occurs across the principal deformation front. These latter structures have been recognized in previous surveys, but not with such clarity. The data offer excellent potential to determine rates of tectonic shortening across the outer part of the subduction zone, through balancing of the depth converted seismic sections. Two profiles also cross a 70 km long seamount ridge that is entering the subduction zone in the centre of the margin, and provide insights into the early deformation effects of subducting seamounts on accretionary wedges. The dataset as a whole, combined with existing data, will enable improved imaging of a fundamental lateral tectonic transition from predominantly frontal accretion in the central Hikurangi margin to predominantly tectonic erosion in the north.

TALK – Thu pm

GEOPHYSICAL ANALYSIS OF THE CRUSTAL TRANSITION FROM EAST CAPE, NEW ZEALAND TO THE OFFSHORE RAUKUMARA BASIN.

D. Bassett[1], T. Stern[1], R. Sutherland[2] and S. Henrys[2]
[1] Victoria University of Wellington
[2] GNS Science
Corresponding author: Dan.Bassett@vuw.ac.nz

The Raukumara Basin within the forearc of the Hikurangi subduction zone contains one of the thickest sedimentary packages among New Zealand basins. It is relatively unexplored and both the hydrocarbon potential, and tectonic processes which lead to its formation remain unexplained. Positioned within the transition zone from oceanic-oceanic to oceanic-continental subduction; the Raukumara basin is optimally located to test both the tectonic implications of this transition, and the recently proposed link between forearc basins characterised by large gravity lows and subduction erosion.

This study will be part of a joint collaboration between GNS Science, IFM-GEOMAR (Germany), and VUW. A mix of seismic reflection, refraction and wide angle data were collected off East Cape in March-April 2007 and this survey was followed by acquisition of a larger industry standard seismic reflection data set by Crown Minerals (MED) in the same region. A subset of these data sets will be used to ascertain the nature of the crustal transition between the East Cape and the Raukumara Basin.

Understanding the thickness and nature of the crust beneath the Raukumara Basin will lead to better understanding of both the resource potential of the region and possible hazards linked to subduction zone earthquakes. These data may also facilitate investigation into the active tectonic evolution of the basin which may place constraints on the age and origin of the sediment it contains.

POSTER 43

CONTINUOUS DEFORMATION MAP OF NEW ZEALAND FROM ACTIVE FAULTING

J. Beavan[1], **M. Haines**[1,2], **N. Litchfield**[1], **R. Van Dissen**[1], **P. Barnes**[3], **J. Haines**[2]

[1]GNS Science, [2]Cambridge University, [3]NIWA
(j.beavan@gns.cri.nz)

A map of the long-term deformation of New Zealand has been generated by fitting a continuous strain-rate field to strain-rate data derived from both onshore and offshore active fault information. The source for onshore active fault data is the GNS active faults database; for offshore faults we use published and unpublished NIWA data from the Fiordland, Cook Strait and Hikurangi Margin regions. The data that we model consist of: (1) the locations of fault traces; (2) numerical estimates of dip and slip direction for each fault segment, or the general style of the faulting if numerical values are not known; and (3) slip rates where these are known. Uncertainties on all these parameters are also included in the modelling.

The country is divided into a grid with 5-10 km dimensions, and the strain-rate tensor within each element is calculated by Kostrov summation of the strain rates of all fault segments passing through that element. A covariance matrix is calculated from the estimated uncertainties of the active faulting data, making allowance for faults that pass through multiple grid elements. A background strain-rate variance is added to all grid elements to allow for missing faults or off-fault deformation. The background variance can also be varied from place to place to allow some areas to deform more easily than others. A continuous strain-rate field is then fit to these data under a thin-sheet approximation, optionally applying Australia-Pacific relative plate-motion at the boundaries of the model. The spatial resolution of the model is on the order of the crustal thickness, ~15 km.

Differences between the input and output strain-rate fields highlight regions where the active faulting data are inconsistent, or the assumptions of the model are inaccurate. For example, strain rates do not match well at the junction between the Alpine Fault and the Marlborough faults, suggesting that estimated rates are too high on the Marlborough faults or that deformation within the Southern Alps is missing from the model. Some normal faults, such as those in southern Taranaki, are inconsistent with the model, presumably because these are essentially surface features associated with uplift rather than being crustal-scale faults as assumed by the model.

The long-term (ca 10-100 ka) deformation pattern from active fault data can also be compared with the short-term (ca 10-15 yr) deformation rates from GPS. These comparisons highlight regions where the present-day strain-rate field is dominated by elastic deformation. They may also highlight regions, both onshore and offshore, where further work is needed to understand and interpret the discrepancies between the short-term and long-term rates.

KEYNOTE TALK – Wed pm

RANGITAIKI PLAINS: ANOTHER VEIL IS LIFTED. NEW LIDAR DATA FROM BAY OF PLENTY, NEW ZEALAND

J.G. Begg[1] **& V. Mouslopoulou**[2]
[1]GNS Science, PO Box 30-368, Lower Hutt
[2]Fault Analysis Group, School of Geological Sciences, University College Dublin
j.begg@gns.cri.nz

The Rangitaiki Plains extend across one of the world's fastest spreading areas, the Taupo Rift near where it is intersected by the active strike-slip North Island Fault System in the Bay of Plenty. The tectonic activity of the region was emphatically illustrated by the 1987 Edgecumbe earthquake (M_w 6.3), when a number of northeast-striking normal faults ruptured. However, the scarcity of surface fault traces within the plains in comparison with other parts of the rift, onshore and offshore, has long been puzzling.

High resolution LiDAR data (vertical resolution of <0.1 m) collected recently across the plains by Environment Bay of Plenty Regional Council reveal vivid topographical images of tectonic features that conventional datasets (i.e., topographic maps, aerial photograph analysis, field mapping) can not resolve. Derivative images reveal numerous previously unrecognised fault scarps in a density that matches that of faults in the Taupo Rift elsewhere. Active faults previously mapped to the southwest and northeast (offshore) can now be aligned with identifiable scarps across the plains.

The Edgecumbe Fault, which is the most significant tectonic feature on the plains, can now be extended both southwest and northeast of the 1987 rupture. Scarp height measurements obtained at various locations along the fault exceed slip values of the 1987 earthquake, supporting the inference that the scarp records multiple surface rupturing events since deposition of the Taupo pumice alluvium (< 1.8 ka).

A series of discontinuous beach ridges are preserved between the coast at Whakatane and the stranded early Holocene sea cliffs near Awakeri (9.5 km to the south). The Edgecumbe Fault truncates these beach ridges. Topographic profiles obtained along and across the beach ridge crests indicate that this block of land has suffered only minor vertical deformation during the last 5.2-7.5 ka.

Similar beach ridge sequences are not present northwest of the Edgecumbe Fault, where they are probably buried beneath a blanket of redeposited pumiceous alluvium and peat. The average elevation of beach ridge crests deposited at the coast today is 5-7 m. The minimum elevation of the Rangitaiki Plains is 1.5 m below sea level, just 2.6 km south of the coast near the Rangitaiki River. Combining these data, we derive a net value for subsidence since deposition of Kaharoa pumice alluvium.

The presence of multiple fault traces that displace Taupo and Kaharoa alluvial deposits across the Rangitaiki Plains suggest therefore that Edgecumbe-like earthquakes are more frequent than previously inferred.

AMBIENT NOISE IMAGING OF NEWZEALAND'S GEOLOGICAL ROOTS

Y.Behr[1] & J. Townend[1] & M. Savage[1] & S. Bannister[2]
[1]Victoria University of Wellington, PO Box 600, New Zealand
[2]GNS Science, Lower Hutt, New Zealand
yannik.behr@vuw.ac.nz

We use seismic noise recorded on permanent and portable broadband seismometers to determine the shear wave structure of the crust and upper mantle. As shown in a pilot project by Lin et al. (2007) the velocity-distribution of seismic surface waves in New Zealand can be extracted from information that is contained in the seismic noise. To obtain this information a recently developed and tested method called "ambient noise tomography" is used, which is based on the idea that coherent parts of seismic noise mainly correspond to surface waves generated by coupled oceanic and atmospheric processes. Comparing noise recordings of the same time period at two seismological stations by cross-correlation yields a reliable measurement of a surface wave travelling between those two stations. This gives us the possibility to determine surface wave dispersion curves and hence to perform a tomographic inversion from the group velocity measurements at each period.

The resolution of the resulting tomographic maps mostly depends on the distribution and density of inter-station paths. Thus one aim of this study is to incorporate data from temporary seismometer deployments as well as longer time-spans of data from permanent seismological stations in order to increase the resolution. Later the surface wave dispersion curves shall be inverted to 1-D and 3-D shear wave velocity models.

We inverted surface waves travelling between two stations of the temporary deployment NORD on the Northland peninsula. The preliminary results show a relatively thin crust of 22 km to 26 km. Crustal thickness as well as upper mantle and crustal velocities correspond well to an earlier study on joint inversion of surface waves and receiver functions in this region by Horspool et al. (2006).

TALK – Wed pm

LOWER CRUST – UPPER MANTLE STRUCTURE AND BRIGHT REFLECTORS UNDER THE TAUPO VOLCANIC ZONE

A.M. Benson[1], **T.A. Stern**[1] **& S. Bannister**[2]
[1]School of Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington.
[2]GNS Science, Lower Hutt.
(adrian.benson@vuw.ac.nz)

One of the unresolved aspects of the Taupo Volcanic Zone is the composition of rocks between 20 -35 km depth and whether these rocks are upper mantle or have been accreted to the lower crust. The NIGHT experiment (2000-2001) recorded unusually strong reflections from interfaces at ~20 and ~35 km depth (hereafter PmP_1 and PmP_2 respectively). Stratford & Stern (2004; 2006) interpreted the PmP2 reflections as being from an intra-mantle melt body, whereas Harrison & White (2004) concluded that the PmP2 interface is the continental moho. The MORC experiment has been designed to augment the NIGHT results by providing high-density seismic reflection/refraction data through the central TVZ, allowing us to characterise the PmP_2 reflector and resolve whether continental crust in the TVZ is being thinned or thickened in response to back-arc extension. Spatial variability of PmP_2 amplitudes indicate that the reflector is limited in width and has strong amplitude variation with offset (AVO) properties. Velocity modelling and ray-tracing of the MORC data constrain the PmP_2 reflector to be an isolated body at 30-35 km depth directly beneath the TVZ. The reflector has a lateral extent of ~35 km, but may be < 20 km wide once Fresnel-zone effects are allowed for. PmP_2 arrivals are not observed for source-receiver offsets < 40 km, whereas at offsets > 70km PmP_2 are up to 10 times stronger than PmP1 arrivals. Modelling of the relative AVO properties of PmP_2 and PmP_1 arrivals indicates that the PmP_2 could be produced by an interface across which there is either a very large decrease in Vs (i.e. an increase in fluid content/partial melt) or an > 1 km/s increase in Vp (i.e. decrease in temperature). These results suggest that the PmP_2 reflector is not the continental Moho as such. We infer that the reflector is a body of increased partial melt accumulated within the upper mantle or at the base of an otherwise seismically unreflective moho.

TALK – Thu am

A QUARTER CENTURY OF TECTONICS IN THE TAUPO RIFT (TAUPO VOLCANIC ZONE); A PERSONAL VIEW

Kelvin Berryman
GNS Science, PO Box 30368, Lower Hutt. k.berryman@gns.cri.nz

My professional introduction to the TVZ was with an eye to tephra under Colin Vucetich's unique instructional style. Tectonics didn't figure prominently in those days but tephra remains a crucial age tool in tectonic geology. From July 1983 (the earthquake swarm and associated minor faulting) interest in tectonics in the TVZ, actually the Taupo Rift from a tectonic standpoint, has been ever increasing. In 1984 a strand of the Paeroa fault was trenched as part of the natural gas pipeline construction, and then in March 1987 the Edgecumbe earthquake and associated rupture of the Edgecumbe and related faults, really captured our attention. The 1987 event in itself generate significant new knowledge and further enquiry of active faults, but damage to the Matahina Dam in the earthquake began a significant consultancy thread to Rift studies. Seismic stability reviews of all the Waikato River hydro-facilities have followed. These studies, coupled with an increasing tectonic research effort, high resolution GPS surveys from the early 1990's, university research, and increasingly improved geophysical and marine datasets, have all contributed to an explosion of interest in Rift tectonics.

For me, some important results to date include:
(1) most of the major faults of the Taupo Rift rupture have millennial repeat times with up to a few metres of surface displacement (1987 faulting at Edgecumbe is typical); **(2)** secondary faulting and triggered slip of mm-decimetre scale is very common on nearby faults; **(3)** offshore studies of the Rift have been spectacularly successful, and have provided insights to Rift evolution (fault growth especially) that are hard to replicate on land; **(4)** through the mid-late Quaternary there is a migration of faulting away from the northwestern side of the older Rift toward the centre or southeast side; **(5)** there has been episodic lengthening of the Rift, with formation of the Tongariro domain in only the past few hundred kyr, perhaps, or probably, consequent on the massive Whakamaru and associated ignimbrite eruptions; **(6)** faulting is a relatively common in association with volcanism – in some cases apparently leading and in other cases during, the eruptive event; **(7)** the Rift is segmented, with parallel-sided segments with constant extension rate, but overall extension diminishes southward, to achieve the overall "fan-shaped" extension.

Current hot topics, in my view, include:
(1) what are the kinematics and strain fields between Rift segments to achieve significant reductions in extension rate southward? **(2)** what is the nature of the eastern margin of the Rift in the east Taupo-Kawerau sector? **(3)** is Rift propagation a continuous or episodic process? **(4)** is clustering a marked phenomena of surface faulting in the Rift, suggestive of episodic tectonic or tectonic/volcanic crises? **(5)** what is the nature of, and mechanisms controlling, volcano-fault interactions, and can physical understanding of processes lead to some predictive capacity? **(6)** can integration of geophysical, geochemical, geodetic, and geologic data lead to a quantitative understanding of how volcanism, faulting, and aseismic processes, in space and time, accommodate the underlying tectonic rifting process.

IRON-RICH CLINKERS PRODUCED BY SPONTANEOUS COMBUSTION AND INDUSTRIAL BURNING OF ROTOWARO COAL : IMPLICATIONS FOR THE MOBILISATION AND CONCENTRATION OF IRON

Philippa Black[1], Mike Hall[2] & Naze Masalehdani[3]
[1] Geology SEGGS, University of Auckland, Private Bad 92019, Auckland
[2] Solid Energy New Zealand Ltd, Rotowaro Office, Huntly
[3] Sciences de la Terre, PBDS, Université de Lille1, 59655 Villeneuve d'Ascq, France.

A common phenomenon associated with spontaneous combustion of coal and the pyrometamorphism of adjacent clay-rich coal measures is iron-enrichment of the baked and fused sediments. Magnetite, or less commonly haematite-rich "clinkers" and "slags", and iron-rich "paralavas" have been described from many localities around the world but the source of the iron and the mechanism by which it is mobilised and concentrated is not understood.

Subbituminous Rotowaro coals are noted for their propensity to spontaneously combust and thus produce good examples of natural slags and fused sediments in which magnetite, fayalite, orthoferrosilite, anorthite, cristobalite and tridymite are the most common minerals. Studies of the mineral assemblages provide temperature estimates for reactions in the range of 1,000 to 1427 degrees C which is close to the measured ash fusion temperatures for Rotowaro coals.

We have also examined clinkers from industrial - scale boilers burning Rotowaro coal. Rotowaro coals as supplied to these industries are low ash and hence most of the material in the clinkers must have been derived from the "ash" content of the coal itself. The clinkers also have iron-rich mineral assemblages, dominated by magnetite, fayalite, orthoferrosilite, and anorthite, similar to those in the natural clinkers.

We suggest that the source of the iron in both the natural and artificial clinkers is largely derived from the coal itself, and that the iron is mobilized at high temperatures during the combustion process.

TALK – Wed am

LATE NEOGENE BIOFACIES IN CENTRAL HAWKE'S BAY: SEQUENCE STRATIGRAPHIC AND PALEOGEOGRAPHIC IMPLICATIONS

Kyle J. Bland[1,2], Austin J.W. Hendy[3], Peter J.J. Kamp[1], & Campbell S. Nelson[1]

[1]Dept. Earth and Ocean Sciences, Univ. of Waikato, Private Bag 3105, Hamilton, NZ
[2]GNS Science, PO Box 30-368, Lower Hutt 5040, NZ
[3]Dept. of Geology, University of Cincinnati, Cincinnati, OH 45221-0013, USA
k.bland@gns.cri.nz

Macrofossil biofacies have proven to be useful aids in identifying paleoenvironments within depositional systems. The lateral and vertical distributions of molluscan macrofaunal associations allow sequence architecture and stacking patterns to be assessed, and controls to be placed on magnitudes of sea-level fluctuations. Macrofaunal data utilised in this study were acquired during fieldwork at outcrops (over 310 field observations, providing semi-quantitative abundance, and presence-absence data), or in the laboratory from analysis of 112 bulk samples with census counts undertaken on molluscan macrofauna within them. Thirty macrofaunal associations and six subassociations have been differentiated for the Miocene to Early Pleistocene succession in central Hawke's Bay. Sixteen of these groups were defined from Q-mode cluster analysis, the remainder defined from field-based observations where bulk sampling was not possible or practical. Associations occurring in the shelfal Late Pliocene to Early Pleistocene part of the basin fill are the focus of this presentation.

Two major subsets can be delineated from the cluster analysis on the basis of abundance of the bivalve genera *Tawera* (typically RST-TST) and *Talochlamys* (HST). The *Tawera*-dominated subset contains three discrete clusters, two of which (*Tawera-Crepidula* and *Tawera-Patro* subassociations) typically occur in RST deposits, and the other (*Tawera* association) in TST deposits. The *Talochlamys*-dominated associations are typically present in HSTs.

The *Austrovenus* association contains diagnostic estuarine taxa, and is present only in TSTs deposited close to the highstand shoreline. Other shallow-water associations, such as the *Fellaster, Zethalia,* and *Paphies* associations, occur mostly in uppermost parts of RSTs, although may occasionally occur in TSTs. Associations characterised by the genera *Pratulum* and *Neilo* are normally restricted to lower parts of HSTs, representing maximum sea-level highstand. Other associations, such as the *Dosinia (Kereia), Ostrea, Atrina,* and *Maorimactra*, represent transitions from nearshore to outer shelf facies, both laterally and vertically within sequences. In TSTs, an across-shelf transition can be observed from the *Austrovenus* association, which passes into the *Ostrea*-glycymerid, *Ostrea-Purpurocardia, Eumarcia, Tawera,* and *Ostrea* associations.

The preservation of macrofaunal associations can also provide clues to their sequence stratigraphic positions. Many RST associations, such as the *Crepidula-Sigapatella* and *Tawera-Crepidula* associations, probably occupied sediment-winnowed environments. TST biofacies (e.g., *Ostrea* association) also relate to sediment-starved environments, whereas the low density of HST associations, such as the *Atrina, Dosinia (Kereia),* and *Pratulum* associations, indicates "normal" sedimentation during such times.

TALK – Tue pm

GEONET: MONITORING NEW ZEALAND'S NATURAL HAZARDS

L. Bland & **S. Tresch**
GNS Science, 1 Fairway Drive, Avalon, Lower Hutt
(l.bland@gns.cri.nz, s.tresch@gns.cri.nz)

New Zealand sits astride a major plate boundary system, in which the Australian plate and the Pacific plate are being driven together, creating subduction zones in the north and south of the country, and the strike-slip Alpine Fault along the South Island. This dynamic geological setting, in conjunction with the country's topography, makes the country vulnerable to a number of potentially disastrous natural hazards, including earthquakes, volcanism, landslides and tsunami. Operated by GNS Science and funded by the New Zealand Earthquake Commission (EQC), the GeoNet Project was set up in 2001 to provide real-time monitoring of these hazards. The project uses nationwide networks of seismograph and GPS stations to collect data on New Zealand's earthquake, strain, and deformation patterns. The completion of most of the core national monitoring networks in the last five years has improved the timing and accuracy of incoming data, and the project's focus has now shifted to the extension of regional seismic and GPS networks, the construction of a nation-wide tsunami gauge network and the development of data products to promote better uptake of this valuable resource. The data collected by the New Zealand GeoNet Project are fundamental to a better understanding of the natural hazards faced by this country and in turn, this knowledge will improve their detection and management. It is hoped that the dissemination of accurate and timely information by GeoNet will aid planning and community preparation before a disaster strikes, and facilitate effective emergency responses afterwards, speeding the subsequent recovery of affected communities.

SUBMARINE LANDSCAPE EVOLUTION IN RESPONSE TO SUBDUCTION PROCESSES, NORTHERN HIKURANGI MARGIN, NZ

K.L. Bodger[1], J.R. Pettinga[1] and P.M. Barnes[2]
[1]Dept. of Geological Sciences, Univ. of Canterbury, Christchurch, New Zealand
[2]National Institute of Water & Atmospheric Research, Wellington, New Zealand
k.bodger@geol.canterbury.ac.nz

The steep forearc slope along the northern sector of the obliquely convergent Hikurangi subduction zone is undergoing tectonic erosion in response to subduction of the unusually thick oceanic lithosphere of the Hikurangi Plateau studded with numerous seamounts.

The origin of the Poverty Bay Indentation is attributed to multiple seamount impacts, triggering numerous large-scale gravitational collapse structures, multiple debris flow and avalanche deposits, which range in down-slope length from a few hundred metres to more than 40 km. The indentation has also been simultaneously eroded by canyon systems. The indentation is directly offshore of the Waipaoa River which has a high sediment yield of 15 Mt/yr into the marine system. In Holocene times much of this sediment is trapped in depocentres on the Poverty shelf, while during lowstand cycles sediment bypasses directly into the head of the canyon and contributes significantly to continued modification of the indentation.

The Poverty Bay Indentation can be divided up into a series of morpho-structural domains reflecting contrasting effects of seamount subduction on the evolution of the margin and the re-entrant. North of the canyon system seamount impact has led to the development of an over-steepened margin with fault reactivation, inversion and over-printing, leading to very complex structural styles of deformation and geometry. There is evidence of an older, inactive thrust front buried beneath the upper and mid-slope basins. Beneath the mid-slope a subducted seamount is revealed by the presence of relief on the subduction interface and associated structural complexity in the over-riding wedge. The Poverty Bay canyon represents a structural transition zone coinciding with the indentation. The slope south of the canyon conforms more closely to a classic accretionary slope deformation style. Here backthrusts propagate from shallow levels, and inversion occurs in the mid slope and continental shelf basins. Prograding clinoforms in basin fill overlie a buried inactive thrust system beneath the shelf.

Interpretations indicate that: i) seamount impact significantly influences the structural evolution, and submarine geomorphology of the inboard slope of the Hikurangi subduction zone, including the generation of large-scale gravitational collapse features; ii) the large gully systems located at the upper shelf slope boundary represent the most likely source areas for the multiple mega debris flows recognised from seafloor morphology and in seismic sections; iii) there exists a complex interaction between the evolving thrust-driven submarine ridges, ponded slope basins and the structural geometry and evolution of the near-surface fault zones (imbrication); and iv) the submarine canyons may initiate complex patterns of fault zone segmentation and displacement transfer within the accretionary slope.

LASER ABLATION FORAMINFERAL Mg/Ca & OCEAN TEMPERATURES

Bolton, A.[1] & Marr, J.[1], Baker, J. [1], Dunbar, G.[2], Carter, L[2]. Bostock, H[3]. Crundwell, M[4]., Northcote, L[3].

[1]SGEES, [2]ARC, Victoria Univ. Wellington, PO Box 600, Wellington, New Zealand, [3]NIWA Ltd, Private Bag 14-901, Wellington, New Zealand, [4]GNS Science Ltd, PO Box 30368, Lower Hutt, New Zealand
annette.bolton@vuw.ac.nz

Mg/Ca values from foraminiferal shells are widely used as proxies for past ocean temperatures and numerous empirical calibrations between foraminiferal Mg/Ca and calcification temperature exist. However, these studies also highlight the species and in some cases regional and method specific nature of these calibrations.

Previous workers have typically analysed bulk shells in solution, whereas we employ Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) which has several advantages over solution methods. First, the high spatial resolution (25µm spot size) allows us to target individual foraminiferal chambers, thus avoiding some complications arising from the analysis of whole shells in solution (e.g. avoiding gametogenic calcite). Second, LA-ICPMS is "micro-destructive", with most of the shell preserved after analysis and thus available for other geochemical measurements (e.g. $\delta^{18}O$). Third, additional elements (e.g. Ba, Mn, Zn, Sr, Al) can be measured nearly simultaneously – data that can contribute to understanding Mg/Ca variability within shells as well as providing additional environmental information.

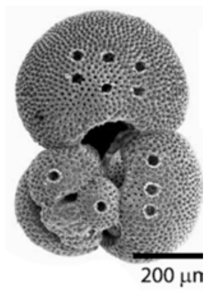


Fig. 1 Laser ablation sample holes made in *Globigerinoides sacculifer* (from Eggins et al. EPSL 2003).

Using LA-ICPMS, we have measured Mg/Ca in *Globigerinoides ruber, Neogloboquadrina incompta* (planktic) and *Uvigerina* (benthic) foraminifera from several South Pacific Ocean locations with widely differing water temperatures, leading towards an Mg/Ca paleo-water temperature calibration for this region. We aim to use this calibration to reconstruct ocean temperatures around NZ during "super-warm" encountered in the mid-Holocene, MIS-11 (~400 Ka) and MIS-31 (~1070 Ka).

Furthermore, our preliminary results from the analysis of individual chambers in shells from core top samples shows a wide range of Mg/Ca values, and thus temperatures (using published calibrations) within each sample. For example, Coral Sea *G. ruber* yields a mean temperature of 26.1ºC, but with outliers at 23.2ºC and 28.5ºC in the same sample. Similarly, *N. incompta* from east of New Zealand yield a mean temperature of 7.9ºC, with outliers at 2.0 and 15.1ºC, highlighting the possibility of extracting additional paleo-environmental (seasonality, ocean mixing) information from foraminiferal Mg/Ca.

Sample material was provided by National Institute of Water and Atmospheric Research (NIWA) and the Australian Institute of Marine Science (AIMS) and their assistance is gratefully acknowledged.

TALK – Tue am

GEOCHEMISTRY OF VOLCANISM IN THE MIOCENE-PLIOCENE HAURAKI VOLCANIC REGION, NORTH ISLAND

M.A. Booden[1*], **J.L. Mauk**[1], **R.M. Briggs**[2], **R.L. Brathwaite**[3]
[1] SGGES, University of Auckland, Private Bag 92019, Auckland 1142.
[2] Dept. Earth & Ocean Sc., University of Waikato, Private Bag 3105, Hamilton 3240.
[3] GNS Science, PO Box 30-368, Lower Hutt, 5040.
*corresponding author: m.booden@auckland.ac.nz

Early Miocene to Late Pliocene arc volcanism on the North Island was concentrated in the Hauraki Volcanic Region, comprising the Coromandel Peninsula, Great Barrier Island, the Hauraki Graben and the Hunua Ranges. Volcanism progressed from an early andesitic phase (18-10.5 Ma) to an intermediate phase with basaltic, andesitic and rhyolitic activity (10-4 Ma) and finally a period of mainly rhyolitic activity (4-2 Ma), followed by the transfer of activity to the presently active Taupo Volcanic Zone.
New trace element data on circa 200 rock samples covering the volcanic stratigraphy of the region shed light on the development of volcanism and relations between rock types. Basalts, andesites and minor dacites are characterized by typical medium-K, calc-alkaline arc-type major and trace element compositions with few significant differences between formations. A repeated trend towards more evolved magma composition over time is observed in both early and intermediate phase andesites, suggesting the existence of two spatially and temporally separate magmatic systems as opposed to continuous activity throughout the area. Interestingly, barium abundances indicate that intermediate-phase basalts and andesites are genetically related, while early-phase andesites seem to be derived from primary melts with a different starting composition, assuming no significant difference between the crustal sections underlying the respective areas. This suggests a change in the nature of the subduction system around 10.5 Ma.
Rhyolite trace element compositions suggest derivation by partial melting from an andesite-like source rock. Different centres, and different eruption sites within some centres, each have distinct trace element characteristics, suggesting the source is heterogeneous. This source is likely to be the meta-sedimentary greywacke basement or the lower crust, rather than the compositionally homogeneous contemporaneous andesites.

TALK – Tue am

USING CARBON ISOTOPES TO TRACE INTERMEDIATE WATERS, PAST AND PRESENT, IN THE SOUTH PACIFIC

Helen Bostock[1], Bradley Opdyke[2]
[1]NIWA, Greta Point, Wellington, New Zealand
[2]Department of Earth and Marine Sciences, Australian National University, Canberra, Australia

The carbon isotopic composition of dissolved total inorganic carbon (TIC) in the ocean is influenced by three factors 1) air-sea exchange, 2) biological productivity and 3) ocean circulation. It is important to understand the modern distribution of the $\delta^{13}C_{TIC}$ in the oceans as $\delta^{13}C$ in fossil foraminifera in marine sediment cores are a major tool for reconstructing oceanic circulation and variations in the carbon cycle in the past.

We have used data from the World Ocean Circulation Experiment (WOCE) to look at the modern distribution of $\delta^{13}C_{TIC,}$ and a number of other geochemical tracers, to understand the circulation of Antarctic Intermediate Waters (AAIW) of the south Pacific. The intermediate waters show a broad range in $\delta^{13}C_{TIC,}$ which makes this an ideal tracer for ocean circulation.

The modern data is compared to $\delta^{13}C_b$ measured on benthic foraminifera, *Cibicidoides spp.* from a sediment core in the Tasman Sea to look at changes in the AAIW over the last 30 kyr. The $\delta^{13}C_b$ data highlight changes in the AAIW over the last glacial/interglacial cycle, which suggest the intermediate waters may have been a more dominant water mass during the last glacial maximum and may have played a considerable role during the deglaciation.

CRUST AND MANTLE STRUCTURE ACROSS SOUTHERN SOUTH ISLAND FROM P, S, SKS TELESEISMIC RECEIVER FUNCTIONS

S. Bourguignon[1], M.K. Savage[1] & T.A. Stern[1]
Institute of Geophysics, Victoria University of Wellington, PO Box 600, Wellington
sandra.bourguignon@vuw.ac.nz

Along-strike variations of lithospheric deformation within the South Island oblique collision region are not well understood or constrained. For example, crustal deformation extends at least twice as far away from the plate boundary in the southern South Island (Otago) as in the central South Island. Proposed explanations include variations in angle of convergence and a change from weaker Canterbury rocks to stronger Otago Schists.

We examine the crust and mantle structure beneath the South Island using P-to-S, S-to-P and SKS-to-P conversions from distant earthquakes (so called P, S and SKS teleseismic receiver functions). In active tectonic regions especially, crustal reverberations may complicate P receiver functions by interfering with P-to-S conversions. In contrast, S and SKS receiver functions are devoid of such reverberations and thus prove helpful at discriminating reverberations in the P receiver functions.

We explore the sensitivity of S and SKS receiver functions to dipping boundaries and anisotropy, and derive models of the lithosphere across the southern South Island (Jackson Bay, Wanaka and Earnsleugh Geonet stations) and beneath Rata Peak (central Southern Alps). The analysis reveals thickening of the crust from 30—39 km in the west (Jackson Bay) and 30—34 km in the east (eastern Otago) to 39—47 km beneath the Southern Alps. A mantle discontinuity is imaged at 55—75 km depth, which suggests a phase transition or mechanical decoupling. Finally, S receiver functions at Rata Peak exhibit conversions, which we attribute to the lithosphere-asthenosphere boundary at a depth of ca. 120 km.

TALK – Wed pm

SEISMIC VELOCITY STRUCTURE OF THE SHALLOW PART OF THE ALPINE FAULT AND GRAVITY STUDY OF THE BASEMENT FEATURES IN THE WHATAROA RIVER FLOOD PLAIN, CENTRAL WESTLAND, SOUTH ISLAND

N. Brikke[1] & T. A. Stern[1]
[1]Institute of Geophysics, SGEES, Victoria University of Wellington
nicolasbrikke@hotmail.com

Although the deep and middle sections of the Alpine fault have extensively been studied, the shallow part has had relatively minor geophysical attention. This seismic study focuses on the basement geometry and the determination of the upper-crustal velocity structure of the Alpine fault in the vicinity of the Whataroa River flood plain in Central Westland, South Island.

Data from a gravity line of November 2006, the GNS gravity database and from four of the westernmost shot gathers from the SIGHT'96 project were used for this project.

The gravity data were modelled to constrain the seismic refraction models. A ray-tracing software was used to establish the velocity structure of the shallow part of the Alpine fault.

Low-velocities of 3—4 km/s were found adjacent to the east and the west of the 1 km thick high-velocity foliated mylonite strip immediately east of the Alpine fault's surface trace and as deep as 6 km and as far as 15 km westwards of the fault. Mylonite velocities were in the range of 5.5—6 km/s

The low velocities are attributed to fault associated rocks such as cataclasites and fault gouge, whereas the higher velocities are related to the presence of mylonites or high metamorphic grade alpine schists. An important amount of low-velocity fault-related rocks are inferred to lie on the west of the fault.

Gravity and seismic data show the position and the dimensions of a glacial overdeeping at the mouth of the Whataroa River. This kettle-hole, possibly caused by the Whataroa-Perth catchment glacier during New Zealand's last glacial maximum, is 10 km in length, up to 3 km in width and is filled in with up to 1600 m of glacial sediments.

CONSTRAINING ACTIVE FAULT BEHAVIOUR IN RIFT ZONES

Jonathan M. Bull
National Oceanography Centre Southampton, SO14 3ZH, U.K.
bull@soton.ac.uk

The spatial and temporal accumulation of slip from multiple earthquake cycles on active faults is poorly understood. Here, we describe a methodology that can determine the time period of observation necessary to reliably constrain fault behaviour, using marine high-resolution reflection seismology and a constrained stratigraphy. Detailed studies of active faults in the offshore Whakatane Graben and the Corinth Rift show that while displacement profiles are consistent for longer time periods, profiles determined for short time intervals (2 - 3 kyr) are highly irregular, with pronounced minima. This indicates temporal and spatial variability in incremental displacement associated with surface-rupturing slip events. There is spatial variability in slip rates along fault segments, with minima at locations of fault interaction or where fault linkage has occurred in the past. This evidence suggests that some earthquakes appear to have been confined to specific segments, whereas larger composite ruptures have involved the entire fault. The short-term variability in fault behaviour suggests that fault activity rates inferred from geodetic surveys or surface ruptures from a single earthquake, may not adequately represent the longer-term activity nor reflect its future behaviour. Different magnitude events may occur along the same fault segment, with asperities preventing whole segment rupture for smaller magnitude events.

THE CREEP OF CREATIONISM – IS IT RELEVANT TO TEACHING EARTH SCIENCES?

A. Campbell[1]
[1]Dept. of Biological Sciences, University of Waikato
acampbel@waikato.ac.nz

We tend to think of creationism as being a peculiarly US problem. And certainly the creationism vs. evolution conflict is much more apparent there. But recent events, including the consultation over New Zealand's new draft science curriculum, have made it clear that creationism is alive and well in New Zealand. Why should this concern geo-scientists? Because rejection of evolution implies rejection of a substantial body of geological evidence – and because promotion of creationism carries with it a lack of understanding of the nature and processes of science.

REFINED LATE HOLOCENE HISTORY OF SURFACE RUPTURING EARTHQUAKES AND SLIP RATES ON THE SOUTHERN WAIRARAPA FAULT

R. C. Carne[1], T. A. Little[1], R. Van Dissen[2], and L. Schermer[3]
[1]School of Geography, Environment and Earth Sciences, VUW
[2]GNS Science, P. O. Box 30368, Lower Hutt
[3]Geology Department, Western Washington University, Bellingham, WA, USA 98225
(rachel.carne@vuw.ac.nz)

Little is known about the frequency and character of earthquakes on the Wairarapa Fault prior to 1855. Secondary evidence for earthquakes along the southern part of the fault has come from indirect methods, especially gravel beach ridges at Turakirae Head that were raised in response to Wairarapa Fault earthquakes (McSaveney et al., 2006). These ridges have been assumed to record the complete set of late Holocene earthquakes and to yield a mean recurrence interval for the Wairarapa Fault of ~2200 years. Paleoseismic trenching provides a more direct method for resolving that fault's earthquake chronology, and thus also to evaluate the accuracy or completeness of the uplifted gravel beach ridges as a paleoseismic tool.

As part of the 'Its Our Fault' project, in 2005 two trenches were excavated in a small pull-apart graben inset into the "Waiohine" gravel surface near Cross Creek (one across each bounding fault) (Little et al., 2006), together with trenches at 2 other sites in southern Wairarapa Valley. In 2007 we excavated 2 new trenches at Cross Creek adjacent to the previous 2 trenches in order to obtain a detailed and robust earthquake chronology from one of the best available sites along the southern Wairarapa Fault. 14 ^{14}C samples were analysed from these new trenches, giving a total of 32 ^{14}C ages at Cross Creek. Five surface rupturing events since ~5500 yrs BP are recorded by deformed peat layers and variably faulted and deformed colluvial wedges. The evidence indicates that both strands of the graben ruptured concurrently in all but 1 of the earthquakes. Three of the events coincide with the inferred timing of Turakirae Head uplift events, the youngest of which is 1855. The older two of the Turakirae-equivalent earthquakes we date in the trenches at 2340-1940 and 5280-4620 yrs BP (calibrated years, 95% confidence). Two events resolved in the trenches are additional to the Turakirae-expressed ones, a situation that was confirmed by the 2007 trenches. The preferred ages of these "extra" events are 3690-3070 and 920-800 yrs BP (penultimate event). Indirect evidence for these has been reported by other workers at Pencarrow Head and Rongotai Isthmus. ^{14}C ages of 10.5 and 11.1 ±0.06 ka were obtained for peats interbedded within "Waiohine" terrace gravels. If this result is regionally applicable it suggests a Wairarapa Fault slip rate of >9 mm/yr, based on terrace riser offsets at the Waiohine River (Lensen & Vella, 1971, and work in progress).

Our results suggest that the southern part of the Wairarapa Fault has ruptured with a mean recurrence of ~1200 years since ~5500 yrs BP. This implies a late Holocene slip rate of ~12 mm/yr, assuming a mean slip per-event of ~15 m. The lack of a complete set of beach ridges at Turakirae Head may reflect earthquakes with smaller uplifts, or unfavourable coastal conditions for discrete beach ridges to form such that a new ridge may not have had time to form or was accreted to a pre-existing one.

POSTER 45

UNDERSTANDING AND DEALING WITH A WARMER WORLD

Lionel Carter
Victoria University, PO Box 600, Wellington.
(Lionel.Carter@vuw.ac.nz)

When asked "What kept him awake at night?" the eminent meteorologist and New Zealander, Dr Kevin Trenberth replied "Climate change is already happening". That was in 2005, the year of the devastating hurricanes, Katrina, Rita and Wilma. In 2006, and despite predictions of another extreme season, near-normal hurricane activity returned to the Atlantic.

Such discrepancies emphasise the sometimes erratic behaviour of Earth's climate, which along with

- its slow pace of change – compared to our life times;
- the complexities of trying to comprehend the entire land, ocean atmosphere system;
- incomplete knowledge of the environment especially in the Southern Hemisphere;
- the strong and often conflicting public debate, and
- strong political and commercial interests

all underscore the difficulty in understanding change.

In this presentation I explore those various aspects to help improve our appreciation of what is actually happening. An improved understanding will equip us to better deal with living in a warmer world and to put in place the measures that reduce our influence of the climate system.

CHALLENGES IN GROWING APPLICATIONS FOR GEONET'S CGPS NETWORK

A. Cervelli[1], G.Clitheroe[1] & the GeoNet Team.
[1] GNS Science, PO Box 30368, Lower Hutt, New Zealand.
(a.cervelli@gns.cri.nz)

The GeoNet Project has to date installed 65 continuous GPS (cGPS) stations along the length of the Hikurangi Margin and within the Central Volcanic Region, North Island, New Zealand. This regionally focused cGPS network is designed for scientific and hazard monitoring purposes, and complements Land Information New Zealand's (LINZ) 32 PositioNZ sites which provide a backbone of cGPS stations across New Zealand. The existing networks were designed and built as near real-time data networks, from which logged files are downloaded from internet connected receivers on a routine basis, usually every hour. Daily summary files for each site are provided to the public via the GeoNet website. The network continues to grow rapidly, with another 65 sites planned for the next three years.

In addition to downloaded cGPS data, there are an increasing number of applications and a strong demand for high-rate real-time data. From a hazard monitoring perspective, high-rate real-time cGPS data could be applied in areas such as active volcano and landslide monitoring, or to assess co-seismic deformation and the tsunamigenic potential of large earthquakes. Real-time positioning from streamed GPS data also has a wide range of commercial applications from land surveying to inventory mapping for risk analysis. On behalf of LINZ, GNS Science is currently testing a 1 second data streaming service, which allows surveyors to undertake real-time observations without the need to set up their own base station. This test has shown that while the station spacing and geometry of our existing network is adequate to provide this service to land surveyors nationwide, the current communications infrastructure can't always support real-time data streaming. Network development linked to streaming high-rate real-time data from the existing cGPS network will require communications infrastructure upgrades to allow for increased bandwidth and ensure reliability of long-lived data connections.

TALK – Wed am

SEISMICITY IN TAUPO VOLCANIC ZONE GEOTHERMAL SYSTEMS: EARTHQUAKE CLUSTERING AND FOCAL MECHANISMS REVEALED BY WAVEFORM CROSS-CORRELATION

D. Clarke[1], J. Townend[1], M. Savage[1], S. Bannister[2] & S. Sherburn[3]
[1]Institute of Geophysics, Victoria University of Wellington, PO Box 600, Wellington
[2]GNS Science, PO Box 30368, Lower Hutt
[3]GNS Science, Private Bag 2000, Taupo
daniel.clarke@vuw.ac.nz

The geothermal fields of the Taupo Volcanic Zone (TVZ) are an excellent setting in which to investigate the processes governing seismicity in shallow crustal environments. We are currently working to accurately locate low-magnitude seismicity in the Rotorua and Kawerau geothermal systems, compute focal mechanism parameters, and analyse the spatial and temporal clustering of earthquakes in relation to known structures and reservoir conditions.

We have selected two sets of shallow (<20 km) earthquakes that occurred between 1984 and 2004 in and around the Rotorua and Kawerau geothermal areas. These archives contain approximately 500 and 1800 events, respectively, and include events recorded during the deployment of a dense seismometer array in the TVZ in 1995. As reported previously, we have determined one-dimensional P- and S-wave velocity models for each area using the best-recorded events. We have since employed waveform-based techniques (cross-correlation) and a double-difference relocation algorithm to make optimal use of the seismograms for each earthquake in obtaining a suite of final earthquake locations.

Having obtained reliable earthquake locations for both Rotorua and Kawerau, we are now working to better characterise the seismicity in these two settings. The waveform cross-correlation results enable us to identify groups of highly similar earthquakes and analyse their spatiotemporal behaviour. Knowing that a number of earthquakes occurred in close proximity to one another and generated highly correlated waveforms enables us to amalgamate otherwise sparse P-wave first motion records and compute focal mechanisms for the group as a whole.

We have identified 11 clusters of three or more relocated earthquakes in Rotorua, the largest of which consists of 26 relocated events. Most of these earthquakes are confined to the southern end of Lake Rotorua and beneath Ngongotaha. In Kawerau, the earthquakes are less confined and follow a broadly northeast trending distribution. Here, we identify 16 earthquake clusters consisting of up to seven relocated events.

SUBVOLCANIC PLUMBING SYSTEMS BENEATH CALDERA VOLCANOES: IMPORTANCE OF CRUSTAL STRUCTURE

J.W. Cole, C. D. Deering & R.E. Turnbull

Dept. of Geological Sciences, University of Canterbury, PB 4800, Christchurch 8020
(jim.cole@canterbury.ac.nz)

A study funded by Marsden contract UOC0508 is currently underway to understand the physical and chemical processes that occur beneath Okataina caldera complex (OCC), Taupo Volcanic Zone (TVZ), New Zealand. This includes a compilation of existing geochemical data from eruptives of OCC, and additional new data from early caldera-forming events, in particular those associated with the c.280ka Matahina ignimbrite. Plutonic lithic blocks, brought up by several eruptive units, including the c.60ka Rotoiti ignimbrite and 1314AD Kaharoa eruption from Tarawera volcano, are being used to identify petrographic and compositional ranges within the high-level sub-volcanic magma chambers beneath OCC.

Older exposed high-level granite bodies are regarded as potential analogues of these magma chambers, and those from the Coastal Maine Magmatic Province (USA), the southern Nevada/northwestern Arizona (USA) plutons and the Bungaree Intrusives of Stewart Island, New Zealand, are compared to the data from OCC in order to build up a 3-D picture of the subsurface magma system there.

All of the data collected so far suggests that intrusion of mafic magmas into the high level (c.5-8 km depth) silicic magma chambers is a very important process beneath OCC. These mafic magmas rise through dikes parallel to the regional faults in the TVZ, and intrude into the ‘active’ part of the silicic magma chambers as sill-like bodies, in places breaking up into ‘pillow-like’ forms. Some mixing and mingling occurs. The silicic magma chambers themselves are also elongated parallel to the regional faults and detailed chemistry suggests extensive mixing between high-level magma bodies.

TALK – Thu pm

DEVELOPING GEOPHYSICAL TOOLS TO UNDERSTAND THE INTERNAL DYNAMICS OF MOVING LAHARS: THE MARCH 18TH RUAPEHU LAHAR

S. E. Cole[1], S. J. Cronin[1], H. K. McMillan[1], G. Lube[1], S. Sherburn[2], V. Manville[2]
[1]INR, Massey University, Private Bag 11-222, Palmerston North 4442
[2]GNS Science, Wairakei Research Centre, Private Bag 2000, Taupo
s.e.cole@massey.ac.nz

Lahar dynamics and evolution are poorly understood due primarily to a lack of information about flow characteristics. The predicted Mt Ruapehu Crater Lake outbreak provided a unique opportunity to gather information about a lahar. On 18th March 2007, the long-awaited dam-collapse occurred, releasing an estimated $1.3x10^6$ m^3 of water from the lake. A variety of geophysical equipment had been installed at a series of sites along the Whangaehu Channel in order to capture the lahar as it flowed past, making this the most comprehensively studied flow ever.

Observations and data were collected pre- and post-event, as well as during the flow itself, in order to monitor the changing properties of the channel and the interactions between streamflow and lahar. Stage, pore pressure, fixed-video and seismological records were collected, which clearly showed the passage of the lahar. In addition, time-series bulk-flow samples were collected at various sites throughout the catchment, and have been analysed for sediment concentration, particle size distribution and chemical content. Post-event GPS surveys collected data about tidelines, superelevation and cross sections of the channel.

Using the multi-component observational data at the key site of Colliers Bridge (82 km from source) the seismological records have been interpreted to provide a proxy for measuring motion of particles, particle collisions and interaction with banks and channel substrate, along with bulk-flow excitation. By splitting a broadband signal into frequency bands, we can identify variable degrees of excitation across these bands as a function of seismic source. In this case, particle collisions with the flow substrate and channel margins (especially bed-load particles), are recorded in preferential excitation of high-frequency bands (>10 Hz and expecially >40 Hz). By using simple ratios of high over low frequency bands, a proxy for sediment concentration and bed-load transport can be demonstrated. Combining these with the other data, it is possible to develop new methods to estimate maximum flow velocities and discharges in sediment-rich flows, using modified slope-area calculations.

Analysis of instrumental records, along with observation and depositional information, allows for greater understanding of lahars and their processes. Since it is not always possible to witness and sample flows as they pass, other methods of understanding the records at a site must be used. By using our datasets at Ruapehu and Indonesia, seismic records can potentially be developed as proxies for sediment concentration, bed-load activity, particle-bed interactions, flow turbulence and velocity.

TALK – Wed pm

EMERGENCY MANAGEMENT IN SCHOOLS

M. A. Coomer, D. M. Johnston

GNS Science, PO Box 30368, Lower Hutt
m.coomer@gns.cri.nz

Wellington is a region at potential risk from a range of natural hazards, and children and their families have been identified as particularly vulnerable to the effects of hazard events. In collaboration with local Emergency Management organizations, GNS Science has undertaken a research project in the Wellington region aimed at assisting children, youth, and families cope more effectively with the effects of disasters. The research project aims to assess the level of Emergency Management education and preparedness in Wellington, Hutt Valley, Porirua, and Kapiti Coast schools, looks at current Emergency Management teaching and exercises within schools, assesses the information and resources available, and looks at how they are used for Emergency management education and preparedness in schools. We anticipate the findings of this survey will lead to more uptake of hazard information within school curriculum teaching. Increasing our children's knowledge of New Zealand hazards and improving their preparedness if a hazard event should occur can only benefit their future.

PLAGIOCLASE AND GARNET COMPOSITIONS REVEAL STRUCTURE OF THE ALPINE FAULT MYLONITE ZONE

Alan F Cooper and Richard J Norris
Geology Department University of Otago, Dunedin
alan.cooper@stonebow.otago.ac.nz

Late Neogene convergence and uplift across the Australia-Pacific plate boundary has exhumed a section of the Pacific crust exhibiting a prograde metamorphic sequence in the Alpine Schist from pumpellyite-actinolite, through greenschist to amphibolite facies. In the hanging wall of the Alpine Fault this sequence has been overprinted by a 1 km wide zone of cataclasis and mylonitisation, with rocks grading eastwards into high-grade, oligoclase zone schists.

North of Haast River the fault zone is dominated by high-grade oligoclase zone-derived mylonites, but also contains rocks containing prominent relict porphyroblasts of albite ($An_{0-1}Ab_{97-98}Or_{1-2}$), in some rocks with partial thin overgrowths of oligoclase (ranging between specimens from $An_{14-15}Ab_{84-86}Or_{0-1}$ to $An_{23-24}Ab_{76-77}Or_{0}$). Coexisting garnet ranges from $Alm_{56}Gross_{21}Spess_{23}$ to $Alm_{24}Gross_{31}Spess_{45}$. Textures, mineral assemblages and mineral compositions are characteristic of prograde garnet zone conditions, but are dissimilar to the characteristics of garnet zone rocks that occur immediately to the east in that (a) garnet coexists with albite alone, and (b) garnet compositions are anomalously almandine-poor and spessartine-rich. The assemblages and mineralogy are, however, similar to those in schists from East, Central and West Otago (Brown 1967, Mortimer 2000, White 1996).

Peristerite plagioclase assemblages (albite + oligoclase) have been documented from the length of the Alpine Fault zone along the Haast-Paringa Cattle Track, from the Paringa, Mahitahi and Makawhio Rivers, northwards to Havelock Creek where compositions of $An_{1}Ab_{98-99}Or_{0-1}$ and $An_{18-20}Ab_{79-81}Or_{0-1}$ occur. Further north, at Cook River, mylonites contain myrmekite-bearing oligoclase, a texture described elsewhere from oligoclase zone rocks, immediately upgrade of the disappearance of albite.

Garnet zone peristerite-bearing protoliths from which these low-grade mylonites could be derived are (a) at depth in the footwall of the present day Alpine Fault trace. Here they would represent relict Pacific plate material, effectively accreted to the Australian plate and stranded by the shallowing of the fault trace as displacement evolved from purely dextral strike slip in the early Neogene to the present day dextral reverse oblique slip. Alternatively, (b), the low-grade rocks could be derived from the southwest and translated by strike slip displacement along the Alpine Fault. In the vicinity of the Jackson River, Alpine Schists contain feldspar-porphyroblastic pelites containing sporadic biotite, and garnet coexisting with albite ($An_{0-1}Ab_{99-100}Or_{0-1}$). Garnet compositions range from $Alm_{49}Gross_{17}Spess_{34}$ to $Alm_{15}Gross_{32}Spess_{53}$, remarkably similar to those observed in mylonites now exposed north of Haast River. Although only garnet-albite zone assemblages occur east of the Jackson River mylonite zone, metamorphic grade in the Alpine Schists increases northeastwards to the oligoclase zone documented at Okuru and Haast Rivers. Peristerite-bearing and garnet-albite-bearing rocks would therefore be available for incorporation into the mylonite zone in the Jackson-Arawhata area to be translated by ductile shearing for distances of up to 100 km along the Alpine Fault.

TALK – Wed pm

LAHAR-STREAMFLOW INTERACTIONS, NEW DATA FROM 18 MARCH 2007 LAHAR AT RUAPEHU, NEW ZEALAND

S.J.Cronin[1], G. Lube[1], S.E.Cole[1], H.K. McMillan[1], V. Neall[1], J. Procter[1], A. Zernack[1], M. Turner[1], C. Robertson[1], A. Moebis[1], R.B. Stewart[1], K. Martelli[1], K. Holt[1], M. Irwin[1], J. Lecointre[1], J-C. Thouret[2], P. Kellman[3]

[1]INR, Massey University, Private Bag 11 222, Palmerston North, New Zealand
[2]Laboratoire Magmas et Volcans, University Blaise-Pascal, Clermont Ferrand, France
[3]University of Leeds, United Kingdom
s.j.cronin@massey.ac.nz

Ruapehu lahars are typically derived from eruptions or outbursts from the hydrothermally heated Crater Lake. Hence the chemical contrast of this pulse of acidic brine into normal streamflow can be used, alongside sediment concentration and flow stage/discharge to understand the interaction of lahars and river water in their path. Observations of eruption-triggered lahars in the Whangaehu River in 1995 led to the following model: 1) a head of normal stream water, with low sediment and salt concentrations persisting up to the peak stage; 2) a mixing zone between stream water and incoming brine, accompanied by a rise in sediment concentration to a peak that lagged peak stage by 15-45 minutes; 3) highly sediment-charged flow with decreasing stage and increasing salt concentrations that reach a maximum up to 15-30 minutes after the sediment concentration peak; followed by 4) a long tail where the flow slowly returns to normal streamflow conditions.

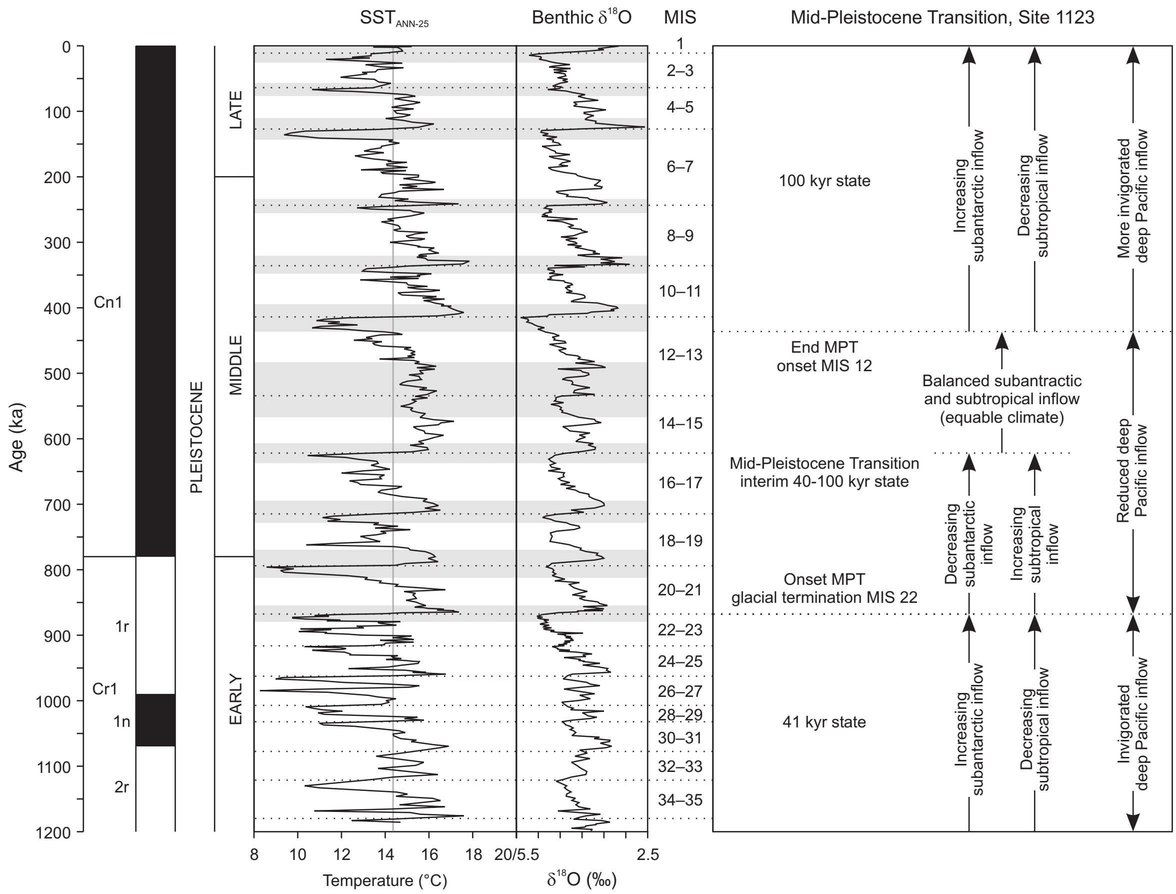
For the 18 March 2007 lake-breakout lahar from Ruapehu, we were able to mobilise several observer teams to collect a far more detailed set of time-series data at sites along the Whangaehu River. This data was also expanded upon by the use of a broad-band seismometer to allow determination of the content and energy of coarse sediment within and at the base the flow, and highly detailed sampling of sediments deposited during passage. These new data sets confirm and expand on previous observations from the Ruapehu lahars. In all cases suspended sediment, bedload sediment and salt concentration peaks lag the maximum stage and discharge. The observations from dip samples are expanded upon by the seismic signals, where a peak in overall vibration energy lags the stage/discharge maxima. Depositional records also record three distinct units corresponding to stages 2, 3 and 4. The new data implies that the head of the lahar wave appears to comprise normal stream water. This could be explained as a kinetic wave phenomenon, where the celerity of the lahar waveform is higher than the velocity of the material-wave pulse of crater lake water and sediment. The energy waveform hence propagates ahead of the material wave, into the streamwater of the Whangaehu River. Erosion of bank sediments and debris by the energy wave water column, appears to cause enough energy loss that it cannot accelerate unhindered from the pulse of crater-lake water and sediment.

TALK – Wed pm

GLACIAL–INTERGLACIAL OCEAN CLIMATE VARIABILITY AT ODP SITE 1123 DURING THE MID-PLEISTOCENE TRANSITION

Martin Crundwell [1]*, George Scott [1], Tim Naish [1,2], Lionel Carter [2,3]
[1]GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand, [2]National Institute of Water and Atmosphere, Private Bag 14901, Wellington, New Zealand, [3]Antarctic Research Centre, Victoria University of Wellington, Private Bag, Wellington, NZ.
m.crundwell@gns.cri.nz

Planktonic foraminiferal assemblages and artificial neural network estimates of sea-surface temperature (SST) at ODP Site 1123 (41°47.2'S, 171°29.9'W; 3290 m deep), east of New Zealand, reveal a high-resolution history of glacial–interglacial (G–I) variability at the Subtropical Front (STF) for the last 1.2 million years, including the Mid-Pleistocene climate transition (MPT). Most G–I cycles of ~100 kyr duration have short periods of cold glacial and warm deglacial climate centred on glacial terminations, followed by long temperate interglacial periods. During glacial–deglacial transitions, maximum abundances of subantarctic and subtropical taxa coincide with SST minima and maxima, and lead ice volume by up to 8 kyrs. Such relationships reflect the competing influence of subantarctic and subtropical surface inflows during glacial and deglacial periods, respectively, suggesting alternate polar and tropical forcing of southern mid-latitude ocean climate. The lead of SSTs and subtropical inflow over ice volume points to tropical forcing of southern mid-latitude ocean-climate during deglacial warming. This contrasts with the established hypothesis that southern hemisphere ocean climate is driven by the influence of continental glaciations.



TALK – Tue am

CRUSTAL SEISMIC REFLECTION MEASUREMENTS ACROSS THE BAY OF PLENTY

F J Davey
GNS Science, P O Box 30368, Lower Hutt
(fdavey@gns.cri.nz)

Crustal seismic reflection data show a distinct reflector at 5.5 s two way travel time (twt) under eastern Taupo Volcanic Zone (TVZ) that, from seismic refraction data, is inferred to correspond to the Moho underlain by low seismic wave speed mantle. The eastern margin of the TVZ is marked by a strong narrow band of reflectivity that dips steeply eastwards under the East Cape peninsula to depths of about 30 km (9 seconds twt) and is interpreted as marking the Moho. A discontinuous band of reflectors lies at a depth of about 11 - 12 seconds twt under the TVZ. It may correspond to the strong reflector imaged in the upper mantle to the south of this region by wide angle seismic measurements, but is deeper and extends to the subducted plate in the east. The shallow low wave speed mantle is characterised by strong discontinuous reflecting elements to depths of about 12 s twt where the sub-horizontal band of reflections occur. These strong chaotic reflections occur for about 25 km across the eastern TVZ, underlying the region of active faulting, and coinciding with a zone interpreted as underplating/low velocity mantle or highly intruded lower crust. A similar region of discontinuous reflecting elements is detected further to west, coincident with the extrapolation of the Havre Trough rifting trend through Mayor Island. It is proposed that the transfer zone for the back arc rifting of the Havre Trough into the continental rifting of the TVZ coincides with a broad region centred on the Bay of Plenty.

NEW PERSPECTIVES ON DIFFERENTIATION PROCESSES AT ARC VOLCANOES

Jon Davidson
Department. of Earth Sciences, University of Durham, Durham DH1 3LE, UK
j.p.davidson@durham.ac.uk

The need to understand differentiation processes in arc magmas is both practical (because such processes dictate the chemical and physical state of the magmas and their capacity to erupt explosively) and academic (as such processes control the evolution and composition of crust and mantle). Recognition that plumbing systems and magmatic processes at arc volcanoes are complex and require careful stratigraphically-constrained geochemical and petrological approaches has prompted us to explore new ways of constraining what processes operate and on what timescales. We have accordingly developed an approach called *crystal isotope stratigraphy* (CIS) which retrieves isotopic data in the context of the petrographic and textural features of a rock. The approach relies on the fact that isotope ratios (of Sr, Pb, Nd, Hf, Os) are not fractionated by natural processes such as fractionation and melting, and can therefore be used to fingerprint the components involved in magmageneisis and evolution.

Recent work using Sr isotopic microsampling on a number of magmatic centres from the Pacific Rim and beyond has shown that;

1. Isotopic diversity at the inter-and intra-mineral scale is common, suggesting that open system processes are rife
2. Isotopic diversity among crystals from a single rock suggests that crystals represent a mechanically aggregated cargo, often not in equilibrium with the melt (glass/ groundmass) in which they are erupted
3. Isotopic profiles of single crystals can be used to elucidate differentiation histories as events such as contamination and recharge are faithfully recorded in core –rim traverses
4. Isotopic disequilibrium between crystal rims and host glass/ matrix constrains timescales of crystal entrainment to be short – better resolution trace element profiling has returned timescales of weeks to years.
5. Mineral-scale isotopic diversity in plutonic rocks suggests that they, like their volcanic counterparts, retain memory of open system differentiation processes. The fact that this information is retained in plutons rather than diffusively re-equilibrated places upper limits on the timescales of cooling.
6. The common occurrence of isotopic diversity among minerals in young fresh rocks means that isochron approaches need to be carefully evaluated, as the assumption that initial ratios are identical is clearly commonly violated.

We conclude that processes of cumulate cannibalisation and crystal entrainment at arc volcanoes, occurring over the lifetime of individual magmatic centres are the rule rather than the exception.

MAGNETIC SURVEYING OF BROTHERS VOLCANO, KERMADEC ARC – HIGH RESOLUTION NEAR-BOTTOM AUV SURVEYING AND REGIONAL SURFACE-TOW MEASUREMENTS

Bryan Davy[1], Cornel de Ronde[1], Maurice Tivey[2], Bob Embley[3], Dana Yoerger[2]

1. GNS Science, Lower Hutt, New Zealand, b.davy@gns.cri.nz
2. Woods Hole Institution, Woods Hole, Massacusetts, USA
3. Pacific Marine Environmental Laboratory, Seattle, Washington , USA

The magnetic anomaly signature over volcanic deposits records information on the extent of volcanism, the polarity of the field at the time of eruption, the nature of the deposits (e.g. lava, volcaniclastic) and the subsequent evolution of these deposits. The absence of a magnetic anomaly signal can often be used to identify areas where hydrothermal alteration of the host lava chemistry, through interaction with hot water, has removed most of the rock magnetization. This was the basis of surveying of Brothers volcano, conducted from *R/V Sonne* in July-August, 2007, which targeted the identification of modern and fossil hydrothermal vent fields using magnetic methods.

Brothers volcano, located about 310 km northeast of New Zealand along the magmatic front of the Kermadec arc, is one of the best studied of intraoceanic arc submarine volcanoes. Its 3.0 x 3.5 km caldera has a long axis oriented about N320ºE and has more than 300 m relief from a rim at ~1500 m to a maximum depth of 1880 m in its northwest corner. Two major hydrothermal systems were discovered at Brothers in the late 1990s: a high temperature (up to 302ºC) field located on the northwest wall of the caldera and a lower temperature gas-rich system, situated on the summits of a pair of dacitic cones that fill the southeast half of the caldera.

Surface-tow magnetic data are limited to resolving source features with wavelengths of 1-2 km, or greater, for the water depths found over Brothers. In order to obtain much higher horizontal feature resolution magnetic data were recorded at heights of 10-50 m above the volcano using an autonomous underwater vehicle (AUV) known as ABE. Preliminary results show a strong correlation between areas of interpreted demagnetization and areas of known hydrothermal activity. A newly discovered vent field on the western wall of the caldera also correlates with a demagnetized area, as does an area thought to represent an extinct vent field on the southeastern side of the caldera.

Regional surface-tow magnetic data reveal the Brothers volcano to be a zone of relative low-magnetic anomaly raising the question of whether this is a reverse polarity signature (and hence implying an age of > 0.7 Ma for Brothers volcano) or an extended zone of thinned magnetic source layer associated with an underlying magma chamber. The question of what this and other regional zones of reversed magnetization observable within the back-arc imply is examined in the light of previous discussions of extended magnetic anomalies by Malahoff et al. (1982) and Wright (1993).

TALK – Tue am

DISTINCT MAGMA TYPES OF THE TAUPO VOLCANIC ZONE, NEW ZEALAND: IMPLICATIONS FOR RHYOLITE PETROGENESIS

C.D. Deering & J.W. Cole
Dept. of Geological Sciences, University of Canterbury, PB 4800, Christchurch 8020
cdd21@student.canterbury.ac.nz

Rhyolites generated in the modern Taupo Volcanic Zone (TVZ), New Zealand have previously been interpreted as having evolved by a combination of limited fractional crystallization and crustal assimilation. Polytopic vector analysis (PVA), a multivariate statistical analysis of over 475 andesitic to rhyolitic bulk-rock samples (24 analytes) representing over 560 ka of volcanism from along the entire TVZ has provided a robust platform for rhyolite characterization and provide new insight on rhyolite petrogenesis in TVZ. Two rhyolite end-members (EM) have been established and are described based on several important characteristics. Type 1(T1): a crystal-rich (up to 45%), plag+qtz±amph±cgt±biotite+Fe-Ti oxides, low-T(720-820ºC) rhyodacite-rhyolite and Type 2(T2): crystal-poor (<10%), plag+opx±qtz±tr amph+Fe-Ti oxides, high-T(802-941ºC) rhyodacite-rhyolite.

Recently discovered juvenile, pumice clasts ranging from andesitic to dacitic with a range of cystallinities from 5 to 50%, associated with Okataina eruptives, demonstrate bulk-rock and mineral compositional variations consistent with fractional crystallization. This andesitic component is separately defined in the PVA as a mafic EM that correlates with the other T1 TVZ rhyolites along a linear array. This range of bulk-rock sample compositions and mineral contents correlate well with those observed in recent melting experiments performed on high-Al, medium-K, gabbroic rock by Sisson et al. (2005).

The geochemical array defined by multivariate statistics and compared with recent experiments are consistent with an origin for the T1 rhyodacite-rhyolite magma type by crystal fractionation to form a lower crustal mush with subsequent removal of rhyolitic melt which is stored in mid to upper crustal chambers. Remaining magmas are produced as a result of mixing between the two EM magmas and are considered hybrids. A complete characterization of the T2 magma type petrogenesis is currently being investigated, but initial interpretations suggest the magma is also a primary, mantle derived melt. The results of this geochemical analysis have important implications for constraining a petrogenetic model for the generation of rhyolites in the modern TVZ.

TALK – Tue pm

SEISMIC PHENOMENA ASSOCIATED WITH SLOW SLIP NEAR GISBORNE IN 2004

Emily Delahaye[1], John Townend[1], Martin Reyners[2] & Garry Rogers[3]
[1] Institute of Geophysics, Victoria University of Wellington, PO Box 600, Wellington
[2] GNS Science, PO Box 30368, Wellington
[3] Pacific Geoscience Centre, Geological Survey of Canada, Sidney, BC, Canada
john.townend@vuw.ac.nz

The advent of *GeoNet*, and in particular its close integration of continuous global positioning system and seismological networks, has facilitated the detection and characterisation of several novel geophysical phenomena. One such phenomenon is geodetically detected slow slip, several episodes of which have occurred beneath the eastern North Island since 2002. Where slow slip has been detected in subduction zones overseas, notably in Cascadia and southwest Japan, it is associated with bursts of coherent seismic energy ("seismic tremor"). We have been working to determine whether seismic tremor — or another seismic signal — also accompanies slow slip in the Hikurangi subduction zone.

We have systematically reviewed 20 weeks of continuous broadband seismic data spanning two slow slip events near Gisborne (2002 and 2004) and a longer-duration event beneath Manawatu (2004–2005). Despite careful analysis, we have not detected seismic tremor with the characteristics seen elsewhere during any of these slow events. Instead, our analysis reveals a pronounced increase in microseismicity during the 2004 Gisborne event that is *spatially* restricted to a region of the subducting plate downdip from the slow slip patch inferred by Douglas et al. (2005) from GPS observations and *temporally* restricted to the period of slow slip. This increased rate of local seismicity is not evident in the routine analysis records and was only detected by a methodical review of continuous seismic data. The 2004 slow slip event therefore appears to have triggered microearthquakes with magnitudes of M_L 1–2 whose spatiotemporal relationship to the slow slip is similar to that reported for microseismicity beneath the island of Hawai'i by Segall et al (2006). The onset, extent, and duration of enhanced microseismicity can be modelled using a rate-and-state friction model; our preliminary modelling of the 2004 Gisborne event suggests that the microseismicity responded to a shorter-duration stress transient at depth than the surface deformation signal recorded by GPS.

TALK – Wed am

PALAEOTSUNAMI SOURCES FOR THE BAY OF PLENTY

W.P. de Lange, G.S. Prasetya, K.C. Spiers, V.G. Moon
Deptartment of Earth & Ocean Sciences, University of Waikato, Private Bag 3105, Hamilton 3204, New Zealand
w.delange@waikato.ac.nz

Palaeotsunami data are becoming more available for the Bay of Plenty, with several large events recognised over the last 7000 years.. Linking deposits to credible sources permits refinement of frequency-magnitude data, particularly for rare large magnitude events.

Numerical modelling of potential sources in the Bay of Plenty and the Southwest Pacific has been undertaken over the last 25 years. The results of these simulations were used to constrain potential source regions for major palaeotsunami events, by matching the longshore tsunami wave height distributions predicted with those recorded by palaeotsunami data. Four main sources of large tsunami were identified: caldera eruption at Mayor Island; volcanic edifice collapse at White Island; large subduction earthquake along the Tonga-Kermadec Trench; and caldera eruption at Mt Healy.
The 6300 BP eruption of White Island was capable of generating>10 m tsunami along the Bay of Plenty coast, and is tentatively linked to the oldest palaeotsunami deposits reported. An edifice failure at White Island generates smaller waves around 2-5 m, but locally reaching 10 m. This source is proposed for deposits dating to 2200-2500 BP. Local earthquake sources have been extensively modelled, but have been found to generate small tsunami that are considered unlikely to leave significant deposits.
The largest tsunami event detected so far occurred around the start of the 15th Century. Two potential sources capable of generating this event were identified: a large subduction thrust earthquake in the Tonga-Kermadec subduction zone; and a caldera–forming eruption at Mt Healy submarine volcano.

Both these sources were modelled in more detail, confirming that both produced the observed distribution of wave heights inferred from tsunami deposits. The modelled seismic source required seabed displacements typically associated with a moment magnitude of 9.3-9.5 using standard seismic models. As the section of the Tonga-Kermadec subduction zone acting as a source is relatively sediment free, with abyssal hills orientated at 70-90° to the fault plane, it is considered that this source is unlikely to achieve the necessary earthquake magnitude.

The Mt Healy caldera erupted at the start of the 15th Century, and one of the eruptive products, the Loisels Pumice, is a constituent of many of the tsunami deposits. It is considered likely that the Mt Healy eruption was contemporaneous with the tsunami. Numerical modelling assuming an eruption of similar magnitude to the 1883 Krakatau Eruption replicated the inferred tsunami wave height distribution. Based on the Mt Healy caldera dimensions, this scale of eruption is reasonable. Hence, a volcanic source is considered more credible than a seismic source.

KEYNOTE TALK – Wed am

BREAKDOWN OF QUARTZITE XENOLITHS IN NGAURUHOE LAVA AND THEIR INTERACTION WITH THE HOST ANDESITE MELT

F. Della Pasqua, G. Kilgour, G. Jolly
GNS Science, Wairakei Research Centre, Taupo
f.dellapasqua@gns.cri.nz

Ngauruhoe volcano is one of the most active cone volcanoes in the Taupo Volcanic Zone. Monomineralic quartzite xenoliths (>90 % quartz) exhibit typical granoblastic textures and represent the most abundant xenolith type at Ngauruhoe. The origin of these xenoliths, as well as the extent to which they interact with the host magma prior to eruption, have been the subject of detailed studies and lively debate. In this study we note two petrographic characteristics of Ngauruhoe xenoliths that can be helpful in assessing the extent of magma-xenolith interaction.

Although the vast majority of the quartzite xenoliths are characterised by equigranular mosaic textures, we note that the morphologies of the margins (outer 2-3 mm) of the xenoliths are commonly characterised by a systematic decrease in grainsize toward the contact with the host melt. Coarsening of grainsize towards the xenolith margin was not observed in any of the xenoliths studied.

We believe that these finer grained margins developed after assimilation, and as a result of interaction of the quartzite xenoliths with the host magma. The edges of the xenoliths also vary from smoothly curved ("Type-I") to irregular ("Type-II") edges, the latter defined by grain shape and size. Irregular outlines were only observed in association with the development of finer grained margins. These Type II textures are consistent with a mechanical breakdown process that is also emphasised by the presence of "detached" quartz grains adjacent to irregular xenolith margins. Nonetheless, our study of xenolith fragments showed that detached grains are absent at distances greater than 5 cm away from the xenolith. Other researchers have shown that a narrow microcrystalline reaction zone <500 µm across, enriched in silica-rich glass relative to the host andesitic groundmass, can surround the xenoliths. Here we note that this reaction zone is common but only found in association with irregular outlines. Thus the inferred breakdown sequence for Ngauruhoe xenoliths after entrapment is 1) partial dissolution (development of smooth edges) 2) development of finer grained margins 3) development of irregular edges and 4) mechanical/chemical disintegration and contamination of the surrounding host magma.

POSTER 1

THE CENTRAL OTAGO DEFORMATION (COD) NETWORK

Paul Denys[1], Mike Denham and John Beavan[2]
[1]School of Surveying, Otago University, PO Box 56, Dunedin
[2]GNS Science, PO Box 30368, Lower Hutt
pdenys@surveying.otago.ac.nz

A preliminary study undertaken in Central Otago by Norris and Nicolls (2004) demonstrated that the range fronts in the region exhibited distributed deformation, even though no continuous range-scale surface ruptures were evident. In addition, GPS campaign data spanning some 10 years indicated broad scale contraction rates in the order of 2 mm/year. These contraction rates are roughly perpendicular to the strike of the faults and are consistent with the long-term contraction across the region based on fault displacement.

One of the conclusions drawn by Norris and Nicolls (2004), based on the geological and geodetic data, was that East Otago should be viewed as a potentially active seismic region. While there is evidence of widespread activity during the Holocene on the East Otago geological structures, it is possible that the seismic hazard is higher in this region than previously thought.

Using geodetic quality GPS equipment, the Central Otago Deformation (COD) network was establish in June 2004, initially with 6 marks with an additional 14 marks added in December 2005. As the estimated crustal deformation is small, at less than 2mm/year, the network has been designed for high accuracy as well as ease and fast deployment of the GPS equipment. All marks are force centred to minimize equipment (no tripods are required) and are located at sites that are secure and accessible with a 2 wheel drive vehicle. The network is observed as a GNSS campaign network at least twice a year with site occupation of between 4-7 days in order to reduce the effect of atmospheric biases through precise modelling. We will present preliminary results based on data collect over nearly four years.

Reference

Norris, R. J. and R. Nicolls (2004). Strain Accumulation and Epiodicty of Fault Movements in Otago. Dunedin, New Zealand, Otago University. Report undertaken for EQC Research, Number 01/445: p140.

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW) FOR CHARACTERISING THE INTERNAL STRUCTURE OF ACTIVE FAULT ZONES

B. Duffy[1], J. Campbell[1] & M. Finnemore[1, 2]
[1]Dept. of Geological Sciences, University of Canterbury, Christchurch.
[2]Southern Geophysical Limited, Christchurch
bgd20@student.canterbury.ac.nz

Structures are often built in areas where there are undetected or poorly defined faults. Where these structures are sited near to, or across such faults or fault zones, they may sustain both shaking and ground deformation damage during an earthquake. Management of such seismic hazards needs to be based on accurate identification of the potential damage zone. In the case of buried faults the application of non-invasive geophysical survey methods is often desirable.

The multi-channel analysis of surface waves (MASW) shallow seismic survey method is used here to image a buried fault zone in Torlesse greywacke under a gravel overburden. Rapid data acquisition uses a towable land streamer carrying a multichannel geophone string providing both data redundancy and reduction in labour. An MASW survey records dispersive Rayleigh waves. The fundamental mode wave velocities are plotted against their frequencies to produce a fundamental mode dispersion curve. The curves for each record are then inverted to determine s-wave velocity with depth and the resulting 1D inversions juxtaposed to construct a 2D shear wave velocity profile. This pseudo-section defines the fault zone and acts as a proxy for changes in rock mass properties. The MASW technique is particularly sensitive to field parameter selection which was explored experimentally. Processing procedures and problems are outlined and briefly discussed.

The velocity profiles are presented and interpreted in relation to adjacent profiles, to the local geomorphology and to geotechnical characterisation of exposed bedrock in a parallel river channel. The profiles correlate well with fluvial bedrock and fault zone exposures. Predictably the shear zone is shown to be characterized by low s-wave velocities compared with adjacent competent bedrock. The velocity drop is consistent with fracture development and weathering observed on site and with fault zone velocities measured in horizontal crossholes. Less predictable details of the internal structure of the wider deformation zone were also imaged. On this basis, MASW is shown to provide a useful complement to geomorphological mapping and trenching for rapid delineation of fault zones in Torlesse greywacke.

TALK – Wed am

TRACKING VAGRANTS - KNOWN NEW ZEALAND COMATULIDS

Michael K. Eagle
Geology Department, University of Auckland, Private Bag 92019, Auckland.
Natural History, Auckland Museum, Private Bag 92018, Auckland.
mikee@aucklandmuseum.com

Comatulids are the most diverse and abundant of living crinoids, occurring as nektic vagrants from the inter-tidal zone to the abyss. Their initial appearance in the Triassic, major radiation in the Jurassic, and further diversification during the Cenozoic, include the only members of the class now living in shallow water. Possible fatal predation and scavenging complicated by a lack of appropriate facies and non-preservation explains their rarity in the fossil record. The first known comatulid is the Early Otapirian *Paracomatula triadica* Hagdorn & Campbell 1993 from the Lepredour Shellbeds, Bourake Formation, Ile Ducos, New Caledonia. No comatulids are known from the Jurassic of New Zealand, probably due to a lack of appropriate facies. The Notocrinidae are represented in the Middle Jurassic, Late Cretaceous and Eocene of Europe and the New Zealand Piripauan occurrence of *Semiometra* n. sp. in the Conway Siltstone, Haumuri Bluff, Marlborough, appears to be a Mesozoic, Tethyan migrant.

No comatulids are known from the Palaeocene; those from the Eocene collected at Kakanui, North Otago are un-described. North Island Late Oligocene (Duntroonian) comatulids belong to the Conometridae and include endemic *Moanametra torehinaensis* Eagle 2001 and *Pseudoconometra coromandelensis* Eagle, 2001 from the Torehina Formation, Waitete Bay, Coromandel. South Island Duntroonian–Waitakian comatulids occur at: Green Valley, Otago; Tarakohe, Nelson; Three Sisters (Hakataramea Valley), Pentland Hills and Hurstlea, South Canterbury. Only some of the comatulids occurring in the Meyers Pass Limestone Member, Otekaike Limestone Formation at the Ardlogie Station limepit, Pentland Hills, and at Haugh's Quarry, Hurstlea, have been described. New species are assigned the genera *Amphorometra*, *Cypelometra*, *Vicetiametra*, *Stenometra*, *Hertha*, C*omaster*, and P*alaeoantedon*. Two new families incorporating new genera and species occur at Ardlogie Station. Taxa at both fossil localities occur in a shallow, inner- to middle-shelf biostrome facies in association with stalked crinoids at, or close to, the Oligocene–Miocene boundary and are part of a large, diverse brachiopod, bryozoan, molluscan, pennatulacean, and echinoderm assemblage.

New Zealand stalked crinoids appear to have migrated into deeper water (outer-shelf to abyssal) in the Middle to Late Waitakian facilitated by a new tectonic plate boundary, associated continental shelf subsidence, and a significant increase of detrital sediment flowing off-shore, none of which appears to have greatly influenced comatulid faunas.

Early Miocene and later comatulid communities of inner to mid-shelf (e.g. North Cape Scientific Reserve (Otaian); Pakurangi Point, Kaipara Harbour (Altonian)) do not have stalked crinoids in association. Because of the rarity of fossil comatulids, the New Zealand fauna is an important record of taxonomic occurrence and aids understanding of the evolution of Southern Hemisphere and world-wide crinoids.

TALK – Tue pm

QMAP WHANGAREI: THE NEW 1:250 000 GEOLOGICAL MAP OF CENTRAL NORTHLAND

S.W. Edbrooke & F.J. Brook
GNS Science, PO Box 30368, Lower Hutt
s.edbrooke@gns.cri.nz

Preparation of the new 1:250 000 geological map of the Whangarei area is well advanced and a provisional version of the map is presented. The Whangarei map covers about 8600 km^2 of central Northland, from the northern shore of the Kaipara Harbour north to the Whangaroa Harbour. It extends offshore up to 25 km west of the North Kaipara Barrier and up to 100 km east of Northland where several offshore island groups are included. It completes the coverage of Northland, joining with the previously published Kaitaia and Auckland maps.

The map area is underlain by Permian to Early Cretaceous basement rocks belonging to four tectonostratigraphic terranes, but only two are exposed. In the east, greywacke and argillite of the Waipapa composite terrane outcrop between Whangaroa Harbour and Te Arai Point. In the northwest, metagreywacke and argillite with associated basalt, chert and volcanic sediments form the Waipapa horst, and are correlated with the Caples terrane. Late Eocene to Oligocene coal measures, glauconitic sandstone, calcareous mudstone and limestone of the Te Kuiti Group unconformably overlie basement rocks. Most of the Cretaceous and Paleogene rocks in the map area are displaced sedimentary rocks and ocean floor volcanics, present in thrust-bounded units and melange of the Northland Allochthon, which were emplaced in the Early Miocene. Autochthonous Early Miocene sedimentary rocks of the Waitemata Group underlie and overlie the Northland Allochthon, and Otaua, Waitakere and Coromandel Group sedimentary and volcanic rocks overlie it. Intermittent volcanism since the Early Miocene produced numerous subduction-related, stratovolcano complexes (Northland Volcanic Arc; buried offshore and largely eroded onshore), and younger basalt flows of intraplate character. Pleistocene and Holocene sediments comprise mainly the extensive dune complexes present on the west coast and locally on the east coast.

This map differs significantly from the earlier 1:250 000 maps of Northland, mainly in the interpretation and mapping of the displaced, complexly deformed Cretaceous and Paleogene rocks, and their relationship to autochthonous sediments. The improved understanding of these rocks since the 1960s has developed from better dating and the numerous structural and stratigraphic studies that have been undertaken. Displaced rocks of the Northland Allochthon are included in four tectonostratigraphic units. The Tupou Complex comprises Early Cretaceous sandstone and conglomerate in the Whangaroa area, the Mangakahia Complex includes extensive areas of Late Cretaceous to Eocene terrigenous clastic facies, the Motatau Complex includes Eocene and Oligocene carbonate-rich sediments, and the Tangihua Complex comprises Cretaceous to Paleocene ophiolites. In the northern part of the map area the allochthon comprises a series of thrust-bounded nappes of these four units, but in the south it is predominantly composed of melange containing tectonic blocks of Mangakahia Complex, Motatau Complex, Te Kuiti Group, and Waitemata Group lithologies.

DECONVOLVING TEMPERATURE AND CARBONATE ION EFFECTS ON MG/CA IN PLANKTIC FORAMINIFERA

S. Eggins[1], A. Sadekov[1], H. Spero[2] and A. Russell [2]
[1]RSES, The Australian National University, Canberra, 0200, ACT, Australia
[2]Dept. of Geology, Univ. of California, Davis, CA 95616, USA
Stephen.Eggins@anu.edu.au

The bulk shell Mg/Ca composition of planktonic foraminifera has a well established temperature sensitivity of +9-10% per ºC, which underpins the widespread application of foraminiferal Mg/Ca to reconstruct past seawater temperature. However, laboratory culture studies indicate that bulk Mg/Ca compositions may be significantly influenced by [CO_3^{2-}] concentration, specifically increasing at low [CO_3^{2-}] (e.g. Russell et al., 2004). Moreover, new microanalysis based studies reveal the development of Mg/Ca heterogeneity, as growth banding, within individual foraminifers (Eggins et al., 2004; Sadekov et al., 2005) in possible response to day-night cycle in calcite saturation state driven by the daytime photosynthesis/night-time respiration of algal symbionts. To test the origin of Mg/Ca banding we have grown individual *Orbulina universa* in laboratory cultures under a 12 hour (high-light) day:12 hour night (dark) light-cycle. By synchronizing switching between day and night lighting with the transfer of foraminifers between ambient and Ba-spiked seawater we have introduced markers for calcite precipitated during the day and at night. High resolution compositional profiling using laser ablation ICPMS confirm that the previously observed Mg/Ca banding reflects a diel cycle and that the development of high Mg/Ca bands occurs at night. This is also consistent with precipitation of high Mg/Ca calcite under reduced [CO_3^{2-}] concentrations at night due to the alternating dominance of respiration (night-time) and photosynthesis (daytime) on the carbonate system within the foraminiferal microenvironment. These results will be compared to and used to interpret the Mg/Ca banding characteristics of fossil *Orbulina universa*, and also discussed in terms of their potential use to deconvolve both palaeo-seawter temperature and carbonate system parameters.

TALK – Tue am

CONTROLS ON THE TERMINATION OF THE TAUPO RIFT; RESULTS FROM 3D ANALOGUE AND NUMERICAL MODELS

S. Ellis[1], P. Villamor[1] & G. Schreurs[2],
[1]GNS Science, P.O. Box 30 368, Lower Hutt
[2]University of Bern, Bern, Switzerland
s.ellis@gns.cri.nz

At the southern end of the Taupo Rift, the NNE-SSW strike of rift-flanking faults gives way to a series of structures striking at an oblique angle to the extension direction. The active faults comprise 3 main sets: a N-S striking graben, representing the southern section of the Taupo Rift; (2) NE-trending, and (3) WNW-ESE to E-W trending faults. The superposition of the fault sets creates a box-like structure at the southern end of the rift, with faults intersecting at high angles (Villamor and Berryman 2006). The tectonic evolution of the rift termination is not well understood. In particular, why do 3 different fault sets form at angles to each other? Is this a natural consequence of rift propagation southward, or does it result from other processes and changes in rift dynamics and/or lithospheric structure to the south?

Using 3D analogue and numerical models, we test which of the following factors may explain the change in structural style at the southern end of the TVZ: (1) A consequence of step-wise southward rift propagation from thermally weakened to "normal" continental crust; (2) rift propagation in an direction oblique to extension; (3) inherited crustal structure (including crustal thickness changes); and (4) a change in kinematics from extension to compression owing to rotation of the forearc.

Our preliminary results show that it is difficult to explain the change in structural trend as a natural consequence of rift propagation, even though stress directions are predicted to rotate at the rift tip. The box-like fault pattern is most simply explained as a combination of rotational effects from a transition from extensional to compressional tectonics, and reactivation of pre-existing brittle fabric.

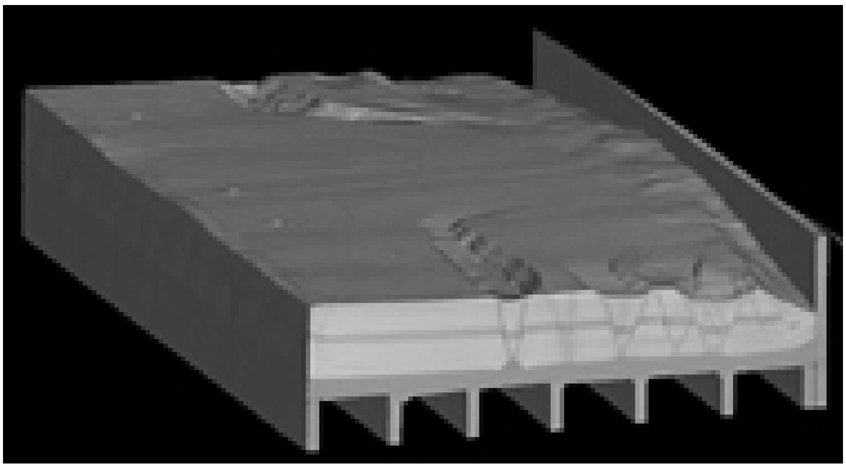


Figure: A 3D example of the tomographic view through the analogue experiments, with distributed rifting (central part of sand box) and a propagating rift (far- and near-field with oblique and orthogonal rifting, respectively). A change in rift orientation at the end of propagating rifts results from a change in extension magnitude along the boundary wall at right.

POSTER 13

PETROLOGY OF SOME MIOCENE COLD-SEEP LIMESTONES IN RAUKUMARA PENINSULA, EAST COAST BASIN: GEOLOGIC EVIDENCE FOR PAST SEABED HYDROCARBON SEEPAGE

Sarah Ewen[1], Kathleen Campbell[2], Campbell Nelson[1], Steven Hood[1] & David Francis[3]
[1]Dept of Earth & Ocean Sciences, Univ. Waikato, Private Bag 3105, Hamilton, NZ
[2]Dept of Geology, Univ. Auckland, Private Bag 92019, Auckland, NZ
[3]Geological Research Ltd, PO Box 30819, Lower Hutt
sme12@waikato.ac.nz

Cold seeps mark sites of focused fluid migration and subsequent expulsion at the sea floor. Often these fluids are rich in hydrocarbons such as methane. Anaerobic oxidation of methane (AOM) acts as a major biogeochemical driving force behind carbonate precipitation at seeps sites and is responsible for the presence of chemosynthesis-based communities that thrive in such environments. The ensuing biological activity and precipitation of methane-derived authigenic carbonate (MDAC) at seep sites, results in chemoherm build-ups, which upon burial may be preserved in the rock record as a unique variety of limestone.

In recent years, ancient seep limestones have been increasingly reported, many of which were originally misinterpreted, and their identification may be aided by recognising diagnostic characteristics of modern MDACs. Features include the precipitation of carbonate in a variety of morphologies (e.g., crusts, pillars, slabs, pavements and blebs), mineralogies and crystal fabrics, very light carbon isotopic signatures, and assemblages of unusual chemosynthesis-based biota.

In the Raukumara Peninsula of North Island, several occurrences of discrete limestone bodies are known to be enclosed within deep-water mudstones of Miocene age. While their previous interpretation has been inconclusive it is now apparent that many of the anomalous features in these limestones are consistent with an MDAC origin as exemplified by modern seeps. Reconnaissance field and petrologic studies at three of the limestone localities (Rocky Knob, Karikarihuata and Tauwhareparae) demonstrate that rapid vertical and lateral changes in lithofacies occur both on a macro- and microscopic scale, likely reflecting the dynamic nature of fluid ascent and expulsion at the sea floor and the subsequent evolution of the seep system as a whole. Early petrographic results reveal a complex diagenetic history involving brecciation, veining and multi-phase carbonate precipitation of isopachous fibrous aragonite, calcitic spar and micrite cements. Ongoing more detailed petrological and geochemical analysis of the limestones should enable an assessment of the type and origin of migrating fluids, the evolving nature of the fluid migration pathways, and the changes in fluid dynamics which result from carbonate precipitation and the consequent restriction of fluid expulsion.

This study is part of a wider collaborative project examining the occurrence of cold seep systems in North Island. It aims to construct a conceptual model of seabed fluid seepage during the Neogene, and ultimately apply the results to modern fluid escape along the Hikurangi Margin, and to evaluate implications for the East Coast Basin petroleum system.

POSTER 62

SUBSIDENCE STYLE IN THE SOUTH-EASTERN WANGANUI BASIN

Erik Ewig & Tim Stern
Institute of Geophysics,Victoria University of Wellington, New Zealand
erik.ewig@vuw.ac.nz

The back-arc region of the North Island subduction zone can be divided into two distinct zones: to the north there is the Taupo Volcanic Zone with extension, recent uplift, volcanism and high heatflow; in contrast, to the south there is the South Wanganui Basin - a region of broad crustal down-warp, with predominantly reverse faulting. The basin is Pliocene-Pleistocene in age, and the subducted plate lies at a depths of 25 to 200 km beneath the basin. The depocenter of this basin has migrated south-southwest with time, driven at least partly by the Quaternary uplift and doming of the central North Island. Sediments in the basin dip gently towards this depocentre and are cut by NE-NNE-trending faults that are generally dowthrown towards the center of the basin.

Offshore, the basin has been surveyed with a number of oil industry and CRI-funded multichannel seismic surveys. Onshore, the basin is known only from scattered geophysical surveys and a few exploration wells. This study presents an overview of the basement structure at the south-eastern edge of Wanganui Basin by means of active seismic and gravity measurements. Results from 10 gravity transect lines running from the foothills of the Tararua Ranges into the Wanganui Basin, most accompanied by active seismic data acquisition are presented. All these lines show clear evidence of faulting, often with numerous troughs and ridges associated with them. These faults, like the ones offshore, are running in NE direction, parallel to the Tararua Range front. The observed faulting sense is reverse as well as normal but due to the high angle nature of the majority of the observed faults, often the sense can not be determined unambiguously. The reverse faults agree well with the notion of crustal downwarp in a region of geodetically-determined, mild compression. The driving force of the normal faults are still subject of discussion but are believed to originate from) a local second order effect due to dextral strike slip motion along the major faults, b) tensional forces have been or are still active in this area or c) flexural bending stresses superimposed on an overall compressive stress field. Some faults in the west of the study area are highly likely to be still active within the last 100,000 years. However, a significant amount of deformation has to be accommodated by processes other than brittle faulting in the upper crust.

TALK – Wed pm

ORIGIN OF THE CHRYSTALLS BEACH COMPLEX: AN ANALOGUE TO THE ACTIVE HIKURANGI MARGIN SUBDUCTION CHANNEL?

Ake Fagereng and Richard H. Sibson
Department of Geology, University of Otago, PO Box 56, Dunedin 9054, New Zealand
ake@geology.co.nz

In the northeast of the Hikurangi subduction margin, seismological studies have defined a 1-2 km thick layer of high Vp/Vs, low Qp and distributed microearthquake activity along the subduction megathrust interface (Eberhart-Phillips & Chadwick, 2002). This zone is interpreted as a 'subduction channel' consisting of a fluid-saturated, highly sheared mixture of trench-fill sediments, which have been subducted below (or eroded from) the accretionary prism. Subduction channels are believed to be common features of active convergent margins (von Huene & Scholl, 1991).

The Chrystalls Beach Complex, SE Otago, is a possible analogue for an active subduction channel. This complex is an enigmatic part of the Otago Schist, and comprises an intensely sheared mixture of chert, terrigenous mud and sand, minor volcanogenic sediments and pillow lavas. It has a 'block-in-matrix' mélange structure, where asymmetric, dismembered beds of sand-rich competent material are enclosed within a relatively incompetent, cleaved pelitic matrix. In such a complex, the bulk rheology and strength both depend critically on the ratio of competent to incompetent material. The rock assemblage has been progressively deformed in a top-to-the-north shear zone, and is pervaded by an anastomosing network of quartz/calcite veins, where individual veins can be traced for tens of metres. Extension veins within this network indicate episodes where the tensile overpressure condition ($P_f > \sigma_3$) has been locally attained. Initially the sediments experienced compaction, volume loss and layer-parallel soft sediment shearing, developing a slaty cleavage and viscous S/C shear structures. The dense vein network developed during subsequent brittle deformation. The mineral assemblage (pumpellyite-chlorite to pumpellyite-actinolite), mica b_0 spacing and illite crystallinity indicate deformation in a high pressure – low temperature environment (~ 3-6kbar, ~ 200-300°C). This P-T environment and structural character appear to match that inferred for microseismically active portions of the Hikurangi subduction channel. Slickenfibres coating shear veins in the Chrystalls Beach Complex formed by a 'crack-seal' mechanism, suggesting formation by episodic slip coupled to fluid pressure cycling and solution transfer. These veins may therefore record incremental slip associated with microearthquakes like those seen in near-lithostatically overpressured regions of active subduction zones and other creeping fault segments.

In the Chrystalls Beach Complex, shear veins are commonly localised along lithological contacts, while extension veins are concentrated in the more competent units. If the process forming these veins mirrors the triggering mechanism of subduction zone microseismicity, then the structure and composition of the subduction channel shear zone impose a significant control on deformation along the subduction thrust interface. In particular, heterogeneity in fluid pressure and mud/sand ratio seems likely to be an important source of strength heterogeneity along the interplate megathrust.

35 YEARS OF GEOCHEMICAL RESEARCH ON THE TONGA – KERMADEC – NEW ZEALAND SUBDUCTION SYSTEM: AN OVERVIEW

John Gamble
Department of Geology, National University of Ireland, University College Cork, Ireland

The Tonga – Kermadec – New Zealand Oceanic to Continental subduction system continues to play a major role in the development of understanding of how subduction zone magmatism works and how continental crust forms on Earth. In this paper I will review the history of contemporary research on subduction zones and zone magmas, with particular reference to work on the Tonga – Kermadec – New Zealand system. Also, it is not widely recognised that volcanic rocks from this arc have been to the fore in the development and application of a number of advances in geochemistry

The talk will be divided into a number of parts, each dealing with specific aspects of subduction systems: Historical, Geophysics, Tectonics, Petrology, Geochemistry and New techniques. Among the topics I will discuss are: (i) The deep recycling of slabs; (ii) Evidence for recycling sediment at subduction zones and links between recycling and on-going erosion; (iii) Coupled geochemical evolution of arcs and back arc basins; (iv) Links between tectonics, andesites and rhyolites in oceanic and continental arc systems; (v) Open system, non-systematic magmatic processes on arc-type volcanoes.

Finally, I would like to pay homage to two papers that I read as an undergraduate at Queen's Belfast in 1969/70. The first was Ross Taylor's "Ni in Andesites" paper (G.C.A., 1969, 33, 275 – 286), the second was Dan Karig's "Ridges and Basins of the Tonga – Kermadec island arc system", (JGR, 1970, 75, p 239 - 254). These papers kindled an interest in arc volcanism and the SW Pacific, the rest is down to good luck, hard work, great friends, colleagues and family.

UNDERSTANDING RISK ASSESSMENT AND VISUALISING GEOLOGICAL PROCESSES THROUGH TIME WITH BASIN MODELLING

Malcolm Geddes
GNS Science

Multi-1D basin models provide a means of modelling basin evolution and the development of associated petroleum systems. BASSIM is a multi-1D modeller developed by GNS Science and University of Utah to model basin evolution which has recently undergone a makeover to increase its speed and capability.

BASSIM takes grids of isopachs, lithologic composition, depositional ages, and paleo-bathymetric data and models the thermal, tectonic and depositional development of the basin, tracking the generation of hydrocarbons through time. This detailed basin evolution model accurately accounts for effects such as time-transgressive deposition, erosional unconformities and volcanic intrusions. Recent improvements allow a generic approach to include multiple kinetic reactions related to the generation and breakdown of hydrocarbons in the deep oil kitchens within the sedimentary basin. Code upgrades to allow the parallel runs on PC clusters has resulted in a significant reduction in runtimes.

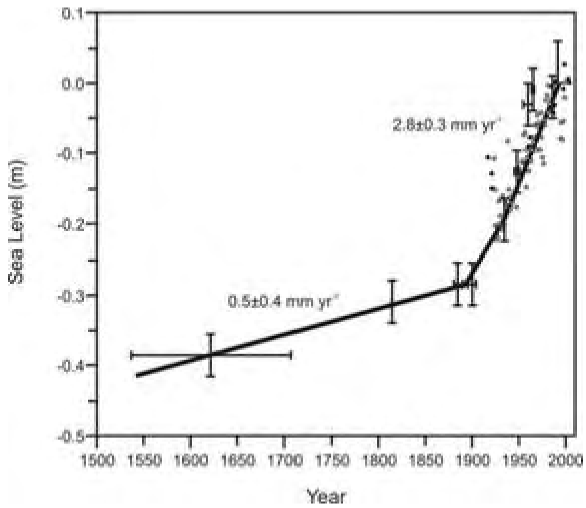
Basin models are often poorly constrained with large uncertainties in many of the inputs. The impact such uncertainty has on basin model behaviour can normally only be ascertained through sensitivity testing, which is particularly time-consuming. Reduced run-times provide an opportunity to investigate statistical uncertainty through developing probabilistic models. A Montecarlo approach has been implemented with the code, allowing input parameters to be defined as statistical distributions to provide an estimate of output uncertainty.

The application of Montecarlo methods or probabilistic models encourage greater confidence in the effects of input uncertainty and provide improvements to risk assessment for petroleum prospects and plays. Model sensitivities will be reviewed and visualisation of an evolving basin will be presented.

20TH CENTURY ACCELERATION OF SEA-LEVEL RISE IN NEW ZEALAND

W. Roland Gehrels[1], Bruce W. Hayward[2], Rewi M. Newnham[1], Katherine E. Southall[3], Ashwaq T. Sabaa[2] and Hugh R. Grenfell[2]
1.School of Geography, University of Plymouth, United Kingdom
2.Geomarine Research, 49 Swainston Rd., St. Johns, Auckland, New Zealand
3.Department of Geography, Trinity College, University of Dublin, Dublin 2, Ireland
Email contact: b.hayward@geomarine.org.nz

Tide-gauge records in the southern hemisphere are of little use when comparing 19th and 20th century rates of sea-level rise. The Permanent Service for Mean Sea Level lists eight tide-gauge records from the southern hemisphere with at least 60 years of data for the period 1900 –2000, two of which are found in New Zealand. Starting dates for these records are 1904 (Auckland) and 1924 (Lyttelton). As 19th century sea-level measurements are virtually non-existent in the southwest Pacific region, the only feasible way of reconstructing sea-level changes at high resolution from before the tide-gauge era is through the use of proxy studies. We present results of the first foraminifera-based sea-level study in the southern-hemisphere from Pounawea, South Otago. It provides evidence of rapid rates of 20th century sea-level rise when compared to sea-level change during preceding centuries. We documented the stratigraphy of a salt meadow and investigated the vertical distributions of live and dead salt-meadow and marsh foraminifera in surface transects to assess their usefulness as sea-level indicators. Fossil foraminifera in core sections were used to reconstruct the sea-level changes. We dated the sequences using AMS ^{14}C and a number of stratigraphic markers (pollen, Pb concentrations, $^{206}Pb/^{207}Pb$ ratios, charcoal and ^{137}Cs) which, when linked with historical documentation, provide useful ages for key horizons in the cores. The reconstruction shows a slow sea-level rise of 0.2±0.3 mm/yr between AD 1600 and 1900. The reconstructed rate during the 20th century is markedly faster and is estimated at 3.1±0.1 mm/yr, in reasonable agreement with the rate of 2.5±0.3 mm/yr measured by the Lyttelton tide gauge between 1925 and 2000. We investigated the bio- and lithostratigraphy of several other marshes in southern New Zealand and found that recent salt-marsh accumulation has occurred primarily in direct response to rapid rates of sea-level rise during the 20th century. The salt marshes therefore provide a valuable sedimentary archive of the history of recent sea-level changes.



Reconstructed sea-level index points from Pounawea, southern New Zealand, including age and altitude errors. Also shown are annual tide-gauge observations at Lyttelton (open dots) and Bluff (black dots).

TALK – Tue pm

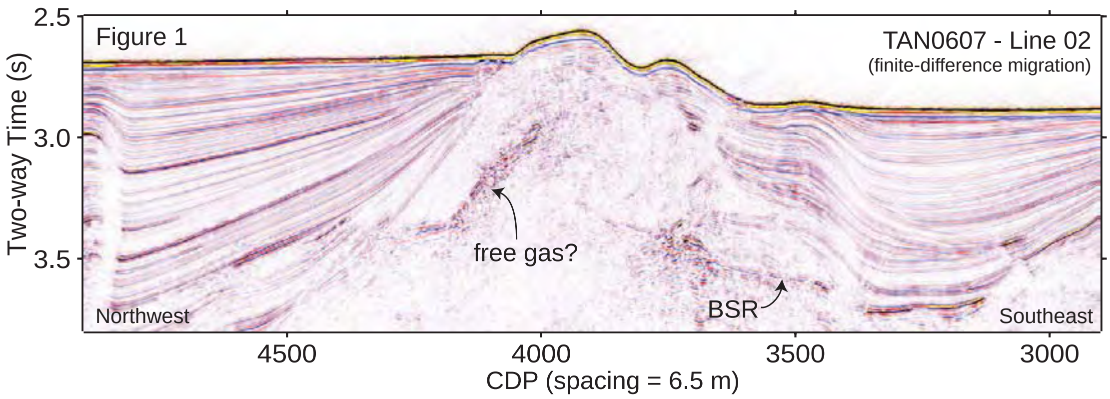
ACTIVE FAULT-PROPAGATION FOLDING AND GAS HYDRATES IN THE HIKURANGI MARGIN (NORTH ISLAND, NEW ZEALAND)

F.C. Ghisetti[1], A.R. Gorman[1], G.J. Crutchley[1], I.A Pecher[2], S. Toulmin[2], Stuart A. Henrys[3] and the students of GEOL430-2007[1]
[1]University of Otago, Department of Geology, PO Box 56, Dunedin
[2]Inst. of Petroleum Engineering, Heriot-Watt University, Edinburgh EH14 4AS, UK
[3]GNS Science, PO Box 30368, Lower Hutt
francesca.ghisetti@otago.ac.nz

Mechanisms of oblique collision at the Hikurangi subduction margin (offshore North Island) are recorded by the complex sequence of folds and faults that deform the Miocene, Plio-Pleistocene and Holocene sedimentary units in the accretionary wedge, detached above the westward-subducting Pacific Plate. These structures are assumed to play a significant (but often poorly understood) role in controlling the position, entrapment and/or escape pathways of gas hydrates and associated free gas accumulations that have been the object of intense research in the recent years.

The acquisition in 2006 of nine seismic reflection profiles and detailed sea-floor bathymetry at Porangahau Ridge, ~40 km east of Cape Turnaround (see Fig.), enable a geometrical investigation of a prominent N-S fault-propagation anticline, crosscut by a sub-parallel, E-verging thrust fault, located ~25 km west of the outer thrust front. No local well exists for calibrating the seismic lines, but the seismic stratigraphy established by previous authors in conterminous regions is used for defining the Plio-Quaternary age of the sequence that fills the perched basin onlapping the western limb of the anticline.

From N to S, the close (~1.8 km) spacing of the seismic lines facilitates mapping changes in crestal elevation, amplitude and axial-perpendicular shortening of the anticline, in relation to the position and displacement of the cross-cutting thrust fault. These structural changes are also reflected in the distinctive N-S change in position, elevation, and reflectivity patterns of the bottom simulating reflection (marking the base of gas hydrate stability) and underlying free gas accumulations. The definition of the 3D geometry and the sequential restoration of the detached and thrust-breached syn-sedimentary anticline provide significant constraints on the kinematics and pathways of methane in the outer accretionary prism.



TALK – Thu pm

THRESHOLDS FOR COASTAL EROSION FROM SEA-LEVEL RISE ALONG OPEN-EXPOSED SANDY COASTS

Jeremy G Gibb
Coastal Management Consultancy Limited, 555 Esdaile Road, R.D.6, Tauranga
jgibbcmc@ihug.co.nz

Depending on both rate and magnitude, sea-level rise (SLR) is a well-established factor contributing to long-term shoreline retreat. The most compelling evidence for this is the effects of the postglacial marine transgression (PMT) when the shoreline everywhere around New Zealand migrated landward from the seaward edge of the continental shelf to what is now the landward edge of the Holocene coastal plain. Eustatic sea-level rose about 115m during the PMT between 18ka and 6.5ka (6,500 years B.P.) at a net rate of 10mm/y with rates up to about 15mm/y. During this period, the shoreline retreated some 30-40km landward in the Bay of Plenty (BOP) at about -2.5 to -3.5m/y.

Following the culmination of the PMT at the present sea-level about 6.5±0.1ka (7.3±0.1ka secular corrected), eustatic fluctuations on the order of a few decimetres have occurred, with a period of relative sea-level stability over the last 3ka. Over the last 6.5ka other factors such as sedimentation and tectonic uplift have predominated resulting in shoreline advance in many places and the formation of the Holocene coastal plain. In the western BOP, the coastal plain has advanced some 2-8km at about 0.3 to 1.0m/y over the past 7.3ka and a maximum of 10-15km in the Rangitaiki Plains at 1.4 to 2.1m/y, despite tectonic downdrop at -0.4 to -2.0mm/y, equivalent to an apparent SLR.

Where accurate historical rates of long-term duneline advance or retreat are known it is possible to determine likely thresholds for duneline retreat from erosion using the well-established "*Bruun Rule*". Per Bruun first demonstrated in 1962 that where the sea floor is in equilibrium with sea-level, a rise in sea-level promoted coastal erosion through the landward translation of the nearshore beach profile.

The dunelines of western Rangitaiki Plains, northern Poverty Bay and Waiotahi Beach have advanced from accretion at 1.42m/y, 0.9m/y, and 0.57m/y on average last century, respectively, from abundant supplies of fluvial sand. SLR will have to reach and exceed 40mm/y, 18mm/y and 9mm/y, respectively, to reverse this trend to retreat from erosion. At the Mount, the duneline along Marine Parade has advanced at 0.15 to 0.36m/y from longshore drift. SLR will have to reach and exceed 4.5 to 11.0mm/y to reverse this trend to duneline retreat.

The above examples of advancing dunelines have occurred during a SLR of about 1.6mm/y last century around New Zealand. This century, SLR is projected to accelerate to 5-8mm/y by about 2100, reaching and exceeding 10mm/y beyond 2100 (the PMT rate) as a consequence of global warming and discharges from the Antarctic and Greenland ice sheets. Under these scenarios, reversals from duneline advance to retreat are not likely to occur along Marine Parade until the end of this century, and not until well after 2100 along the Rangitaiki Plains, Poverty Bay and Waiotahi Beach. For dunelines with zero historic trend like Papamoa Township, SLR of 5-8mm/y is likely to result in a progressive reversal to duneline retreat at -0.17 to -0.28m/y by about 2100.

QUATERNARY STRUCTURE, MORPHOLOGY, AND STRATIGRAPHY OF THE OTAGO AND SOUTH CANTERBURY SHELVES FROM 18 YEARS OF SUB-BOTTOM SEISMIC PROFILING INVESTIGATIONS

A.R. Gorman[1], M.G. Hill[1], P.O. Koons[2], C.A. Landis[1], T.M.H. Allan[3], T. Johnstone[4], A.R. Orpin[5], F.L. Gray[6], D. Wilson[7], and E.C. Osterberg[2]

[1]Department of Geology, University of Otago, PO Box 56, Dunedin
[2]Department of Geological Sciences, University of Maine, Orono, ME 04469, USA
[3]OMV New Zealand, Level 10, Deloitte House, 10 Brandon Street, Wellington
[4]TGS, Level 5 – 1100 Hay Street, West Perth, WA 6005, Australia
[5]NIWA, Private Bag 14901, Wellington
[6]49 Saxton Road, RD1, New Plymouth
[7]WesternGeco, 10001 Richmond Avenue, Houston, TX 77042, USA
andrew.gorman@otago.ac.nz

The seafloor off the South Canterbury and Otago coast is characterised by a relatively narrow (15- to 30-km-wide) shelf incised by several submarine canyons, five adjacent to Otago Pennisula alone, that feed into the deep Bounty Trough, several hundred km to the east. The Quaternary shallow-marine sediments of the shelf and slope preserve a detailed stratigraphic record of sea-level change, and identify repeated incisions of coastal-plain channels and active structures.

A series of high-resolution single-channel seismic reflection surveys has been undertaken over the last 18 years on the Otago Shelf on board the University of Otago's *RV Munida* by a number of postgraduate investigators. Six of these analogue boomer surveys were recently digitised, merged with navigation data, and archived in SEG-Y format. This has facilitated further digital processing and analysis of the dataset. In particular, the application of swell and band-pass filters, deconvolution, and poststack migration have improved the resolution of the data sets that can now be analysed with modern seismic interpretation software.

We present a synthesis of these reprocessed data that have been used to address the following questions.

1. What role do coast-perpendicular and coast-parallel structures have on lowstand sedimentation on the shelf?
2. What is the nature of groundwater flow within the shelf and how is it affected by Pleistocene-to-recent sea level variation?
3. How might elevated pore pressures influence the geomechanical properties of the margin sediments?
4. What is the linkage between hydrological (vent/chimney), erosional (canyon development) and structural (basement controls on sedimentation) processes. on this passive margin?
5. How did the eruption of the Dunedin Volcanic Complex affect the development of the shelf?

TALK – Tue pm

DEPOSITIONAL RECORD OF HISTORIC LAHARS WITHIN THE UPPER WHANGAEHU VALLEY, MT. RUAPEHU

A. H. Graettinger[1], V. Manville[2], R.M. Briggs[1]
[1]Department of Earth and Ocean Sciences, University of Waikato, Hamilton
[2]GNS Science, Wairakei Research Centre, Private Bag 2000, Taupo
ag45@waikato.ac.nz

Volcanic debris flows (lahars) are a regular occurrence on Ruapehu volcano, and may be produced by the explosive ejection of Crater Lake water, the remobilisation of tephra deposits by heavy rain, or by the sudden release of water from Crater Lake due to failure of a tephra/ice dam. Sedimentological and chronological reconstructions of historic and pre-historic lahars have been conducted on the ring plain, but work on historic deposits closer to Crater Lake in the upper reaches of the Whangaehu River, has been limited.

The sedimentology, depositional extent, and geomorphology of Ruapehu lahar deposits since 1861 have been described for the first 9 km of the Whangaehu Valley. These descriptions contribute to the quantification of conditions leading up to the anticipated March 18, 2007 lahar. Field investigations were supported by two LIDAR surveys and high resolution orthophotos to map historic lahar terraces in the valley prior to (2006) and after the 2007 event. Historic vertical and oblique aerial photos enabled mapping of lahar inundation areas for 1945, 1953, 1975, September 1995, and October 1995. Partial deposit reconstructions of events in 1968 and 1999 were also created from these records. Grain size distribution, componentry, and geomorphology of the 1861, 1975, September 1995, October 1995, 1999 and 2007 lahar deposits have been compared.

The historic deposits reflect a variety of flow sizes and types, but all remain channel confined. The lahar deposits are massive, very poorly sorted, silty gravels that form a series of unconsolidated terraces. The eruption-generated 1975 and September 1995 deposits are similar to the Crater Lake release 2007 deposits, displaying well defined and widely distributed terraces with large scale, up to 2 m wide and 15 m long, bouldery streamlined bedforms. Remobilisation lahars from October 1995 and 1999 had smaller deposit volumes and a finer grain size but still display the same sedimentological characteristics. The 1975 eruption-triggered lahar was the largest measured event in the Whangaehu gorge, with a peak discharge of c. 5000 m^3/s. The 2007 lahar was the next largest at c. 2500 m^3/s.

The componentry of the historic lahars is similar, since all events are sourced from eruptions through the Crater Lake, eroding material found confined to the valley. However, the deposits can be differentiated by proportions of lithological components and in some cases anthropogenic debris. The distribution of deposits terraces within the valley and proportions of components in the deposits, including scoria and lake sediment, show a strong correlation to the type of triggering mechanism.

TALK – Wed pm

TOWARDS A BETTER UNDERSTANDING OF THE PETROGENESIS OF VOLCANIC ROCKS FROM THE KERMADEC INTRA-OCEANIC ARC

I.J. Graham[1], I.E.M. Smith[2] & I.C. Wright[3]

[1]GNS Science, 1 Fairway Drive, PO Box 30 368, Lower Hutt, New Zealand
[2]Geology Department, University of Auckland, Auckland, New Zealand
[3]National Institute for Water and Atmospheric Research, Wellington, New Zealand
i.graham@gns.cri.nz

Over the past 8 years, the entire c. 1150 km long Kermadec arc front, to just beyond the Monowai volcanic centre, has been systematically surveyed during reconnaissance expeditions led by GNS Science and NIWA, resulting in the discovery of more than 30 new submarine volcanic centres. These have been mapped by multibeam and sampled for water column plume signatures, hydrothermal fluids, and fresh, altered and mineralised volcanic rocks. Attaining representative samples of fresh rocks from the seafloor for petrogenetic analysis has proved particularly difficult because of the limitations of the sampling methods used and hydrothermal and seawater alteration of the rocks. The least expensive and most widely used sampling method, dredging, is often non-specific as to location, and has a difficult-to-avoid sample bias in preferentially recovering more recently erupted material. Sampling using submersibles is more site-specific, but is relatively expensive and therefore limited in coverage. That said, adherence to strict sampling and data handling procedures can ensure that sample data sets are representative (of the youngest eruptives), balanced, and contain only analyses of an acceptable quality (i.e., are minimally contaminated, of high precision, and calibrated to international standards). Representative data sets for the Kermadec Arc, generated in this way, reveal subtle petrological differences between volcanic centres and along the arc that can be related to changes in tectonic regime, which in turn may be influenced by factors such as mantle heterogeneity, the changing nature of the down-going slab, and variable thickness of the sub-arc crust. Within individual volcanic centres, well-defined geochemical and isotopic trends provide strong pointers to the main petrogenetic process or processes at work (crystal fractionation, crustal anatexis, crustal assimilation, and magma mixing), allowing robust models to be constructed. A critical factor missing, but available for sub-aerial parts of the arc, is time.

TALK – Tue am

HOW NORMAL ARE NORMAL FAULTS IN VOLCANIC RIFTS?

Darren Gravley[1], Julie Rowland[1], Colin J.N. Wilson[1] & Graham Leonard[2].
[1]Geology Programme, SGGES, University of Auckland.
[2]GNS Science.

In the central Taupo Volcanic Zone (TVZ), displacement rates may be highly variable on individual faults over short time scales. Using the record of displacement over the past 60 k.y. on normal fault traces across the Ngakuru Graben, several investigators have found that displacement rates become more stable with increasing fault size when aggregated over the entire rift. They concluded that while elastic fault interaction and interdependencies may generate short-term fluctuations in the timing and magnitude of earthquake-related displacements, such interactions also ultimately result in steady-state displacement rates on million-year time scales. Of relevance here, paleoseismic data recorded over the past 60 k.y. do not support the notion of widespread triggering of fault slip during individual volcanic eruptions 10-100km from the study area.

However, applying these results to the entire central TVZ over its 1.6 m.y. history is problematic. Extrapolating any steady-state type of fault behaviour over time periods of $>10^4$-10^5 years may disguise complex interactions between volcanism, magmatism and tectonism. Such interactions may trigger accelerated slip on normal faults over a wide range of temporal and spatial scales. Field studies show that accelerated rifting in the TVZ coincided temporally with periods of widespread magmatism involving the eruption of >3,000 km^3 of magma. Between ca. 340 and 240 ka, a flare-up of ≥7 caldera-forming eruptions occurred across the entire central TVZ, with concomitant increases in time-averaged displacement rates on faults. This is displayed by exposures on the Bay of Plenty coast at 300 masl of the 280 ka Matahina ignimbrite, overlying marine sediments on the western rift shoulder of the Whakatane Graben. The scale and timing of uplift of this ignimbrite match those seen on the eastern rift shoulder and indicate that the Whakatane Graben is younger than 300 ka. Was the Matahina ignimbrite uplifted in increments of slip over 280 k.y., or in clustered slip events, or by abnormally large slip events?

Elsewhere in the TVZ, some large fault displacements occurred over very short time periods. For example, paleogeographic reconstruction of the Ngakuru Graben area indicates that collateral subsidence accompanied the twin Mamaku and Ohakuri ignimbrite eruptions at ca. 240 ka. Withdrawal of magma from the vicinity of the slightly older Horohoro dome, during and/or after the twin eruptions triggered a single large slip event along a fault that cuts across the dome and displaces the Mamaku ignimbrite (sourced from the Rotorua caldera) by >200 metres. Displacement on the Waihi fault at the southern end of Lake Taupo is similarly inferred to have resulted from magma migration in association with the 26.5 ka Oruanui caldera-forming eruption. Younger examples from the TVZ and elsewhere demonstrate the accrual of slip on near-surface faults in association with magma migration (e.g., Taupo 1800 a, Dabbahu 2005). We therefore conclude that accelerated fault displacement consequent on magmatism may be an important, if spatially and temporally variable component of extensional strain within the Taupo Volcanic Zone.

TALK – Thu pm

GUILIELMITES - A TRACE FOSSIL IT AIN'T

Gregory, M. R.[1] and Raine, J. I.[2]
[1]Geology Programme (SGGS), The University of Auckland,
[2]GNS Science
m.gregory@auckland.ac.nz

Late in 2006 I was approached through FRED (New Zealand Fossil Record File) to comment on, if not verify the identity of a collection of 'trace fossils' that had been provisionally placed in the ichnotaxon "*Guilielmites cf. permianus*" by Ian Raine. I was both surprised and bemused for this was an ichnofossil unknown to me, and hence had not been recorded in the catalogue of New Zealand trace fossils compiled for the forthcoming *Species 2000 vol.* (Gregory, in press). Referring to the Treatise on Invertebrate Paleontology I quickly found "Guilielmites" is considered a pseudo-(trace)fossil.

During the course of field mapping on the West Coast in December 1982, Simon Nathan and David Titheridge had come across some unusual "discoidal" structures in strongly-cleaved, carbonaceous shales outcropping on the side of the road that ascends to Mount Rochfort. They commented that "These peculiar round structures seem quite common in one particular band of black carbonaceous shale…" of the Brunner Coal Measures (Arnold Series). Specimens collected by Nathan and Titheridge are typically flattened discoidal bodies lying parallel to fissility planes in the black shale, with diameters between 20 mm and >60 mm. Broken specimens suggest maximum diameters could exceed 80 mm. Exposed surfaces are generally smooth and polished. At the central core of these bodies lies a slightly depressed, and massive, circular boss or plug, *c.*5 mm across. This is encircled by a gently raised and broader, convex-up zone that is often characterized by radiating, closely spaced, fine striations. In some instances the discoidal bodies appear to be stacked into layers that may be slightly offset, and resemble the recently described (pseudo)trace fossil *Amanitichnus omittus.* In some instances marcasite or pyrite may be evident along striae and "sand dollars" are often mistaken for echinoid impressions. The patterns developed are also often suggestive of, if not claimed to be evidence of medusoid impressions (*i.e.*jelly fish). The Rochfort Rd "Guilielmites" are associated with the decalcified impressions of fresh-water unionids – probably *Hyridella.* This factor together with evidence of algal mats and bioturbation suggests the depositional setting was a broad and shallow, fresh water lake or swamp.

"Guilielmites" like many other enigmatic structures has received limited and/or spasmodic mention in the lexicon of geology. Interpretations of possible origins have been varied and chequered. These include both organic (the initial identification was as a plant seed and latterly invertebrate activities) and inorganic processes. Modern explanations have focused on mechanical compaction and slickensides, water expulsion, and diagenesis (*e.g.* Seilacher, 2001).

Gregory, M.R. (in press). Trace fossils, whispers of ancient life. *In* Gordon, D.P (*editor*) The New Zealand Inventory of Biodiversity:A Species 2000 symposium review. Canterbury University Press, Christchurch.

Seilacher, A. 2001. Concretion morphologies reflecting diagenetic and epigenetic pathways. *Sedimentary Geology 143*; 41-57.

THE MICROFOSSIL RECORD OF HUMAN IMPACTS – A PROGRESS REPORT ON NEW ZEALAND STUDIES.

H.R. Grenfell & B.W. Hayward
Geomarine Research, 49 Swainston Rd, St Johns, Auckland.
h.grenfell@geomarine.org.nz

For the past five years part of our research effort has focussed on the potential of microfossils (foraminifera, diatoms, ostracods, palynomorphs) to document human impacts in New Zealand estuaries. We have investigated in detail historical and existing sewage disposal in the Manukau Harbour, the impact of stormwater run-off in the Waitemata Harbour, marine farming in Mahurangi Harbour and currently the effects of human assisted marine invaders (*Spartina* and *Musculista*). Other impacts such as dairy effluent, tip leachates, dockyards and marinas in coastal settings have also been explored.

Estuaries are the most stressed of marine systems and often act as sinks for pollutants. Determining just how the current condition of estuarine ecosystems relates to a hypothetical pre-impact state is very difficult. While monitoring the concentration of trace metals, sediments, coliform bacteria and other pollutants are useful they do not document the relative status of the soft-sediment biota. For remedial initiatives to be at all effective it is important to "see" what historic changes have occurred to the pre-impact communities. The only clues come from the hard-parts of a small portion of the original biota that are preserved in late Holocene sediment cores. However the macrofaunal record is at best patchy and not easily investigated using coring techniques.

Once an age model has been established, changes (or lack of) in the benthic microfossils can be related to pre-human, Polynesian, early European and late European phases. For example changes in salinity, and probably pH, are commonly marked following early European deforestation and late European urbanisation. This paper summarises the methodologies and outcomes of our research which can serve as the basis for future research documenting other impacts and any restoration efforts.

TALK – Tue pm

MODELING SEISMIC ANISOTROPY ACROSS THE CENTRAL VOLCANIC REGION

Sonja M. Greve & **Martha K. Savage**
Institute of Geophysics, Victoria University of Wellington
sonja.greve@vuw.ac.nz

Seismic anisotropy across the Hikurangi subduction zone as exhibited by shear wave splitting exhibits strong lateral changes over distances of about 250 km. Teleseismic S-phases show trench parallel fast polarisations across the fore arc and back arc region, with increasing delay times. In the arc region, delay times reach up to 4.5 s, one of the largest delay times measured in the world. Such large delay times suggest strong anisotropy or long travel paths through the anisotropic regions. Delay times decrease systematically in the back arc region. In contrast, local S-phases exhibit a distinct change from trench parallel fast orientations in the fore arc to trench perpendicular in the back arc, with average delay times of 0.35 s. In the far back arc, we observe no apparent anisotropy for teleseismic S-phases.

A conceptual model for the observed anisotropic pattern defines three different anisotropic regions across the subduction zone: 1) In the fore arc region, with trench parallel fast orientations and delay times of 2-3 s, anisotropy is attributed to trench parallel mantle flow below the slab with possible contributions from anisotropy in the slab. 2) High, frequency dependent anisotropy in the mantle wedge together with the sub-slab anisotropy add up to cause the high delay times observed in the arc region. 3) In the far back arc region, the mantle wedge dynamic seems to end. The apparent isotropy must be caused by different dynamics, e.g. vertical mantle flow or small-scale convection.

We test our proposed hypothesis of the anisotropic regions using anisotropic wave propagation in 2D and 3D. The finite difference and one-way wave equation modelling codes we use allow us to set up regions with different anisotropic characteristics such as fast orientations and anisotropic strength. Large-scale models of the subduction zone (several hundreds of kilometers) incorporating the proposed anisotropic regions of our interpretation result in similar anisotropic pattern to the measurements. Although models are not unique, they support the interpretation of anisotropy across the Hikurangi subduction zone.

In addition to large-scale models of the subduction zone, we test the proposed frequency dependence. We compare different approaches such as small-scale (several tens of kilometers) finite difference and analytical models to calculate frequency dependent anisotropy due to melt occurring in inclusions, cracks or bands. Initial results stress the scale dependence of anisotropy as a function of the size of inclusions and the wavelength. To observe frequency dependent anisotropy for local and teleseismic shear waves, e.g. for frequency ranges of 0.01-1 Hz, aligned inclusions have to be on the order of 1-100 m.

DEVELOPING A METHOD FOR EXTRACTING RHEOLOGICAL INFORMATION FOR QUARTZ FROM NATURALLY DEFORMED ROCKS

S. Grigull[1], T. A. Little[1], S. M. Ellis[2]
[1]School of Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington
[2]GNS Science, PO Box 30368, Lower Hutt
Susanne.Grigull@vuw.ac.nz

We are developing a method to extract rheological information from neotectonically sheared quartz veins exposed in the central Southern Alps, New Zealand. These exposures can be viewed as the result of a natural experiment on quartz undertaken in the mid-lower crust (~450°C, >20 km depth) during upramping of the Pacific plate onto the Alpine Fault. There, the quartz veins were subjected to transiently high shear stresses and high fluid pressures (310 MPa to 560 MPa) causing local embrittlement of some of the veins. Many of the veins, however, did not fracture, but were ductilely sheared at minimum strain rates of $\sim10^{-13}$ s^{-1}. Simultaneously with the shearing, the quartzofeldspathic host rocks of the veins were faulted brittlely. Fault surface plastering qtz-clc-chl veins suggest slip by an aseismic stable sliding process. Where brittle fault tips in the host schist encountered the older quartz veins, the faults terminated into ductile shear zones in the quartz. Most of the ductilely sheared veins were “smeared out” to finite shear strains of 5-15. Which deformation mechanism accommodated this high strain? What were the rheological properties of the sheared quartz?

We first developed a graphical-algebraic projection method to depict the “true” shape and displacement of the sheared veins from observations on arbitrarily oriented outcrops. The true shape is defined to be that seen on a plane perpendicular to the shear zone and parallel to the slip vector. Of particular interest are changes in thickness and orientation of the veins across the shear zones and their curvature distribution. We also quantify the relationships between undeformed vein thickness vs. width and magnitude of the ductile shear component.

We use FE modelling to simulate the evolution of the above described natural vein structures. We aim to obtain a set of applicable flow law parameters for the deformed quartz veins within the known sets of physical conditions and deformation rates. First small strain models were set up, assuming displacement rate boundary conditions, a brittle fault terminating into a quartz vein, a deformation temperature of 450°C, a yield stress of 100 MPa, and an initial dislocation creep law modified from that of Paterson & Luan (1990). Preliminary modelling results indicate that fully ductile deformation of the veins should only be possible if the quartz was at least 1000 times weaker than the enclosing schist. In order to approximate the shape of the quartz veins, the power law stress exponent would need to be $n \geq 4$. The results also show that the fraction of ductile creep strain in the veins decreases as a) the imposed displacement rate increases, and as b) the vein thickness decreases.

The next step in this project will be to improve the remeshing process in the models in order to achieve higher shear strains, simulating the values that are observed in the field. At the time of the conference we hope to present more realistic modelling data that represent the rheology of these natural quartz veins.

RHENIUM – OSMIUM SYSTEMATICS IN SUBDUCTION ZONES: CONSTRAINTS FROM THE SOUTHERN KERMADEC ARC

M.R. Handler[1], K. Suzuki[2], R.J. Wysoczanski[1], I.C. Wright[3] & J.A. Gamble[4]
[1]SGEES, Victoria Univ. Wellington, PO Box 600, Wellington
[2]Institute for Research on Earth Evolution, JAMSTEC, Kanagawa, Japan
[3]National Institute of Water & Atmospheric Research, Wellington
[4]Dept of Geology, University College Cork, Ireland.
(monica.handler@vuw.ac.nz)

The behaviour of the sulfur-associated chalcophile elements (e.g. Re, Cu, and the platinum-group elements Ir, Os, Ru, Rh, Pt, Pd) in subduction zone environments is poorly understood, including the role of recycling processes and behaviour during magma evolution. The radiogenic Re-Os isotopic system has the potential to be an important tracer both of chalcophile metals and of crust – mantle interaction as Re and Os are strongly fractionated during partial melting of the mantle leading to very different Os isotopic compositions for mantle and crust (mantle $^{187}Os/^{188}Os \sim 0.12$; oceanic crust $^{187}Os/^{188}Os \geq 0.14$; continental crust $^{187}Os/^{188}Os \sim 1$). Utilising the Re-Os system in arc lavas is currently hindered by ambiguity in two key areas: whether radiogenic, crust-like Os signals in arc lavas represent a deep recycled component or crustal assimilation, and whether low Re concentrations of typical arc lavas reflect limited Re recycling or volatile-loss processes even in submarine erupted lavas.

Studies of mantle-wedge peridotites suggest that Os may be mobilised from the subducting slab, adding radiogenic Os to the mantle wedge. How pervasive and effective this enrichment process may be is unclear, particularly whether recycled Os is transferred to the overlying arc crust. Limited published studies on arc lavas typically report radiogenic Os compositions that correlate with decreasing Os concentration indicative of two component mixing between mantle-like and crust-like end-members. Whilst the radiogenic Os component in the lavas may represent recycling, studies in continental arc settings point to crustal contamination. Arc lavas typically have low Os concentrations (typically <50ppt Os), and intra-oceanic arcs may also be vulnerable to crustal contamination. Experimental studies indicate Re should be more mobile than Os in the Cl-fluid rich, oxidized arc environment, yet most reported arc lavas, dominantly subaerially erupted, have very low Re concentrations. Significantly higher Re concentrations reported for melt inclusions from a fluid-dominated arc suggest degassing may hold the key to low whole rock Re concentrations.

We will present Re and Os isotopic data, together with lithophile element data, for submarine erupted, basaltic to basaltic andesite lavas from the intra-oceanic southern Kermadec Arc to address these key issues. Whole rock Re analyses support degassing as the key control on Re concentrations in volcanic front arc lavas. Although Os isotopic data provide hints of a limited recycled component, overall, current whole rock Os and Re data appear to provide greater potential for tracing high-level magma chamber processes rather than deep source recycling.

RELATIONSHIPS BETWEEN DISCONTINUITY FEATURES AND SILICA CONTENT IN LIMESTONE AT McDONALD'S LIME QUARRY, TE KUITI

Orla Hansen, Campbell S. Nelson, Steven D. Hood & Vicki G. Moon
Dept of Earth & Ocean Sciences, Univ. Waikato, Private Bag 3105, Hamilton, NZ
koh2@waikato.ac.nz

McDonald's Lime operates a quarry in late Oligocene–early Miocene Otorohanga Limestone (Te Kuiti Group) at Oparure, about 10 km northwest of Te Kuiti. The limestone resource (80-100% $CaCO_3$) is quarried for a variety of industrial applications, including agricultural lime as a fertiliser, high grade lime for water purification and road construction, and steel grade lime in the steel manufacturing process. The various end uses require tight quality control on the amount of non-carbonate ('silica') material in the limestone as too high a content can cause serious processing problems, especially for the steel industry. To aid in this regard, this study focuses on determining the nature, distribution and origin of the variable silica content that occurs in the quarry limestone.

The silica is mainly associated with discontinuities that are genetically associated with different periods of limestone evolution, namely:
(1) Syndepositional – discontinuities related to processes at the time of limestone deposition, such as grain lamination and bioturbation structures. Occur rarely.
(2) Diagenetic - discontinuities related to processes of burial and cementation (compaction, pressure-dissolution) of the limestone, such as dissolution seams and subhorizontal stylolites. Occur abundantly.
(3) Tectonic - discontinuities related to deformation and uplift of the limestone rock mass, such as subvertical stylolites, joints and faults. Occur commonly.
(4) Weathering – discontinuities resulting from dissolution of limestone by percolating fresh rain and ground water, such as runnels, caves and collapse features. Occur rarely.

Silica associated with types (1) and (2) discontinuities is inherited from within the host limestone itself, and so the silica minerals can be regarded as of primary origin. The main non-carbonate minerals identified here are quartz, feldspar, clays, glauconite and pyrite. Their content ranges from up to 20% silica in diffuse, wispy seams over intervals up to 300 mm or more thick, to as much as 40-80% silica in thinner (<1-20 mm thick), but abundant, discrete seams that separate the limestone into flags. Discrete stylolites, both subhorizontal and subvertical, are infrequent and always thin (<2 mm thick).

In contrast, the silica associated with types (3) and (4) discontinuities is mainly introduced from some external source to the limestone, typically from infiltration of fresh water carrying silica detritals down from overlying mudrock, volcanic ash and/or soil horizons, or precipitating minerals *in situ*, and so the silica minerals can be regarded as secondary in origin. The main non-carbonate minerals identified here include quartz, feldspar, palygorskite, altered clays and iron oxides and hydroxides in fill deposits having 15-100% silica, the highest silica values being associated with type 4 discontinuities.

TALK – Thu am

THE LAST GLOBAL EXTINCTION IN THE DEEP SEA – PULSED CONTRACTION OF BENTHIC FORAMINIFERAL POPULATIONS PRIOR TO DISAPPEARANCE

Bruce W. Hayward[1], Shungo Kawagata[1,2], Hugh R. Grenfell[1], Ashwaq T. Sabaa[1] and Tanya O'Neill[3]
[1]Geomarine Research, 49 Swainston Rd, St Johns, Auckland.
[2]Now at Yokohama National University, Yokohama, Japan.
[3]Department of Earth Science, Massey University, Priv. Bag 11222, Palmerston North.
a.sabaa@geomarine.org.nz

Twenty percent (19 genera, 95 species) of cosmopolitan, deep-sea (500-4000 m), benthic foraminiferal species became extinct during the late Pliocene-Middle Pleistocene (3-0.12 Ma), with the peak of extinctions (76 species) occurring during the mid-Pleistocene Climate Transition (MPT, 1.2-0.55 Ma). One whole family (Stilostomellidae, 30 species) was wiped out and a second (Pleurostomellidae, 29 species) was decimated with just one species possibly surviving through to the present.

Our studies at 21 deep sea core sites show widespread pulsed declines in abundance and diversity of the extinction group species during more extreme glacials, with partial interglacial recoveries. These declines started in late Pliocene in southern-sourced deep water masses (AABW, CPDW) and extending into intermediate waters (AAIW, NADW) in the MPT, with the youngest declines in sites furthest downstream from high-latitude intermediate waters source areas. We infer that the unusual apertures that were targeted by this extinction period were adaptations for a specific food, and that it was probably the demise of this that resulted in the foraminiferal extinctions. Maybe increased cold and oxygenation of the southern-sourced deep-water masses impacted on this deep-water microbial food source during major late Pliocene and Early Pleistocene glacials when Antarctic ice was substantially expanded. The food source in intermediate water was not impacted until major glacials in the MPT when there was significant expansion of polar sea ice in both hemispheres and major changes in the source areas, temperature and oxygenation of global intermediate waters.

How could cosmopolitan deep-sea benthic foraminifera progressively be wiped out over a long period, when it is known that they are capable of rapid bottom-current dispersal and repopulation of the sea-floor after a die-off, such as occurred during some Pliocene and Pleistocene glacials? Full or partial interglacial recoveries of the abundance and diversity occurred when favourable conditions returned to these sites, presumably a result of down-current dispersal from surviving populations. Where there were no survivors or refugia upstream of a site, then recolonisation did not occur or was extremely slow and fortuitous.

Significant declines beneath intermediate and northern-sourced deep water did not occur until MPT glacials. As these waters circulated they would have gradually warmed and become less oxygenated and thus sites furthest downstream (e.g. Caribbean) would have been impacted last. Again, recolonisation during interglacials preferentially occurred in a downstream direction, contributing to the partial interglacial recoveries and the timing differences in the declines between different sites and basins.

DIAGENESIS AND METHANE IN LAKE ROTORUA

Chris Hendy[1], Carmel Mangan[1], Olivia Motion[1], Lisa Pearson[1], and David Hamilton[2]

[1]Department of Chemistry, University of Waikato
[2]Department of Biological Sciences, University of Waikato
chendy@waikato.ac.nz

Diatomaceous ooze accumulates in the deeper waters of Lake Rotorua at rates of about 1cm per year, taking with it typically 6-8% organic carbon. Oxidation of the carbon begins within a nepheloid layer 10-30cm above the lake bottom and continues with burial resulting in strongly reducing conditions extending several cm above the lake bed. Iron and manganese are reduced resulting in the remobilisation of many trace elements. Sulfate is reduced to sulfide and framboidal pyrite precipitates. Anaerobic fermentation produces methane and carbon dioxide. Most of the carbon dioxide dissolves raising the bicarbonate concentration of the pore waters but the methane forms bubbles within the diatomaceous ooze rendering them opaque to sonic sounding. Supersaturation of the methane results in gas ebullition at rates of about 4 million cubic metres per year. Gas ebullition appears to be episodic and results in flat bottomed depressions in the sediment typically 50m in diameter and 5m deep. A large number of such depressions have been located in the bed of Lake Rotorua, most of which have started refilling with gas. The volume of the depressions suggests a total reserve of ~800 million cubic metres of gas, typically 97% methane and 3% carbon dioxide. Ebullition of the methane is likely to play a significant role in recycling phosphate and ammonium ions back into the overlying lake water to stimulate repeated algal blooms.

TALK – Tue pm

MAGMATISM IN THE HAVRE TROUGH: NEW INSIGHTS FROM NEW SAMPLES

J. Hergt[1], R. Wysoczanski[2], E. Todd[3], I. Wright[4] & M. Leybourne[5]
[1]School of Earth Sciences, The University of Melbourne, Vic. 3010 Australia
[2]SGEES, Victoria University of Wellington, NZ
[3]Earth & Planetary Sciences Department, UCSC, Santa Cruz, CA, 95064, USA
[4]National Institute of Water & Atmospheric Research, Wellington, NZ
[5]GNS Science, Lower Hutt, NZ
jhergt@unimelb.edu.au

In contrast with the wealth of material derived from drilling and dredging programs in some back-arc basins (e.g., the Lau Basin), samples from the Havre Trough are rare. Consequently, unlike the Lau Basin where detailed studies have revealed compositional variations in magmas both with respect to their age and geographic/geodynamic context, opportunities to contribute to our understanding of magmatism in the Havre Trough are substantial.

In October 2006, 27 new basalt samples from two sections were collected from the floor of the Havre Trough employing the Japanese research vessel *Yokosuka* and the Shinkai 6500 submersible. Both sample suites relate to a deep NE-SW trending rift valley located in the vicinity of 33˚27' to 33˚34' S and 179˚30' to 179˚36' E. Deeper than all previously mapped rift features, this particular region plunges to ~4,000 mbsl at its deepest point. One sample suite represents a section from the western flank of the rift structure, with 15 samples retrieved over a vertical distance of almost 360 m. The second suite, comprising 12 samples, was collected from a small NE-SW trending volcanic ridge feature located in the centre of the rift and oriented parallel to its margins. The ridge rises approximately 200 m from the floor of the rift and the sample suite includes basaltic rocks occurring at the base of this feature (at a depth of 3660 mbsl) up section for almost 130 m.

Both sample locations preserve spectacular magma flow features such as lava tubes and pillow basalts. Furthermore, all of the samples obtained in this study are vesicular, despite their depth of eruption, and many contain segregation vesicles. The samples from both sections are fresh or only slightly altered and share similar petrographic features. On the basis of lighter sediment cover we would estimate the magmatism in the floor of the rift to be more recent than that preserved on the slopes of the western flank. Thus, although the two suites are unlikely to be comagmatic, it is our view that the eruption episodes were not separated by a long hiatus.

New bulk rock major (XRF) and trace element (ICPMS) data for both sample suites confirm the primitive composition of these magmas, anticipated on the basis of abundant olivine phenocrysts observed in some samples. ICPMS trace element data have also been acquired for glass chips removed from each sample where available. The relationship between these two suites will be explored and the new insights they provide to help unravel the magmatic history of the Havre Trough discussed.

TALK – Tue am

MIOCENE STRATIGRAPHY AND STRUCTURE OF THE NORTHLAND PLATEAU

R. Herzer[1], G. Chaproniere[2], P. Quilty[3], N. Mortimer[1], B. Davy[1], C. Jones[1], C. Hollis[1]
[1]GNS Science, P.O. Box 30368, Lower Hutt, [2]Australian National University, Canberra, Australia, [3]U Tasmania, Hobart, Australia r.herzer@gns.cri.nz

Seismic units of the Northland Plateau are dated by paleontological and radiometric ages of dredge samples. They are in ascending order: (1) acoustic basements: E – flat-topped or block-faulted and tilted basement, including Miocene Cavalli high-grade metamorphics and probably ophiolites and Mesozoic terranes; D – disrupted unit, commonly at the limit of seismic penetration, with chaotic reflectors and some layered facies, presumed to be the Northland Allochthon; C – andesitic volcanoes and their volcanic apron deposits, of earliest Miocene to Middle Miocene age; (2) bedded units: B – high-amplitude unit of latest Oligocene to late Early Miocene age, commonly volcaniclasticand deposited in fault angles and synclines, and now exposed in structural uplifts (Parengarenga - Waitemata equivalent); AB – low amplitude unit, of local and regional basin fill and foreset slope facies, locally gently folded and faulted, of late Early to Middle Miocene age; A - passive regional sediment blanket mainly of turbidite, contourite and pelagic drape facies of mid-Middle or Late Miocene to Recent age.

The inner-plateau basin has a structure distinct from the constructional volcanic outer plateau and the intensely faulted continental shelf and slope. Many parts of the basin were in the photic and wave zones or above sea-level in the Early Miocene. During Unit B time there were active tectonic and volcanic highs and basins, with different sedimentary facies coexisting in close proximity. The inner-platau basin generally subsided in the early Middle Miocene (Unit AB time) to be fully submarine with much reduced volcanogenic input. Could a widely uplifted inner-plateau basin have been the source of the onland Northland Allochthon in the earliest Miocene?

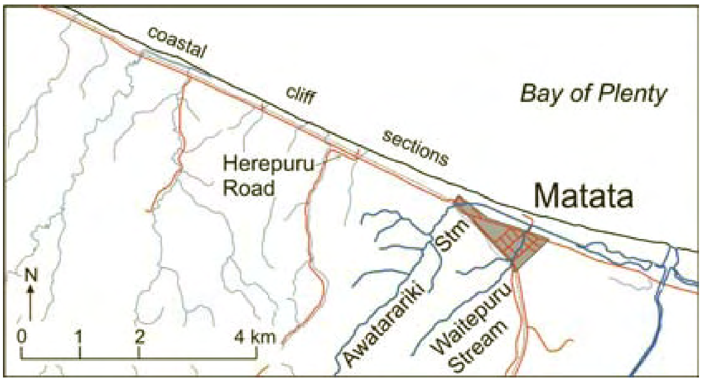
On the volcanic outer plateau, there is no evidence of shallow water or erosion, even on the seamounts; volcanism and sedimentation took place in upper to lower bathyal depths, somewhat shallower than the present. The volcanic outer plateau appears to have remained passively constructional in the Miocene. There is scant evidence of faulting, even along the Van der Linden lineament (the strong magnetic dipole that is thought to be a crustal boundary), but then the seismic data are scant as well.

The continental slope and shelf are cut by faults that are part of the Miocene Vening Meinesz Fracture Zone and may link to an ancestral North Island Fault System. There is no evidence of through-going faults in the inner-plateau basin which is faulted in some places and unfaulted in others. Its discontinuous structural pattern suggests that, if it was affected in the Early Miocene by strike-slip, it was via relays with restraining bends and pull-aparts. There are no data to tell when the VMFZ on the continental shelf stopped moving, but modest compressive deformation affected parts of the inner-plateau basin in the Middle Miocene after unit AB was deposited. The timing coincides with compressive deformation in the Reinga Basin, the dramatic fault reversal that created the Wanganella Ridge, and possibly the early North Taranaki Graben.

MATATA 2005-2007: LESSONS LEARNT AND ASSUMPTIONS TESTED

D. C. H. Hikuroa[1], C. J. N. Wilson[1], D. M. Gravley[1]
[1]Institute of Earth Science and Engineering, Univ. Auckland
d.hikuroa@auckland.ac.nz

Two and a half years ago debris-flows and associated debris-floods struck Matata, in the eastern Bay of Plenty (see below), with devastating and disastrous results. Heavy rainfall in the catchments behind Matata township on May 18, 2005, triggered widespread landslips and generated debris flows that destroyed many homes.



Local stream beds were heavily scoured, yielding excellent exposures of Pleistocene marine and terrestrial sediments with interbedded primary pyroclastic and secondary reworked volcaniclastic deposits, but I digress. A management plan of the hazard posed by debris-flows in the future continues to be debated. In this presentation I will discuss the record of debris-flows in Matata and give some of the insights we have gained from working in the area for over 4 years, in particular, the flux of sediment into the debris-flow source regions.

AN EOCENE MARINE TURTLE FROM THE WHANGAREI AREA

Jane Hill[1] and Jack Grant-Mackie[2]
[1]PO Box 112, Whareora, Whangarei
[2]Geology Programme, University of Auckland, PB 92019, Auckland
j.grant-mackie@auckland.ac.nz

The well-preserved partial skeleton of a large apparently marine turtle has been recovered *in situ* from a roadside cutting in Runangan Ruatangata Greensand 7 km east of Whangarei. It is represented by most of one fore-limb, some fused vertebrae, and rib and carapace fragments.

This is the second such record for the Northland Eocene. Richard Köhler, in his 1996 PhD thesis, identified as "Cheloniidae, genus and species indet." an assemblage of bones, including humerus, from the Runungan part of the Pahi Greensand on Pahi Peninsula, Kaipara Harbour. These bones are well enough preserved to make close comparisons, especially of the humeri. The Pahi specimen is long (211 mm) and relatively slender, whereas the Whangarei humerus is much shorter (135 mm, lacking a small part of the proximal end) and more massive**.** The differences in gross form strongly suggest they are neither conspecific nor congeneric.

None of the other turtle remains featuring in Köhler's thesis correspond with our material. Continuing search has focused on the Late Eocene *Eochelone brabantica* Dollo, from Belgium. The humerus of this species differs from ours in only minor ways, although, unfortunately, no fully adequate image of its humerus has been published, to our knowledge. Working from thumbnail outline sketches of the humerus and those of other bones of the type skeleton suggests that there is a close relationship between the two.

The extent of intraspecific variability in *E. brabantica* has not yet been established, but a number of specimens is known from the type area and their variability is being checked. There may be a significant range, within which the Whangarei specimen could fall. That the two may be conspecific is not ruled out by distance. Given the ranges of modern species of marine turtles, a near-global range for the Whangarei species is not impossible.

At the least, the two seem certainly congeneric, and for the present we identify the bones as *Eochelone* sp. cf. *E. brabantica* Dollo 1903, the first record hof the genus in the Southern Hemisphere.

POSTER 16

MICROSTRUCTURAL EVIDENCE FOR 3D DEFORMATION HISTORY OF QUARTZ VEINS EXHUMED FROM DEEP BRITTLE-DUCTILE SHEAR ZONES

Matthew P. Hill[1] & Timothy A. Little[2]
[1]Kenex Knowledge Systems Ltd, PO Box 41136 Eastbourne, Wellington, New Zealand
[2] Victoria University of Wellington, PO Box 600, Wellington, New Zealand
matt@kenex.co.nz

Glacially exposed shear zones in the Southern Alps of New Zealand have provided a superb natural laboratory from which to derive insight into the microstructural evolution of naturally deformed quartz in the lower crust. The shears are exposed in a ~2 km wide zone 6–8 km structurally above the Alpine Fault in the central section of the Southern Alps near the Fox and Franz Josef glaciers. The shears occur as systematically spaced arrays of near-vertical and sub-parallel shears in biotite-zone quartzofeldspathic schist and strike approximately parallel to the Alpine Fault. Quartz-carbonate veins embedded within the schist (typically 1-5 cm thick) are commonly smoothly and ductiley sheared in a dextral oblique (west-side-up) sense. Mineral fibre lineations that decorate the brittle part of the shear surfaces record a mean displacement vector that pitches ~35^{o} SW. The mean shear strain (slip/width ratio) that accomplished the ductile deformation, recorded by the displaced quartz-carbonate marker veins, is 4.8 ± 0.3 and the shear spacing in the arrays 25 ± 5 cm.

Field-based structural mapping, along with optical microscopy, and measurements of quartz crystallographic preferred orientations (CPO) are used to resolve the shear zone kinematics and rheology of quartz in the ductile parts of the shear zones. On the basis of these data, a late Cenozoic strain path for ductile vein deformation can be reconstructed. This includes shear development as deeply embrittled backshears during up-ramping at the base of the Alpine Fault. This was a transient period of brittle-ductile deformation in the lower crust at elevated strain-rates and high temperatures. After up-ramping, a stress-drop and deactivation of the shears lead to subsequent recrystallisation of the microstructures before exhumation several m.y. later.

Based on the c-axis CPO's of quartz in the deformed quartz-carbonate veins, the ductile deformation process that accomplished the shearing was not a plane strain, simple shear process, but a complex 3D flow with a triclinic symmetry. This is recognised from the discordance between the near-vertical ductile extension direction derived from quartz CPO fabrics and the moderately pitching finite displacement vector recorded by the mineral lineations. The record of near-vertical extension is most likely due to the efficiency of irrotational deformation in the intermediate principle strain direction being recorded by the crystallographic fabrics compared to the shear direction where the instantaneous and finite directions are never coincident. The CPO fabrics in the deformed veins are also surprisingly weak compared with other published examples of quartz deformation in shear zones, especially considering the high ductile shear strain in this study. These remarkably weak fabrics may reflect a combination of factors, including perhaps, the complex triclinic flow geometry, the polymineralic composition of the deforming veins, deformation accommodated by grain boundary sliding, and further overprinting periods of static and dynamic recrystallisation during exhumation.

GEOTHERMAL SYSTEMS ALONG VOLCANIC ARCS IN INDONESIA

M. P. Hochstein[1] **& S. Sudarman**[2]

[1]Geothermal Institute and SGGE, University of Auckland, Priv.Bag 92019, Auckland, NZ
[2]Indonesian Geothermal Assoc., Jl Gatot Subroto Kav 18, Jakarta Sel. 12950, Indonesia
mp.hochstein@auckland.ac.nz

Over 200 active geothermal systems have been found along active volcanic arc segments in Indonesia (c. 4000 km exposed total length). They outnumber c. 70 active and c. 60 dormant (< 10,000 yr old) volcanoes. Some 70 geothermal prospects were identified as 'potential high-temperature systems' by the mid 1980's. About 45 of these have been explored in detail and 21 were tested by deep (0.5 to 3 km) exploratory drilling. This lead to the discovery of 15 productive high-temperature geothermal reservoirs. All explored prospects are hosted by Quaternary volcanic rocks, associated with arc volcanism, and half occur beneath the slopes of active or dormant stratovolcanoes.

Several geothermal reservoir types were encountered: liquid-dominated, vapour-dominated, and a new 'substratum vapour-layer' subtype. Each type can be modified by central or marginal plumes containing magmatic fluids (volcanic geothermal systems). There are 18 volcanic geothermal systems among the 45 explored prospects. Large concealed outflows are a characteristic feature of most Indonesian liquid dominated systems. Six of the 15 productive reservoirs are now under exploitation and supply steam to electricity plants (800 MWe capacity).

QUATERNARY GEOLOGY AND UPLIFT RATES ON CHATHAM ISLAND

K.Holt
Institute of Natural Resources, Massey University, Palmerston North, New Zealand
k.holt@massey.ac.nz

The Chatham Islands represent an emergent portion of the crest of the Chatham Rise and preserve the easternmost exposures of Quaternary deposits of the New Zealand microcontinent. A combination of sedimentology, mineralogy, tephrochronology and palynology have been used to construct a chronostratigraphy for Chatham Island, the largest Island within the group.

The Quaternary record of the Island comprises mainly deposits from terrestrial environments, predominantly thick blanket peats and aeolian sand, which range from latest Castlecliffian to Haweran/Recent in age. Quaternary deposits that demonstratably predate this age range (i.e. > Oxygen Isotope Stage 13) have not been recognised anywhere on the Island.

Two rhyolitic tephra beds derived from the TVZ in mainland New Zealand are present on the Island: the 26.5 kyr Kawakawa Tephra and the ~345 kyr Rangitawa Tephra. They have provided the principal means for time control within and between stratigraphic sequences on the Island.

Marine terraces and associated wave cut surfaces occur at a number of heights around Chatham Island. Speculative uplift rates have been calculated based on the height and interpreted age of these surfaces. The resulting values range between 0.0057 – 0.128mm/yr and are very low compared with more tectonically active areas of mainland New Zealand.

Variations in rates of uplift across Chatham Island cannot be explained by a simple tilting or doming uplift model or by faulting, thus more work is required to understand the mechanisms of deformation in operation in the Chathams region.

POSTER 17

TOWARDS PARAGENESIS OF MIOCENE COLD-SEEP CARBONATE DEPOSITS, SOUTHERN HAWKE'S BAY

Steven Hood[1], Campbell Nelson[1], Kathleen Campbell[2] & David Francis[3]
[1]Dept. of Earth & Ocean Sciences, University of Waikato, Private Bag 3105, Hamilton
[2]Dept. of Geology, University of Auckland, Private Bag 92019, Auckland
[3]Geological Research Ltd, PO Box 30819, Lower Hutt
s.hood@waikato.ac.nz

The convergent plate tectonic setting of the East Coast Basin forearc of North Island, New Zealand, affords not only a rare opportunity to study the migration of hydrocarbon-bearing fluids at modern-day onland and adjacent offshore cold-seep sites, but also at numerous paleoseafloor sites archived within methane-derived authigenic carbonate deposits (MDACs) dating back to Early Miocene times. These fossilised chemosynthesis-based ecosystems occur in two major geographic localities, one to the north of Gisborne and the other to the east of Dannevirke.

This study, as part of an integrated and multidisciplinary Marsden funded collaborative project researching ancient seep deposits within East Coast Basin, focuses on newly discovered seep-related carbonate bodies and those recognised in earlier reconnaissance work but otherwise little documented. A total of five major isolated ancient seep fields (Ngawaka, Wanstead, Ugly Hill, Haunui, Wilder Road) have been identified over a distance of about 20 km and occur within 4 km along strike of the western limb of the Akitio Syncline. This work will integrate sedimentology, biostratigraphy, advanced petrography (fluid inclusion and cathodoluminescence analysis), and isotopic and elemental geochemistry of fossils and authigenic cement phases.

These southern ancient fossiliferous MDACs are hosted within the near basal deep-water mudstone facies of the Early Miocene (Altonian) Ihungia Formation. In outcrop the limestones commonly form unremarkable blocks, pods, lenses or mounds and, in contrast to northern occurrences, are associated with often coarser siliciclastic (sandy) lithologies. The limestones are characterised by seep-dwelling benthic paleo-community assemblages comprising particularly dense coquinas of articulated lucinid and/or vesicomyid bivalve fossils. They preserve primary vuggy porosity due to incomplete cementation by different varieties of micrite and methane-derived authigenic carbonate cement types. These minerals (calcite, aragonite, ?dolomite) appear from preliminary analysis to have formed via microbially mediated, anaerobic oxidation of methane (AOM) and have distinctly negative ^{13}C isotopic signatures, although comparatively less depleted in comparison with northern carbonates. Rocks record brecciation events followed by fracture healing by major aragonite veins reflecting multiple and often destructive fluid injection events, and they include micritic peloids and clotted and wavy laminar structures suggestive of precipitation in microbial films (thrombolites).

This study aims to elucidate the complex geochemical, physical, and biological interactions operating at these seep localities and to provide an overall temporal and spatial paragenetic sequence from which fluid-diagenetic pathway dynamics can be better understood within the wider context of the overall East Coast Basin geological setting.

POSTER 63

SHIFTING SANDS, SHIFTING PARADIGMS

Anne Hume , Giovanni Coco , Mal Green

1. School of Education, Waikato University, Private Bag 3105, Hamilton, NZ
2. National Institute of Water and Atmospheric Research, PO Box 11115, Hamilton, NZ
3. National Institute of Water and Atmospheric Research, PO Box 11115, Hamilton, NZ

annehume@waikato.ac.nz

To achieve international calls for the public understanding of science, many educators are pointing to the important role school education programmes play in creating scientifically literate societies of the future. However research findings reveal that even when curricular goals promote scientific literacy they are rarely translated into classroom practice. Teachers' lack of understanding of the nature of science and the unavailability of appropriate teaching and learning resources have been identified as factors contributing to the non achievement of these goals.

This paper presents an account of contemporary scientific inquiry at work to highlight key aspects of the nature of such inquiry. In the context of earth sciences the story illustrates the part paradigms play in guiding scientific endeavour and how new scientific knowledge is generated. It is hoped that such narratives can facilitate teacher professional learning as well as teacher education and serve as useful learning contexts to motivate student interest and understanding of scientific inquiry.

SEISMIC ANISOTROPY AS AN ERUPTION FORECASTING TOOL AT MOUNT RUAPEHU

Jessica Johnson[1], Andreas Wessel[1] Martha Savage[1] and Tony Hurst[2]
[1]Institute of Geophysics, School of Earth Sciences, Victoria University of Wellington, New Zealand.
[2]GNS Science, Lower Hutt, New Zealand
(jessica.johnson@vuw.ac.nz)

Mount Ruapehu is an andesitic stratovolcano in the back-arc of the Hikurangi subduction zone, North Island, New Zealand. On average it has large, destructive eruptions every ten years. There are villages around the volcano and the flanks are used for recreation such as skiing, therefore monitoring of the volcano is crucial. The method of shear-wave splitting analysis at volcanoes has the potential to provide a new tool for midterm eruption forecasts and provide information about the current state of the volcano within an eruption cycle.

A change in the polarisation direction of the first shear wave due to a difference in seismic velocity anisotropy was first observed by Miller and Savage (2001). The fast direction appeared to change by nearly 90^o after the large 1995/96 eruptions. Changes in the local stress within the crust seem to be the most likely explanation. These changes in stress are associated with a release of pressure after the expulsion of magmatic products such as magma and gases during the eruption, whose forces are powerful enough to locally overprint the regional stress regime.

Further work has been carried out by Gerst and Savage (2004) following a deployment of seismic stations in 2002. A partial return to the pre-eruption stress state through interpretation of further anisotropy measurements was observed.

A new automatic shear wave splitting measurement technique has been applied to the 2002 data. It satisfactorily reproduces the results from previous studies. Preliminary results using this new method on data from several permanent broadband stations, deployed in 2004 and 2005, indicate that (unlike 2002) deep events now give similar results as were obtained at the pre-eruption state in 1994.

We plan to use data from repeatable sources, recorded at the permanent broadband seismic network on Ruapehu, to monitor temporal variations in anisotropy orientation and test the hypothesis that they are caused by changes in local stress. Existing data from repeatable sources include controlled detonations of unwanted Army explosives and steadily occurring clusters of small earthquakes in the Waiouru seismic region, where families of identical earthquakes are common.

THE DUN MOUNTAIN OPHIOLITE BELT AND PERMIAN TO JURASSIC GONDWANAN ACCRETION

Dushan Jugum, Richard Norris, J. Michael Palin

Geology Department, PO Box 56, University of Otago, Dunedin
(dushan@geology.co.nz)

Whole rock geochemistry and Laser Ablation ICPMS U/Pb zircon dating have been used to create new models for the formation and accretion of the Dun Mountain Ophiolite Belt (DMOB) and its neighbouring terranes in New Zealand.

The Dun Mountain Ophiolite had two main stages of igneous activity, an early ocean ridge assemblage and a latter supra-subduction event. The early phase has been dated by Sivell and McCulloch (2000), at 308 Ma and the latter, which comprises the bulk of the rock mass, at 280 Ma (Kimbrough et al. 1992). The first dykes of the supra-subduction phase are plagiogranites with amphibolite inclusions. These dykes were injected along pre-existing normal faults, believed to be remnants of initial ocean floor spreading, which were remobilised in compression before the dykes fully cooled.

There are no pelagic sediments on top of the Dun Mountain Belt. Instead it is overlain by breccias and conglomerates (which are) cross-cut by the last phase of igneous activity. The sandstone directly overlying these has a depositional age of <260 Ma from detrital zircons, leaving a 20 Ma time-gap with no sedimentation record.

Plagiogranites make up a minor amount (<1%) of the total volume of rock within the Dun Mountain Belt over most of its length. However, the proportion of felsic rocks increases toward the southern end, where plagiogranites and granodiorites become dominant. New tectonic modelling of the geometry of the DMOB implies that this variation was related to distance from the subduction zone. This suggests that there once was a felsic proto arc running the whole length of the belt, which has since been eroded due to subsequent uplift along the current plate boundary.

On the eastern side of the DMOB, structurally underneath, there is a strip of ophiolite melange up to two kilometres wide. The basaltic blocks from this melange show similar whole rock geochemistry to the stage one ocean ridge basalts of the DMOB. The sedimentary rocks within the melange show the same modal mineralogy (QFL) and detrital zircon pattern as the sediments that overly the DMOB except they are finer grained, implying a more distal source.

The Aspiring Terrane lies structurally beneath the Caples Terrane and ranges from Early-Triassic to Mid-Jurassic (<155 Ma) in age as determined by detrital zircons. This is within the lower greenschist facies of the Haast Schist which at that location reached the Ar retention temperature at 145-139 Ma (Gray and Foster, 2004). This gives <10-16 MA for these zircons to form, erode, metamorphose and be cooled to the Ar retention temperature.

TALK – Wed pm

THE SHALLOW SUBSURFACE S WAVE VELOCITY STRUCTURES OF THE KOREAN PENINSULA OBTAINED BY INVERSION OF RAYLEIGH WAVE DISPERSION

H. Jung[1] & Y. Jang[2]
[1]Kunsan Nation University, S. Korea,
[2]ChonBuk National University
hjjung@kunsan.ac.kr

We analyzed the Rayleigh waves from two crustal scale refraction seismic experiments which were carried out in 2002 and 2004 in the Korean peninsula. The two refraction profiles, one in WNW-ESE and the other in NNW-SSE, were 294 and 335 km long respectively. 500-1000 kg explosives were detonated in drill holes at depths of 80-150 m. We obtained the fundamental and the first mode phase velocities and the fundamental group velocities in the period range between 0.3 ~ 1.2 sec for the four different tectonic regions (Kyeonggi and Yeongnam massifs, Okcheon fold belt and Gyeongsang basin) of the Korean peninsula. Particle motions of the fundamental and the first mode Rayleigh waves were extracted from the three component seismograms. Overall, the shear wave velocity increases from 2.5 to 3.4 km/sec from the surface to the depth of 1.2 km. The shear wave velocities for the fold belt and the basin were lower than those for the massifs by 500 m/sec in the upper 400 m depth. Below this depth, the shear wave velocity difference between the two (massif vs foldbelt and basin) becomes small, ~ 300 m/sec. The spatial resolution of the shear wave inversion was improved by including the first mode phase velocities of Rayleigh waves.

WHAKATANE - ASTRIDE NORTH ISLAND GEOLOGICAL MOVEMENT FOR 25 MILLION YEARS

David Kear, 34, West End, Ohope, Whakatane, New Zealand
(kear@xtra.co.nz)

Whakatane District includes the sites of: (a) NZ's most recent major volcanic eruptive disaster (Tarawera 1886); (b) its most recent major earthquake in insurance terms (Edgecumbe 1987); & (c) its only regularly active major fault zone (Matata). Thus its Neogene tectonic history is of interest. The Waitemata Tectonic Event of ca 25 Ma created the Te Kuiti-Waitemata unconformity in the west of the North Island; and also initiated (a) a single "North Island Subduction System"; (b) the Northland Allochthon (the first specific North Island record of major rock mass movement); & (c) Greater Northland's andesitic volcanism. Since then, three classes of North Island volcanism have been recognised, which do not merge together, and are quite distinct (e.g.) in major product, cone form, threat to humans, and above all in tectonic setting. They were dated initially by stages of volcano erosion, and later by radiometric methods. Major North Island movement was thereby identified, and when reconstructed for 25 Ma, placed Whakatane offshore of about today's location of Whangarei. Migration rates of from 1 to 6 cm/yr have also been identified for North Island Neogene tectonism and volcanism.

The subsequent Kiwitahi Tectonic Event, of ca 15 Ma, initiated the movement of the Alpine Fault in both islands. It moved much of offshore Northland to become onshore "East Coast", and Whakatane to a location ca offshore Waihi. The Subduction System had moved south steadily, causing volcanism to migrate through Coromandel, and the westwards thrusting to impose ca 25^o of curvature on southern North Island. Later, the Kaimai Tectonic Event (5-2.5 Ma) confined Alpine Fault movement to the South Island, and imposed steadily increasing curvature on the North, totalling ca 60^o by today. That caused the island to rip open along the Alpine Fault's abandoned trace, and so created progressively the triangular Central Volcanic Region over the last 2.5 Myr (with straight fault bounded sides). The Subduction System moved on, becoming the Hikurangi System. Three time/space zones are recognised in the CVR, based on volcano ages.

Edgecumbe Earthquake research identified a minor tectonic event at 400 ka, when the site of most or all of the CVR's "ripping away", moved from the Alpine Fault to an original lesser parallel fault 20-25 km to the east, leaving a strip of basement greywacke behind, 20-25 km wide – at Otamarakau. That lesser fault is now the major Matata Fault Zone, the Rangitaiki Plains' western limit. In its 400 kyr of activity it has moved Whakatane eastwards from Matata at a long-term average of "an inch a year", creating the 10 km-wide, dairying Rangitaiki Plains where nothing existed before. The return period for such earthquake intensity has been estimated as 100 years, implying the next event around 2085-90, and providing an opportunity for coarse earthquake prediction. The previous event, 100 years & 9 months earlier at Tarawera, provides some credence. The 1886 fissure opened in the same sense and direction as that in 1987, suggesting that the event was one of ripping open the volcano prematurely, and causing an immature volcanic eruption of basalt, rather than a full-cycle explosive eruption of rhyolite.

[Free copies of a booklet on this item will be available at the Conference]

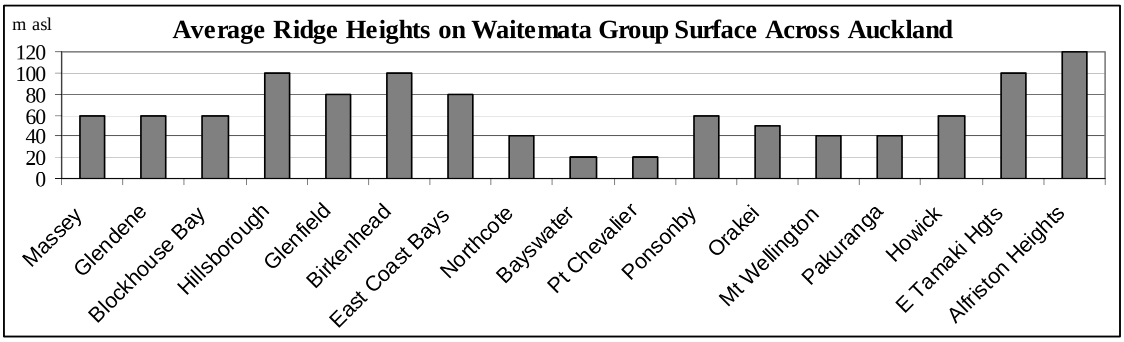
JAFfA – JUST ANOTHER FAULT FOR AUCKLAND – A PRELIMINARY INVESTIGATION OF BLOCK FAULTING

Jill Kenny
1 Sheralee Place, Bucklands Beach, Auckland, 2014
jill.kenny@xtra.co.nz

The recently published Auckland Qmap indicates recognised and inferred regional block faulting in the Hunua and Maraetai hills to the east, in the Franklin District to the south, and in the Waitakere Ranges to the west. Offshore to the west, seismic measurements show evidence of large scale fault splays aligned approximately ENE-WSW. These faults are not extrapolated eastwards on to land. Borehole data and geophysical measurements throughout the Manukau Lowlands and Awhitu Peninsula have established block faulting beneath Quaternary sediments. In the upper Waitemata Harbour area across to Whangaparaoa Peninsula, faults are more associated with thrusting southwards of the Northland Allochthon. Although many small scale faults have been recognised, no large-scale faulting has been mapped crossing Auckland itself.

In this project, an attempt has been made to prove that the block faulting surrounding Auckland also occurs within Auckland. This anomaly has been ignored in the past, largely because there are no convenient marker horizons within the Waitemata Group that can be followed sufficiently far to establish fault offsets. Also, geophysical measurements that may determine hidden faults are affected by the Quaternary ash from the Auckland Volcanic Field. A small study used borehole and detailed gravity data to determine the pre-volcanic topography beneath Mt Eden–Epsom, but no faults were discerned.

There is only one marker horizon that can be followed – the "Late Miocene" eroded Waitemata surface. This peneplain is very obvious as near-horizontal ridges across Auckland, along which many of Auckland's main arterial roads are constructed. However, the peneplain no longer exists at a constant height above sea level. This project illustrates that ridge heights are not concordant.



Lineations have been mapped that may be planes of weakness representing faults separating these regions of different heights. The results show block faults across Auckland. Some provide an eastward extension of the splay faults from offshore west coast; others are subparallel to the Hunua, Wairoa and Waikopua Faults, which may be associated with the NNW-SSE-trending Hauraki rift zone to the east of Auckland.

LITHIUM VARIATIONS IN MINERALS AND MELT INCLUSIONS FROM THE OCTOBER 2004 ERUPTION OF MOUNT ST HELENS, WA: LINKING PRE-ERUPTIVE VOLATILE TRANSFER TO THE INITIATION OF ERUPTION?

Adam J.R. Kent[1] and Michael C. Rowe[1]

Department of Geosciences, Oregon State University, Corvallis OR USA
adam.kent@geo.oregonstate.edu

Increases in magma chamber pressure related to vapor exsolution and transfer provide one mechanism for the initiation of eruptions in silicic volcanoes. The 2004 eruption of Mount St Helens provides a potential example of the link between vapor transfer and eruption initiation where geochemical tracers can be used to recognize and constrain the timing of vapor transfer.

In-situ analysis of Li and other trace elements in plagioclase and melt inclusions from the October 2004 eruption of Mount St Helens, Washington shows enrichment in Li in plagioclase in lavas and ashes erupted during the initial phase of the eruption. Lithium contents are up to a factor of ~2 higher than in subsequently erupted material. Melt inclusions also show Li contents up to ~200 µg/g, and have water contents as high as ~3 wt.% - equivalent to P_{H2O} ~100 MPa. Observed enrichments in Li are also similar in many ways to those reported from the 1980 eruption. Elevated Li in plagioclase requires increased Li in co-existing melt, relative to elements with similar K_D (e.g. Ba, Pb and La), consistent with high Li in melt inclusions.

We suggest that Li enrichment represents upward transfer and accumulation of an alkali-enriched vapor within the uppermost portion of the Mount St Helens magma reservoir since 1986. Alkali metals partition strongly into exsolved brine, and rapid diffusion of Li allows plagioclase to re-equilibrate with Li-enriched melt within days to weeks. Cooling and eruption then “quench” in the Li signature - although Li within the melt phase is lost via shallow-pressure degassing. High Li melt inclusions are variably enriched in other vapor-transported components, such as Cl, B and K. Diffusion modeling based on differences in Li contents between plagioclase phenocrysts and coexisting gabbroic inclusions, suggests that enrichment in Li occurred immediately (within at least one year) prior to eruption. This, together with the observation that highest Li contents in plagioclase occur in ashes from early phreatomagmatic eruptions suggest that accumulation of a vapor phase contributed to triggering the 2004 eruption.

KEYNOTE TALK – Tue pm

THE OCTOBER 2006 ERUPTION OF RUAPEHU CRATER LAKE

G. Kilgour, A. Jolly, S. Sherburn, B. Scott, C. Miller, A. Rae
GNS Science, Wairakei Research Centre, Taupo
g.kilgour@gns.cri.nz

On 4 October, 2006 an evolving seismic sequence signalled the onset of a minor eruption at Ruapehu Crater Lake. Seismicity for the eruptive sequence included, volcano-tectonic earthquakes, harmonic tremor and spasmodic tremor pulses. The sequence began at 21:22 (all local times) with a rapid sequence of ~15 broad spectrum volcano-tectonic earthquakes (largest 2.8 ML). These events occurred until about 21:25 after which an emergent tremor signal, having a dominant spectral frequency of 2.3 Hz, began. The emergent tremor pulse slowly grew for about two minutes until it evolved into a spasmodic pattern (also dominated by 2.3 Hz energy). Approximately 25 of these spasmodic pulses, the largest of which had a local magnitude of 2.9 ML, occurred between 21:27 and 21:34. After this flurry, the underlying tremor persisted for several hours as part of a waning sequence. No acoustic signals (characteristic of strongly explosive eruptions) were recorded on pressure-sensing microphones located 2 and 9 km from Crater Lake.

Poor weather hindered efforts to confirm the occurrence of an eruption until 7 October when GNS Science staff landed at the crater edge. Subsequent detailed visual observations confirmed that the lake level had risen about 1.3 m. In addition, wave run-up deposits (composed of coarse black ash) were observed about 3.1 m above the new lake level. Significantly, there were no associated airfall deposits observed on the inner crater flanks. The visual observations suggest that the eruption was subaqueous in character and produced waves of substantial height (possibly as high as 4.5 m above the old lake level). The (~1 cm thick) ash deposit was sampled and examined under binocular microscope, with the same samples analysed by XRD. The bulk of the ash is made up of unaltered 1995-1996 Ruapehu eruption derived andesitic ash that probably resided on the lake bottom prior to the October eruption. Small portions of the erupted material are andesite that is intensely altered to yellow-orange laumontite. Laumontite, a zeolite, is a common mineral found in geothermal areas and has a temperature of formation of 110 to 230 °C.

Based on the seismic signals, the lack of acoustic signals, the size of the eruption, the location of deposits, and the presence of a minor amount of moderately high temperature minerals in the ash deposit; the October, 2006 eruption at Ruapehu Crater Lake was subaqueous in character and hydrothermal in origin. This eruption highlights the near field hazards posed by small hydrothermal eruptions which can occur with no effective warning. This eruption also had implications for the subsequent breach and lahar on 18 March, 2007.

POSTER 30

ACTIVE CONTINENTAL RIFT TRANSFER ZONE BETWEEN WHAKATANE GRABEN (TAUPO RIFT) AND SOUTHERN HAVRE TROUGH, OFFSHORE BAY OF PLENTY

Geoffroy Lamarche and Philip M. Barnes

NIWA, Private Bag 14-901, Wellington 6021. g.lamarche@niwa.co.nz

Oblique continental rifting in the offshore Taupo Volcanic Zone and Southern Havre Trough is expressed in a very dense system of NNE-trending, active normal faults widely distributed over the central and northern Bay of Plenty. Faults are identified from seafloor scarps and displacements of the post-last glacial transgressive surface (<20ka), imaged using high-resolution seismic reflection profiles, multibeam bathymetric data, and side-scan sonar imagery. We defined 6 tectonic domains from the fault distribution and structural style within 100 km of the coast, which suggest a progressive transition of active extensional deformation from the Taupo Fault Belt onshore North Island to the Havre Trough. Within 50 km of the coast, rifting is mostly concentrated in the 20 km-wide Whakatane Graben (Whakatane Domain), with less significant extension accommodated along the offshore extension of the North Island Dextral Fault Belt (Opotiki Domain) to the east, and in the Motiti Graben (Tauranga Domain) to west. The structural style is that of back-tilted basement blocks and intervening half-grabens controlled by large NW-dipping faults with intersecting antithetic faults within the 3 km-thick sedimentary sequence. The Whakatane Domain terminates east of White Island. To the west and overlapping the Whakatane Domain for ~20 km, the Wairaka Domain consists of a 10-15 km-wide system of faults extending along a series of volcanic ridges and seamounts that terminate at the Whakatane Seamount 100 km to the NNE. Westward, the Tauranga Domain largely overlaps the Whakatane and Wairaka domains and includes faults in the 40 km-wide Motiti Graben and Tauranga Trough. The cumulative vertical displacements measured along faults across the Tauranga Domain increase northward, which suggest an increase in extension rate until 37°S where the fault system is offset to the NW into the Havre Domain. The Havre Domain overlaps the Tauranga Domain to the NW for ~30 km and consists essentially of the southern termination of the Havre Trough. The very high topographic expression indicates that most of the extensional deformation is accommodated across the Ngatoro Graben. Along the Western Bay of Plenty - Eastern Coromandel Peninsula shelf, subdued fault traces indicate that a minor component of extension is occurring as far west as the Aldermen Trough. Slip rates along individual faults were estimated using the displacement of the post-last glacial transgressive surface in water depths <150 m, and the estimated contribution of individual faults to the total tectonic extension (12-20 mm/yr) in deeper water on the basis of fault scarp geomorphology. Similar rates of extension have been estimated in southern Havre Trough, as further south across the Whakatane and Motiti grabens, and suggest that extension in the Whakatane Graben, which represents the northern termination of the Taupo Fault Belt, is gradually transferred to the Southern Havre Trough through a series of overlapping fault systems together cumulating > 80 km of left-stepping offset.

STATISTICAL ASSESSMENTS OF EARTHQUAKE RECURRENCE FOR THE WELLINGTON-HUTT VALLEY SEGMENT OF THE WELLINGTON FAULT

R. M. Langridge[1], R. Van Dissen[1], D. Rhoades[1], P. Villamor[1], K. Wilson[1], N. Litchfield[1], D. Clark[2], R. Carne[3], M. Stirling[1], & E. Barnett[4] & A. Lyman[5]

[1]GNS Science, PO Box 30-368, Lower Hutt.
[2]GeoScience Australia, Canberra, Australia. [3], Victoria University, Wellington
[4]University of Washington, Seattle. [5]c/- 61 Townsend Rd, Miramar 6022.
r.langridge@gns.cri.nz

New paleoseismic results from a data-rich trench on the Wellington-Hutt Valley segment of the Wellington Fault have allowed for a more robust statistical assessment of earthquake recurrence on this segment of the fault. The paleoseismic data, collected as part of the It's Our Fault project, are used to generate Monte Carlo simulations of the event age and recurrence interval distributions. Based on a combination of stratigraphic (peats buried by colluvium/scree) and structural (faulting) evidence we recognise up to 4 dateable, co-seismic events in the Te Kopahou-1 trench, at the south coast of Wellington, within the last c. 3000 yr.

We have developed 6 different earthquake event age models that draw increasingly on trench interpretations, data from previous trenches, and/or less certain data in order to extend the length of the paleoseismic record and to further constrain the event timing. In addition, for 4 of these examples we have run simulations in parallel with a Slip Rate-SED* model of recurrence interval for the fault, using a lognormal distribution of a c. 140 kyr slip rate (6-7.6 mm/yr) in combination with a single event displacement* (SED) of 4.2 +/- 1.3 m (i.e. SED with CoV of 0.3).

We present here two variations of the results from 20,000 random number results in which both of the distributions of Recurrence Interval include the effects of the Slip Rate-SED model. The first, which includes the last 3 dated paleo-earthquake events with some interpretative weighting gives a mean, median, and 95\% lower and upper bounds of 641, 605, 332, and 1107 yr, respectively for earthquake recurrence. The second model includes the last 4 dated paleo-earthquake events (3 inter-event times) with increased interpretive weighting. This model yields recurrence times with parameters of 625, 591, 352, and 1074 yr, respectively. These same 2 models run using the paleoearthquake data alone yield mean intervals of c. 900 and 740 yr based on 3 and 4 events, respectively.

We recognise that the recurrence interval distributions are lognormal in form (as is the Slip Rate model). The Slip Rate distribution, the CoV on SED, and the paleoearthquake record each have significant uncertainties that strongly impact the recurrence interval results. The beauty of our technique is that all of these uncertainties are taken into account. Further work will be undertaken to improve these models to output the most robust recurrence model for New Zealand's highest seismic risk fault segment.

MANAGING VOLCANIC RISK IN DENSELY POPULATED COASTAL AREAS: AN INTERNATIONAL PERSPECTIVE

Jérôme Lecointre
Volcanic Risk Solutions, Massey University, Private Bag 11222, Palmerston North
J.A.Lecointre@massey.ac.nz

The sudden reawakening of volcanoes located in the vicinity of densely populated areas presents a major challenge for civil defence authorities and emergency managers. The large concentration of population and the presence of key infrastructure in urban centres make these areas highly vulnerable both in terms of potential casualties and economic losses. In coastal regions, additional hazards should be taken into account (i.e. hydromagmatism, landslides, tsunami generation), while harbours regrouping critical industrial and public transport functions might be durably affected by renewed volcanic activity. Eruptive scenarios designed for planning and training purposes in this context usually integrate detailed GIS-based hazard maps showing at-risk sectors, lifelines and evacuation routes. Nowadays, monitoring networks developed around volcanic edifices ensure that early detection of precursor signs is secured and alert levels updated, allowing CDEM authorities to dispatch timely warnings to the local populations, and to organise a prompt response to any critical emergency situation.

We look in this presentation at two historical cases, the May 1902 eruption of Montagne Pelée (Martinique), and the AD 1631 eruption of Vesuvius (Bay of Naples), where heavy casualty numbers and long-term economic disruption resulted from a lack of scientific knowledge at the time of these events. A key factor contributing to these failures was the misinterpretation of critical pre-paroxysmal signs that led to poor decision-making processes. In both cases, the cities of St-Pierre and Naples were considered as safe heavens for and by the displaced populations, a large portion of them being sourced from rural and/or coastal settlements dispersed around the reawaken volcanoes. We argue that, in addition to the devastation generated by the eruptions, cultural differences between city dwellers and rural populations might have played a significant role in the tragic outcome of these historical events.

In New Zealand, Auckland, New Plymouth and Whakatane provide examples of large- to small-size cities being directly at risk from renewed eruptive activity from nearby volcanic centres. Urbanisation in popular coastal areas is growing at a fast rate, attracting major economic investments and new, diverse populations (migrants, tourists) in regions exposed to multiple volcanic hazards. For these reasons, the concept of an 'acceptable level of risk' should be constantly reviewed, as expectations from various communities are evolving. Recent exceptional natural events (Manawatu February 2004 flood, storm-induced 2005 Matata debris flows, 1995 and 2007 Ruapehu lahars) should be seen as good opportunities to engage and educate local populations living in exposed areas about volcanic and other natural hazards. In addition to the implementation of temporary evacuation measures, lessons from the past suggest that for long-term solutions, only pragmatic, cost-effective, and well-accepted mitigation options should be seek by environmental planners in order to ensure the continuity of essential socio-economic functions and services in the designated 'at-risk' communities.

TALK – Wed pm

STRUCTURAL CONTROLS ON CHANGING DIFFERENTIATION PATHWAYS AT AN ARC VOLCANO, MT. RUAPEHU - NEW ZEALAND.

T. R. Lee[1*], C. G. Macpherson[1], J. P. Davidson[1], R. C. Price[2], J. A. Gamble[3] & I. E. Smith[4]

[1]Department of Earth Sciences, University of Durham, UK
[2]School of Earth Sciences, University of Waikato, Hamilton, New Zealand
[3]Department of Geology, University of Cork, Ireland
[4]School of Geography, Geology and Environmental Science, University of Auckland, New Zealand
t.r.lee@durham.ac.uk

Intra-crustal recycling has been identified as a key component in the generation of andesites at Mt. Ruapehu, New Zealand. The crustal column beneath Ruapehu is composed of two main lithologies; a 5-10 km thick lower crustal meta-igneous granulite overlain by a 15-25 km thick Permian – mid Cretaceous meta-sedimentary sequence. Previous modelling of crustal contamination using Ruapehu lavas has indicated a role for meta-sedimentary material. However, on the basis of new trace element and Sr, Hf and O isotope data for lavas and crustal xenoliths we have identified a distinct change in the assimilants between the oldest formation (Te Herenga) and the younger formations (Post Te Herenga). Te Herenga lavas are a product of lower crustal differentiation involving assimilation of meta-igneous granulite. Post Te Herenga lavas display evidence for interaction with the same meta-igneous granulite followed by interaction with meta-sedimentary crust. This change in assimilant coincides with increased rates of extension at the southern tip of the TVZ. We propose that the change in melt-crust interaction from Te Herenga to Post Te Herenga lavas is a response to adjustments in differentiation depth. Fault movement dating suggests major geochemical changes in lavas can be broadly correlated with increased rates of extension within the Ruapehu crustal column.

POSTER 2

ENGINEERING GEOLOGY OF THE NORTHLAND ALLOCHTHON, SILVERDALE

Kori Lentfer
Coffey Geotechnics, PO Box 256, 20B Tamariki Avenue, Orewa
kori_lentfer@coffey.com

The Northland Allochthon is prone to land instability even on relatively gentle slopes. The soils and underlying rockmass are noted for being geotechnically challenging with slope instability occurring on slopes as gentle as 10°.

The Northland Allochthon rocks in the Silverdale area comprise Hukerenui Mudstone, Whangai Formation siltstone/calcareous siltstone, and Punakitere Sandstone of Mangakahia complex with minor Mahurangi Limestone of the Motatau Complex. They show significant variation in terms of their lithological and physical properties, structural features and slope movement processes.

The main aims of this study were to investigate the influence of mineralogy, microfabrics, defects and structure on physical and engineering geological properties, topography, geomorphology and slope movement mechanisms and discover which units are most susceptible to failure.

Methods involved the analysis of rock mass lithologies and their weathering products at micro- to macroscopic scales, in the laboratory and the field. Local/outcrop scale to regional scale geomorphological mapping and field observations were made to analyse topography and slope movement characteristics. Subsoil data from boreholes, trial pits and excavations was utilised where available.

Residual clay soils often become soft near the transition zone as water content increases. Intact rock strengths increase with increasing calcite and decreasing smectite content. Slaking due to high smectite contents and rapid chemical weather rates precludes formation of rock outcrops.

The highly to completely weathered transition zone is where shear planes or shear zones associated with translational slope movement occur. The often sheared and contorted transition zone fabric is considered to be primarily the result of slope movements with laminar microfabrics on polished defects resulting in very low residual friction angles.

Rock mass defects including folding, faults and dominant fracture sets may provide structural control on stability of slopes where continuous defects or rock fabrics can act as release surfaces for slope movements occurring within the transition zone.

Land gradients and geomorphic features can be correlated with underlying lithologic units. The gentles slopes tend to be underlain by Hukerenui Mudstone and the steepest underlain by calcareous Whangai Formation of Mahurangi Limestone.

Smectite-rich Hukerenui Mudstone was the weakest/least stable lithologic unit and calcareous Whangai Formation siltstone and Mahurangi Limestone were the strongest and most stable.

VOLCANIC HAZARD ASSESSMENT FOR THE AUCKLAND VOLCANIC FIELD: STATE OF THE PLAY

Jan Lindsay[1] and Graham Leonard[2]
Institute of Earth Science and Engineering, The University of Auckland
GNS Science, Wellington
j.lindsay@auckland.ac.nz

The Auckland Volcanic Field (AVF) is a small-volume, intraplate, largely monogenetic basaltic field located directly beneath New Zealand's largest city, Auckland (pop. 1.3 million). Activity in the field has occurred from about 50 scattered vents during the past 250,000 years, the most recent eruption producing the small shield volcano of Rangitoto about 700 years ago. Past volcanism, comparison with eruptions from analogue volcanic fields and a mantle anomaly at depths of about 70-90 km beneath Auckland all suggest the Field will erupt again. A reawakening is likely to generate a new volcano. Although the likely eruptive style is well known, Rangitoto displays anomalous petrology, eruptive style and size, indicating a possible change in evolution of the Field.

Determining magnitude-frequency relationships for the AVF has been hampered by the difficulty in dating past eruptions. Major inroads in determining relative ages have been made in recent years as part of the paleolake drilling programme, where tephra records reveal significant ash fall from a local eruption on average at least once every 2,500 years over the last 50,000 years. The emerging tephra record, together with recent geophysical research, is providing growing evidence that activity in the Field is not regular. Volcanoes may have erupted in clusters over time, followed by long quiet periods. A clustering of past C-14 age determinations from AVF centres in the 20-30 ka age bracket may reflect a convergence towards the maximum age limitation of the technique at the time, although a new C-14 date of 28.6 cal. ka (weighted mean; n=6) for the Three Kings volcano also falls within this time range. K-Ar and thermoluminescence experiments conducted over past decades have yielded few reliable ages for those deposits older than can be dated using C-14. Two new ages obtained by K-Ar (Mochizuki et al., 2004, EPS 56: 283-288) are, however, encouragingly robust. New techniques for sample selection, preparation and data analysis may provide better results in coming years via both Ar-Ar and K-Ar techniques.

Some volcanoes (e.g. Pupuke, Rangitoto, Mt Wellington/Purchas Hill) show complex episodes of activity (separated by time breaks) rather than single "monogenetic" events. Future ascent rates are expected to be fast, corresponding to a short period of precursory seismic activity (hours to days).

Assessing long-term hazard and associated risk remains challenging, although the latter must be considered potentially high given the high physical and economic vulnerability of Auckland City. Auckland has a Contingency Plan for a local eruption, due to be tested and revised during a national simulation exercise "Ruaumoko" in 2008. The monitoring network is being expanded to include downhole seismometers, and better communication and collaboration is being fostered through the new 'Auckland: It's Our Volcano' consortium.

TALK – Wed pm

AVULSION OF PYROCLASTIC FLOWS FROM CHANNELS: A CASE-STUDY FROM THE 2006 GUNUNG MERAPI ERUPTION, INDONESIA

Gert Lube and Shane J Cronin
INR, Massey University, Private Bag 11 222, Palmerston North, New Zealand
g.lube@massey.ac.nz

Most of our current understanding of pyroclastic flow behaviour stems from interpretations made from the sedimentary character of their deposits. This is extremely challenging, because fresh deposits are typically in highly hazardous areas and normally have experienced little erosion and vertical exposure. By contrast, older deposits in typical volcano-sedimentary sequences are incompletely preserved and exposed, making reconstruction of deposit facies and their geometric relationship with flow paths very difficult. Through fortuitous timing and the assistance of the EQC, we present data from a study of recently erupted and partly eroded pyroclastic flow deposits from Indonesia, showing an ideal combination of youth and exposure.

On 14 June 2006, multiple lava-dome collapses on Mt Merapi fed one hour of block-and-ash flows that travelled for 7 km down the Gendol valley. For the uppermost 3.5 km of travel (over slopes from 35-10^{o}) a broad-valley fill of deposit remains with only minor lateral-surge damaged areas. Below 3.5 km the flows were funnelled into a deep and narrow box-shape canyon. In several locations they spilled onto overbank areas and travelled at times>1.5 km over areas hitherto not anticipated as direct hazard zones. Timely evacuation of more than 24,000 inhabitants was the major reason that only two people were killed in the village of Kali Adem – one of the locations completely inundated during this event.

By late December 2006, rainy-season induced erosion into the still-hot deposits produced three-dimensional exposures from most proximal to termination reaches. This gave us the unique opportunity to examine (and measure with RTK-GPS) the lateral and longitudinal facies variations and to quantify the topographic conditions under which these flows spilled out onto overbank areas. We demonstrate that the propensity for channel avulsion depends on a combination of travel distance/velocity, valley cross-section and its sinuosity. Deposits were examined through 15 vertical profiles in the channel facies, along with 24 profiles on interfluve areas through the overbank facies. Identified sub-units, boundaries and vertical variations within each section were characterised and channel-sampled.

Along with direct observational and seismic data, we will present one of the most complete data records of mid-volume block-and-ash flow deposits, typical of NZ volcanoes such as Mt Taranaki. We will conclude with a new space- and time dependent model of flow structure and deposition mechanisms of dense pyroclastic flows and address some implications for future hazard mitigation for block-and-ash flows on New Zealand's active volcanoes.

TALK – Wed pm

GEOPHYSICAL EXPLORATION

Keith Machin
Department of Geological Sciences, University of Canterbury, Private Bag 4800, Christchurch.
Keith.Machin@canterbury.ac.nz

Geophysical exploration gives us an understanding of physics and science in the real world.

Geophysics is used for pure research and this is undertaken by Crown Research Institutes (NIWA and GNS) and Universities. An example of this is how marine geophysicists examine the topography and subsurface structure of the deep-ocean sea-floor using a variety of techniques.

Geophysics is used to search for valuable resources with the objective of economic exploitation. Companies use the information obtained through the application of geophysical methods to make decisions of where to look for oil, gas, coal, water and minerals. How New Zealand can use its natural resources for economic sustainability for future generations is an important question for us all to consider.

Methods of exploration include ground penetrating radar, electromagnetic induction, magnetic, resistivity, seismic reflection and refraction and multi channel analysis of seismic waves (MASW). Exploration for coal and oil uses downhole logging tools, vertical seismic profiling and drilling. Marine geophysicists use multibeam sounders to examine the topography of the sea bed and seismic refection surveys to examine subsurface structures of the sea floor.

These methods of geophysical exploration can be used as exciting and relevant contexts in which to learn physics and can be used to show school students how principles of physics are applied to solve real world problems.

THE 18TH MARCH 2007 BREAK-OUT LAHAR FROM CRATER LAKE, RUAPEHU: AN OVERVIEW

V.Manville[1,*], S.J.Cronin[2], and members of the Crater Lake lahar REsearch Team (CLARET)

[1]GNS Science, Wairakei Research Centre, Private Bag 2000, Taupo, New Zealand
[2]Institute of Natural Resources, Massey University, PB 11-222, Palmerston North, New Zealand
*(v.manville@gns.cri.nz)

On 18th March 2007, the refilling summit Crater Lake of Mt. Ruapehu, New Zealand's highest volcano, breached an unstable barrier of tephra emplaced on the rock rim of the crater by volcanic activity 11 years previously. In the ensuing flood, c. 1.3 million m^3 of hot acidic water was released in less than 90 minutes, entraining snow, ice, colluvium and older lahar deposits along its flow path to become a hyperconcentrated/non-cohesive debris flow with a peak discharge of c. 2500 m^3/s in the Whangaehu Gorge. Owing to the foreseen nature of this event, a collective of New Zealand and international researchers were able to put in place a comprehensive science programme to capture maximum scientific benefit from a single discrete lahar.
The science plan comprised a number of complementary components including:

1. Instrumentation of the 155 km long flow path with a diverse range of traditional and experimental sensors in order to capture time-series data on key flow parameters
2. Use of fixed digital still, video and web-cameras to collect visual information at instrumented sites, with additional footage shot by media organisations and members of the public.
3. Mobilisation of observer teams to collect time-series lahar samples and visual records at downstream locations.
4. Characterisation and quantification of geomorphic changes caused by the lahar through capture of pre-and post-event, sub-metre resolution topographic and ortho-image data using airborne LiDAR and ground-based TLS and dGPS surveys.
5. Mapping of ephemeral lahar high-water marks using dGPS to determine stage heights, energy slopes, and flow velocities.
6. Traditional forensic field and laboratory sedimentology to study depositional sequences for cross-correlation with instrumental and observational data.
7. Development and calibration of a range of numerical models of lahar behaviour.

By combining skills and resources we have captured arguably the most complete dataset on a single lahar anywhere in the world. Multi-parameter time-series data from multiple sites will enable us to analyse the downstream evolution of the flow from its inception as a clear-water discharge from the failing tephra dam, to its maximum discharge and sediment concentration, and then its subsequent attenuation and dilution during its downstream propagation and interaction with the ambient river. This will in turn help improve mitigation and planning approaches for protection of communities from both volcanic and non-volcanic lake break-outs, lahars, debris flows and hyperconcentrated flows in New Zealand and around the world.

KEYNOTE TALK – Wed pm

A RECORD OF NEW ZEALAND OCEAN TEMPERATURES FROM THE LAST GLACIAL MAXIMUM TO PRESENT: INSIGHTS FROM Mg/Ca RATIOS IN FORAMINIFERA

Julene Marr[1], Joel Baker,[1] Lionel Carter,[1] Gavin Dunbar[1] and Lisa Northcote [2]

[1]School of Geography, Environment and Earth Sciences and Antarctic Research Centre, Victoria University of Wellington, P.O. Box 600, Wellington (julene.marr@vuw.ac.nz)
[2] National Institute of Water and Atmosphere, Private Bag 14901 Wellington

The sediment core recovered from site MD97-2121 *ca.* 100 km east of Hawke Bay (40˚S; 178E) at 2314 m water depth, represents a well dated, high resolution (ca. 37 cm/kyr) sedimentary record of the last glacial maximum (LGM) through to the present. We are using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to measure Mg/Ca ratios in benthic (*Uvigerina spp*.) and planktonic (*Globorotalia inflata*) foraminifera in order to examine changes in the deep and shallow ocean temperatures during the last deglaciation. The laser ablation method provides the opportunity to examine in detail the validity of the Mg/Ca carbonate ocean paleothermometer when applied to foraminifera. For example, it is possible to link temperatures determined from single chambers of tests of foraminifera to their ecology, as well as screen analyses critically for the presence of gametogenic/secondary calcite and to identify unreliable data where other elements (Al, Mn) reveal the presence of contaminants

Preliminary work has focused on *Uvigerina spp*. LA-ICP-MS analyses were performed with a New Wave 193 nm solid state laser coupled to an Agilent 7500CS ICP-MS at VUW. Analyses of foraminiferal calcite are calibrated by intervening analyses of NIST610 silicate glass standard, which results in Mg/Ca ratios that are accurate to within ±2%. The ratios of Mg, Al, Mn, Zn, Sr and Ba to Ca are measured during each 100 s analysis as a 25 µm hole is progressively ablated through the wall of the foraminiferal test.

Analyses using different cleaning procedures reveal that careful cleaning is critical if reliable bottom water temperatures are to be obtained from the benthic foraminifera. Diagenetic material adhering to the outside of tests can produce Mg/Ca ratios 100% higher than that obtained on cleaned tests, which produces calculated ocean temperatures ca. 10˚C higher than reality. Analytical tests show that Mg/Ca ratios vary systematically by ~ 0.15 mmol/mol (10-20%) along the length of single tests of *Uvigerina spp.*, which results in apparent variations in calculated bottom water temperatures of ca. 3-4˚C. Distinct variations of ~ 0.05 mmol/mol have additionally been identified through the test walls. Such changes may be due to biomineralisation or vital effects occurring during calcite precipitation. Preliminary results from MD97-2121 indicate that Holocene bottom water temperatures are ca. 3˚C. Furthermore, Mg/Ca ratios of *Uvigerina spp.* decrease by ~ 0.2 mmol/mol from the LGM through to the present day. Using the Mg/Ca-temperature calibration for *Uvigerina spp*. of Lear *et al*. (2003), this indicates a relative temperature change of ca. 3ºC for the Hawke Bay bottom water temperatures. A Mg/Ca record for foraminfera from MD97-2121 will be integrated with the the oxygen isotope record of foraminifera from the same core that, for example, shows a ~1.6‰ $\delta^{18}O$ decrease in benthic foraminifera from the LGM to present (Carter et al., in press).

POSTER 18

FOREST REFUGIA DURING THE LAST GLACIATION

M. J. Marra
PaleoEnvirons
220 Nixon St.
Hamilton, NZ
mjmarra@ihug.co.nz

The nature of the New Zealand's ecological landscape under past glacial conditions is not well understood, particularly relating to the characteristics and location of glacial refugia.

Over recent years a clearer picture of the glacial landscape is emerging. New methods, such as fossil beetle research, are providing unique data of localised environmental conditions that challenge traditional regional pollen reconstructions and confirm the theory that pockets of forest may have survived in a number of sheltered locations. Fossil beetle data show forest refugia at a number of sites and suggest forests were more widespread than previously thought. In regions such as the eastern South Island, where pollen indicates a grassy landscape over many thousands of years, the fossil beetles show forest refugia at four sites located in Marlborough, Nelson Lakes District, Rakaia Valley and Banks Peninsula. Similarly, although pollen indicates western South Island was also grassy (shrubs and trees perhaps more abundant than in the east), the fossil beetles indicate forest existed between 37 k – 21 k cal yrs BP. In southern North Island, the fossil beetle assemblage and fossil leaves from the Waitotara Valley aged 34 k – 30 k cal yrs BP show *Nothofagus menziesii* for around 4,000 years which is an important finding as the local pollen record indicates that forest stands were rare in Taranaki lowlands at this time.

Locating refugia is important for understanding the present day distribution patterns and the extent to which the ecological patterns of the last glacial explain modern biogeography.

TALK – Tue am

MIOCENE AGE TEPHRA DEPOSITS AT THE GABLE END FORELAND, EAST COAST BASIN, NORTH ISLAND NEW ZEALAND.

Ray Marx[1], James White[1] and Vern Manville[2]
[1]Department of Geology, University of Otago, PO Box 56, Dunedin, New Zealand.
[2]GNS Science, Private Bag 2000, Taupo, New Zealand.
(ray.marx@stonebow.otago.ac.nz)

Tephra beds are abundant in upper Miocene marine deposits uplifted along the east coast of New Zealand's North Island. These were deposited in the East Coast Basin, which is a major tectonic depression along a NNE-SSW trending accretionary wedge. This wedge lies adjacent to that part of the Tonga-Kermadec-Hikurangi subduction zone along which the oceanic Pacific Plate is obliquely subducting beneath continental lithosphere of the North Island at ~ 40-50 mm/yr. Uplift of the Miocene deposits reflects ongoing convergence along this margin.

The Gable End Foreland is a prominent headland located 28 kms northeast of Gisborne in the Poverty Bay district, North Island, New Zealand. Captain James Cook named this feature during his first voyage to New Zealand in 1769, when he observed the prominent 136 metre high, white sail-like cliff at the end of the foreland. The headland cliff exposes the thickest and youngest of 144 tephra beds, which are enclosed in silty mud deposits and dip steeply northeastward at ~75º. Altogether, the Gable End Foreland provides a true stratigraphic thickness of ~394 metres, of which volcaniclastic deposits make up ~42.5 metres. The thinnest beds are glassy, crystal-rich deposits ~1 cm thick, but the distinctive ‘gable end’ like cliff that caught Captain Cook’s eye is an impressive 12 metre thick composite deposit.

The succession at the Gable End Foreland includes a mix of both suspension deposits and sediment gravity flow deposits. Enclosing marine calcareous silty-mudrock deposits have some bioturbation but few macrofossils. The grain size and shape of the tephra beds suggest that some transport and reworking took place before final deposition. Bedding features, such as Bouma B, C and D are characteristic of density-current deposits. The beds are pumiceous with both rounded and unrounded grains. Some beds are reverse graded due to hydrodynamic sorting of sediment that includes ash, crystals, pumice lapilli and occasional charcoal fragments.

Few, if any of the tephra layers can be shown to have formed by simple settling through the water column of atmospheric plume transported ash. The tephra in the beds are interpreted to have arrived in density currents fed from terrestrial drainage systems into which primary pyroclastic deposits were emplaced.

We infer that this succession was deposited medial to the source volcanic centres in a relatively quiet setting below wave base, perhaps on the continental slope. Yet, a lack of evidence for either deformation or slumping in this unbroken sequence suggests a flat depositional surface, perhaps within an intraslope minibasin that allowed regular pu lses of sediment from a distributary channel to pond.

RISKSCAPE – DESIGNING A MULTIHAZARD MODELLING TOOL

I. Matcham[1], J. Schmidt[2], G. Turek[2], A. King[1], R. Bell[3] & R. Pringle[1]
[1]GNS Science, PO Box 30368, Lower Hutt
[2]NIWA, PO Box 8602, Christchurch
[3]NIWA, PO Box 11115, Hamilton
i.matcham@gns.cri.nz

The Riskscape project aims to create a tool which will facilitate the modelling of disparate hazards to produce comparable damage results. Thus, for example, earthquake and flood can both be modelled and present a monetary damage result, or the same two hazards can be modelled to present a cost in terms of lives lost or injuries.

The underlying philosophy throughout the construction of the Riskscape tool has been to ‘assume nothing.’ Thus the tool does not require the presence of a GIS system nor does it require the hazard or risk modellers to calculate their damages in a particular way. The onus has therefore been on the Riskscape development team to design a set of protocols and specifications that allow the Riskscape ‘engine’ to interact with modelling results and other components of the system. This has been achieved through the development of a robust architecture and a documented and systematic approach to each stage of the risk analysis process. RiskScape is built in the java programming language and uses XML and other open standards to achieve maximum portability and interoperability.

AUTOMATED DETECTION OF SLOW SLIP EVENTS AT THE HIKURANGI SUBDUCTION ZONE WITH CONTINUOUS GPS TIME SERIES

Robert McCaffrey, John Beavan, Laura Wallace
GNS Science, PO Box 30368, Lower Hutt
r.mccaffrey@gns.cri.nz

As has been observed at many subduction zones, slow slip events (SSE) occur at the Hikurangi subduction zone east of the North Island. The events observed to date range in duration from a few days to 18 months and have equivalent moment magnitudes ranging from 6.4 to 7.1. Large slow slip events are easily recognized in the position-time series by changes in slopes in one to three components at multiple sites. Slow slip events have important implications for subduction dynamics and perhaps for earthquake hazards as well.

We are developing a method to quickly locate slow slip events in time and space using continuous GPS time series collected by GeoNet. The goals are to find events that may be too small to identify by eye and to detect the onset of slow slip events in real time. The basis of the method is cross-correlating the time series with synthetic Green's functions representing slip events on the subduction interface.

First we low-pass the time series and then transform them into a local 'block' reference frame by removing trends that are due to rotations of the sites in external reference frames. In theory this leaves only trends in the time series that reflect strain build-up from the subduction zone (plus any other strain sources). These time series are cross-correlated in time with a series of synthetic slip events generated at a grid of source locations on the fault plane. For times and places when no slow slip event occurs, the correlation produces a negative slope in the cross-correlation time series (CCTS) because the steady elastic loading of the crust by subduction and the slip event move the sites in generally opposite directions. During an SSE the crustal strain relaxes and sites move seaward in the same direction as predicted by the synthetic slip event, producing a positive slope in the CCTS. The peak amplitude observed in the CCTS is very sensitive to the location of the SSE in space and time. We will also report on experiments in real-time detection of SSEs. Specifically, the goal is to estimate how long it will take after the onset of an SSE before we know with confidence that it is happening.

ORIGIN AND EVOLUTION OF MID-CRETACEOUS VOLCANISM, MARLBOROUGH, NEW ZEALAND

Alex J. McCoy-West and Joel A. Baker
School of Geography, Environment and Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
(mccoywalex@student.vuw.ac.nz)

The Lookout Volcanics are part of a mafic to ultramafic igneous complex preserved in a fault angle depression bounded by the Awatere Fault located in Marlborough, South Island, New Zealand. Volcanism occurred at ~100 Ma and was mostly terrestrial with minor marine tuffs and non-volcanic sediments preserved at the top of the section. The volcanic rocks cover an area of ~50 km^2 with > 1000 m of basalt preserved near Mount Lookout. Based on the remaining outcrops in the Awatere and Clarence valleys the pre-erosion eruptive volume of this major volcanic episode was ~1500 km^3. This episode of volcanism occurred just prior to the onset of the rifting of New Zealand from Gondwana, and may have been cogenetic with a mid-Cretaceous mantle plume that created lithospheric instability, allowing rifting to begin. Moreover, it is the oldest example of the HIMU-like volcanic rocks that occur sporadically throughout the New Zealand region.

We have carried out detailed sampling (103 samples) of the Lookout Volcanics and constructed a ca. 600 m composite stratigraphic section, largely based on a continuous sequence of lava flows outcropping in Middlehurst Stream. The basal section of the volcanics outcrops in two separate localities ~6 km apart displaying a sharp contact between the volcanics and underlying terrestrial sediments, which in turn rest on shallow marine sediments of Ngaterian age (100.2-95.2 Ma). The basal lava package varies between these localities with the basal flow exhibiting varied petrography.

Petrographically, four major rock types have been identified in the sequence: (1) highly porphyritic ankaramites containing ~40-60% large phenocrysts of olivine (Fo_{88-76}) + augite ($Ca_{43}Mg_{49}Fe_{7}$-$Ca_{40}Mg_{40}Fe_{19}$) ± plagioclase (An_{90-64}) + ilmenite ± Cr spinel; (2) moderately porphyritic basalts containing ~10-35% phenocrysts of olivine (Fo_{86-75}) + augite ± plagioclase (An_{82-64}) + ilmenite ± Cr spinel; (3) highly porphyritic basalts containing ~40-55% phenocrysts of plagioclase (An_{77-64}) + augite + ilmenite; and (4) almost aphyric basalts containing < 5% phenocrysts of plagioclase (An_{89-65}) + augite + ilmenite.

Major and trace element analysis of whole rock and mineral phases of the collected samples is underway, along with MC-ICPMS measurement of isotopic ratios in a subset of lava flows. Initial results include Sr isotopic ratios measured on 24 lava flows, 18 of which are from the continuous stratigraphic section. $^{87}Sr/^{86}Sr$ ratios vary from 0.7030 to 0.7039 in this section, with the flows with more radiogenic Sr being predominantly in the upper part of the section. The flow with the highest $^{87}Sr/^{86}Sr$ ($^{87}Sr/^{86}Sr$ = 0.7043) is a Si-saturated flow containing orthopyroxene phenocrysts found near the base of Mount Lookout. Hf-Nd-Pb isotope work is ongoing to further constrain the petrogenesis of the Lookout Volcanics.

NEOGENE SEDIMENTATION AND HISTORY OF THE WEST ANTARCTIC ICE SHEET - INITIAL RESULTS FROM THE ANDRILL MCMURDO ICE SHELF PROJECT

R.M. McKay, R. D. Powell, T. R. Naish, L. A. Krissek, G. H. Browne, L. Carter, E. A. Cowan, G. B. Dunbar, T. I. Wilch, and the ANDRILL-MIS Science team
[1]Dept. of Geology and Env. Geosciences, Northern Illinois Univ., USA, [2] Antarctic Res. Centre, Victoria Univ. of Wellington, New Zealand, [3]GNS Science, Lower Hutt, New Zealand, [4]Dept. of Geosciences, The Ohio State Univ., Columbus, USA, [5] Dept. of Geology, Appalachian State Univ., USA, [6] Dept. of Geology, Albion College, USA, [7]http://www.andrill.org/support/references/appendixc.html; rob.mckay@vuw.ac.nz

During the 2006/07 austral summer, the ANDRILL project recovered a 1,285m-long record of Antarctic continental shelf sedimentation from beneath the McMurdo Ice Shelf. The alternating glacial-interglacial sediment packages interbedded with volcanics provides a record of Antarctic glacial and climatic change through the Neogene. Eleven lithofacies are recognised in the core, and these are characterized into three cycle motifs used for sequence stratigraphic interpretations. The core is divided into eight Lithostratigraphic Units (LSU) based on significant lithological changes observed downcore, and represent major changes in glacial regime or volcanic activity. The youngest unit, LSU 1 (0-82.74 mbsf, Pleistocene), consists of truncated diamictites interstratified with thin sand and mud beds, and represents the coldest periods characterized by the dominance of a grounded, polar ice sheet in the vicinity of Ross Island. LSU 2-4 (146.79 to 584.6 mbsf) represent the Pliocene section of the core and displays evidence of a warmer-than-present climate, with regular oscillations between diamictite and beds of volcanic mud, sand and diatomite. LSU 4 (382.95 to 584.6 mbsf) is notable for the presence of a 76.26 m thick zone of almost continuous diatomite. LSU 5 (586.45 to 759.32 mbsf) contains a rapidly deposited interval of interbedded volcanic muds, sands and diamictites, and includes a 2.6 m thick lava unit. The Late Miocene (LSU 6.1-6.3, 759.32 to 1063.42 mbsf) is dominated by interstratified diamictites and mudstone units, and appears to be associated with significant subglacial meltwater discharge, with outwash mud dominating the glacimarine environment. The earlier Miocene (LSU 6.4 , 1063.42 to 1220.15 mbsf) is dominated by diamictite, suggesting a colder glacial regime, similar to that documented during the Quaternary. LSU 7 (1220.15 to 1275.24 mbsf) represents another phase of nearby volcanic activity, while the base of the core (LSU 8, 1275.24 – 1284.87 mbsf) consists of diamictites. This record has the potential of constraining the dynamics of the WAIS and Ross Ice Shelf/Sheet throughout the Neogene. The significant results thus far are that the Antarctic Ice Sheet has undergone considerable changes throughout this time period, from a massive cold polar ice sheet in the earlier Miocene, through to one that was warmer and had significant subglacial stream discharges in late Miocene-Pliocene. A return to cold polar ice sheets occurred during the Quaternary. Further facies analyses and modelling will be used to clearly define the important implications of these characteristics on ice sheet dynamics and response times to warming and cooling periods.

Acknowledgements. The authors thank all national scientific funding agencies of ANDRILL member countries. We thank Webster Drilling, their drillers and support staff and especially Alex Pyne. We also acknowledge the great support from Raytheon Polar Services, the ANDRILL Science Management Office, and the Florida State University curatorial staff. Lastly, we recognize the tremendous contributions made by all of our colleagues who contributed to the MIS Project.

VIRTUAL EARTH SCIENCE FIELD TRIPS IN NEW ZEALAND: ENTHUSING SCHOOL CHILDREN IN EARTH SCIENCE USING REAL WORLD, REAL TIME CONTEXTS

Audrie McKenzie[1] and Jan Lindsay[2]
[1]LEARNZ Project, Heurisko Ltd, Learning Technology Specialists
[2]Institute of Earth Science and Engineering, The University of Auckland

amckenzie@heurisko.co.nz; j.lindsay@auckland.ac.nz

Increasingly, students are being unintentionally separated from real world contexts where learning is set in practical, work/research/business/government situations due to school organisation, convenience, cost and supposed efficiency in learning. Hand in hand with this has been the increasing use of internet as a teaching tool to engage school children in educational activities. Use of the internet to provide virtual field trips is a useful, low cost strategy that helps bridge the gap between schools and real world contexts.

LEARNZ, a government-supported online educational programme, has been running virtual field trips for primary and secondary school children to New Zealand sites of geological interest for over 10 years. In recent years, field trip destinations have included Rangitoto volcano, Tongariro volcano, Andrill drilling project in Antarctica, Aoraki mountains, gold mines in Central Otago, coal mines in Waikato and earth science focussed trips on the West Coast of the South Island. Linkage to the New Zealand curriculum and low enrolment costs ensure a high level of uptake amongst schools; typically 50-100 classes participate in each trip. Each field trip involves a combination of background reading, live audioconferencing between students and "experts" (e.g. geologists), semi-live video feeds, competitions, web board discussions, classroom activities and teacher and student feedback, all facilitated by the "LEARNZ teacher" who participates in field trips on site. Classes may participate synchronously and asynchronously. Schools register online for $75 per year and class field trip enrolment is free. Currently 366 schools are registered and 1307 classes are enrolled in current, future and archived trips.

Real world stories, especially if they are experienced in real time, have more credibility than any static off-the-shelf teaching resource. They also provide students with an expectation that everything they learn has relevance; someone is actually out in the world working on these issues. Furthermore, using real world, real time contexts will grow students' belief that their education is rooted in the real world and therefore has meaning.

THE 25 SEPTEMBER 2007 PHREATIC ERUPTION AT MOUNT RUAPEHU, GEONET RESPONSE AND PRELIMINARY SCIENTIFIC RESULTS

Craig Miller, Arthur Jolly, Bruce Christenson, Vern Manville, Geoff Kilgour, Steve Sherburn, Gill Jolly, Brad Scott, Karen Britten, Michael Rosenberg, Jeremy Cole-Baker, Dave Keen. Kyoko Kataoka, Neville Palmer, Katy Hodgson
GNS Science, Wairakei Research Centre, Taupo, Email: a.jolly@gns.cri.nz

Mt. Ruapehu erupted on 25 September 2007 at 8.26 PM NZDT generating a moderate steam column to about 15,000 feet, a directed ballistic and surge deposit of coarse blocks and ash to the north of the Crater Lake, and initiated lahars in the Whangaehu and Whakapapa ski field catchments. The explosion was witnessed by two climbers bivouacked at Dome Shelter, one of whom was seriously injured by a volcanic block and required evacuation from the summit. The Whakapapa ski field lahar was narrowly avoided by a ski field groomer working near the Far West T Bar. Subsequent impacts of the eruption included the temporary evacuation of some ski field lodges and the temporary closure of the ski fields in the immediate aftermath of the event. The eruption was similar to the 1969, 1975 and 1988 eruptions. It was smaller than the 1969 and 1975 events, but larger than the 1988 event. Seismicity for the main eruption lasted for about 4 minutes and included an explosive phase which lasted for less than 1 minute and a post-explosion phase which probably indicated lahars and vent backfill/stabilisation. The event magnitude was 2.9 M_L, below the detection threshold of 3.0 M_L for the Ruapehu Eruption Detection System (EDS). The Scientific Alert Level was increased to Alert Level 2-(Minor Eruptive Activity) shortly after the eruption. Following the eruption, there was an increase in the level of volcanic tremor, which declined to near background levels within 24 hours. Subsequent seismicity included background noise punctuated by intermittent bursts of tremor for next several days.

Post-eruption monitoring by *GeoNet* focused on collection of evidence to decide whether there was new magmatic activity. Visual observations conducted on 26-28 September revealed a ballistic (rock debris) apron extending northward as far as Far West T bar (~2000 meters from the Crater Lake). The ballistics comprise various rock types, from old andesitic lava flows, a variety of tephra, and vent-fill debris. The highly mobile snow slurry lahars reached half-way down the Far West T-bar in Whakapapa and beyond the *TranzRail* gauge (28 km distant) in the Whangaehu River. A number of sulphur–bearing rocks contained molten sulphur textures, indicating vent temperatures at the base of the lake in excess of 119 °C. Other ballistics contained mineral cements which indicated hydrothermal sealing of the vent prior to the eruption. Observation of the Crater Lake revealed that the northern vent was vigorously discharging gas, with strong sulphur slick formation, and white frothy, gas-rich patches at the surface. Prior to the eruption (on 8 September) the lake temperature was 13° C, increasing to 19° C on 28 September. The lake level had dropped by 1-2 m as a result of the eruption. Post eruption gas-geochemical values of CO_2 and SO_2 were unchanged relative to pre-eruption measurements. Based on these results, the *GeoNet* team concluded that the eruption was hydrothermal in nature with no magmatic influence. On 9 October the Science Alert Level was changed back to its pre-eruption state (Alert Level 1-(Signs of volcano unrest)).

LANDSLIDING IN OTUMOETAI, 2005

D. Milner
Tonkin & Taylor, P.O. Box 317, Tauranga
dmilner@tonkin.co.nz

The geology of Tauranga City and surrounds comprises a sequence of marine and alluvial sediments interbedded with airfall deposits and ignimbrites. These deposits form steep slopes and contain sensitive weathered ashes which are geotechnically problematic.

In May 2005, widespread slope failure was experienced around Tauranga during a 1 in 100 year rainfall event. Particular areas affected were Otumoetai, Maungatapu and Welcome Bay. In Otumoetai, failures concentrated towards the heads of gullies, and on high, steep slopes. These generally began as block slides, but quickly became debris/mud flows as they moved and broke up. The main cause of this instability was overland flow and surface infiltration. This overland flow concentrated towards the heads of gullies and at the crests slopes that were vulnerable to landslippage.

Human interactions also played a role in supplying water to vulnerable slopes. The presence of roads, driveways, foot paths and roofs mean that large areas of the ground surface are impervious to rainwater. Water from these areas either goes into soak-holes or into reticulated stormwater systems. However, many of the stormwater systems and soak-holes could not cope with the amount of rain experienced on 18 May 2005. Roads and paths became rivers that contributed to overland flow with water reaching vulnerable slopes more quickly than it normally would. Many of the soak-holes were probably also inadequate for the volume of water experienced during the storm. They are likely to have overflowed contributing to the overland flow. They would also have allowed surface water to access deeper levels of the ground at a faster rate than would naturally occur.

This paper focuses on these human interactions and in particular the effect that soak-holes had on slope stability in Otumoetai during May 2005. It presents the findings of a study into the decommissioning of soak-holes and where their removal would best enhance slope stability.

TALK – Wed pm

MAGMATIC AND PHREATOMAGMATIC TEPHRAS IN FINE ASH SUCCESSIONS OF AN ARC VOLCANIC COMPLEX, THE MANGATAWAI TEPHRA FORMATION, TONGARIRO VOLCANIC CENTRE, NEW ZEALAND

Anja Möbis, Shane J. Cronin, Károly Németh
Volcanic Risk Solution, Massey University, Palmerston North
A.Moebis@massey.ac.nz

Fine ash represents a significant volumetric proportion of eruptive products at arc-related composite volcanoes. However, due to difficulties in interpreting fragmentation, transportation and depositional histories, these deposits are commonly overlooked in volcanic studies. Here we present new results that contribute to the interpretation of volcanic processes from fine ash deposits, The Mangatawai Tephra Formation (MTF), defined by Topping (1973), represents the early eruptive history of Ngauruhoe, the youngest cone of the Tongariro volcano complex in the central North Island, New Zealand. The layers of fine ash of the MTF were deposited between 2500 to 1800 yrs B.P (Fergusson and Rafter, 1959). MTF consists of a series of 30-60 individual layers of fine ash, each representing individual eruptions or clusters of closely-spaced events. Textural characteristics such as laminar-bedding, cross-bedding, wavy structures and occasional presence of core type accretionary lapilli suggest that the MTF is a complex succession of distal fall and pyroclastic surge units. The colour of individual layers is a very distinctive feature of the MTF with variations from pale-grey, red, purple to black which appear to result from a combination of different eruption styles, weathering and possibly different sources. The grain-size distribution and the unit lithologies suggest that the MTF succession was not exclusively derived from Ngauruhoe volcano: 20–40 % of the layers may be derived from Ruapehu. Subtle geochemical differences as well as contrasts in the morphology of the glass shards and titanomagnetites can be used in some cases to distinguish the dual sources.

The very fine grained nature of the tephra layers and highly fragmented ash particles, together with textural features such as vesicular deposits and the presence of accretionary lapilli indicate some magma–water interaction (phreatomagmatic eruptions) causing fragmentation of the magma. The deposits are often very thin, show undulating wavy bedding and poor sorting, all indicators of pyroclastic surges. If so, these are unusually widely distributed surges, reaching up to 12 km. The 1974/75 eruptions of Ngauruhoe exhibited vulcanian and strombolian style eruptions, but did not produce surges travelling beyond one kilometre. An alternative explanation of these layers could be that they were deposited by rain-flushing of tephra clouds.

The different eruption styles of the individual layers of the Mangatawai Tephra Formation were also assessed by SEM examination of selected volcanic glass shards. Morphological analyses of volcanic glass shards of the youngest member of the Tufa Trig Formation derived from the Ruapehu 1995-96 eruption revealed evidence of a complex magmatic and phreatomagmatic fragmentation history. This is in good agreement with direct observational records of phreatomagmatic and strombolian eruptions phases. The results of this comparison were then applied to the different layers of the MTF and eruption products of the 1995-96 Ruapehu eruptions and confirm the interpretation of a phreatomagmatic origin based on field characteristics.

VOLCANIC ASH FALL FREQUENCIES AND HAZARDS BASED ON NEW AUCKLAND MAAR SEDIMENT RECORDS.

C. M. Molloy, P. Shane
SGGES, University of Auckland, Private Bag 92019, Auckland, New Zealand
c.molloy@auckland.ac.nz

The study of late Quaternary tephra in New Zealand plays a vital role in constructing a chronology of paleoclimatic events and the eruptive history of the major volcanic centres. Sediment sequences in Auckland maar craters contain tephra which provide insight into the likelihood of future eruptions on New Zealand's largest metropolitan area and age control for poorly dated basaltic eruptions from the Auckland Volcanic Field.

Three maar Auckland maar craters were drilled in the summer of 2006-2007. A 49 m long core extracted from the Hopua basaltic explosion crater recovered 37.5 m of mid to late Holocene marine silts. The marine silts overlie 11.5 m of finely laminated lacustrine sediments, which contains 29 well preserved tephra beds ranging in thickness from 0.5 mm to 460 mm. An 81 m long core extracted from the centre of the Orakei Basin crater recovered 24.5 m of mid to late Holocene marine mud. The marine and organic muds overlie 56.5 m of grey and brown finely (0.3-1 mm) laminated lacustrine sediments which contains 43 well preserved tephra beds ranging in thickness from 0.5 mm to 910 mm. A 16.5 m long core extracted from the centre of Lake Pupuke of finely (0.5-1 mm) laminated lacustrine highly organic fibrous sediments. This core contained 38 well preserved tephra beds ranging in thickness from 0.5 mm to 330 mm.

The tephra have been derived from local and distal sources (>200 km). In the last 67 ka, nine were erupted from the Okataina Volcanic Centre, six from the Taupo Volcanic Centre, two from Mayor Island, thirty-one from the Egmont Volcanic Centre, three from the Tongariro Volcanic Centre, and twenty-one from the Auckland Volcanic Field. The tephra beds were identified by stratigraphic position and through the correlation of microprobe geochemistry. The tephrostratigraphic framework is underpinned by seven rhyolitic tephra beds, namely Tuhua (c. 7,005 ± 155 cal yr), Rotoma (c. 9,505 ± 25 cal yr), Waiohau (c. 13,635 ± 165 cal yr), Kawakawa (c. 26,500 cal yr), Okaia (c. 29246 ± 1266 cal yr), Hauparu (37 ka), and Rotoehu (~50 ka). New stratigraphic control provides age estimates of Auckland volcanic field eruptions which exhibit an interval of increased activity at 25-30 ka, and relative quiescence in the last 18 ka.

The tephra record indicates that the Auckland City region has been frequently impacted by ash fall from many sources. The assessment of the event frequency, from both distal and local fall deposits, can provide reliable data for hazard reoccurrence calculations. Egmont is the most frequent contributor of ash to Auckland. However, there are few tephra in the Holocene record suggesting a significant change in atmospheric circulation in the last 10 ka. It appears, from this record, that volcanoes distant from Auckland present a greater civil hazard than local volcanoes.

TALK – Wed pm

UPDATE ON PALEONTOLOGICAL DATABASE DEVELOPMENT

B. Morrison[1], J.I. Raine[2] & J.E. Simes[2]
[1]GNS Science, Private Bag 1930, Dunedin
[2]GNS Science, PO Box 30368, Lower Hutt
b.morrison@gns.cri.nz

The New Zealand Fossil Record File (FRF) and National Paleontological Collection and Database (NPC) are recognised as Nationally Significant Databases by FRST and are being developed under the GNS National Paleontological Databases (PDB) programme. The programme aims to improve digital access to these databases and promote the use of them by both national and international researchers. The programme has been running for over two years now and considerable progress has been made.

The Fossil Record File is a paper database stored in filing cabinets throughout NZ. A digital version of the FRF, known as FRED, has existed for some time, but for many localities it only has the grid reference. Digitising the full paper record into FRED is a major task in the PDB programme involving several part-time data entry staff. At current rates we expect to have completed 50% of the localities by the end of 2007 and are on target to complete the job by 30 June 2009.

FRED can be accessed on the web at http://www.fred.org.nz. Using this website registered users can search the FRED database for localities and view/print the data (including maps). FRED contains a large number of paleontological records generated from GNS research and commercial work. By default records have all been marked as confidential and have not been accessible to non-GNS users, but we have now started working through these and making as many as possible open-file and accessible to all. The website can be used for the entire process of submitting a new locality to the FRF. There is also an off-line data entry spreadsheet which has just been extended to allow users to enter paleontological and adoption records. We have also now added functionality to allow users to download query result sets for further processing.

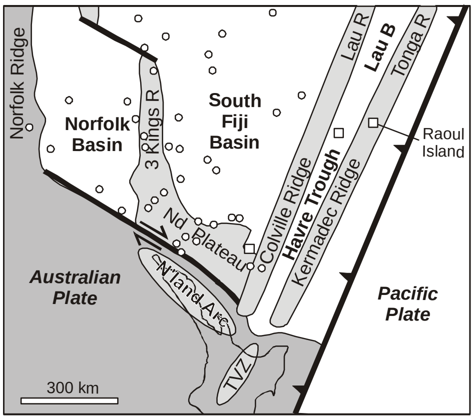
The NPC is a physical fossil collection and it includes a large number of type and figured specimens, and comprehensive stratigraphic and geological collections of fossil taxa from New Zealand and its surrounding area (including Antarctica). We have almost completed shifting this collection into our new facilities at Avalon, Lower Hutt and as part of this process are re-arranging and upgrading the storage of the specimens. We have begun experimenting with 3D, full-colour laser scanning as well as traditional moulding and casting to produce replicas of important specimens for external researchers and public displays.

The PDB programme is also funding the maintenance/development of several smaller databases. New material is being continuously added to The NZ Stratigraphic Lexicon (http://data.gns.cri.nz/stratlex) and we are investigating developing a lexicon for the Ross Sea area of Antarctica. The NZ Fossil Spores and Pollen database (http://www.gns.cri.nz/what/earthhist/fossils/spore_pollen/catalog/index.htm) has been updated and we have started working on a similar online database based on Beu & Maxwell's 1990 Cenozoic Mollusca of New Zealand.

MIOCENE-QUATERNARY EVOLUTION OF SW PACIFIC ARCS AND BACKARC BASINS: NEW AGES AND A CHOICE OF TECTONIC MODELS

<u>Nick Mortimer</u>[1], Mike Palin[2] & Rick Herzer[3]

[1]GNS Science, Private Bag 1930, Dunedin
[2]Dept. of Geology, Otago University, PO Box 56, Dunedin
[3]GNS Science, PO Box 30368, Lower Hutt
n.mortimer@gns.cri.nz



The TVZ and Kermadec-Tonga Ridges, and Havre Trough-Lau Basins are the volcanic arc and backarc basins caused by present day Pacific-Australian plate subduction. Their extinct predecessors are arrayed to the west.

Recently published Ar-Ar ages from the offshore NZ region include a 1.1±0.4 Ma (2σ) whole rock age on a Havre Trough basalt, 1.2±0.8 Ma plagioclase age on an easternmost Northland Plateau (= Colville Ridge related) basalt, 19-26 Ma ages from Norfolk and South Fiji Basin scarps and DSDP holes, 15-21 Ma ages from sodic and potassic seamounts in the Norfolk and South Fiji Basins, and 15-32 Ma ages from arc lavas dredged from the Three Kings Ridge and Northland Plateau (Mortimer et al. 2007, Marine Geology).

Plutonic xenoliths have been long been recognised from the 3.7 ka Matatirohia Tephra of Raoul (Thomas 1888, Lloyd & Nathan 1981, Worthington 1998). We report a new LAICPMS U-Pb age of 1.25±0.06 Ma (2σ, MSWD= 3.3, n=35/35 grains) for zircons from a granitoid xenolith. This is far older than the age of the enclosing tuff. Clearly the granitoid does not represent Gondwana or Paleogene arc basement (the hypothesis we originally set out to test), but it does show that the recently erupted dacites are not the first cycle of intraoceanic silicic magmatism in the Kermadec Islands.

The three Quaternary ages indicate that volcanism was active at c. 1.2 Ma across the full width of a then-actively-rifting Colville-Havre-Kermadec system. Magmatism on the Colville Ridge ranges back to 5.5±0.2 Ma (based on one other whole rock K-Ar age; Adams et al. 1994). In onland North Island, there is a fairly continuous record of Northland-TVZ arc magmatism from 23-0 Ma but, except in the Lau Islands, there is no record of offshore arc (or intraplate) volcanism in the interval 14-5 Ma. And in the offshore basins there is no record of backarc basin spreading in the interval 19-1 Ma. **Either** the missing Late Miocene arc and backarc rocks are yet to be dredged and drilled on the Colville Ridge and in the eastern South Fiji Basin. **Or** for some as yet unexplained reason, arc volcanism and/or back arc spreading in the SW Pacific shut down for a period of between 9 and 18 million years while Pacific-Australian plate convergence continued.

TALK – Tue am

MORPHOTECTONICS OF THE OFFSHORE HIKURANGI SUBDUCTION-COLLISION TRANSITION ZONE: TECTONICALLY FORCED SLOPE-FAILURES IN MARGIN DEVELOPMENT

Joshu J. Mountjoy[1,2]; Philip M. Barnes[2] and Jarg R. Pettinga[1]
[1]University of Canterbury, Private Bag 4800, Christchurch 8140, New Zealand.
[2]NIWA Private Bag 14901, Wellington 6241, New Zealand.
j.mountjoy@niwa.co.nz

The transition from the westward dipping oblique subduction to continental transpression on the Hikurangi Margin is marked by the 1500 square kilometre shelf indenting Cook Strait submarine canyon system. Simrad EM300 multibeam bathymetric coverage of the canyons and adjacent slopes, supported by multichannel and 3.5 kHz seismic data, resolves the geomorphic signature of structural and erosional processes in detail.

The Cook Strait canyons and adjacent slopes show widespread evidence for tectonic forcing of topographic development, erosion and canyon geometry. Tectonic forcing controls an interplay in landscape evolution between: a) macro-scale structural development of accretionary wedge morphology at the transfer from a convergent thrust fault dominated margin to a strike-slip dominated oblique collision zone; and b) the ongoing erosion of the margin through processes such as submarine bedrock landsliding and turbidity current erosion influenced by folding, active faulting and high levels of earthquake generated strong ground motion.

Mapping based on visual interpretation of DTM's and morphometric analysis shows widespread slope failure in various modes including: i) translational landslides with ~150 metre high scarps and exhumed planar low angle (2 degree) stratigraphic surfaces; ii) deep-seated (200-300 metre) collapses occurring adjacent to principle canyon channels on stepped low angle stratigraphic surface; and iii) slope dilation and (?)rockfall style failure of basement greywacke. While several large displaced slide masses are recognised, very little landslide debris remains visible in the majority of channel floors, despite the large number of evacuated slide scars documented. This indicates either regular canyon flushing by turbidites removing or obscuring landslide debris, or observed failures have been inactive for a significant period of time. Portions of the landscape are smoothed and show little evidence of erosional activity while others appear angular and actively eroding. We recognise staged rejuvenation of submarine "catchments" and serial multibeam has imaged a small-scale failure on an incision front wall confirming activity under the present climatic regime.

THE ROUND TOP ROCK AVALANCHE, WEST COAST, NEW ZEALAND

<u>A. Mueller</u>, T. Davies & M. McSaveney
Dept. Geological Sciences, Canterbury University, Christchurch
amu27@student.canterbury.ac.nz

Inland from Hokitika lies the 5 km^2, 45 x 10^6 m^3 large Round Top rock avalanche. It originated in mylonitic schist from a ridge traversed by the Alpine Fault and it was emplaced onto a wide alluvial plain. Previous mapping by Wright (1998) established its boundaries, age, and size. Building on this work, further site investigations have been carried out with specific focus on deposit morphology and substrate involvement during emplacement. The most prominent morphological features are elongate ridges aligned radially from the source in the medial zone, and digitate emplacement with more subdued topography in the distal reaches. With each of these features are associated specific types of avalanche-substrate interactions. Bulldozed peaty soil and fluvial sequences have been discovered at ridge fronts, whereas intense substrate disruption and chaotic mixing is typical for the motion-parallel sides of ridges. Swampy depressions usually accompany these features just a few metres away from the ridge. Within the distal digitate zone are areas that lack rock avalanche cover, but which are completely surrounded by the deposit. Swampy depressions with small ‘sand-volcanoes’ are characteristic features here. All the evidence suggests that the substrates were saturated at the time of rock avalanche emplacement and that they were mobilised by the overriding rock mass. The ridges appear to have ploughed into the substratum, dislodged and bulldozed it ahead and squeezed it to the sides of ridges, respectively. It is proposed that ridge-formation (or –preservation) at Round Top was a function of saturated substrate involvement in its emplacement, as has been suggested by previous authors for other locations. Sand-volcanoes are also known to occur in earthquake-liquefied material and this idea is adopted here, so that the substrate was sufficiently liquefied by the event to ‘boil’ to the surface where not covered by avalanche debris. The Round Top case confirms that rock avalanche emplacement across deformable and saturated substrates introduces complexities, producing distinctive avalanche morphologies and modifying avalanche behaviour.

TALK – Wed pm

U-Pb DATING OF OVERGROWTHS ON ZIRCON FROM THE OTAGO SCHIST, NEW ZEALAND

D. B. Murphy, J. Vry R. Wysoczanski & J. Baker
SGEES, Victoria University of Wellington, P.O. Box 600, Wellington
Dave.Murphy@vuw.ac.nz

Previously unrecognised thin overgrowths on detrital zircons in garnet-biotite-albite zone samples of the Otago Schist, New Zealand (Fig. 1) provide the potential to determine the timing of major metamorphic episodes or dewatering events that affected these rocks and similar rocks worldwide. High-resolution U-Pb age determination studies of these zircon overgrowths are being undertaken using laser ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICPMS) in the geochemistry laboratory at Victoria University of Wellington. Results of LA-ICPMS trace element studies will be used to clarify understanding of the origin of these overgrowths.

Timing constraints are essential for understanding any geological record. Isotopic dating of overgrowths on zircon, a widespread and physically robust accessory mineral that resists age resetting to temperatures as high as 800 °C[1], has the potential to improve understanding of the timing of low to moderate temperature (≤ 450-500 °C) geological events. At these conditions commonly applied geochronometers (e.g. K-Ar, 40Ar/39Ar, Rb-Sr) are variably affected and compromised by inheritance and later isotopic resetting.

The zircon can have a complex overgrowth structure that could yield timing information about the tectonic event(s) that have affected these rocks or their protoliths. In the samples we have studied, the outermost margins of the zircon grains have a narrow, discontinuously-developed rim that is bright in cathodoluminescence (CL) imaging. This rim typically is characterised by small (~4µm thick) hat-shaped outgrowths resembling those that form at low temperatures (as low as ~250 °C) on zircon in slates[2]. A thicker overgrowth that is dark in CL images can occur inside this (see Fig. 1). A comparable overgrowth on a zircon from a sample of the Alpine Schist near Hokitika gave a Jurassic SHRIMP U-Pb age of ~165 Ma, conceivably recording the timing of an early episode of metamorphism and dewatering at the time the Otago Schist formed. Our goal is to obtain more detailed and reliable age constraints on the complex geological history of New Zealand.

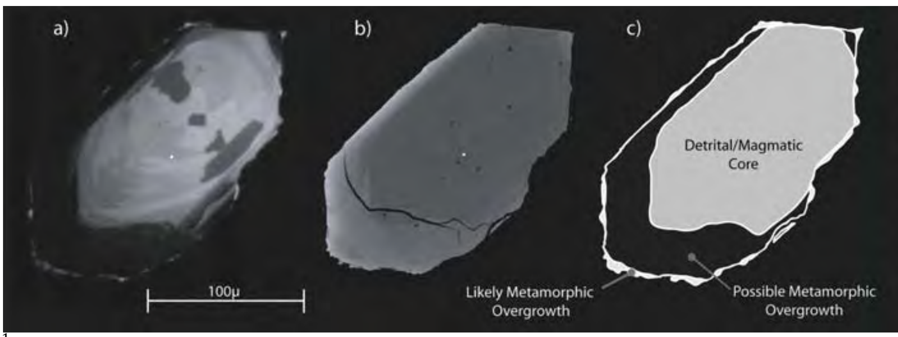


Figure 1. Images of zircon grain JV06-03 Zrn09, showing magmatic zonation in the crystal core and two possible metamorphic overgrowth structures surrounding it. Dimensions: 110µ x 250µ. a) Cathodoluminescence (CL) image. b) Back-scattered electron (BSE) image. c) Cartoon diagram showing structures interpereted through both CL and BSE imaging.

[1]Hanchar, J. M. & Hoskin, P. W. O. (eds) Zircon (2003) Reviews in Mineralogy & Geochemistry **53**: 500
[2]Rasmussen, B. (2005) Contributions to Mineralogy and Petrology, **150**: 146-155

POSTER 51

FLANK MARGIN CAVES IN NEW ZEALAND TERTIARY LIMESTONES

John E. Mylroie[1], Joan R. Mylroie[1] & Campbell S. Nelson[2]
[1] Dept of Geosciences, Mississippi State Univ., Mississippi State, MS 39762, USA
[2] Dept of Earth & Ocean Sciences, Univ. Waikato, Private Bag 3105, Hamilton, NZ
c.nelson@waikato.ac.nz

Mixing of marine and fresh waters in coastal settings can produce unique dissolutional features both on the surface and in the subsurface of carbonate rocks. One such outcome of mixing dissolution is the formation of flank margin caves that are widely reported in young, diagenetically immature (i.e., eogenetic), warm-water carbonates from tropical coastal locations, such as the Bahamas and Yucatun. Whether or not flank margin caves also form in older, diagenetically mature (i.e., telogenetic) carbonates, including those of cool-water heritage, is presently poorly appreciated.

New Zealand has widespread occurrences of Tertiary limestones of predominantly temperate-latitude (i.e., non-tropical) affinity that are also typically very well cemented and diagenetically mature (i.e., telogenetic). We have examined examples of these limestones in coastal outcrops on both North Island (Raglan Harbour, Kawhia Harbour, Napier, and Waipu Cove) and South Island (Pohara, Paturau River, Punakaiki, Kakanui, and Kaikoura), to determine if flank margin caves, produced by mixing dissolution, are present. In coastal settings, caves in carbonate rock can be the outcome of pseudokarst processes, primarily wave erosion, as well as karst processes not associated with fresh and sea-water mixing, such as epikarst features and conduit-flow stream caves. Flank margin caves have been successfully identified in New Zealand for the first time and are differentiated from other cave types by the following criteria: phreatic dissolutional morphologies at the wall rock and chamber scales; absence of turbulent flow wall sculpture and sediment deposits; and lack of integration of adjacent caves into a continuous flow path.

The active tectonics of New Zealand creates a variable sea-level situation. The relatively short time of sea-level stability limits the size of the New Zealand flank margin caves compared to tectonically-stable environments, such as the Bahamas, where glacioeustasy alone controls sea-level stability. Uplift events can be identified as slow and steady when the flank margin caves are uniformly elongated in the vertical direction, and episodic when the flank margin caves show widening and tube development at discrete horizons that cut across rock structure. New Zealand flank margin caves contain information that remains to be assessed on uplift duration and rates independent of other commonly used measures, and therefore can provide a calibration to other methods.

SEEKING JAMES HECTOR (1834-1907)

Simon Nathan
s.nathan@xtra.co.nz

It is 100 years since the death of James Hector, first director of the New Zealand Geological Survey. This was marked by a symposium at Te Papa in Wellington on 8 November 2007. Speakers outlined the range of contributions that Hector made to New Zealand science.

James Hector arrived in New Zealand in 1962 to undertake a geological survey of Dunedin province. Appointed Director of the New Zealand Geological Survey 1865, he was also in charge of the Colonial Museum (now Te Papa). He helped found the New Zealand Institute (now Royal Society of New Zealand), and was the government's main scientific adviser for over 35 years until he retired in 1903. Hector had wide interests. He installed New Zealand's first seismograph, and was responsible for the time service and weather forecasting as well as serving on many committees and commissions.

Although he had a high public profile, there is remarkably little information on Hector's private life or his personal views. As an experienced administrator and public servant, he generally avoided committing opinions to paper on any but scientific matters. It is clear, however, that he did not attempt to suppress opinions that were contrary to his own in the *Transactions of the New Zealand Institute,* and remained on good terms with a wide range of correspondents.

WHAT HAS BEEN THE VARIABILITY IN CLIMATE OVER THE LAST 100-1000 YEARS?

H. L. Neil[1], J. Nott[2], R. Thresher[3], J. Haig[2], P. Marriott[1], D. Tracey[1]

[1] NIWA, Private Bag 14 901, Kilbirnie, Wellington, New Zealand
[2]TESAG, James Cook University, PO Box 6811 Cairns, Queensland, Australia
[3] CSIRO Marine Research, GPO Box 1538, Hobart, Tasmania 7001 Australia
(h.neil@niwa.co.nz)

Historical climate records reveal how important the linkages between ocean, atmosphere and changes in land-cover are. The last few decades to centuries of direct climate measurements contain only a small range of climate variability; while oceanic climate time-series only extend over the past decade. The extension of these records back in time is imperative to allow the better use of oceans and also to enable proper hazard mitigation for >1 billion people living within 30km of a coastline globally.

Datasets of the recent past are few. The northern hemisphere has the best historical coverage while coverage of the tropics and Southern Hemisphere is still poor, although rapidly being addressed. Here we present two high resolution datasets of the recent past obtained from growth rings of long-lived corals and stalagmites. Both are potentially sensitive at an annual scale for reconstructing climate changes.

1) Four high-resolution micro-milled records of Mg/Ca and $\delta^{18}O$ from deep-sea corals collected at ~1000m water depth around New Zealand. Corals can live from decades to hundreds of years and their calcite matrix can record relatively rapid changes in the environment. An understanding of deep-sea corals is needed to appreciate the nature, extent and possible mitigation of any climate and associated oceanic impacts. Coral specimens used here belong to the bamboo coral species *Lepidisis* spp and *Keratoisis* spp. Two different climatic patterns were observed within the New Zealand region. Some corals indicate long-term cooling from the mid-19th century whilst others suggest a variable oceanic state. The records presented here potentially reflect a response of intermediate waters to variability in regional currents and long term changes within the Subtropical Gyre over the past century.

2) A high-resolution micro-milled record of the isotopic signature of tropical cyclone-generated rains. New Zealand has experienced several major ex-tropical cyclones, while the South Pacific Islands and Northern Australia are subject to severe tropical cyclones. Risk assessment of these events is based on short instrumented records that are assumed to be a reasonable reflection of cyclones over much longer time periods. In order to test this assumption we need to construct and examine long-term geological records that are of sufficient resolution to reveal variations of at least decadal to century scales. Until now this has been a difficult task. Here we present a record from annually deposited calcite stalagmite layers for the past eight centuries.

PRELIMINARY PALAEOMAGNETIC RECORD FROM HOKITIKA CANYON LEVEE, NEW ZEALAND SECTOR OF THE SOUTH PACIFIC

F.E. Nelson[1], G.S. Wilson[1] and Shipboard party MD152/MATACORE
[1]Department of Geology, University of Otago, Dunedin, New Zealand
fen000@gmail.com

The Challenger Plateau off the West Coast of the South Island formed one of the target areas for the MATACORE "Tectonic and climatic controls on sediment budget" cruise in 2006. Tectonic uplift of the Southern Alps within the westerly wind belt has led to high-resolution offshore sediment accumulation. We present new palaeomagnetic data, which provides both age control and proxies for changing environmental parameters. Three cores (MD06-2987, 2988, 2989; 27-40m long) were sub-sampled using u-channels onboard RV *Marion-Dufresne II*. Natural remanent magnetization (NRM) and anhysteretic remanent magnetization (ARM) were measured with a pass-through, high resolution 2G Enterprises cryogenic magnetometer in the shielded University of Otago Palaeomagnetic Research Facility. A magnetic polarity reversal (Brunhes/Matuyama boundary), tephra layers and relative paleointensity records provide age control and allow correlation between cores. Initial magnetic susceptibility (χ_0) was measured every centimetre with a Bartington susceptibility metre (0.1 SI units). Time-series analysis (multi-taper method) of magnetic susceptibility indicates spectral power in the Milankovitch bands and several additional sub-Milankovitch bands. New Zealand and its continental shelf are situated in a unique position to track changes in the global ocean and climate system.

POSTER 20

VOLCANIC EVOLUTION, ORAL TRADITIONS OF VOLCANISM OF WESTERN SAMOA (SW PACIFIC) AND THEIR VOLCANIC HAZARD IMPLICATIONS

K. Németh[1], S. J. Cronin[1], F. Lolo[2], M. Leavasa[2], D. S. Solomona[3], F. Nelson[2]
[1]Volcanic Risk Solutions, Massey University, PB. 11222, Palmerston North, NZ
[2] Ministry of Natural Resources, and Environment, Apia, Upolu, Western Samoa
[3] Tufulele Village, Apia, Upolu, Western Samoa
k.nemeth@massey.ac.nz

Savai'i and Upolu are the western-most and largest islands of the Samoan group and have experienced a long period of volcanism (>2 My). Reliable estimation of recurrence intervals between eruptions and hence an accurate assessment of volcanic hazard is hindered by a lack of age data on past events. Recent eruptions occurred on Savai'i in 1905-1911 (Matavanu), 1902 (Mauga Mu and Mata o le Afi [fire peak]) and 1760 (Maunga Afi [fire mountain]). Other evidence for repeated volcanic activity on both islands during human occupation includes: fresh tuff/scoria cones such as Tafua Savai'i; possibly as young as 610 ± 60 yrs B.P), as well as another 5 radiocarbon dates of between 700 and 2500 yrs B.P. for individual lava flows and tephra falls in various locations around Savai'i. Although Upolu does not have the youngest of the mapped Holocene volcanic rocks, it has several areas mapped as early Holocene in age (> 5 ky) and fresh volcanic landforms/deposits. Direct evidence includes a radiocarbon date of 1915 ± 65 yrs B.P., giving the maximum age of a phreatomagmatic tuff cone offshore of Cape Tapaga, east Upolu. In addition to geological studies, a program working with local communities has been started to promote their understanding of their natural surroundings and potential volcanic hazard. Village visits of Samoan facilitators targeted high-ranking (titled, elderly) individuals for explanations of local features, including their genesis, use and associated geo-hazards. Areas where young eruptions (<3500 yr BP) are suspected from geological observations were targeted. In stark contrast to communities in Vanuatu or the Solomon Islands, the village communities appear to have very limited knowledge of their volcanic heritage. Major youthful volcanic landforms show from their names that they were once significant (e.g. Tafua Upolu or Tafua Savai'i; Tafua = fire mountain/volcano, a cognate of "Tofua" – the large Tongan volcano and "Tavuyaga" in Fiji). However, these no longer appear to play an important role in modern everyday life and few if any legends are attached to them. Almost all legends know from these areas deal with origins of Samoans on their islands (overlain by strong Christen teachings), and past disputes/battles and wrongdoings between tribes/neighbours. The only exceptions to this were distal volcanic memories identified in legends from East Upolu, where offshore islands (tuff cones) are associated with giant explosions. During village visits, maps were drawn by individuals and groups highlighting the resources and landscapes important in their life. The majority of the maps were prepared as 3D-oblique view sketches, rather than plan-views, showing little in common to the plan-view hazard maps of the area. In addition, maps were commonly restricted to the strict boundaries of local communities, ignoring major features (such as fresh volcanic cones) that were in the territory of "next door" villages. These perspectives need to be focused upon in future iterations of hazard maps and hazard education programmes.

POST-CALDERA VOLCANISM IN THE YENKAHE CALDERA, TANNA ISLAND, VANUATU

K. Németh [1], S.J. Cronin [1], A. Möbis [1], D. Charley [1,2]
[1] Volcanic Risk Solutions, CS-INR, Massey University, Palmerston North, NZ
[2] Department of Water Resources, Geology and Mines, Port Vila, Vanuatu
k.nemeth@massey.ac.nz

Yenkahe Caldera is a 4 km diameter Quaternary andesitic caldera formed in the southern part of Tanna Island. The Siwi Pyroclastic Sequence is associated with the caldera-forming event and consists of a variably welded andesitic pumice ignimbrite overlain by other mass-flow breccias. Within the caldera, along the margins of a rapidly rising, resurgent block structure is a succession of overlapping scoria/tephra cones, including the presently active Yasur volcano. Yasur has been in semi-continual eruption since at least 300 years (witnessed by Cook in his travels), producing hourly to daily strombolian, vulcanian and phreatomagmatic explosions. In addition, on a c. 30 yr cycle, larger sub-Plinian eruptions occur. The rapidly growing Yasur cone has also gone through several collapse events, building a broad base of landslide and intercalated talus deposit. Much of the pyroclastic products of Yasur have accumulated within the Yenkahe Caldera, forming a broad unvegetated ash plain, which at times has also been a shallow lake. Fragmentation processes during Yasur eruptions include (1) magmatic, with ash units showing Pelee's tears and vesicular juvenile clasts, as well as (2) phreatomagmatic, with ash showing blocky shapes and dense chilled glass. A long-lived, shallow caldera lake (Lake Siwi) within the central Yenkahe caldera was present up to 2000, whereupon, following a particularly rainy period the lake water broke out and drained within several hours causing a locally damaging flood. A deep canyon was cut during this event and now exposes accumulated tephra of up to c. 1000 years of activity from Yasur and proto cones. The uppermost ~ 20 m succession consists of well-bedded, fine to coarse ash and lapilli layers. These beds are predominantly fall units with minor surge, interbedded with calcite-rich reworked water-laden volcaniclastic sediments. In the middle of the section a truncated unit with large rip-up clasts, unidirectional cross bedding and polylithologic clasts indicates an earlier caldera lake outbreak event. This caldera filling succession sits over a tephra series of dune bedded, accretionary lapilli-rich units suggestive of dominantly base-surge transportation. These beds gradually transform into a block and lapilli-rich massive, weakly bedded unit interpreted to be a proximal part of a pre-Yasur intra-caldera tephra ring. The dip directions and the 3D architecture of this tephra ring suggest that it functioned as a dam behind which Lake Siwi originally formed. In general, other phreatomagmatic tephra units in the intra-caldera region suggest a wet eruptive environment for the early post-caldera eruptives. The later magmatic fragmentation from Yasur cone and older vents appears to relate to the ongoing rapid uplift of the caldera floor. Despite this, the deep crater floor of the active vents of Yasur is near to the present day sea level and also receives considerable surface and groundwater influx during lulls in activity, hence periodic, more explosive phreatomagmatic eruptions still occur.

IGNEOUS GEOCHEMISTRY OF THE NOUMEA BASIN, NEW CALEDONIA.

K. Nicholson[1], P.M. Black[2], C. Picard[3] & P.Maurizot[4]
[1]Dept. of Geology, Ball State University, Muncie, IN 47306, USA.
[2] Dept. of Geology, University of Auckland, Private Bag 92019, Auckland, NZ.
[3] Lab. de Geologié, Université du Nouvelle Caledonie, BP4477, Noumea, New Caledonia.
[4] BRGM, BP 56, Noumea, New Caledonia.
k.nichols@bsu.edu

The Noumea Basin represents a transgressive sedimentary sequence that contains cogenetic rhyolitic lavas and less voluminous mafic and intermediate volcanic rocks (Figure 2). Within the basin late Cretaceous sedimentary rocks (Pilou Formation) unconformably overlie Lower Jurassic volcanoclastic rocks, and are overlain by olisthostromes of ultramafics, Paleocene-Eocene basic volcanics and Eocene flysch and chert-limestone sequences. There are three distinct volcanic horizons recognized in the lower part of the Pilou Fm (Noesmoen and Tissot, 1958): Jacob Peak, Catiramon and Nogouta Horizons (Hz). The Jacob Peak Hz is composed of extensive rhyolitic lavas and associated silica tuffs. The Catiramona Hz is dominated by voluminous rhyolitic flows and welded tuffs, tuffs and conglomerates, and rare autobrecciated basaltic lavas, and redeposited basic volcanic debris. Again the Nogouta Hz is dominated by rhyolitic lavas, however, this horizon also includes thick lenses and beds of basic and intermediate volcanic debris, associated bedded tuffs and rare mafic intrusions. The igneous lithologies include olivine-augite basalts, augite andesites, hornblende-augite andesites, hornblende andesites, rhyodacites and high-Si rhyolites.

Preliminary geochemical interpretations are based on 35 new XRF and ICP-MS analyses, combined with 20 old unpublished ICP-MS analyses. There are two distinct geochemical groups present within the sample set.

Group A rocks have greater than 55wt.% SiO_2 and low wt.% TiO_2, they are medium-K, have a very slight positive Nd-Ta anomaly and a negative Ti anomaly. In general the Group A rocks have characteristics similar to OIB (ocean island basalt).

Group B rocks range between 47 and 78wt.% SiO_2 , are low-medium-K and have a definite calc-alkaline fractionation trend. The Group B rocks have distinct negative Nd-Ta and Ti anomalies typical of rocks formed in a volcanic arc environment. Further interpretation of the data may allow separation of Group B rocks into two subgroups given that some samples appear to have a negative Zr-Hf anomaly and others do not.

In addition to further geochemical analysis, continuing work in the Noumea Basin includes geochronology and isotopic analyses. The results of this work will be compared to similar sequences in New Zealand and elsewhere in the region.

TARANAKI FAULT STRUCTURE AND KINEMATIC HISTORY; IMPLICATIONS FOR NORTH ISLAND SUBDUCTION

A. Nicol[1] **& V. Stagpoole**[1]
[1]GNS Science, PO Box 30368, Lower Hutt, New Zealand
a.nicol@gns.cri.nz

The Taranaki Fault is a thrust antithetic to the Hikurangi margin subduction thrust, forms the eastern margin of the Taranaki Basin and is part of a system that extends for at least 600 km in continental crust of western New Zealand. In the North Island displacement on the Taranaki Fault is inferred to have accrued in response to motion of the subducting Pacific Plate, and growth analysis of this structure contributes to an improved understanding of subduction processes. Two-dimensional seismic-reflection lines (2-5 km spacing), tied to recently drilled wells and outcrop, together with magneto-telluric and gravity models provide a rare opportunity to investigate the geometry and kinematic history of a large thrust antithetic to a subducting plate. These data indicate that the fault is thick skinned with dips of 25 to 45° to depths of at least 12 km. The fault accommodated at least 12-15 km of dip-slip displacement since the Middle Eocene (ca. 40-43 Ma). The northern tip of the active section of the fault stepped southwards at least three times between the Middle Eocene and Early Pliocene, producing a total tip retreat of 400-450 km. The history of displacements on the Taranaki Fault is consistent with initiation of Hikurangi margin subduction during the Middle Eocene, up to 20 Myr earlier than some previous estimates. We propose that the increase in the rates of upper plate deformation during the Early Miocene could have arisen due to a rapid southward migration of the Pacific-Australia Euler pole away from New Zealand at this time (rather than subduction initiation). Decreases in the active length of the Taranaki Fault throughout the Tertiary suggest that the subducting plate changed both location and orientation relative to the fault. Fault tip retreat may have been generated by clockwise rotation of the subduction margin and associated slab rollback, which resulted in stepwise isolation of the fault from the driving down-going Pacific Plate.

NEW SEA-FLOOR FEATURES DISCOVERED ON THE CHATHAM RISE AND CHALLENGER PLATEAU BY MULTI-BEAM MAPPING DURING OCEAN SURVEY 20/20

S. Nodder, J. Mitchell, M. Dunkin[1], K. Mackay, A. Pallentin and A.-L. Verdier

National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, s.nodder@niwa.co.nz

[1] Now Wellington City Council

The main aims of Chatham Rise-Challenger Plateau project of the Ocean Survey 20/20 programme are to estimate and compare sea-bed biodiversity and habitats to facilitate management plan development for sustainable use of marine resources in these two oceanographically different environments (i.e., high vs low productivity, frontal vs single water mass, high vs low fishing intensity). Newly discovered sea-floor features, mapped during three Ocean Survey 20/20 voyages to the Chatham Rise and Challenger Plateau in 2006-07, include ancient ice-berg scours, pock-mark fields, extinct undersea volcanoes and seamounts, submarine landslides and slope channels. These features have been revealed in detail using multi-beam data, collected by RV *Tangaroa*'s hull-mounted Simrad EM300 swath echo-sounder, and integrated with follow-up biodiversity surveys using video and still photography, epibenthic sleds and sediment corers. The reflectivity of the sea-bed is an important component of habitat mapping, together with aspects of the sea-floor shape, slope and roughness, all of which were mapped on several transects across the Chatham Rise and Challenger Plateau. The back-scatter signal from the multi-beam data has been further processed using a novel software package *SonarScope*, developed by IFREMER (France), in order to better characterise the sea-floor substrate type. Not surprisingly, high back-scatter contrasts are found in areas of rocky or consolidated substrates where encrusting organisms, such as sponges, corals and anenomes, predominate. Low back-scatter responses occur in more unconsolidated sediments, such that characteristic soft-sediment fauna (e.g., burrowing crustaceans, echinoderms) are more important constituents of the sea-floor community. Eventually, these data will be integrated more completely with biological sea-bed samples that were collected on the same voyages to address the main aims of Ocean Survey 20/20.

FORAMINIFERAL MORPHOLOGICAL ODDITIES: EVIDIENCE OF ASEXUAL BUDDING?

L. Northcote & H. Neil
National Institute of Water & Atmosphere, Private Bag 14 901 Kilbirnie, Wellington,
l.northcote@niwa.co.nz

Budding is the formation of one or more individuals from a parent organism and commonly occurs among many protozoa and other marine invertebrates. To date, this phenomenon has never been described in live planktic foraminifera.

A sediment trap experiment conducted for one year across Campbell Plateau showed many examples of what appear to be asexually budding planktic foraminifera in several non-spinose species. These were found to be more abundant in spring on the Antarctic Circumpolar Current-swept margin of the eastern Campbell flank, than in the quiescent waters of the plateau interior at Pukaki Rise. In most cases, there are two or more budding forams in various stages of emergence from the ‘parent’ test.

Understanding the conditions which gave rise to these aberrants may help us in assessing those which have been found in fossil assemblages and further enhance our knowledge of planktic foraminiferal reproduction in general.

CONTROLS ON THE DISTRIBUTION OF CONCRETIONARY SEEP CARBONATES, EAST CAPE, NORTH ISLAND

Stephanie L. Nyman[1], Campbell S. Nelson[1], Kathleen A. Campbell[2], Murray R. Gregory[2], Nicola Tonkin[2]
[1] Dept of Earth & Ocean Sciences, Univ. Waikato, Private Bag 3105, Hamilton, NZ
[2] Dept of Geology, Univ. Auckland, Private Bag 92019, Auckland, NZ
snyman@waikato.ac.nz

Methane derived authigenic carbonate (MDAC) is associated with the development of hydrocarbon seeps. In modern continental margin settings, such seep carbonates can occur on the sea floor where subsurface fluids have migrated from depth along focused pathways initiated from overpressured sediments, fluid buoyancy, and fault/fracture systems. The geological structures marking the ascent pathways in the subsurface are poorly understood, but one such structure is concretionary carbonate pipes or tubes. These tubular concretions can form a variety of morphologies, sizes, and mineralogies which reflect differences in tectonic setting, stratigraphic position, and fluid migration pathways during seep field development.

Tubular concretions are known in deep-water Miocene mudrocks from several localities in the North Island, with some particularly fine examples near East Cape. Here the tubular concretions have the largest diameters of examples known worldwide, ranging up to 4 to 9 m across, and form three main morphologies: pipe-like, tapered, and doughnut shaped. The concretions are hosted in middle to upper slope, very fine sandy mudstones and muddy sandstones of the 200-300 m-thick late Miocene Pohutu Formation. They occur mainly in the upper part of the formation, cropping out over 6 km of the shore platform from Horoera Point to Maruhou Point, with the main exposure stretching for 2 km at Horoera Point. Here, dipping strata, folding, jointing, and faulting diversify the structure. Reconnaissance mapping of the platform and helicopter aerial photography have been carried out to investigate any relationships between these structural aspects, the formation of the tubular concretions, and evolution of the seepage system. The concretions appear aligned in stratigraphic horizons, in places also along joints and faults. Joint splitting and rejoining around concretions, and fractured concretions on faults, suggest they formed pre- and/or possibly contemporaneously with the structure.

Determining the timing relationship of concretion formation and structural deformation, alongside investigations of the subsurface manifestations of seabed fluid flow, will help understand the development of seepage systems and the controls on focused fluid migration towards the seafloor. The Miocene concretionary plumbing network exposed on the East Cape platform may provide a conceptual model for the subsurface fluid migration system of the offshore seeps along the modern Hikurangi Margin.

Aerial photo of tubular concretions along major fractures, Horoera Point, East Cape

A MIDDLE MIOCENE OCEANOGRAPHIC RECORD FROM WESTERN-SOUTHLAND, NEW ZEALAND OF ECCENTRICITY-OBLIQUITY PACED GLACIATIONS OF THE CRYOSPHERE

Christian Ohneiser & Gary Wilson

Department of Geology, University of Otago, PO Box 56, Dunedin
christian.ohneiser@stonebow.otago.ac.nz

We present a unique magnetic susceptibility and paleocurrent record of the middle Miocene expansion of the cryosphere from the South-West Pacific. An astronomically tuned, high resolution, magneto-biostratigraphic age model provides robust age control of the magnetic susceptibility and Anisotropy of Magnetic Susceptibility (AMS) data collected from a mudstone succession in Western Southland, New Zealand. The magnetic susceptibility record gives a measure of the carbonate content of the sediment and therefore serves as a proxy for ice volume linked ocean productivity. Spectral and wavelet analysis of the magnetic susceptibility record revealed alternating periods of eccentricity and obliquity cycling. AMS data are here used as a proxy for current strength and suggest a dynamic ocean system around New Zealand with three phases of increasing and decreasing current strengths under a waxing and waning cryosphere at ~13.7 Ma, ~15 Ma and ~15.8 Ma. In all cases times of maximum inflow and hence ice volume were paced with eccentricity and deglaciations were paced with obliquity. The data indicate that large ice sheets favour or amplify eccentricity as suggested by Imbrie *et al* (1993) and that for long periods in the middle Miocene eccentricity paced glaciations were dominant.

Imbrie, J.; Berger, A.; Boyle, E. A.; Clemens, S. C.; Duffy, A.; Howard, W. R.; Kukla, G.; Kutzbach, J.; Martinson, D. G.; McIntyre, A.; Mix, A. C.; Molfino, B.; Morley, J. J.; Peterson, L. C.; Pisias, N. G.; Prell, W. L.; Raymo, M. E.; Shackleton, N. J.; Toggweiler, J. R. 1993: On the structure and origin of major glaciation cycles 2. The 100000-year cycle. Paleoceanography 8: 699-736.

MICROSEISMICITY SURVEY OF THE CENTRAL ALPINE FAULT

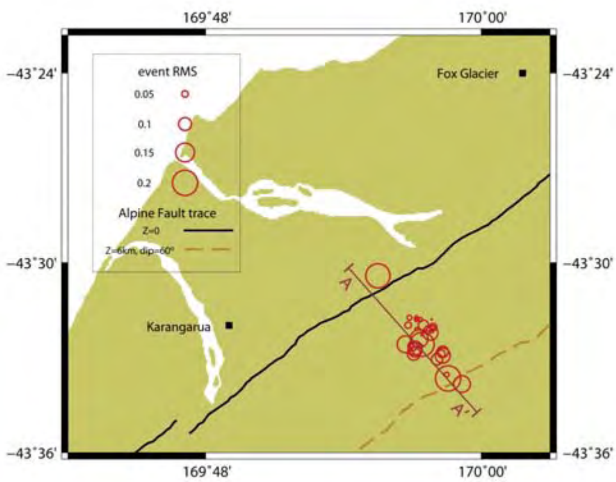
B.C. O'Keefe, E. Smith, M. Savage
School of Geography, Environment and Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington (okeefebron@student.vuw.ac.nz)

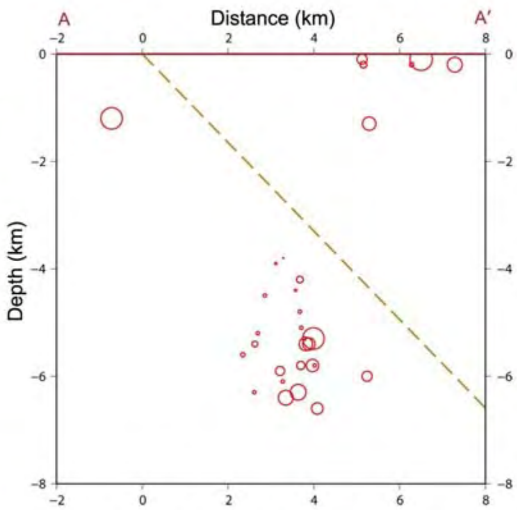
The central Alpine Fault between Harihari and Karangarua is recognised as having a significantly lower seismicity level than the regions to the northeast and southwest. A temporary array (CAlF) of nine seismographs (including three broadband instruments) was augmented with three Geonet stations bounding the array. The resulting catalogue covered six months from September 2006 through March 2007.

During early October, an earthquake swarm near Fox Glacier was recorded within the southern limits of CAlF. The national network catalogued 10 events including three events M> 4 (M4.3, 4.4, and 4.6). A further 23 events were catalogued from the CAlF recordings.

The figures below show the locations of the swarm events with scale of RMS of time residuals. An indication of the Alpine Fault hypothetically dipping at 60° is shown at 6km depth in the left figure and dipping in the A-A' cross-section. The swarm is located in two clusters: one below the Alpine Fault and the other near the surface. The linear trend of the swarm may indicate a fault dipping at 65° perpendicular to and crossing the Alpine Fault. Alternatively, a cluster of events below the fault could be redistributing stress to cause nearby shallow earthquakes.

The analysis of this swarm and the catalogue as a whole will be summarised and discussed, including locations, temporal and spatial trends, and relocations using HypoDD.





POSTER 32

DOES FLUID FLOW IN THE TAUPO VOLCANIC ZONE CONTROL THE POSITION OF THE BRITTLE-DUCTILE TRANSITION?

Nicholas H. S. Oliver[1], John G. McLellan[1], Hugh M. Bibby[2], Bruce E. Hobbs[3], Martin Reyners[2], Julie V. Rowland[4], Tim A. Stern[5], Adrian Benson[5], Euan G. C. Smith[5], Cameron Huddlestone-Holmes[1], Stuart F. Simmons[4], Richard H. Sibson[6], Warwick M. Kissling[7]

[1] Earth and Environmental Sciences, James Cook Uni., Townsville, Australia 4811
[2]GNS Science, PO Box 30368, Lower Hutt, NZ
[3]CSIRO Exploration and Mining, PO Box 1130, Bentley, Australia, 6102
[4]Geology Department, University of Auckland, Private Bag 92019, Auckland, NZ
[5]Geography, Environment & Earth Sciences, VUW, PO Box 600, Wellington, NZ
[6]Department of Geology, University of Otago, PO Box 56, Dunedin, NZ
[7]Industrial Research Laboratories, Wellington, NZ
nick.oliver@jcu.edu.au

Extreme heat flow of 700 mWm^{-2} recorded in the central TVZ is unusual in the sense that it appears to be quasi-steady state over 10's or 100's of thousand years, and this contribution attempts to explain this stability using finite difference modelling codes of coupled heat flow, fluid flow, and deformation. Some of our previous working numerical models proposed that large extensional faulting events might catastrophically disrupt fluid convection in the upper crust. However, the time scales over which both eruptions and earthquake faulting occur in the TVZ appear too rapid to terminate, or shift over > km-scales, the locus of upwelling fluid zones, even for large events like Taupo eruptions or the Edgecumbe earthquakes. Some of us have also proposed that faults in basement underneath the TVZ might control or influence the location of hydrothermal cells, but others have pointed out that the heat flow in the TVZ appears to require that the lower half of the crust underneath Taupo must be dominated by melt advection (not faulted greywacke) to explain the high heat flows in the upper crust. Fracture- and reaction-induced permeability in the upwelling zones is also considered important to pin the convection cells in time and space. The paradox is that heat loss by convective fluid flow in the upper crust must be very efficient, and very stable, to balance the unusual heat flow requirements of the TVZ and keep the base of the brittle crust at about 10km, in contrast to south of the TVZ where the seismogenic zone plunges southwards to depths in excess of 40 km. Our challenge is to come up with a plausible set of boundary conditions for this very efficient heat transfer and for the role of the TVZ within the Hikurangi margin tectonic setting.

Our models must appropriately deal with heat dissipation from the surface of the TVZ because this may impact on how the lower crust and upper mantle are treated in future geophysical modelling. Using a radiative surface heat loss function that accounts for boiling and condensation, coupled with a viscous-plastic-elastic (Burger's) material that is capable of defining the brittle-ductile transition in a self-consistent manner, we are attempting to reach a solution that produces a stable brittle-ductile transition and that also is not grossly disrupted by upper crustal normal faulting.

WORMS, CLAMS AND DONUTS: DISCOVERY AND MAPPING OF NEW METHANE SEEPS ALONG THE ACTIVE EAST COAST MARGIN OF NEW ZEALAND

Alan Orpin[1], Ashley Rowden[1], David Bowden[1], Jens Greinert[2], Cliff Law[1], Scott Nodder[1], Geoffroy Lamarche[1], Peter Hill[1], Arne Pallentin[1]

[1]National Institute of Water and Atmospheric Research (NIWA), Private Bag 14-901 Kilbirnie, Wellington, New Zealand, a.orpin@niwa.co.nz
[2]Marie Curie Fellow, Renard Centre of Marine Geology Department of Geology and Soil Science Ghent University, Krijgslaan 281 s.8 B-9000 Gent, Belgium

New Zealand and American institutes studying the water chemistry and biodiversity of chemosynthetic habitats discovered numerous new cold seep sites along the East Coast margin of New Zealand during research cruises in October and November 2006 ("Cook Strait Methane", RENEWZ I – NEW ZEEPS, funded by NOAA and NIWA). Here, oblique convergent tectonics has led to the development of a thick accretionary wedge of deformed tertiary mudstones. Forty years of historical geophysical and fisheries surveys around NZ built up a library of "unusual seafloor phenomena". Not until the early nineties were these realized as potential evidence for submarine cold seeps, where methane-rich fluids percolate out of the seafloor. Here, seeps can sustain very unusual "islands" of biological communities that don't use light for energy, and to match the odd biology seep sites typically have slabs, crusts, donuts, and chimneys of carbonate. A land-mark study by Lewis and Marshall (1996) compiled the occurrences of seep-related fossils and carbonate concretions collected from dredges and fouled in fishing nets, together with geophysical evidence of suspect seep sites and flares. One of these sites off the Wairarapa has provided NIWA researchers with time-series data that showed persistent methane-enrichment above a flare since September 2005. In isolation these discoveries were somewhat serendipitous in nature, but collectively established a compelling case for cold seeps environments along a wide area of the East Coast margin.

Localities published by Lewis & Marshall (1996) formed the framework for a research cruise aimed specifically at precisely locating seep sites and undertaking in situ visual investigations and sampling. Once on location a systematic series of surveys were undertaken to provide increasingly tighter control on the precise occurrence, dimension and geomorphology of the site. The key ingredient to the success of this approach was the continual refinement of observational data within a geospatial software environment. The end result was a seafloor, water chemistry, and faunal sampling routine that could isolate targets to within 30 m at 1000 m water depth in the absence of a ROV or dynamic positioning system.

This presentation will cover some history and highlights from these voyages that paved the way for further international research cruises earlier this year.

EARTH SCIENCE IN CONTEXT ON THE SCIENCE LEARNING HUB WEBSITE

Kathrin Otrel-Cass[1], Di Hartwell[1], Alister Jones[2], Bronwen Cowie[1], Diane Dinnis[3]
[1]Centre for Science & Technology Education Research, University of Waikato
[2]School of Education, University of Waikato
[3]Wilf Malcolm Institute of Educational Research
kathrino@waikato.ac.nz

Presenting science in context enables science teachers to demonstrate to their students how to connect and apply knowledge. Unrelated and atomised information tends to reinforce rote learning and students are likely to forget information quickly. Ideally science teaching focuses on learning outcomes which make science relevant, encourages critical thinking, increases communication between students and science and technology communities, reinforces social responsibility and increase interest and achievement in science. Research shows that when students learn science in context using internet technology their interest and understanding can be enhanced.

The New Zealand Science Learning Hub is a website that provides contemporary, contextualised resources that aim to enhance science teaching and learning. This website has been funded by the Ministry of Research, Science & Technology and was launched in July 2007. It is also an online portal to link science research organisations with schools. The focus of the website is to provide resources for science teachers of Years 9 & 10 students. The Science Learning Hub is organised into regional teams from Auckland, Waikato, Wellington and Christchurch. To date, the teams have produced materials around four contexts, two of which have a strong focus on concepts and ideas relating to Earth Science: Icy Ecosystems (Antarctica) and Earthquakes. Each context is prepared by providing an initial introductory article which is then supported through further categories that put the context into perspective for teachers and their students. The categories are: Science Ideas and Concepts, New Zealand Research, Evidence Trail, Timeline, Teaching and Learning Approaches, People, Question bank, Key terms and Multimedia.

The Icy Ecosystem context for example introduces the context by focusing on icebergs in the Antarctic, why they are important, why and how scientists study them. Students can explore topics like sea ice, icebergs and ecosystems, past climates, continental drift, ice/land ratio in Antarctica. These topics can be explored by using inquiry questions that focus on using techniques like cross sectional drawings of the Antarctic Peninsula or activities that explore changes in the salinity of water. Support material like videos or animations also aim to facilitate science learning in context. Scientists tell what their research focus is in relationship to the context and what intrigues them about their studies. They also provide explanations for technical details such as drilling for ice core samples and transporting data back to New Zealand. Early feedback from the monthly web report shows that the uptake amongst science teachers in New Zealand is very promising.

TSUNAMI MONITORING IN REAL-TIME

N. Patterson[1] & the Tsunami Network Team[1,2]
[1]GNS Science, 1 Fairway Drive, Avalon, Lower Hutt
[2]Land Information New Zealand, 160 Lambton Quay, Wellington
n.patterson@gns.cri.nz

GNS Science (via the GeoNet project) in partnership with Land Information New Zealand (LINZ) are installing a real-time tsunami gauge network. The tsunami gauge network is part of the New Zealand government's tsunami preparedness initiatives following the Sumatra "Boxing Day" tsunami in 2004. Sea-level data collected from the tsunami gauges will assist in emergency response following the detection of a tsunami and be freely available for research. Moreover, the tsunami gauge network will contribute to an international collaboration to collect and share real-time sea-level data in the Pacific.

The network will consist of 20 stations (two being installed by Australia) that will be located around the New Zealand coastline and on offshore islands. Each station will be equipped with dual pressure gauges that will either be secured to the sea floor or attached to an existing structure such as a wharf. Data will be transmitted in real-time to the GeoNet Data Management Centre where it will be made freely available via the GeoNet website, *www.geonet.org.nz*. Here, we present the locations of the new tsunami monitoring stations, describe station design, and discuss data acquisition and availability.

SEDIMENTATION ON THE NORTH KAIPARA CONTINENTAL MARGIN, WESTERN NORTHLAND, NEW ZEALAND: SOME INTERIM RESULTS

Danielle S. Payne, Campbell S. Nelson & Steven D. Hood
Dept of Earth & Ocean Sciences, Univ. Waikato, Private Bag 3105, Hamilton, NZ
dsp9@waikato.ac.nz

The north Kaipara continental margin (NKCM) extends from Kaipara Harbour north to Cape Reinga at the top of North Island. It is one of the few coastal-shelf-slope regions of New Zealand whose bottom sediments have not been comprehensively mapped. Sediment sampling of the shelf and upper slope out to about 1000 m depth was conducted in 1978 during a New Zealand Oceanographic Institute research cruise on the original RV *Tangaroa* to the Three Kings platform, immediately north of North Island. 54 surficial grab samples and 3 gravity cores were collected from the NKCM, but no subsequent analytical work or interpretations were ever made for these collections. Together with new sampling of the onland beach-dune-harbour complexes, this project is investigating the texture, composition and distribution of bottom sediments on the NKCM, their provenance, and their sedimentation history in relation to both modern and past (relict) processes.

Siliciclastic sands and mixed carbonate-siliciclastic sands characterise the margin bottom sediments. Moderately to well sorted fine sands dominate on the shelf and very fine sands on the slope. A mud fraction becomes significant (>50%) only in the south at >300 m depth, and a mud band also occurs at mid shelf depths off Ninety Mile Beach.

The siliciclastic mineralogy is dominated by quartz and feldspar, forming 60-80% of samples from <100 m water depth; small amounts (<5%) of the micas muscovite and biotite are ubiquitous across the NKCM, especially towards the south. Heavy minerals typically comprise <5% of the sediment but are more significant at <50 m depth at the mouth of Herekino Harbour and offshore from Maunganui Bluff. Hornblende and garnet dominate, then augite and hypersthene. The siliciclastic mineralogy is consistent with ultimate derivation from several sources including greywackes, andesites, granites and schists to the south in western North Island and northern South Island.

The carbonate content becomes significant (>30% $CaCO_3$) only in the northern NKCM, reaching >70% west of Cape Reinga. It increases offshore in the south to 30-50% $CaCO_3$ at >500 m depth. Calcite dominates, but aragonite becomes significant north of Tauroa Point. Overall, bivalves (*Scalpomactra scalpellum*, *Nucula nitidula*, *Hiatella arctica* and *Pleuromeris zelandica*) dominate the >0.5 mm carbonate fraction, often including gastropods (A*ustrofusus glans* and *Sigapatella tenuis*). Bryozoans become abundant north of Tauroa Point, while foraminifera only dominate to the south at >200 m depth. The skeletal fraction shows a distinctive trend from fresh/modern-looking material at <100 m water depth to gradually increasing amounts of degraded/relict material at >200 m depth in the north and 600 m in the south.

A feature of the sediment mineralogy at outer shelf depths (150-200 m) off Tauroa Point is the abundance (>75%) of glauconite pelletal sand (greensand) and, nearby, of phosphatic lithoclasts. The greensand-phosphate association attests to likely long-lived upwelling and sediment condensation in the vicinity of parts of the NKCM shelf edge.

All the sedimentary data in this study are reported in distribution maps for the NKCM.

TALK – Tue pm

THE SEDIMENTS OF LAKE ROTORUA, NEW ZEALAND

Lisa Pearson[1], Chris Hendy[1] and David Hamilton[2]
[1]Department of Chemistry, University of Waikato
[2]Department of Biological Sciences, University of Waikato
lkp6@waikato.ac.nz

163 shallow cores taken from Lake Rotorua over a two year period has shown two types of sediments: coarse, dense (density c. 0.5 g/cm^3 dry) sediments comprised of clastic erosion products and coarse rhyolitic airfall components and can be found in water depths typically less than 10 metres (covering approximately 60% of the lake area); and fine, low-density (~0.02 g/cm^3) diatomaceous ooze found in water depths greater than 10 metres. The diatomaceous ooze has accumulated from deposition of biota, predominantly diatom frustules of *Aulacoseira granulata*. The sediment contains a record of volcanic eruptions, with the Tarawera Tephra typically found 0.5 m below the sediment water interface and Kaharoa Tephra typically between 2 to 3 m depth, in water depths of 10-15 m.

Phosphorus concentration in Lake Rotorua sediments decreases with sediment depth. In the centre of the lake phosphorus concentrations in the top 2 cm can exceed 2500 g/tonne and decline to 800 g/tonne at 20 cm depth. Accumulation rate of phosphorus in the sediment based on the nutrient budget is approximatly 29.6 t/yr. Iron and manganese concentrations in the sediment depend on the availability of the element and the sedimentation rate of diatom frustules, and are controlled by the redox conditions in the sediment. The average concentration of iron and manganese in the sediment is approximately 8000 g/tonne and between 300 and 400 g/tonne, respectively. Iron accumulates in the sediment at a rate of 385 t/yr and manganese at 17.9 t/yr. Maximum concentrations of arsenic in the sediment are 250 g/tonne but are generally between 50-100 g/tonne, depending on the water depth. Lead concentrations are typically below 15 g/tonne. Sediment concentrations of both arsenic and lead are highly correlated with iron and manganese concentrations in the sediment and mimic the respective concentration profiles. Arsenic and lead accumulate in the sediment at a rate of 3.71 and 0.49 t/yr, respectively. All elements show a peak in concentration in the tephra layers.

POSTER 23

LIPIDS IN TUBULAR CONCRETIONS FROM NEW ZEALAND PETROLIFEROUS BASINS: EVIDENCE FOR INVOLVEMENT OF ANAEROBIC METHANE OXIDATION

Michael Pearson[1], Emma Grosjean[2], Stephanie Nyman[1], Graham Logan[2], Campbell Nelson[1], Steven Hood[1] & Kathleen Campbell[3]
[1]Dept of Earth & Ocean Sciences, Univ. Waikato, Private Bag 3105, Hamilton, NZ
[2]Geoscience Australia, GPO Box 378, Canberra ACT 2601, Australia
[3]Dept. of Geology, Univ. Auckland, Private Bag 92019, Auckland, NZ
michaelp@waikato.ac.nz

Preliminary data are presented for lipids extracted from Miocene carbonate concretions and one seep limestone collected from the East Coast and Taranaki basins. Most concretions studied have morphologies suggestive of conduits or pipes that channelled the escape of subsurface fluids and/or hydrocarbon gases, but a spheroidal concretion and host shales were included for comparison. The lipids extracted comprise a range of organic compounds including hydrocarbons, fatty acids and alcohols but also specific marker compounds previously reported to be associated with carbonates formed by subsurface anaerobic oxidation (AOM) of upwardly seeping methane gas. Abundances of archaeol, dialkylyl glycerol diether and macrocylcic diether are strongly covariant, with archaeol dominant. Archaeol is most prominent in the Cape Turnagain concretion (East Coast Basin, Wairarapa) in which another widely reported AOM marker, pentamethyl icosane (PMI) also occurs. By comparison, PMI is absent in the host shale and archeol is at trace level. Other East Coast pipe-like concretions from Rocky Knob and East Cape localities yielded PMI-bearing lipids at least in subsamples close to the central conduit. Archaeol is less consistently present. Host shales again yielded traces at most of either marker.

Stable carbon (C) isotope ratios for PMI, archaeol and related putative marker compounds have not yet been determined. Bulk carbonate C isotope compositions of the Taranaki and Rocky Knob calcitic concretions in which PMI is prominent are strongly C^{13}-depleted (consistent with AOM origin); however dolomitic Cape Turnagain and East Cape concretions with prominent PMI and archaeol are not. Further work in progress includes C isotopic analysis of marker compounds as well as further lipid extraction of new field samples.

POSTER 64

HIGH-RESOLUTION RECORD OF TEPHRA-DATED LATE-HOLOCENE SEDIMENTS FROM LAKE ROTORUA

Rachel Pickett[1,2], Chris Hendy[1], David J. Lowe[2] & Roger Briggs[2]
[1]Department of Chemistry, University of Waikato, Private Bag 3105, Hamilton 3240
[2]Department of Earth and Ocean Sciences, University of Waikato, Private Bag 3105, Hamilton 3240
rcp4@waikato.ac.nz

Waters deeper than 10 m in Lake Rotorua contain an undisturbed sedimentary record of diatomaceous ooze punctuated by tephra deposits. Echo sounding shows most of the deeper lake sediments to be too full of methane to allow sub-bottom profiling, but rare windows show regular tephra bedding. We have cored to a depth of 8 metres. A chronology is being developed using radiocarbon dating and tephrochronology. Preliminary tephra identifications indicate that the base of the core is aged about 5500 cal yr BP, and so the average sedimentation rate for the entire core is very fast, about 1.46 mm/yr (i.e. each millimetre represents about 0.69 yr). Consequently, the sediments, laminated in places, provide an excellent opportunity to develop a high-resolution palaeoclimatic record for the Late Holocene via analyses of a range of properties including magnetic susceptibility, grain size, and their mineralogical, chemical and biological compositions. Seven tephra layers occur in the core including Tarawera (10 June, 1886) and Kaharoa (1314 ± 12 AD) and possibly Whakatane tephra (5530 ± 60 cal yr BP) at the base. These three tephras were erupted from the nearby Okataina Volcanic Centre, the first two from Mt Tarawera and the last from Mt Haraharo. Three of the as-yet uncorrelated tephras are rhyolitic and the other is probably andesitic. The tephras are being characterised and correlated using ferromagnesian mineralogical assemblages, major element analyses of glass (via the electron microprobe) and trace element analyses of glass (via laser-abalation ICP-MS). It is possible that cryptotephras (diminutive, fine grained glass shards sparsely preserved and essentially invisible in the field) are additionally present. We will attempt to locate and identify any that are present.

POSTER 24

VOLCANOLOGY OF THE CATASTROPHIC ABRIGO ERUPTION, TENERIFE AND ITS RELEVANCE TO VOLCANIC HAZARDS IN NEW ZEALAND

A. Pittari[1,2], R. Cas[2], H. Nichols[3], J. Wolff[3] & J. Martí[4]
[1]Dept. of Earth & Ocean Sciences, The University of Waikato, Private Bag 3105, Hamilton, 3240, New Zealand, apittari@waikato.ac.nz
[2]School of Geosciences, PO Box 28E, Monash University, Victoria, Australia
[3]Dept of Geology, Washington State University, Pullman, Washington, 99164, USA
[4]Instituto de Ciencias de la Tierra (Jaume Almera), CSIC, Lluis Solé i Sabaris s/n, 08028, Barcelona, Spain

The Las Cañadas volcanic edifice and its summit caldera on Tenerife, Canary Islands, has a complex history of stratovolcano-building phases and catastrophic mass-wasting phases, including lateral flank collapse events and caldera-forming pyroclastic eruptions. Caldera-forming eruptions, which generate destructive pyroclastic flows, pose a major threat to the island. The Taupo Volcanic Zone (TVZ), New Zealand, also features a range of calderas and stratovolcanoes, which have the potential to generate major ignimbrite-forming eruptions and mass-wasting events. Knowledge of the physical volcanic processes, derived from the well-exposed pyroclastic deposits on Tenerife, can assist in understanding the similar processes in the TVZ.

The lithic-rich, phonolitic Abrigo Ignimbrite represents the last major explosive caldera-forming eruption (~186 ka) and is one of the most widespread volcanic units on Tenerife. A major landslide event, which formed the Icod palaeovalley on the northern flank of the edifice, occurred around the same time, although its genetic relationship to the Abrigo eruption is not known. The Abrigo Ignimbrite consists of multiple massive to stratified lithic-rich ignmbrite depositional units preserved around the lower flanks on all sides of the Las Cañadas edifice and on the northeastern part of the caldera wall. However, much of the original volume is likely to occur in the offshore sedimentary basin or buried beneath later intra-caldera lavas. On the southern flanks, where it is best preserved, the deposit is up to 25 m thick within palaeovalleys, but thins to <1 m on the adjacent interfluves. Valley-ponded deposits consist of two massive, lithic-rich depositional units, which have internally complex facies variations, separated by a thin fine ash layer, and include multiple lithic pebble to cobble concentration zones and isolated substrate-derived lithic boulders. Veneer deposits on the interfluves are generally stratified, and relatively lithic-poor.

Pyroclastic flows, associated with ongoing syneruptive caldera collapse, were channelled along major radial ravines around the edifice and spread out as sheetlike flows on the lower slopes and coastal plains, burying much of the landscape. Coastline modification and major tsunami generation would have occurred with the entry of pyroclastic flows into the sea, and also with the Icod landslide around the same time. The abundance of coarse lithic clasts, especially large boulders transported as bedload within the pyroclastic flows, indicate significantly high and destructive dynamic pressures. Some caldera-related ignimbrites in the TVZ are also lithic-rich (e.g. Kaingaroa Ignimbrite, Reporoa caldera) and could pose similar hazards to the Abrigo Ignimbrite on Tenerife.

TALK – Wed pm

THE PLACE OF EARTH SCIENCE IN THE NEW SCIENCE CURRICULUM

Jenny Pollock
Nelson College for Girls, Trafalgar Street, Nelson &
President of New Zealand Association of Science Educators
Co-ordinator of GSNZ Geo-education group
Co-ordinator of SCIPEB – Standing committee for Earth Sciences of NZASE

Planet Earth and Beyond has been part of the New Zealand Science curriculum since 1993. It has been thoroughly reviewed and there are some significant changes.

It was recognised that the focus of the Planet Earth and Beyond Strand needed to be widened. Since the development of the last Science curriculum, three “big” ideas have developed that need to influence the teaching and learning of the Planet Earth and Beyond strand.

The first of these is Earth Systems Science (ESS). This recognizes that Earth has four main spheres, the geosphere (rocks), the hydrosphere (water), the atmosphere (air), and the biosphere (life) with numerous interactions between them. Neither sphere is more important than the other. To fully understand Planet Earth and our Solar System an interdisciplinary approach is needed. The ESS approach will also be used to consider conditions on other planets as well.

For at least a decade Earth Science and Geology departments at schools and universities world wide have been changing to an Earth Systems Science approach. New Zealand schools would be left behind if the focus of PEB had not been changed.

The second idea is that Planet Earth provides all resources, apart from those from the Sun, and that these are finite. This is linked to the third idea which is that of guardianship of Planet Earth and its resources. The PEB strand has been developed to provide the knowledge and understanding necessary for considering the issues facing our planet.

ACTIVE FAULTING AND SEISMIC HAZARD IN COOK STRAIT USING HIGH-RESOLUTION SEISMIC DATA.

Nicolas Pondard, Philip M. Barnes, Geoffroy Lamarche and Joshu Mountjoy
National Institute of Water & Atmospheric Research (NIWA), Private Bag 14-901, Wellington 6021
(n.pondard@niwa.co.nz)

Active faults in Cook Strait have been mapped in detail, revealing the relationships between the Marlborough fault system (Alpine Fault, South Island), the North Island Dextral Fault Belt, and the southern Hikurangi margin. Multi-beam bathymetry, high-resolution (boomer) and multi-channel seismic reflection data have been recently acquired to study the morphology and geology of these faults, including their distribution, geometry and displacement rates. These data provide critical observations to unravel plate boundary kinematics in the region, and to identify earthquake sources near the city of Wellington. The submarine fault system is characterized by a series of 5 to 20 km wide step-overs. Whilst the predominant structural trend is SW-NE in the South and North islands, faults are clearly oriented E-W in Cook Strait. Submarine faults are segmented (10-70 km long), accommodating a combination of late Quaternary strike-slip and extension in northern Cook Strait, and a combination of strike-slip and compression in southern Cook Strait, consistent with the geometry of the step-overs. The vertical component of faulting is subordinate to the dextral component. Deeper geometry of the faults reveals an important structural inheritance and suggests tectonic inversion. Imaging of the last major transgressive surfaces (120 ka and 20.5-to-6.5 ka) enables to estimate vertical slip-rates. Holocene vertical slip-rates range 0.5 - 2 mm/yr and appear to compete with high sedimentation and erosion rates. Thus most of the resulting fault scarps are continuously levelled on the seafloor. Stratigraphy of the post-glacial mud deposit (Holocene) documents the growth and earthquake activity associated with the faults. Preliminary evaluations suggest recurrence intervals of 1000 to 3000 years along the Wairau, Cloudy and Vernon faults, corresponding to co-seismic vertical displacements of 0.5 to 6 m. A probable rupture of one of these segments alone would correspond to a Mw 6.5 to 7.5 earthquake. Scenarios with events involving onshore segments and their corresponding offshore extension are plausible. However through-going earthquake ruptures across Cook Strait appear less probable. The next phase of the study is to refine the evaluation of fault slip rates and paleo-earthquake information, and to produce Coulomb stress models incorporating the new submarine evidence.

TALK – Wed am

RESPONSE OF WELLINGTON HARBOUR TO THE 2007 SOLOMON ISLANDS AND PERU TSUNAMIS

W. L. Power[1]
[1]GNS Science, 1 Fairway Drive, Avalon, Lower Hutt
w.power@gns.cri.nz

The LINZ/GeoNet real-time tsunami gauge network is currently being established nationwide. This is expected to include up to 20 tide gauges installed around the coast and on offshore islands. Data from this network will be made available to the general public via the Geonet website, and this will provide new research opportunities for scientists interested in coastal phenomena. As an example of the use of this data for scientific research we have studied the output of the Wellington Harbour gauge, located on Queens Wharf, during the 2nd April Solomon Islands and 15 August Peru tsunamis.

We present raw and de-tided data from the two studied tsunamis, and spectrogram plots illustrating the energy at different frequencies as a function of time. We will also present computer models illustrating the tsunami propagation and travel-times for these events.

The response measured by the tide gauge is shown to be related to the normal modes of the harbour. Following both tsunamis there were pronounced oscillations in water level with a period of slightly shorter than 30 minutes, corresponding to the 2nd and 3rd lowest order modes of harbour oscillation (Abraham, 1997). Oscillations of about this period were also notable in the response of Wellington harbour to the 1855 Wairarapa (Grapes & Downes, 1997), 1868 Peru/Chile, 1960 Chile (Gilmour 1990) and 1964 Alaska (Gilmour 1990) tsunamis.

Abraham, E.R.C. 1997, Seiche Modes of Wellington Harbour, New Zealand. New Zealand Journal of Marine and Freshwater Research, vol 31, 191-200.

Gilmour,A.E. 1990, Response of Wellington Harbour to the tsunamis of 1960 and 1964. New Zealand Journal of Marine and Freshwater Research, vol 24, 229-231.

Grapes, R. and Downes, G., The 1855 Wairarapa, New Zealand, Earthquake – Analysis of Historical Data, Bulletin of the New Zealand Society for Earthquake Engineering, vol 30, 271-368.

MANTLE SOURCE COMPOSITIONS FOR THE BASALTIC COMPONENT IN NORTH ISLAND ANDESITIC VOLCANOES – A LITHOSPHERIC SOURCE FOR TARANAKI ANDESITES?

Richard Price[1] , Anke Zernack[2] , Ian Smith[3], John Gamble[4], & Bob Stewart[2]
[1]Science and Engineering, University of Waikato, Hamilton, New Zealand
[2]Institute Natural Resources, Massey University, Palmerston Nth, New Zealand
[3]Geology programme, SGGES, University of Auckland, Auckland, New Zealand
[4]Department of Geology, UCC, National University of Ireland, Cork, Ireland
(r.price@waikato.ac.nz)

Among those studying subduction-related volcanic rocks there is now general agreement that the magmas that these represent have an ultimate origin in the mantle wedge above subducting slabs. Mineralogical transformations occur as the slab descends into the asthenospheric mantle and fluids released from these reactions cause partial melting of the overlying mantle wedge to produce primitive basaltic magmas. Andesitic and rhyolitic magmas are generated when these primitive magmas arrive within and interact with the lithosphere.

North Island andesitic volcanic rocks are the products of complex polybaric processes involving varying degrees of assimilation and crystal fractionation within the crust and on andesitic volcanoes such as Ruapehu and Taranaki, eruptives with compositions that might represent the primitive mantle-derived component are very rare. For andesites, whole rock, glass, and mineral chemistry can provide insights into the detailed workings of the crustal level magmatic systems but it is difficult to use this information to draw inferences about the processes taking place in the mantle or the nature of the mantle sources from which a basaltic component may have derived.

Within debris avalanche deposits making up the older (>100 ka) ring plain of Taranaki, we have sampled clasts with relative primitive compositions. These compositions can be used to derive estimates of the trace element chemistry of possible mantle sources, which can then be compared with those from which Taupo Volcanic Zone (TVZ) and Kermadec basalts derived. The mantle sources for Taranaki basalts were significantly more enriched than those from which TVZ or Kermadec basalts were generated. Furthermore, Taranaki basalts show a range in composition that appears to indicate variability in the mantle source. One possible explanation is that Taranaki magmatism is not directly related to present day subduction but is instead associated with lithospheric delamination, as suggested by Stern et al. (2006).

Comparisons of model mantle source compositions for North Island and Kermadec subduction-related and intra-plate basaltic rocks indicate considerable variability, with variable development of ‘arc’ trace element signatures. ‘Arc’ signatures in the mantle are not necessarily directly related to present day subduction and in some cases they may reflect the effects of past subduction events on the lithospheric mantle.

Reference

Stern, T.A., Stratford, W.R., and Salmon, M.L. (2007) Subduction evolution and mantle dynamics at a continental margin: central North Island, New Zealand. *Reviews of Geophysics* 44, RG4002, doi:10.1029/2005RG000171, 2006

SIMULATION OF THE ANTICIPATED "BREAKOUT LAHAR" AT RUAPEHU USING TITAN 2D

J.N. Procter [1], M.F. Sheridan [2], S.J. Cronin [1], A. Patra [2], H.J.R. Keys [4], A.V.Zernack[1], M.B.Turner[1] M.Irwin[1].

1. Institute of Natural Resources, Massey University, Private Bag 11 222, Palmerston North, NZ
2. Geophysical Mass Flow Modelling Group, State University of New York at Buffalo, NY 14260, USA
4. Department of Conservation, Turangi-Taupo Conservancy, Private Bag, Turangi, New Zealand

Since the 1996 eruptions of Ruapehu, the potential for a dam-breakout lahar was immediately recognised, due to the accumulation of tephra over the former Crater Lake outlet level. Over the last ten years a number of studies focused on characterising and simulating a lake breakout lahar with an emphasis on quantifying the risk to specific significant points of infrastructure. A protection structure "the bund" was the largest hazard-mitigative structure yet built along the Whangaehu catchment, located near the edge of the National Park. The structure, at c. 9.5 km downstream of Crater Lake was designed to stop lahars spilling northward and into the Tongariro catchment. Since its suggestion, the structure has also been a point of importance and a focus of study on effective lahar hazard mitigation.

The bund effectiveness was tested in this study by simulating a range of flow scenarios in this channel reach using two versions of the Titan2D mass flow modelling code. Titan-2D is a depth averaged, "shallow water" flow model, simulating either a dry granular flow, or a two-phase viscous fluid + granular flow developed by the Geophysical Mass Flow Modelling group at SUNY Buffalo. The major innovative feature of this code is that it solves the movement of a granular or two-phase flow of initially specified volume over natural terrains by using an adaptive grid. We present a comparison of simulations (run before the 18 March 2007 break-out lahar) to the actual event.

The Titan2D models were extremely accurate in predicating both the inundation areas and travel times of the lahar at various points along the upper flow channel down to the bund. The velocities and discharges predicted at the bund were up to 20% higher than those of the 2007 flow, but matched closely those of the largest 1995 event in this area. Predicted paths of flow, including locations of side-channel spill-over, all corresponded with those in the March 2007 event. In addition the simulations showed features such as flow super-elevation in corners and hydraulic ponding that correspond well to actual observations and measurements.

SEISMIC AND PETROFABRIC STUDIES FROM SOUTH ISLAND RED MOUNTAINS, NEW ZEALAND

V.B.Rajasekhar[1], M. Savage[1], R.Davey[1], I.Das[1,2] T.Little[1] J.Louie[3] & B. Tikoff[4]
[1]Institute of Geophysics, Victoria University of Wellington, NZ
[2]Indian Institute of Technology, Kharagpur, India
[3]University of Nevada, Reno
[4] University of Wisconsin, Madison
Rajasekhar.Vadlamannati@vuw.ac.nz

We study deformation mechanisms within the crust and upper mantle by comparing seismic and structural measurements of peridotite fabric at Red Mountain for different scale domains. We measure fabric from microscopic through km scales by comparing crystallographic preferred orientations (CPO) of peridotites with field measurements of seismic anisotropy along lines of 100-200 m length, and with shear-wave splitting of local and teleseismic earthquakes, which reveal anisotropy from ~1-100 km scale.

Shear wave splitting (SP) on teleseismic SKS phases from stations on and near Red Mountain are similar to previous measurements on South Island. Polarizations of the first-arriving waves (φ) are in the range of 15 to 60 deg with 1.9 – 3.1 s delay times (dt), consistent with previous olivine CPO interpretations due to shearing parallel to the Alpine Fault at mantle depths. Preliminary average SP measurements for local earthquakes with depth >100 km have φ of 55 deg, consistent with the SKS results, but dt is much smaller, at 0.03 ± 0.01 s (1σ). Shallower events yield φ of 145 deg with dt = 0.32 ± 0.003 s.

Similar to shallow S-wave splitting, shallow seismic P-wave speeds for waves traveling in the upper few meters are faster (1.8 ± 0.1 km/s) along a profile oriented at 150 degrees than along the orthogonal profile (1.4 ± 0.15 km/s), yielding anisotropy of 23 ± 9.5 %. The S-wave velocity for the average top 30 m calculated from surface wave analysis on the radial components yielded 14 % anisotropy, with a fast direction of 150 degrees. Shear wave splitting measurements from hammer shots yield delay times of 0.01 ± 0.005 s with the fast orientations in the 120-150 deg range.

Electron Back-Scattered Diffraction studies of crystallographic orientation of olivine were carried out on three peridotite samples, reveals dislocation creep within a high-temperature [100] (010) slip system. Average S wave anisotropy of these samples based on the single-crystal elastic constant tensors is a maximum of 7.3 % for a wave traveling in the foliation plane normal to the flow direction, and φ is sub-parallel to the olivine [100] axes representing the flow direction marked by lineation.

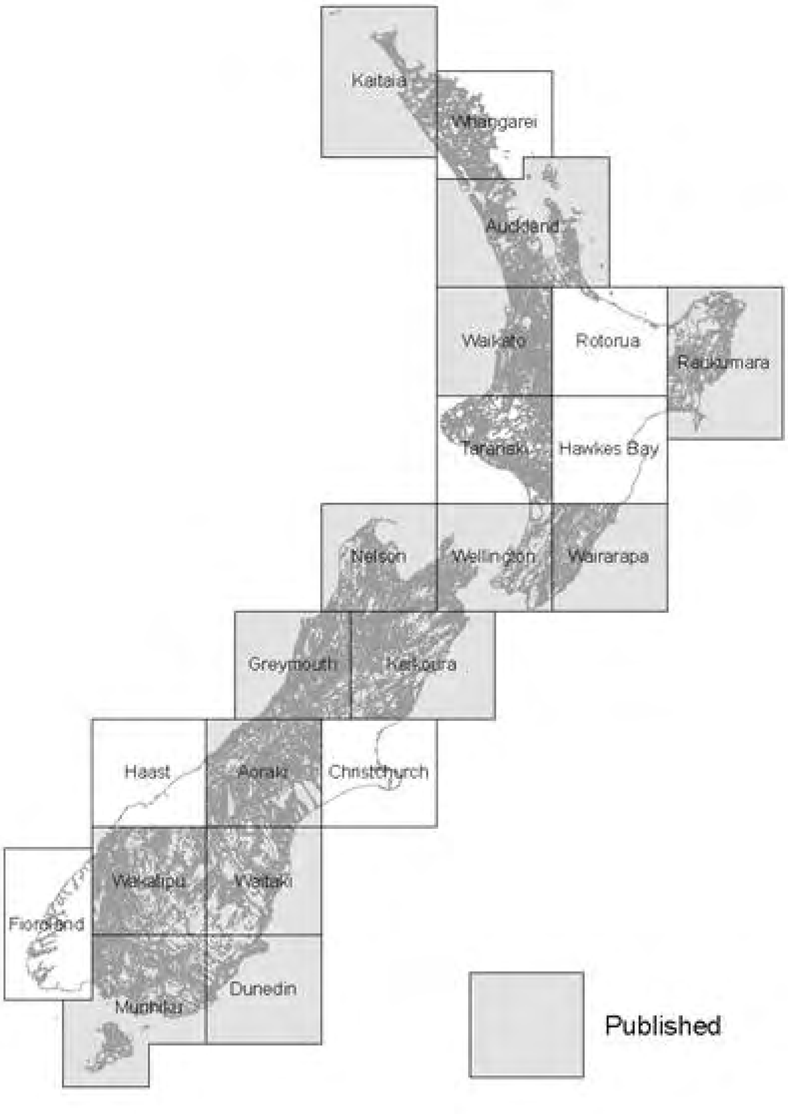
Shallow anisotropy measured from near surface studies and shallow local earthquake SP is parallel to the near-surface cracking (~ 120 deg), consistent with anisotropy caused by cracks rather than by mineral alignment. The depth distribution of the cracks is not well constrained, but must be at least as deep as one km to affect earthquake waves with periods of 0.5 s. This suggests that the NE/SW anisotropy measured from teleseismic phases is not being contaminated by near surface crustal mineral alignment, but instead may be caused by shear-induced olivine alignment at mantle depths.

POSTER 52

THE QMAP 1:250 000 GEOLOGICAL MAP OF NEW ZEALAND: LINKING CAPE REINGA TO STEWART ISLAND.

Mark Rattenbury, John Begg, Steve Edbrooke,
David Heron, Julie Lee and Dougal Townsend
GNS Science, P.O. Box 30-368, Lower Hutt
m.rattenbury@gns.cri.nz

With the publication of the fourteenth QMAP sheet (Aoraki) and the completion of most fieldwork the QMAP 1:250 000 Geological Map of New Zealand programme is increasingly in a map and text production phase. Three of the remaining QMAP sheets (Taranaki, Whangarei and Christchurch) exist in preliminary map form and the remainder (Rotorua, Hawkes Bay, Haast and Fiordland) will be digitised over the next 18 months. The GIS capture of the Whangarei and Taranaki sheets has resulted in continuous digital geological map coverage from Cape Reinga to Stewart Island. Over the next 2½ years the GIS data underpinning QMAP geology will be made "seamless" by linking edge-matched data across sheet boundaries.



POSTER 53-54

WATER-ROCK INTERACTION IN SOUTH ISLAND MINERAL SPRING SYSTEMS, NEW ZEALAND

A. G. Reyes
GNS-Science, 1 Fairway Drive, Avalon, Lower Hutt
a.reyes@gns.cri.nz

Mineral waters discharging from springs or shallow boreholes contain at least 250 mg/kg total dissolved solids and may be thermal or cold. In this study overtly thermal waters have temperatures at least 4^{o}C above the mean annual ambient air temperature which varies from about 10^{o}C in South Island to 16^{o}C in North Island. However similar to thermal springs, cold mineral springs provide insight into processes in the crust and, in some regions of New Zealand, have geothermally-viable temperatures at depth, blurring the difference between geothermally-significant and -insignificant water discharges. In South Island there are at least 60 mineral spring systems and warm waters in wells located in 6 tectono-geographic regions including (1) coastal Canterbury Plains adjacent to Banks Peninsula, (2) northern Taieri near Dunedin, (3) northwestern half of the South Island west of the Alpine fault, (4) Marlborough Fault Zone (MFZ), (5) Alpine Fault Zone (AFZ) and (6) Southland. No samples were taken from Southland where the mineral waters discharge from wells.

In the most recent survey, maximum water discharge temperatures range from 20-30^{o}C in Dunedin and the coastal Canterbury Plains to as high as 66^{o}C in the Alpine and Marlborough Fault Zones. Except for the mineral springs in the northwestern half of the South Island, which sometimes discharge highly saline formation waters, most of the mineral waters in the South Island are meteoric in origin. However gases indicate deep seated mantle sources for a spring in Poison Bay that noisily spurts out H_2-rich gas and from a shallow well near Dunedin.

Shallow subsurface temperatures along the MFZ and AFZ, based on the SiO_2 and K/Mg geothermometers, have a range of 40-160^{o}C. Deeper-sourced waters, based on the Na/K geothermometer, indicate subsurface temperatures of 120-250^{o}C. The highest Na/K temperatures are found in springs discharging along the Alpine Fault where the heat flux and uplift rate are highest, and also in mineral waters discharging from a shallow oil well drilled in the early 1900's in Kotuku, west of the AFZ. In the Canterbury Plains and near Dunedin, subsurface temperatures range from 60-80^{o}C at shallow depths to 180-200^{o}C at deeper regions.

The volume of overtly thermal waters discharged in the MFZ, at about $1x10^9$ l/a, is larger than in the AFZ at 6×10^8 l/a despite the length of the AFZ and the higher number of springs along the AFZ at 24 vs 14 along the MFZ. Among the South Island springs, the highest HCO_3/Cl ratios are confined in springs located along the MFZ, within the Hope Fault and its subsidiaries. Despite the high HCO_3/Cl ratios, the spring waters are in near equilibrium with the rock. In contrast spring waters along the AFZ with lower HCO_3/Cl are farther away from the equilibrium with the rock suggesting differences in the permeability, meteoric water throughput, storage and circulation and degree of water-rock interaction between the AFZ and MFZ.

TALK – Thu am

WHAT DO SMALL EARTHQUAKES TELL US ABOUT PLATE COUPLING IN THE SOUTHERN NORTH ISLAND?

Martin Reyners
GNS Science, PO Box 30 368, Lower Hutt
m.reyners@gns.cri.nz

Recently GPS instruments have provided estimates of the spatial distribution of coupling at the Hikurangi subduction thrust, as well as areas of slow slip on the thrust. At the same time, tomographic inversions for the seismic velocities (Vp and Vp/Vs) and attenuation (Qp^{-1}) have provided images of the three-dimensional structure of the plates surrounding the thrust. One suggestion coming out of this work is that competent terranes in the overlying plate may act as aquicludes, increasing pore pressures in the rocks below. This begs the question of whether such terranes might control the distribution of coupling at the subduction thrust. This seems to be the case in the southern North Island, where the Rakaia/Haast schist terrane impacts the shallow part of the subduction thrust. GPS measurements indicate that this region is currently strongly coupled.

If the overlying plate does in fact modulate fluid conditions at the plate interface and within the subducted plate, we should see this reflected in the distribution of small earthquakes. After all, nearly all earthquakes will involve fluids, even those within the mantle of the subducted plate, where dehydration embrittlement provides a ready fluid source. To this end, we have relocated all earthquakes in the southern North Island shallower than 100 km that occurred between 1990 and 2005 inclusive (over 66,000 events in total), using our new three-dimensional seismic velocity model. We have then partitioned these events into those in the overlying plate and those in the subducted plate, using both the distribution of seismicity in the dipping seismic zone and constraints from active source experiments. We have further subdivided events in the subducted plate into those within the upper plane of the dipping seismic zone (i.e. within 15 km of the plate interface and thus in the subducted crust) and those in the lower plane in the uppermost mantle.

The relocated seismicity shows a correlation with the distribution of coupling at the plate interface deduced from GPS. In particular, activity in the lower plane of the dipping seismic zone shows a very good correlation with the 20 mm/yr slip rate deficit contour, with seismicity concentrating on the edges of the strongly coupled region. In the upper plane of the dipping seismic zone, seismicity is more clustered within the strongly coupled region, with earthquakes defining sub-vertical faults, oriented along the strike of the subduction zone. Incremental slip on these faults suggests a fluid-rich subducted crust beneath the strongly coupled region. In the overlying plate, seismicity concentrates downdip of the strongly coupled region, and is distributed throughout the crust and uppermost mantle. This suggests efficient transport of fluid across the plate interface in this region. Overall, the seismicity distribution is consistent with the suggestion that structure in the overlying plate modulates fluid conditions at the plate interface, and hence controls the distribution of plate coupling.

TALK – Wed pm

IMPLEMENTATION OF ROUTINE REGIONAL MOMENT TENSOR ANALYSIS IN NEW ZEALAND

John Ristau[1]
[1]GNS Science, Lower Hutt, New Zealand
j.ristau@gns.cri.nz

New Zealand and the surrounding offshore region is one of the most seismically active areas in the world with approximately 350 earthquakes of local magnitude (ML) >= 4 each year, with around 100 of those being ML >= 4.5. On average the Global Centroid Moment Tensor (CMT) project calculates 6-7 CMT's for the New Zealand region every year for earthquakes M >~ 5. Earthquakes with M < 5 do not generate energy at low enough frequencies to allow moment tensor solutions to be calculated using teleseismic methods. Higher frequencies must be used and velocity models specific to the source region are required to accurately model the observed waveforms and calculate reliable moment tensor solutions. Over the past five years a network of more than 40 three-component broadband seismometers has been installed across New Zealand. As a result moment tensor analysis of regional seismic data (source-receiver distances < 1000 km) for earthquakes with moment magnitude (Mw) >~ 3.5 – 4.5 is now possible in New Zealand and the immediate offshore region. It has been found that using one 1-D velocity model for the North Island and one for the South Island is sufficient for calculating the moment tensor. To date more than 190 moment tensor solutions have been calculated for New Zealand dating back to October 2003 with Mw 3.6 – 5.6 and depths 2 – 230 km which complements the Global CMT database of more than 190 solutions, of which around 170 are for events prior to October 2003. A reasonable estimate for the number of regional moment tensor solutions that will be able to be calculated per year is around 50 – 60 which will give about a factor of 10 increase in the number of moment tensor solutions available for New Zealand and provide valuable data for tectonic studies and seismic hazard analysis. The focus in this paper will be on some of the important issues encountered while implementing the moment tensor technique in New Zealand and some general observations. Preliminary results suggest that ML is often significantly larger than Mw with the discrepancy depending on the location and source depth. Preliminary results also show a lack of energy at frequencies as low as 0.02 Hz for events with Mw > 4 which is typically present in other regions in the world. As a result higher frequency bands often need to be used to calculate moment tensor solutions in New Zealand.

INTEGRATING SCIENCE INTO LAND USE PLANNING FOR VOLCANIC HAZARDS

C. Robertson [1], **B. Glavovic** [2]
[1] School of People, Environment and Planning, Massey University, Palmerston North
with funding from Institute of Natural Resources, Massey University, Palmerston North
[2] School of People, Environment and Planning, Massey University, Palmerston North
C.R.Robertson@massey.ac.nz

Natural hazards are frequent phenomena worldwide and present a major challenge for sustainability. Natural hazards only escalate into disasters when people are unable to cope with the impacts. In order to reduce societal vulnerability and increase resiliency, hazard avoidance and mitigation should be integrated into land use planning and public decision-making. These planning and decision-making processes need to be informed by credible scientific information about the magnitude, frequency and likelihood of future events, as well as understanding about vulnerability and coping capacity.

There is a paucity of literature relating to the incorporation of scientific information on natural hazards into land use planning. The majority of literature focuses on the risk, probability and magnitude of hazards and recovery planning. While these elements are important, there is little attempt to discuss the use of scientific information in land use planning for the purpose of reducing community vulnerability.

In order to determine the major barriers to and opportunities for integrating scientific information into land use planning documents a case study on Egmont volcano and South Taranaki District Council was undertaken. The study concluded that there are five primary barriers for integrating scientific information into land use planning documents. These barriers were (i) the current focus on mitigation and recovery planning results in little attention being focused on reduction planning; (ii) local government is unable to interpret and utilise scientific information when it is presented in a technical format; (iii) the true risks associated with volcanic activity in Taranaki are not realised due to the flawed transfer of information from the scientist to the planner; (iv) uncertainty exists regarding the roles and responsibilities of different groups for hazard reduction; and (v) scientific information is primarily focused on the risk, probability and magnitude of hazards with inadequate attention focused on understanding the vulnerability of communities to hazard risks.

A number of opportunities exist for integrating scientific information into land use planning for volcanic hazards. These include (i) refining the communication techniques utilised to transfer information between scientists and planners; (ii) increasing local government awareness of the risks posed by volcanic activity and the vulnerability of local communities to volcanic events; and (iii) clarifying who is responsible for reduction planning. A fundamental opportunity also lies in developing a civic science approach to natural hazards. Science needs to broaden the scope of traditional research to include socio-political and economic dimensions of hazards. This holistic approach would seek to mainstream natural hazards into planning and decision-making processes by developing a more integrated, inclusive and reflective approach to understanding and address hazard risks.

CENTROID MOMENT TENSOR INVERSIONS FROM GEONET DATA TO PROVIDE A LOCAL MOMENT MAGNITUDE SCALE FOR NEW ZEALAND

E. de J. Robertson[1,2], E. G. C. Smith[1] & R. Robinson[2]
[1] Institute of Geophysics, Victoria University of Wellington
[2] GNS Science, Lower Hutt
e.robertson@gns.cri.nz

The aim of this project is to enable accurate earthquake magnitudes (moment magnitude, M_W) to be calculated routinely and in near real-time for New Zealand earthquakes. This is done by inversion of waveform data to obtain Centroid Moment Tensors (CMTs). CMTs also provide information on fault-type and potentially better depth information.

Currently only local magnitude (M_L) is routinely calculated for New Zealand earthquakes, and M_L is known to significantly underestimate the size of earthquakes above M_W ~6.5, and may also overestimate the size of some earthquakes. Accurate values of M_W will help scientists and emergency managers by providing accurate estimates of an earthquake's size, which, combined with accurate estimates of fault-type and depth, can lead to better estimation of its shaking potential, likely damage and the likelihood of tsunami generation.

We use a well-established CMT inversion method, the Time-Domain [seismic] Moment Tensor Inversion algorithm (TDMT_INVC, Dreger, 2003) and apply it to GeoNet broad-band waveform data to generate moment tensor solutions for New Zealand earthquakes. Some modifications to this software were made.

CMTs were calculated for twenty-four New Zealand earthquakes from 2000-2005. The Global CMT project has calculated CMT solutions for twenty-two of these, and the Global CMT project solutions are compared to the solutions obtained in this project to test the accuracy of the solutions obtained using the TDMT_INVC code.

The moment magnitude values are close to the Global CMT values for all earthquakes. The CMTs could only be determined for a few of the earthquakes studied. The value of the moment magnitude appears to be less sensitive to errors in the velocity model and earthquake location (epicentre and depth) than the CMT solution.

Distinguishing legitimate seismic signal from background seismic noise is likely to be the biggest problem in routine inversions.

POSTER 37

SHEAR ZONES AND BOUNDARY LAYERS: MODELLING OF ALPINE FAULT MYLONITES

Jesse C. Robertson[1], Richard J. Norris[1], Alan F. Cooper[1], Ross Vennell[2]
Dept. of Geology, Univ. of Otago, PO Box 56, Dunedin
Dept. of Marine Science, Univ. of Otago, PO Box 56, Dunedin
robje658@student.otago.ac.nz

The Alpine Fault Zone (AFZ) is the primary structure controlling the geological, geomorphologic and tectonic characteristics of the South Island. Significant Cenozoic displacements have occurred across the AFZ, both horizontally and vertically, due to the oblique motion of the Pacific Plate with respect to the Australian Plate. Uplift of the hanging wall of the AFZ has exposed sections of mylonite at the western range front of the Southern Alps.

Field examination of exposed sections through the Alpine Fault Zone show that the mylonite belt exhumed in the hanging wall of the AFZ cannot be considered a constant-time or constant-space section. Deformation may be active in different parts of the mylonite belts at different times, and hence determining the uplift path for a section of mylonite is not a trivial problem and is one which must be solved by a combination of intensive field observations and physical modelling.

Boundary layers occur in a flow when the conditions of flow (e.g. temperature, velocity fields) change rapidly over a small layer. These flows are characterised by their high length to width ratios ($L/W \gg 1$), and this flow geometry permits a simplification of the governing fluid equations. Flow in a shear zone occurs as a very thin layer and it is suggested that the flow may be governed by boundary layer flow characteristics.

A fluid dynamic model for strain and temperature profiles within the mylonite belt has been developed based on boundary layer theory under Newtonian flow conditions with a temperature-dependent rheology determined from thermally activated crystal plastic deformation. It is shown that the boundary layer behaviour of large displacement structures such as the AFZ may be in part driven by the thermal profile across the shear zone, and hence that the shear zone will continue to grow at a rate determined by thermal diffusion from the hanging wall into the foot wall.

SEISMICALLY DRIVEN FACIES CHARACTERIZATION USING AN INNOVATIVE INTEGRATED APPROACH: KUPE FIELD, TARANAKI BASIN, NEW ZEALAND

Roncaglia, L., Baur J., Bushe, H., Ilg, B., Jones, C., Leitner, B., King, P., Milner, M., Morgans, H.E., Zhu, H.

We present an innovative integrated workflow for the characterization of siliciclastic systems in the Kupe Field, Taranaki Basin. The methodology uses integration of geophysical, geological and biostratigraphic interpretation to produce an improved facies characterisation. A suite of single- and multitrace seismic attributes is analysed to visualize seismic facies within the main seismostratigraphic sequences. Integrating attribute analysis data with the geologic information in 3D, facies properties – such as depositional settings and paleo-water depth – are reconstructed. The strength of this technique lies in the fact that facies modelling is not constrained to match upscaled well data and consequently these data serve to validate the outcome. Seismic attribute maps are compared to existing paleogeography reconstructions to support attribute interpretation and improve previous constraints on the paleo-depositional environments.

This workflow builds upon a methodology that has been used successfully for the characterization of siliciclastic sequences. The objective of the approach is to improve the ability to capture the heterogeneity in facies distribution, and thus use the resulting facies model to both provide improved predictive ability and identify previously undiscovered development opportunities. The application and outcome of this integrated workflow to the Kupe field is presented in this talk.

INSIGHTS INTO THE 2006 RAOUL ISLAND ERUPTION FROM DEPOSIT CHARACTERISTICS AND ERUPTION EFFECTS

M.D. Rosenberg[1], **C.J.N. Wilson**[2], **D.M. Gravley**[2], **M. Rotella**[2, 3], **M.W. Borella**[2]
[1]GNS Science, Private Bag 2000, Taupo.
[2]Department of Geology, SGGES, University of Auckland
[3]Department of Geology & Geophysics, SOEST, University of Hawaii
m.rosenberg@gns.cri.nz

A small-volume, short duration magmatic-hydrothermal eruption of Raoul Volcano in the Kermadec Islands 1000 km northeast of New Zealand occurred on March 17th 2006. Our recent field work examined the deposits and effects of numerous contemporaneous and successive explosions during this eruption within Raoul Caldera, from at least 35 sub-craters focussed around Green Lake. Tephra fall from a low plume covered ~9 km^2 of the island west of Green Lake. A ~0.5 km^2 area surrounding Green Lake was devastated by lateral blasts, dm- to m-thick tephra fall, and ballistic block emplacement. The eruption ejected ~0.2 x 10^6 m^3 of lithic and pumice debris, lake sediment and water. Although the eruption was probably indirectly triggered by magma (Christenson et al. *Eos* 88(5) 30 January 2007), we found no evidence in our fieldwork for the presence of juvenile magmatic clasts in the ejecta.

Complex patterns of ejecta dispersal and the relative timing of surge- and fall- deposited tephra is suggested by thickness distributions, tree-fall and ballistic block impact directions, surface lithologies, and stratigraphy of the ejecta. Some vents or vent zones were highly energetic, producing high-velocity low-angle blasts, sending 50-80 cm blocks >0.5 km from vent, destroying post-1964 pohutukawa forest and probably contributing most of the ash, steam and water to the ~700 m high plume. In contrast, explosions at close-nearby vents were relatively very weakly energetic despite their large crater diameters and ejecta from them may have spread radially only 100-200 m.

At different locations, up to five crudely planar bedded subunits were distinguished by their grainsize, components and colour. A clay-rich and vesicular matrix is evidence that the tephra was damp and cohesive when emplaced. In typical order of abundance, lithic clasts are: finely vesicular pale to dark brown dacitic pumice (from Rangitahua cone), indurated mudstone and sandstone (Green Lake sediment), tuff breccia and constituent clasts (various but mostly unknown sources), plagioclase-rich mafic lava (Moumoukai Formation), hydrothermally altered (epidote-chlorite) lava and tuff, and hydrothermal vein material. Fragments of hydrothermal carbonate-sulphate vein fill and cavity lining material were most commonly found within 200 m of the “Marker Bay” crater and were rare in the E and NE sectors of the ejecta blanket. The distribution of this material and its absence from ejecta from new deep craters on the E side of Green Lake suggests that mineral sealing was not uniform or pervasive beneath Green Lake.

Rangitahua pumice is the most abundant lapilli sized component in all but one area of the deposit. This signifies that most ejecta was from vents cutting the Rangitahua cone, NW of Green Lake and attests to a shallow source depth for most of the ejecta. Three of the vents in this area were dominant during the eruption, as shown by tree fall directions and ballistic block azimuths that commonly point directly towards this area.

ALONG-AXIS VARIATIONS IN THE RIFTING PROCESS, TAUPO VOLCANIC ZONE.

Julie Rowland, Colin Wilson & Darren Gravley.
Geology Programme, SGGES, University of Auckland.

The young TVZ (< 2 My) is a rifting andesitic arc over most of its along-strike extent. However, the central region is characterised by exceptional rhyolite productivity. This volcanic segmentation reflects along-axis variations in the magmatic plumbing system and presumably the thermal state of the crust, with implications for the mechanics of rifting. Over the last few years geophysical investigations have improved our understanding of the rheological structure of the central TVZ. Seismicity defines a brittle layer less than 8km thick, increasing to the south to >20km in the vicinity of Mt. Ruapehu. Along the eastern margin of the central TVZ, estimates of conductivity together with receiver function inversions indicate the presence of partial melt within a few kilometres of the base of the seismogenic zone, as may be expected given the tremendous heat flow manifest in the high-temperature geothermal systems (> $4000MW_{th}$). Active source seismic studies indicate *P*-wave velocities of 6.9 – $7.3kms^{-1}$ from 16-30km depth, consistent with a heavily intruded or underplated lower crust. Together with rheological arguments based on the transition from convection to conduction with increasing depth, these studies support the notion that much, if not all, of the mid-crust (10-15km depth) beneath the Taupo-Reporoa Basin is near the critical temperature for partial melt and extremely weak. There are few studies to inform our understanding of crustal rheology northeast of Okataina. However, seismicity extends to somewhat greater depths (e.g. 1987 Edgecumbe earthquake), heat flow appears to be much lower (10% of central TVZ values) and rhyolite volcanism, though present offshore, appears to be less productive.

Observations from narrow continental rifts elsewhere (e.g. East Africa, Iceland) demonstrate that the rifting process is influenced by interactions amongst tectonic, volcanic and magmatic cycles. Along-axis variations in magmatism may therefore be expected to exert a significant control on the manner in which extensional strain is accommodated in the TVZ. To the north and south of the central TVZ, broad monoclines, disrupted to various degrees by normal faults, dip to the SE against major NW-facing fault zones. In contrast, rift axes defined by fault facing directions divide the central TVZ into a series of symmetrical rift segments with a length scale of ~ 20 km. A regional-scale monocline is not apparent from surface geology or subsurface geophysical data though a major (> 2km vertical offset, L ~ 65 km), currently inactive fault zone forms the SE boundary to the central TVZ. Within the central TVZ, the enormous natural heat output and elevation above sea-level reflects the intrusion into the lower-crust of vast amounts of magma. Recent field investigations demonstrate the occurrence of coupling between fault growth and volcanic / magmatic processes in this region. These observations suggest that rifting in the central TVZ is strongly influenced by the behaviour of the magmatic plumbing system, with rifting localised above zones of thermally weakened crust and activated at times by magma migration.

FOSSIL BRYOZOANS FROM THE WANGANUI BASIN: A SURVEY OF COLONY GROWTH FORMS.

Seabourne Rust
Department of Geology, SGGES, University of Auckland. s.rust@auckland.ac.nz

Phylum Bryozoa consists of colonial, sessile, filter-feeding animals, most of which are microscopic (individuals called zooids are between 0.3-1.5mm in length). Numbers of bryozoan zooids make up colonies in a variety of forms, commonly found encrusting hard substrates in nearshore and shelf seas. Marine bryozoans may form flat sheets, regular lacy networks or coral-like branched growths.

New Zealand's temperate seas are especially rich in bryozoans, with >955 living species recorded and a high degree of endemism. Bryozoans are also relatively common as fossils in our Cenozoic marine sedimentary rocks, especially carbonates where they are often the dominant sediment contributors. Key groups represented are the Orders CYCLOSTOMATA and CHEILOSTOMATA.

Bryozoan colonies can be classified simply according to their morphology, that is, the colony growth form. Colony form has been used as a tool in environmental interpretation of both modern and fossil faunas. A useful advantage of this approach is that detailed taxonomy of the diverse number of bryozoan species is not necessarily needed. Studies suggest that correlations exist between the bryozoan growth form association in a unit, and the original habitat and depositional environment.

Numerous fossilised remains of bryozoan colonies have been collected from Pliocene and Pleistocene age marine-deposited strata of the Wanganui Basin, North Island. These have been classified into categories based on colony construction, including 2-dimensional encrusting, erect branching and free-living forms. Key groups are then subdivided further, depending on the classification scheme used. Generally samples from Wanganui sediments show variation in the proportional abundance and diversity of bryozoan growth forms present. One must use caution when using bryozoan growth form abundances as depth indicators, as most common taxa have wide bathymetric ranges. Typically many different growth forms occurred together in the more bryozoan-rich samples. Some bryozoan growth forms characterised certain environments (e. g. free-living forms in shallow shelf sandy settings), but most were not exclusive in their distribution. Erect bryozoans were an important component in a number of horizons at Wanganui, as they are today on the New Zealand shelf, including branching cyclostomes of the Cinctiporidae and Horneridae. In the sequence overall however, encrusting species dominate the assemblages.

Changes in growth form dominance and relative abundance, through the sequences at Wanganui, imply changing environmental conditions or ecological factors affecting bryozoan growth. Local sedimentation rates and water currents are likely to have influenced colony growth and form. The fluctuating nature of these associations through time suggests a response to alternating, repetitive processes (such as cyclic sea-level change). Also, taphonomic influences on the preservation and distribution of each bryozoan colony form are significant and must be considered in each sample.

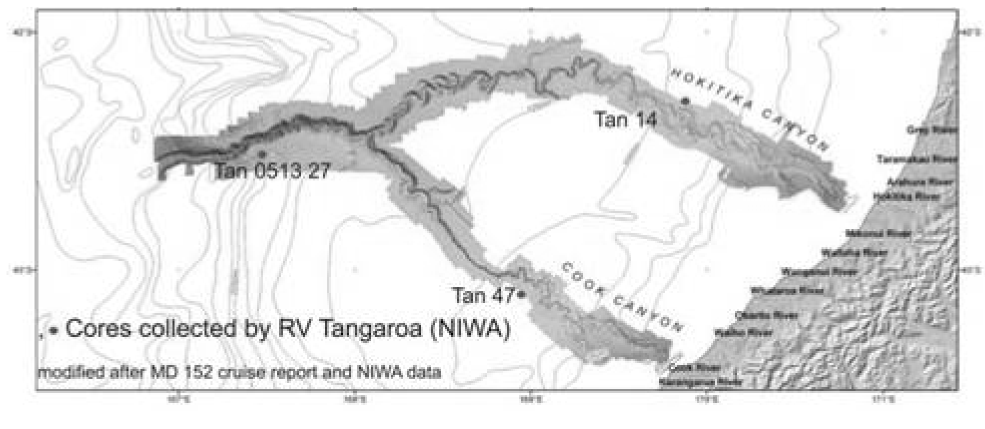
AN OXYGEN ISOTOPE STRATIGRAPHY OF THE HOKITIKA AND COOK SUBMARINE CANYONS, WEST COAST, SOUTH ISLAND, NEW ZEALAND

M.T. Ryan [1], **G. B. Dunbar** [2], **H. Bostock**[3] **and H. L. Neil** [3]
[1] School of Geography, Environment and Earth Sciences, VUW, N. Z, PO Box 600, Wellington, [2] Antarctic Research Centre, VUW, N. Z, PO Box 600, Wellington
[3] National Institute of Water and Atmospheric Research, Private Bag 14-901, Wellington; (ryanmath@student.vuw.ac.nz)

An oxygen isotope stratigraphy has been developed for the little studied continental slope that lies immediately seaward of the Hokitika and Cook river catchments draining Westland National Park. This region includes the Hokitika and Cook submarine canyon system, which extends at least 650 km westward from the continental shelf to the abyssal plain. The canyons are up to 20 km wide and 1 km below the surrounding seafloor in places (see figure) and are major conduits for the substantial (62Mt/yr) amounts of suspended sediment eroded from the Southern Alps and deposited in the Tasman Sea.

A series of piston, gravity and kasten cores were collected from overbank deposits of the Hokitika-Cook canyon system during cruise 0513 of the *RV Tangaroa*. Subsequently three cores (Tan 47, 190 cm long; Tan 14, 325cm long; Tan 27, 336 cm long) were selected for oxygen isotope analysis on the basis of their geographic location (Fig. 1). The oxygen isotope ratio of 3-4 specimens of *Globigerina bulloides* from the 300-355 µm size fraction was determined at 10 cm intervals in each core. Comparison with the standard SPECMAP oxygen isotope curve of Martinson et al. (1987) suggests a basal age of 70 Ka for TAN 47 and an average sedimentation rate of 2.71 cm/ky, 220 Ka for TAN 14 (1.47cm/ky) and 130 Ka (2.58cm/ky) for TAN 27. Furthermore, we have used cm-spaced magnetic susceptibility and colour spectrum data from a number of other cores to correlate time-depth horizons across the study area. These results suggest sediment accumulation can be up to twice as rapid on the southern sides of the levees during the Late Quaternary.

Fig.1. High resolution bathymetric map of the Hokitika-Cook canyon system off the West Coast of the South Island, New Zealand showing the location of cores used in this study.



This detailed chronology will provide the basis for a comparison of marine (plankton geochemistry) and terrestrial (pollen and spores) paleoclimate records of the NZ environment to past climate change, including periods when global temperatures were warmer than today. Acknowledgements: NIWA, GNS Science.

POSTER 26

THE TECTONIC-SIGNIFICANCE OF THE TARANAKI-RUAPEHU LINE

Michelle Salmon, Tim Stern, Martha Savage
Institute of Geophysics
Victoria University of Wellington
Corresponding email address: tim.stern@vuw.ac.nz

A combination of gravity, seismic crustal structure, magnetotelluric, seismic attenuation, seismic anisotropy, and crustal seismicity show evidence of a remarkable discontinuity in both the crust (i.e the Moho) and upper mantle beneath a line between the active volcanoes of Mt Taranaki and Ruapehu. What makes this discontinuity particularly curious is that it is orientated east-west, almost at right-angles to the present plate boundary.

As far back as 1970 the line joining the active volcanoes of Mts. Taranaki and Ruapehu (the T-R line) was recognised as defining a fundamental boundary in the subjacent mantle. To the north of the line both attenuation (Q^{-1}) and mantle electrical conductivity is high whereas to the south of the line they are low. Also associated with the line is a strong north-south gravity gradient. A 1987 gravity interpretation featured a 10 km step in the Moho directly beneath the T-R line, which is isostatically balanced by hot, low-density mantle. The assumption here is one of local isostatic compensation. More recent seismological research provides direct evidence (from Receiver Functions) for a Moho step of ~ 7 km directly beneath the T-R line with a further more gradual thickening of the crust to the south. The step is from 26 km-thick crust to the north, to 33 km south of the line with uncertainties of ± 1 km. Intense seismicity is closely linked to the TR-line and closely clusters around the seismologically determined step in the Moho .

We argue that although fluids may be part of the explanation for the T-R line they can't be the ultimate cause. A mechanical explanation is required to explain both the seismicity and the Moho step. Our favoured hypothesis is that the seismicity is due to the step being a recent feature created by the detachment of thickened mantle lithosphere and lower crust that accumulated north of the T-R line during the Miocene. This explanation would also account for the presence of hi-K volcanism of the Waikato-Taranaki region, including Mt Taranaki, and the Pliocene uplift of this area. In the western USA, for example, there is a strong correlation of hi-K volcanism with regions of detached mantle lithosphere and regional uplift.

An explanation for the T-R line is central to not only explaining aspects of North Island tectonics, but also has broader implications for the development of active continental margins in general.

INTEGRATION OF GPS AND DIFFERENTIAL INSAR DATA FOR DERIVATION OF HIGH-RESOLUTION THREE-DIMENSIONAL VELOCITY MAPS

S. Samsonov[1,2,] K. Tiampo[2], J. Rundle[3], J. Fernandez[4] & Z. Li[5]

[1]GNS Science, Lower Hutt, New Zealand (s.samsonov@gns.cri.nz)
[2]Department of Earth Sciences, University of Western Ontario, Canada
[3]W.M. Keck Center for Active Visualization in the Earth Sciences, UC Davis, USA
[4]Instituto de Astronomía y Geodesia (CSIC-UCM), Ciudad Universitaria, Spain
[5]Department of Geomatic Engineering, University College London, UK

A spatio-temporal Bayesian modelling technique based on optimization of Gibbs energy function within MRF framework is used to derive three-dimensional high-resolution surface motion maps over a given time period (complete with error estimates) from spatially sparse GPS and temporarily sparse DInSAR data. The velocity field was calculated for three independent regions. In the first part the DInSAR-GPS optimization technique was used to investigate the velocity field of the southern California region near Los Angeles. The GPS data from SCIGN and one ERS-2 MODIS corrected DInSAR interferogram were used to perform the optimization. The results of the optimization revealed a strong shortening effect across the region with the high degree of accuracy. A few areas of subsidence due to groundwater and oil extractions were identified. In the second part, the technique was applied to investigate the creep motion of the southern San Andreas Fault around the Salton Sea. Previous works suggest that the fault in that region creeps with constant velocity in a horizontal strike-slip direction. This work, however, suggests that either the creep velocity is not constant over time or the motion is not completely horizontal. These conclusions are derived from the analysis of two velocity fields for 1992-1998 and 1997-2001 which show different signals. In the final part, preliminary results are presented for the modification of the GPS-DInSAR optimization technique for campaign GPS and ENVISAT DInSAR data of Tenerife Island. The goal of this work is to fuse both geodetic data sets, observe surface deformations and better characterize potential precursors of volcanic activity. Currently some source inversion studies are performed in order to identify potentially hazardous areas.

PETROGENESIS OF LARGE-VOLUME SILICIC MAGMATISM IN TAUPO VOLCANIC ZONE AND SOUTHERN KERMADEC ARC: EVIDENCE FROM MELT INCLUSIONS

Kate Saunders, Joel Baker & Richard Wysoczanski
School of Geography, Environment and Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington
kate.saunders@vuw.ac.nz

The mechanisms for generating large-volume silicic magmas in arcs range from end-member models of fractional crystallisation of parental mafic magmas to partial melting of lower crust. Distinguishing between these models is particularly difficult as rocks of similar composition can potentially be generated by either mechanism. A solution to this paradox may lie in the analysis of melt inclusions - small pockets of melt trapped in crystals as they grow from the evolving magma. By documenting the evolution of silicic magmas using melt inclusions trapped at different stages of magma genesis, the different mechanism(s) for silicic magma generation might be distinguished.

The Taupo Volcanic Zone (TVZ) and Kermadec Arc have produced voluminous amounts of silicic magmas, and provide an ideal setting to investigate the comparative petrogenesis of silicic magmas in a continental and oceanic arc setting, respectively. Microanalysis of melt inclusions were conducted on four TVZ (Whakamaru, Oruanui, Taupo and Rotorua Ash) and one Kermadec Arc (Healy) rhyolite–rhyodacites. Orthopyroxene-, plagioclase- and quartz-hosted melt inclusions and groundmass glass display diverse major element (e.g. SiO_2 74-79 wt %; CaO 0.2-2.5 wt %; FeO 0-3 wt %) and trace element (e.g. Sr 17-180 ppm; Ba 140-1500 ppm) compositions. Geochemical trends are observed within ignimbrites from individual eruptions however, compositional differences between eruptions are limited. Quantitative modelling of rare earth element concentrations of Healy melt inclusions demonstrate that 70-80% fractional crystallisation from basaltic parental melts can account for the generation of silicic magmas in the oceanic environment, consistent with isotopic data of the host lavas. K_2O (2.1-5.4 wt % TVZ; 1.1-1.8 wt % Healy) concentrations and Ce/Yb (7.9- 42 TVZ; 4.1-9.2 Healy) ratios of melt inclusions indicate that assimilation of greywacke accompanied fractional crystallisation in the TVZ. These processes cannot, however, account for the range in melt inclusion compositions observed within individual eruptive products of the TVZ. Whakamaru and Oruanui melt inclusion compositions delineate a mixing line between the most fractionated melt inclusion composition and a composition consistent with a partial melt of greywacke.

A model for the generation of silicic magmas in the continental TVZ is proposed through the combined fractionation of parental basaltic melts and assimilation of greywacke country rock. These magmas accumulate in a crystal mush zone whereby evolved interstitial rhyolitic melts are generated. These melts subsequently migrate into upper crustal magma chambers at 2-6 km depth (determined from water saturation pressures of melt inclusions) and mix with greywacke partial melts prior to eruption.

TALK – Tue pm

SEISMIC ANISOTROPY ACROSS THE TARANAKI-RUAPEHU LINE.

M. K. Savage, M. Bardout, M. Salmon, S. Greve and A. Wessel
Institute of Geophysics, Victoria University of Wellington, Box 600, Wellington
Martha.Savage@vuw.ac.nz

The highest point on the North Island of New Zealand is near its centre on Mt. Ruapehu Volcano, which is the southernmost in a line of active volcanoes associated with extension in the Taupo Volcanic Zone, the southern limit of the Lau-Havre Trough. South of Mt. Ruapehu, compression occurs and volcanism stops, but subduction continues. An east-west trending boundary between Mt. Ruapehu and Mt. Taranaki volcanoes is delineated by a strong gravity gradient, change in crustal thickness, and abrupt changes in seismic attenuation, and has been termed the "Taranaki-Ruapehu Line" (Salmon, 2007). Shear wave splitting determined from SKS phases on broadband stations exhibit strong, trench-parallel (extension-perpendicular) anisotropy both south of the line and north east of the line near the centre of the extending region. However, SKS waves recorded north of the line and west of the extending region do not split, suggesting isotropy. (Greve and Savage, 2007). Anisotropy measurements from local S phases recorded on sparsely-spaced stations also suggest changes from well-aligned shear wave polarisations south of the line to more scattered measurements north of the line (Audoine et al., 2004). Several models have been proposed to explain the north-south changes. These include: 1) in the north, extension carries fluids away from the plate, allowing the fluids to spread westward while to the south, compression and plate-boundary parallel flow confine the fluids to the slab itself. (Audoine et al. 2004) 2) Thickened crust to the south shut off the vertical flow of fluids, driving northeastward flow of the mantle, increasing the fluids available in the north (Reyners et al. 2006). 3) In the west and central North Island Miocene shortening of ~ 100 km led to a series of a Rayleigh-Taylor instabilities that have since detached to be replaced by an asthenospheric upwelling (Stern et al. 2006).

We use seismic data gathered by seven temporary three-component stations set up across the Taranaki-Ruapehu line (TRL) to determine anisotropy in local S phases in an attempt to delineate more accurately the location of the change in anisotropy, and to explain the mechanism for the change. Preliminary results of shear-wave splitting delay times (dt) and fast polarisations are made from 409 phases. No overall correlation between dt and depth is found, which is attributed to a complex and rapidly changing anisotropic structure. Yet the anisotropy is consistent for phases arriving within close incidence angles and back azimuths; we attribute this to lateral variations in anisotropy. North of the line, within the extending region, extension-perpendicular fast orientations dominate with delay times from 0.5 to 0.8s, consistent with large splitting observed on SKS phases. Closer to the TRL, E-W trending fast orientations are more frequent and small delay times (0.1 to 0.3s) are common. We propose that the smaller delay times are caused by re-splitting in the crust due to anisotropic crustal structures parallel to the TRL. We plan to incorporate more measurements by using a newly developed automatic technique to test if the preliminary results hold.

ALUMINIUM-26 TO MAGNESIUM-26 ISOTOPE DATING PLANETARY DIFFERENTIATION IN THE YOUNG SOLAR SYSTEM

Martin Schiller and Joel A. Baker
School of Geography, Environment and Earth Sciences, Victoria University of Wellington, P.O. Box 600,Wellington, New Zealand (martin.schiller@vuw.ac.nz)

Magnesium has three isotopes (24, 25 & 26) of which one can be produced by the short-lived decay of ^{26}Al (^{26}Al $\rightarrow$ ^{26}Mg; $t_{1/2}$ = 0.73 Myr), which was injected into the proto-Solar System by a stellar source shortly before its formation. Since the demonstration of the former presence of ^{26}Al in calcium-aluminium-rich inclusions (CAIs; the Solar System's oldest solids)) [1], the ^{26}Al-to-^{26}Mg chronometer has been used to date the relative timing of solids in undifferentiated meteorites (chondrites) as well as the formation of some basaltic meteorites [e.g., 2,3]. Recent application of multiple-collector inductively coupled plasma mass spectrometry (MC-ICPMS) to Mg isotope analysis has opened up a new range of dating opportunities. In particular, small ^{26}Mg excesses or deficits in meteorites and their constituents should now be resolvable that will allow dating of material that was previously impossible to date. For example, small ^{26}Mg excesses in bulk basaltic meteorites might be used to date the increase in Al/Mg ratio associated with the formation of basaltic magmas. Conversely, Al/Mg = 0 in some types of differentiated meteorites and their minerals should allow ^{26}Mg deficits to date their formation if this took place within 2 Myr of CAI formation.

The ^{26}Mg excesses and deficits expected from such processes will be ca. < ±0.050‰ and require both the precision and accuracy of Mg isotope measurements to be ca. ±0.005‰ if the full potential of the ^{26}Al-to-^{26}Mg dating system is to be utilised. We have developed ion exchange procedures designed to separate Mg from samples with yields of > 99.5% and with > 99.5% purity. Mg isotope ratios are measured on a Nu Plasma MC-ICPMS at Victoria University of Wellington. Multiple analyses of samples results in weighted means with uncertainties that are ≤ ±0.005‰. A number of tests were conducted to examine the veracity of Mg isotope data obtainable by MC-ICPMS and indicate that it is possible to resolve ^{26}Mg anomalies to high precision and accuracy (≤ ±0.005‰) in meteorites, which should allow extension of ^{26}Al-to-^{26}Mg dating to meteorite materials with small anomalies. We have measured Mg isotope ratios to high precision for meteorites where small ^{26}Mg excesses (angrites, eucrites) and deficits (pallasite olivines, ureilites, aubrites) have previously been reported [e.g., 4]. Our results show that basaltic meteorites with super-chondritic Al/Mg have small excesses of ^{26}Mg, and the size of these excesses is not related to small nucleosynthetic anomalies of other elements (O, Ti, Cr, Ni) in different types of basaltic meteorites. These excesses date planetary differentiation to 2.5-4.1 Myr after Solar System formation. Differentiated meteorites with Al/Mg ratios of essentially zero (e.g., olivine from pallasites – samples of the core mantle boundary of planetesimals) have small deficits of ^{26}Mg that date planetary differentiation to 1.1 Myr after Solar System formation. Thermal modelling of a small planet formed by instantaneous accretion and heated by the radioactive ^{26}Al decay demonstrates that planetary accretion took place 0.2-0.8 Myr after Solar System formation, thereby constraining the growth of planetesimals in the young Sun's proto-planetary disc.

References: [1] Lee T. et al. (1976) GRL 3, 109-112. [2] Kita N.T. et al. (2000) GCA 64, 3913-3922. [3] Srinivasan G. et al. (1999) Science 284, 1348-1350. [4] Bizzarro. M. et al. (2005) ApJ 632, L41-44.

GREAT SOUTH BASIN AND EAST COAST HYDROCARBON POTENTIAL: THE TARTAN AND WAIPAWA FORMATIONS AS AGE AND FACIES EQUIVALENT SOURCE ROCKS

Poul Schioler and Lucia Roncaglia
GNS Science, 1 Fairway Drive, Avalon, P.O. Box 30368, Lower Hutt

The lithostratigraphy, age and depositional setting of sediments of the Hoiho to Rakiura Groups in eight exploration wells in the Great South Basin have been recently reassessed (Schioler et al., 2007). In the wake of that study, a visual particulate organic matter analysis (palynofacies analysis) has been carried out on samples below, within and above the Tartan Formation. The Tartan Formation is a 20–63 m thick, dark brown-coloured mudstone, sandwiched between the Wickliffe and Laing Formations. With TOC values commonly in the range 4–8 % (Sutherland et al. 2002) it is an excellent source rock for hydrocarbons. The Tartan Formation occurs in six Great South Basin wells and is of late Teurian (Late Paleocene) age. This is the same stratigraphic level as the Waipawa Formation of the East Coast Basin as dated by Crouch (2001) and Hollis et al. (2005).

Palynofacies analysis of the sample kerogen in the four wells Hoiho-1C, Kawau-1A, Pakaha-1 and Toroa-1 shows that the Tartan Formation contains very high percentages of degraded brown phytoclasts and very rare marine algae (Fig.1). If interpreted in terms of physical setting on a marine shelf transect, this assemblage indicate deposition in a marginally marine, nearshore environment. Similarly, kerogen from the Waipawa Formation exposed in the Te Hoe River, northwestern Hawke' s Bay, is dominated by terrestrial derived organic matter such as brown phytoclasts and sporomorphs, and is relatively poor in marine algae, indicating deposition in a nearshore marine environment, relatively close to the shoreline. Based on the relatively low content of amorphous organic matter in the Tartan Formation, we infer deposition under oxic to dysoxic conditions suggesting good to moderate bottom water ventilation in the basin.

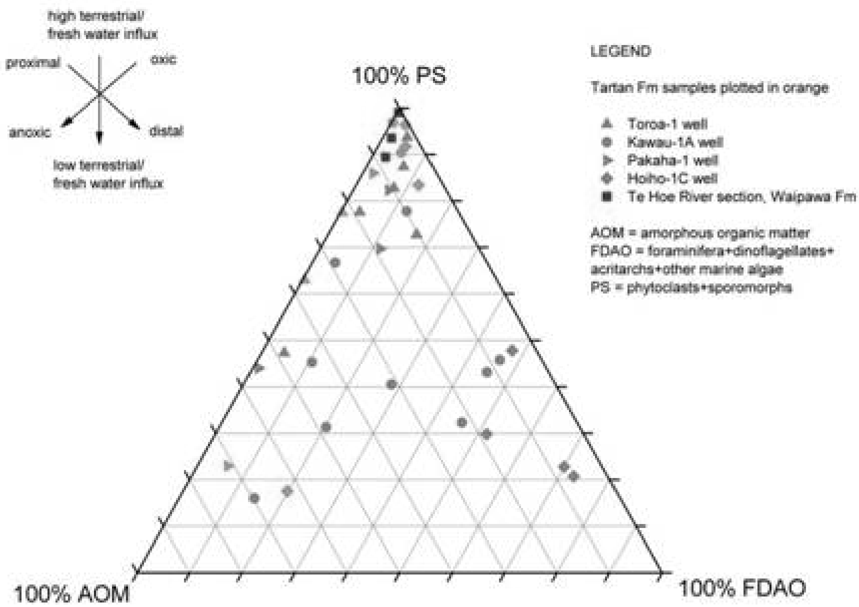


Fig. 1. Particulate organic matter ternary diagram of the relative numerical particle frequency (% of total) in the Wickliffe-Tartan-Laing Formations interval in four exploration wells from the Great South Basin, and Waipawa Formation in the Te Hoe River section, East Coast Basin. The plotted groups together constitute 100%.

PRIMARY VOLCANICLASTIC DEPOSITS AT LOIHI SEAMOUNT, HAWAII: EVIDENCE FOR SUBMARINE EXPLOSIVE ACTIVITY?

C. Ian Schipper[1], James D.L. White[1] & Bruce F. Houghton[2]
[1]Geol. Dept., University of Otago, PO Box 56, Leith St., Dunedin, 9016, New Zealand
[2]SOEST, Univ. of Hawaii at Manoa, 1680 East-West Rd., Honolulu HI, 96822, USA
ianschipper@hotmail.com

While the mechanisms of magma withdrawal, fragmentation, and dispersal are well-constrained for subaerial eruptions, they have not been rigorously determined for submarine ones. Considering that the vast majority of Earth's volcanic activity is submarine, it is important to constrain the mechanisms controlling submarine eruptions and the onset of explosivity, both to extend our understanding of volcanic processes generally, and of explosive submarine eruptions specifically.

Loihi seamount is the youngest and southernmost volcano in the Hawaiian Islands group, and has grown to ~1200 m below sea level since ca. 40 ka. Several submersible studies on Loihi have documented widespread primary volcaniclastic deposits that are comparable to the products of explosive subaerial eruptions of similar composition.
In October 2006, we returned to Loihi with the Hawaiian Undersea Research Laboratory (HURL) Pisces IV manned submersible, to examine and systematically sample some of these deposits. Using established techniques for interpreting subaerial primary volcaniclastic deposits, we are developing a semi-quantitative model(s) for different styles of submarine explosive eruptions at Loihi. Our approach rigorously addresses evolution of magmatic volatiles, as well as effects of magma-water interaction and high hydrostatic pressures in the submarine environment.

We present observations from 4 deposits in the Northeastern summit region of Loihi: 2 bedded deposits with exposed and systematically sampled internal stratigraphy, and 2 conical features from which the outer veneers were sampled. The data available for each deposit varies due to differences in exposure and to sampling limitations of the Pisces IV. We examine features of each deposit at a variety of scales: from outcrop geometry (+/- stratigraphy), to sample characteristics (grain size, sorting, componentry), to individual clast textures. By quantifying many physical parameters for each deposit, we gain insight into the variety and complexity of explosive eruption styles at Loihi. Future work with the deposits will use microanalytical techniques to further quantify volatile budgets.

POSTER 10

THE APPLICATION OF A SPATIO-TEMPORAL SEISMICITY MODEL TO THE VRANCEA SEISMIC ZONE, ROMANIA

Scholz Nastasja, Euan Smith
Victoria University of Wellington
nastasja.scholz@freenet.de

A seismicity model which is based on aftershocks is used. With the empirical distribution function of inter-event times of these aftershocks, which form superclusters with their respective main shocks, a new propability function of earthquake recurrence times is developed. This function consists of a Omori's aftershock decay law of the form 1/t, modified with modulating exponential functions to remove the singularities at Zero and Infinity, and a simple exponential Poisson model. The resulting model has only two parameters: the proportion of causally related events and the Poisson time constant and gives a probability distribution for the time to the next earthquake above a specified magnitude conditional on the time since the last.

This model is applied to Romanian data from a catalogue which spans the time from 984 AD to 2005 AD. The earthquakes in this catalogue all happened in a spatially confined area, the Vrancea Seismic Zone (VSZ). It is a result from continental collision and 16 M years ago, leading to subduction. It is assumed that it is slab detachment, which causes several major earthquakes during each century. The VSZ is part of the Carpathian Mountains, which in turn belong to the Alpine-Carpathian orogenic belt. This belt reaches from Eastern France to the Black Sea and is a result of the collision between the African, Arabian and Eurasian plates.

Seismicity in the VSZ is found in shallow and intermediate depths with most of the major earthquakes occurring in the almost vertical down going slab.

TEMPORAL AND SPATIAL RELATIONSHIPS BETWEEN TECTONIC EXTENSION AND VOLCANISM IN THE OKATAINA VOLCANIC COMPLEX, NEW ZEALAND

H. Seebeck[1,2], **A. Nicol**[1], **T. Stern**[2], **V. Stagpoole**[1]

[1]GNS Science, PO Box 30-368, Lower Hutt, New Zealand
[2]Institute of Geophysics, Victoria University of Wellington, New Zealand
Corresponding author: H.Seebeck@gns.cri.nz

Continental rifts typically exhibit a close temporal and spatial relationship between normal faulting and magma emplacement. Tectono-volcanic processes accommodate regional extension, however, the extent to which they are interdependent can be uncertain. In this study we examine the inter-relationships between volcanism and faulting over the last ~280 ka in, and adjacent to, the Okataina Volcanic Complex. We chiefly focus on whether; i) the location, geometry and kinematics of normal faults influenced volcanism, ii) caldera collapse and dike intrusion enhanced fault displacements, and iii) how much tectonic extension, if any, has been taken up by volcanic processes within the complex.

The Okataina Volcanic Complex is the most recently active of the eight major rhyolitic eruptive centers in the Taupo Volcanic Zone. The volcanic complex is comprised of a multiple caldera collapse complex <400 ka in age (c. 3 km deep) with associated resurgent domes (including Tarawera and the basaltic fissure eruption 1886). Due to the wealth of published volcanic data and the exceptional surface expression of faults, the southern margin of the Okataina Volcanic Complex is an ideal location to test the interdependence between faulting and volcanism over several orders of magnitude, ranging from historic times through to ~280 ka.

To assess the relations between faulting and volcanism we have mapped fault vertical displacements from historical observations (Smith 1886), topographic analysis of high resolution digital elevation models, seismic reflection lines (Davy & Bibby 2005) and gravity modeling (i.e. 2½D two layer and exponentially decreasing density with depth). The available data suggest that the largest faults pass through the volcanic complex, pre-date volcanism, and appear to have influenced the locations of linear volcanic vents and caldera margins. Although historical records (Smith 1886) suggest that some faults at the southern termination of the Tarawera 1886 dike experienced minor (<20 cm) dilation during this event, this and previous dike intrusions do not appear to have significantly modified fault displacements since ~60 ka. By contrast, caldera collapse events between 60 and 280 ka may have utilized pre-existing faults, in some cases increasing their vertical displacements by a factor of 2 and 4 across the topographic and inner collapse structures of the caldera respectively. Displacements induced by caldera collapse are primarily of volcanic origin and do not accommodate significant tectonic extension within the Okataina Volcanic Complex.

Smith, S. P. (1886) The Eruption of Tarawera: a report to the Surveyor-General. Wellington Government Printer. 65-68.

Davy, B.; Bibby, H. (2005) Seismic reflection imaging of the Haroharo Caldera boundary beneath Lake Tarawera, Okataina Volcanic Centre, New Zealand. *New Zealand Journal of Geology & Geophysics* 48: 153-166.

SPATIAL RELATIOSHIP BETWEEN STRUCTURES AND GEOTHERMAL ACTIVITY OF THE TVZ, WITH A CASE STUDY (WAIRAKEI)

F. Sepúlveda[1,2], J. Rowland[1], S. F. Simmons[1,2]
[1]School of Geography, Geology and Environmental Science, Univ. of Auckland
[2]Institute of Earth Sciences and Engineering, Univ. of Auckland.

The Taupo Volcanic Zone (TVZ) is a complex volcanic-tectonic-geothermal system active over the last 1.6 Ma, where NE-trending, rifting-related structures are relatively well documented. However, nearly EW and NW structural lineaments, collectively referred to as "oblique" lineaments here, are also recognizable over the entire TVZ. In the vicinity of the Wairakei geothermal field, the orientation of exposed structures (faults, fractures and veins) also fall into both rift-related and oblique categories. On a regional scale, geothermal areas tend to occur in areas with low density of structural lineaments, irrespective of their orientation, and commonly in the vicinity of high fault-density regions (Figure 1). At Wairakei, both the resistivity boundary and high-temperature regions seem to be partly shaped by oblique lineaments. We explain these observations in terms of: (1) major faults/discontinuities either favour focused infiltration of cold meteoric water or act preferentially as barriers for the circulation of hydrothermal fluids; (2) strength recovery induced by long-term hydrothermal alteration (particularly self-sealing along fault planes), hinders fault reactivation, resulting in the apparent negative correlation between geothermal activity and fault zones.

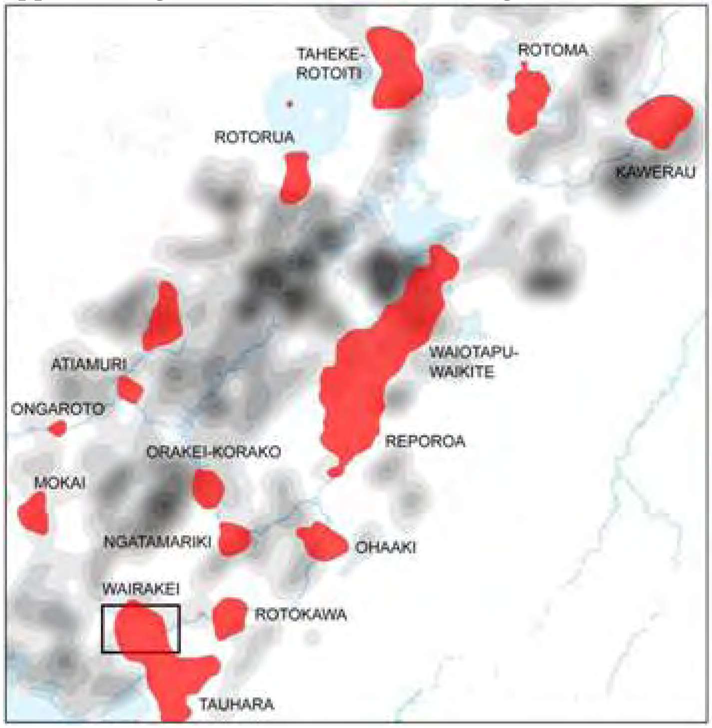


Figure 1. Map of the TVZ showing rift fault-density distributions (black = highest density; white = lowest density) and geothermal areas (in red; based on 30-Ohm-meter contours from the resistivity map of Bibby et al. 1998). The rectangle area highlights the location of the Wairakei geothermal field.

UPPER MANTLE PROPERTIES BENEATH THE CENTRAL NORTH ISLAND

A.M. Seward[1], E.G.C. Smith[1] & C.M. Henderson[1]
[1]Institute of Geophysics, SGEES, Victoria University of Wellington
anya.seward@vuw.ac.nz

The central North Island represents a rare example of back-arc spreading impinging on a continental lithosphere, providing an ideal, and accessible environment for studying the dynamics and properties of the associated features. This project focuses on modelling the structure of the upper mantle through variations in Pn wave velocities.

A combination of National Network Seismometers (GEONET-GNS), local Volcanic Seismic Monitoring Networks (GEONET-GNS) and temporary VUW seismograph deployments are used to collect data from various earthquakes, during the time period of 1990 - 2000 and deployments in 2004 - 2005 (Western North Island Passive Seismic Experiment) and 2005 - 2006 (Coromandel Passive Seismic Experiment). Arrival times were differenced at pairs of seismic stations, to eliminate the effects of non-exact origin times, and epicentral locations. Our dataset consists of approximately 12000 Pn observations from around 3000 local earthquakes, at 72 various GEONET monitored stations and 19 VUW temporary deployment stations.

These observations are then modelled using least-square collocation, where both the deterministic and random parts of the model are estimated simultaneously. The deterministic part is simply that which leads to the usual parameters of least-squares. The random part is a zero mean, normally distributed process that occurs along with the deterministic part of the model representing the wavelength of resultant velocities.

The resulting model indicates distinct lateral variations of low and high mantle velocities. Along the western North Island, mantle velocities of 7.9 ± 0.2 kms^{-1} are detected, while along the east coast, velocities as high as 8.6 ± 0.2 kms^{-1} are seen. Beneath the CVR, mantle velocities as low as 7.4 ± 0.1 kms^{-1} can be seen across a 100 km wide zone.

Estimates of Pn anisotropy indicate a strong trench-parallel direction throughout the eastern and central North Island, ceasing to nulls in the west. The magnitude of anisotropy is dependant on our input parameters, however the direction appears to be constant (independent of inputs), and correlate with SKS splitting anisotropy measurements throughout the North Island.

INCREMENTAL GROWTH OF RHYOLITE MAGMA SYSTEMS: INSIGHTS FROM TARAWERA VOLCANO, NEW ZEALAND

Phil Shane[1], Vicki Smith[2] & Ian Nairn[3]
[1]University of Auckland, Private Bag 92019, Auckland
[2]University of Bristol, Bristol BS8 1RJ, United Kingdom
[3]GNS Science, Wairakei Research Centre, Taupo
pa.shane@auckland.ac.nz

Post-22 ka eruptions from Tarawera volcano have recorded the discrete physiochemical properties of 1-10 km^3-sized rhyolitic melt batches extracted from a crystal mush zone that had insufficient time and/or spatial barriers to prevent re-equilibration between the contemporaneous melts. Phenocryst formation based on phase equilibrium is consistent with depths of < 8 km, close to the crustal brittle-ductile transition, that may have played a role in melt accumulation and sill formation. The rhyolites are extracted interstitial melts from a crystal mush zone that would have left a large un-eruptible crystal residuum. This crystal pile would have contributed to later melt production. The crystal mush zone may have evolved or been partly inherited from long term (>100 kyrs) silicic activity at Okataina Volcanic Centre. It consisted of range of states from fully crystalline regions represented by granitoid lithic ejecta to largely molten pods (>70-80% melt) represented by pumice. Pumice heterogeneity in most of the eruption episodes show that two or more distinct melts occurred contemporaneously in the upper mush zone as isolated melt pockets that underwent independent crystallisation histories. The individual melt batches are compositionally (e.g., ranges in Sr <15 ppm; Rb <7 ppm) and thermally (range <40°C) homogeneous, and display characteristic crystallinity and ferromagnesian phases. Mingling between the melts was restricted to short-lived contact in the conduit during eruption as demonstrated by disequilibrium Fe-Ti oxides and melts. The entire magmatic system was transient with melt formation and depletion on a 1000-yr scale. In addition, the melt pods waxed and waned in response to open system magma recharge that periodically rejuvenated the system into eruption and contributed to the diversity of melts. Basaltic intrusion plays a role at several levels in the magma system, as well as being the fundamental deep (<16 km) origin of the magmatism. Shallow basaltic intrusion (>8 km) is recognised in each eruption in the form of juvenile ejecta, enclaves and/or crystal components. In addition, silicic recharge recognised some events in the form of matrix glass enriched in Sr and Ti relative to quartz melt inclusions. Deep basaltic intrusions may have re-melted the underlying crystal pile to produce melts enriched with compatible elements, that percolated into the overlying mush zone. The thin and actively rifting lithosphere in the Taupo Vocanic Zone contributes to the rapid magma production and emission allowing contemporaneous magma batches and recharge events to be easily recognised in the ejecta. In a less active tectonic setting, the magma batches may have accumulated and amalgamated producing a homogenised or stratified body (depending on dominant processes). The character of Tarawera magmatism supports the concept of incremental growth and the transient heterogeneous state of silicic magma systems that are never completely molten.

TALK – Tue pm

GEOPHYSICAL CONSTRAINS ON THE SEDIMENT BUDGET OF OTAGO HARBOUR, NEW ZEALAND

Amy E. Shears[1], Abigail M. Smith[2] & Andrew R. Gorman[3]
[1]Environmental Science Programme, University of Otago
[2]Dept. of Marine Science, University of Otago
[3]Dept. of Geology, University of Otago
sheam564@student.otago.ac.nz

Otago Harbour, at 45°50’ S, on the east coast of the South Island, is a narrow tidal inlet approximately 23 km long and 2 km wide. The harbour stands today as the result of volcanism, sea-level change, erosion and human activities. The harbour is situated in an eroded caldera of a mid Miocene (13-10 Ma) complex shield volcano centred at the current location of Port Chalmers. The Dunedin volcano is believed to have had a diameter in excess of 40 km, much of which has been subject to extensive erosion (Bishop & Turnbull, 1996). Since the Late Quaternary, the morphology of the Otago coastline has been notably influenced by the glacial/interglacial sea-level variations. The transgression of the sea across the shelf break is believed to have caused the infilling of two coastal river valleys, creating the extensive sand flats observed in the harbour today.

Dredging of the seafloor and reclamation of marginal land in Otago Harbour that commenced in the mid 1800s has influenced the harbour’s natural coastal processes and geomorphology. To date, 370 ha of the Otago Harbour has been reclaimed, making up 8% of the harbour area (Bennet, 1995). Maintenance dredging is still common but new capital dredging is now restricted. Port Otago Ltd has recently (August 2007) proposed further development of the port, including extensive capital dredging, to enable larger ships to navigate through the harbour.

The aim of this research was to develop, for the first time, a sediment budget for the Otago Harbour in order to assist future management, particularly management of dredging activities. Extensive earlier research on many aspects of the harbour has been used to constrain the input and output components for this sediment budget. New geophysical data have been collected to investigate the storage of sediment within the harbour.

We here present the results of three complementary research methods that have been applied to estimate sediment storage. These are: (1) a seismic reflection survey of Otago Harbour using a Ferranti ORE Geopulse Sub-Bottom Profiling System, (2) a gravimetric survey of cross-sectional profiles across the harbour using a Worden gravimeter, and (3) an investigation of historical studies provided by Port Otago Ltd.

Bennet, N.M. 1995. *Otago Harbour: Development and development control and the effects of these on the environment.* Unpublished thesis for Masters in Science, Institute of Offshore Engineering, Heriot-Watt University, Edinburgh.

Bishop, D.G. & Turnbull, I.M. (compilers) 1996. *Geology of the Dunedin area*. Institute of the Geological and Nuclear Sciences: Lower Hutt, New Zealand.

RUPTURING IN FLUID-OVERPRESSURED CRUST – RECENT COMPRESSIONAL INVERSION EARTHQUAKES IN JAPAN AND THEIR LESSONS FOR NEW ZEALAND

R.H. Sibson[1]
[1]Dept. of Geology, University of Otago, P.O. Box 56, Dunedin 9054
rick.sibson@otago.ac.nz

Over the past four years, several strong earthquakes in the upper crust of Honshu, Japan, have involved reverse-slip rupturing on inherited normal faults along the margins of Miocene extensional basins. These include the 2003 M_w6.5 Northern Miyagi earthquake sequence, the 2004 M_w6.6 Mid-Niigata Prefecture sequence, the 2007 M_w6.7 Noto-Hanto sequence, and perhaps also the 2007 M_w6.6 Niigata-Ken Chuetsu-Oki sequence. On the basis of their focal mechanisms and high-resolution aftershock distributions, at least three of the principal mainshocks involved close-to-pure reverse slip on faults dipping at 50-60° along the basin margins. They represent increments of compressional inversion which has been ongoing since the Late Pliocene, but which is not far advanced because the hangingwalls of the faults are still occupied by Neogene basins up to 5 km deep.

Because of their near-pure dip-slip character, reactivation of these reverse faults can be analysed in terms of 2D frictional mechanics. On the assumption of horizontal trajectories of maximum compressive stress (σ_1), it is evident that rupturing during these earthquakes took place on faults that were poorly oriented for frictional reactivation, approaching the angle of frictional lock-up for 'Byerlee' coefficients of rock friction. In the 2004 Mid-Niigata sequence, five $M_J > 6$ ruptures with foci in the 7–12 km depth range defined a criss-crossing network of steep reverse faults disrupted by lower-dipping thrusts, suggesting competition between reactivation of the steep inherited faults and the formation of (younger?) more favourably oriented thrusts. The inference from frictional mechanics is that reactivation of such structures requires near-lithostatic but probably variable fluid-overpressuring within the rock-mass. Evidence for overpressures in and around the fault systems includes borehole measurements in the sedimentary basins plus a range of anomalous seismological and electrical characteristics. These last also suggest an overpressured mid-crust below the seismogenic zone with fluids possibly derived from the underlying subducting slab.

Compressional inversion in New Zealand in areas such as the NW South Island appears to have advanced further than in Japan but there are lessons to be learnt in terms of fluid involvement in fault mechanics, and assessment of earthquake hazard from inversion structures. This presents particular problems because: (i) the structures are geometrically complex with monoclinal folds associated with a mixture of inherited and new-formed reverse fault segments; (ii) finite slip across the structures may be low or even contrary to that expected in the prevailing stress field; (iii) the complex structural assemblages may be wholly or partly concealed by young sedimentary cover along basin margins; and (iv) the dependence of fault failure on fluid-overpressure as well as tectonic stress may contribute to erratic recurrence behaviour.

TALK – Wed am

HUBBERT'S PEAK FOR GLOBAL OIL PRODUCTION: OVER THE HILL, OR DO ALPS ON ALPS ARISE?

R.H. Sibson[1]
[1]Dept. of Geology, University of Otago, P.O. Box 56, Dunedin 9054
rick.sibson@otago.ac.nz

Oil is convenient, easy to transport, and has high volumetric energy density. It is the prime energy for transport but is also the basis of modern food supply. The ratio of oil-energy to food-energy is ~10:1, taking account not only of the diesel power required for tilling and transport but also the oil-base of pesticides, fertilisers, etc. Debate over future oil supply and the ultimate recoverable resource (URR) rages between pessimists (often geologists) and optimists (mainly economists) who insist 'Micawberishly' that *'something will turn up'*, making great play over reserve growth from improved technology. What is clear is that future supply will be affected by both geological and above-ground factors (local/international politics, infrastructure development, weather, warfare). A critical issue is the maintenance of delivery flows as well as production flows. The Gulf States are cited as holding two thirds of the world's reserves but the numbers are highly suspect ('everyone lies!') and do not seem to take account of depletion. Economic growth in the producing countries also means that oil available for export will decrease faster than actual oil production.

Signs are, however, that the global peak in the production of conventional oil is happening about now. It is over 40 years since the peak in global oil discovery in the mid-1960's, the typical lag-time for individual oilfields (though advanced extraction technology may shorten this as in the North Sea). Since the mid-1980's we have been consuming more oil per year than we are discovering. Globally we are discovering something approaching one cubic kilometre of new oil reserves per year. This seems a lot until one considers that we are currently burning ~5 cubic kilometres per year – *a one square kilometre column higher than Mont Blanc!* Replacing this energy source is a daunting challenge. Around the world the giant oilfields (Ghawar, Canterell, Burgan, Samotlar, Daqing, North Sea) are depleting at 5-15% p.a. and replacements are not being found. OECD aggregate production peaked in 1997, and 60 of the 98 oil-producing countries appear to be past their individual production peaks.

Global depletion is now ~4% p.a. while demand continues to rise at ~2% p.a. driven in part by the booming economies of China and India. It is increasingly difficult for production to meet this rising demand. At the same time, the efficiency of energy production is steadily decreasing. We have moved from an EROEI of 100:1 in the heyday of oil discovery to current levels of c. 1.5:1 for production from Canadian tar sands. The transition to non-conventional oil sources (coal-to-liquids, tar sands, oil shales?) will be grossly inefficient and environmentally harmful (water pollution, waste, CO_2). History teaches us that we are not good at anticipating production peaks - Hubbert's 1956 forecast of a c. 1970 peak in US lower 48 production was treated with derision until well after it occurred. The UK North Sea peak in 1999 was largely unanticipated. As has been noted, we may only become aware of the global peak *'in the rear-view mirror'*. But the road across the peak is likely to be bumpy with oil price fluctuating wildly through erratic cycles of growth and recession.

THE POSSIBLE ROLE OF MANTLE INSTABILITIES IN INITIATING BACK-ARC SPREADING

Tim Stern[1], Michelle Salmon[1,2], Wanda Stratford[1,3], Anya Seward[1], Euan Smith[1], <u>Mark Henderson[1]</u>, Erik Ewig, [1] Martha Savage[1], Sonja Greve[1]

1- Institute of Geophysics, Victoria University of Wellington, Wellington, New Zealand

2- Now at RSES, ANU, Canberra, Australia

3- Now at Dept of Geology, Uni of Copenhagen, Copenhagen, Denmark.

mark.henderson@vuw.ac.nz

Back–arc extension and spreading has been splitting apart the central North Island of New Zealand since the Pliocene. But the impressive volcanism and geothermal activity linked to this extension belies the extensive period of compression, and thrusting that dominated the pre-Pliocene tectonics of the central North Island. Up to 100 km of Oligocene-Miocene shortening is estimated from both deep seismic lines and plate reconstructions beneath the western North Island. Crustal uplift, erosion and sedimentary deposition easily account for the removal of the shortened crust during this time. Yet, the consequences of shortening ~ 100 km of mantle lithosphere are not so obvious. We present a series of seemingly disparate geophysical and geological observations that appear to be most easily explained by thickening of the mantle lithosphere and its ultimate disposal by viscous flow and detachment. These observations include:

1. Parallel zones of late Miocene extension and volcanism that developed each side of the central region of compression;
2. A rapid, domal, surface-uplift of ~1 km for western and central North Island that is dated at ~ 5 Ma and is over a region 200 by 200 km in extent;
3. Low Pn and Sn wave-speeds indicating the mantle lithosphere is missing;
4. Lack of Pn and SKS anisotropy in the western North Island despite anisotropy being pervasive elsewhere in New Zealand;
5. Unusually thin crust (~ 25 km) over much of the western North Island;
6. High-K volcanism over the western North Island during the Pliocene.
7. 600 km deep earthquakes beneath the western North Island.

Any one of these 7 observations could be explained by the plate tectonic paradigm. It is, however, the explanation of all 7 observations by a single process that makes the concept of convective removal of thickened mantle lithosphere compelling. If correct, the late-Miocene removal of the thickened mantle lithosphere was a possible kick–start mechanism for consequent Pliocene back-arc extension and spreading within the central North Island.

A LARGE-SCALE, NEAR-SEA LEVEL, SILICIC CALDERA-FORMING ERUPTION IN EFATE? AN ALTERNATIVE MODEL FOR THE 1 MA EFATE PUMICE FORMATION, VANUATU, SW-PACIFIC

[1]**R.B. Stewart**, [1]**K. Németh,** [1]**S.J. Cronin,** [2]**D Charley**
[1]Volcanic Risk Solutions, CS-INR, Massey University, Palmerston North, NZ
[2]Department of Water Resources, Geology and Mines, Port Vila, Vanuatu
R.B.Stewart@massey.ac.nz

The Efate Pumice Formation (EPF) is a rhyodacitic volcaniclastic succession widespread in the central part of Efate Island, and on small islands to the north. The volcanic succession was inferred to result from a major, entirely subaqueous explosive event north of Efate Island. The accumulated pumice-rich units were previously interpreted to be subaqueous pyroclastic density current deposits on the basis of their bedding, componentry and stratigraphy characteristics. Here we suggest an alternative eruptive scenario of this widespread succession based on recent field work at key locations. The major part of the EPF is distributed in central Efate, where pumiceous pyroclastic rock units several hundred meters thick are found within fault scarp cliffs elevated about 800 m above present day sea level. The basal 200 m of the pumiceous succession is composed of massive to weakly bedded pumiceous lapilli tuff units, each 2-3 m thick. This succession is interbedded with wavy, undulatory and dune bedded pumiceous tuff units, characteristic of co-ignimbrite surges and ground surges. Hence, the surge beds imply that the intervening units comprise a subaerial ignimbrite succession. There are no sedimentary indicators in the basal units that are consistent with water-supported transportation and/or deposition. Upwards the basal facies grade toward 200 m of massive to finely bedded, fossil-rich pumiceous volcaniclastic sand and silt interbedded with pumice gravels. Cross-lamination and convolute-bedding in this upper unit, accompanied by dish-structures and dewatering pipes, suggest traction and suspension deposition from water-supported density currents followed by loading deformation. This unit is interpreted to be deposited from reworking of the earlier volcaniclastic pumiceous units in a wet environment, such as a lagoon. The pumiceous succession is topped by reef limestone, which presumably preserved the entire EPF against erosion.

During formation of the EPF, we now propose a combination of initial subaerial ignimbrite-forming eruptions, followed by caldera subsidence. The basal part of the EPF, commonly referred to as Efate Pumice Breccia, is considered to be a normal subaerial rhyodacitic ignimbrite sequence, rather than a succession of subaqueously formed pyroclastic density currents. The upper volcaniclastic successions in our model represent intra-caldera pumiceous volcaniclastic deposits accumulated in a shallow marine environment in the resultant caldera. The present day elevated position of the succession is a result of a combination of potential caldera resurgence and ongoing arc-related uplift in the region.

HOW DO SUBAQUEOUS SLUMPS TRANSFORM INTO TURBIDITY CURRENTS?

L. J. Strachan
School of Geography, Geology and Environmental Sciences, Auckland University, Private Bag 92019, Auckland Mail Centre 1142, Auckland, New Zealand.
l.strachan@auckland.ac.nz

The process by which subaqueous slumps transform into other flow types is an understudied phenomenon. Generally, sedimentologists have assumed that this is how many turbidity currents form, yet there is a paucity of information relating to the specific processes involved. This is surprising because without clarification of the formative processes of surge-turbidity currents and debris flows, a physical understanding of the full mechanics of such flows, from inception to deposition, cannot be fully founded.

This presentation aims to redress this imbalance and investigates the processes of slump flow transformation using a well-exposed example, where the precursor slump and flows to which it was transforming have been preserved in the outcrop.
A detailed field investigation of the Lower Miocene, Little Manly Slump, located within the Waitemata Basin, New Zealand, reveals a complex deposit, comprised of a lower slump-debrite unit and an upper turbidite unit.

Reconstruction of slump evolution shows that slump motion was unsteady and non-uniform, and that flow transformation is directly linked. Flow transformation is inferred to have progressed through the multiple processes of body transformation, fluidization transformation and surface transformation (*sensu* Fisher, 1983). This study shows that flow transformation did not result in *en masse* transformation to a debris flow by a single process, but rather was characterised by partial transformation of the slump to generate a three-phase flow.

TALK – Thu am

AGE OF GLACIAL LANDSCAPES OFFSET BY THE ALPINE FAULT AND PRECISE SLIP RATE DETERMINATION

Rupert Sutherland
GNS Science, 1 Fairway Drive, Avalon, PO Box 30-368, Lower Hutt
R.Sutherland@gns.cri.nz

Glacial erosion and deposition processes created the first-order morphology of mountainous terrane in southwest South Island, and this landscape is cut and offset by the Alpine Fault. A study of cosmogenic nuclide concentrations in the upper surfaces of moraine boulders of the Cascade Plateau shows that moraine deposition events culminated at 83-75 ka, 66-58 ka, and 22-19 ka (GSA Bulletin 119: 443-451). There is a notable correlation between the earliest two events and times of insolation minima in New Zealand. Offset glacial landforms are identified at 12 localities in 9 river valleys. Offsets cluster at ~435, 1240, and 1850 m, consistent with a uniform slip rate and three phases of glacial retreat. The peak of an offset fluvial aggradation surface is correlated with the Last Glacial Maximum at 22 ka. Displacement rates derived from features with assumed ages of 18, 22, 58, and 79 cal. ka are 24.2 ± 2.2, 23.2 ± 4.9, 21.4 ± 2.6, and 23.5 ± 2.7 mm/yr, respectively, with uncertainties at the 95% confidence level. The joint probability, weighted mean, and arithmetic mean of all observations pooled by rank are 23.1 ± 1.5, 23.2 ± 1.4, and 23.1 ± 1.7 mm/yr, respectively. Hence, the mean surface displacement rate and 95% confidence interval for the section of the Alpine fault between Milford Sound and Jacksons Bay is precisely determined to be 23.1 ± 1.7 mm/yr (GSA Bulletin 118: 464-474).

TALK – Wed pm

CROSS-ARC ISOTOPIC AND TRACE ELEMENT HETEROGENEITY IN THE SOUTHERN HAVRE TROUGH

E. Todd[1], M. Handler[2], J. Gill[1], R. Wysoczanski[2], I. Wright[3] & J. Gamble[4]
[1]Earth & Planetary Sciences Department, UCSC, Santa Cruz, CA, 95064, USA
[2]SGEES, Victoria University of Wellington, NZ
[3]National Institute of Water & Atmospheric Research, Wellington, NZ
[4]Department of Geology, University College Cork, Ireland
etodd@pmc.ucsc.edu

The prominent Rumble V cross-arc magmatic ridge at ~36˚S in the southern Kermadec Arc - Havre Trough is interpreted to have been derived by synchronous arc-like constructional volcanism across an actively rifting back-arc. The shallow ridge (≤ 2200 mbsl) contrasts sharply with adjacent and regional deep, arc-orthogonal elongate rift basins to the north and south (≥ 2600 to > 4000 mbsl). Basalts collected from the cross-arc and from rift basins range from Mg# =55 to 75 and generally have low TiO_2 (<1.0), but the cross-arc ridge has higher K_2O (0.3 to 1.0) than adjacent rift basins (< 0.2).

Most of the sampled cross-arc lavas have some degree of elemental and isotopic characteristics consistent with contributions of subduction-zone components, including negative HFSE and positive LILE anomalies relative to REE. This "arc" signature is highly variable among the cross-arc basalts, some having minimal to positive HFSE anomalies, but all are LREE enriched compared with adjacent rift basalts. Cross-arc basalts have higher Ba/La and Th/LREE than adjacent rift basalts, suggesting contribution of subducted sediment (Plank, 2005). Th/Nd versus ratios of fluid-mobile element to less fluid-mobile or immobile elements (e.g. Pb/Nd, Ba/Nb) indicate that subduction components in cross-arc basalts range from fluid to sediment-melt. A large range of Zr/Hf (35 to 65) exceeds ratios for locally subducting sediments (~35 to 40) and does not correlate with Th/Nd.

Cross-arc basalts plot sub-parallel to the Mantle Array for $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ and describe a steeper slope and tighter array than the active Kermadec front volcanoes. With few exceptions, cross-arc basalts define the radiogenic end of a linear array with depleted rift basalts. Both rift and cross-arc basalts mix towards a higher $^{206}Pb/^{204}Pb$ component than the arc front. Most Havre Trough basalts are "Pacific" in Hf-Nd isotope space, but cross-arc lavas define a broader field than rift basalts, defining a high-$^{176}Hf/^{177}Hf$ trend (at, or just above the Terrestrial Array) and a low-$^{176}Hf/^{177}Hf$ trend for a given $^{143}Nd/^{144}Nd$. Rift basalts are more consistent with the low-$^{176}Hf/^{177}Hf$ trend. Bulk mixing of local mantle with new and published compositions of local sediment, sediment melts, and slab-derived fluids cannot account for the observed range for cross-arc lavas. Positive correlation between $^{176}Hf/^{177}Hf$ and Hf/Hf* for Havre basalts suggest that low-$^{176}Hf/^{177}Hf$ can be explained by the addition of sediment melts where zircon is residual. Conversely, negative correlation between $^{176}Hf/^{177}Hf$ and Nd/Hf for some cross-arc and rift basalts indicates Hf mobility during subduction-component addition. "Correcting" cross-arc and rift basalts to zero ΔNd (e.g. no Hf anomaly; Pearce et al., 2007) gives both negative $\Delta\varepsilon Nd_{I/P}$ ("Pacific") and neutral to slightly positive $\Delta\varepsilon Nd_{I/P}$ ("Indian").

26AL-26MG DATING THE SOLAR SYSTEM'S OLDEST SOLIDS

Chris C. Town, Martin Schiller and Joel A. Baker
School of Geography, Environment and Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
(townchri@student.vuw.ac.nz)

Refractory inclusions include calcium-aluminium-rich inclusions (CAIs) and amoeboid olivine aggregates (AOAs), both of which are minor constituents of undifferentiated chondrite meteorites. Long- and short-lived chronometers have shown these inclusions to be the oldest material (currently sampled) that formed in our Solar System [1,2]. Thus, high precision dating, petrographic, chemical and isotopic studies of refractory inclusions offer insights into the chemical and astrophysical environment present in the solar nebula and/or proto-planetary disc during formation of our Solar System. A particularly important aspect of CAIs is the evidence they contain, in the form of 26Mg excesses, for the former presence of the short-lived isotope 26Al (mean life = 1.05 Myr), which decays to 26Mg [1]. Recent studies [3,4] have suggested that the initial 26Al abundance of CAIs from carbonaceous chondrites (Allende, NWA779, SAH98044, Vigarano) is higher (26Al/27Al0 = 6 x 10-5) than the "canonical" value of *ca*. 5 x 10-5 which has been the basis of 26Al-26Mg dating meteoritic material for several decades. Moreover, these studies have suggested that CAIs formed over an incredibly brief time interval of <20,000 yr. However, reinvestigation of the 26Al-26Mg systematics of six CAIs from the carbonaceous chondrite Allende [5], has questioned the revision of the initial abundance of 26Al in CAIs to the super-canonical value.

Here, we report on a petrographic, chemical and isotopic study of 15 refractory inclusions from CV and CK carbonaceous chondrites, as well as an inter-laboratory comparison of the six CAIs analysed in [5], provided to us by Dr Qing-zhu Yin and Benjamin Jacobsen from the University of California, Davis (USA). Nine refractory inclusions were removed from meteorite slices and broken or sawn into two parts. One part was mounted in epoxy, polished and mineral phases analysed for major elements by electron microprobe and trace elements by laser ablation inductively coupled plasma mass spectrometry (ICP-MS) at VUW. The other part of each inclusion was lightly crushed and hand-picked fragments of the inclusion or mineral separates digested. The digested sample was aliquoted into two portions – one for determination of the Al/Mg ratio by ICP-MS and the other subjected to cation exchange separation of Mg for isotopic analysis of Mg by multiple collector ICP-MS at VUW. Al/Mg and Mg isotope ratios for the six Allende CAIs studied by [5] and reanalysed at VUW show some subtle differences as compared to analyses made in Davis but, despite this, confirm the results of [5] i.e. all the studied inclusions have 26Al/27Al0 ~ 5 x 10-5. Initial 26Al abundances of three new CAIs studied at VUW also have 26Al/27Al0 ~ 5 x 10-5 and suggest that reports of higher 26Al/27Al0 in CAIs are: (a) compromised by analytical artefacts or, (b) reflect a much longer period (*ca*. 300,000 yr) of CAI formation in the young Solar System than currently recognised or, (c) uniform thermal resetting of all the CAIs studied by [5] and us. However, a precise internal isochron (PX-WR) we obtained for a coarse-grained Type B CAI lacks an elevated initial 26Mg abundance, which precludes (c) as being an explanation for the discrepant results reported by these recent 26Al-26Mg dating studies of CAIs.

References: [1] Lee T. et al. (1976) *GRL, 3*, 41-44 [2] Amelin Y. et al. (2002) *Science, 297*, 1678-1683 [3] Thrane K. et al. (2006) *APJ, 646*, L159-L162 [4] Young E. D. et al. (2005) *Science, 308*, 223-227. [5] Jacobson B. et al. (2007) *LPS XXXVIII*, Abstract #1491.

RHEOLOGICAL EVOLUTION OF HIGH STRAIN FAULT ROCKS ALONG A RETROGRADE P-T PATH – THE ALPINE FAULT MYLONITES

V. G. Toy[1], R.J. Norris[1], A.F. Cooper[1] and D.J. Prior[2]
[1] Geology Department, University of Otago, Dunedin
[2] School of Earth and Ocean Sciences, University of Liverpool, United Kingdom
virginia@geology.co.nz

The mylonite zone exhumed from depth below the Alpine Fault presents a unique opportunity to examine fault rock development under changing metamorphic conditions but fixed kinematic boundary constraints. The strains that were accommodated during mylonitisation range up to the highest measured in the world to date. Our kinematic data indicate the mylonites experienced simultaneous pure shear stretches up-dip of the fault of α~3.5 and simple shear strain ranging up to γ=150, with an exponential decrease in total simple shear strain with distance from the core of the fault.

There are marked differenced between high strain ultramylonites and low strain protomylonites. Ti-in-biotite thermometry indicates ultramylonites retain mineralogy characteristic of close to the peak P-T conditions in the protolith. Quartz crystallographic preferred orientation (CPO) fabrics, microstructures and quartz recrystallised grainsizes are also characteristic of deformation at amphibolite facies conditions. Conversely, protomylonites contain retrograde Ti-deficient biotite and chlorite after biotite in localised syn-mylonitic shear bands, and have CPO fabrics typical of deformation at greenschist facies conditions. These observations suggest there was little viscous deformation of the higher strain materials in the middle crust, perhaps due to strain hardening, and that the fault zone broadened to include hangingwall material at shallower depths in the viscous regime. However, mixed H_2O-CO_2 fluid inclusions in partially dynamically recrystallised late vein quartz in the ultramylonites show that they were actively deforming by viscous mechanisms during exhumation to depths of ~4.5 km and temperatures of ~325±15°C.

We conclude that the higher strain mylonites were deformed under mid-crustal P-T conditions but did not behave as expected due to their previous deformation history and so interpret the following evolutionary path: During the early stages of mylonitisation at amphibolite facies conditions, crustal rheology was controlled by dislocation creep of quartz. Strong CPOs were formed, promoting geometric softening and localisation of deformation into the mylonites. In the volumetrically dominant quartzofeldspathic aggregates, the protolith schist fabrics were progressively reconstituted to fine-grained materials in which the constituent minerals were well mixed. At depths shallower than ~15-20 km, a mixed frictional-viscous deformation mechanism, comprising dislocation creep of quartz and frictional sliding on weak mica basal planes, was favoured in the fine-grained aggregate. The aggregate may have deformed in an episodic manner during transitory high-stress loading events associated with rupture of the overlying brittle crust. The high stresses would have allowed activation of the harder, but preferably oriented, prism<a> slip system in quartz, and metamorphic equilibration may have been prevented over the short timescale of the high strain rate events.

CYCLIC MAGMA EVOLUTION AND ASSOCIATED ERUPTION EPISODES OF ANDESITE STRATO-VOLCANOES: A CASE STUDY FROM MT TARANAKI, NZ

<u>Michael Turner</u>[1] Bob Stewart[1] Shane Cronin[1] Ian Smith[2] Mark Bebbington[1,3]
1. Institute of Natural Resources, Massey University, Private Bag 11 222, Palmerston North
2. School of Geography, Geology and Environmental Sciences, University of Auckland, Private Bag 92019, Auckland
3. Institute of Information Science and Technology, Massey University, Private Bag 11 222, Palmerston North
(m.b.turner@massey.ac.nz)

The eruption records of andesitic strato-volcanoes are inherently complex, but they often indicate decadal periods of intense activity, followed by centuries of only intermitted events. Acquiring accurate eruption records and understanding the volcanic processes behind eruption intervals are important to the development of realistic hazard assessments and volcanic emergency planning. A detailed study of Mt Taranaki's Holocene eruption record provides clarity to magmatic processes of andesite volcanoes and helps to demystify these seemingly complex volcanoes.

Compositional profiles and zoning textures of plagioclase, amphibole and clinopyroxene phenocrysts of Mt Taranaki eruptions give evidence of magma reheating and/or recharge of the upper magma storage region (between 6 – 10 km depth). These recharge events appear to occur on varying decadal to century timescales. In contrast, the relatively fast elemental diffusion rates within titanomagnetites mean that the proportions of Al, Mn and Mg, for example, reflect variations in surrounding melt composition (and to a lesser degree the magma temperature and fO_2) on shorter time scales. For most of Mt Taranaki's Holocene history, titanomagnetite compositions and whole-rock trace element data display distinctive 1500-2000 year cycles. Most importantly, these cycles correspond exactly with the overall eruption event frequency curve for Taranaki. We suggest that a developing lower crustal 'Hot Zone' (c.f. Annen et al. 2006) is the cause of these cycles, with each cycle being the result of mantle-sourced intrusions into a lower crustal sill/dyke complex. The intruded melt undergoes 1500 years of assimilation, fractionation and crystallisation (AFC) processes and residual melt from these cooling bodies periodically rises to feed the upper magma storage region (producing the recharge signature of the phenocryst assemblage). Superimposed on this 1500-yr cyclic trend, from ~3000 yrs BP Taranaki's magma composition has included a much greater mafic component, associated with development of the satellite cone of Fanthams Peak. This could be evidence for Taranaki's "Hot zone" having reached a critical temperature whereby more mafic melts are able to rise.

Annen, C., Blundy, J.D., Sparks, R.S.J., 2006. The Genesis of Intermediate and Silicic Magmas in Deep Crustal Hot Zones, Journal of Petrology, 47, pp 505-539.

NUMERICAL MODELLING OF MECHANICAL CONTROLS ON COEVAL STEEP AND SHALLOW DIPPING AURIFEROUS QUARTZ VEIN FORMATION IN A THRUST ZONE, MACRAES MINE, NEW ZEALAND

Phaedra Upton[1], Mike Begbie[2], Dave Craw[1]

[1]Geology Department, University of Otago, PO Box 56, Dunedin, New Zealand
[2]Oceana Gold Limited, PO Box 84, Palmerston, Otago, New Zealand
phaedra.upton@stonebow.otago.ac.nz

The Hyde-Macraes Shear Zone (HMSZ) is a regionally-continuous, low-angle NE dipping (~15º) late-metamorphic thrust zone in the Mesozoic Otago Schist. The shear zone, which is host to large volumes of mineralized schist, consists of foliated fissile schist with some massive schist pods. Two sets of quartz veins are found within the HMSZ; thrust-related, shallowly-dipping veins that were emplaced parallel or subparallel to the shears, and swarms of steeply-dipping extensional veins which cut across the metamorphic foliation. The latter are restricted to the massive schist pods. Mutual crosscutting relationships occur between steep extensional veins and shallow-dipping veins suggesting that they formed contemporaneously. The co-existence of these two vein types locally implies local rotation of the principal stress axes to produce extensional veins within a regional thrust setting. The steep extensional veins are spatially related to lateral and oblique ramps within the HMSZ. Three-dimensional mechanical models shows that under certain conditions it is possible for extension-related structures to form during shortening due to local changes in the stress state without the need for a regional scale switch in the imposed stress field. Mechanical requirements include a reduced differential stress, a positive volumetric strain, and an increase in the horizontal shear stress. The geometry of lateral or oblique ramps can produce favourable conditions for extensional vein formation when combined with a high fluid pressure and oblique convergence. For a shear zone similar to the HMSZ these conditions can be produced across a lateral ramp with an oblique convergence direction. The massive schist pods, with no internal anisotropy, will behave as predicted by the models. The fissile schist, which has a strong anisotropy due to original lithology and focused shearing, is unlikely to behave as predicted by the models as failure will occur along the internal planes of weakness rather than by tensile failure of the bulk rock. This is in accordance with field observations which show a spatial association between the massive schist pods and the steep extensional veins. Convergence directions ranging from SW to WNW have been proposed for the HMSZ. Our models suggest that during steep extensional vein formation, the convergence direction is likely to have been top to ~WNW.

CLIMATE VARIABILITY IN SOUTH WESTLAND, NEW ZEALAND FROM 30,000 TO 15,000 CAL YR BP.

Marcus Vandergoes[1,2], Ann Dieffenbacher-Krall[2], George Denton[2], Rewi Newnham[3]
[1]GNS Science, PO Box 30368 Lower Hutt, New Zealand
[2] Climate Change Institute, University of Maine, Orono, ME 04469, USA.
[3] School of Geography, University of Plymouth, Plymouth, PL4 8AA, United Kingdom.
m.vandergoes@gns.cri.nz

Determining the precise timing and magnitude of climate change in the mid latitudes of the Southern Hemisphere is key to understanding the role of the Southern Hemisphere in driving global glacial cycles and identifying interhemispheric leads and lags in the climate system. Here we use pollen analysis, chrironomid-based temperature reconstructions and precise AMS dating from Galway Tarn, south Westland, to outline the complex structure and timing of climate fluctuations between 30 and 15 ka including the Last Glacial Cold Period (LGCP) in southern New Zealand. The sequence includes the Kawakawa Tephra preserved as a visible fine ash and shows a mostly cold interval, indicated by predominance of alpine grassland, interrupted by two milder interstadials characterised by moderate increases in sub-alpine shrubs. The onset of cooling marked by expansion of alpine grassland, occurred at this site ca 29,500 cal. BP, prior to the deposition of the Kawakawa Tephra. Cool conditions were generally maintained until around 18,400 cal. BP. Milder interstadial conditions occurred between ca 25,800 and 23,800 cal. BP and 22,800 and 20,000 cal. BP. A coarse resolution chironomid-based summer temperature reconstruction indicates a 3.5-4^{o}C cooling at the site during the LGCP and provides preliminary evidence of minor shifts toward less severe temperatures during the identified pollen interstadials. The same structure of two interstadials within the LGCP is observed at two nearby pollen sites in South Westland as well as in speleothem, marine $\delta^{18}O$, and glacial ice advance records in southern New Zealand. The high resolution multi-proxy record from Galway Tarn provides a benchmark for understanding the complex pattern of LGM climate change emerging from terrestrial climate proxies in this region.

"IT'S OUR FAULT"
BETTER DEFINING THE EARTHQUAKE RISK IN WELLINGTON

R. Van Dissen[1], **T. Webb**[1], **K. Berryman**[1], **H. Brackley**[1], **A. King**[1] **P. Barnes**[2], **J. Beavan**[1], **R. Carne**[3], **U. Cochran**[1], **G. Lamarche**[2], **R. Langridge**[1], **N. Litchfield**[1], **T. Little**[3], **N. Palmer**[1], **N. Pondard**[2], **R. Robinson**[1], **P. Villamor**[1], **K. Wilson**[1]

[1]GNS Science, [2]NIWA, [3]Victoria University of Wellington
(r.vandissen@gns.cri.nz)

The overall goal of the "It's Our Fault" programme is to see Wellington positioned to become a more resilient city through a comprehensive study of the likelihood of large Wellington earthquakes, the size of these earthquakes, their effects and their impacts on the built environment. The entire "It's Our Fault" programme will be implemented over a seven year period and comprises four main components: Likelihood, Size, Effects and Impacts. "It's Our Fault" is jointly funded by EQC, ACC & Wellington City Council, managed by GNS Science, and directionally overseen by a Steering Committee comprising members from each organisation. "It's Our Fault" is in its second year of funding, with work to date focused within the first component (Likelihood) of the programme. An overview of the composition and results of this component will be presented at the conference.

In a national context, seismic risk is concentrated in the Wellington region and is predominantly the result of large earthquakes on the Wellington Fault. These risk estimates, though based on international best-practice, assume that earthquakes occur randomly in time and that large earthquakes on a given fault do not affect other nearby faults. Preliminary analysis indicates, however, that the 1855 M ~8 Wairarapa earthquake may have delayed the next Wellington Fault earthquake, perhaps by as much as several hundred years. This result, if true, would have a profound effect on estimation of seismic risk in Wellington. Accordingly, this result needs rigorous testing through the development of more realistic long term synthetic seismicity catalogues, and validation through comparisons with actual fault activity and earth deformation data. This, in essence, is the focus of the Likelihood component of "It's Our Fault". There are three main aspects to the Likelihood component: 1) Geological investigations to extend and further constrain the sequence of surface rupture earthquakes on the major Wellington region faults (including the subduction interface), and to better constrain their location and rate of movement. 2) Geodetic, GPS, studies of the Wellington region to constrain the extent of the currently locked portion of subduction thrust under Wellington, and to possibly further constrain slip rate uncertainties for the major upper plate faults in the region. 3) Synthetic seismicity modelling of the Wellington region to investigate the stress interactions of the major faults, and to specifically assess the rupture statistics and interactions of the Wellington-Wairarapa fault-pair. Results from 1) and 2) will provide critical input and validation for 3).

The goal of "It's Our Fault" is ambitious, and to meet it will require expertise and collaboration across a number of interrelated disciplines. The Likelihood component embraces the efforts of earth scientists from GNS Science, NIWA & Victoria University of Wellington. Subsequent phases of "It's Our Fault", particularly the Effects and Impacts components will incorporate engineering, planning and social science expertise.

QUANTITATIVE ANALYSIS OF BACKSCATTER DATA AND CHARACTERISATION OF SEAFLOOR PHYSICAL PROPERTIES IN THE COOK STRAIT REGION, NEW ZEALAND

Anne-Laure Verdier[1,] Geoffroy Lamarche[1], Xavier Lurton[2], Jean-Marie Augustin[2], Scott Nodder[1], and Alan Orpin[1]

1 - NIWA, Private Bag 14-901, Wellington 6021. a.verdier@niwa.co.nz

2 - IFREMER, BP70, 29280 Plouzané, France.

Echo-sounder backscatter intensity is a relative measure of the sound scattering by the seafloor. Backscatter strength is a function of the seafloor substrate and roughness, i.e., it is associated with physical parameters such as sediment grain size, porosity, and small-scale topography. Therefore, quantification of the backscattered signal can potentially provide a means to remotely parameterise the physical nature of the seafloor and efficiently generate regional-scale maps of geological and possibly biological significance.

Our collaborative geoacoustics research with IFREMER (France) is focused in the Cook Strait region, where a wealth of EM300 multibeam bathymetry and backscatter data (~ 30 kHz) were collected as part of NIWA's FRST-funded marine geology programme. These data are augmented by an extensive historical geological database (e.g., seafloor photographs, sediment and rock samples, and high-resolution seismic reflection profiles), and thus provide an excellent opportunity to ground-truth and quantify the backscatter signal based a wide range of parameters.

The processing of the backscatter signal, aiming to remove the effects of the recording equipment, seafloor topography, and the water column, is undertaken using the newly implemented *SonarScope®* software, developed by IFREMER (France). The processing includes image mosaicing, signal calibration and compensation, noise filtering, as well as image segmentation and textural analysis. The backscatter signal is processed at an enhanced resolution over a 5, 10 or 20 m grid, depending on water depth. Profiles of backscatter intensity as a function of grazing angles that are readily available from the co-registered multibeam bathymetry data are extracted from the raw data; thus producing an end result independent from the seafloor topography.

Analysis of the backscatter data in Cook Strait resulted in the identification of local geological, sedimentological, topographic, and possibly biological features otherwise not recognised with conventional surveying. A catalogue of acoustic responses and physical parameters has been created at specific sites of interest, with the long-term aim of developing acoustic templates that are applicable to a wider range of environments. Examples of this detailed analysis of local features include: 1) high reflectivity areas with rough micro-topography and carbonate cementation from relict cold seeps; 2) low reflectivity associated with the tops of sand waves and ridges in central Cook Strait; 3) complex reflectivity patterns at outcropping active fault scarps, as part of our submarine seismic hazard studies; and 4) reflectivity contrasts in canyons axes to provide an indication of sediment transport.

New statistical compensation of the backscatter data from another location allows a proof-of-concept biodiversity mapping exercise. The method utilised ecological theory to predict biodiversity from a knowledge of seabed substrate heterogeneity. The latter could be derived from the segmentation of the backscatter data, such that acquisition artefacts are properly compensated for and attenuated. This technique will be of importance for the large-scale Ocean Survey 20/20 initiative, investigating the relationships between benthic habitats and biodiversity on the Chatham Rise and Challenger Plateau.

INTERACTIONS BETWEEN PREHISTORIC VOLCANIC ERUPTIONS FROM OKATAINA VOLCANIC CENTRE AND SURFACE RUPTURE OF NEARBY ACTIVE FAULTS.

P. Villamor[1] , K. Berryman[1] & I.A. Nairn[2]
[1]GNS Science, P.O. Box 30 368, Lower Hutt
[2] Geological Investigations, Lake Okareka RD5, Rotorua
p.villamor@gns.cri.nz

In paleoseismic excavations across fault lines close to Okataina Volcanic Centre we have found evidence for close time associations between individual eruptions and surface rupture of faults during the last ~ 15,000 years.

The Okataina Volcanic Centre is located between two active segments of the Taupo Rift, the Ngakuru Graben to the south and the Whakatane graben to the north. In this area, volcanism in the last ~25,000 years has been spatially constrained to two major volcanic lineaments, the Haroharo Vent Zone and Tarawera Vent Zone that are both sub parallel to the fault trends. Active faults run into the margins of the Okataina Volcanic Centre from both southwest and northeast. Some fault tips overlap in space with the end of the volcanic vent lineaments, but in general active faulting is not dominant within the Okataina Volcanic Centre.

We have recorded at least 10 cases where surface rupture has occurred on faults at a distance either just prior to, or during, a volcanic eruption. In some cases we only have evidence of one fault rupturing in association with volcanic eruptions. In other cases several faults have ruptured in association with an eruption. The faults that have ruptured in association with eruptions are not necessarily located along strike of the volcanic vent zone where the eruption occurred (in one third of the cases they are not). From our dataset the maximum distance between volcanic vent and the point of evidence of associated fault rupture is 44 km. In this small sample we cannot find a clear relation between eruptive volumes and distance to associated surface rupture, but the spatial and temporal associations do provide some guidance in further assessing triggering processes and interactions between faults and volcanoes.

TALK – Thu pm

MODELING THE THERMAL REGIME OF THE HIKURANGI SUBDUCTION ZONE

I. Wada[1], J. Townend[2], K. Wang[1,3], M. Reyners[4] & S. Ellis[4]
[1] School of Earth and Ocean Sciences, Univ. Victoria, Victoria, BC, Canada
[2] School of Geography, Environment, and Earth Sciences, Victoria Univ. of Wellington
[3] Pacific Geoscience Centre, Geological Survey of Canada, Sidney, BC, Canada
[4] GNS Science, Lower Hutt, New Zealand
john.townend@vuw.ac.nz

Large volumes of aqueous fluid are likely released from the thick, oceanic Hikurangi Plateau as it is subducted along the Hikurangi margin, magnifying the effects of fluids on such diverse subduction zone processes as mantle wedge serpentinization, arc volcanism, earthquakes, and possibly slow slip and related phenomena. Dehydration of the subducting slab is governed by the ambient temperature conditions: in this study, we are developing 2-D steady-state thermal models of the Hikurangi margin, focussing in particular on fluid availability and the thermal conditions governing the processes listed above. The forearc thermal regime is strongly affected by mantle wedge flow, the pattern of which depends on mantle wedge rheology and viscous coupling between the slab and overriding mantle. In our model, a temperature- and stress-dependent rheology for wet olivine is used to represent the mantle wedge, and slab-mantle wedge coupling is constrained by limited surface heat flow data and the location of the volcanic arc, beneath which the mantle wedge temperature is presumed to exceed 1200°C. In the present reconnaissance study, we focus only on the forearc region where the effects of rifting in the Taupo Volcanic Zone are minor compared to those of mantle wedge flow. Our model predicts relatively vigorous mantle wedge flow with a small, stagnant mantle wedge nose. The thermally-defined seismogenic zone predicted with our model extends to much greater depths than have been inferred from geodetic and seismic observations, pointing to the need for further study into other physical processes that may limit the extent of megathrust slip in this region. Our model suggests that recently observed slow slip events on the plate interface take place at temperatures of well below 350°C and that dehydration of the subducted Hikurangi plateau peaks at 60–125 km depths. Dehydration of the subducting crust is expected to facilitate intraslab earthquakes and provide large fluid fluxes into the hot mantle wedge, facilitating melt generation. The large fluid supply originating from the unusually thick subducting crust, in conjunction with rifting, may account for voluminous arc magmatism in the Taupo Volcanic Zone. At depths shallower than 60 km, little metamorphic fluid is released from the slab, and the overriding stagnant mantle wedge may stay relatively dry even though the ambient temperatures would enable serpentinization. At the southern end of the Hikurangi margin, highly oblique subduction and collision-dominated convergence make it difficult to study the subduction zone's thermal structure using a 2-D model. However, low seismic attenuation in the mantle wedge and feeble arc volcanism suggest a large, cold mantle wedge nose and hence a significantly different thermal regime from that further north. Northeast of New Zealand, normal-thickness oceanic crust is being subducted, and the fluid supply is expected to be correspondingly smaller than to the south: our model for the Kermadec arc predicts a cooler mantle wedge corner and deeper dehydration of the subducting crust. These contrasting features should lead to large differences in subduction zone processes.

POSTER 61

CRUSTAL DEFORMATION IN THE RIFT: FOCUS ON SOUTHERN TVZ KINEMATICS

Laura Wallace[1], Pilar Villamor[1], John Beavan[1], and Neville Palmer[1]

[1]GNS Science, PO Box 30368, Lower Hutt
l.wallace@gns.cri.nz

Crustal strains at the southern termination of rifting in the Taupo Volcanic Zone (TVZ) are complex. Faulting at the southern termination is characterized by three sets of normal faults that are in cross-cutting relationships, leading Villamor and Berryman (2006) to propose that the minimum principal stress axis must change orientation over a short distance. They suggested that this occurs due to the kinematics of tectonic block rotations in the Hikurangi margin. Here, we conduct more detailed modelling of these block rotations at the southern termination of the TVZ using geological slip rates and slip vectors, GPS velocities, and regional earthquake slip vectors to better define the kinematics of deformation there. Numerous studies have also recognized that the rift propagates southward (e.g., Gamble et al., 2003; Price et al., 2005; Villamor and Berryman, 2006). We will discuss mechanisms (in the context of the regional tectonics) that could lead to southward propagation of the rift.

We will also show the latest campaign GPS results bearing on crustal deformation within the TVZ. These have involved an ongoing effort over the last few years to increase the spatial and temporal density of campaign GPS observations in the central North Island, in order to gain a clearer picture of the complex contemporary crustal deformation there. Of particular interest are results from a new campaign GPS transect along the Bay of Plenty coastline, which provide some interesting insights into the partitioning of extensional strain in that region.

BAYESIAN METHODS OF FOCAL MECHANISM ESTIMATION

David Walsh[1], Richard Arnold[1], & John Townend[2]
[1]School of Mathematics, Statistics and Computer Science, Victoria University
[2]Inst. of Geophysics, School of Geog. Env. & Earth Sciences, Victoria University
david.walsh@mcs.vuw.ac.nz

Earthquakes are important signatures of the stress in the earth's crust. In order to interpret the constraints earthquakes place on the stress field it is important to summarise – in a statistically valid way – the information that observations of earthquakes contain. The focal mechanism of an earthquake describes the geometry of the fault on which the earthquake occurred using three parameters: the strike, dip and rake. We are investigating a Bayesian method of estimating these focal mechanism parameters, and here we apply these methods to phase data from the Raukumara Peninsula, New Zealand.

Bayes' rule is a simple probabilistic theorem that can be used to assess the degree to which certain data support certain hypotheses. In this project, we use Bayesian techniques to formulate a posterior probability density function (PDF) for the strike, dip and rake of an earthquake, given our data (the directions of first motions at an array of seismometers), a velocity model (assumed known) and a model for the observational errors. The Bayesian model allows any prior knowledge of the focal mechanism to be combined with a likelihood function describing the relationship between the observed data and the focal mechanism parameters. When we apply these methods to the Raukumara Peninsula data, we use a detailed three-dimensional velocity model

The posterior probability distribution that results from our Bayesian modelling is a function tabulated on a three dimensional grid of strike, dip and rake values. An equivalent representation of a focal mechanism is as an orthogonal matrix with columns equal to the slip vector, the null vector and the fault-normal vector. We approximate such a distribution using a Matrix-Fisher distribution, which describes the distribution of random orthogonal matrices, and thus can be used to describe the distribution of focal mechanisms. Also using the Raukumara Peninsula data, we present here the results of the Maximum Likelihood Estimation of the parameter matrix that defines the Matrix-Fisher distribution with the closest fit to our Bayesian posterior PDF.

CHRONOLOGY OF HOLOCENE SPRINGSTON FORMATION GRAVEL DEPOSITION UNDER CHRISTCHURCH CITY

P.A. White[1] and J.H. Weeber[2]
[1] GNS Science, Private Bag 2000, Taupo
[2] J.H. Weeber, Environment Canterbury, PO Box 345, Christchurch

Holocene Springston Formation gravel deposition under Christchurch City is assessed with maps of Christchurch surface features such as pre-urbanisation geography, soils, current geomorphic features and ground elevation; geological logs and 3D models of sedimentary geology; and radiocarbon dates. Springston Formation gravel deposition, associated with pre-historic channels of the Waimakariri River, is interpreted as a set of gravel lobes that cross Christchurch City from west to east.

The distribution of unconnected gravel lobes generally reflects the distribution of surface features that potentially identify gravel lobes. For example the locations of springs are commonly associated with gravel lobes. Therefore the gravel lobes are probably the geological units that allow groundwater flow from unconfined aquifers west of Christchurch to springs in Christchurch City.

The chronology of Springston Formation gravel sedimentation is estimated using radiocarbon dates of sediments in the Christchurch City area. The chronology of sedimentation is summarised as, from older to younger, with approximate ages:

- Halswell connected gravel deposition started 8800 years ago and ended 5000 years ago;
- Sydenham connected gravel deposition started 6300 years ago and ended 2800 years ago;
- Sydenham unconnected gravel deposition was in two phases:
  - phase 1 deposition started 4100 years ago, however the end of sedimentation is undated. Sediments in this phase may have originated from the Fendalton gravel lobe (deposition phase 1) with deposition in the Yaldhurst lobe;
  - phase 2 deposition started 3000 years ago, however the end of sedimentation is undated;
- Fendalton connected gravel deposition has an unknown start date and ended 4400 years ago;
- Fendalton unconnected gravel was deposited in two phases:
  - phase 1 deposition began 4200 years ago and ended 3000 years ago;
  - phase 2 deposition started 2000 years ago and ended 1600 years ago;
- Belfast unconnected gravel - depositional ages unknown;
- Old South Branch connected gravel deposition started 4000 years ago.

Generally the age of commencement of Holocene Springston Formation deposition youngs to the north, i.e. the Waimakariri River has generally moved northwards in the last 8000 years.

TALK – Tue pm

A NEW HIGH-RESOLUTION CLIMATE RECORD FOR NEW ZEALAND COVERING THE PERIOD 11-73 KYR B.P.

Thomas Whittaker[1,2], Chris Hendy[1], John Hellstrom[3] and Steve Cooke[2]
[1] Dept. of Chemistry, Univ. of Waikato, Hamilton, N.Z.
[2] Dept. of Earth & Ocean Sciences, Univ. of Waikato, Hamilton, N.Z.
[3] School of Earth Science, Univ. of Melbourne, Victoria, Australia
tew3@waikato.ac.nz

Speleothems, layered secondary cave calcite deposits such as stalagmites, stalactites and flowstones, have been shown to offer much potential as palaeoclimate archives. Here we present a new, high-resolution independently-dated palaeoclimate record from a 628 mm tall stalagmite which formed in Hollywood Cave, Westland. Over 550 stable oxygen and carbon isotope measurement pairs are supported with a chronology from 13 sequential ^{230}Th dates. The speleothem grew between 73 and 11 kyr B.P. Growth rates varied from 1.7–39.3 mm/kyr and current data resolution yields one sample per 25–250 years.

Weak covariance between δ^{13}C and δ^{18}O in the speleothem calcite suggests that recorded climate signals are primarily driven by precipitation amount and source. The two isotope proxies indicate cool and wet conditions prevailed between 12-16, 19-30 and 57-70 kyr B.P., while climate was drier 30-35 kyr B.P. However, superimposed on these general trends are significant, abrupt fluctuations operating on centennial to millennial timescales. Many of these abrupt events can be matched to known periods of glacier advance and retreat in the Southern Alps and also to abrupt events found in both Greenland and Antarctic ice core records.

PALEOMAGNETIC RESEARCH AT OTAGO - LOOKING BEYOND THE GEOMAGNETIC POLARITY TIME SCALE

G. Wilson, F. Nelson, C. Ohneiser, A. Quinn, J. Robbins & C. Zeeden
Geology Department, University of Otago, PO Box 56, Dunedin
gary.wilson@otago.ac.nz

Traditionally, applications of paleomagnetism to New Zealand geological problems have involved the determination of remanent magnetic direction and it's use in magnetostratigraphic correlation or defining crustal rotation. While traditional integrated magnetic polarity stratigraphy remains a powerful dating and correlation tool, modern paleoclimate studies require a resolution applicable to the human dimension. Recent research at the Otago Paleomagnetic Research Facility has been employing environmental magnetic analysis integrated with other multiproxy techniques to provide millennial and submillenial age resolution for Neogene-Recent sedimentary successions. Environmental magnetism essentially involves the application of bulk magnetic response of a sample as a proxy for magnetic grain-type, -size, -concentration or -alignment. When dealing with sedimentary successions, each of these parameters is indicative of changing environmental conditions and processes including changes in the paleogeomagnetic field intensity.

The 2G Enterprises long-core cryogenic magnetometer at Otago allows high-resolution (cm) measurement of magnetic parameters such as magnetic grain concentration and bulk magnetisability, through the use of an in-line magnetic susceptibility loop and Anhysteretic Remanent Magnetiser (ARM). Where, magnetic mineralogy, grain-size and concentrations are relatively uniform in a stratigraphic succession, changes in bulk magnetisability can be linked to variations in field intensity at the time of grain alignment. Various potential reference records from the Northern Hemisphere and South Altlantic combine to produce a paleointensity reference record back to 4 Ma with patchy coverage before that. The intensity record correlates well with polarity indicators - the lowest relative paleointensities occur at times of field reversal and other short periods of reduced intensity align with geomagnetic field excursions variously reported around the globe. Between reversal and excursion events, intensity history provides a unique pattern with peaks and troughs currently resolvable to between 1 and 10 k.y.

Recent measurements of sediment cores collected from East and West coasts of the South Island and East Coast of the North Island confirm the global pattern of relative paleointensity even at the 1-10 k.y. scale at least for the last several hundred thousand years. We have been able to validate our correlations using a number of geomagnetic excursions within the Brunhes Normal Chron. Where magnetic grain-size and concentration is not uniform, we have been able to use spectral analysis of the magnetic susceptibility on long cores as well as at the outcrop to detect nested orbital cyclicities, which provide a 10-20 k.y. framework for age models. With the recent acquisition of an AGICO MFK-1A spinner kappabridge, we are now able to determine anisotropy of magnetic susceptibility and hence confirm environmental controls on magnetic susceptibility cycles through a link to waxing and waning ocean currents found to parallel magnetic susceptibility variations.

TALK – Tue am

SUBDUCTION ZONE TRACE ELEMENT SYSTEMATICS: WHEN ARE ANOMALIES NORMAL?

J. Woodhead[1], J. Hergt[1], L. Edwards[1] & A. Greig[1]
[1]School of Earth Sciences, The University of Melbourne, Vic. 3010 Australia
jdwood@unimelb.edu.au

The recent advent of MC-ICPMS analytical technologies has re-invigorated debate on the significance of Hf-isotope variations in subduction-related rocks. In parallel with these investigations the occurrence of Hf elemental anomalies (relative to the REE) in arc lavas has also attracted much attention. Two recent papers exemplify these discussions. Pearce et al (1999) use negative Hf anomalies to track the addition of a subduction component to the sub-arc mantle, whereas Tollstrup & Gill (2005) suggest that negative Hf anomalies in arc magmas require trace quantities of residual rutile, zircon and monazite to be stabilised in the subducting slab.

In our own studies of a variety of arc datasets we have observed that, where high quality ICPMS trace element data are available, and data are filtered to include suites of samples from individual volcanoes or volcanic centres, a correlation is often observed between Hf anomalies and indices of differentiation such as silica. This suggests that magmatic differentiation has a significant role to play in the generation of such anomalies and, furthermore, the nature of the correlation (less negative anomalies occurring in more differentiated samples) is at odds with models involving crystallisation of minor phases such as zircon in highly silicic samples.

To investigate this intriguing observation further we have conducted bulk-rock ICPMS trace element analyses of gabbroic xenoliths from the Mariana Arc and laser ablation ICPMS analyses of the mineral phases present within these. All of the xenoliths and the dominant trace element-carrying phases within them are characterised by more negative Hf anomalies than the most extreme values observed in the arc lavas. Furthermore, the compositions of the xenoliths are consistent with a cumulate origin and extend the differentiation trends defined by the arc rocks to higher MgO contents.

The definition of ‘anomalous’ Hf is based upon the underlying assumption that partition coefficients during melting in the subduction zone environment approximate those observed for melting of typical mantle peridotite. Even if this is correct our results indicate that Hf and the REE can partition differently into the fractionating assemblage during magma evolution, thereby modifying their relationship in the primary melt.

Although this is the subject of ongoing investigation, our first-order conclusion is that great caution must be exercised in using so-called ‘Hf anomalies’ as indicators of source phenomena when a significant proportion of the observed variation might well be attributed to ‘normal’ processes of low pressure fractional crystallisation.

References

Pearce, J et al (1999) Journal of Petrology 40, 1579-1611.
Tollstrup, D & Gill, J (2005) Geology 33, 737-740.

TONGA - KERMADEC ARC CALDERAS: A REVIEW OF CALDERA MORPHOLOGY AND STRUCTURE

I.C. Wright[1], I.J. Graham[2], P. Stoffers[3], & C.J.N. Wilson[4]
[1]NIWA, Private Box 14-901, Wellington,
[2]GNS Science, P.O. Box 30-368, Lower Hutt,
[3]Institute of Geosciences, University of Kiel, Kiel, Germany,
[4]School of Geography, Geology and Environmental Science, University of Auckland, Private Bag 92019, Auckland
(i.wright@niwa.cri.nz)

Within the 870 km long sector of the Tonga – Kermadec arc (between 35°S to 21°S), over 50 individual >1 km wide calderas, associated with silicic eruptives, have been identified from five multibeam mapping surveys from 2002 – 2007. Caldera distribution is mostly, though not exclusively, along the central - northern Kermadec and southern Tonga arc sectors. In contrast, metrics of caldera morphology are mostly consistent along the arc; average caldera floor water-depth is 1050 m (range 1860 - 260 m), average caldera long axis is 4.9 km (range 11.6 - 1 km), and average caldera rim water-depth is 800 m (range 1500 - 160 m). As in the onshore extension of the arc (Taupo Volcanic Zone), regional arc and backarc extension strongly controls caldera structure – caldera elongation (average length:width ratio of 1.26) is orientated predominantly orthogonal to the basement rift fabric. Various styles of caldera collapse (including trap-door and funnel structures) are recognised from both multibeam and multi-channel seismic reflection data. More than half of the calderas show evidence of repetitive and nested collapse. Caldera breaching and rim collapse are common, and can be associated with mass-gravity pyroclastic debris flows, imaged as large-scale sediment bed-forms in multibeam and multi-channel seismic data. Similarly, post-collapse volcanism (but not structural resurgence) is common with both intra-caldera dome construction, and formation of cone vents and explosion pits around the caldera rim. Such post-collapse volcanism is variable in composition, however, intra-caldera dome and rim eruptives are commonly rhyolitic and basaltic, respectively.

CONSTRUCTIONAL VOLCANISM AND BACK-ARC RIFTING IN THE SOUTHERN HAVRE TROUGH

R. Wysoczanski[1], E. Todd[2], I. Wright[3], J. Hergt[4] & M. Leybourne[5]
[1]SGEES, Victoria University of Wellington, NZ
[2]Earth & Planetary Sciences Department, UCSC, Santa Cruz, CA, 95064, USA
[3]National Institute of Water & Atmospheric Research, Wellington, NZ
[4]School of Earth Sciences, The University of Melbourne, Vic. 3010 Australia
[5]GNS Science, Lower Hutt, NZ
Richard.Wysoczanski@vuw.ac.nz

The structure and composition of the Southern Havre Trough (SHT) back-arc is poorly understood with previous mapping and sampling limited to south of the Rumble Rift (35°30'S). New multibeam surveying by the R/V *Yokosuka* in October 2006 has revealed the SHT to consist of elongated deep rifts (> 4000 m) in the central-eastern portion, extended platforms of basement of near constant depth (2500 m) with elongate ridge highs across the back-arc, separated by shallower basins (< 3000 m), and volcanos and seamounts that extend to within close proximity of the Colville Ridge. The structural fabric of the back-arc is dominated by the NE-SW trend of grabens and basement ridges that are orthogonal to the arc front, although a large central pull-apart basin trends NNE, parallel to the arc front. Back-scatter imaging reveals regions of high reflectivity in the deep rifts, both on the rift floor and flanks, on seamounts and on ridge tops of basement highs, suggestive of young volcanism in these regions. By contrast, basement plateaus have low reflectivity indicating older compositions and/or sediment cover.

The Deep Hottie Rift, a 4000 m multiple – flanked graben at the north of the survey area (centred on 33°30' S) was sampled and surveyed using the SHINKAI 6500 manned submersible. Two dives were conducted, one on a ridge protruding from the floor of the rift (3660 - 3430m) and the other on the western flank (2950 – 2600 m) of the rift below the basement platform. Samples collected from the rift (27) are vesicular porphyritic basalts with glass rims, thin Mn crusts (<1 mm) and a fresh appearance indicative of young volcanism. The phenocryst assemblage (5-15%) consists of olivine + Cr-spinel ± clinopyroxene, with plagioclase occurring only as a groundmass phase. High forsterite contents of olivine (Fo 88-91) and Cr# of Cr-spinels indicate a mineral assemblage in equilibrium with mantle conditions.

Pillow rim glass compositions range from 52.0 – 52.6 wt.% SiO_2, Mg# = 54.4 – 65.0, and have low K and low Ti compared to back-arc basalts previously sampled from the Ngatoro and Rumble Rifts at the southern end of the SHT. Trace element concentrations show characteristics typical of subduction zone basalts, with enriched LILEs, Pb and Sr concentrations relative to MORB and depleted Nb, Zr and Hf anomalies. Rare earth element patterns, however, are flat to slightly LREE enriched ([Ce/Yb]n = 0.98 – 1.62) with concentrations similar to N-MORB. Water species concentrations (1.3 – 2.2 wt. % H_2O) and carbon contents below detection limit are consistent with degassing to eruption pressures, but indicate high water contents in a MORB-like mantle source fluxed by slab fluids (e.g. Ba/Nb = 35-72) with little or no sediment melt component (e.g. [La/Sm]n = 0.5-0.9).

TALK – Tue am

REVISED STRATIGRAPHY OF THE RING-PLAIN SUCCESSION SURROUNDING MT. TARANAKI

A.V. Zernack[1], J.N. Procter[1] & S.J. Cronin[1]
[1]INR, Massey University, Private Bag 11 222, Palmerston North, NZ
A.V.Zernack@massey.ac.nz

The first geological maps of Taranaki subdivided the apron of volcaniclastic material surrounding the Taranaki volcanoes into several segments of different ages and origin based on geomorphological features as well as soil properties. These so-called "ring-plains of laharic agglomerate" were thought to have formed during periods of Pleistocene glaciation while the corresponding interglacial periods were marked by marine benches. Five ring-plains were attributed to Kaitake and Pouakai Volcanoes and two younger ones to Mt. Taranaki, named Stratford and Opunake Lahars.

Later studies established a detailed stratigraphy of cone-forming deposits as well as the younger landscape-shaping parts of the Mt. Taranaki ring-plain. Five debris avalanche deposits, resulting from collapses of former edifices, were recognised and their distribution mapped. These new formations added more detail to the geologic map and mostly replaced the older units. An exception is the volcaniclastic sequence in south-west Taranaki, which is still referred to as Stratford and Opunake Formations according to the former subdivision of the ring-plain.

Remapping of these formations showed a greater complexity of volcaniclastic lithofacies and allowed a more detailed reconstruction of the past volcanic activity at Mt. Taranaki. A larger number of debris avalanche deposits were identified than previously described, as well as a wide variety of volcanic mass-flow and reworked deposits. The different lithofacies show a repeating pattern of deposition, and can be related to phases of cone-construction or collapse events, depending on their sedimentological characteristics. This concept of cyclic growth and destruction can be applied to the entire volcanic history of Mt. Taranaki and illustrates that ring-plain formation is controlled primarily by volcanic edifice-growth and stability cycles rather than purely climatic influences.

Former studies used the term Formation for single units as well as for deposit sequences and thus created a confusing stratigraphic terminology for the ring-plain succession at Mt. Taranaki. A new nomenclature is needed, one that is more consistent and uniform throughout the entire succession. We present a revised stratigraphic structure based on the new model of cyclic volcaniclastic sedimentation. Each Formation is defined as the deposits representing one complete volcanic cycle, which includes a phase of cone construction followed by collapse of the edifice. The deposits produced during the period of edifice growth and those generated by collapse represent individual Members. These stratigraphic Members can comprise deposit packages related to individual eruptive episodes as well as single mappable units of different origin.