CHARACTERISATION OF NEW ZEALAND NEPHRITE JADE USING ITS GEOLOGICAL AGE AND STRONTIUM ISOTOPIC COMPOSITION

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New Zealand pounamu (nephrite jade) occurs in several 'fields' in the South Island, mainly in northern Southland and North Westland. The usual occurrence is in metasomatic reaction zones forming tremolite of unusual texture, where gabbro/dolerite/harzburgite undergoing serpentinitization is adjacent to siliciclastic metasediments (and metavolcanics).

For the probable Early Permian gabbro/dolerite pounamu precursors, Rb-Sr age and Sr-isotope data suggest a primitive origin, with initial $^{87}Sr/^{86}Sr$ ratios, c. 0.7032.

However, the Permian-Triassic metasediment precursors have more elevated initial $^{87}Sr/^{86}Sr$ ratios, whose values confirm their suggested terrane origins: <0.7050 (Caples), 0.7050-0.7065 (Dun Mountain-Maitai), >0.7090 (Torlesse). Pounamu from in situ occurrences in the Livingstone Mountains, northern Southland (Dun Mountain-Maitai terrane) and Arahura River, North Westland (Torlesse terrane), have initial $^{87}Sr/^{86}Sr$ ratios close to the metasediment values noted above. The gabbro and dolerite Sr contributions to pounamu formation thus clearly play a very minor role.

Sr isotopic ratios may thus provide a useful characteristic of the New Zealand nephrite jade 'fields'. Since Torlesse and Caples terrane rocks occur within Alpine and Otago Schists of quite different ages, it is possible that metamorphic age variations may also play a finer-scale role in determining Sr-isotopic compositions.

ORAL

THE GRANULITE FACIES WESTERN FIORDLAND ORTHOGNEISS IN SOUTHWEST FIORDLAND

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Recently QMAP Fiordland has investigated the southern-most part of the Cretaceous Western Fiordland Orthogneiss (WFO) suite and its relationships to adjacent Paleozoic metasedimentary rocks. In central-west Fiordland, 10-20km to the north of the area mapped, previous work indicates granulite facies (ca. 10-12kbar) WFO is juxtaposed against Paleozoic amphibolite facies (ca. 7-9 kbar) metasedimentary rocks across the Doubtful Sound Shear Zone (DSSZ). A more complex variety of gneisses and field relationships characterise the southern-most part of the WFO suite. Breaksea Island, much of northern Resolution Island and the area between Breaksea Sound and the Coal River mouth are underlain by distinct coarse banded clinopyroxene-garnet and plagioclase-garnet-clinopyroxene gneisses that are widely retrogressed to hornblendite and plagioclase-hornblende gneiss. Igneous textures have been completely destroyed during metamorphism and deformation. These rocks are collectively referred to as the Breaksea Gneisses. Eastern Resolution Island, inner parts of Breaksea Sound, much of Wet Jacket Arm and the Acheron Passage are underlain by a homogenous dioritic orthogneiss in which igneous textures are widely preserved despite granulite facies metamorphism and development of garnetiferous anorthosite leucosomes. These rocks are referred to as Malaspina Gneiss since they are contiguous with WFO mapped in Doubtful Sound of the same name. Dikes of Malaspina Gneiss cut layering in the Breaksea Gneiss indicating that the former is the younger unit. Significant deformation, metamorphism and recrystallisation appear to have separated emplacement of these two members of the WFO suite, but the magnitude of their age difference is not known.

Breaksea Gneisses are juxtaposed against Paleozoic rocks across both broader ductile shears similar to the DSSZ and younger brittle faults. Reconnaissance thermobarometry of unretrogressed Breaksea Gneiss indicates peak metamorphic pressures of ca. 15-16kbar accompanied by growth of omphacitic clinopyroxene, probably before emplacement of the Malaspina Gneiss, making these the highest grade rocks discovered to date in Fiordland. Intrusive contacts between the younger Malaspina Gneiss and adjacent rocks are still widely preserved indicating that the DSSZ does not enclose the entire circumference of the WFO in southwest Fiordland. Trondhemitic leucosomes with locally abundant peritectic garnet define a narrow thermal aureole a few 100 metres wide along the intrusive margins of the Malaspina Gneiss in Paleozoic psammites and amphibolites, unnamed older gabbro, and the Cretaceous Supper Cove Orthogneiss. Rare xenoliths confirm the intrusive relationship between Malaspina Gneiss and the adjacent units. Reconnaissance thermobarometry indicates pressures of ca. 10-12kbar during aureole development in Wet Jacket Arm. Amphibolite facies assemblages remain outside the aureole indicating that equilibration to granulite facies assemblages only occurred within the immediate vicinity of the Malaspina Gneiss suggesting reaction kinetics were an important control on the extent to which granulite facies assemblages developed in country rocks intruded by the WFO.

ORAL

LATE NEOGENE BARNACLE-RICH LIMESTONES, MATAPIRO-OMAHU, HAWKE'S BAY: THEIR LIFE FROM DEPOSITION TO UPLIFT

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A new GIS-based 1:40,000 scale geological map has been produced for the Matapiro-Omahu region, between the Tutaekuri and Ngaruroro Rivers, west of Napier city in eastern North Island. The rocks occupy the southern part of the regional Matapiro Syncline, are of late Pliocene-early Pleistocene age (Nukumaruan), are contained within the Petane Group, and comprise a cyclothemic succession of formations of terrigenous mudstone and limestone, with some conglomerate.

The three limestone units, in ascending order the Tangoio Limestone, Matapiro Limestone and Puketautahi Limestone, tend to stand proud in the landscape and provide good mappable horizons, while the intervening mudstones are poorly exposed. The Tangoio Limestone is restricted to the eastern limb of the Matapiro Syncline and grades to fossiliferous greywacke gravels (Sherenden Conglomerate Member) towards the west. The pebbly Matapiro Limestone is distributed throughout the southern part of the syncline, while the Puketautahi Limestone caps the hills on the western limb.

Sedimentological and petrographic analyses of the three limestones indicate that they are all barnacle-dominated with an increasing proportion of bivalve material up through the units, and with small amounts of bryozoans, echinoderms, benthic foraminifera, and occasional serpulids and red algae. Skeletal grains are commonly microbored. The rocks are mainly skeletal grainstones, less commonly skeletal packstones, and carbonate contents average 70-80%. Cements involve a variety of calcite spar fabrics, including syntaxial rim, isopachous fringe, meniscus and equant types, usually non-ferroan and with non- to dull cathodoluminescence. The spar cements were precipitated during shallowest burial (likely no more than about 200 m), involving mild pressure-dissolution of skeletons, and during subsequent uplift when dissolution of aragonitic shells provided a later stage of equant and micro-equant cement. Most of the limestones retain moderate porosity in outcrop.

The skeletal composition is consistent with deposition of all three limestones in a similar high energy, current swept seaway environment (Ruataniwha Strait) at inner shelf depths. Deposition was associated with rapidly transgressing seas coupled with low terrigenous sediment supply, forming relatively thin transgressive systems tract (TST) carbonate deposits. Highstand systems tract (HST) deposits are represented by the intervening, thicker, mid-shelf mudstones, which accumulated over longer durations than the limestones. Four major cyclothems (TST + HST) are identified for the mapped succession, the depositional settings being primarily controlled by glacio-eustatic sea level fluctuations near the opening of the Ruataniwha Strait into Hawke Bay in the Nukumaruan, during a period of slow basin subsidence followed eventually by uplift and exhumation of the whole succession.

ORAL

FISH, FRUSTULES, FRUITS, A FLOWER - AND LOTS OF LEAVES: AN INVESTIGATION INTO THE BIOTA OF AN EARLY MIOCENE MAAR LAKE

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Preliminary findings from a finely varved diatomite deposit formed during the Early Miocene in a maar lake near Middlemarch, Otago are presented. The varves are alternately dark and light and the light coloured layers are made up almost entirely of diatom frustules with some freshwater sponge spicules. The diatom flora is overwhelmingly dominated by a single species, Encyonema jordanii (Grunow) Mills. The sponge(s) probably encrusted plant material such as stems of water plants and dead leaves. Limited excavations in the upper few metres of the deposit have yielded several entire fish skeletons up to 15 cm long that belong to a new species of galaxiid. The diatomite contains numerous fruits and seeds in different states of preservation; these are mainly small and difficult to identify, but some of the larger fruits may be myrtaceous. One 20 mm diameter flower, Fouldenia staminosa Bannister, D.E.Lee and Raine, 2005, was preserved complete with anthers from which excellently preserved pollen was collected and preparations made for both light and electron microscopy. Identification of pollen and spores from the matrix on the same bedding plane as the flower produced a list of more than 55 pollen types, including new taxa (Bannister et al. 2005). Angiosperm leaves are numerous; those collected from the layers of diatom frustules are better preserved than those from darker, more organic layers and we surmise that mucus from the vast numbers of diatoms has assisted in preservation of the leaf material. Some leaves have both upper and lower surface cuticles present and cuticle preparations for over 150 individual leaves representing several families and genera, some with close affinities to extant genera, have been made. The leaves appear to be mainly from forest trees and lianes with moderately thick cuticles; as yet no herbaceous leaves or examples of leaves with thin cuticles have been found. Leaf venation is not always visible but various methods for clearing leaves to expose venation, and methods of leaf preservation, have been developed. A database incorporating cuticular features and leaf architecture is being compiled together with a reference collection of cuticles from extant trees and lianes from both New Zealand and Australia.

Bannister, J.M., Lee, D.E., & Raine, J.I. 2005: Morphology and palaeoenvironmental context of *Fouldenia staminosa*, a fossil flower with associated pollen from the Early Miocene of Otago, New Zealand. *New Zealand Journal of Botany 43*: 515-525

ORAL

TECTONIC EVOLUTION OF THE SOUTH FIJI BASIN: UNCLOS HELPS TACKLE REGIONAL TECTONICS

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Marine surveys to study the evolution of remnant arcs and backarc basins north of New Zealand have been complemented by United Nations Convention on the Law of the Sea (UNCLOS) surveys by three countries – France, New Zealand and Australia – with potential extended continental shelf claims in the region. The UNCLOS factor allowed 9 cruises to focus on the region in the past 9 years, collecting approximately 30,000 km of seismic reflection (5,000 deep crustal), 263,700 sq km of swath bathymetry, and 70 dredge samples. Feedback through sharing or publishing data and joint participation allowed efficient planning and deployment of academic and UNCLOS cruises. Two models for South Fiji and Norfolk basin evolution arise from current studies: at the level of the Three Kings Ridge – Norfolk Basin – southern South Fiji Basin both involve Pacific trench roll-back and southward propagating spreading, but one also uses two subduction systems and arc-continent collision. Linked spreading of the Norfolk Basin and South Fiji Basin is invoked in both models, but the veracity and geodynamics of the link are not investigated. A growing body of petrological and radiometric evidence and the tectonics of the New Zealand continental margin point to tandem Early Miocene spreading of the South Fiji Basin and Norfolk Basin despite published magnetic interpretations that would confine South Fiji Basin spreading to the Oligocene. The Franco-NZ NOUCAPLAC-1 cruise, the last cruise relevant to UNCLOS in this region, included a scientific objective to investigate the South Fiji Basin–Norfolk Basin link in the critical area bounded by the Loyalty Ridge, the Cook Fracture Zone, the Bounty spreading centre and the Julia Lineament with swath mapping, magnetics and seismic reflection. Initial results show a complex bathymetry where a possible link between the Bounty spreading centre and the Cook Fracture Zone involves ridge propagation, overlapping spreading centres, rift blocks and overprinting volcanoes. The link to the Julia Lineament was not adequately tested due to sparse coverage. Closer to the Loyalty Ridge, a thick, faulted sedimentary basin was found.

POSTER

INITIAL WAVEHEIGHT OF LANDSLIDE TRIGGERED TSUNAMIS: APPLICATION OF A SIMPLISTIC EMPIRICAL APPROACH

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The seafloor associated with New Zealand's active margin is locally susceptible to slope failure. In areas of frequent large earthquakes, steep slopes, and high sediment load, submarine landslides are extremely common. Large failures, particularly in shallow water, may be capable of generating damaging tsunami waves. Whilst there have been few studies to model landslide tsunami in New Zealand (e.g., Magill, 2001; Walters et al., submitted), NIWA is developing a growing database of submarine landslide distribution and geomorphologies derived from high-resolution multibeam bathymetry data. These data offer an opportunity to evaluate landslides as a potential source of tsunami waves.

Studies by other workers (Watts et al., 2003) involving simple laboratory experiments of slope failure, derived empirical relationships between landslide geometry, water depth, various slope parameters, and the initial tsunami wave height generated from the draw down of the ocean surface over a submarine landslide failure. Whilst there are severe limitations in such an approach, and consequently very large uncertainties in the tsunami wave heights at the source, these relationships have been applied to real field examples on continental margins (e.g., McAdoo et al. 2000, McAdoo & Watts, 2004, de Lange & Moon, 2004). Although simplistic the approach offers a method of rapidly approximating the potential tsunami wave heights from a large landslide population.

In this study we apply these empirical relationships to evaluate tsunami wave heights generated at the source of landslides, by analyzing the geomorphology of a subset of nearly 300 landslide failures recognised in Cook Strait and the Bay of Plenty. The landslides studied are from a wide range of water depths, from about 100 m to > 2000 m, and the majority has surface areas of < 5 km^2. The method involves the measurement, within an ESRI ArcGIS framework, of a number of the landslide scar parameters from bathymetric DTMs, including maximum width, length, thickness via the head scarp height, slope angle, and water depth. The height of the initial tsunami waves were calculated using an empirical relationship developed for translational slides.

The results of the calculations indicate initial draw-down tsunami wave heights of up to 6 m at the source of the landslides. Tsunami experts at NIWA suggest the uncertainties on the wave heights may be as much as a factor of three. In the absence of dating of individual landslides, we constructed relationships between frequency (annual rate of return) and initial wave height, by estimating a range of return times that might conceivably cover the entire populations studied. We correlated these relationships with an estimate of initial wave height for the giant Ruatoria Landslide, and we note differences between the Cook Strait and Bay of Plenty populations. Our study is strictly limited to the initial wave heights at the landslide sources and does not consider the propagation, amplification, and attenuation of the waves approaching the coast.

POSTER

TOWARDS A CLIMATE EVENT STRATIGRAPHY FOR NEW ZEALAND OVER THE PAST 30,000 YEARS

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A poster summarizing representative evidence for environmental conditions and climate change in New Zealand during the past 30,000 years is an initial contribution to the INTIMATE (INTegration of Ice-core, MArine and TErrestrial records) initiative of the INQUA (International Union for Quaternary Research) Paleoclimate Commission. The aim of this international initiative is to improve knowledge of the nature, timing and regional-to-global extent of climatic and environmental changes that have occurred since the Last Glaciation.

The poster depicts key New Zealand onshore and offshore records that include the Last Glacial Maximum and/or the Last Glacial-Interglacial Transition from a variety of latitudes and elevations. Inset maps show New Zealand's oceanographic setting, extent of glaciers, and distribution of vegetation zones at approximately 22,000 calendar years ago and at modern times (incorporating the inferred vegetation distribution at c. 1250 AD, before deforestation associated with human settlement). The calendar-age timescale is based on a combination of volcanic ash (tephra) and radiometric dates. Ice core records from Antarctica and Greenland are shown for comparison with New Zealand records.

High-resolution records are derived from sediment-filled volcanic craters in Auckland (total carbon, carbon isotopes and pollen), wetlands in northeast North Island, central North Island and western South Island (pollen), marine sediments off eastern North Island (oxygen isotopes), and stalagmites in caves in northwest South Island (carbon and oxygen isotopes). In addition, the poster includes a range of lower resolution or fragmentary records of climatic events, based on glacial landforms and deposits (central Southern Alps, South Island), river terraces and deposits, loess deposits (eastern North and South Islands), and aeolian quartz silt in non-quartzose, loess-like, andesitic tephric deposits of western North Island.

The poster reflects work-in-progress and aims to assist comparison of the New Zealand paleoclimatic records with those from the wider Australasian region and elsewhere. The immediate goal is the establishment of an Australasian-INTIMATE climate event stratigraphy by the New Zealand and Australian paleoclimate communities, for presentation at the 2007 INQUA Cairns Symposium.

POSTER

LATE QUATERNARY DISPLACEMENTS ON THE WAITANGI FAULT, AVIEMORE DAM, SOUTH ISLAND, NEW ZEALAND

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Aviemore Dam was constructed across the Waitaki River valley in the mid-1960s. The dam straddles the steeply WSW-dipping Waitangi Fault. At the time of construction, no evidence of late Quaternary movement was documented on the fault. However, in the mid-1990s, dam safety review investigations unearthed evidence of late Quaternary deformation, and this led to the detailed paleoseismological investigations that provided data for displacement characterisation of the fault and subsequent evaluations of dam safety under direct fault rupture loadings.

The primary paleoseismology investigation method was the excavation of 10 trenches, the largest of which was up to 10 m deep and 180 m long, across faults and folds within 1 km of the dam, accompanied by geological mapping of surface exposures and landforms. Detailed logging of the trench walls (typically 1:20 scale) documented the geometry of Late Quaternary deposits and the locations, amount and sense of slip of the most recent fault displacements. Over 30 samples were dated to constrain the timing of past fault movements, using, where possible, at least two duplicate methods of luminescence, and complemented in a few instances by radiocarbon.

The investigations documented two, and possibly three, surface rupture fault movements on the Waitangi Fault in the last c. 23,000 years, with the most recent movement between 13,100 and 14,100 years ago. These ruptures were located on, or up to 6 m west of, the bedrock fault that juxtaposes Mesozoic- and Tertiary-age rocks (respectively east and west of the fault). Relative upthrow has been to the west in the late Quaternary. This represents a reversal from a net westerly downthrow that accumulated during the late Tertiary as shown by the Mesozoic versus Tertiary rock relationships across the fault.

The two most recent surface ruptures had single-event, west-side-up, vertical separations of c. 0.5 m (penultimate) and c. 1.5 m (most recent). Slickenside-lineations, and other slip indicators, show an oblique right-lateral – reverse sense of late Quaternary rupture, with a horizontal (H) component greater than the vertical (V) component (ratios of displacement in the range of 1H:3V to 1H:1V). In addition, a zone of "small-scale" late Quaternary faults and folds, with single-event vertical separations of up to 0.7 m, extends up to at least 150 m west of the Waitangi Fault.

The fault displacement characteristics documented from the field investigations were subsequently used to derive earthquake performance assessments for the dam, and to evaluate dam safety under direct fault rupture loadings.

ORAL

THE DEVELOPMENT OF ANTARCTIC GLACIAL HISTORY OVER THE LAST FIFTY YEARS

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Fifty years ago it was thought that the Northern Hemisphere had experienced 4 glacial episodes over the last two million years, and no-one supposed the Southern Hemisphere would be much different. That view was changed radically in 1973 with the first Antarctic offshore drilling by the Glomar Challenger in the Ross Sea. The cruise, which was led by Denny Hayes and Larry Frakes and included three New Zealanders, Derek Burns, Peter Webb and me, cored through glacial sediments that dated back 25 million years. The cruise that followed, Leg 29, led by Jim Kennett and Bob Houtz, cored a series of deep ocean sites to the north that covered the Cenozoic Era. This yielded the first oxygen isotope curve, from which they concluded there was Antarctic cooling and sea ice in the latest Eocene, and the formation of an ice sheet like today's in the middle Miocene.

The Leg 29 results could not, however, resolve the relative contributions of ice volume and temperature to the isotope signal, and gave no indication of the style or extent of Antarctic glaciation. Therefore further drilling was planned both through DSDP in other parts of the Antarctic margin (Antarctic Peninsula and Prydz Bay) and through the use of a land-based drilling system from the fast ice of McMurdo Sound, where NZ-led efforts had identified a sedimentary basin suitable for drilling close to the edge of the Transantarctic Mountains (and the East Antarctic ice sheet).

This drilling (www.geo.vuw.ac.nz/croberts), along with recent high-resolution deep-sea isotope records, has now led to the following history.

Around 34 Ma an ice sheet reaches the coast on both sides of Antarctica. Subsequent ice sheets advanced and retreated on Milankovitch frequencies, causing variations in eustatic sea level of the order of 50 m through Oligocene and early Miocene times. Low beech forest persisted around the coast throughout this period.

- Around 14 Ma the ice sheet developed a persistent core with margins close to its present limits and largely frozen to its bed. During the warm Pliocene coastal Antarctica was warmer by several degrees, but there is no firm evidence that the East Antarctic ice sheet collapsed.
- From 2.5 Ma to the present the Antarctic ice sheet has responded to sea level variations induced by Northern Hemisphere ice sheets, but only on a scale of ~15 m of sea level equivalent.
- Future drilling by the ANDRILL consortium will investigate Quaternary behaviour of the Ross Ice Shelf, and Antarctic climate during the middle Miocene transition, in the McMurdo area (http://andrill.org/).

ORAL

THE CAPE ROBERTS PROJECT: TECTONIC AND CLIMATIC HISTORY OF THE VICTORIA LAND COAST, ANTARCTICA OVER THE LAST 34 MA.

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From 1997 to 1999 the Cape Roberts Project (http/www.geo.vuw.ac.nz/croberts) drilled 3 holes off the Victoria Land coast at 77.0ºS and 163.7ºE. The project was a cooperative venture between scientists, administrators and Antarctic support personnel from 7 countries. The aim was to investigate the early history of the East Antarctic ice sheet and the West Antarctic Rift System, using a 55 tonne drilling system set up 13 to 16 km offshore on fast sea ice. Water depths ranged from 153 m to 295 m and core recovery for the 1680 m drilled was 95%. The cores are a high quality nearshore marine sedimentary record for the period from 17 to 34 Ma ago and are well-dated from volcanic ash, biostratigraphy, Sr isotopes and magnetostratigraphy.

Key findings are:

i. Provenance studies indicate the Transantarctic Mountains had achieved most of their present height by 34 Ma. Apatite fission track studies show Cenozoic denudation began at ~55 Ma, but CRP core studies show that most of the 1500 m of subsidence on the western margin of the Victoria Land Basin took place from 34 to 29 Ma, slowing down to almost none by 17 Ma, and none since that time (Wilson et al., *Geology*, submitted). This changes the established view of the West Antarctic Rift System.

ii. The stratigraphy is largely cyclic repetitions of shallow glacimarine facies, with well-dated cycles of glacial advance and retreat around 24 Ma showing that the Antarctic ice sheet responded to orbital forcing at that time, much as the Northern Hemisphere ice sheets have done in the Quaternary (Naish et al., *Nature*, 2001).

iii. Pollen records show the cooling of the Victoria Land coast from a temperate climate (>34 Ma) to a cool temperate climate (34 to ~17 Ma) (Prebble et al, Palaeogeography, Palaeoclimatology, Palaeoecology, in press). This record shows no hint of the late Oligocene warming inferred from deep-sea isotopes by Zachos et al (Science, 2001). An alternative explanation for the apparent warming has now been provided by Pekar et al (*Palaeogeography, Palaeoclimatology, Palaeoecology*, in press).

iv. Rapid sedimentation and multiple dating techniques on CRP core have provided a new potential calibration point for the Oligocene-Miocene boundary at 23.7 Ma (Wilson et al., *Geology*, 2002).

v. A 2-m-thick shell bed within 43 m of Quaternary strata in CRP-1, and dated at 1.1 Ma, records a "super-interglacial" period (MIS 31) when the Antarctic coast was ice-free and significantly warmer than today (Scherer et al., *Nature*, in review).

Detailed results from individual drill holes can be found in 10 issues of the journal Terra Antartica between 1998 and 2001.

POSTER

CRETACEOUS-EOCENE TRANSGRESSION MARKED BY CHANGES IN SEDIMENT PROVENANCE AND GLAUCONITE FORMATION, BROKEN RIVER TO WAIPARA/IRONCREEK FORMATIONS

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Detailed provenance analysis and glauconite morphology of the Broken River and overlying Ironcreek/Waipara greensand Formations were conducted at 4 localities: the Mandamus-Dove River confluence, Waipara River, Avoca, and Castle Hill basin. The basal Broken River Formation is a fluvial boulder conglomerate interbedded with sandstones, mudstones, and coal dated as Haumurian (L. Cretaceous) by pollen. The transgression is marked by a gradual drowning of the fluvial conglomerates with glauconite appearing in the beds immediately overlying the conglomerates in all localities. These estuary deposits contain a mixture of nascent, micaceous, and evolved/mature types of glaucony, previously described as Types A and B by McConchie and Lewis (1978). In transgressive successions, glauconitization commonly post–dates coarse grained sedimentation in nearshore areas. Upsection, evolved/mature glaucony dominates, in some beds formed in situ (autochthonous) and in other beds transported from nearby (para-autochthonous) to line foresets. The age of the greensand units is Mangaorapan - Whaingaroan (Early Eocene Late Eocene). The extremely low sedimentation rate from Cretaceous to Eocene is necessary to form the evolved/mature type of glauconite.

Clast counts from the basal conglomerates indicate derivation from very local sources, the underlying Torlesse greywackes and/or the Mandamus Igneous Complex. Quartzose sandstones plot in the interior craton province in QFL plots for both Broken River and Waipara/Ironcreek Formations. Sandstone lithics are probably derived from Torlesse greywacke. Alkali feldspars dominate over plagioclase indicating a probable felsic plutonic source. SEM-cathodoluminescence on quartz grains indicates a mixture of plutonic and metamorphic quartz with minor volcanic input. Plutonic grains are identified by microcracking features, and are possibly derived from western Province batholiths such as the Karamea or Separation Point Batholiths. Polycrystalline/dark CL quartz grains indicate a relative high-grade metamorphic source such as the Haast/Otago Schist, while dark CL monocrystalline quartz grains indicate a low to medium metamorphic grade, possibly the Alpine schist, Otago Schist, or Greenland Group. Volcanic quartz is zoned with straight extinction and was most likely derived from the Cretaceous Mt Somers rhyolites and not the underlying Mandamus Igneous Complex due to a lack of coarse quartz crystals.

The provenance analysis suggests local derivation of sediments while fluvial deposition occurred followed by more distal derivation once transported in the nearshore marine setting. The glauconite analysis indicates extremely low sedimentation rates with autochthonous/para-autochthonous glaucony formation in nearshore marine settings, possibly even estuary environments.

POSTER

SEDIMENTOLOGY OF THE MAHOENUI GROUP, KING COUNTRY REGION

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The Mahoenui Group is of Early Miocene age (Otaian Stage) and accumulated in the King Country region of western North Island. It represents a discrete depocentre that formed during the early Otaian and became structurally inverted during the late Otaian or early Altonian. The present area of outcrop is probably less than the original extent of the depocentre, as its southern margin is buried beneath younger formations, and its eastern margin is erosionally truncated within the Hauhangaroa Range. The western margin was bounded by the Tongaporutu-Herangi structural high, which was being deformed (uplifted) during sedimentation. The Mahoenui Group conformably overlies the Oligocene Te Kuiti Group in the northern and eastern parts of the basin where this contact is exposed, and marks dramatic and sudden deepening from shelfal to bathyal depths, corresponding to a lithological change from carbonate to siliciclastic sediments. Mahoenui Group is unconformably overlain by late Early Miocene (Altonian) Mokau Group in the north and west, and by the middle Miocene (Lillburnian) Otunui Formation in the south and east.

Mahoenui Group comprises a flysch succession in the south (Taumarunui Formation) and a massive mudstone facies in the north (Taumatamaire Formation). Facies analysis of the Taumarunui Formation confirms earlier oil company investigations that it comprises turbidities and intervening hemipelagic mudstone, that would have accumulated as broad submarine fan deposits at bathyal depths. The scale of the fans is larger than the largest of the outcrops, some of which are hundreds of metres long. Surprisingly, there is no evidence of a regressive shelf or slope succession at the top of the group, which was probably thin and eroded during the inversion phase prior to accumulation of younger units. The Taumatamaire Formation comprises mainly massive mudstone. Along the western margin (Herangi High) the mudstone is interspersed with several limestone members (Awakino Limestone; Black Creek Limestone); the carbonate sediments were sourced along the contemporary rocky shoreline of the Herangi High underlain by Murihiku basement, and dispersed across a very narrow east-facing shelf and down the slope into the basin.

Paleocurrent measurements derived from flute casts and tool marks indicate that the flysch facies were sourced from the south, and the depositional system probably prograded to the north. Muddy sediment and carbonate were locally derived from basement exposed along the Herangi High, but this was probably a minor source. The sandstone beds are cemented with calcite, and glauconite comprises a surprisingly high proportion of their content (10%). Mica is an accessory mineral, suggesting that schistose or gneissic terrane (in South Island) contributed sediments to the basin.

POSTER

MANTLE OR CRUST? FIRST RESULTS FROM A DETAILED ACTIVE-SOURCE SEISMIC EXPERIMENT ACROSS THE TAUPO VOLCANIC ZONE

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Seismic studies of the central North Island have consistently shown the Taupo Volcanic Zone to be a region of attenuated continental crust underlain by mantle of anomalously low seismic velocity (~7.4 km.s^{-1}). However, the nature of the crust-mantle boundary beneath the rift and, in particular, the position of the Moho remain contentious. Active source data acquired during the 2001 NIGhT experiment detected two prominent reflectors at depth: a ~ 15 km deep horizon (PmP1) and an unusually strong set of reflections from an interface at ~30 km (PmP2). These NIGhT data have given rise to divergent models of the lower-crust and upper-mantle. Harrison & White (2004) place the base of the crust at 30 km (= PmP2) and infer that the 15 km interval between PmP1 and PmP2 is under-plated and/or intruded lower crust. Stratford & Stern (2004) suggest that the Moho lies between 15 and 20 km depth and interpret the PmP2 reflections as being from the top of an intra-mantle fluid/melt body of unknown thickness but limited lateral extent. We present preliminary results from a recently completed active source seismic experiment (MORC) that seeks to address the issue of what constitutes Mantle OR Crust beneath the TVZ.

Building upon the results of NIGhT, the MORC experiment was designed to provide a enhanced data set to examine the character of the 30 km deep PmP2 reflector. Nine dynamite shots of between 500 and 1300 kg were detonated into a 120 km long array across the northern end of Lake Taupo. The shot geometry and the deployment of 714 receivers (600 IRIS Texans, 96 geophones on multi-channel systems, and 18 3-component seismometers) with an average spacing of ~200 m provides a ten-fold increase in spatial resolution relative to the NIGhT data. Reflections from the 15 km deep PmP1 horizon are present in the MORC data, however the dominant features are arrivals from PmP2 at a depth of ~ 30 km. The occurrence and amplitude of the PmP2 reflections are strongly dependent on both the shot position and receiver offset. Initial ray-tracing of the PmP2 reflections suggests the interface is of limited lateral extent and located directly below the active (eastern) part of the main TVZ rift. For stations with both PmP1 and PmP2 arrivals it is possible to directly compare the relative amplitude of these two phases. At large offsets the amplitude of PmP2 reflections are at least 5 times those of PmP1 phases, which are modelled as being from a < 6.0 km.s^{-1} to 6.8 km.s^{-1} velocity boundary (Stratford & Stern, 2004). These results indicate the PmP2 reflections must be due to a large change in the velocity and/or physical properties of rocks at 30 km depth.

Further work to characterise the crust-mantle structure beneath the TVZ will include ray-trace and tomographic modelling of the combined MORC and NIGhT datasets, the production of a stacked low-fold seismic section, and detailed analysis of the AVO properties of the PmP2 and other reflectors.

ORAL

SEAFLOOR STRUCTURAL GEOMORPHIC EVOLUTION IN RESPONSE TO SUBDUCTION PROCESSES, POVERTY BAY INDENTATION, NEW ZEALAND

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The >4000 km^2 Poverty Bay Indentation, in the northern sector of the Hikurangi subduction margin, consists of a well-developed canyon system, small accretionary wedge, landslide scars and debris flow deposits. Outboard of the Hikurangi trench the subducting plate incorporates the Hikurangi Plateau, a section of anomalously thick Mesozoic age oceanic crust (10-15 km) studded with seamounts and guyots (flat-topped seamounts).

Morphologically the Hikurangi margin changes markedly from south to north of the Poverty Bay Indentation. To the south, the margin is characterised by a thick trench-fill turbidite section and a wide, low-taper accretionary wedge with numerous thrust ridges and slope basins. To the north of the indentation the margin is narrow, relatively steep, and characterised by non-accretion and tectonic erosion associated with reduced sediment supply, seamount/guyot subduction, and gravitational failures. The transition between the characteristics of the two sectors is evident in the study area with the developed accretionary wedge and gentler slopes in the southern half contrasting with the steep slopes and numerous failures to the north of the canyon system.

High quality bathymetric images of the Poverty Bay Indentation and adjacent regions of the Hikurangi subduction zone acquired by NIWA using a SIMRAD EM300 multibeam system provide excellent seafloor morphologic resolution covering the entire continental slope from 50 – 3500 m water depth. These images have been converted into a Digital Elevation Model (DEM) allowing three-dimensional analyses of the seafloor.

Initial DEM interpretations suggest that:

i. seamount impact significantly influences the structure/tectonic evolution, and submarine geomorphology of the inboard slope of the Hikurangi subduction zone, including the generation of large-scale gravitational collapse features;

ii. large gully systems located at the shelf – slope boundary are source areas for mega-debris flows recognised in mid-slope basins;

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.

v. The addition of high quality 3.5 kHz single-channel and multi-channel seismic reflection data complements the morphological and structural surface interpretation. In particular, this allows investigation into the impact of thrust fault loading and seamount subduction on the margin at a mid to deep crustal level. Correlation between the surface expressions of these processes and the underlying tectonics will be the next stage in this project.

POSTER

TRACE ELEMENT GEOCHEMICAL EVIDENCE FOR A LACUSTRINE ENVIRONMENT OF DEPOSITION OF LATE ARCHAEAN FORTESCUE GROUP STROMATOLITIC CARBONATES, WESTERN AUSTRALIA

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The late Archaean Fortescue Group (2.78-2.63 Ga) in the Pilbara Craton, Western Australia, records a transition in depositional environments from subaerial in the lower part of the group, to marine in the upper part of the group. Stromatolitic carbonates (i.e. microbialites that formed by precipitation of minerals due to metabolic activity or decay of microbial communities and/or associated organic matter) occur throughout the stratigraphic section at various levels, and their trace element geochemistry is used to make inferences about the ambient water from which these carbonates were precipitated. In particular, rare earth elements (REE) and Yttrium were analysed to address whether

i. Fortescue carbonates display a marine geochemical signature or show compositional similarity to modern-day lacustrine waters and their deposits and

ii. to identify temporal trends in the geochemistry that may be consistent with a transition from deposition in a subaerial/lacustrine to marine environment.

Detailed inspection reveals that Fortescue microbialites lack trace element characteristics that are diagnostic of carbonates deposited in a marine environment. In particular, the Fortescue Group samples lack distinct La (expressed as La/[3Pr-2Nd] in shale-normalised diagrams) and Gd $[Gd/(2Tb-Dy]_{shale}$ anomalies and supra-chondritic Y/Ho ratios, which are well-developed in seawater carbonates formed throughout Earth history, from at least 3.4 Ga. The late Archaean microbialites also lack depletion of the light REE relative to the middle and heavy REE when shale-normalised, in contrast to seawater and marine carbonates, which are typically HREE enriched. Importantly, no temporal trends in the geochemistry that is consistent with a marine deposition can be identified as a function of the relative stratigraphic height of the carbonates in this study.

It is concluded, on the basis of the trace element geochemical evidence presented herein, that late Archaean stromatolitic carbonates of the Fortescue Group record deposition in a lacustrine environment, to the top of the group. Our study demonstrates that trace element geochemistry is a powerful tool to constrain depositional environments of ancient (and modern) carbonate rocks. To our knowledge, our study is the first to document the geochemical characteristics of carbonates formed through microbial activity in an ancient lake setting, with important implications for the development of early life.

POSTER

THE ORIGIN OF NEW ZEALAND: CAMBRIAN INTRA-OCEANIC ARC ACCRETION TO THE GONDWANA MARGIN CONSTRAINS THE LOCATION OF PROTO-NEW ZEALAND

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Data from New Zealand (NZ) and northern Victoria Land (NVL, Antarctica) indicate strongly that the Cambrian Devil River intra-oceanic arc accreted to the Gondwana margin in the Middle to Late Cambrian. The close similarity of NZ arc rocks and immediate post-arc sediments to those of northern Victoria Land (Antarctica) firmly place the two regions in the same tectonic framework and imply paleogeographic proximity. The arc & back-arc setting in NZ and NVL contrasts with accepted models of fore-arc collision for Cambrian orogenesis in Tasmania and southern Australia.

Combined sedimentological, paleontological, geochemical and geochronological data from NZ and NVL show that by the Middle to Late Cambrian, the accreted arcs were partially buried by the deposits of major fluvial systems derived from sources both within the arc and within the Gondwana continent. In NZ, sandstone clasts of Precambrian Gondwana origin first appear in channelised marine conglomerate in the youngest part of the Tasman Formation (Boomerangian stage) and are joined, in the succeeding marginal marine to fluvial Lockett Conglomerate (Mindyallan stage), by continental-arc plutonic clasts. In NVL, rare clasts of continental-arc plutonic rocks occur in Boomerangian and older rocks, but conglomerates with arc plutonic clasts become abundant only in the upper part of the Mariner Group (Mindyallan and Idamean stages). These conglomerates are marine and interbedded with turdidites and fossiliferous mudstones. The fluvial Carryer Conglomerate is probably late Idamean or younger. Thus the first appearance of coarse fluvial deposits is 1-2 million years later in NVL than in NZ.

There is considerable evidence that the Ross Orogeny was the result of oblique convergence and that the tectonic-plutonic maximum progressed from south (near polar) to north. In this context, back-arc basin closure and arc accretion most probably progressed from south to north. The data above suggest that the NZ portion of the back-arc basin and arc lay to the south of the NVL portion, possibly east of southern Victoria Land.

Comparisons of post-Ross-Delamerian sedimentation of Latest Cambrian-Ordovician age in mainland Australia and Antarctica with that in New Zealand show significant differences. Australian and Antarctic Ordovician rocks are very thick and almost entirely detrital, whereas the NZ Ordovician includes thick developments of carbonate rocks (Arthur Marble, Takaka terrane). Only in Tasmania are Ordovician carbonates well developed but Tasmania is now generally considered to have been a crustal block separate from Australia. Together, these data suggest that the attachment of the NZ portion of the arc to the continental margin may have been short-lived and that the proto-NZ block was rifted away from the Gondwana margin in the early Ordovician and became an isolated crustal block within the broader Lachlan belt. In contrast the Buller terrane closely resembles the western Lachlan fold-belt.

ORAL

LABORATORY MODELLING OF SEISMICALLY TRIGGERED MOUNTAINSIDE COLLAPSES

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Strong seismic events can initiate slope failure leading to devastating mass movements of a wide range of sizes and types. Earthquake-induced rock avalanches represent one of the most damaging of all seismic hazards. This research project focuses on the kinematic response of mountain slopes to strong seismic shaking. We are designing a physical laboratory model at small scale (1:10,000) that will simulate controlled seismic waves propagating through a three-dimensional mountain model. The relative position of the mountain to the direction of the incoming seismic wave field, topographic modification and local resonance effects are likely to be important factors for triggering deep-seated failures within the mountain leading to catastrophic mountainside collapses and characteristically bowl-shaped source scars. Seismic waves interfering with local geological and topographical conditions will produce site-specific ground motions within the mountain edifice. The measurement of ground motion at different positions of the small-scale mountain surface will provide information on the effect of slope topography on strong seismic ground motion. The combination of the physical laboratory modelling data with a numerical analysis will then be used to evaluate dynamic internal stress fields developed, to infer the location of potential deep-seated failure surfaces, and to estimate possible volumes of seismically triggered mass movements. In addition to the laboratory modelling a seismic field experiment will provide an indication of the degree to which the small-scale model data can be extrapolated to comparable full-scale field situations. Detailed geotechnical field investigations of coseismic landslide sites within the Southern Alps of New Zealand (e.g. Acheron, Craigieburn rock avalanche) will provide information about specific rock fabrics and morphological parameters and will be used as a reference to improve and calibrate the physical laboratory and numerical modelling. This research project is a combination of physical laboratory and numerical modelling techniques with seismic field tests and geotechnical investigations to deepen the understanding of coseismic landslide initiation within bedrock mountain edifices. It can be seen as a first attempt to set up a deterministically-based methodology for evaluating mountain slopes susceptibility to failure during strong earthquakes and for predicting the impacts of future coseismic landslides.

POSTER

RECENT ALPINE FAULT EARTHQUAKES

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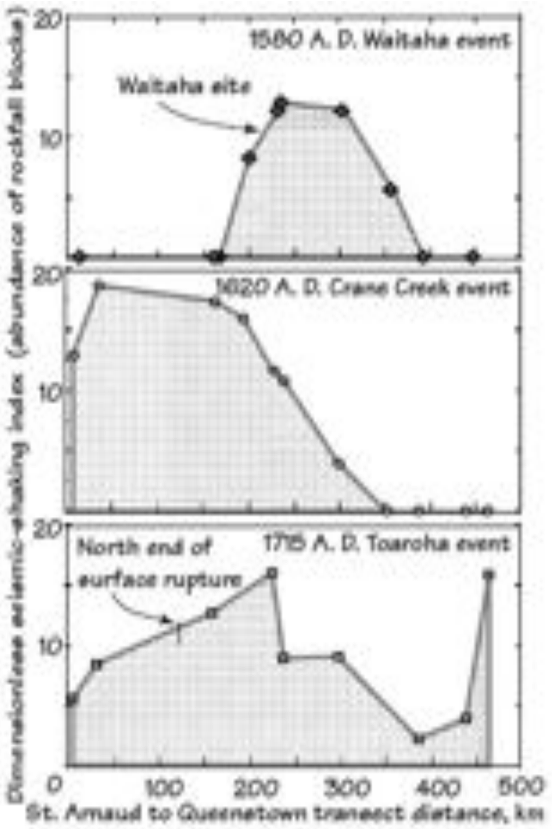
Tree-ring analyses and lichenometry precisely date a recent cluster of three Alpine fault earthquakes, and describe their seismic shaking intensities. Marked suppressions of annual growth rings of New Zealand cedar (*Libocedrus bidwillii*) at seismically sensitive Oroko Swamp and Alex Knob are attributed to prehistorical surface ruptures on the nearby Alpine fault. These forest disturbance events were synchronous (± 2 yr at 2α) with regional rockfall events dated by lichenometry using *Rhizocarpon* subgenus *Rhizocarpon*. Using the names of previous workers these are, ± 5 yr, the 1715 Toaroha, 1615 Crane Creek, and 1580 A. D. Waitaha events.

This cluster of magnitude Mw ~7 earthquakes occurred in a brief time span of only 135yr. The Waitaha event was the smallest, with a surface rupture limited to the central Alpine fault. Crane Creek was the largest event with a surface rupture that probably extended from the Nelson Lakes to the central Alpine fault. The Toaroha event consisted of two surface ruptures, one from north-central and the other on the southern Alpine fault.



This figure shows trends in seismic shaking based on spatial variations in the abundance of rock-fall blocks dating to times of the three most recent prehistoric Alpine fault earthquakes. An index value of 10 or more is about equivalent to a Mercalli seismic shaking intensity of 7 or more.

ORAL

EXPLORING CONSTRAINTS ON ANTIQUITY OF TERRESTRIAL LIFE IN NEW ZEALAND

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The New Zealand land surface appears to be less than 25 million years old.

It therefore follows that the modern terrestrial biota is not descended from archaic ancestors residing on proto-New Zealand (Zealandia) when it broke away from Gondwana. Rather, it has evolved from accidental arrivals since New Zealand became emergent. For all that, the modern biota is indeed derived from lands of Gondwanan heritage.

Our first statement is a bold assertion. It is based on systematic investigation of the geological evidence for 'islands' during latest Oligocene to earliest Miocene time. These 'islands' were first portrayed by Charles Fleming in 1959 and have subsequently become established in most treatments of New Zealand geological history and paleogeography since formation of the Geological Society 50 years ago.

Our studies have shown that the geological evidence for the existence of islands during latest Oligocene to earliest Miocene time is either non-existent or so wanting that we can confidently conclude that any islands that may have existed were small and short-lived. Here we critically evaluate four inferred mid-Cenozoic islands in: Fiordland, Central Otago, Northwest Nelson and central North Island.

As part of this analysis, we have identified eight factors that appear to have influenced paleogeographic map reconstructions.

This research has grown from exploration of regional planar surfaces in the New Zealand landscape and particularly the Waipounamu Erosion Surface as expressed in Otago and the Chatham Islands, and is supported by the ChEARS Marsden Project.

All available geological evidence suggests that Zealandia broke away from Gondwana c. 85 Ma and then slowly sank 1,000 to 3,000 metres over a period of c. 60 million years, culminating in complete submergence c. 23 Ma (Waitakian). Shortly following this, plate boundary collision became vigorous resulting in tectonic emergence of New Zealand. This process is ongoing.

ORAL

UNCOVERING THE FACE OF THE EASTERN NEW ZEALAND MARGIN – A VIEW FROM THE OCEAN

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Our knowledge of New Zealand's eastern margin, including the active Hikurangi and passive Bounty sectors, is surprisingly recent. Even though the broad outlines of these sectors were charted as early as 1910, it was not until 1958 that Hikurangi Trench and Bounty Trough were formally recognized. Being the pre-plate tectonic era, the forces behind these major oceanic forms were unclear. Hikurangi Trench was regarded as either a compressional or tensional feature, whereas Bounty Trough was seen as the consequence of large-scale uplift of the bordering Chatham Rise and Bounty Platform.

Marine studies began in earnest in the mid-1960s. Systematic surveys were undertaken by the Navy and government research groups, but more significant was the oceanographic and geophysical transects run by the USNS *Eltanin*. This network of survey lines provided the first regional view of the eastern margin. Single channel seismic lines, in particular, highlighted the architecture of acoustic basement and sediment fill, as well as prominent morphological features. In Bounty Trough, the discovery of a canyon-channel system hinted at the long-distance transfer of South Island sediment to the deep ocean via turbidity currents. Likewise, the presence of a prominent axial channel and 2km-thick sedimentary fill in southern Hikurangi Trench, indicated similar trench-fill processes supplemented by the mass wasting of trench walls. However, the margin's place within a plate tectonic model had yet to be appreciated.

Intellectual and technological advances of the 1970s started to shift emphasis from descriptive to process-oriented research. The shelf circulation and eustatic oscillations of sea level were shown to be key drivers of Quaternary sedimentation on and off the margin. The imprint of sea level change on a tectonically active seabed was identified on the Hikurangi margin, yielding landmark papers on sequence stratigraphy and sediment mass transport. Industry seismic data, especially that collected on the reconnaissance voyages of MOBIL's *Fred H. Moore*, mapped the eastern margin in unprecedented detail. By 1978, results from marine and terrestrial research were sufficient to finally bring New Zealand into the plate tectonic fold; no doubt giving satisfaction to pioneers and early converts to plate theory. Thus, the foundation was laid for a suite of studies, fuelled by committed scientists and research facilities, and aided by rapidly developing technologies that included deep ocean drilling, satellite navigation, multichannel seismic profiling, remote sensing from space, seabed mapping systems and computer-based facilities to handle the ever-expanding stream of data. It is a measure of these efforts, that eastern margin science has achieved significant international recognition. But that status should not invite complacency. Much of the margin remains untouched. Thus, the scene is set for another 50 years of discovery.

ORAL

CANTERBURY DRIFTS, SW PACIFIC OCEAN RECORD OF INTERMEDIATE DEPTH WATER FLOWS SINCE 24 MA

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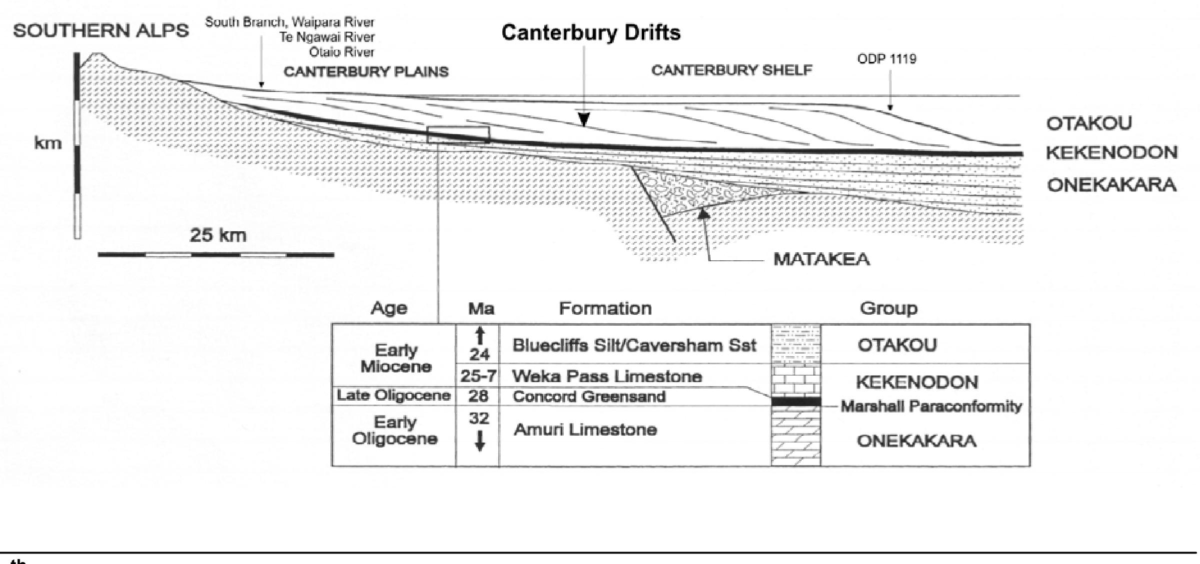
The Canterbury Drifts were deposited in water depths between 400 and 1500 m by northward flowing, cold, intermediate depth water masses - Subantarctic Mode Water (SAMW), Antarctic Intermediate Water (AAIW), and their predecessor current flows. Drift accumulation started at 24 Ma, fed by terrigenous sediment derived from the newly rising Alpine Fault plate boundary in the west, which has built a progradational shelf-slope sediment prism up to 130 km wide at rates of eastward advance of up to 5.4 km/My. These regionally extensive, intermediate-depth sediment drifts can be examined in outcrop (Bluecliffs Silt and younger equivalents), in marine drillcore (ODP Site 1119) and at the modern seabed.

pervasive background of cm-scale, planar or wispy alternating muddy and sandy silts, consistent with deposition from rhythmically fluctuating bottom currents. In the Plio-Pleistocene, the sand:silt lithological rhythmicity occurs in synchroneity with Milankovitch-scale climate cycling; periods of inferred faster current flow (sand intervals) mostly correspond to warm climatic intervals.

The drifts vary in thickness from 300 m near the early Miocene shoreline, where they were accumulating in limited shallow water accommodation, to 2000+ m under the modern shelf edge. Mounded drifts first occur at 15 Ma (Middle Miocene), their appearance perhaps reflecting more vigorous intermediate water flow consequent upon worldwide climatic deterioration between 15 and 13 Ma. A further change from large (more than 10 km wide) to smaller (1-3 km wide) mounded slope drifts occurs at 3.1 Ma, marking further cooling, the inception of discrete SAMW flows, and initiation of the Subantarctic Front. The natural gamma ray record from Site 1119 contains a history since 3.9 Ma of the waxing and waning of the New Zealand mountain ice cap. Back to ~0.7 Ma, this record closely mirrors the climate history of Antarctica, as manifested in the Vostok and EPICA ice cores, at 0.1 to 0.6 ka resolution. Beyond, and back to 3.9 Ma, the gamma record reflects southern mid-latitude ice-volumes, and perhaps Antarctic polar plateau temperature, at a resolution of 1.3 ky.

ORAL



THE "SO-CALLED MARSHALL PARACONFORMITY[1]" HISTORICAL SIGNIFICANCE OF UNCONFORMITIES IN THE KAIKOURA SYNTHEM, EASTERN SOUTH ISLAND

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Between the 1860s and the early part of the 20th century, exploration geologists Julius von Haast, James Hector, Frederick Hutton, Alexander McKay, James Park, Pat Marshall, Robert Speight, Charles Cotton and J. Allan Thomson engaged in a lively debate about the classification of New Zealand "Cretaceo-Tertiary" strata. In eastern South Island, these strata were deposited in the Canterbury Basin, and are now classified in the successive Matakea (rift-fill), Onekakara (transgressive ramp), Kekenodon (carbonate platform), Otakou (regressive progrades and drifts) and Hawkdun (piedmont gravel) Groups of the Kaikoura Synthem. Pivotal to the historical debate was the identification of, and significance accorded to, claimed unconformities at different stratigraphic levels. Illuminated by hindsight, and armed with modern sedimentary knowledge and age-dating techniques, some of the arguments used to justify particular past stratigraphic interpretations seem arcane. Notwithstanding, all but one of the "unconformities" claimed by historic geologists have a broader stratigraphic significance, albeit in ways that mostly differ from their 19th century interpretation.

In ascending stratigraphic order, the unconformities (and their modern interpretation) include:

i. that which separates the base of the Kaikoura Synthem from underlying Rangitata Synthem strata (post-Rangitata or pre-Kaikoura unconformity; basin creation by Cretaceous rifting),
ii. the contact between the Waipara and Oamaru series of Hutton (1874, 1885) (the Amuri and Weka Pass Limestone junction, now termed the Marshall Paraconformity; creation of the Southern Ocean and the Antarctic Circumpolar Current);
iii. the contact between the Oamaru and Pareora Series of Hutton (1899) (the Weka Pass-Bluecliffs Formation contact; seaward downlap of Otakou Group clinoforms),
iv. the "Weka Pass rail cutting" unconformity (Hutton, 1887), claimed to be at the Grey Marls-Mt. Brown Beds contact, but actually lying within the Mt. Brown Beds (Southburn Sand; chanellisation within the regressive shoreface succession), and
v. the contact between the Mt. Brown Beds and overlying deeper marine siltstones (Motunau and Greta beds) (deepening-surface, and basin formation, caused by Pliocene transtensional tectonism; north margin of Canterbury Basin only).

Since its first description by Hutton (1885), detailed study by Speight & Wild (1918), and naming by Carter & Landis (1972), the significance of the Marshall Paraconformity has been controversial. Haast, Hector and Park and many later geologists failed to see or make comment on an unconformity at this horizon, McKay and Marshall argued strongly against its presence, Jenkins (1975) and Findlay (1980) denied its wider significance, and Lewis (1992) inferred a partly tectonic origin. High resolution dating of the ~4 to 33 My-long gap across the surface (Fulthorpe et al., 1994; Graham et al., 2004; Nelson et al., 2004), and palaeoceanographic interpretation (Carter et al., 2004), have confirmed its regional significance. The Marshall Paraconformity is the sedimentary pivot around which turns the entire Kaikoura history of the New Zealand Plateau.

Nelson, C.S. et al., 2004: Strontium isotope dating of the New Zealand Oligocene. *New Zealand Journal of Geology & Geophysics 47*: 719-730.

ORAL

MINING-INDUCED DEBRIS FLOW EVENTS IN THE GREYMOUTH COALFIELD

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In Mid 1998, miners working the United Mine in the 10 Mile area of the Greymouth Coalfield noticed changes in Doherty Creek which they had to cross to access the mine. The Creek would run dirty during fine weather and small rushes of debris occurred, one of which washed away the coal bins for an adjacent mine. On the 24th of August 1998 a huge amount of water, trees, mud and rocks rushed down the creek blocking access to the mine. No significant rain had occurred in the preceding period. The miners' observations suggested that the material was coming from Solid Energy's Strongman # 2 underground mine which was working at the head of Doherty Creek

On the 23rd of September 1998 the United Mine workers heard an horrendous roar from the head of Doherty Creek and when they emerged they found a large wall of debris damming the creek above the mine access. Again the weather was fine at the time. On the night of 24th of September it rained and on the following morning the miners arrived at work to find the debris moving. Just after they retreated down the road, the debris dam failed and the resulting debris flow destroyed the road end and access to the mine.

What went wrong? The Strongman # 2 mine is in rugged terrain with coal outcropping against an escarpment. The licence conditions required a reasonable range of environmental protections. Mining best practice and the mine plan and called for an outcrop barrier, however, the mine plan also called for high extraction under shallow cover. Problems soon occurred with surface subsidence developing from early 1996. Extensive extraction of the outcrop barrier was also initiated in 1996. This lead to the collapse of the escarpment and the generation of debris flows in Doherty Creek. These debris flows ultimately destroyed access to mines operating in the area. The ongoing instability precluded restoration of access as the safety of workers could not be guaranteed nor was it possible to design a new cost effective means of access that would survive any future debris flows from the degraded catchment.

The court cases that arose out of the debris flow damage have now all been settled but the subsidence, escarpment damage and associated mine fires at Strongman Mine is having an ongoing environmental impact. Just as important is the damage done to the reputation of coal mining on the Coast, and of the mining industry as a whole as a socially and environmentally aware industry.

The consequence has been for a far greater level of scrutiny of other mining projects such as Pike River. To some extent this degree of scrutiny is beneficial because it can be too easy for mine developers to "accentuate the positive" and minimise the potential downsides. Industry acceptance of the rigorous examination of the issues by independent analysts may help to offset the concerns of those currently concerned at the impact of mining in NZ.

POSTER

A LONG TIME COMING: WILL NIAGARA 1 BE THE SOUTH ISLAND'S FIRST COMMERCIAL OIL WELL?

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Niagara 1 is located in the Aratika Forest, between Lake Brunner and Greymouth on the West Coast of the South Island. The well was drilled by New Zealand Oil and Gas in 1985 as a test production well using the Rockdrill 20 rig. The well was a limited success in that hydrocarbons were discovered and some oil was recovered to surface during testing. The well was subsequently suspended pending a re-entry and a new well was drilled to test the projected up-dip extension to the play. The updip well, Niagara 2 was poorly located and thus not a success and NZOG subsequently surrendered the permit.

Ocean Harvest obtained the permit in late 2000 and undertook a review of the potential for Niagara 1. The existing data was reviewed by Western Exploration who concluded that the poor production performance of the well was most likely due to formation damage resulting from drilling with an excessively overbalanced mud over the production zones. M Pearson (Pers comm) of Kappa SEA reviewed and re-interpreted and available test production data in 2002 and confirmed the formation damage assessment. The kappa assessment also considered 40 bbl/day to be a realistic production target.

Since 2002, Western Exploration and Ocean Harvest have been exploring cost effective solutions for undertaking a re-entry of the well. Because of uncertainty over the potential of the well, mobilisation of a full-scale oil rig could not be justified because of the impact this would have on project economics. Alternatives such as the Failing DMX used to undertake the P&A of Blenheim 1 were explored but lack of trained crew precluded that option. Eventually a suitable rig was obtained and crew trained to undertake the re-entry in 2005.

The re-entry was more successful than anticipated with oil and gas flows to the surface immediately after the bridge plug had been drilled through and additional flows once the main production zone was reached. A post re-entry review suggested that the 40 bbl/day production target is a minima and production of up to 80 bbl/day plus enough gas for small scale on site power generation is possible.

The design of the Niagara 1 well impacts on the development programme. In particular the 5" production casing and the barefoot completion below the casing shoe constrains our ability to install suitable artificial lift equipment. A production design has been formulated and is presently being tested. In addition, existing seismic will be reprocessed and additional seismic acquisition is planned. Depending on the results a new well may be drilled to intersect the producing formation within the fault bound Niagara structure.

ORAL

POTENTIAL FOR A 6000 YEAR RECORD OF ALPINE FAULT EARTHQUAKES FROM HOKURI CREEK, SOUTH WESTLAND

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A large surface-rupturing earthquake on the Alpine Fault is one of New Zealand's most significant natural hazard scenarios. Current estimates of recurrence interval for Alpine Fault rupture events rely on calculation from slip rates and single event displacements or from age determination of the last three or four earthquakes. A 16 m thick sequence of lake and wetland sediments immediately adjacent to the Alpine Fault in Hokuri Creek, south Westland has the potential to dramatically improve these estimates. The sequence spans the last c. 6000 years and consists of c. 25 silt-peat couplets. Couplets are thought to represent repeated cycles of ponding and drainage with silt units deposited in ponded open water and peat deposited under wetland conditions. For at least part of its history, the lake outlet crossed the Alpine Fault thereby causing drainage to be fault-controlled. It is likely that every time the Alpine Fault ruptured to the surface in the last 6000 years, it affected the hydrology of this waterbody. Preliminary counts indicate the rate of couplet formation (one every 240 years) is consistent with existing recurrence interval estimates. Horizons containing soft sediment deformation features provide additional evidence of strong earthquake shaking.

Initial field observations suggest the Hokuri Creek lake sequence has the potential to provide a c. 25 event paleoseismic record – one of the longest obtained globally. We present a progress report on the research required to identify and extract paleoseismic information from this sequence. Paleoenvironmental analysis is currently underway to better define major silt-peat couplets and their mechanism of formation. Plant macrofossils and diatom microfossils are used to characterise depositional environment. Radiocarbon dating of leaves and reed material provides a basic chronology for the sequence. However further age control will be required to establish an event chronology. Further work on the paleogeography of the valley will also be required to understand the relationship between drainage patterns and the fault.

The ultimate aim of the research is better definition of Alpine Fault earthquake recurrence and an improved understanding of the fault's mid to late Holocene activity. In particular, obtaining data with which to assess variability in earthquake recurrence would enable significant refinement of probabilistic seismic hazard models. Such information will lead to improved assessments of the hazard that the Alpine Fault poses to New Zealanders.

POSTER

SEDIMENTOLOGY AND TEPHROCHRONOLOGY OF LAST-GLACIAL LAKE SEDIMENTS AND PEAT FROM SOUTH WESTLAND

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We undertook a high resolution study of cores from two lakes in South Westland aimed at determining the nature and timing of abrupt climate change during the Last Glacial–Interglacial transition. Cores were collected from Skiffington Swamp and Galway Tarn in South Westland and the sediments characterised by measuring magnetic susceptibility, percent organic carbon (by loss on ignition), grain size and mineralogy. Pollen assemblages had been analysed previously (Vandergoes and Fitzsimons, 2003). Both sites contain a visible tephra layer identified as the Aokautere Ash (Kawakawa Tephra, 22.6 ^{14}C ka or c. 26.5 cal ka) based on stratigraphic position and existing geochemical analysis. This layer provides an excellent chronostratigraphic reference point. Several other peaks in glass shard concentration were identified during microscope analysis and concentrated with heavy liquid techniques for geochemical analysis by electron microprobe. This showed that all samples were consistent with the Kawakawa Tephra.

Existing pollen data for both cores (Vandergoes and Fitzsimons, 2003; Vandergoes, unpublished data) exhibit a grass pollen peak interpreted to represent the Last Glacial Maximum (LGM), followed by a reduction in grass and a later rise in tall trees as the climate ameliorated. Our analysis showed a distinctive and abrupt increase in the combustible organic carbon content of both cores, occurring after the decline of the grass peak and just before the rise in tall-tree pollen. A possible interpretation of this change is the retreat of ice from near the site and rapid re-vegetation of exposed outwash plains by grasslands. This led to a reduction in loess input as vegetation covered and stabilised the exposed source areas. Grain size data were less conclusive. Both cores showed a higher degree of variability in the latter part of the LGM, with a period of coarser grain size commencing just before, and finishing just after, the sudden increase in organic matter seen in the loss on ignition results. Galway tarn showed a very distinct period of finer grain size prior to this coarse period, seeming to coincide with the LGM grass peak. This period of fine sediment deposition is also present in the Skiffington Swamp results but is less distinct. Galway Tarn samples were found to have a very high phytolith content, which may have contributed to the less distinct grain size results. The mineralogy of the Skiffington Swamp core was examined by optical microscope using point counting methods. A peak in micaceous mineral content (as a percentage of total mineral grains) was found corresponding with the end of the LGM. A rapid reduction in mica content was found to correlate well with the rise in organic content as shown by the loss on ignition results. This is interpreted to represent a reduction in mica supply as outwash areas were re-vegetated after glacier retreat.

Vandergoes, M. J.; Fitzsimons, S. J. 2003: The Last Glacial-Interglacial transition (LGIT) in South Westland, New Zealand: paleoecological insight into mid-latitude Southern Hemisphere climate change *Quaternary Science Reviews 22*: 1461-1476.

POSTER

MUDDY WATERS ~ OFFSHORE RECORDS OF ONSHORE RESPONSES TO ABRUPT CLIMATE EVENTS

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Most palaeoclimate proxies recorded from marine sediments, are in fact of a marine origin, e.g., $\alpha^{18}O$, $\alpha^{13}C$ and alkenones, and therefore record the oceanic systems' responses to the changing climate. However, the terrigenous sediment which has accumulated in large quantities in the offshore area around New Zealand, started life onshore. Erosion of the South Island of New Zealand contributes almost 0.7% of the total riverine sediment loading to the oceans per year and is inferred to have been much greater during glacials, particularly during transitions between climate states. Hence the timing of events, which generate the sediment are likely to be offset from the records of the same events in marine proxies.

The arrival of terrigenous sediment into the marine system is likely to be delayed by its transit from the site of origin to the marine system. Sediment supplied to the Bounty Trough off eastern South Island is first trapped by the large natural lakes which retain about 15% of the sediment yield to the east of the Alps. Configuration of the Canterbury Shelf during glacials is such that the delivery of this sediment by-passes the shelf and is directly deposited into the troughs and canyons east of South Island. In core MD97-2120, arrival of characteristic silt-sized grains is offset by over 50 cm at both Termination II (MOIS 6/5) and Termination I (MOIS 2/1), this equates to approximately 10,000 years based on the existing $\alpha^{18}O$ records, i.e., the sediment did not arrive in the Bounty Trough until interglacial warming was at its maximum.

The modern west coast system is slightly different as it lacks the trapping capacity of the lakes and the proximity of the Southern Alps is much closer. Approximately 10 times more sediment is injected into the west coast system than into the Bounty Trough.

New core sites (TAN0409-173 and -174) off the Hokitika and Haast Canyons in the Tasman Sea, are being investigated to determine how much greater the sediment loading is and what the delivery rate is compared with the east coast sediment system. We suggest this high sediment loading would be exacerbated during glacial times and during the climate transitions.

The west coast cores will enable us to assess how abrupt climate changes will be expressed in the sediment record, given the delivery rate should be faster and lacking the 'holding' capacity of the lakes. Knowing this will contribute to climate change modelling and our understanding of the climate system.

POSTER

HOW GOOD IS THE FOSSIL RECORD? NEW ZEALAND MIGHT HAVE THE ANSWER

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Estimates of past biodiversity, speciation rates and extinction rates based on the fossil record, have built-in assumptions about completeness of the fossil record. Biodiversity change and evolutionary rate metrics have become increasingly sophisticated in recent years, but there has been no corresponding improvement in estimates of completeness. This is because completeness of fossil populations is extremely difficult to measure. It is widely recognised that a major contributor to incompleteness is size bias – the preferential loss of small sized species from the fossil record. Using the exceptionally good fossil record of New Zealand Recent and Cenozoic Mollusca, we use a novel approach to estimate the magnitude of the bias against small body size and the effect of this bias on completeness of the fossil record. Our database of 3907 fossil species represents an original living pool of 9086 species, from which 36% have been removed by size culling, 27% from the smallest size class (<5mm) alone. In contrast, non-size related losses comprise only 21% of the total. Exhaustive collection and preparation techniques, not used for most of the samples, demonstrates that the loss of small taxa can be reduced by nearly a half. This implies that just over half of the size-related loss is due to non-preservation and just under a half is due to non-collection.

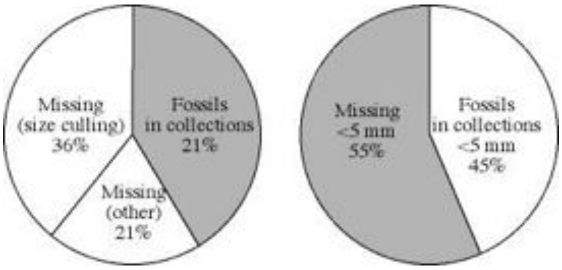

Fig. 1. Left, more than half of living mollusc species are culled out and not found in fossil collections, due mainly to their small size (size culling, 36%), but also to other causes (21%). Right, size culling removes more than half of the smallest size class alone.

ORAL

POUNAMU RESOURCE ASSESSMENT & CHARACTERISATION

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Pounamu is a M–ori collective term for semi-precious stone scientifically referred to as nephrite, semi-nephrite, jade or bowenite (tangiwai) that is composed predominantly of metamorphic tremolite in a felted, fibrous texture. It is Aotearoa/New Zealand's icon mineral material. Ownership and management of this important taonga (treasure) has been vested in Te R–nanga o Ng–iTahu as part of a Treaty of Waitangi settlement process. Increasing demand from the tourist, jewellery, fashion and sculpture industries, as well as cultural renaissance, has placed pressure on the pounamu resource. This had led to nephrite importation, allegations that foreign material is being marketed falsely as New Zealand pounamu, and wider concerns over the potential for exploitation/over-use and theft of genuine pounamu.

Research is underway to characterise different pounamu source regions by defining their "genetic fingerprint". The geological age and radiogenic isotopic composition of Aotearoa/New Zealand pounamu is distinguished from other nephrite jade occurrences overseas, due to relatively young cooling ages. Strontium isotope ratios distinguish pounamu from different source areas within Aotearoa/New Zealand (whakapapa), with signatures reflecting the host terrane rocks (their family) and their position in a sequence of metamorphic events (their generation). The research will provide a tool for archaeological research, trademark and resource protection.

Mineral resource assessments normally aim to define the total volume/tonnage present, which is generally assumed to be finite, applying drilling and geostatistical modelling. Pounamu resource assessment requires a different approach, as its intrinsic value is insufficient to warrant modern exploration methods (e.g. drilling, geophysics). Pounamu is only known to occur at a restricted few in-situ (hard-rock) localities. It is primarily found in transported (alluvial) detrital river and glacial outwash deposits, where collectable material has short term variability due to erosion and transport processes. A new methodology is being developed aiming to define

i. the total resource present,
ii. the relative rate of change in the availability of that resource through erosion and other geological processes,
iii. active areas where new material is likely to be exposed (e.g. by erosion), and
iv. appropriate extraction rates for sustainable use. The methodology will provide a holistic overview of the resource in different regions of Aotearoa/ New Zealand, and may be applicable to other transient or restricted natural resources that occur within geologically active environments (e.g. supplies of driftwood on beaches).

POSTER

QMAP AORAKI: THE NEW 1:250 000 GEOLOGICAL MAP OF CENTRAL SOUTH ISLAND

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A revised 1:250 000 geology map of the central South Island, QMAP Aoraki, is in the final stages of compilation and nearing publication. Aoraki is the only South Island QMAP sheet that spans from offshore west coast to offshore east coast. It overlaps in part with the original 1:250 000 Mt Cook, Hokitika, Hurunui & Christchurch geology maps compiled in the 1960s (Gair 1967, Warren 1967, Gregg 1964, Suggate 1972). Aoraki's improvements over the earlier maps include the detail of greywacke and schist mapping, more extensive mapping of Quaternary deposits in hill and mountain country, and the recognition and detail of numerous new faults and folds, many demonstrably active. As with other QMAPs, the primary emphasis is compilation of existing data, from published (e.g. maps, papers) and unpublished (e.g. reports, theses) sources. Additional mapping as part of QMAP aimed to fill data gaps, ensure uniform levels of data detail, or resolve major conflicts of interpretation. The map has been compiled at 1:50 000 scale into a Geographic Information System (GIS), but with sufficient generalisation for legible presentation at 1:250 000 scale.

New mapping has added much improved understanding of the Rakaia (Torlesse) terrane. Greywacke/schist mapping emphasises textural zonation (t.z.) rather than the mineral zonation (chlorite, biotite, garnet) of the earlier maps, although the new map also depicts mineral isograds. Alpine schist fabrics and isograds vary considerably along the plate boundary, and schist units are not parallel to the Alpine Fault. Bedding trends in t.z.1 greywacke are emphasised with formlines. A regional swing in bedding strike (from 320° to 030°) commences around 60 km SE of the Alpine Fault, mimicking the oroclinal bend of Mesozoic terranes in the southern South Island. Bedding faces mainly west or southwest, with locally eastward-facing, overturned, sections up to 10 km thick. Steeply plunging folds become progressively tighter and with shorter wavelength approaching the Alpine Fault. En echelon northeast-striking, reverse-dextral oblique-slip faults dipping 40-60° NW are common in the central Southern Alps. Steeply plunging folds are transected, overthrust and rotated by late Cenozoic displacement on these faults.

Relatively few changes have been made to the mapping of Cretaceous to Pliocene sediments, a tribute to the quality of Cenozoic stratigraphy and paleontology in the 1960s. However, the QMAP Aoraki units and legend contain more lithostratigraphic information, reflecting the Cretaceous-Cenozoic transgression and regression in more detail than on the earlier maps. Quaternary map units on QMAP Aoraki include scree, colluvium & landslide debris, in addition to the glacial and fluvial deposits emphasised by earlier maps. Faults and folds are depicted as active only where there is good geomorphic evidence of late Quaternary deformation. Other structures, particularly those outcropping in the mountainous Southern Alps lack of evidence of activity, rather than showing evidence of inactivity.

POSTER

LATE CRETACEOUS EUSTASY AND THE EAST COAST BASIN - THE GOOD NEWS!

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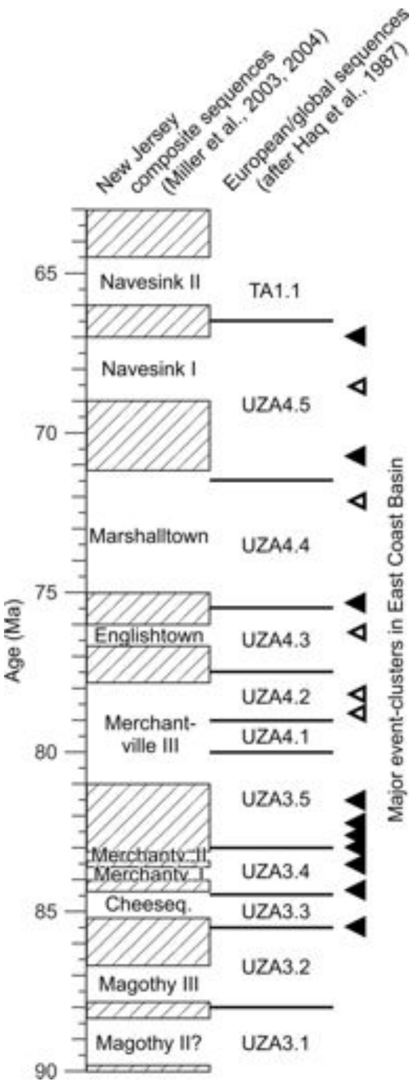
Distinguishing tectonic from supposedly eustatic Upper Cretaceous sequences is highly problematic for New Zealand successions that are structurally and/or stratigraphically complex and remote from well-studied Northern Hemisphere localities. The problem is largely one of resolution in chronostratigraphic correlation, and conclusions may vary depending on philosophies and approaches to correlation. A complementary study (Schiøler et al., this volume), based on palynofacies analysis and zonal correlations, found little evidence for Late Cretaceous eustatic signatures in the East Coast Basin. Here we take a different approach that employs multidimensional graphic correlation using constrained optimization (CONOP) to derive a high-resolution correlation for 15 Coniacian-Maastrichtian sections in the East Coast Basin. The resulting composite section, based on 398 well-constrained lowest- or highest-occurrence bioevents, yields 183 event levels and an average chronostratigraphic resolution of approximately 142 Kyr. The age of the composite is calibrated using seven dated bioevents; two of these events are tied to geochemical or paleomagnetic datums.

CONOP cannot resolve unconformities that occur across all sampled sections. We suggest, however, that such unconformities are represented by large event-clusters at single composite levels, and 13 such event-clusters are identified. Of these, 10 lie within hiatus intervals recorded from the New Jersey coastal plain and interpreted as eustatic sequence boundaries; the probability of this coincidence arising by chance alone is c. 8%. Although provisional, these results suggest that high resolution quantitative stratigraphy can provide a potent tool for the resolution and global correlation of stratigraphic sequences. Furthermore, our findings add support for recent studies that have argued for the presence of Late Cretaceous eustatic sea-level changes.



Inferred U. Cretaceous eustatic unconformities (shaded) and sequence boundaries, and significant event-clusters in the East Coast Basin: filled triangles = clusters that coincide with New Jersey unconformities; open triangles = clusters that do not.

ORAL

WHERE IS THE CENOMANIAN-TURONIAN BOUNDARY IN NEW ZEALAND, AND IS THERE A HYDROCARBON SOURCE ROCK ASSOCIATED WITH IT?

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An oceanic anoxic event around the time of the Cenomanian-Turonian boundary (CTB) in many parts of the world resulted in widespread occurrence of black shales and a hydrocarbon source rock interval. Did a similar event occur in New Zealand? Hydrocarbon generation modelling (Field & Uruski et al. 1997) suggests there was generation of hydrocarbons from mid-Cretaceous rocks on the East Coast North Island, but we do not know specifically what the sources for these hydrocarbons were.

Crampton et al. (2001) placed the CTB within the Arowhanan Stage at Mangaotane Stream, Raukumara Peninsula. The Mangaotane section of grey, red and green mudstones, with minor sandstones, was re-collected in detail for the present study and samples were analysed for carbon isotopes and total organic carbon (TOC). A carbon isotope signature consistent with that at the CTB in other parts of the world was found within the Arowhanan, but RockEval results indicate that the event at Mangaotane Stream did not produce high enough TOCs to form a good source rock.

We cannot rule out the possibility that there are CTB black shales elsewhere on the East Coast or in the New Zealand region. The absence at Mangaotane Stream might be due to factors in its local setting such as rate of terrigenous input, paleobathymetry or oceanic paleocurrents. Our results confirm the correlation of the Arowhanan with the CTB (Cooper 2004), provide a SW Pacific datapoint for modellers of Cretaceous paleoclimates, and indicates that the CTB event in New Zealand was, at least in detail, different to that at classic Northern Hemisphere sections.

Crampton, J.S., Raine, I., Strong, P., Wilson, G. 2001: Integrated biostratigraphy of the Raukumara Series (Cenomanian-Coniacian) at Mangaotane Stream, Raukumara Peninsula, New Zealand. New Zealand Journal of Geology and Geophysics 44: 365-389.

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Field, B.D., Uruski, C.I., and others, 1997: Cretaceous-Cenozoic geology and petroleum systems of the East Coast Region, New Zealand. Institute of Geological and Nuclear Sciences Monograph 19. 301pp.

POSTER

CHRONIC HEALTH IMPACT OF FLUORIDE DUE TO VOLCANIC DEGASSING ON AMBRYM, VANUATU

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Fluoride is a common constituent of volcanic ash and has been implicated in human and animal morbidity and mortality, for example the Laki Fissure eruptions in Iceland (1783-1784, 1947, and 1970). The 1995-1996 Ruapehu eruptions also resulted in thousands of sheep deaths which similarly were attributed to acute fluoride poisoning.

The island volcano Ambrym has several open vents, including Marum and Benbow, within a centrally-located caldera. These have been semi-continuously active for at least two to three hundred years. The predominant southeast trade winds direct volcanic plumes toward the west where the majority of the population of over 9000 resides. Wind variability, particularly during the cyclone season, ensures that no area of Ambrym is entirely immune from volcanic emissions.

In January 2005, the Ambrym plume was emitting SO_2 at 14 000 - 20 000 tonnes/day, with a fluoride output estimated to be up to 1 100 tonnes/day. The continuous degassing from Ambrym's vents leads to acid rain and ash fall causing damage to food crops and vegetation. In terms of acute human health impacts, respiratory and gastric symptoms are commonly reported following particularly intense periods of activity. This study focuses on the chronic human health impacts that prolonged exposure to volcanogenic fluoride may have on the local population.

The plume fluoride appears to be very efficiently scavenged by rainfall, which the island residents collect for drinking and cooking purposes. Drinking water samples collected in January 2005 typically contained between 3-10 ppm F, with streams, shallow ground wells and coconuts having similarly high F contents. To put this in perspective, the World Health Organisation recommends < 1.0 ppm F in the drinking water of populations living in tropical environments.

In humans, ingested fluoride is deposited primarily in bones and teeth. Dental fluorosis – evidenced by white or brown discolouration of teeth - is the first visible sign of over-exposure to fluoride and occurs where levels of fluoride in drinking water are 1-2 ppm. The Dean's Index is a visual scale for the classification of fluorosis and was used to assess over 250 children in West Ambrym. Of these children, 53% and 8% respectively, fell into the two highest categories of Moderate and Severe. The dental results and water analyses suggest that skeletal fluorosis, a condition involving weakening of bones, which in its severest form is crippling, is a potential health issue. As fluorosis has been linked with Ruapehu's eruptions, this study is of significance for researchers investigating the risks associated with possible prolonged degassing of any of New Zealand's Central North Island volcanoes.

ORAL

WHERE ARE THE GIANT TUFF CONE AND IGNIMBRITES OF AMBRYM? A MORE CONVENTIONAL STORY OF MAFIC VOLCANISM AT AMRBYM VOLCANO, VANUATU.

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Ambrym is located in the central part of the Vanuatu volcanic arc and forms a triangular shaped island around 60 km long on its NE-SW axis. The NW-SE oriented rift zone accommodates most of the historic eruptions from this arc-basaltic volcano and a series of older overlapping edifices make up the northern portion. A 12 km-wide caldera dominates the centre of the island, containing two active tuff/scoria cones (Benbow, Marum) and many smaller open vents. Semi-continuous ash falls and periodic lava flows inundate the caldera and choke stream networks down-slope with remobilised pyroclastics. Since the mid 90's Ambrym has been regarded as a type-locality for a "*giant tuff cone*", that formed by enormous phreatomagmatic eruptions, which accompanied disruption of an edifice to form the large caldera. This theory, however, is entirely built on field observations of a layer-cake stratigraphy constructed from a mosaic of sections. Current field studies revisiting these sites and others, show that this mosaic is false, and many of the sections cannot possibly be related to one another either genetically or chronologically. Our studies indicate that the island is a composite structure, formed of many generations of coalescing monogenetic volcanic fields. The type localities of the "*giant tuff cone*" (dacitic) pycroclastic flow deposits in the northern shoreline of the island we interpret to be either (1) mafic phreatomagmatic fall and surge sequences (in places hydrothermally altered) or in other cases (2) stacks of lahar and fluvial sediment derived from the caldera outflow and forming valley-fills. These successions are typical of many new sites described around the volcano which imply several generations of a frequently active mafic volcano, with coalescing fields of lava, base-surge deposits and falls (often with accretionary lapilli), along with abundant deposits of fluvially reworked pyroclastics. There is no evidence for a climactic (or for that matter dacitic) explosive caldera-forming event, which concurs with investigations in the 60's and 70's. The active central vents shows a combination of prheatomagmatic to magmatic explosive and effusive events that are seemingly strongly controlled by the hydrogeology and architecture of the island. Marum and Benbow are well-developed tuff cones with deep and complex craters, where pit crater formation as well as phreatomagmatic explosive eruption induced crater subsidence play a major role in their formation. Flank eruptions forming monogenetic fields commonly started with central eruptions such as in 1913, suggesting a strong coupling mechanism of central and flank eruptions. Magma rise in the centre of the island, followed by intense degassing and drainage of degassed magma along lateral dykes is inferred by us to be the major means by which the central 12-km wide caldera slowly formed. This caldera formed over a long-term stable shallow magma storage system. Hence we suggest, that the theory of the "*giant tuff cone*" is not necessary to explain the volcaniclastic facies associations of Ambrym, and the formation of its caldera. This volcano should hence never be used as a comparative example for large-scale explosive phreatomagmatism – as has been done on several occasions since the mid 90's. This conclusion also highlights that the volcanic hazard of Ambrym is rather dominated by the potential interaction of magma and water along the NW and SE rift edge and the style of eruptions in the central vent rather than potential major caldera forming events that may disrupt the island and impact upon the region.

ORAL

EARLY PALEOGENE BIOSTRATIGRAPHIC RECORD FROM THE NERITIC MID-WAIPARA RIVER SECTION, NORTH CANTERBURY

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Detailed studies of early Paleogene South Pacific sedimentary records are limited, but are critical in providing proxy data for validating general circulation models and understanding natural processes that led to major perturbations in carbon cycling and global climate. Some of the most complete South Pacific early Paleogene records are from distal pelagic successions in the Clarence Valley, Marlborough, but corresponding well-exposed records from proximal settings are currently limited. The mid-Waipara River Section, North Canterbury, has a well-exposed and near continuous early Paleogene shelf succession, providing an opportunity to document biological and sedimentological response to climatic changes in a proximal setting during the Paleocene to Middle Eocene (~65–46 Ma).

From the mid-Waipara River Section, a detailed suite of 265 samples has been collected from Paleocene, Paleocene/Eocene boundary, and Early to Middle Eocene successions of the Conway and Loburn Formations, Waipara Greensand and Ashley Mudstone. All samples are incorporated in a detailed tape and compass survey map, and the collections are documented in six lithologic columns that represent a geographic and stratigraphic progression from the westernmost (oldest) to the easternmost (youngest) location (Morgans et al., 2005). Integrated studies of sedimentology, foraminifera, dinoflagellate cysts, calcareous nannofossils, spores/pollen, and carbon isotopes are being completed.

Biostratigraphic results suggest the top of the Conway Formation youngs in an eastward direction from uppermost Cretaceous in the Waipara South Branch section to lower Paleocene in the mid-Waipara River section. A near-complete ~120 m thick Paleocene record is sampled, with diverse calcareous and organic-walled microfossil assemblages in the Early and early Late Paleocene. Calcareous faunas are absent throughout most of the Waipara Greensand (Late Paleocene) and age control is primarily from dinoflagellate cysts. Initial bulk organic $\delta^{13}C$ isotope results suggest the late Paleocene carbon isotope maximum (~59.5–56 Ma) is present in the upper Waipara Greensand (Stormont Member), along with a geochemical signature that is characteristic of the Waipawa (Black Shale) Formation. The Paleocene/Eocene boundary, or initial Eocene thermal maximum (~55 Ma), is tentatively recognised in the uppermost Waipara Greensand, however further palynological and $\delta^{13}C$ isotope analyses are needed. While continuous in-situ earliest Eocene (Waipawan) sediments are not presently exposed, a detailed Early to Middle Eocene (Mangaorapan–Heretaungan) Ashley Mudstone record indicates most of the Early Eocene climatic optimum (~53–50 Ma) is represented.

Morgans, H.E.G., Jones, C.M., Crouch, E.M., et al., 2005: Upper Cretaceous to Eocene stratigraphy and sample collections, mid-Waipara River Section, North Canterbury. *Institute of Geological and Nuclear Sciences science report 2003/08*. 101 p.

ORAL

VEGETATION AND CLIMATE CHANGE AT THE PALEOCENE-EOCENE TRANSITION

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Plant microfossil (spore/pollen) assemblages from New Zealand Paleocene–Eocene (P–E) sedimentary sections show a general change from predominantly gymnosperm-rich Paleocene floras (zone PM3) to *Casuarina*-dominated angiosperm-rich floras in the Early Eocene (zone MH1). Modern relatives of the fossil plant taxa and vegetation analogues indicate this change is related to significant climatic warming, although the precise timing and extent of more subtle vegetation change during the P–E transition remains poorly documented. Previous studies (e.g., Tawanui section, Hawkes Bay, and Moeraki-Hampden section, Otago) suggest that the main vegetation change in the Paleocene–Eocene occurred in the upper Waipawan Stage (earliest Eocene) and post-dated the significant climatic and carbon cycle perturbation at the P–E boundary (~55 Ma). Plant microfossil records are currently being studied from a silica-sand quarry at Mt Somers, South Canterbury, and in the Kumara-2 core, central Westland, to elucidate the timing and scale of vegetation change during the P–E transition.

Gymnosperm pollen and Proteaceae and small triporate angiosperm pollen are abundant in the lower part of the Kumara-2 core (1739-50 m), and a Late Paleocene age is suggested. Coastal marine sediments are present from ~1733-38 m, with abundant cysts of the marine dinoflagellate genus *Apectodinium* recorded in the middle of this unit. Coincident with the base of the marine horizon, pollen indicative of warm climates (e.g., *Cupanieidites orthoteichus, Spinizonocolpites prominatus*) are first recognised and become a recognisable component of the spore/pollen assemblage. Spores/pollen are absent from a channel fill sand at 1722-33 m, but above this unit the assemblage is diverse, angiosperm pollen are abundant and *Casuarina* pollen (zone MH1) markedly increase in the upper part of the studied core. Abundant *Apectodinium* dinocysts in the coastal marine unit suggests this interval lies very close to the P–E boundary, and it appears this marine incursion may be related to a thermal expansion of ocean waters and slight sea-level rise at the time of extreme warming at the P–E boundary. Compound-specific organic carbon isotope analyses are currently being completed to confirm the presence and position of the P–E boundary.

Within the sand dominated Broken River Formation-Homebush Sandstone section at Mt Somers, fine-grained mudstone layers were sampled where possible and palynomorph assemblages examined. A Late Paleocene sample contains common gymnosperms and appears to be terrestrial, although marine dinocysts have previously been recorded from a similar horizon. Above this, a prominent ~3 m grey mudstone contains abundant cysts of the marine dinoflagellate genus *Apectodinium*, indicating an early Waipawan age. Marine conditions persist in the overlying mudstone layers examined, with an uppermost glauconitic sandstone unit containing dinocysts indicative of the Mangaorapan Stage. Pollen indicative of warm climates are present by the early Waipawan (prominent mudstone unit), and *Casuarina* pollen (zone MH1) is abundant in the upper glauconitic sandstone unit.

POSTER

"100 KM PER MILLION YEARS" A HIGHLY-DYNAMIC DEPOSITIONAL MODEL FOR LATE MIOCENE ROCKS IN TARANAKI BASIN

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New biostratigraphic dating techniques challenge traditional exploration paradigms and suggest a highly dynamic depositional model is more appropriate for late Miocene rocks in Taranaki Basin, with multiple deep-water sedimentary systems of considerable thickness, developed on local geographic scales, over timescales of orbital proportions (40-100 kyr). Although the general pattern and tempo of late Miocene sedimentation are clearly dictated by climate forcing, suborbital-scale variations in sedimentary patterns and rates of deposition reflect a complex history of shelf progradation, tempered by sediment supply and accommodation, and tectonic controls within and adjacent to the basin. The observed dynamism in sedimentation is consistent with the tectonic development of the eastern Taranaki Basin margin (e.g. King and Thrasher, 1996), and with detailed outcrop based stratigraphic studies undertaken by GNS (e.g. King et al., 1993; Browne and Slatt, 2002), and also with many of the problems associated with hydrocarbon reservoir sequences (e.g. poor correlation and dating, rapid facies variations, and variable reservoir characteristics).

In this presentation, we outline some of the new biostratigraphic tools that have been developed specifically to address correlation problems associated with late Miocene rocks in Taranaki Basin. Examples from Pukearuhe-1 and outcrop studies are given, of extremely high estimated rates of sedimentation, based on weight standardized counts of planktic and benthic foraminifers, millennial scale dating of deep-water sediments, using a non-linear age interpolation method, and facies analysis, based on minimum paleodepth data. When applied in combination, the new biostratigraphic tools provide a robust temporal and paleoenvironmental framework that enables the temporal and spatial relationships of late Miocene depositional systems to be interrogated at a level of resolution similar to seismic. Although developed for late Miocene depositional systems in Taranaki Basin, the new biostratigraphic tools can be applied to late Miocene rocks in most New Zealand sedimentary basins, and the methodologies adapted for other stratigraphic intervals.

ORAL

A PROBABILISTIC LANDSLIDE HAZARD MODEL FOR NEW ZEALAND

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A probabilistic landslide hazard model for New Zealand has been developed, by producing landslide-area magnitude/frequency curves. Calibrating the magnitude/ frequency curves using landslide catalogue data allows the absolute and relative frequency of landslide-areas of a stipulated magnitude or in a stipulated time interval to be determined for a selected terrain.

Landslide-area data for New Zealand have been subdivided into landslide terrains based on geology, slope angle and landslide density. For each landslide terrain the landslide-area data (from an inventory of New Zealand landslides) is plotted as a magnitude/frequency curve in log/log space. The slope of the magnitude/frequency curve in log/log space approximates a straight line for the larger magnitude landslide-area data in each terrain. The slope of the magnitude/frequency curve varies for different terrains indicating that the landslide hazard varies across the different terrains. The slopes of the magnitude/frequency curves for the New Zealand landslide terrains range from 1.25 to 2.94 and are similar to the range of values reported in the literature for landslide magnitude/frequency data (1.75-3.30).

The magnitude/frequency curves are calibrated with respect to time using a nine-year catalogue of landslide occurrences in New Zealand. This allows the absolute landslide-area magnitude/frequency curve for each terrain to be determined. To directly compare the landslide magnitude/frequency curves in each of the terrains, we calculate the relative landslide magnitude/frequency curves by normalising terrain areas to a standard area unit of 10,000 km^2.

Comparison of the relative landslide magnitude/frequency curves shows an order of magnitude difference in the rate at which landslides occur in the lowest and highest hazard terrains. The relative landslide magnitude/frequency curves determined for each terrain allow probabilistic landslide hazard maps for New Zealand to be generated. Probabilistic landslide hazard maps for New Zealand are used to show either the largest landslide that is expected to occur in a given terrain for a stipulated time interval (e.g. 100 or 475 years) or alternatively the return period for a stipulated landslide-area (e.g. 10,000 m^3; 100,000 m^3 or 1,000,000 m^3).

ORAL

THE VOLCANOLOGY AND GEOCHEMISTRY OF THE 13.8 – 22.5 KA ROTOAIRA ERUPTIVE SEQUENCE, TONGARIRO VOLCANIC CENTRE, NEW ZEALAND

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This study focuses on the 13.8 – 22.5 ka Rotoaira eruptive sequence, the youngest of which is the Rotoaira Lapilli (13.8 ka). Three units make up the distal deposits of the Rotoaira eruptive sequence, Tongariro Volcanic Centre, and are bracketed by the rhyolitic 11.9 ka Waiohau and 22.5 ka Oruanui tephras. Rerewhakaaitu tephra (14.7 ka) lies between the youngest and the middle deposit of the Rotoaira sequence. All three units are separated by paleosols. Glass, mineral and whole rock geochemistry has been carried out on lapilli-sized pumices from the distal, medial and proximal deposits of the three units of the Rotoaira eruptive sequence. Each unit has a distinct geochemical composition. Glass data indicate many of the clasts are heterogeneous and each eruptive episode has a wide range in SiO_2 (58-78 wt %) and K_2O (1.6-4.0 wt %) composition suggesting magma mingling. Disequilibrium features in thin sections are further evidence of magma mingling. Temporal variations in composition are apparent. The oldest deposit of the eruption sequence (PR1) is less evolved than the younger deposits (SiO_2=62 wt %), the middle deposit (PR2) has SiO_2=66 wt % and the final eruption deposit has bimodal chemistry of SiO_2=64 wt % and SiO_2=71 wt %. Temporal variations are also evident within the youngest deposit of the eruption sequence (PR3). The oldest stratigraphic layer has SiO_2=69 wt %, the middle layer has an increased SiO_2 composition (SiO_2=72 wt %) with a wider range. The youngest layer has a bimodal composition with distinct modes at SiO_2=64 wt % and SiO_2=73 wt%. This may indicate several small pockets of magma were being sequentially tapped during the eruption. Individual clasts from two of the three eruptions contain compositions similar to Taupo Volcanic Zone rhyolites. This could imply that bodies of rhyolitic magma resided farther south than the existing calderas. Fe-Ti oxides demonstrate a wide range of temperatures (787-1194°C) and oxygen fugacities (NNO-0.98 to +0.98). All three eruptions show a range in temperature and the thermal variability is consistent with the geochemical variability. Whole rock data have been used to compare the Rotoaira eruptive sequence to other eruptions from Tongariro as well as eruptions from Ruapehu. The data show that the Rotoaira sequence is more Mg- and Fe-rich than younger Tongariro eruptions. Correlation between distal, medial and proximal deposits has been attempted using glass geochemistry to fingerprint the deposits in order to determine the vent location. The data suggest that North Crater is the source of at least one episode of the Rotoaira eruptive sequence, located on the northern side of Tongariro massif. North Crater is also suspected to be the source vent for other two eruptions in the Rotoaira sequence.

ORAL

MORPHING IN AND OUT AND ROUND-ABOUT

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The biodiversity and paleobiogeography of New Zealand and New Caledonian Mesozoic crinoids involve gradual change of species over time, migratory larvae, and an ability to occupy many marine niches. New Zealand Mesozoic crinoid remains are preserved rarely as calcite or ferric morphs, mainly as leached-out external moulds – nearly always as disarticulated elements, mainly columnals. Post-Palaeozoic columnals are generally straight forward to classify within a 'natural' taxonomic system to family, genus, and not uncommonly, species level (due to limited morphological diversity), or as "morphospecies".

Triassic crinoids occur in both the Rakaia and Murihiku Terranes of North and South Islands in neritic volcarenite sequences deposited at different times in fore-arc basins within an island arc. Jurassic crinoids are confined to the Murihiku Terrane of both islands, in an accretionary prism of volcaniclastic, metagreywacke sandstones and siltstones (Western Terrane Group) offshore from continental Gondwana. Cretaceous crinoids occur in basement cover rocks in North, South, and Pitt Islands. Early Triassic Nelsonian and Malakovian *Holocrinus* is the sole survivor of the Permian-Triassic extinction event, recorded only from the Murihiku Terrane. Etalian taxa include Tethyan *Dadocrinus*, and endemic *Maoricrinites; Aoteacrinus* occurs in both the Murihiku and Rakaia Terranes. The Middle to Late Triassic sustained a great biodiversity of benthic genera including Tethyan *Holocrinus, Tollmannicrinus, Encrinus, Tyrolecrinus, Silesiacrinus, Angulocrinus, Eckicrinus, Singularicrinus, Chelocrinus*, the comatulid *Paracomatula*, and cosmopolitan *Seirocrinus* and *Isocrinus*, variously co-occurring in Southland, Catlins, Nelson, and Awakino facies of the Murihiku Terrane. The Triassic-Jurassic second order extinction event was the last to impact greatly upon the evolution of New Zealand crinoid taxa, decimating populations, but appears favourably disposed towards the Isocrinida. Jurassic Tethyan migration is exemplified by benthic *Apsidocrinus, Chariocrinus, Hispidocrinus*, and dominant cosmopolitan pseudo-pelagic *Pentacrinites*, and *Seirocrinus* occurring only in the Murihiku Terrane. These and a new genus are radiated remnants of a depleted biodiversity. Anomalous to the ongoing re-colonisation of New Zealand by larval dispersion is that cosmopolitan sessile millericrinids are almost non-existent. Cretaceous Austral Province benthic *Eugenicrinites, Bourgueticrinus, Dunnicrinus, Apiocrinites, Austinocrinus, Balanocrinus, Isselicrinus, Neilsenicrinus*, comatulid *Semiometra,* and pelagic *Poecilocrinus* demonstrate a continued incursion of Tethyan, and later cosmopolitan faunas.

The K/T extinction event had little immediate impact upon genera, with *Apiocrinites, Isselicrinus, Neilsenicrinus*, and *Isocrinus* transcending the boundary. A main Tertiary evolutionary thrust involving isocrinids, bourgueticrinids, millericrinids and comatulids radiated from Cretaceous and Palaeocene genera to occupy New Zealand waters today. Extant members of the Crinoidea have remained virtually unchanged in general overall structure and morphology. Extant species are not an ancient remnant, but the consequence of many 'revival' episodes over time.

ORAL

STRUCTURAL GEOLOGY AND GEODYNAMIC MODELING OF LINKING FAULTS IN THE MARLBOROUGH FAULT ZONE, SOUTH ISLAND, NEW ZEALAND

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We present the preliminary results of a combined field-based and 3-d geodynamic modeling study on cross faults that link the major faults in the Marlborough Fault Zone, South Island. Our goal is to understand the kinematic mechanisms for transfer of strain between the main dextral oblique-slip structures, which are, from northwest to southeast, the Wairau, Awatere, Clarence, Elliot and Hope Faults. There has been a gradual temporal southeastward migration in the loci of strike-slip displacement across these faults in the late Quaternary, with the Hope Fault currently carrying the highest slip rates. This is a response to the southeastward development of the Marlborough Fault System over time.

We have combined lineament analyses on DEMs and air photographs with structural measurement in the field to unravel the structural geology, fault kinematics and tectonic geomorphology of the Marlborough Fault Zone. The 3-d modeling will allow for an integration of the surface and subsurface structures to depths of circa 30 km. This study will reveal the nature of strain partitioning in the Marlborough Fault Zone as well as plate-scale interactions between the strongly coupled overriding Australian and subducting Pacific plates.

The active cross faults dissect the regions between the main Marlborough faults into large uplifted blocks. Kinematic mechanisms for the uplift include: 1) block rotation within a dextral-reverse duplex where opposite corners of the duplex will undergo either extension/collapse or collision/thrusting; or 2) up-dip partitioning along the main Marlborough faults which at the free surface are dominated by dextral strike-slip motion but in the hanging wall are a product of distributed reverse oblique slip displacement.

DEM and air photograph analyses show the following: 1) north striking cross faults up to 40 km in length extend between the main Marlborough faults and have a sigmoidal S-shape indicating that they have been affected by dextral shear; 2) NNE striking fractures and faults are parallel to bedding form lines in the Torlesse; 3) these fractures are common and evenly distributed between the Wairau and Awatere faults, less abundant between the Awatere and Clarence faults and rare between the Clarence and Hope faults; 4) NE striking fractures and faults parallel to the main Marlborough Faults decrease in number from the Wairau to the Hope fault; 5) a roughly N striking pivot or hinge zone delineates a strike change from 080° (translational) to 065° (transpressional) for the main Marlborough faults; 6) this pivot zone is marked by at least two diamond-shaped fault-bounded blocks up to 40 km in length; 7) one block is bounded by the Clarence-Eliot faults with another somewhat less well defined block between the Clarence and Awatere faults; 8) west of the pivot zone the cross faults are topographically entrenched and connect between the main Marlborough faults whereas east of the pivot they are shorter, discontinuous and have subdued geomorphic expression.

POSTER

A SEISMIC-GRAVITY STUDY OF THE SOUTHEASTERN BOUNDARY OF THE WANGANUI BASIN

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Located between the axial ranges of the North Island and the south Taranaki Basin, the Wanganui Basin is a region of broad crustal down-warp with predominantly reverse faulting. The Basin is of Pliocene-Pleistocene age, with sediments directly over Mesozoic basement. Sediments in the basin dip gently towards a central depocentre and are cut by NE-NNE-trending faults that are generally downthrown towards the centre of the basin. The depocenter of this basin has migrated south-southwest with time, driven at least in part by the Quaternary uplift and doming of the central North Island.

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. Part of this study is directed to learn about the southeastern corner of the Wanganui Basin and the transition to the Tararua Ranges. We report three new active-source seismic lines and three reprocessed existing active source seismic lines. All these lines show clear evidence of faulting. The majority of the faults are high angle reverse faults. Because of the rapid deposition of sediments, and shifting sand dunes, these active to recently active faults could be classified as blind thrusts. However, there are also a few normal faults visible especially in the coastal Levin area. The reverse faults agree well with the notion of crustal downwarp in a region of geodetically-determined, mild compression. Three possible explanations for the normal faults are a) 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.

We have started to create models to test for the origin of the –150 mgal Bouguer/isostatic gravity anomaly that dominates Wanganui Basin. The anomaly can only partially be explained by the sediment fill and it is one of the most compelling geophysical observations in the Wanganui area, if not the whole North Island. Initial 3D models show that the gravity anomaly associated with the basin is generally consistent with a downwarp model of the entire crust. However, the downwarp of the Moho has to be significantly greater than the downwarp of the sediment-basement interface to fit the observed gravity anomaly. Hence we propose a model of lithospheric shortening where thickening increases with depth.

POSTER

WHAT SOURCE ROCK POTENTIAL DOES THE WAIPAWA FORMATION HAVE BEYOND THE EAST COAST BASIN? AN OUTCROP-BASED CASE STUDY FROM NORTHLAND

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The Paleocene Waipawa (Black Shale) Formation is a known source of oil in the East Coast and north Taranaki basins. It is likely to be a significant source rock in adjacent basins in Northland and Canterbury and the Great South Basin. In order to determine the extent and character of the formation in northern Northland, we studied Waipawa-like dark-grey mudstones exposed in Price's and Black's quarries in the allochthonous sequence at Ohia, west of Taipa, and a shore platform exposure in the autochthonous sequence at Whatuwhiwhi, Karikari Peninsula. The Ohia and Whatuwhiwhi exposures are inferred to record distal and proximal deposition, respectively, off the northeastern margin of Northland within the so-called North Slope Basin.

The quarry outcrops are highly deformed, making determination of stratigraphic orientation and thickness difficult. Dinoflagellate biostratigraphy shows that the sequence in Price's Quarry is overturned and ranges in age from Late Cretaceous to late Paleocene. Although this age range encompasses that in which the Waipawa Formation was deposited, the distinctive geochemical signature of the formation is not evident in any of the quarry samples. Despite an oily smell and sulphurous efflorescence, all samples have low TOC and light bulk →^{13}C values (less than 1% and -26‰, respectively). Based on these features, the entire sequence is correlated with the siliceous mudstone facies of the Whangai Formation. In contrast, the typically high TOCs and heavy →^{13}C values (> -24‰) of the Waipawa Formation are found in petroliferous mudstone exposed in Black's Quarry, 1.5 km to the east. Dinoflagellates confirm a Paleocene age. Although a stratigraphic thickness of 40 m is suggested, it is difficult to confirm due to poor bedding and numerous faults. The formation here is immature (T_{max} 421–427 °C) and TOC and HI values of 10–11% and 426–445 mg HC/g TOC, respectively, indicate good potential for both oil and gas generation. At Whatuwhiwhi, the well-bedded Haumurian–Teurian Waiari Formation includes a lower chert-dominated facies and an upper mudstone-dominated facies. The former has a Whangai-type geochemical signature whereas the latter has a Waipawa-type geochemical signature. However, a lack of palynomorphs and almost completely exhausted petroleum potentials (S2 < 0.15 mg HC/g rock) indicate that the Waipawa-like interval has been thermally altered by nearby Miocene intrusives to an extent that makes correlation with the Waipawa Formation uncertain. The heavy isotopic signature may be a result of this thermal alteration.

The results of this study indicate that good quality Waipawa Formation source rock is likely to be present in the sedimentary succession offshore northeastern Northland. However, its thickness is uncertain and it is likely to grade laterally and vertically into comparatively organic-lean siliceous facies of the Whangai Formation. Seismic facies mapping and paleoenvironmental reconstructions are recommended to better define the extent and quality of this important source rock.

POSTER

DISTRIBUTION AND SEISMIC CHARACTERISATION OF GAS HYDRATES IN FIORDLAND, NEW ZEALAND

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We have compiled the distribution of gas hydrates on the Fiordland margin based on the occurrence of BSRs in an extensive database of seismic reflection data, acquired by academic, government and petroleum research cruises over the last 30 years. Bottom simulating reflections (BSRs) are thereby found in an area of approximately 2200 sq km on the continental slope south-west. Main characteristics of the BSRs include:

1. predominately negative polarity compared to the seafloor reflection, which infers to a decrease in acoustic impedance,
2. the reflections follow the morphology of the seafloor, thereby crosscutting strata, and
3. strong variations of amplitudes with offset (AVO), indicating the presence of free gas below the reflection. In addition, the existence of free gas is supported by a reduced interval velocity distribution below the BSR, with velocity decreases of up to 30% compared to the overlaying layers.

Because seismic reflection data is the only available data source in the Fiordland region (other a priori information like well information is not available) a simultaneous AVO inversion algorithm is used to obtain rock property attributes of P-impedance, v_p/v_s, and density, respectively. This information is used to verify the quantities of gas hydrate and their potential as a gas reserve in this region.

POSTER

MID-PLEISTOCENE EXTINCTION OF DEEP-SEA OSTRACODA?

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The last identified global marine extinction event (‘*the Stilostomella extinction*’) occurred about 600-900ka during the mid Pleistocene climate transition. It is not only the most recent deep-sea extinction, but also least studied because recovery of sediments of that age and environment of deposition are still most effectively achieved by examination of relatively few, widely distributed cores. This extinction affected benthic foraminifera, in particular 82 species and 17 genera, including one complete family (Stilostomellidae – 21 species). A second family (Pleurostomellidae – 24 species) also suffered significant extinction, however two species of that group have been recovered in sediments which post-date the mid-Pleistocene event.

In an attempt to determine whether benthic ostracods (Podocopida) have also been affected by the ‘*Stilostomella event*’ as an ongoing MSc thesis project, a single ODP core from the northern flank of the Chatham Rise, New Zealand, is being examined. Ostracods are crustaceans in which the soft anatomy is encapsulated in a bivalved, calcareous carapace. Valves of this microscopic organism are commonly preserved in deep-sea sediments and as result, ostracods present the most complete biogeographic and stratigraphic record of any metazoan in the deep sea. This fact provides an opportunity to examine whether more complex, benthic deep-sea marine organisms were also affected by the extinction event and if so, to then provide an additional insight into what environmental factors led to the significant loss of biodiversity. The results of this project will also make a contribution to our understanding of ostracod diversification through time with particular reference to significant Late Pliocene-Pleistocene events described for bradleyinid and trachyleberid species especially from the Southern Ocean. Significant problems relating to taxonomy and taphonomy have and continue to hinder progress.

Samples studied are from the ODP core 1125 located about 600km east of the South Island at 1359 m depth on the northern side of the Chatham Rise. The samples are from the top of the core down to approximately 42 mbsf, covering the last 2.5 Ma, i.e. late Pliocene to Recent. There is a significant variation between samples in terms of grain size, ostracod population (total number of specimens and diversity) and the disproportionate number of juvenile valves. Some groups are well represented, including *Bradleya, Taracythere, Krithe* and *Apatihowella*, which form the main cluster of target species for this project. The occurrence of *Bradleya pygmaea* in core 1125 (1359 m) is significant because it has been recorded in Pliocene abyssal/bathyal sediments elsewhere in the Southwest Pacific, and was also recovered in uppermost Quaternary sediment from that Plateau. It is, however, no longer living on the Campbell Plateau, which implies steepening thermal gradients and an associated shoaling as significant influences on both the latitudinal and depth distribution of Podocopid ostracods.

ORAL

TRACKING CRUSTAL DIFFERENTIATION AND ASSIMILATION PROCESSES AT ARC VOLCANOES: A URANIUM SERIES ISOTOPE PERSPECTIVE

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Parent-daughter isotope systems that decay on time scales appropriate to the rates of processes themselves have proved powerful tools in tracking the histories of many arc-related processes from fluid release during plate subduction to dynamic melting of the mantle wedge. However, the rates inferred for mantle processes can only be considered real if the effects of continental crustal interaction are demonstrably minimal. In order to try and deconvolve mantle and crustal processes in this context we consider two contrasting case studies.

Ruapehu volcano, New Zealand: On an equiline diagram the Ruapehu samples form a subtle positive array that extends from Taupo rhyolites and is intermediate between them and Kermadec lavas. It is conceivable from this data that a simple model of mixing between mantle-derived melts and Taupo crustal melts may explain the Ruapehu disequilibria. However, other reservoirs may be involved. For example, the range of calculated disequilibria derived from elemental Th/U ratios in averaged metasedimentary xenoliths, Torlesse and Waipapa basement averages could also be involved. Thus an alternative, although speculative, model is that Ruapehu samples reflect melts sourced from the lower to middle crust (as sampled in the xenolith suite), mixed with those generated at shallower levels (represented by Taupo-like magmas). Irrespective of the exact details of likely components, the key aspect of these systematics is that for the first time, there is sufficient information available to show that an inclined array on the equiline diagram for a single volcanic suite is unequivocally the product of open system processes: mixing between mantle or lower to mid-crustal melts and shallow upper crustal components.

Okmok volcano, Aleutian arc: At face value, ^{238}U-^{230}Th disequilibria in young volcanics from Okmok suggest time scales of 50 kyr or less for some combination of mantle-crustal processes to take place. Given good evidence in the arc as a whole for fluid transfer from the subducted plate to take less than 10 kyr to reach the arc volcano (George et al., 2003), this additional time could reasonably be supposed to relate to a crustal process. Extremely good negative correlations between Sr and O isotopes are consistent with crustal assimilation of low $\delta^{18}O$, hydrothermally-altered wallrocks. While the correlation between these two parameters and ($^{230}Th/^{232}Th$) appears to be less coherent, it is striking that these activity ratios broadly increase with increasing Sr isotope ratios and decreasing $\delta^{18}O$. The assimilant could therefore be hydrothermally-altered arc crust of relatively recent age of less than 100 kyr.

ORAL

THE SURFACE IMAGE OF AN ACTIVELY GROWING – INVERTED? – REVERSE FAULT: THE OSTLER FAULT IN THE MACKENZIE BASIN (SOUTH ISLAND, NEW ZEALAND)

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A reappraisal of the geometry and structural evolution of the Ostler fault within the Mackenzie basin is under way. A new geological map of the fault zone (scale 1:50,000) is almost complete, and two seismic reflection lines across the fault will be acquired by A. Gorman in the early months of 2006 (Otago University Research Grant). The Ostler fault is a 50 km long, N-S reverse fault, dipping 30º-50º W. Previous studies have documented the segmented nature of the fault, average rates of deformation ~1 mm/yr, and the occurrence of two seismic events in the last 6 ka. According to Kleffmann and Stern (in preparation) the Ostler fault bounds the edge of a strong gravimetric gradient of residual Bouguer anomalies, with a minimum < -200 µN/kg west of the fault. This setting is interpreted in terms of a buried marine Tertiary basin, controlled by earlier normal faults. The deep geometry of the fault is largely unresolved, but stratigraphic and structural features revealed by surface mapping need to be considered in any interpretation.

A >1000 m thick sequence of terrestrial mudstones, siltstones and gravels (Pliocene?-Pleistocene?) is exposed in the fault hanging wall only. Internal architecture reveals a growth geometry of beds tilted 30º-60º W, unconformably overlain by coarse gravels (120 ka?). Above, six orders of river terraces are preserved, with the three highest orders correlating to the 35, 22-17 and 14 ka moraines. Terrace distribution indicates shifting of fault-transverse drainages, relatable to episodic uplift of the upthrown block during progressive northward propagation of segment ruptures in the late

Pleistocene-Holocene. The 22-17 ka terrace records on its carved surface the inversion of flow direction (from east- to west-directed) of an early paleodrainage, forced by backtilting of the hanging wall. The Ostler fault consists of sub-parallel, splaying segments within a deformation zone up to 2 km wide. Faults are marked by fresh scarps (→20 m high), which truncate suspended drainage systems. N-S anticlinal deformation of the hanging wall is traced by deformation of the 125 and 22-17 ka terraces, with the fold crest truncated by systems of N-S, W-dipping normal faults.

A preliminary interpretation that incorporates the surface geology and the available geophysical information is that the Ostler fault is a footwall shortcut to an inverted normal fault that bounds the eastern margin of a Mesozoic (?) - Tertiary basin hidden below the thick Plio-Pleistocene cover. Compressional inversion of the early normal fault and shortening of the basin infilling since Miocene times has resulted in the progressive elevation of the fault hanging wall during deposition of the Plio-Pleistocene terrestrial sequence, and in the propagation of a number of reverse fault splays that cut the continental sequence at surface. This interpretation will be tested by the planned seismic profiles, adding to our understanding of compressional deformation off the Alpine Fault.

ORAL

EARLY CRETACEOUS UPPER CRUSTAL MAGMATISM IN SOUTHWEST FIORDLAND: GEOCHRONOLOGICAL AND GEOCHEMICAL HIGHLIGHTS

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Southwest Fiordland contains an important record of Early Cretaceous plutonism, which is not complicated by a polyphase metamorphic overprint as in central and northern Fiordland. Recent mapping as part of the IGNS Qmap Fiordland programme (work in progress) has identified multiple Paleozoic through Mesozoic plutons composing the previously undivided Kakapo Granite of Wood (1960) in southwest Fiordland (Turnbull, pers. com.). Field, petrographic, geochemical, and geochronologic data reveal a transition from early Cretaceous LoSY to HiSY magmatism (cf. Tulloch & Kimbrough 2003) in the area around Preservation Inlet.

The Revolver Pluton (Rp) of c.200 km^2 is the largest unit. It is a LoSY, coarse grained biotite granite with distinctive pink alkali feldspar megacrysts. LA-ICP-MS zircon U-Pb dating of Rp from Revolver Bay yields an age of 132.4 ± 1.0 Ma, in agreement with an unpublished TIMS zircon age of Tulloch (reported in Mortimer at al., 1999). Granodiorite from the northeast sector of Rp, here named the Long Scarp Granodiorite (Lsg), gives a coeval age of 132.0 ± 0.9 Ma and may represent a marginal facies of Rp. Treble Mountain Granite (Tmg, Turnbull, pers. com.) is a medium to coarse grained biotite granite that intrudes Rp on the west side of Isthmus Sound, and yields an age of 130.4 ± 0.9 Ma. Tmg locally exhibits severe hydrothermal alteration and hosts epithermal base-metal vein mineralisation which was worked in the historic Tarawera Mine. Trevaccoon Diorite (Tdi, Turnbull, pers. com.) is a hornblende gabbro that outcrops along the western shore of Long Sound north of Lady Bay and has an age of 128.7 ± 1.0 Ma. A younger granite, here named Upper Blacklock Granite (Ubg), occurs between Rp and Lsg. Ubg is petrographically similar to Rp, but can be distinguished on the basis of its geochemistry and age of 124.7 ± 1.0 Ma. Hornblende-rich HiSY diorite to gabbro, here named Only Island Diorite (Oid), outcrops south from Only Island where it intrudes Ubg. The composition and age of 122.1 ± 0.9 Ma of Oid suggest it is a higher level, unmetamorphosed equivalent of the Western Fiordland Orthogneiss.

The presence of 15% inherited 149-136 Ma zircons in all units except Oid suggests a shared deeper source region comparable in age to Median Suite rocks dated by Muir et al. (1998) in eastern Fiordland. Oxygen isotope values (whole rock $\rightarrow^{18}O$ = 6-9, quartz $\rightarrow^{18}O$ = 8-10) for all units other than Tmg are consistent with such a source and, together with the rarity of older inherited zircons, limit contamination by the surrounding Ordovician metasediments ($\rightarrow^{18}O$ whole rock = 12-18). Tmg quartz and feldspar $\rightarrow^{18}O$ are strongly depleted indicating that hydrothermal alteration was caused by circulation of meteoric water. This supports the interpretation that plutons in the region were intruded at shallow crustal levels (<10 km).

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ORAL

EMPIRICAL SCALING RELATIONS FOR SEISMIC FAULTS

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We are trying to clarify the scaling relations between several parameters of seismic faults: the fault length (L), slip rate (S), recurrence interval of large earthquakes (T) and coseismic displacement (D). To do this, we have compiled a data set of about 600 ground-breaking faults (extensional, compressional and strike-slip) from all continents. For each fault, the parameters included in the database have not been estimated one from another. We have tested four relations proposed previously, and found a new one:

1. Wallace (1970) suggested that T = D / (S – C), where C is the creep rate. This parameter is frequently zero, and is rarely known. Excluding it, the relation becomes T →D/S, and holds for most faults for which T, D, and S were available in our database.
2. The previous formulae suggest that T is proportional to S^{-1}. This was previously verified for a smaller data set by Villamor and Berryman (1999), and also holds in ours.
3. As previously found in smaller data sets (Bilham and Bodin, 1992; Nicol et al., 1997; Wesnousky, 1999; Nicol et al., 2005), longer faults tend to have faster slip rates. In our composite data set, S is roughly proportional to L^2.
4. From relations [2] and [3], T should be roughly proportional to L^{-2}, and our data show that this is the case. This is important to seismic hazard assessment: it implies that earthquakes on large faults can not only be larger, but also more frequent, than those of short faults. Turcotte (1992) also proposed that T was proportional to a negative power of L, although Marrett (1994) pointed out that this power could be positive for large faults, and Nicol et al. (2005) assumed that T and L do not correlate to each other, at least in extensional faults.
5. Finally, a new scaling relation has been found for the whole data set: S is proportional to the ratio L/T. Interestingly, this relation (as [1]) is dimensionally homogeneous (both its sides are measured in the same units), and less scattered than relations [2] and [4], where T is also involved. Because L and S are among the easiest parameters to determine, this relation could be useful as a first-order approximation of T. In case D is also known, T can be better estimated by using relation [1].

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ORAL

PETROLOGY OF NEWLY DISCOVERED SUBMARINE VOLCANIC ROCKS FROM THE TONGA-KERMADEC ARC: INITIAL RESULTS

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The NZAPLUME III research cruise to the northern Kermadec – southern Tonga arc during September-October 2004 mapped and dredge-sampled eight newly discovered volcanic centres along the arc-front, including Monowai, now known to have a caldera complex immediately to the north of the previously mapped cone. These centres, which typically include one or more calderas with multiple associated volcanic cones, have an average spacing of 47 km, slightly greater than the average spacing of 41 km for the entire Kermadec arc (i.e., from Whakatane in the south to Monowai to the north). All of the newly discovered volcanic centres show evidence of hydrothermal venting and, in the case of Monowai, recent eruptive activity.

The dredged lavas have calc-alkaline compositions ranging from high-alumina basalt to rhyolite, confirming the occurrence of evolved lava compositions associated with caldera structures along the entire Kermadec arc. Three of the volcanic centres exhibit the full compositional range from basalt to rhyolite, three are basalt-andesite, and the remaining two entirely rhyolitic. In contrast to published results for the southern Kermadec arc, there is no evidence for compositional bimodality, with the data set containing sub-equal proportions of basalt, basaltic andesite, andesite, dacite, rhyodacite and rhyolite. Despite the variety of volcanic edifices sampled, all of the volcanic centres yield tight geochemical correlations for major and trace elements, which are interpreted to indicate simple mixing or fractionation processes. There is a suggestion, yet to be fully established with trace element or isotopic modelling, that three of the four southern-most centres, spanning some 200 km of arc-front, are genetically related.

ORAL

Volcanic Centre	Latitude °S	SiO_2 wt%		
		Minimum	Maximum	Mean
'V'	25.19	47	69	57.4
'U'	25.44	50	71	58.6
Monowai	25.95	49	62	52.9
'T'	26.39	50	73	65.2
'S'	26.81	69	72	71.5
'R'	27.20	72	74	73.3
'P'	27.86	50	65	58.3
'O'	28.59	56	61	57.6
All		***47***	***74***	***60.4***

INCREASED FRESHWATER RUNOFF FROM THE GROWTH OF URBAN AUCKLAND - THE GREATEST CAUSE OF ESTUARINE FAUNAL CHANGE

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Microfossils and molluscs from 13 upper Waitemata Harbour and Tamaki Estuary cores provide a record of human impact on sheltered coastal marine to estuarine environments around the fringes of growing Auckland City. Polynesian forest clearance had only minor impact compared with the increasing tempo of changes in European times. Although sedimentation rate has increased there is no consistent trend towards increasing mud or sand. In all sites, marine ostracods and infaunal bivalves were decimated in European times and largely disappear from the record, coincident with increased abundance of large diatoms and thecamoebians. The foraminiferal microfossil record is the most complete and documents a progressive switch from calcareous-dominated faunas to the agglutinate-dominated faunas of today.

All observed changes are similar to those documented in transects passing from the marine environment up an estuary and suggest that increased freshwater runoff from the mushrooming urban areas of Auckland city is the primary driver, not sediment or pollutants. This is further supported by the observation that changes occur during late Polynesian to early European times in the upper Waitemata Harbour, versus late European times (post 1950) in the Tamaki Estuary when impervious surfaces increase dramatically. If increased freshwater is indeed the culprit, carrying out remedial measures will be problematic.

ORAL

VOLCANIC GEOLOGY OF THE ORTON BRADLEY FORMATION

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The Orton Bradley Formation was deposited during the period 9.5 – 8.6 Ma. It is part of the Mt Herbert Volcanic Group of central Banks Peninsula, Canterbury, which is considered to be the intermediate stage of volcanism between Lyttelton Volcano (11 – 9.7 Ma) and Akaroa Volcano (9.3 – 8 Ma). Prior to the emplacement of the Mt Herbert Volcanic Group, sector collapse occurred on the southeast side of Lyttelton Volcano. This collapse was probably the result of persistent rifting, similar to that of Valle del Bove, Mt Etna. The sector collapse destroyed the existing crater rim, and provided a pathway for renewed / migrating volcanism in central Banks Peninsula.

This collapse structure would have produced a large horseshoe-shaped amphitheatre with a hummocky surface, and would have controlled the deposition / emplacement of later volcanic and fluvial activity. The upper sector of the breach contained alluvial fans, and a topographic low, steep source, amphitheatre, which constrained the initial Homestead Lava Member (*new name*) flows at the base of the Orton Bradley Formation. Mud deposits formed in localised depressions, on top of the topographically controlled lava flows. A period of hydrovolcanic eruptions then took place to form the Mt Bradley Volcaniclastic Member, a low angle tuff ring formed by both 'wet' and 'dry' base surges. 'Wet' base surges occurred when there was excess water supplied at the vent, whereas 'dry' base surges occurred when water was limited, or used in previous eruptions. Magma / water interaction was shallow, promoting rapid chilling and fragmentation. Eruption through a shallow standing body of water is supported by the presence of middle mud deposits, the majority of blocks over bombs, preservation of delicate cuspate edges on glass fragments, large U-shaped channels, and fluvial deposits and erosion surfaces between eruptive packages. Hawaiian style eruptive activity marked the cessation of phreatomagmatic activity, and formed a thin lava flow. This flow blocked drainage, allowing the development of a lake, and formed the upper mud deposits.

A second phase of effusive and phreatomagmatic activity then occurred, producing the interfingering Packhorse Lava Member (*new name*) flows and Tablelands Volcaniclastic Member. Packhorse Lava Member flows overcame the topographic controlled upper sector collapse and flowed further to the southeast. On exiting the steep sided collapse flows fanned out, but were constrained to the east by the growing edifice of Akaroa Volcano. The succession was then capped by Mt Herbert and flank-fed Akaroa lava flows.

POSTER

EVOLUTION OF THE PALEO-PACIFIC GONDWANA MARGIN: ISOTOPIC CONSTRAINTS FROM WEST ANTARCTIC XENOLITHS

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West Antarctica and eastern Australia formed part of the contiguous Paleo-Pacific Gondwana margin during Late Proterozoic to Mesozoic times. Key aspects of the regional evolution of this margin, including the nature and age of the component terranes, remain contentious due to the poor exposure of crustal sequences resulting from the extensive ice and sedimentary basin cover in West Antarctica and eastern Australia, respectively. Samples of the deep crust and lithospheric mantle are restricted to xenoliths incorporated in the Cenozoic lavas that have been emplaced along much of the length of this margin, and which can preserve unique age and process information that may be valuable in interpreting continent evolution. Earlier work in southeastern Australia in particular, has demonstrated the potential of the Re-Os isotopic system for constraining the timing of events recorded in the lithospheric mantle of the Paleo-Pacific Gondwana margin, with implications for continent structure and evolution (Handler and Bennett, 2001).

We will present new Os and Nd isotopic data for lithospheric xenoliths from Marie Byrd Land and Victoria Land, Antarctica, together with previously published Re-Os data and model ages from along the PaleoPacific Gondwana margin in southeastern Australia and central Marie Byrd Land (McBride et al., 1996; Handler and Bennett, 2001; Handler et al., 2003), and discuss their implications for the development of the margin. The results suggest preservation of Proterozoic lithospheric mantle along the sampled length of the margin. Striking observations include: the similarity of the oldest PaleoProterozoic Os model ages found beneath the Delamerian Fold Belt of southeastern Australia and beneath West Antarctica; preservation of a ca. 500 Ma age from central Marie Byrd Land; and the suggestion that a significant melting event may have affected the mantle beneath both southeast Australia and Marie Byrd Land ca. 900 – 1100 Ma. The timing of this speculated MesoProterozoic mantle event(s) coincides with the age of a significant peak in the U-Pb detrital zircon age spectra of the vast turbidite deposits of the Paleo-Pacific Gondwana margin (Wysoczanski and Allibone, 2004).

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ORAL

SEQUENCE STRATIGRAPHY AND ARCHITECTURAL ELEMENTS OF THE GIANT FORESETS FORMATION, NORTHERN TARANAKI BASIN, NEW ZEALAND

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The modern continental margin, northern Taranaki Basin, is underlain by a thick, mud-dominated, Pliocene and Pleistocene succession (Giant Foresets Formation, GFF) clearly imaged in seismic reflection datasets. A study focusing on the geometry and internal reflection character of the Giant Foresets Formation has revealed structural, sedimentological, and eustatic controls on its accumulation.

Isopach maps prepared for northern Taranaki Basin show shifts through time in the location of sediment accumulation of the Mangaa Formation and Giant Foresets Formation. During the Early Pliocene (Opoitian Stage) deposition was focused in the southern part of the Northern Graben. The progradational front moved into the vicinity of Arawa-1 and Taimana-1 on the Western Platform during the early-Late Pliocene (Waipipian and Mangapanian Stages), forming large mounded slope fans. Through the latest Pliocene (Mangapanian - lower Nukumaruan Stages) the progradational front moved rapidly to the north and west through and across the Northern Graben to form a distinct shelf-slope depositional front. During the Pleistocene (upper Nukumaruan Stage – Recent), the progradational front straightened out reaching the present position of the shelf-slope break. Even during the Pleistocene, broad subsidence persisted in the Northern Graben, trapping a proportion of the sediment flux being delivered to this part of the basin.

The Late Pliocene part of the GFF, particularly where it prograded on to the Western Platform, displays classic clinoform profiles, with over steepening having resulted in mass-failure of paleoslopes. Major degradation of the shelf edge and slope occurred during the Early Pleistocene, reflecting a change in the calibre and flux of sediment sourced to the continental margin.

Detailed examination of part of the GFF not significantly affected by mass-failure indicates that small-scale channel levee and overbank deposits dominate slope deposition, while basin floor deposits are characterised by slope-disconnected muddy and silty basin floor fans, with little lateral continuity between systems. In a sequence stratigraphic context, many of the dominant components of each seismic unit (slumps, fans, and channel-levee complexes) were deposited during the falling (RST) and low (LST) sea level parts of a relative sea level cycle, resulting in highly asymmetric sequences. While the Giant Foresets Formation is considered to have minor potential in terms of containing sandstone-dominated stratigraphic traps, it does afford the opportunity to study in detail how deep-water clastic systems respond or evolved in response to the various factors that control depositional architectures, particularly in a rapidly prograding muddy continental margin system.

POSTER

THE MEDIAN TECTONIC LINE INITIATED AS A LATE CARBONIFEROUS CONTINENTAL TRUNCATION ZONE

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For a 50th anniversary meeting a little preliminary history might be permitted in an abstract. In 1941 two topics were important in the Geological Survey tea-room in Wellington, one being Fyfe's Line and the other the Alpine Fault. The evidence for the Alpine Fault was properly published in writing, but that for Fyfe's Line was not, and so it gradually lost prominence. The Alpine Fault continued to be discussed with fervour after Wellman announced at the Pan-Pacific Science Congress in 1949 that there had been major strike-slip on it. He was brief and hesitant, and did not publish in writing until 1953. Fyfe's Line was re-recognised, completely independently in 1967, by Landis and Coombs who named it the Median Tectonic Line (MTL).

In the 1930s Benson, Bartrum, Keble and King correlated the graptolite zones of the Western Province of New Zealand with those of the Bendigo-Ballarat goldfields in Australia. Rocks similar to those between Brook Street and Dun Mountain were recognised far to the north at Gympie by mining engineer T.R. Hacket in the 1860s (Mike Johnston, pers. comm. 2005) and were again recognised in 1972 by Harrington. He attempted to draw a schematic map (the poster) showing the Brook Street rocks passing through Lord Howe Rise and Norfolk Ridge to Australia. A severe problem appeared immediately. It is that in eastern Australia there is a space of 1400 km between Bendigo-Ballarat and Gympie, but in New Zealand there is a space of only 40 km between the Takaka Terrane and the western side of Brook Street. The gap of 1400 km in Australia is occupied by the eastern half of the Lachlan Foldbelt and the whole of the New England Orogen. Most of those rocks are missing in New Zealand. The working hypothesis offered to explain that situation is that the missing rocks were removed tectonically and that the MTL marks a Late Carboniferous continental truncation zone. The date of truncation, c. 305 Ma, matches the date of opening of the extensional Sydney-Bowen and Cooper Basins (Harrington, BMR Bull. 231).

The Brook Street–Gympie volcanic arc was out in the ocean, far out, because it contains no record of the intense Permian glaciation on the continent. It is possible to argue that Late Devonian and Carboniferous arc split in the Early Permian into active and remnant arcs separated by an interarc basin in which the non-continental Maitai sediments were deposited. The two arcs had wide outer arc-flanks one of which is preserved between Gympie and the Esk Basin, and another in the Caples Terrane.

The Carboniferous truncation zone had thin Permian passive margin sediments on it. It became an arc-continent suture zone when the oceanic Brook Street volcanic arc system docked with it in the Early and Mid Triassic. Sediment sources then changed dramatically. The key to that is best preserved in Queensland where a major foreland volcanic basin, the Esk Basin, 400 km long and with associated plutons, formed immediately to the west of the suture. Resedimented ashfalls from the Esk andesitic and felsic volcanoes, and from volcanoes in younger basins to the south, formed the main sediments in the Murihiku-Maryborough portion of the interarc basin. In New Zealand the Mid and Late Triassic rocks of the Rakaia Sub-terrane were further from the ashfalls and so received mainly continental material.

POSTER

MICROFOSSIL RECORD OF SEVEN LARGE EARTHQUAKES IN THE PAST 7500 CAL. YRS IN SOUTHERN HAWKE'S BAY

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Foraminiferal and diatom assemblages in eleven cores (3-7.5 m deep) from brackish Ahuriri Inlet in southern Hawke's Bay, New Zealand, provide a record of 8.5 m of subsidence followed by 1.5 m of uplift in the last 7500 cal years. Modern Analogue Technique was used to estimate paleotidal elevation (subtidal to extreme high water spring level) of the 97 richest foraminiferal assemblages. The most precise estimates are for marginal high tidal salt marsh assemblages and the least precise are from low tidal and subtidal assemblages from near the centre of the inlet. These paleoelevation estimates combined with sediment thicknesses, age determinations (from tephrostratigraphy and radiocarbon dates), the New Zealand Holocene sea level curve, and estimates of compaction, identify the Holocene land elevation changes and earthquake-displacement events in each core.

By combining the records from all cores, we recognise the following major, earthquake-related displacements: ~7200 cal yrs BP (>-0.6 m displacement); ~5800 cal yrs BP; ~4200 cal yrs BP (~ - 1.5 m); ~3000 cal yrs BP (-1.4 to -1.8 m); ~1600 cal yrs BP (~ -1.7 m); ~600 cal yrs BP (~ -1 m); 1931AD Napier Earthquake (+1.5 m). The six, large (possibly subduction interface) subsidence events in the last 7200 years have had a return time of 1000-1400 years. Identified displacement events have a range of sedimentary expressions, from an eroded and burrowed hiatus surface, to an abrupt lithologic switch from mud to sand, or peat to shelly mud, or in some places no change in sediment character whatsoever.

ORAL

CRETACEOUS OCEANIC RED BEDS (CORB'S) IN NEW ZEALAND: EVIDENCE FOR A GLOBAL PHENOMENON?

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During the Cretaceous, New Zealand occupied a position on the Pacific margin of Gondwana. In the Aptian it was located at a latitude of 75°S – 85°S and, by the end of the Maastrichtian, was at a latitude of 55°S – 65°S. The Cretaceous System spans a major transition in the geological history of New Zealand, marking the end of prolonged subduction on the Pacific margin of Gondwanaland, and by the end of the Cretaceous, complete separation of New Zealand from all other Gondwanan fragments.

Early Cretaceous strata occur as structurally complex, uppermost sections of a thick, Mesozoic 'basement' sequence. Unconformably overlying the 'basement' rocks are structurally relatively uncomplicated late Early to Late Cretaceous 'cover' formations, comprising three characteristic successions. (1) Thick (up to 4000 m) non-marine sequences; (2) thick (up to 3000 m) relatively complete successions of Albian to Santonian marine, terrigenous, clastic rocks; and (3) relatively thin (<500 m) non-marine to marine transgressive successions of Conaician to Maastrichtian terrigenous clastic strata. CORB's in New Zealand are found in (2), the Albian to Santonian marine successions, at a number of localities in the Raukumara Peninsula and Wairarapa in the North Island, and Marlborough in the South Island. The North Island CORB's are found in mudstone-dominated sequences, the Marlborough CORB's in mudstone-sandstone sequences, and all range in age from uppermost Cenomanian to Coniacian. They occur as either 0.5 – 6 m thick red mudstones or as 10 – 20 m thick intervals of interbedded red, green, and olive-grey mudstone.

The presence of CORB's in New Zealand, at such a distance from other known CORB deposits located in the Northern Hemisphere, has major implications for their formation and suggests the driving forces were likely a global phenomenon.

ORAL

THE ESTABLISHMENT OF JAMES HECTOR IN OTAGO

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In September, 1860, the Otago Provincial Government approached its Home Agents in Edinburgh to find a Provincial Geologist. The Agents sought the advice of Sir Roderick Murchison, who was then Director of the British Geological Survey as well as President of the Royal Geographical Society, in London, and Alexander Keith Johnston, Geographer to the Queen. Murchison had led the recommendation of Hector to the British North American (Palliser) Expedition (1857-1859) where he had shown outstanding ability as a geologist and natural historian, an explorer, an enthusiastic leader in physically difficult country, as well as in personnel management, written reports and cartography. Thus Murchison's recommendation of Hector for Otago was eminently predictable. Hector considered that the £600 annual salary offered was inadequate and submitted that, for £800, he would purchase and ship all the equipment and instruments. As a condition of his appointment, Hector negotiated with Charles S. Wood, of the Bristol School of Mines, as assistant and the matter was closed in London on 27th December, 1861 when the Minute of Agreement was signed. Whilst Hector's medical training was acknowledged as part of his appointment to the British North American Expedition, that qualification played no part in his appointment in Otago.

Hector came to Dunedin at quite the most important time in its history since the 1848 settlement and any consideration of him must include some acknowledgement of the political and social environment of his arrival. Brief consideration can be made of a few salient events which impacted upon Dunedin, even before the official proclamation of the Tuapeka gold field in June, 1861. Events and public contemplation of this period that were particularly pertinent to Hector's arrival were the exploration and opening up of the country. Transitory as it may have been, the same brief period witnessed two peculiarly coincident events in Otago - the rise and fall of the gold and the entrance and exit of James Hector.

Hector's arrival in Otago also had significant peripheral consequences. It was through Joseph D. Hooker's introduction that he met John Buchanan; in Dunedin, Hector renewed his field and personal acquaintance with John W. Sullivan, with whom he had worked in Canada; Hector brought with him the ill-fated mining chemist C.S Wood, who was obliged to take his skills, with his terminal illness, to Melbourne so soon after; and, of course, over all this was the image and influence of that Geologist of Empire, Sir Rodney Murchison, Bt.

ORAL

RADIOLARIAN-BASED INDICATORS OF OCEANOGRAPHIC CHANGES, OFFSHORE EASTERN NEW ZEALAND, OVER THE LAST 500,000 YEARS

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Radiolarians are a diverse group of microzooplankton that construct ornate tests of opaline silica which are commonly preserved in marine sediments. The group is widely used in paleoceanographic studies, but has been underutilised in the South Pacific. We have undertaken quantitative analysis of radiolarian assemblages in Pleistocene-Holocene sediment cores from three sites north of the Chatham Rise: IMAGES site MD97-2121 and ODP sites 1123 and 1124. The radiolarian assemblages consist of a mixture of subtropical, subantarctic and transitional species, typical of temperate waters. Some 300 radiolarian species or higher level categories have been identified and most samples contain over 80 taxa. In this study we compare late Pleistocene faunal changes within these cores with local modern radiolarian distributions in surface sediments to determine how climatic changes over the last 500 ka may have affected oceanographic conditions and sea surface temperatures in this region. We utilise preliminary sea surface temperature (SST) determinations using the modern analogue technique (MAT) and a modern dataset of 31 core-top assemblages.

For the coastal region represented by MD97-2121, the last deglaciation (15-10 ka BP) was characterised by progressive warming from 15°C to 17°C and decreasing biosiliceous accumulation. The interaction of the subtropical East Cape Current and subantarctic waters jetting northward through Mernoo Gap may have promoted biosiliceous productivity in this near-coastal region in glacial times. There is little evidence from radiolarians for cooling of surface waters during the intervals correlated with the Antarctic Cold Reversal or Younger Dryas. However, a warming pulse is identified close to the termination of the Younger Dryas, c. 11.5-10 ka. Peak warmth of 17°C at 9-4.5 ka is associated with the Holocene Climatic Optimum.

For the oceanic regions represented by ODP 1123 and 1124, MAT estimates are coarse, reflecting a lack of close analogues to the assemblages at these sites in the local core-top dataset. Nevertheless, glacial-interglacial cycles are well-defined with SSTs falling to 14°C in glacials and rising to 17°C in interglacials – similar to the modern seasonal range.

POSTER

THE GREENHOUSE BEHIND THE LAB: WHAT KAIKOURA'S LIMESTONE TELLS US ABOUT THE CONSEQUENCES OF GLOBAL WARMING

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Muzzle Group strata exposed in a narrow gully behind the University of Canterbury Kaikoura Field Station record deposition at the southern margin of the Marlborough sub-basin under a greenhouse climate between 70 and 50 million years ago. Upper Cretaceous micritic limestone of the Mead Hill Formation is unconformably overlain by a 7 m thick interval of Paleocene-Eocene Teredo Limestone, consisting of highly bioturbated glauconitic sandstone. This basal member of the Amuri Limestone is overlain by >20 m of lower Eocene Lower Marl, which consists of alternating beds of marl and micritic limestone.

Correlation with similar successions in middle and northern Clarence River valley (Hollis et al. 2005a, b) indicate that lithofacies changes reflect climatically induced variation in ocean circulation, oceanic productivity and terrigenous sediment supply across a bathyal carbonate ramp. While Paleocene erosion, glaucony, and condensed sedimentation occurred in proximal settings (Kaikoura, mid-Clarence valley), a thick succession of biosiliceous sediment was deposited in distal settings (northern Clarence valley). This implies vigorous ocean circulation and enhanced coastal upwelling during a period of relatively cool climatic conditions. Early Eocene deposition of thick marl-rich sedimentary successions throughout the sub-basin suggests sluggish circulation and reduced upwelling during a period of warm climatic conditions. Distinctive marl-dominated intervals that can be correlated across the sub-basin represent episodes of extreme warming, notably the Initial Eocene Thermal Maximum (55 Ma) and the Early Eocene Climatic Optimum (53-50 Ma). These intervals are characterised by light carbon isotope signatures, short-lived occurrences of warm-water calcareous nannoplankton, planktic foraminifera and radiolarians, and acmes of some warm-water taxa. A significant increase in terrigenous flux suggests that the extreme warmth caused increased precipitation and weathering in the terrestrial hinterland.

These results are consistent with general circulation models for Eocene greenhouse conditions (560 ppm CO_2) that place New Zealand within a transition zone between a warm, subtropical, oligotrophic gyre to the north and a cool, eutrophic, cyclonic gyre to the south. Within this regime, additional warming is predicted to cause southward expansion of the subtropical gyre and increase precipitation over the New Zealand landmass.

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ORAL

QUATERNARY TEPHRA BEDS PRESERVED ON CHATHAM ISLAND: THEIR IDENTIFICATION AND SIGNIFICANCE IN INTERPRETING ASSOCIATED DEPOSITS AND PALEOVEGETATION

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The Chatham Islands preserve the easternmost occurrences of terrestrial Quaternary deposits of the New Zealand microcontinent. These include dune sands, loess, extensive blanket peats, and rhyolitic tephras derived from the TVZ in mainland New Zealand. At least three separate rhyolitic events are preserved as macroscopic tephra beds at many different locations around Chatham Island.

The youngest of these is the well known and well dated Kawakawa Tephra, which is ubiquitous about the Island, occurring in peat, sand, colluvium and loess deposits, providing an excellent marker for LGM studies on the Island.

The c.340 ka Rangitawa Tephra is present at three or more sites around the Island. At one of these locations it occurs less than two metres below the Kawakawa Tephra, indicating either extended periods of non-deposition or periods of erosion at these sites on the Island during the mid to late Quaternary.

In addition, devitrified tephra beds at three different localities have been recognised using ferromagnesian mineral content and geochemistry of ilmenite grains. At present, their ages are still unknown, but zircon grains preserved within these tephras are to be fission track dated which will aid in identifying them.

The occurrences and stratigraphic significance of the various tephras will be discussed in relation to the landscape evolution and vegetation history of Chatham Island.

ORAL

PETROLOGY OF TRANSGRESSIVE COOL-WATER LIMESTONE SEQUENCES IN NORTHERN TE KUITI GROUP, WAIKATO BASIN, NEW ZEALAND

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The mainly Oligocene Te Kuiti Group is a broadly transgressive mixed-siliciclastic cool-water carbonate succession occurring in King Country and Waikato Basins, central western North Island. The group consists of six 3rd to 4th order (1 to 5 Ma) sequences. Each of sequences 2 to 6 includes a major transgressive limestone unit at their base. The field characteristics and petrology of these limestones are little known in the Waikato Basin (from Port Waikato to Kawhia) in contrast to their correlatives to the south in King Country Basin (includes Te Kuiti/Waitomo area). Current study of these northern limestone units is providing new insights into the evolution of the Waikato Basin during the Oligocene.

The earliest Oligocene Elgood limestone of sequence 2, the lowermost of the Te Kuiti Group limestones, commonly onlaps onto Mesozoic basement rocks (e.g. Port Waikato). This limestone is tight, flaggy, well-cemented, c.10-12 m thick, and comprises pure biosparites, and occasionally biomicsparites. Skeletons are dominated by calcareous red algae, bryozoans, benthic foraminifera, and echinoderms, suggestive of shallow-shelf water depths. The mid-Oligocene Awaroa Limestone of sequence 3, onlapping onto Ahirau Sandstone, is restricted to the Kawhia region, has a flaggy appearance, and is commonly 10-18 m thick. Rocks are dominated by bryozoan, benthic foraminiferal, and echinoderm biosparites suggestive of mid-shelf water depths. The mid-Late Oligocene Waimai Limestone of sequence 4 onlaps Kotuku Siltstone and is distinctly tabular cross-bedded. Rocks include a spectrum of biosparites through to rarer biomicrites. Bioclasts are dominantly bryozoans, echinoderms, and benthic foraminifera typical of mid-shelf water depths. The late Oligocene Raglan Limestone of sequence 5 is commonly c.10 m thick, locally up to 20 m, and is restricted to northern Raglan Harbour area. This limestone transgressed onto Patikirau Siltstone, and is a slabby, intensely bioturbated, planktic foraminiferal biomicrite indicative of accumulation at outer-shelf water depths. The latest Oligocene-earliest Miocene Otorohanga Limestone or its equivalent of sequence 6, the uppermost limestone of the Te Kuiti Group, onlaps the Waitomo Sandstone and is restricted in occurrence to Gibson's Beach. The limestone is a flaggy, dense, well-cemented, pure limestone c.8 m thick. Rocks are bryozoan, echinoderm, benthic foraminiferal dominated biomicsparites indicative of mid to outer-shelf water depths.

Data suggest that during the Oligocene Waikato Basin experienced six major transgressive events characterised by siliciclastic sediment starvation and the establishment of carbonate factories at commonly inner- to mid-shelfal depths. Sea level changes were probably mainly tectonically driven with a superimposed glacio-eustatic component. The calcite cementation of these limestones is consistent with burial-induced cementation associated with pressure-dissolution of skeletal material at subsurface depths of several 100s of metres.

POSTER

MECHANICAL PARAMETERS AND SEDIMENT RHEOLOGY IN THE SUBMARINE MATAKAOA AVALANCHES, EAST CAPE REGION

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Swath bathymetry and seismic reflection data acquired over the 45 km-long, ~30 km-wide Matakaoa re-entrant provide evidence of active erosion and mass failure processes. Slope gullies, large failure scars and channels incise the >1000 m thick, seaward dipping sedimentary section of the northern margin of the East Cape region. Seismic reflection profiles from the East of the re-entrant show single catastrophic debris avalanche of low recurrence, whereas profiles acquired along the re-entrant axis provide evidences of repetitive debris flows resulting from regular failures of the recent sediments cover. Deep-seated anticlines and the proximity of the active subduction front of the Hikurangi Margin suggest structural and tectonic controls on this complex system of debris avalanches and debris flows that extend northward over more than 200 km.

Undisturbed piston cores, collected at three sites between 600 and 1500 m water depth, provided samples for geotechnical testing. The coring sites are located on both east and west sides of the re-entrant. The east of the re-entrant corresponds to a stable, undisturbed platform, whereas the west side sediment-cover presents evidence of instability. These sites were chosen to highlight possible variability in mechanical behaviour according to morpho-structural features.

Sediment mechanical parameters are calculated in order to model slope instabilities and to test trigger mechanisms. Triaxial tests are conducted under high values of isotropic consolidation stresses, varying from 300 to 2000 kPa, so as to simulate stresses existing at depths of 30 to 200 m where the avalanche rupture surface is imaged on seismic profiles. The tests allow us to determine the shearing resistance, axial strain and stress deviator, and to calculate mechanical parameters as the cohesion and the effective internal friction angle. The shearing resistance is required to constrain the boundary conditions of the sediments rheology for stability models (i.e. limiting axial stress and strain at the rupture). It is also possible to determine the theoretical boundary between stability and rupture domains. The first results of the tests give internal friction angles ranging from 22º to 25°, and undrained cohesion values from 0 to 30 kPa.

Using these mechanical parameters in the stability equation (finite elements modelling and Mohr-Coulomb rupture criteria) will help to understand the role of external parameters (e.g., variations in sea-level, seismic accelerations, lithostatic loading) in the triggering of failures in the Matakaoa landslides. The modelling of slope instabilities will help to constrain the modalities of emplacement of the multiple phases observed in the Matakaoa submarine avalanche complex.

ORAL

THE FIRST PTEROSAUR BONE FROM THE LATE CRETACEOUS OF THE SOUTH ISLAND, NEW ZEALAND

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New Zealand's record of Mesozoic terrestrial vertebrates is very limited; almost all of the specimens have come from the Late Cretaceous shallow marine sediments exposed in Mangahouanga Stream, Southern Hawkes Bay. Most were collected and described by Dr. Joan Wiffen and others. Included in the known fauna are Pterosaurs which are represented by a scapula? and the distal end of an ulna.

Recently the author discovered an uncatalogued bone in the reference collection of the Institute of Geological and Nuclear Sciences (GNS, formerly the New Zealand Geological Survey).

The specimen is a large, hollow, very thin-walled distal? portion of a long bone. It is poorly preserved with few identifiable anatomical features. The surfaces on the end of the bone are damaged or worn. It is tentatively identified here as the distal? end of an, as yet, unidentified pterosaur wing long bone. The referral of the specimen to the Order Pterosauria is based on its large size (20 mm minimum shaft diameter), hollow shaft (now infilled with sediment), and very thin walls (1 mm thick). The shaft has a flattened, ovoid cross-section.

The specimen was collected by C.A. Fleming in May 1955 from the "Black Grit", Mikonui Stream, near Haumuri (Amuri) Bluff, just south of Kaikoura. This unit (equivalent to the Tarapuhi Grit of Warren and Speden 1977) has recently been redated, using improved dinoflagellates biozonations, as lower Middle Campanian (Crampton et al 2000).

It is probable that the specimen was collected by Fleming during a field excursion organised during the 11th Annual Geological Survey Staff Conference, held at Kaikoura between the 10th and 16th May 1955. The excursion, on Thursday the 12th May, planned to visit Haumuri Bluff between 2 and 4pm and then pass by Mikonui Stream on the way back to the meet the bus at Oaro. This particular conference is also of note historically; as it was during this conference the inaugural meeting of the New Zealand Geological Society was held (Hayward 1980)

This specimen is the first pterosaur bone recorded from the South Island of New Zealand. It also represents the earliest verifiable collection of a Mesozoic terrestrial vertebrate in New Zealand, predating Dr. Joan Wiffen's dinosaur discoveries by more than 20 years. Unfortunately it was not recognised for what it was for almost 50 years.

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POSTER

THE RELATIONSHIP BETWEEN THE CAPLES AND DUN MOUNTAIN TERRANES

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Geochemical and structural data will be presented to help interpret the melanged boundary between the Caples and Dun Mountain Terranes. Preliminary data indicates that:

1. The Windon Melange extends from the East Eglinton to Windley Rivers in Southland (approx. 54 Km) and its geochemistry and lithology are distinct from the Dun Mountain Ophiolite. The Windon Melange is fault bounded and is located to the east of the Dun Mountain Ophiolite.
2. There is no reason to separate the Harris Saddle and the West Burn Formation of the Caples Terrane as they share stratigraphical location, lithology and igneous geochemistry. This composite formation occurs to the east of the Windon Melange, however small fault blocks have been found between the Windon Melange and the Dun Mountain Ophiolite.
3. The Patuki Melange of Nelson and the Windon Melange of Southland can be considered to be of identical origin.
4. There is no visible evidence for an original relationship between the Greenstone (Croisilles) Melange and the Windon (Patuki) Melange.
5. The Dun Mountain Ophiolite, although block faulted and internally sheared is not melanged, away from major bounding fault zones.

Where these terranes are out of their normal order, a model of flexural strike slip due to the Cenozoic dextral movement in the South Island is proposed for their emplacement. This modal has already been proposed to explain repeated lithologies near West Dome (Cawood, 1986) and here the idea will be expanded to include the Livingstone Mountains and the Red Hills in Nelson, with cooperating structural evidence. It has also been observed that the active part of the boundaries between these units has shifted several times.

The different strengths of serpentinite and ultramafic rock are manifested in the distribution of strain along the Dun Mountain Ophiolite. This has a significant effect on the current pattern of New Zealand's geology. One of the more significant examples is a bend in the Dun Mountain Ophiolite and neighbouring terranes of approximately 45° near the Red Hills in Nelson.

POSTER

GONE BUT NOT FORGOTTEN - CASUALTIES OF THE LAST GLOBAL EXTINCTION

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The extinction of a group of elongate, cylindrical deep-sea benthic foraminifera occurred during the mid-Pleistocene Climatic Transition (MPT), between 1.2 and 0.55 Ma. This extinction was first recognised ~25 years ago and until recently its full impact was undocumented. Our studies in eighteen ODP cores from the North Atlantic, South Atlantic, Caribbean, Mediterranean, Southern Ocean, North Indian, South China Sea and South-west Pacific, show that at least 82 species and 17 genera became extinct during this period of major global climate and oceanographic change. A further 4 species and 3 genera declined dramatically during the MPT, but survived through in low numbers in geographically-restricted refugia. One complete family (Stilostomellidae – 21 species), characterised by an unusual tooth structure in its necked aperture, became extinct at this time; and a second family (Pleurostomellidae – 24 species), also characterised by unusual elliptical or hooded apertures, was killed off except for two species that appear to have just survived through. A further 30 species in the large Nodosariidae family also died out and most of these too, had unusual cribrate or narrow, constricted apertures.

Prior to the MPT, many of the extinct species had cosmopolitan distributions at middle bathyal to upper abyssal depths (600-3000 m), although a minority had geographically-limited distributions. Our studies indicate that ~20% of the global diversity of benthic foraminifera at these depths (excluding the diverse unilocular taxa) became extinct during the MPT. This was an extinction rate of ~30% of the middle bathyal-upper abyssal fauna/myrs, which is an order of magnitude greater than the background extinction rate for deep-sea benthic foraminifera of ~2-3%/ myrs.

ORAL

"CM/YR" IS NOW AVAILABLE – WHAT OF THE NEXT 50 YEARS?

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In its first 50 years, our Society exceeded all expectations and world geology underwent its greatest revolution. Belief in the Alpine Fault led to that in Continental Drift, which sparked off a new era of Plate Tectonics with a new unit for its movements of "cm/yr". There seems general acceptance of these concepts in NZ, regarding other parts of the world. Let us hope that the next 50 years will bring comparable acceptance regarding NZ itself. Conclusions involving "plate tectonic-like" movements by many authors have been commonly ignored in appropriate diagrams and papers – by various means ranging from denying all discussion, to preferring a belief in zero-movement.

Plate tectonic conclusions, many dating back over decades rather than years, that seem not to be fully accepted in general papers (or need more convincing reporting?), include:

→*Northland Allochthon* it took half those 50 years, for even discussion to be acceptable.

→*Central Volcanic Region (CVR)* was created from nothing since 2.5 Ma, along with the Havre Trough. Stern's diagram illustrating that situation is nearly 20 years old.

→*Alpine Fault* was active in both North and South Islands up to ca 5 Ma (major North Island faulting has long been widely noted and joined commonly to the Alpine Fault); its trace is now precisely located as the CVR's boundary, & could become widely adopted.

→ *Offshore Northland* has been shown to have moved southeast between 15 & 5 Ma to become the East Coast - in many publications dating back between 10 and 38 years.

→*Whakatane* was moved southeast at 2→cm/year for 400 k.yr (evidence 10+ years old).

→*Clockwise North Island Rotation* since 15 Ma – a 30 year-old average of 65^{o} has been supported recently, but the effects of rotation are seldom considered in general papers.

→ *Three North Island "Tectonic Events"* (ca 10 m.yr apart since 25 Ma) have been named, but ignored, for ca 10 years; they allow changes in compression & tension to be dated accurately and linked to (e.g.) important changes in the local class of volcanism.

→ *A Single Subduction System,* initially off Northland, moved & rotated progressively via Coromandel offshore, to become the Hikurangi Subduction System with only one change in the rotation rate at a tectonic event. No new data are necessarily needed to reach such conclusions as these. A 1963 diagram, based solely on then published (pre- radiometric) data, nevertheless illustrated the creation of the CVR from nothing.

The North Island predominates in these examples, but the 2005 fieldtrip programme emphasises an accelerating interest in Marlborough's plate tectonic history - reflected in several recent convincing papers. Compatibility of evidence from the two islands, at specific points backwards in time, will be a key objective for the second 50 years – Alpine Fault movement, large rotation, tectonic events, subsurface termination of subduction, effects on non-geologic factors etc. However the overwhelming need will be to promote a greater acceptance of the reality of NZ Plate Tectonics, in both thinking and writing. Should that be achieved, the next 50 years will be as exciting and rewarding scientifically for the next generation as the last 50 years have been for us, and NZ will once again stimulate world thinking about the revolutionary science of plate tectonics.

ORAL

IS THE LATE CRETACEOUS WARD COASTAL SUCCESSION ALLOCHTHONOUS?

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Over most of NE Marlborough, the Haumurian sedimentary rocks consist of a lower portion, comprising the fine-grained clastic Whangai Formation (locally Herring Formation) typically comprising a monotonous succession of massive or finely-laminated dark silty or very fine sandy mudstone, which passes upwards abruptly or with rapid transition into the siliceous limestone of the Mead Hill Formation, occupying the upper portion. In the coastal area east of Ward, however, the Whangai Formation includes massive sandstone bodies, a thick turbidite unit, and debris flow deposits.

A large proportion of the lower half of the exposed Haumurian succession, which contains dinoflagellates of late early Haumurian (*I. korojonense* Zone) age, is occupied by a body of massive well-sorted fine sandstone, up to 120 m thick. The lower and upper contacts of the sandstone body with the enclosing Whangai Formation are sharp, with large, rounded blocks and rafts up to 2 m thick of laminated dark mudstone of the underlying Whangai Formation present in the basal 15 m, suggesting erosion and incorporation in a sandy debris flow. The younger part of the succession is largely fine-grained, with scattered intervals of matrix-supported conglomerate or graded sandstone up to 5 m thick, interpreted to represent debris flows, slumps and turbidites, and occupying shallow channels. Soft-sediment slumping occurs at several horizons. The fine-grained succession passes upwards either directly into the Flaxbourne Limestone, a ~20 m thick siliceous/calcareous unit of late Haumurian (*P. granulatum* Subzone) age, or into channelled, massive, well-sorted fine sandstone bodies up to 20 m thick, which in turn pass upwards into the Flaxbourne Limestone. A 220+ m thick unit of turbidite sandstones occupies the stratigraphic position between the Flaxbourne Limestone and the latest Cretaceous and Paleocene Mead Hill Formation. The thick sandstone bodies are inferred to occupy channel systems, and the turbidite unit represents either the infill of a depression or a laterally-migrating submarine fan.

With the exception of scattered sandstone beds in the otherwise fine-grained Woodside Creek succession, none of the coarser units are traceable to the west of the London Hill Fault, a major Neogene structure forming the western boundary of the Ward coastal area. A limited amount of dextral strike-slip movement (~4 km), as well as overthrusting, was inferred to have occurred across the fault during the Neogene (Audru, 1996), but this is unlikely to account for the marked difference in sedimentary facies across it. There are, however, similarities between the Haumurian Ward coastal succession and the equivalent succession at Tora in SE Wairarapa, where similar channels, slumps and coarse clastic deposits also occur in the upper part of the sequence. The Late Cretaceous succession at Tora represents the southernmost segment in the eastern North Island of the partly allochthonous Eastern Sub-belt, and it is possible that the Sub-belt extended further south to include the Ward coastal area, with the London Hill Fault marking the tectonic boundary of a well-travelled block.

Reference.

Audru, J-C. 1996: De la subduction d'Hikurangi à la Faille Alpine, region de Marlborough, Nouvelle Zélande. Ph.D. thesis, University of Nice, France.

ORAL

FAULT CHARACTERISATION AND EARTHQUAKE SOURCE IDENTIFICATION IN THE OFFSHORE BAY OF PLENTY

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We identify and map active faults within 100 km of the Bay of Plenty coast, from interpretation of >8,000 km of high-resolution seismic reflection profiles, >11,000 km^2 of multibeam bathymetric data, and archived side-scan sonar imagery. Active normal faulting in the central Bay of Plenty is associated with continental back-arc extension in the offshore NNE-trending Taupo Volcanic Zone and southern Havre Trough. In the eastern Bay of Plenty, the faults include N-S-trending components of the North Island Dextral Fault Belt (NIDFB), and NW-SE striking reverse faults related to the deformation of north-western Raukumara Peninsula. The data set enables the recognition of fault displacements <0.5 m in the near-surface sediments. From the spatial relationships between the highly distributed surface fault traces, both at depth and in map view, we identified specific fault zones that are interpreted to represent discrete earthquake sources. The sources are characterised by their tectonic styles (normal, reverse, strike-slip), rupture lengths expressed at the seafloor, fault width, and thickness of the seismogenic zone (8 km in the TVZ and southern Havre Trough; 12 and 15 km in the western and eastern Bay of Plenty shelves, respectively). For each earthquake source, we derive earthquake moment magnitudes (M_w) using an empirical regression relating rupture dimensions to M_w. We assumed M_w 5.8 as a lower threshold for ground rupturing earthquakes in the TVZ, corresponding to a rupture length of 6-7 km, according to published length-magnitude empirical correlations from a global compilation of faults. To estimate slip rates, we mainly use (1) the displacement of the 7 to 20 kyr old post-last glacial transgressive surface (PGS) in water depths shallower than 150 m; and (2) the estimated contribution of individual faults to the total tectonic extension (12-20 mm/yr) across the Bay of Plenty continental slope and deep water basins, on the basis of fault scarp geomorphology.

We interpreted 166 individual potential earthquake sources in the offshore Bay of Plenty, and 36 composite scenarios by considering the combined rupture of adjacent offshore sources during an earthquake, or the extension of an offshore rupture onto land. Most of the faults are previously unrecognised in seismic hazard models, in particular the reverse faults in the eastern Bay of Plenty, and normal faults close to Tauranga. Assigned rupture lengths range from 6 to 51 km, and are associated with magnitudes ranging from M_w 5.7 to 7.1. More than 75% of the earthquake sources could generate M_w 6.0 to 6.6. From estimates of the seismic moment (M_o) and slip rate, we determine single event displacements and earthquake recurrence intervals. Estimates of coseismic displacements averaged across the fault surfaces range from as little as 0.1 m to 2.4 m, and are likely to be exceeded locally at the ground surface. Recurrence intervals range from 20 to 58,000 years, with an average of ~3000 yrs. There are 25 earthquake sources that have minimum recurrence intervals of less than 100 years, whereas intervals for the sources that probably extend onshore are more than 1000 yrs.

ORAL

USING TREE COLONISATION TO INVESTIGATE THE AGE OF THE MOST RECENT EARTHQUAKE ALONG THE WESTERN HOPE FAULT

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The Hope Fault is the highest slip rate fault in northern South Island and constitutes the major neotectonic link between the Alpine Fault and Hikurangi Subduction Zone - the main plate boundary structures through NZ. The slip rate in the western part of the Hope Fault (Hurunui section) is c. 12 mm/yr and the recurrence time for surface faulting events is c. 310-490 yr. Though the Alpine Fault has an established pre-European fault rupture event (c. 1717 AD) and the Hope River segment of the Hope Fault ruptured in 1888 AD, there is no known rupture record for the Hurunui section.

We have cored 265 beech trees at 15 sites on or adjacent to the active trace of the Hope Fault in order to test whether massive landscape changes during the last 300 yr have been recorded in the growth history of Beech forests there. About 65% of the trees sampled were Red (*Nothofagus fusca*); 28% Silver (*N. menziesii*); and 7% Mountain (*N. solandri* var *cliffortiodes*) Beech. We compare our preliminary results with 14-C dates from sites of landscape change, tree disturbance and one hand-dug trench along the Hurunui section to determine a "most-recent" fault rupture date for the western end of the Hope Fault. Our geomorphic model for large seismic events is for: i) c. 3.4 m average dextral displacement on the fault; ii) high levels of ground shaking capable of affecting patches of trees along the fault trace; (iii) landsliding and sediment generation from smaller catchments surrounding the Hurunui valley; and (iv) deposition of fluvial and fan deposits after the earthquake.

A preliminary analysis of the data suggest there are three major forest re-generation events that can be picked out from multiple sites. They correspond in time to the AD 1888 event; an event in the early-mid 19th century, and an event in the early-mid 18th century.

ORAL

TEREBRATULIDE AND RHYNCHONELLIDE BRACHIOPODS IN NEW ZEALAND – WINNERS AND LOSERS OF THE MESOZOIC MARINE REVOLUTION

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The end-Permian extinction event removed many of the brachiopod clades that had dominated Paleozoic sea floors, and decimated the remainder. By the end of the Early Jurassic, spiriferides and athyrides, members of two of the five articulated brachiopod orders that had survived into the Triassic, had finally disappeared, and brachiopod faunas in New Zealand, as elsewhere, became dominated by a variety of ribbed rhynchonellides with a few species of generally smooth terebratulides making up the balance. Little is known of New Zealand Cretaceous brachiopods, but from the early Cenozoic to the present day, in New Zealand seas as globally, terebratulides have become by far the most abundant and diverse group of brachiopods, greatly outnumbering rhynchonellides in terms of both generic and species richness, and in total biomass. What caused this major shift or changeover in brachiopod faunas since the Mesozoic? Was competition between brachiopods and bivalves a factor? Did the endopunctate terebratulides come through the Mesozoic Marine Revolution more successfully than impunctate rhynchonellides because of superior morphological, physiological and ecological characteristics? We will examine the morphological differences between the two groups, and indicate how these may have enabled the two brachiopod clades to cope with various environmental changes (ocean chemistry, temperature and sea level fluctuations, varied substrates) and biotic filters (competition, feeding efficiency, predation) over the past 200 million years. Our analysis uses examples from New Zealand Mesozoic and Cenozoic strata, and the modern New Zealand brachiopod fauna.

ORAL

SOUTH ISLAND OLIGOCENE UNCONFORMITIES – EVOLUTION OF AN IDEA

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Early mapping in the Canterbury and Otago regions quickly generated controversy about the interpretation of the contact between the Amuri and Weka Pass Limestones and their stratigraphic equivalent. Mappers were divided on whether the contact was conformable or unconformable.

In publications (up to the 1960s) the contact is well described, but is never referred to as an unconformity. In the Oamaru region the two limestones are often separated by a unit of calcareous glauconitic sandstone, and the faunal differences between the underlying limestone (correlated with the Amuri in Canterbury), the glauconitic sandstone and the overlying limestone (correlated with the Weka Pass Limestone) led to the subdivision of the Oligocene into the New Zealand stages Whaingaroan, Duntroonian and Waitakian.

It was not until the biostratigraphy of the Oligocene was much better defined that a definite age break between the Amuri and Weka Pass Limestones was proved, and by this time the correlation of these limestone units was so well established that it was an easy logical step to assume that the age of the unconformity must therefore be the same wherever the two limestones occur.

At this time the Tertiary succession in the South Island was being interpreted as a transgressive-regressive sequence, with the boundary between the two limestones representing starvation due to maximum sea-level. Alternatively, global studies were connecting the change from Greenhouse to Icehouse climates with the development of a strong current circling Antarctica, at around the beginning of the Oligocene. Both these theories were advanced to explain synchronous development of unconformities across the South Island and into the offshore regions.

However, the unconformity itself is quite different across the South Island, and may not be present in some successions. Biostratigraphic studies have confirmed the presence of multiple unconformities within many successions, although only one at others. Other dating methods are more difficult to apply, and only strontium isotope dating has been attempted at what has been described as the type section of the regional unconformity, at Squires Farm in South Canterbury. This date proved to be slightly inconsistent with earlier interpretations and some biostratigraphic results for other successions, but correlates well with some offshore dating from ODP Leg 181.

The current status is impasse, with interpretation of the unconformities as being caused by a single event still the dominant explanation, but insufficient data available to either prove or disprove this hypothesis.

POSTER

DEPOSITIONAL PROCESSES AND SEDIMENTARY FRACTIONATION IN THE FORMATION OF TEPHRA BEDS FROM PYROCLASTIC ERUPTIONS: A STUDY OF POTAKA AND CORRELATIVE KAIMATIRA PUMICE SAND DEPOSITS

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Tephra beds are commonly used to aid in chronostratigraphic reconstruction of sedimentary deposits within which they occur. High-resolution stratigraphic studies of Wanganui Basin sediments have benefited from the abundance of interlayered tephras, many of which have been dated by fission-track methods and/or are correlated with known eruptions in the Taupo Volcanic Zone. The present study has a different aim; which is to investigate the physical processes involved in sedimentary deposition of ash in the marine environment. To do so we are examining the Potaka Tephra at two sites, and the correlative Kaimatira Pumice Sand at another two sites.

The Potaka Tephra locally contains apparently unreworked primary tephra deposits, but through most of its thickness reflects deposition under the influence of waves and currents. Kaimatira Pumice Sand consists of crystals and uncommon pumice fragments derived from pyroclastic deposits, but deposition was entirely by waves and currents, and the original pyroclastic grain population has been reduced to a "lag" of crystals representing an as-yet undetermined fraction of the mixture of crystal-bearing pumice, glass shards, and free crystals that would have characterised the primary particle population.

Our analysis will focus on (1) using bedding structures to determine as precisely as possible the depositional processes that formed different parts of the tephras, (2), geochemical investigation of glass, crystals, and whole pumice to characterise the tephras, for comparison with known primary eruptive products of the TVZ, and (3), for primary parts of the Potaka tephra, determine fine-scale details of the bedding structure and variations in particle population, and interpret these in terms of the processes active in deposition of particles that have been deposited via sedimentation through both air (from the eruptive plume), and water.

POSTER

HIGH-RESOLUTION PALEOCLIMATE SIGNAL FROM EARLY MIOCENE LACUSTRINE DIATOMITE NEAR MIDDLEMARCH, CENTRAL OTAGO, NEW ZEALAND

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A 75-100+ m thick lacustrine diatomite succession near Middlemarch, 45 km northwest of Dunedin, accumulated in a ~1 km diameter maar depression in schist basement. Two diatomite facies are recognised. A thinly laminated biogenic varve facies comprises c.60 % of the 11m lacustrine succession exposed in two mining test pits. This facies consists of diatom-rich light and dark couplets of average thickness <0.5 mm (Fig.1). Dark brown laminae also contain abundant fine plant matter, including leiospheres. Diagenetic pyrite nodules and films are locally present. By analogy with modern lakes, the light-coloured laminae reflect enhanced diatom production when conditions (light, temperature, nutrients) were optimal, probably during spring and summer; dark laminae accumulated during each autumn-winter period. Pinstripe lamination and absence of bioturbation, coupled with exceptionally well-preserved entire galaxiid fish skeletons, numerous leaves and rare flowers, indicate that the profundal lake and its floor were anoxic, supporting no macrofauna. Periodic 3~10 year changes in couplet thickness compare with Quaternary records of ENSO (El-Niño Southern Oscillation) variability and indicate that the southern New Zealand climate was strongly seasonal and ocean-influenced during the early Miocene. The second diatomite facies, dark brown 'speckled' beds, are up to 120 mm thick and distributed throughout the mine exposures. Bases of speckled beds show minor scour relief, with infrequent development of rip-up clast breccias. Speckled beds incorporate abundant diatom aggregates, coarse plant detritus, very minor terrigenous silt, and are often texturally and colour graded. They are invariably capped by 1~6 mm of white diatomite. Speckled beds are interpreted as mass flow deposits resulting from failure of lake margin slope sediment and transport by slurry flows or turbidity currents into the deep basin.

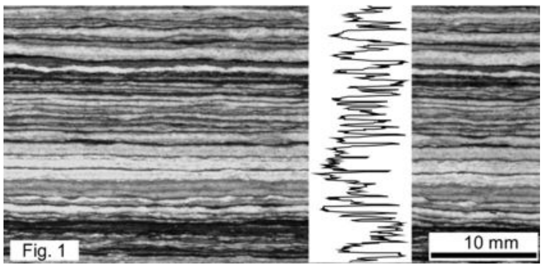

Fig. 1

ORAL

HOLOCENE TECTONIC FLUVIAL TERRACES AT PAKARAE RIVER MOUTH, GISBORNE REGION

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Pakarae River mouth, c. 25 km NE of Gisborne, is the region of fastest coastal uplift along the

Hikurangi Margin, as recorded by a flight of seven Holocene marine terraces. Each marine terrace is interpreted to be coseismic in origin. A flight of fluvial terraces exists immediately upstream of the river mouth. We have investigated these to see: (a) if they grade to the marine terraces, and thus are also coseismic or tectonic terraces, and (b) whether they provide information about the response of the river to coseismic uplift.

The highest (mid Holocene) marine terrace T1 is an aggradational terrace formed by infilling of an estuary during post-glacial sea level rise. Thus the primary terrace gradient would have been horizontal in the downstream, estuary area, or parallel to the low gradient river in the fluvial area upstream. Currently T1 is 24 m above sea level (a.s.l.) at the coast and can be traced as a discontinuous surface for 3.5 km upstream, where it gradually decreases in altitude to 16 m a.s.l. This implies the terrace has been back-tilted.

Stepping down from T1 to the present river are discontinuous flights of up to 6 fluvial terraces, including the prominent modern flood level terrace. The number of terraces increases downstream; the modern flood level terrace is the main terrace 4 km upstream. A smoothed longitudinal terrace profile has been constructed to aid correlation of these largely degradational terraces with the marine terraces at the coast. Some fluvial terraces can be projected to the marine terraces, corroborated by limited tephra age control. Therefore it is likely that some of the fluvial terraces have a coseismic origin. The terrace profile also shows fanning out of the terraces downstream (i.e., successively younger terraces have steeper downstream gradients), with the modern flood level terrace having the steepest downstream gradient of all. This geomorphology likely reflects progressive upstream tilting with the current floodplain yet to be affected by coseismic uplift.

Dislocation modelling will be used to model the upstream tilting with respect to inferred offshore fault sources for the locally high uplift rates.

ORAL

A YOUNG METAMORPHIC CORE COMPLEX ON NORMANBY ISLAND, D'ENTRECASTEAUX ISLANDS, PNG: COMPARISON WITH THE ALPINE FAULT AND IMPLICATIONS FOR CRUSTAL RHEOLOGY DURING RIFTING

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The D'Entrecasteaux Islands in the Woodlark Rift is one of the few places on earth where a mid-ocean ridge (MOR) terminates into a zone of continental rifting, where low-angle normal faults are seismically active, and where eclogite-facies rocks of Pliocene age are at the surface. Located <30 km from an actively spreading MOR, eastern Normanby Island is a Plio-Pliestocene metamorphic core complex (MCC) in a continental rift zone between the Australia and Woodlark plates. The normal fault bounding this MCC provides some interesting comparisons to the Alpine Fault: both are long-lived, high displacement faults that have exhumed lower crustal mylonitic rocks on one side. In both, the uplifted mylonite zones are >1 km thick, and were overprinted by a (much narrower) zone of brittle slip in the plate motion direction during their unroofing. Erosion has probably played a key role in focusing slip on the long-lived Alpine Fault, and quickly removes its scarp during exhumation. By contrast, in PNG, the lower plate has been pulled out a distance of ~50 km from beneath the upper plate where it is preserved as denuded surface that has been only slightly incised by rivers. The surface on Normanby Island is striated by fault-surface megamullions and underlain by mylonitic lineations parallel to Plio-Pliestocene plate motion. Offshore, active half-grabens imply that deeper parts of the PNG detachment fault are still active. Onshore, older, abandoned parts of the detachment have been back-tilted through the horizontal as a result of footwall unloading and buoyant uplift of a flowing lower crust beneath that denuded footwall. The detachment has extensionally reactivated the base of a collisional suture (Papuan ultramafic sheet) to return blueschists back to the surface in the lower plate of this MCC. Elsewhere in the D'Entrecasteaux Islands, the same extensionally everted ultramafic contact has been the locus of shear zones that exhume the world's youngest known eclogites (as young as ~2.8 Ma).

Paleopiezometery based on recrystallised quartz grain-size indicates final flow stresses of ~35-55 MPa. As seismogenic normal faults throughout the Woodlark rift are active with dips of 25-30°, these results imply extreme frictional weakness. This may refect either high pore-fluid pressures or low friction coefficient (μ), perhaps in part the result of serpentinitic protolith of the fault gouge (μ <0.45). This frictional weakening mechanism is probably different than the cause of prolonged, focused slip on the Alpine Fault, where erosion and thermal structure are more important. Focused thinning near the MCC took place several m.y. prior to arrival of the (now adjacent) MOR, and 100's km away from it, thus we infer that MCC-related crustal thinning pre-conditions the crust for later break-up and lithospheric rupturing (not vise versa).

The MCC is bounded by deep-seated transform faults separating domains in which extension has been strongly localized on weak, individual faults (MCC's) vs. where it is distributed.

ORAL

MAPPING THE DEEP SEA: APPLICATION OF MULTIBEAM DATA TO DEEP SEA GEOLOGICAL SAMPLING

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Multibeam echosounders are becoming increasingly and routinely used for detailed seafloor mapping up to several kilometres either side of the survey vessel. Such multibeam data have been used to determine seafloor bathymetry and substrate composition for geological research by accurately map submarine topography, such as seamounts or canyons. In addition, the multibeam seafloor acoustic backscatter data can differentiate between different substrate types, including sediment and exposed bedrock, and hence guide successful geological sampling operations. Multibeam mapping of the ocean bottom is markedly more efficient than conventional single-beam echosounders, and provides greater resolution and accuracy of both seafloor morphology and composition.

Since 2001, the Simrad EM300 multibeam system on NIWA's research vessel Tangaroa has been used extensively in support of ocean geology sampling operations, especially around the east coast of the North Island, Cook Strait, Kermadec Ridge, Norfolk Ridge, and Lord Howe Rise.

The existing charts of these regions have generally proved to be adequate on a large scale, indicating the approximate position of ridges or seamounts. However, on the scale of an individual feature, the depth, size, and shape of a seamount are often poorly charted. The width of seafloor that can be mapped is up to 4 times the water depth, and so at 1000 m depth the bathymetry was determined 2 km either side of the vessel. This enables rapid evaluation of the shape of the seabed, which was often very different from the chart.

The seafloor bathymetry is often rugged and complex, with the multibeam proving essential to the success of sampling several sites. The acoustic backscatter intensity gives an indication of substrate composition, which was used to plan rock dredging and/or sediment sampling operations. It also gives us data on the type of sediment and habitat which may be used later in analyses such as defining a unique benthic community structure.

POSTER

THE WILD WEST: IMAGING WEST COAST SEDIMENT CONDUITS

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New Zealand is in a critical location for reconstructing changes in westerly circulation and evaluating its role in controlling global climate change. Surrounded by vast areas of ocean, the main axial ranges intersect the prevailing westerlies. The Southern Alps of New Zealand are an ideal location to understand the history of the westerly wind system through time as the interaction between orographic effects and the westerlies produce significant precipitation on the West Coast of the South Island.

The first in a probable series of research voyages projected for the West Coast Canyon region off South Island, New Zealand was completed in October 2005. The aim of this research programme is to define a history of glaciation during the late Quaternary in New Zealand, in particular the relationship with the Westerly Wind system and correlation with abrupt climate change globally and to determine the sources and fluxes of sediment influencing the southern New Zealand region.

The West Coast is supplied by 3 of the 5 largest rivers in New Zealand with respect to sediment load. Presently fifty times more sediment is injected into this system than that into the Bounty Trough as a consequence of the closer proximity of the Southern Alps source area and the lack of large natural lakes that trap up to 15% of the sediment yield to the east of the Alps. Glacial-Interglacial changes recorded in sediment sequences in downslope basins should reflect a switch on with large sediment flux in peak glacial times and a switch off during interglacials. At the last glacial maximum, major valley glaciers reached the open coast, probably as grounded tidewater glacial fronts providing voluminous mud, sand and gravel via a range of processes directly to the continental slope (Barnes et al., 2001).

Seafloor topography was surveyed using the Simrad EM300 multibeam sonar, which uses a fan of 135 sonar beams to simultaneously ensonify and map a swath of the seafloor up to a width of up to 5-times the water depth. These bathymetric data are processed within a GIS to form a digital terrain model (DTM). Using spatial analysis functions of GIS, the DTM is interrogated to identify, and define relationships between, products of the bathymetric data, such as slope, coarse- and fine-scaled bathymetric position and rugosity. Sediment patterns, catchment areas and channels can be quantitatively identified and traced. In addition, acoustic backscatter intensities returned with the multibeam were processed to identify the broadscale seafloor composition and possible facies distribution.

POSTER

A DEEP-WATER SHARK FAUNA FROM THE PALEOCENE OF NORTH CANTERBURY

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Apart from the enigmatic *Waiparaconus* Buckeridge 1983 and the remains of a proto-penguin, the Waipara Greensand of North Canterbury is not noted for its macro fossils, but careful searching of exposures along the banks of the Waipara River, at the K/T boundary section and downstream from the Laidmore Road ford, has produced several hundred isolated shark teeth. Preliminary identifications of these remains were provided by the late Ian Keyes, formerly of the Institute of Geological and Nuclear Sciences, who determined that at least seven species were present. The same stratigraphic unit was also investigated in exposures along the North Branch of the Waipara River, close to the confluence with the South Branch.

The shark fauna has now been expanded to include eleven genera, several of which are new records for the New Zealand biota. The orthacodontid, *Sphenodus* Agassiz 1837 has previously been recorded only from the Jurassic of the northern hemisphere and the hexanchid, *Chlamydoselachus* Garman 1884 from Cretaceous to Recent of Europe, North America, Antarctica and Western Australia. The squalid *Megasqualus* Herman 1982 is also only known from the Paleocene to Eocene of Europe and Miocene of Japan and California. The odontaspidids *Palaeohypotodus rutoti* Winkler 1874 and *Odontaspis* cf winkleri Leriche 1905 have not appeared in any literature associated with New Zealand

Comparison with extant species belonging to several of the genera present suggests that the fauna is a deep water one, probably typical of the outer shelf to upper slope. Deep water shark assemblages are quite rare, especially from pre-Miocene deposits, but similar faunas are known from deep water clays of Denmark. This Waipara Greensand fauna will help fill a gap in the poorly known shark faunas of the Paleocene world wide.

This conclusion that the assemblage represents deep water is apparently at odds with the interpretation of the Waipara Greensand as having been deposited in a shallow marine setting under conditions of very slow sedimentation (Browne and Field 1985) and requires further investigation.

Reference

Browne, G.H. and Field, B.D. 1985 The lithostratigraphy of Late Cretaceous to Early Pleistocene rocks of northern Canterbury, New Zealand. New Zealand geological Survey Record 6. 63 pp.

POSTER

INTRACALDERA LAKE BREAK-OUTS FLOODS: GEOMORPHIC SIGNALS, MECHANISMS, AND HAZARDS

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Volcano-hydrologic hazards display a wide variety of causative mechanisms, including those directly related to volcanic activity such as explosive ejection of a crater lake, and indirectly-related phenomena such as rain-triggered lahars and break-out floods from temporary lake impoundments. Amongst the latter, events range in scale from relatively minor outflows triggered by failure of crater walls or the breaching of riverine dams composed of pyroclastic, volcaniclastic, or lava flow material to catastrophic floods generated by the breaching of caldera rims. Multiple intracaldera lake breakouts have been identified in several volcanic arcs, including New Zealand, where they exert a major control on drainage patterns, and Alaska, where three out of twelve Holocene calderas have been identified as flood sources. Palaeohydraulic reconstructions indicate such events rank amongst the largest post-glacial floods on Earth, being exceeded only by late Pleistocene deluges associated with breaching of ice-dammed lakes and pluvial basins. Geomorphic and limited published geologic evidence suggests that numerous candidates for similar phenomena lie in Japan and Kamchatka, where the primary focus has hitherto been on physical volcanology and petrology rather than geomorphology and sedimentology. Intracaldera and crater lake break-outs constitute a significant hazard in volcanic environments worldwide, as they may occur without warning, often long after the initial volcanic crisis has subsided, and can devastate distal alluvial plains where large population centres and infrastructure are typically concentrated.

ORAL

PAST HIGHSTANDS OF LAKE ROTORUA: IMPLICATIONS FOR TECTONISM AND PALAEOGEOGRAPHY IN THE TAUPO VOLCANIC ZONE

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Lake Rotorua currently partially occupies a near-circular 20 km diameter volcano-tectonic depression formed at 220 ka by eruption of the voluminous Mamaku Ignimbrite. Two distinct lacustrine littoral terraces that fringe much of the lake basin, defined on the basis of contrasting geomorphology and field relationships and separated by tephrostratigraphically dateable unconformities, are here correlated with former highstands of the lake. The first and highest elevation terrace (up to 415 m), corresponds to accumulation of a lake in the newly created basin in the immediate aftermath of the Mamaku Ignimbrite eruption. Considerable uncertainty surrounds the direction of overflow of this level, but the lake may have extended southwards through the Hemo Gorge, a v-shaped notch in the topographic rim of the caldera, through the Ngakuru Graben and into the Waikato River drainage. A highstand at this level would be contiguous with Lake Huka in the Taupo-Reporoa area and require a blockage in the Ongaroto Gorge, possibly related to volcanism at the Ohakuri or Maroa volcanic centres. At some later time a northeasterly outlet became established at a lower level through the tectonically subsiding Tikitere Graben into the Haroharo caldera from where it flowed into the Bay of Plenty via the Kawerau Canyon. The second and most extensive littoral terrace (370-380 m), the post-55 ka Rotoiti alloformation, is the product of a durable highstand produced by blockage of this drainage path by eruption of a voluminous unwelded ignimbrite from the adjacent Okataina Volcanic Centre. Lake level was maintained by stable overspill across a welded ignimbrite sill west of the Tikitere Graben into the north-flowing Kaituna River until accumulation of Mangaone Subgroup tephras in the graben could no longer keep pace with active subsidence. Lake level initially dropped rapidly by c. 20 m as the unconsolidated Mangaone tephras were flushed away, before impingement of the falling lake level on the underlying more consolidated Rotoiti pyroclastics produced a short-lived stillstand at c. 350 m marked by a third alloformation comprising cryptic fluvial strath terraces and shoreline deposits in the Rotorua basin. Resumption of down-cutting triggered an apparently catastrophic break-out through the Haroharo route prior to the 26.5 ka Oruanui eruption and a fall in lake level to below 260 m. Episodic growth of resurgent dome complexes between 21 and 9 ka progressively blocked this drainage path, forcing Lake Rotorua to rise to a level where it could overtop a drainage divide on the northern rim of Lake Rotoiti to re-occupy the former Kaituna River course, establishing the current outlet channel.

POSTER

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

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

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

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

ORAL

CHASING BITS AND PIECES OF NEW ZEALAND FROM SOURCE TO SINK: PRELIMINARY RESULTS OF SAND PROVENANCE STUDIES IN THE BOUNTY FAN AND WAIPAOA RIVER SEDIMENTARY SYSTEMS

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Modern sand provenance studies often involve one depositional setting (e.g., fluvial, shelf, deep-marine fan) with few holistic studies tracing source river sediment across shelves to deep-sea fan sinks. Deep-sea sandy turbidite successions can record the evolution of the fluvial and shelf systems that supplied sand, as well as distinct eustatic, climatic, and tectonic signals. The records of such processes also vary according to bedrock lithology, which is fundamentally related to the plate tectonic setting of the sedimentary system. Deciphering these signals in modern and late Cenozoic systems increases our ability to interpret continental margin history preserved in ancient turbidite successions. The practical applications of such studies involve predictions of sand composition in buried deep-sea-fan petroleum reservoirs, which in turn can be directly linked to their likely diagenetic pathway(s) and ultimate reservoir quality.

The sedimentary systems of New Zealand are ideal places for holistic sand provenance studies, and we have embarked on a series of these in conjunction with the MARGINS Source-to-Sink initiative of the US National Science Foundation (NSF), funded through the NSF Opportunities to Enhance Diversity in the Geosciences program. Our study areas are the Bounty Fan (BFS) and Waipaoa Sedimentary (WSS) Systems and our data sets are derived from a combination of: 1) modern river and beach samples; 2) Cenozoic to Mesozoic outcrops within stream drainage basins; 3) piston and box core samples; and 4) sandy core samples from Ocean Drilling Program Site 1122. The combination of the BFS and WSS samples sets includes first cycle and multi-cycle sediments derived from similar clastic sedimentary/metasedimentary source rocks (e.g., Torlesse), as well as sediments derived from progressively metamorphosed versions of these rocks (e.g., Otago Schist), all with variable volcanic input.

To date, sand detrital modes have been determined for parts of each system. Miocene to Quaternary sand from the Bounty Fan is micaceous and quartzofeldspathic with minor metamorphic lithic components. Its composition is similar to that of quartzofeldspathic sand from the Modern Clutha River, but contributions from the Waitaki River (feldspatholithic sand) cannot be ruled out. In contrast, Waipaoa River sand is feldspar poor with the proportion of quartz versus lithic fragments a function of grain size: lithic fragments are concentrated in the coarser sand fraction and quartz and feldspar within the finer sand fraction. Furthermore, there are subtle compositional differences among sand derived from the pre-Pliocene units of the East Coast Allochthon versus uplifted Pliocene sedimentary successions: for example, the latter contribute more calcareous mudstone fragments and vitric volcanic debris than the former.

ORAL

CHINKS IN THE CURTAIN – ADVANCES IN OUR KNOWLEDGE OF NEW ZEALAND CENOZOIC NON-MARINE MOLLUSCS

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The New Zealand molluscan fossil record is overwhelmingly one of marine species. A total of 5482 Cenozoic species were recorded in a recent census; of these 5451 (99.43%) are marine, 20 (0.36%) terrestrial and 11 (0.20%) freshwater. Comparable figures for Recent molluscs (shelled species only) are 4277, 3398 (79.45%), 838 (19.59%) and 41 (0.96%). We report here on recent discoveries that help redress the balance; in particular, we focus on an exceptionally diverse Pliocene fauna from North Canterbury.

Except for the Hyriidae, which are recorded back to the late Cretaceous, the oldest known possibly non-marine Cenozoic molluscs from New Zealand are from the Pomahaka Formation in western Otago.

Many of the molluscs in the highly distinctive fauna (probably Duntroonian, Late Oligocene) are inferred to have been brackish-water or estuarine dwellers, but they also include three species of Hydrobiidae or a related family. Most modern hydrobiids are fresh water inhabitants, but some live in brackish waters, so their occurrence at Pomahaka is ambiguous.

Fortunately, land snails are more readily identifiable as such – the oldest are from three sites in Northland of Otaian (Early Miocene) age, where they are vastly outnumbered by marine molluscs. The material is very limited and some specimens are poorly preserved, but 6 or 7 species are present, representing the pulmonate families Charopidae and Punctidae. Very rare charopids have also been collected from the vertebrate bed in lacustrine siltstone near St Bathans (Manuherikia Group, probably Middle Miocene.)

By far the most prolific sites for non-marine molluscs are in the upper Waipara River in North Canterbury. The original locality – collected by Don Gregg and Pat Suggate in 1961 – is no longer exposed, but other sites in the Kowai Formation have been discovered nearby. Freshwater taxa (Hyriidae, *Pisidium, Potamopyrgus, Glyptophysa*) are present in the lower part of the section (Middle Pliocene?), and diverse assemblages dominated by land snails have been collected from two sites near the top of the unit. One – from opposite "Bellefield" – includes *Georissa* (Hydrocenidae), Cyclophoroidea, *Rhytida* (including eggs), Punctidae and Charopidae (*Allodiscus, Pseudallodiscus, Discocharopa, Fectola, Mitodon, Cavellia*, etc). The associated palynoflora is too poor for dating, but one from Tommy Stream, c 20-30 m lower in the section, is Nukumaruan, Late Pliocene and indicates considerably warmer conditions than those prevailing at the present day (Dallas Mildenhall, pers comm). The Tommy Stream faunule lacks hydrocenids and cyclophoroideans but has a rich punctid and charopid assemblage. Preliminary analysis indicates only limited similarity with the "Bellefield" faunule. The Waipara land snails have considerable potential for addressing paleoclimatic and biogeographic issues and for throwing some light on species-turnover rates.

ORAL

COMPUTER MODELLING OF THE PYROCLASTIC FLOW HAZARDS OF MOUNT NGAURUHOE, TONGARIRO VOLCANIC CENTRE, NZ

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A numerical code for simulating dry flows of granular material, TITAN2D, is used to model scoria-and-ash flows from the 1975 eruption of Mount Ngauruhoe, New Zealand. Most flows from this eruption were formed by the simple collapse of agglutinate, spatter and scoria piled up around the upper vent during eruption. The deposits have well-developed levees, channels and steep flow fronts 1.5 – 2 m in height. The lithology comprises green-black, moderately vesicular scoria; elongate, red-black agglutinate; dense andesitic lava blocks and bombs; and xenolith bearing scoriaceous clasts. Many of the scoria clasts have bread-crusted outer layers and jigsaw jointing, indicators of hot emplacement. To calibrate the method, volumes of three deposits were calculated in ArcMap using cut/fill from pre- and post-1975 Digital Elevation Models (DEMs). Estimates of 1650 m^3, 2900 m^3 and 5400 m^3 were derived for these scoria-and-ash flow deposits, each from single flow events. The volumes were then used as initial inputs in TITAN2D and the flows were modelled on a pre-eruption DEM of the region. Scaled-up flow volumes were modelled in order to evaluate the inundation from larger events at Ngauruhoe. The modelled flows were mostly confined to pre-existing valleys, stopping on gentler slopes. In some cases flows crossed the Mangatepopo Track. During the summer months, there can be on average more than 420 people walking this track daily; thus a pyroclastic flow-forming eruption will present a serious hazard to tourists tramping in the area. The modelling has indicated that the proposed deviation of the Mangatepopo track by the Department of Conservation will increase the risk to people using the track. The TITAN2D model was very successful in modelling the scoria-and-ash flows from the 1975 Ngauruhoe eruptions, and may be a promising technique for predicting the distribution of pyroclastic flow hazards on similar types of volcanoes.

POSTER

MAGMAS OF THE 17,700 YR REREWHAKAAITU ERUPTIVE EPISODE OF TARAWERA VOLCANIC COMPLEX

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The 17.7 ka Rerewhakaaitu eruption from the Tarawera Volcanic Complex, within the Okataina Volcanic Centre, involved ~5 km^3 of magma (DRE). Eruptive products include: a tuff cone (constructed by pyroclastic surge and flow deposits), three domes, a lava flow, and plinian tephra fallout which covered an area of >9000 km^2. Three separate rhyolite magmas were involved in the eruption (T1, T2 and T3). T1 and T2 magmas are high SiO_2 rhyolites, and T3 magma is a low-SiO_2 rhyolite. T1 magma has matrix glass K_2O of 3.43 ± 0.11 (wt.%), whole rock SiO_2 of 77.15 ± 0.24 (wt.%), whole rock Sr values of 91 ± 6 (ppm), orthopyroxene>hornblende mineralogy, Fe-Ti oxide temperature of 763 ± 12 °C, and oxygen fugacity (fO_2) of +0.35 ± 0.12 (NNO). T2 magma has matrix glass K_2O of 4.20 ± 0.09 (wt.%), whole rock SiO_2 of 75.46 ± 0.26 (wt.%), whole rock Sr values of 122 ± 4 (ppm), biotite>hornblende mineralogy, temperature of 704 ± 17 °C, and fO_2 of -0.45 ± 0.14 (NNO). T1 and T2 magmas are represented throughout the pyroclastic sequence and in several domes, and were erupted from the same vent(s). T3 magma, comprising Western Dome only, has matrix glass K_2O of 3.14 ± 0.06 (wt.%), whole rock SiO_2 of 74.12 (wt.%), whole rock Sr values of 174 (ppm), and hornblende-orthopyroxene mineralogy. T1 and T2 magmas are found mingled in some clasts, and a few clasts contain glass intermediate between the two compositions. This demonstrates short-lived contact between the magmas, that were disrupted and mixing in the conduit during eruption. T3 magma did not undergo any mixing and was erupted from a separate vent. The Rerewhakaaitu eruptive event was triggered by a mafic intrusion, which mixed with T1 and T2 magmas. Evidence for this includes mafic micro-blebs (andesitic-dacitic glass composition) in some rhyolite clasts. These clasts also contain a disequilibrium crystal assemblage that includes clinopyroxene and olivine. The magma dynamics of the Rerewhakaaitu eruption appears to be broadly similar to that of the 0.7 ka Kaharoa eruption. Thus, it may be common for discrete bodies of rhyolite magma to accumulate beneath Tarawera prior to priming by mafic intrusion.

POSTER

DUST AS A PROXY FOR CLIMATE CHANGE: A RECORD OF AUSTRALIAN DUST DEPOSITION IN NEW ZEALAND DURING THE HOLOCENE

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The aridity of the Australian continent means dust storms are a common occurrence (McTainsh et al., 1989), with dust transport to New Zealand reported on numerous occasions resulting in red coloured snow and haze (Marx and McGowan, 2005). Contemporary dust events in Australia are strongly influenced by environmental conditions within dust source areas, in particular periods of drought, or increased windiness, to which dust transport rates rapidly respond (McTainsh et al., 2005). Therefore, dust deposition chronologies can be used as an excellent proxy for palaeoenvironmental conditions, such as the degree of aridity in dust source areas and changes in wind strength and dust transport pathways in response to changing synoptic circulation patterns.

We present an α8000 year record of Australian dust deposition extracted from an omobrotrophic peat bog in Central Otago, New Zealand. Using novel tertiary and binary trace element mixing models dust extracted from the bog is provenanced to specific dust source areas within Australia on a catchment-geologic scale. Changing rates of dust deposition, along with the switching on or off of particular dust source areas within Australian are thus used to interpret paleoenvironmental conditions within the region.

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ORAL

A 15,000 YEAR RECORD OF SURFACE-RUPTURING EARTHQUAKES AND FAULT SLIP AT SAXTON RIVER, AWATERE FAULT, NEW ZEALAND

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Fault offsets of a well-preserved flight of fluvial terraces on the Awatere Fault, in northeast South Island, New Zealand, together with trenching studies and dating results for late Quaternary sediments deposited on them, allows the incremental slip history and paleoearthquake chronology to be reconstructed in some detail for this major strike-slip fault. At Saxton River, six fluvial terraces have been progressively displaced across the Molesworth section of the Awatere Fault. Horizontal displacements were measured from microtopographical maps constructed from detailed GPS surveys, and range from ~6 m for an ephemeral channel on the youngest terrace surface to 81 m for a riser above the oldest terrace.

Eight surface-rupturing paleoearthquakes in the last 6.3 ka can be recognised from relationships exposed in a paleoseismic trench excavated across a sagpond on the oldest terrace. The ages of these events are constrained by 12 ^{14}C samples. At least two additional events are recognised between 6.3 and ~15 ka, but these have yet to be precisely dated. These data indicate a mean recurrence interval of 1435 ±165 years on this part of the Awatere Fault. Intervals between individual paleoearthquakes range from <130 to 1750 ±320 cal. years.

New optically stimulated luminescence ages indicate that abandonment of the two oldest terrace treads took place at 14.5 ±1.5 and 6.69 ±0.74 ka B.P. When these OSL ages are combined with previous pebble weathering rind ages of the younger terraces, and with GPS-based measurements of the progressive terrace riser displacements, strike-slip rates on this part of the Awatere Fault can be reconstructed through time. The data indicate that the dextral-slip rate has remained nearly constant at 5.6 ±0.8 mm/a since ~15 ka B.P. Comparing the magnitudes and ages of the terrace riser displacements to the paleoearthquake record allows estimation of a mean per-event horizontal displacement of 4.4 ±0.8 m over the eight most recent surface rupture events. Between ~5 ka and ~2 ka B.P. surface rupturing earthquakes increased in frequency, and decreased in their mean coseismic displacements to <2.6 m. During this time, the sense of local dip-slip also shifted from north side-up to south side-up. Rapid incision of the Saxton River in the mid Holocene may have caused a perturbation in the near-surface stress directions acting on the fault plane beneath the Saxton River valley, forcing a change in the near-surface fault geometry that resulted in the shift in sense of dip-slip.

POSTER

REGIONAL LANDSLIDE HAZARD ASSESSMENTS IN TASMANIA

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Landslides are a significant hazard in Tasmania that have resulted in the destruction of many homes over many years. Landslide damage to properties and infrastructure throughout the State is a significant ongoing cost to the community to repair. Fortunately, there has been minimal loss of life but the potential for catastrophic events in populated areas is well established. Unfortunately in many instances, the currently level of preparedness to this hazard is insufficient despite the lessons of the Thredbo disaster and other events. A significant part of the process of informing communities about natural hazards is the production of hazard maps and the dissemination of this information source. While landslide maps have existed over parts of the state for many years, the methodology has been inconsistent between areas and the concepts of hazard and risk are not in accord with current practice.

Mineral Resources has developed a new methodology to produce regional landslide hazard maps of principal urban areas in the state. This information is designed to assist land managers to improve their land-use planning and risk management strategies. The methodology involves: collation of landslide data into a spatial database; production of geology and geomorphology and landslide inventory 'fact' maps; modelling of rockfall, debris flow and deep seated landslide processes to produce three thematic potential hazard maps. The modelling components employ GIS-based deterministic techniques supported by empirically determined parameters to identify source, runout and setback areas for the three processes described. The frequency of debris-flow events has been attempted through modelling rainfall patterns. A subsequent risk assessment of a repetition of the 1872 Glenorchy landslide indicates that it is in the unacceptable part of the ANCOLD societal risk criteria.

Examples of maps from the Greater Hobart and Launceston study areas and an explanation of the published methodology will be provided.

POSTER

VOLCANOLOGY OF A COMPOSITE CRATER-COMPLEX MARKING THE ONSET OF KAROO FLOOD BASALT VOLCANISM, SOUTH AFRICA

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Volcanic activity during the initial stages of flood basalt volcanism is of interest because it includes explosive to non-explosive magmatic and phreatomagmatic activity that contrasts with effusion-dominated later stages. At one volcanic centre formed during the first stages of flood basalt eruption in South Africa, the Sterkspruit Complex, volcaniclastic rocks more than 140 m thick fill a >40 km^2 crater made up of the coalesced deposits of many small overlapping phreatomagmatic and strombolian debris-filled vents spaced a few hundred metres apart. This crater complex is cut into country rock and is surrounded by a blanket of distal bedded volcaniclastic rocks.

Inside the complex, volcaniclastic rocks filling these small vents show steep, abrupt contacts with host rocks at deep levels but show mainly low-angle, diffuse contacts with the deposits of adjacent centers at shallow levels. Craters housing these vents grew mainly via collapse of their margins rather than by downward quarrying. The 50-100 m thick distal blanket of mainly bedded, fine-grained deposits beyond the Sterkspruit Complex records a variety of fall, flow and reworking processes. Widespread pillow lavas associated with reworked and lacustrine sediments point to an abrupt end to explosive volcanism at Sterkspruit followed by flooding of the lowest part of the crater and rapid burial of the landscape by lava. Subtle differences in the geochemistry of intrusions, volcaniclastic rocks and lava at Sterkspruit indicate that there were at least five discrete magma types involved in eruptions. Field mapping shows that although the magma types can be used as time-markers in the volcanic sequence, implying that each constituted a discrete magma 'batch', two discrete magma types were erupting at the same time, suggesting that each batch was small and fed by local dikes.

The Sterkspruit Complex records

1. shallow-level explosive phreatomagmatic and strombolian eruptions,
2. shallow intrusion and effusion of basalt,
3. lateral growth of large craters via coalescence of many small vents by crater-margin collapse, and
4. transport of debris beyond the complex to blanket pre-eruption topography.

Crater-complexes like Sterkspruit are present at the base of many flood basalt successions and are relevant to models of climate change associated with flood basalt eruptions and add to our understanding of the volcanology, structure and magmatic evolution of large igneous provinces.

ORAL

FACIES ARCHITECTURE OF THE CONWAY FAN DELTA COMPLEX AS IT FORMED TERRACES ALONG THE UPLIFTING HAWKSWOOD RANGE

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Multiple terraces on the east side of the Hawkeswood Range formed as the result of rapid uplift and erosion of the Hawkeswood Range. Terrace surfaces are composite features, with their upper parts representing sub-aerial alluvial fans, which in turn transition to their equivalent shallow marine foreset beds of Quaternary Gilbert-style fan deltas. The terraces/fan surfaces are ~9 km long and ~3 km wide. Incisions have created excellent 3-dimensional views of the underlying Gilbert-style fan delta complex from topsets to prodelta deposits. The flat-lying geomorphic expressions of the terraces have their origin from the tripartite geometry of Gilbert-style fan deltas. These preserved geomorphic features combined with stratigraphy help uncover the complex nesting of terraces and thus a connection to the active tectonics of the region. It was only with the combination of the two techniques that a clear picture of the development of the terraces along Conway Coast was deciphered.

The Conway Fan Delta Complex can be divided into four stages of evolution based on variations in sedimentary facies and geomorphic mapping of the terraces. The first stage involves the uplift of the Hawkeswood Range and subsequent increased sedimentation rate such that alluvial fans prograded to the sea forming the Medina fan delta. Evidence of large slumping events are seen as the oldest fan delta onlaps onto pre-existing marine silts and mud. This is followed by incision, possibly from lowering sea level or from changes in the uplift and sedimentation rate. During the second stage the Dawn Creek fan infills the incised paleovalleys and progrades further basinward; it is the largest of the fan deltas recorded along the Conway Coast. This is again followed by incision. Stage 3 involves deposition of estuarine facies, possibly lateral to a fan delta similar to the modern Conway fan delta/estuary, with in situ Podocarp forest at ~ 8000 BP. This is again followed by incision which is followed by the 4th stage, the infill of the incised valley by the modern fan delta of the Conway River and its progradation.

ORAL

NEW ZEALAND'S FRESHWATER FISH: FOSSILS IN THE CONTEXT OF THE EXTANT FAUNA

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This paper explores what we know of New Zealand's fossil freshwater fishes, and seeks to place them in the context of the extant fauna (based largely on material collected in the last few years by a student from the Geology Department, University of Auckland; Liz Kennedy of GNS, Lower Hutt; and Daphne Lee and Jon Lindqvist, Geology Department, Otago University.)

In the more distant past WRB Oliver mentioned eleotrids from the Pliocene (now known to be mid-Pleistocene) of the Ormond Valley, inland from Gisborne, and also some galaxiids from near Dunedin; Gerald Stokell added galaxiids from near Middlemarch, and I reported on all of these and provided a summary some 30 years ago.

Things have moved rapidly in the past year or so, and we can now report on:

1. A couple of scales from an undetermined lower perciform family from an Early Miocene deposit near Bannockburn;
2. The first fossil record of grayling *(Prototroctes)* from the mid-Pleistocene of the Ormond Valley, as well as:
3. Additional eleotrids of the genus *Gobiomorphus* from the Ormond Valley;
4. An additional eleotrid from Early Miocene deposits near St Bathans; and
5. A series of Early Miocene galaxiid fossils from diatomite deposits near Middlemarch.

There are also numerous fish otoliths in Geology Department, University of Otago collections that have not yet been looked at seriously, and which have potential to provide new revelations.

I will seek to clarify the significance of these fossils in the evolutionary history of the fauna.

ORAL

A PRELIMINARY SEDIMENTATION MODEL FOR BENEATH THE MCMURDO ICE SHELF

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Ross Island has been depressing the crust under its own weight for at least the last million years, and at the same time has been acting as the western pinning point for the Ross Ice Shelf. As a result, a thick sedimentary sequence has accumulated in a sea floor depression now 900 m deep beneath the McMurdo-Ross Ice Shelf on the south side of Ross Island in Windless Bight. These sediments record the history of ocean currents and the ice shelf itself to be investigated as part of the ANDRILL project (http://www.andrill.org/).

Here we present results of two 60-cm-long gravity cores taken from the sea floor beneath the ice shelf in January 2003, and which record recent sedimentation there. Core 1 was taken 5km east of the ice shelf front, and contains a record of the past ~20,000 years. The basal unit is a diamict that contains clasts, some subrounded and striated, and derived from Transantarctic Mountains. This is interpreted as representing basal debris from an expanded Ross Ice Shelf/Sheet at the LGM. This passes upwards into a well-sorted sand layer, which represents locally derived sediment either deposited through a retreating ice shelf or beneath the ice shelf as a result of slope instability. Overlying the sand is a series of fine muds and muddy sands, which are indicative of sub-ice shelf conditions, with only minor fluctuations of the ice shelf front. The biogenic content also suggests that the Ross Ice Shelf front has not retreated significantly from its present position during the Holocene and that seasonally open water has been present in McMurdo Sound for much of this period.

Core 2, taken 12 km east of the ice shelf front, contains a record of the past ~10,000 years. It consists mainly of locally derived sandy mud, and contains a higher biogenic component of diatoms and sponge spicules, typically more than 20%. The uniform nature of this core suggests that current flow has varied little from the present regime (5-20 cm/sec; Robinson, 2005), and also supports the view that the ice shelf front has varied little during the Holocene.

Additional cores are planned for 2005/06 field season and will be used to develop a high resolution sedimentation model in preparation for deep drilling planned by ANDRILL for the 2006/07 season.

ORAL

LATE QUATERNARY PALEOEARTHQUAKES ON THE NORTHERN NORTH ISLAND FAULT SYSTEM, NEW ZEALAND

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The North Island Fault System (NIFS) is the principal strike-slip fault system of the Hikurangi margin, along which the Pacific Plate is being subducted beneath the overriding Australian Plate. The NIFS accommodates up to 50% of the margin-parallel relative plate motion and extends for approximately 450 km, from the Wellington region in the south, to the Bay of Plenty coastline in the north. For its northern c.120 km, the NIFS comprises three main sub-parallel strands (Waiohau, Whakatane & Waimana faults). Northwards along these faults, late Quaternary rates of strike-slip decrease as rates of normal-slip increase, a transition across which horizontal to vertical slip-ratios decrease from 5-10:1 to 0.6:1 (Mouslopoulou et al., 2004). In this talk we will identify the position of this kinematic transition on each of the main faults, and assess whether it may have functioned as a mechanical barrier to rupture propagation during the history of paleoearthquakes known for this region. We use fault-trench log data from 15 trenches and >50 measurements of offset landforms. The ages of key stratigraphic markers are constrained by tephra glass chemistry and ^{14}C dating. Preliminary results suggest that the Whakatane Fault last ruptured since 0.8 kyr BP, while the Waimana and Waiohau faults last ruptured 1.8-2.8 and 1.8-5.6 kyr ago, respectively. Within c. 40 km of the Bay of Plenty coastline, earthquake recurrence intervals average about 2-2.5, 3 and 4.5 kyr on the Whakatane, Waimana, and Waiohau faults, respectively. On individual faults, the timing and number of earthquakes during the Holocene appears to have varied along strike across the kinematic transition zone. On the Ruahine/Waiohau Fault, for example, the strike-slip Ruahine Fault generated 6 Holocene earthquakes, while to the north in the Galatea Basin, where the fault is predominantly normal-slip, only 1-2 Holocene earthquakes have been recorded (Beanland, 1995; Hansen, 1997). A decrease in the number of Holocene earthquakes also appears to occur northwards along the Whakatane Fault, across the kinematic transition zone (between Ruatahuna to Ruatoki North). Although not conclusive, the data suggest that some paleoearthquakes on the Whakatane and Waiohau faults terminated within the kinematic transition zone, which functioned as a mechanical barrier to propagation of large ruptures. The along-strike change in fault kinematics, defined by a 60-70° northward steepening in the pitch of the slip vector on the faults, may therefore separate fault segments which ruptured during strike slip and normal slip dominated earthquakes.

Beanland, S. 1995. PhD Thesis, Victoria University of Wellington, New Zealand.

Hansen J., 1998. PhD Thesis. Massey University, New Zealand.

Mouslopoulou et al., 2004. Geol. Soc. NZ Miscell. Pub. 117A

ORAL

GSNZ VOICES FROM THE PAST

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In 1955 the geological community in New Zealand was rather different from today. The four university departments were small, and the majority of geologists (almost entirely male) worked for the Geological Survey. The lack of a mining industry meant that there were few job openings for graduates. Geology was almost entirely based on surface outcrops, and there was little knowledge of offshore geology or the extent of major hydrocarbon-bearing sedimentary basins.

This talk focuses on some of the individuals who founded the Geological Society of New Zealand in 1955, and will be illustrated by a selection of voices from the past.

ORAL

TWIN PEAKS: THE PRE-MANGERE FORMATION SEQUENCE ON MANGERE ISLAND, CHATHAM ISLANDS

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During early 2005, whilst studies of the Mangere Formation on Mangere Island were in progress as part of the CHEARS Marsden project, an opportunity arose to investigate the pre-Mangere Formation sequence. This paper re-examines the pre-Mangere Formation sequence on Mangere Island and proposes a new Twin Peaks model.

Rangiauria Breccia is mapped as the major volcanic unit forming the edifice of Mangere and Little Mangere Islands. Two distinct lithofacies were originally recognised by Hay *et al.* (1970), but subsequently amalgamated by Campbell et al. (1988). The highly lithified limburgitic breccia lithofacies forms the high bluffs of northern Mangere Island and Little Mangere Island. In contrast, a weakly consolidated limburgitic breccia lithofacies forms the linear southern flank of Mangere Island. Orientation of bedding within these lithofacies points to more than 6 centres of volcanism and a linear vent oriented NE/SW through Douglas Basin. The Breccia and the source vents form two topographically high centres, here referred to as North and South Peaks. Stepping normal faults, and clastic “dykes” infilling tensional cracks from above, indicate significant post-depositional collapse towards the linear vent.

After volcanism ceased a marine strait or embayment existed between the North and South Peaks. In this setting coarse grey sandstones (Landing Point sandstone member) accumulated immediately above the Rangiauria Breccia on the rapidly aggrading outer southern slopes of North Peak. Subsequently these beds were overlain by finer yellow-brown siltstones (Black Robin siltstone member). These beds are highly laminated and cross-stratified having accumulated in the ocean at the foot of ridges radiating from North Peak.

Next, gravitational collapses began from high on the south flank of North Peak, deforming the previous beds over which they flowed and accumulating in the marine strait/embayment. Subsequently, further gravitational collapses occured northwards from South Peak, (mapped as Bag End breccia), carrying up to 6.6 m-sized megaclasts of Rangiauria Breccia into what by this time was a marine embayment. This blocked the northwest entrance of the embayment to the sea, immediately leading to lacustrine conditions under which the wood-bearing siltstones of the basal Mangere Formation began to accumulate.

ORAL

PRELIMINARY EVIDENCE OF DEGLACIAL OCEAN CHANGE IN NEW ZEALANDS SUBANTARCTIC

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We present preliminary stable isotope records from the subantarctic region off New Zealand which are used to demonstrate surface and deep-water responses to the last deglaciation. Data was obtained from a kasten core collected by the R. V. *Tangaroa* in 1997. Fine sampling of this moderate sedimentation rate core yields a record of SW Pacific Ocean conditions over the last glacial cycle, potentially allowing an evaluation of the timing of deglacial events relative to those in Antarctica and the Northern Hemisphere. The 3.5 m-long core, Y8, extends back to at least Marine Isotope Stage (MIS) 6, and was recovered from 1335 m water depth, off the northeastern flank of Bounty Plateau. Presently, the site is south of the Subtropical Front (STF), and is overlain by cool subantarctic surface water and southern sourced deep intermediate waters. The site is in a location likely to be influenced by cross-frontal exchange of surface waters arising from the generation of cold and warm core eddies and subsequent transport north or south respectively.

To examine the ocean's response stable isotopes in foraminifera were analysed from slices averaging 120-250 yr resolution. Surface (up to 400 m deep) waters were investigated using two planktic species. *Globigerina* bulloides is a surface or near-surface dweller, but is also associated with periods of enhanced nutrient supply. These conditions are often related to upwelling, which can occur in different seasons in different regions. *Globorotalia inflata’s* depth range extending to 400 m, and are persistent and numerous in the core. Their oxygen isotopic compositions generally record temperatures colder than co-existing *G. bulloides.* The tendency is for α^{13}C of *G. bulloides* to increase under high productivity conditions, while that of other species, including *G. inflata*, become more negative during increased upwelling of subsurface waters enriched in ^{12}C. For bottom waters, we examined *Uvigerina peregrina*, it records the isotopic signal of pore waters in the upper layers of sediment, which, for oxygen, is close to that of bottom water.

POSTER

RHODOLITH-BEARING LIMESTONES AS TRANSGRESSIVE MARKER BEDS, SOME NORTH ISLAND EXAMPLES

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Rhodoliths are nodular structures mainly composed of superimposed thalli of red coralline algae. Since their development is controlled by an array of ecological parameters, rhodoliths are a valuable source of paleoenvironmental information. However, despite their common use in paleoecological reconstructions, the stratigraphic significance of rhodolith accumulations has seldom been addressed in detail.

In a study of mid-Tertiary rhodolith-bearing deposits from the North Island of New Zealand, rhodolithic units, usually of limited lateral extent, are systematically found above major unconformities at the base of deepening upwards successions. Two types of transgressive rhodolith-bearing deposits may be distinguished on the basis of texture and rhodolith internal structure. Type A deposits are clast supported rhodolithic rudstones containing abundant pebbles and cobbles reworked from the substrate, and are characterized by rhodoliths with dense concentric to columnar internal structure and a high nucleus to algal cover ratio. Type B deposits are rhodolithic floatstones with a matrix usually consisting of bryozoan fragments, benthic foraminifera, and echinoid fragments or terrigenous silty fine sand. The algal nodules of type B units have usually a loose internal framework with irregular to branched crusts.

The two contrasting rhodolith-bearing units are interpreted as characteristic facies of transgressive systems tract (TST) deposits, analogous to shell concentrations formed under conditions of low net sedimentation. We associate our Type A deposits with high energy shoreface settings or narrow submerged paleotopographic lows, and equate them to onlap shellbeds. Type B deposits are likened to backlap or compound (mixed onlap-backlap) shellbeds, formed at the basinward termination of a backstepping sediment body in lower energy settings.

The association between transgression and development of rhodolithic facies is confirmed by a review of published fossil examples, many of which show stratigraphic and compositional attributes analogous to those of the New Zealand occurrences, and also by our observations of a modern rhodolith production site at Whangaparaoa Peninsula north of Auckland, where algal nodules grow above a ravinement surface cut into Waitemata Group deposits during the Holocene sea level rise. It is suggested that a combination of factors, such as low net sedimentary input, nature of the substrate, sea level rise, inherited physiography, and the Heterozoan composition of the association all contribute to determine the relationship between rhodolith-bearing deposits and transgressive settings.

ORAL

WAS THE AD1435 KUWAE EVENT (VANUATU) REALLY THE LARGEST EXPLOSIVE ERUPTION IN THE SW PACIFIC IN THE LAST 1000 YEARS?IMPLICATIONS FOR REGIONAL HAZARD AND GLOBAL CLIMATE

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Kuwae is a legendary landmass inferred to form a large island in the Vanuatu volcanic arc between the islands of Epi, Tongoa and Tongariki. “Kastom” stories among islanders describe a volcanic event that caused a major catastrophe about 700 years ago, removing over half of the the Kuwae island. International publications in the mid-90’s describes these events as dacitic caldera-forming eruptions, covering Tongoa and nearby islands with large ignimbrites. Volcanic signatures from ice cores in the Antarctic were related to these purportedly huge volcanic events based on timing from legends and radiocarbon dating, and global climatic impacts have been inferred. The source for these events was considered by French research groups to be within a double depression mapped in the sea floor, NW of Tongoa. However, “kastom” stories definitively state that the eruption source was SE of Tongoa, in a location where the Geological Survey of the New Hebrides mapped a caldera in the 70’s. The NW caldera has been the source of smaller eruptions in the 1970’s and is named *“Karua”* (new one or second one). New fieldwork has shown that the record of young dacitic to rhyodacitic pumiceous deposits is stratigraphically complex, and much more restricted in distribution than previously considered. On Tongoa, pumiceous ignimbrite and lahar deposits form successions of a few tens of metres thick as coastal fans or wedges, unconformably abutting Holocene basaltic scoria cones and lavas. Pyroclastic flow deposits along the SE coast, at the type section of the Kuwae ignimbrites (and where radiocarbon ages are derived) suggest that flows travelled onshore from a nearby caldera to the SE. A near-vent position is supported by the presence of an up to 2 m thick welded ignimbrite succession, the only one on Tongoa. Texture of the pumiceous deposits suggests deposition from low energy granular flows. Cauliflower bombs, angular juvenile clasts, elutriation pipes, mud coating on large clasts and massive to weak stratification of the units indicate magma-water interaction during the formation of the majority of the successions. Inland, these deposits rapidly thin up valleys to form a minor <0.5 m veneer toward the centre of the island at around 400 m elevation. Similarly, on the NW coast of Tongoa and on a small island to the north (Laika), pyroclastic deposits of apparently similar (but undefined) age form coastal wedges mantling the scoria cones and lava fields (i.e. deposited from offshore to the N and NW). The areal distribution of the deposits is small but complex, with abundant clast morhopology evidence indicating magma-water interaction. These deposits imply small-volume, and low-energy explosive events similar to the 1970’s activity (i.e. Surtseyan type eruptions), with some slightly larger pyroclasitic flow forming events from within the Karua caldera area. Other low-lying coastal fans around Tongoa, are formed by rapidly deposited stacks of pumice-bearing lahar and fluvial deposits, suggesting immediate remobilisation of ignimbrite and other pyroclastics.

These areas are also described in "*kastom*" stories of vast swamp lands covering the shoreline after the Kuwae event. From our evidence it is clear that multiple explosive events took place in this region from at least two submarine caldera systems. However, our evidence does not support that these events were as extremely explosive and as regionally hazardous as described. Instead these explosive events produced small- to medium volume pyroclastic deposits. It is very unlikely that they could have caused significant climatic effect, or a significant extra-regional hazard. We suggest that the mid-Fifteenth Century volcanic signatures described from ice cores, may fit better to other volcanic events in the SW-Pacific such as Kaharoa eruption that clearly was much larger and more explosive.

ORAL

STACKING THE SCHISTS: PROBLEMS IN METAMORPHIC STRATIGRAPHY 1865-1955

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The theoretical problems facing nineteenth and twentieth century geologists in mapping the schists of New Zealand and placing them in stratigraphic order are examined. The settler geologists considered that the schists and greywackes of north-west Nelson and Westland were continuous with those of Otago and Fiordland. The gerologists were always puzzled by the way in which unaltered rocks (usually greywackes) passed 'insensibly' into metamorphic rocks, and their inability to find an unconformity between schists and unaltered rocks. Nevertheless, they drew stratigraphic boundaries between the schists and unaltered rocks that were all arbitrary and all different. The beliefs that the greater the metamorphism the older the formation, and that metamorphic rocks were always older than neighbouring unaltered rocks were used to place the rocks in a single vertical stratigraphic order and led to assumptions of ages ranging from Carboniferous to pre-Cambrian.

Controversy began early in the twentieth century when a few geologists took up the idea that the 'insensible' gradation from unaltered greywackes to schists was real. Patrick Marshall believed there were no unconformities between the rocks of Southland, the greywackes, and the Otago schist, that all were of the same age and all should be included in his grand Trias-Jura Maitai System - except for the metamorphic rocks of northwest Nelson and Fiordland. Marshall's prepared microscope slides showing increasing grades of metamorphism from Nugget Point northwards towards Waipori Gorge earned hesitant support from Noel Benson of Otago. However, Marshall's views were regarded with scepticism by Survey geologists. When Permian fossils were found between Nugget Point and the schists, Marshall's scheme was angrily denounced and the conventional view that a stratigraphic unconformity existed (somewhere) between the schists and the greywackes was reinforced.

During the 1930s, intensive petrological investigations by F.J.Turner of progressive regional metamorphism in Otago and Westland led to his identification of metamorphic zones based on index minerals. Turner then abandoned any stratigraphic subdivision of metamorphic rocks in favour of metamorphic zones and focussed on metamorphic processes rather than geological history. He subdivided Otago's very large area of Chlorite zone greywackes and schists into three sub-zones and with his colleague C.O. Hutton identified a fourth sub-zone. Nevertheless, the New Zealand Geological Survey map of 1947 maintained that the Otago schists were older than the greywackes. Later, the discovery of Triassic fossils in greywackes that clearly graded into schists (Wellman, Grindley and Munden 1955) showed that indeed, the greywackes and schists were both of the same age as the fossiliferous Hokonui rocks of Southland. Soon, Wellman's invention of the New Zealand Geosyncline (1956) and petrological studies by J.J.Reed (1958, 1959) and D.S.Coombs (1960) began answering many questions about our metamorphic rocks and, happily, also uncovered lots of new, enticing geological puzzles.

ORAL

TEMPORAL STABILITY OF REGIONAL DEFORMATION RATES WITHIN THE HIKURANGI SUBDUCTION MARGIN

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Global Positioning System (GPS) geodetic measurements have provided a wealth of new information on the horizontal velocity fields of plates and plate boundary zones over the last 10-15 years. GPS present a snapshot of the finite deformation and, at different locations, is likely to include varying components of elastic, aseismic and seismic strains. Given the short duration of GPS measurements, which often sample part of the interseismic periods of the largest active faults (e.g., <10-100 years) and account for <0.01-0.001% of the total duration of deformation, uncertainties remain as to whether contemporary velocity fields and associated strain rates are comparable to those measured by geological studies over many seismic cycles (e.g., 10 kyr to millions of years). To address this question we compare geological rates of extension, shortening, fault slip and vertical axis rotations, derived from cross sections, seismic-reflection lines, displaced landforms and paleomagnetic data and measured over the last 5 Ma, with results from modelling of GPS velocities from the Hikurangi Subduction margin in the North Island. GPS velocities in the North Island are found to be influenced by two fundamental processes (1) elastic strain due to interseismic coupling on faults in the region, and (2) long-term tectonic block rotations (Wallace et al., 2004). It is the latter component of the GPS velocity field that can be directly compared to geological estimates of block rotation and fault slip rates.

Regional analysis of the Hikurangi margin suggests that within the uncertainties of the data the rates of deformation for both data sets are, in most cases, approximately equal and independent of the sample period. Geological and geodetic datasets both indicate rapid clockwise rotation (2-4 °/Ma) of the eastern North Island. Extension and contractional strains result from the rotation. Margin-parallel velocity gradients arising from the rotation of the eastern North Island account for up to 70% of the margin-parallel component of Pacific/Australia relative plate motion. Stable deformation rates over time periods ranging from 5-10 years to millions of years are consistent with the constant rates of plate motion observed over similar temporal scales and demonstrate the utility of GPS velocity fields for constraining longer-term tectonic deformation (i.e. > 1 earthquake cycle duration). The apparent absence of faults at the ground surface accommodating aseismic creep and of large magnitude earthquakes over the last 10-15 years, suggests that in the upper crust contemporary geodetic strains are predominantly elastic. These contemporary strains are spatially distributed across much of the North Island, however, the compatibility of block-rotation rates and fault-slip rates from geological studies and those from modelling of GPS data indicates that elastic strains will, in the future, mainly be converted to narrow zones of permanent deformation on, or close to, the largest faults (i.e. those faults large enough to be resolved in the regional geology data). Elastic strain release is most likely to take place during large magnitude earthquakes.

Wallace et al. 2004. *JGR 109*, B12406, doi:10.1029/2004JB003241.

ORAL

FROM KAIKOURA TO KAITORETE: NON-INVASIVE GEOPHYSICAL MAPPING OF MAORI BURIAL SITES

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Sacred (*tapu*) sites need to be treated with care and sensitivity. Non-invasive, non-destructive geophysical surveying is an appropriate, optimal way to map the nature and extent of such sites, particularly burial sites – *urupa*. Since 1997, geophysical methods have been successfully used on *urupa* (Nobes, 1999). The response varies from site to site, depending primarily on the nature of the soil and the underlying bedrock.

The results from four sites representing three physical settings are presented here:

1. The Oaro urupa is on top of a hill overlooking the South Pacific, and was the first urupa to be surveyed using geophysical methods (Nobes, 1999). The site's clay soils overlie limestone bedrock. Magnetic, electromagnetic (EM) and ground penetrating radar (GPR) surveys were completed. The responses are clear and unequivocal, once the influences due to fences and the clay are removed.
2. The Koukourarata (Port Levy) and Wairewa (Little River) sites are in loess overlying the volcanic bedrock of Banks Peninsula. The EM responses are apparent but are not as obvious as for the magnetic surveys. The GPR surveys have clear anomalous responses that in most cases can be interpreted as graves (Bateman, 2003).
3. The Mangamaunu urupa is situated in coastal beach sands, next to State Highway 1, just north of Kaikoura and near the hamlet of Hapuku. Anomalous geophysical responses are all present but less obvious than for the Oaro, Koukourarata and Wairewa sites. Nonetheless, we can identify areas where the variable geophysical response is indicative of disturbance that is likely due to graves.

Bateman, L., 2003. Applications of near-surface geophysics in the search for graves in Maori urupa. B.Sc. (Honours) project in Engineering Geology, Department of Geological Sciences, University of Canterbury, 69 pp.

Nobes, David C., 1999. Geophysical surveys of burial sites: a case study of the Oaro urupa, *Geophysics*, 64(2): 357-367.

POSTER

3D IMAGING OF THE FORE- AND BACKTHRUSTS OF THE GLEN LYON SEGMENT OF THE OSTLER FAULT

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A set of closely spaced ground penetrating radar (GPR) and GPS survey lines were acquired across the fore- and backthrusts of the Glen Lyon segment of the Ostler Fault. The project is part of a larger ongoing study of thrust fault processes.

We collected 21 survey lines, 50-m long and 1 m apart, and approximately centred on the fore- and backthrust scarps. In addition, common midpoint (CMP) velocity surveys were completed at each site so that the profiles could be migrated, and the travel time converted to depth. The velocity structure at the two sites was similar, yet subtly different, and consistent with mostly unsaturated sandy and silty gravels. At the forethrust site, the velocity was 110 m/μs (± 10 – 15 m/μs) down to about 4 m depth, rising to 120 ± 10 m/μs before returning to 110 ± 10 m/μs from 5 to 8 m depth. In contrast, the backthrust velocities below the scarp were 110 ± 15 m/μs at shallow depths (< 2m), and 120 – 130 ± 15 m/μs at depths down to 6 m. Above the backthrust scarp, the velocities were more consistent with dry sands and gravels, of the order of 150 m/μs, but were not well constrained. Deeper velocities were not resolved at either site.

The 3D GPR profiles reveal a backthrust with a relatively simple geometry, and dipping 65° ± 8° to the east. For the forethrust, on the other hand, there are from 2 to 4 individual fault displacements visible in the 21 GPR lines, with dips of the order of 56° ± 9° to the west-northwest. These results are consistent with measurements on outcrop (Davis et al., 2005) and GPR profiles from the Benmore segment of the Ostler Fault (Wallace et al., in submission), which yielded dips of 50° and 51°, respectively, ± 9°.

The most recent main fault displacement almost reaches the surface near the top of the current forethrust scarp, with a thin wedge of sediment in front of the fault. The other fault displacements, each with its own sediment wedge, are located at successively greater depths and in front (to the east) of the current scarp. The forethrust position appears to be migrating westward toward the hinterland with each new rupture sequence.

Davis, Kenneth, Burbank, Douglas W., Fisher, Donald, Wallace, Shamus & Nobes, David, 2005. Thrust fault growth and segment linkage in the active Ostler fault zone, New Zealand. *Journal of Structural Geology*, 27: 1528-1546.

Wallace, Shamus C., Nobes, David C., Davis, Kenneth J., Burbank, Douglas W. & White, Antony. Three-dimensional imaging of the Benmore segment of the Ostler Fault, South Island, New Zealand. *Geophysical Journal International*: in submission.

ORAL

ACTIVE FAULTING AND PALEOSEISMICITY OF THE OFFSHORE KAPITI-MANAWATU FAULT SYSTEM, SOUTHERN NORTH ISLAND, NEW ZEALAND

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Seismic hazards associated with active faulting in coastal regions may be under-estimated if recent offshore deformation is not accounted for in hazard analyses. At subduction margins, deformation occurs predominantly in the high-strain forearc basin, but can also extend considerable distance away into the back-arc environment. An example is described here in the offshore, low contractional strain Kapiti-Manawatu Fault System (KFMS), which is located along the eastern margin of the proto back-arc Wanganui Basin, 200 km behind the Hikurangi margin subduction front. High-resolution seismic reflection data show the presence of numerous sea-floor fault scarps and near-surface deformation of late Quaternary and possibly Holocene reflectors on high-angle (>60°), reactivated reverse and normal faults within the KMFS. Continuous sea-floor scarps, which are inferred to correspond to earthquake rupture segments, range from <10 to up to ~50 km in length.

We derive potential maximum credible earthquake moment magnitudes (M_w) using empirical regression equations, developed from global data-sets of predominantly onshore faults that relate fault rupture dimensions to M_w. Slip rates are estimated from vertical displacements of the sea-floor (6.5 ka) and post-last glacial stratigraphic markers (8-9 and 10-11 ka), with ages constrained by the dating of sediment core material collected at strategic locations. Maximum displacements at the sea-floor range from 2 to 30 m, which result in maximum vertical slip rates as high as 3 mm yr^{-1} for the largest structure in the KMFS, the Mascarin Fault, but are typically <1 mm yr^{-1}. The short-term slip rates (<11 ka) are comparable to long-term geological rates (<1.3 Ma). Faults of the KMFS may be able to generate M_w of 6.0-7.5, with recurrence intervals ranging from 2000 to >10 000 years suggesting that previous assertions regarding the low seismic hazard of the Kapiti-Manawatu region may not be substantiated, and needs to be re-appraised. The method used here for determining the paleoseismicity of offshore faults has potentially wider applications elsewhere, and in New Zealand has already been applied to normal (e.g., Cape Egmont Fault, Taranaki; offshore Taupo Volcanic Zone, Bay of Plenty), reverse (e.g., North Canterbury shelf; Lachlan Ridge, Hawkes Bay) and strike-slip faults (e.g., Alpine Fault, Fiordland) in the offshore environment.

ORAL

THE GROWTH OF ANTICLINAL RANGES IN AN ACTIVE FOLD-THRUST BELT, CENTRAL OTAGO, NEW ZEALAND

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The Otago fold-thrust belt is situated east of the Alpine Fault within the zone of distributed deformation along the Australian–Pacific plate boundary in South Island, New Zealand. Average shortening rates across the belt, based on both long-term geological estimates and on preliminary GPS data, are only 2-3 mm/yr. We have employed a combination of geomorphology, structural geology and cosmogenic isotope dating to determine the style and rate of fault-fold propagation, and the evolution of the topography in the central part of the belt. Cosmogenic ^{10}Be measurements were made on “sarsen stones”, remnants of silcrete deposits in the Tertiary sediments overlying the basement schist erosion surface. During uplift of the ranges, the surrounding sediments were rapidly stripped, leaving the silcretes behind. Previous work (E. Bennett et al., J. Geophys. Research, v. 110, B02404, doi: 10.1029/2004JB003184, 2005) has shown that ^{10}Be ages up to 1.3 Ma are not saturated and provide valuable data on the timing of uplift of the underlying ranges.

The data strongly support a model of rapid establishment of fault length followed by increase in amplitude and slow tip propagation. The two ridge systems investigated (Raggedy Range–Blackstone Hill and Rough Ridge–North Rough Ridge) have grown since 1.5 Ma, by either rapid lateral propagation and/or early coalescence of shorter segments, before continuing to increase in height with slower tip extension. Two ridges have developed frontal imbricates within 1 Ma of initiation. Initial growth of all the central/east Otago ranges occurred over a short time period with no systematic progression towards the foreland. Continuing activity across the region indicates the whole thrust belt is ‘out-of-sequence’ in terms of classical thrust kinematics.

Erosion of the ridges is very slow and they closely reflect tectonic deformation above the underlying fault. Elastic dislocation modelling of the topography of North Rough Ridge indicates an underlying fault dipping north-westwards at 45° or less. The slipping fault modeled extends from a depth of 1-2 km down to at least 10 km. The average spacing of the ranges of 18 km, together with their average length of 45 km, suggests that they most likely extend to the base of the seismogenic zone.

The Rough Ridge system of ridges currently forms the drainage divide between streams draining into the Clutha system via the Manuherikia River and streams draining eastwards into the Taieri system. Prior to the growth of these ridges over the last 1.5 Ma, it is likely that the drainage systems were quite different. The resulting major drainage changes may have important ecological effects, for example on the evolution of indigenous fauna.

ORAL

TUBULAR CARBONATE CONCRETIONS AS CONDUITS FOR METHANE ESCAPE FEEDING SEAFLOOR COLD SEEPS: SOME NORTH ISLAND EXAMPLES

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Several Cenozoic sedimentary formations in the North Island of New Zealand include locally prominent development of carbonate concretions which exhibit a variety of broadly tubular shapes, and commonly a central conduit that may be empty or filled with sediment or multiple generations of later carbonate cements. Stable oxygen and carbon isotope data suggest that many of the concreting and later cements were sourced primarily from ascending methane fluids/gases of possible thermogenic origin.

Reconnaissance field studies at localities in onland East Coast and Taranaki basins show several similarities in broad geological setting and associated facies (e.g., within upper slope mudstone), but also local differences likely reflecting their tectonic environment, stratigraphic position, and available fluid migration pathways. In some cases there is a clear association of the tubular concretions with overlying paleo-sea floor seep-carbonate deposits, and we suggest they may mark the subsurface plumbing network of cold seep systems. Tubular concretions clearly aligned along joints and fractures in the East Coast Basin demonstrate an intimate relationship between tectonics and seep development. In eastern Taranaki, the presence of dislodged and mass-emplaced tubular concretions in the axial conglomerates of certain channel facies in slope mudstone suggests a connection between the loci of seep field development and slope failure and canyon cutting on the late Miocene Taranaki margin, possibly influenced by the build up of gas pressures during seep development.

Tubular concretions afford an opportunity to investigate the evolution of cold seeps based on ancient examples, and also the linkage between subsurface and surface portions of such a system. Seep field development has implications for the characterization of fluid flow in sedimentary basins, for the global carbon cycle, for exerting biogeochemical influences on marine communities, and for the evaluation of future hydrocarbon resources, recovery, and drilling and production hazards.

ORAL

NUMERICAL MODELLING OF THE COMPETITION BETWEEN EXTENSION AND CONVECTION IN HYDROTHERMAL SYSTEMS

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In many upper crustal hydrothermal and geothermal systems, inferences have been made about the combined effects of extensional deformation and thermally-induced circulation. Deepening convection cells during progressive extension in the Irish base metals province were proposed to explain a temporal change in the Pb isotope composition of ores formed near or at the surface (Russell, 1986, Irish Assoc. Econ. Geol.), and faults and fractures appear instrumental in localization or compartmentalization of active geothermal systems in the Rhinegraben, and in the Taupo Volcanic Zone (TVZ, Rowland & Sibson, 2004, Geofluids). Faults in these systems appear to act either as conduits or barriers, and as pathways for near surface fluids to access 'impermeable' basement rocks. However, the specific interplay of long-lived fluid convection through permeable rocks, and short-lived fluid pumping along seismically active faults, remains uncertain. We explore here the interactions of thermally and mechanically-induced fluid flow during extension using a fully coupled finite difference code (FLAC). We used generic rift architecture with a blanket of permeable sediments and volcanics on a less permeable rifted basement. Firstly, we applied a basal heat flow and generated stable convection in the cover sequences, and fluid penetrates down into basement with downwelling zones along rift edge faults. However, when we applied extension at strain rates around 5×10^{-14}/s (similar to those in the TVZ), stable convection cells were rapidly destroyed by fluid flowing towards dilatant sites on faults. When we turned the extension off again, stable convection reappeared, but the localisation of upflow zones in the convection cells was controlled by the former position of structurally-driven upflow. Our results may explain why the main NE-trending part of the TVZ is not associated with thermal upwelling, because in our models the zones of active extension correspond with structurally-driven downflow and perturbation of the convection. We speculate that convective- and mechanically driven fluid flow in extension zones is competitive, rather than coupled. Apparent coupling may be a consequence of perturbation of thermal structure by fault-driven flow, which then controls convection cell patterns once deformation subsides.

ORAL

GEOLOGY & STRUCTURE OF THE HAUHUNGAROA RANGE, WESTERN TAUPO VOLCANIC ZONE

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The Hauhungaroa Range lies on the western boundary of the Taupo Volcanic Zone (TVZ), and comprises a Mesozoic metasedimentary (greywacke) basement block bounded by a SE-facing normal fault scarp, with andesite volcanoes at its northern (Pureora and Titiraupenga) and southern (Hauhungaroa) extremities. The range-forming Hauhungaroa Fault scarp appears steep and sharp when viewed remotely, which has led to speculation over its role as an active structure. On the other hand, it may be a relic of past tectonism, perhaps reactivated as a border fault early in the history of rifting within the TVZ, but no longer the focus of extensional strain. Recent fieldwork has better delimited the outcrop areas of some TVZ ignimbrites so that they can be used as chronostratigraphic marker horizons to determine the extent of Quaternary movement on the Hauhungaroa block.

Offset of the Ongatiti ignimbrite (1.2 Ma) together with a lack of offset on the younger Whakamaru group ignimbrites (0.32 Ma) constrain the last Hauhungaroa Fault movement to 0.32-1.2 Ma. In the southern sector of the range, NW-trending minor faults offset the Ongatiti ignimbrite to expose the peneplaned greywacke surface of the range top. These structures align with steps in the gravity profile of the western boundary of the TVZ and their origin may be related to reactivation of pre-existing basement faults. Faults further to the east have been covered by the voluminous Whakamaru Group ignimbrites obscuring any direct observation of pre-0.32 Ma faults. NE trending lineaments are observed east of the Hauhungaroa Fault, suggesting that faulting youngs to the east. We infer that the Hauhungaroa Fault block is an early structural feature within the TVZ and the locus of extensional strain has migrated to the east during the last 300 k.y.

In addition to addressing the question of tectonic activity on the Hauhungaroa block, detailed field mapping in the south east of the range has revealed the presence of a new heavily eroded andesite cone in the area previously mapped as the Hauhungaroa Lahars. The eastern portion of this cone appears to by cut by a NE-trending fault that defines in part the western shore of Lake Taupo. Re-examination of the Hauhungaroa Lahar type locality (T18/435634) leads us to suggest that this locality is a lava flow with pronounced spheroidal weathering. However, detailed mapping shows that both lava flows and laharic material are present, along with colluvial material. The latter has locally mantled the underlying Tertiary sediments (Otunui Formation), acting as an armour and locally preserving the pre-Pleistocene peneplaned surfaces.

POSTER

SPATIAL AND TEMPORAL SEDIMENTATION PATTERNS SUGGEST RAPID, MARGIN-WIDE MUD DISPERSAL AT POVERTY BAY, NEW ZEALAND

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On the eastern Raukumara Ranges active tectonics, vigorous weather systems, and human colonisation have caused widespread erosion of the mudstone- and sandstone-dominated hinterland. The Waipaoa River sedimentary dispersal system has responded to such changes, and is now New Zealand's second largest river in terms of suspended sediment discharge. New sediment accumulation rate data for the Poverty Bay continental shelf and slope derived from radiochemical tracers (^{234}Th, ^{7}Be, ^{210}Pb, ^{137}C), palynological, tephrostratigraphic, and seismic methods suggest rapid, margin-wide dispersal of Waipaoa sediment. A post-glacial mud lobe on the outermost shelf and uppermost slope has been a locus of high sedimentation rates, attaining 40 m thickness in a structurally controlled sub-basin. Here, an offset in the last-glacial erosion surface indicates that deposition was sympathetic with fault activity and the creation of accommodation space, implying that sediment accumulation was not supply limited. Contrary to classical shelf sedimentation models, the highest modern accumulation rates of 1 cm/y occur in three depocenters: one on the outermost shelf, and two on the mid-shelf landward of shelf-edge anticlinal ridges. Shelf rates are about 10 times more than the mid-slope plateau. Moreover, short-lived ^{7}Be activities indicate fluvial sediment is rapidly reaching the outer shelf and upper slope. Similarly, at sub-millennial time scales, pollen records from slope cores fingerprint Polynesian followed by European settlement, and broaden the spatial extent of post-settlement sedimentation initially documented from the Poverty shelf. Changes in sedimentation infer a 2-3 times increase in accumulation on the shelf after European settlement, but a smaller 1-2 times increase on the slope. Over longer time scales, seismic evidence infers slower but steady sedimentation since the last transgression, and that significant cross-shelf sediment pathways pre-date the increase in sedimentation resulting from colonisation and deforestation.

ORAL

THE GRIFFENS ROAD TEPHRAS: VALUABLE MARKER BEDS IN MAPPING THE QUATERNARY OF THE MANAWATU-WANGANUI REGION

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The age of many of the terraces, their cover beds, and underlying units in the lower Manawatu-Wanganui region, has until recently been poorly known. West of Wanganui, the map of Pillans (1990) provides a detailed temporal and spatial record of marine terraces and their cover beds. In Rangitikei, the aggradation terraces on the western side of the river have been mapped by Milne (1973), with minor revisions made by later authors. There remained large tracts of poorly known uplifted terrace land, some folded into growing anticlines. Theses by Massey University and Victoria University students provided some insight into the age and distribution of some of the mid-late Pleistocene deposits. However, recent examination of the landscape during Q-mapping have provided a timely rationale for re-evaluation and integration of the stratigraphic record. Critical to determining the age of the landscape, has been the recognition and identification of the Griffens Road tephras, the Fordell Ash, and the Rangitawa Pumice. The ca. 350ka Rangitawa Pumice (aka Mt Curl Tephra) was already well known on the Aldworth river terrace that formed in Marine Oxygen Isotope Stage (MOI) 10, the Ararata marine terraces (MOI 11) and older terraces. The Griffens Road Tephras, a group of three rhyolitic beds (informally "upper", "middle" and "lower"), were previously known from sites north of Marton (Pillans 1988), and a few sites between the Whanganui and Turakina Rivers (Woolfe 1987, Bussell and Pillans 1992). The slightly younger Fordell Ash, was also found near Wanganui.

The Griffens Road tephras are found in the marine sands, dune sands, gravels and loess that form the Galpin, Marton, Halcombe-Mt Stewart and Feilding anticlines and southern and western flanks of the Pohangina anticline, allowing surfaces in the area to be mapped with confidence. All three may be found in loess on river terraces that can now be correlated to the MOI 10 Aldworth terrace. The middle and upper tephras occur in the marine and terrestrial deposits of the MOI 9c (Braemore) marine terrace. Neither the Griffens Road tephras, nor the slightly younger Fordell ash are found on the wave-cut surface of the MOI 9a (Brunswick) marine terrace, suggesting that they all were deposited between 340 and 300ka. Tentative correlations are made to ignimbrites in the Central North Island.

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POSTER

AUTOSUSPENSION: THEORY AND EXPERIMENT

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An autosuspension current may be defined as a particle-driven gravity flow (turbidity current), which can persist indefinitely without any external supply of energy. Such a current is capable of entraining additional sediment, leading to acceleration. The critical combination of velocity, sediment content, and turbulent energy needed for the current to persist is known as the ignition point (Parker et al., 1986). In their analysis, Parker et al. (loc. cit.) restricted their investigation to spatially-developing currents, and to those in the supercritical field (densiometric Richardson number Ri < 1).

The Parker et al. model can appropriately be used on those submarine channels where topography, sediments, or bedforms provide evidence of active autosuspension. A good example is the Kaikoura Canyon α Hikurangi Channel system, east of New Zealand (Lewis & Pantin, 2002). When the model was applied to this channel system, with plausible values of bottom slope, flow thickness, and sediment grade, it was found that autosuspension was indeed possible, under suitable conditions. However, it was also found that whenever an ignition point was obtainable, the Ri number always fell within the supercritical field. The suspicion grew that perhaps, in the subcritical field

(Ri > 1), there might be no ignition points, and thus no autosuspension. Such a current would deposit sediment, and hence decelerate.

This possibility was tested, using a theoretical model derived from Parker et al., in which subcritical Ri numbers were imposed, together with different values of bottom slope, flow thickness, and sediment grain size. The resulting values of flow velocity, sediment content, and turbulent energy were then entered into the turbulent-energy equation. The energy balance was found to be consistently negative, i.e. energy was being consumed, and thus there would indeed be no ignition, and no autosuspension. The important consequence is, that if a change from super- to subcritical flow (hydraulic jump) can be identified, all of the channel downstream of this point must be essentially depositional.

Natural, submarine autosuspension currents are obviously very difficult to observe, and the reality of autosuspension would therefore be much more convincing if it could be demonstrated in the laboratory. A series of experiments with this objective has been carried out by the Sedimentological Fluid Dynamics Group at Leeds. Gravity currents were generated by allowing a gravity current (saline solution or silica suspension) to flow from a header tank down an elongated tube (5 cm diameter), the whole rig being immersed in plain water. Roughness elements, to improve sediment entrainment, were positioned inside the tube, and a test bed of silica emplaced (the same grade as in the suspensions). The current velocity was monitored throughout the run, together with the shape of the descending plume as it emerged at the lower end of the tube. Allowance was made for any change in hydraulic resistance, due to scouring of the test bed. The time-velocity curves, together with measurements of plume shape, showed good evidence of acceleration due to entrainment of test-bed sediment. Significantly, this confirmed that autosuspension had occurred.

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ORAL

SEPTARIAN CONCRETIONS, FRACTURE FILL ORGANICS AND THE ROLE OF BACTERIA IN CONCRETION FRACTURING

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Stratabound concretion bodies of marine origin in New Zealand and elsewhere commonly consist of anhedral calcite microspar surrounding randomly oriented clay and have high minus-cement porosities. Calcite $\delta^{13}C$ and $\delta^{18}O$ values typically range from -15 to -20‰ PDB and +1 to -2‰ PDB respectively. These data indicate geologically rapid, pervasive cementation in marine pore fluids shortly after deposition, with bicarbonate sourced dominantly from bacterial organic matter oxidation. Septarian fracturing in examples from Moeraki (Palaeocene, New Zealand) and Staffin (Jurassic, Scotland) was probably synchronous with incipient cementation of concretions and resulted in up to 40% volume reduction of the host material. Crack-lining brown, fibrous calcite began to precipitate in oxic to suboxic conditions utilising the same bicarbonate pool and marine pore fluid as the concretion bodies but recording a relative lowering of the redox boundary during a depositional hiatus. The colour of the brown calcite results from an included gel-like polar organic fraction that probably represents bacterially degraded biomass. Putative bacterial remains are also present in the Staffin fracture fill.

A postulated origin for the fracturing suggests it predates or is synchronous with carbonate cementation. Sufficient rigidity for sediment rupturing is provided through the binding of flocculated clay by bacterial secretions. Development of septarian (shrinkage) cracks in muds is envisaged to require pervasive *in situ* bacterial colonisation of sediment volumes, and to depend on the rate of carbonate precipitation versus breakdown of the bacterial clay-complex. Bacterial degradation products are incorporated into early crack-lining brown calcite crystals.

Modification of the early-formed septarian concretions includes brittle (non-septarian) fracturing, and precipitation of strongly ferroan sparry white or yellow calcite cements. Fracture morphologies and internal brecciation of earlier cements suggests a hydraulic fracture mechanism. Carbonate-bound lipid distributions from the yellow calcite cement probably reflect organic matter breakdown and aqueous solubility of resultant fatty acids or their salts. $\delta^{13}C$ and $\delta^{18}O$ data for such late cements are variable suggesting no single bicarbonate source can be invoked. Similar late fracture fills occur in non-marine sideritic concretions that occur in Eocene Waikato Coal Measures in New Zealand.

ORAL

ANTISCARP INITIATION AND EVOLUTION

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Antiscarps are defined here as any uphill facing scarp that may be observed on slopes, regardless of size or scale, and are variously referred to in literature as sackungen, ridge rents, obsequent scarps and reverse scarps. Antiscarps are not a feature of all slopes, but where they are observed in New Zealand, they typically occur sub-parallel to the valley axes near the ridge crests in mountainous regions. In Scotland they have been observed over the entire slope that is from the ridge crest to the valley floor.

This research project aims to identify how seismic activity, slope rock mass properties, and mountain stress field changes by slope loading and unloading from glacial and rock avalanche events, contribute to the initiation and evolution of antiscarps.

Research for this project has so far identified case study areas in New Zealand and in Scotland suitable for analysis of antiscarp formation. In all of the field areas investigated the antiscarps are evident as linear features across the slope with observed lengths ranging from 200–1000+m. Vertical separation from the crest of the antiscarp to the scarp intersection with the slope ranges between 1-5m on the antiscarps observed in New Zealand, and 1-10m for those in Scotland.

None of the chosen case study areas show any evidence to suggest that antiscarp formation is driven by translational movement. The case study antiscarps are typically aligned with defects observed within the respective slopes suggesting that these antiscarps are in situ deformations of the slope rather than secondary features within a larger slope failure. Primary mechanisms considered to drive in situ slope deformation are post-glacial rebound, seismic activity, gravity faulting, and unloading of the slope for mountain by large rockfalls.

POSTER

HIGH-TEMPERATURE DUCTILE EXTENSION PRESERVED IN THE FOOTWALL OF A LOW-ANGLE NORMAL FAULT, MISIMA ISLAND, PAPUA NEW GUINEA

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The oblique collision of the Australian and Pacific plates has resulted in a complicated zone of micro-plates in SE Papua New Guinea. The actively spreading Woodlark rift forms the boundary between the Australian and Woodlark plates to the southeast of the Papuan Peninsula. Seafloor spreading rates vary between 30-40 mm/yr at 152°E and ~70 mm/yr at 156°E (Abers et al, 1997) and are among the fastest in the world. Continental rifting gives way to sea-floor spreading to the east of 151.4° E providing a unique opportunity to study this transition. The rift is a known area of active low-angle normal faulting and metamorphic core complex (MCC) formation including Misima Island, a MCC situated on the Pocklington Rise, ~75 km to the south of the Woodlark spreading centre and 100 km east of its western tip.

A normal fault, which dips ~25° to the NE, is the dominant structural feature on Misima Island, splitting it into two distinct geological domains. Amphibolite-facies felsic and mafic gneisses occur in the lower plate and are placed against greenschist-facies schists and overlying unmetamorphosed conglomerates, volcanics, and other sedimentary rocks in the upper plate. Separating these two domains is a fault zone with a layer of gouge >3m thick. The measured NNE slip direction on the fault (slickenlines) is parallel to the Australia-Woodlark plate vector between 500 ka and 3.5 Ma, calculated from seafloor spreading data (Taylor et al., 1999), showing that the development of this structure was directly related to the extensional tectonics of the Woodlark rift. Beneath the fault there is a 2-3 km thick zone of gneisses that were ductilely deformed in the lower crust during the extension. These gneisses have stretching lineations, commonly defined by elongate hornblende crystals, that trend towards NNE, in the plate motion direction and a shallow dipping foliation that is sup-parallel to the overlying fault plane. Structurally deeper rocks further to the west retain E-W trending lineations on a sub-horizontal foliation, which we interpret as an older, collisional fabric. Directly beneath the fault the basement gneisses are strongly lineated and flaggy, appearing mylonitic at outcrop scale, but lack typical microstructural evidence for non-coaxial deformation as is commonly seen in the lower plate of other MCCs, including those in the nearby D'Entrecasteaux Islands. Quartz CPO analyses by U-stage and electron backscattered diffraction techniques show that deformation beneath the detachment involved a component of simple shear parallel to the lineation with a top-to-the NE sense-of-shear. High-temperature quartz and feldspar deformation mechanisms, and minimal retrogression suggest that the lower plate tectonites preserve an early snapshot of extensional fabrics in the lower crust. These fabrics are preserved because they were exhumed by dominantly brittle processes, involving localised slip on a deeply penetrating detachment fault that transects the middle crust. Localisation of slip on the fault could be due to a weakening effect of high strain-rates on fault gouge material or deep embrittlement caused by prolonged maintenance of high pore-fluid pressures or high strain rates.

ORAL

LATE QUATERNARY LARGE-SCALE ROCK-MASS DEFECT CONTROLLED LANDSLIDES OF EASTERN NORTH ISLAND, NEW ZEALAND: TECTONIC AND CLIMATIC FORCING IN LANDSCAPE EVOLUTION

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Rock mass defect controlled landslides are widespread in the Tertiary bedded marine soft rock terrain of eastern North Island. The location and frequency of these deep-seated bedrock landslides is somewhat predictable and the slides are a dominant process affecting both sediment fluxes and landscape evolution. Most slides appear to be base level controlled and occur after stream incision has exposed a *critical stratigraphic horizon*, defined by thin (typically <20mm), comparatively weak and laterally continuous bedding parallel layers. These horizons are of sedimentary origin (e.g. bedding partings; thin sand, clay and volcanic ash horizons) and may have experienced some prior tectonically induced shear displacement (e.g. flexural slip and/or fault shear). The residual strength of these sedimentary horizons (C_r' = 2.6 – 20 kPa, and ϕ_r = 2° – ~20°) is very low relative to the peak strength of the dominant lithology (C_r' = <300 kPa, and ϕ_r = 30° - 37°). New failures are triggered episodically as deeper critical stratigraphic horizons daylight following stream incision. Failure on multiple near-horizontal critical stratigraphic horizons leads to the development of a “stepped” landscape morphology with extensive block slides, while wedge failures dominate catchments with moderately dipping successions. Orthogonal rock defects also partly control the lateral slide boundaries. The slides are triggered by both short- and long-term *tectonic* (earthquakes; regional uplift) and climatic (seasonal and glacio-eustatic cycles) forcing.

Large bedrock landslide dams are recognized in a number of catchments (e.g. Ngatapa, Waipaoa, Tutira, Waikaremoana, Ponui) and these transient features block drainages and dramatically alter catchment sediment fluxes for periods ranging up to 10^4 years. Reservoir deposits allow quantification of the degree and timing of perturbations to sediment flux, and provide constraints on variations in catchment sediment yield attributable to long-term glacio-eustatic climatic forcing cycles. The influence of these large slope failures is likely to affect the geomorphic development of catchments over a time scale of $10^4 – 10^5$ years.

We have quantified key material strength and landslide geometry parameters that allow numerical landscape evolution models to include large bedrock failures. Such models are needed to investigate the range of conditions leading to sliding (e.g. uplift rates, incision rates, earthquake recurrence and shaking intensity) and the geomorphic consequences of the failures.

POSTER

WHAT DOES THE COLOUR OF PUMICE TELL US?

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The most recent andesitic sub-Plinian eruption of Mt. Taranaki (Burrell Lapilli, AD 1655) produced differing coloured and textured pumices. Porosity, permeability, and textural studies were carried out to understand the mechanisms of pumice formation during this one eruptive episode.

Pumice samples were categorized into four groups based on their colour; [1] uniform pale grey, [2] brown, and [3] black pumice, and [4] banded to transitional clasts ranging from pale grey to dark brown.

Porosity (n=221) and permeability (n=83) measurements were performed on drilled cores (2.54cm x 2.54cm), often collected in two or three mutually perpendicular orientations. Vesicle textures were characterised by optical microscope and using SEM.

Bulk vesicularities (ϕ) are highest for [2] with a median of 70.7%, followed by [1] with 68.5%, [4] with 63.8%, and then [3] with 49.9%. The permeability of the Burrell Lapilli samples is generally up to 10 times higher at given porosities (e.g. $5.3 \times 10^{-11} m^2$ at →=75.1%) compared to literature data for dacitic and rhyolitic pumice compositions. In cores drilled on three mutually perpendicular directions, there was no correlation between porosity and permeability. However, in four specimens with →>60%, the highest permeability occurred with the oriented core of intermediate porosity value. This result suggests that vesicle structure is anisotropic in respect to flow path.

Long cores cut into two were analysed for reproducibility and homogeneity. The data clearly show that the four pumice types are internally homogenous with minor within-category differences in →of 0.1 – 4.0%. However, single larger pumice clasts are heterogeneous and their bulk vesicularity can vary up to 19.9% (n=6).

The bulk rock compositions of all pumice types is nearly identical, implying the difference among pumice types is solely based on physical properties. Vesicle textures reveal that type [1] pumices have thinner bubble walls and less microlites as well as heterogeneous bubble size distributions compared to type [2]. Vesicles in [2] are often deformed, presumably causing higher porosities and permeabilities due to the creation of additional apertures between neighbouring vesicles.

The development of different coloured pumice types is the result of slightly differing physical magma properties, such as temperature and viscosity, resulting in changes in vesicle texture and glass composition. This is directly controlled by syn-eruptive decompression and fragmentation processes rather than the pre-eruptive magma evolution.

Type [1] pumice represents the initial heterogeneous magma foam just prior to eruption followed by type [2] which was able to crystallise microlites due to sudden decompression and/or slower ascent rate. During magma ascent these two magma foams mingle in the conduit imperfectly due to viscosity variations, as observed in [4]. Deformation in type [2] pumices is related to higher eruption temperature, and hence lower viscosity, than type [1] pumice.

POSTER

EXPLOSIVE VS. EFFUSIVE – THE JEKYLL AND HYDE NATURE OF TARANAKI ANDESITES

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The volcanic activity at Mt. Taranaki, New Zealand is principally characterised by three end member type eruptions: [1] lava flow eruptions (effusive), [2] lava dome forming eruptions (effusive/explosive), and [3] sub-Plinian eruptions (explosive). The geological record of volcanic events at Mt. Taranaki is predominantly marked by type [1] and [2]; in the past 800 years predominantly by [2]. The transition from effusive to explosive eruption style within one eruptive event and within long term eruptive periods is still poorly known. To understand the different eruptive behaviour, petrographical and geochemical studies have been undertaken to approach this problem.

The Taranaki andesite rocks can broadly be subdivided into three categories: virtually hornblende (hbl) free rocks [1], hbl containing rocks with different degrees of hbl alteration [2], and unaltered hbl containing rocks [3]. The presence or absence of hbl in volcanic rocks is crucial in terms of water contents of the magma, which strongly influences the eruptive style.

Petrographical data, e.g. degree of alteration of hbl and groundmass glass textures, as well as geochemical data based on e.g. melt inclusions in clinopyroxene and hornblende, give rise to the conclusion that there are two end member magma compositions. We propose the existence of a dry and a wet andesitic magma. The terms dry and wet are used to illustrate whether the magma contains hbl (wet) or not (dry).

We conclude that both magmas are derived from the same initial parental melt at the base of the continental crust which then evolves differently during ascent within the crust. The two magma compositions erupt either as lava flow (dry) or pumice fall (wet), representing the effusive and explosive end members as observed on the earth's surface. Lava dome forming eruptions producing predominantly block-and-ash flow deposits represent hybrid magmas caused by mixing/mingling of dry and wet magma.

ORAL

REFLECTIONS ON DIP SLOPES AND LANDSLIDES IN NORTH-EAST MARLBOROUGH AND THE SOUTHERN ALPS

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Structure, tectonics and geomorphic expression are themes which run through the last 120 years of geologic exploration of the limestone dip slopes of north-east Marlborough. A complementary development is the gravity faulting model of topographic adjustment, which is based upon greywacke Mountains in Marlborough and the Southern Alps. This model has been perpetuated in landslide classifications and the geotechnical literature.

The magnificent dip slopes and limestone gorges of the Chalk Range and Ben More anticline evoked eloquent and passionate comments from Alexander McKay in 1885 and Charles Cotton 70 years later. In the same year (1955) Harold Wellman recognised the Nidd Landslide in limestone and flint near Whernside ridge, parallel to the Chalk Range. Since then, closer examination of the dip slopes has revealed signs of widespread instability such as fracture dilation, ravines, debris flows and screes.

Geotechnical mapping indicates that flexural toppling affects 30 of 34 discrete slope segments, the remainder being rock slides. Each failure is approximately 1 km^2. Toppling is found down to 70m deep in the cataclinal under-dip slopes in which the bedding and dominant fractures dip in the same direction as the slope but more steeply and in excess of 25^0, the apparent friction angle. Where the bedding and fractures dip less than 25^0 there is an abrupt transition to parallel dip slopes, which develop rock slides on bedding parallel crush zones. Slope failure is absent where the limestone is not closely fractured and does not contain crush zones. Recent investigations show that the original model of uniform toppling proposed for the cataclinal slopes is a simplification. Zones of chaotic slope debris intercalated with coherent but disrupted rock mass suggest partial slope collapse in tandem with toppling. Non-uniform toppling across a slope, sideways twisting of toppled masses and sector collapse of topple complexes are features of current slope failure models.

Further south in greywacke and schist some topple complexes are up to 20 km^2 in area and 2 km^3 in volume. Reverse scarps, ridge top depressions and ridge rents are linked to massive toppling of slopes, in some cases back to back. Multiple cracks, a few m wide, several tens of m long and at least a few tens of m deep testify to active spreading along the crests of ridges. The original gravity faulting mechanism of topographic adjustment proposed by Alan Beck in 1968 remains a current model in internationally accepted slope failure classification. Toppling may now be considered as an alternative mechanism and is arguably a better fit of the topographic features and structural details seen in these slopes. Toppling can also be seen as a mechanism for developing bending surfaces, which release rock slides, rock avalanches and debris flows. These slope failures feed copious quantities of sediment into streams and rivers. They start a chain of events, which transfers material from the mountains to the abyss.

ORAL

DECONVOLUTING MIXING, FRACTIONATION AND ASSIMILATION PROCESSES IN ANDESITES FROM RUAPEHU VOLCANO, NEW ZEALAND

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Andesites are now widely recognised as mixtures of crystals and melts that have experienced complex polybaric, polythermal events en route to their sites of eruption. Typical Ruapehu andesites are charged with a cargo of crystals, xenocrysts and xenoliths ranging in size from cm-scale to sub-microscopic, indicating that to varying extents the melts have interacted with and scavenged their surroundings and sources prior to eruption. Complex zoning patterns and melt and crystalline inclusions in the phenocryst/xenocryst populations attest to this complexity.

Magma batches from relatively short-lived events (months /years) can show variation that can replicate almost the complete range of compositions erupted from Ruapehu over much longer (1-10 ka) time spans. High precision trace element and Pb-Sr-Nd isotopic information and new U-Th-Ra disequilibrium data show that it is possible to distinguish between Fractional Crystallisation (FC) and Assimilation with Fractional Crystallisation (AFC) processes in small melt batches. This has important and somewhat unexpected consequences for the interpretation of

U-Th-Ra disequilibria data. In particular, it raises questions about the usefulness of geochronological interpretations of these data for andesitic volcanoes.

The 1995 – 1996 eruptions of Ruapehu were the largest and best sampled events since the dome – forming eruptions of 1945. Nonetheless, the eruptions were small in global terms (< 0.02 km^3) and entirely pyroclastic. Collectively, samples from the eruptions over the past 60 years display a spectrum of chemical compositions extending from andesite to dacite and covering much of the range shown by the prehistoric record, extending back 150 ka. The temporal variations in isotopic and trace element variation for andesites and dacites erupted between 1945 and 1996 are systematic and, in comparison with prehistoric eruptives, they provide the basis of a model for predicting future eruption patterns. The model we have developed for the Ruapehu magmatic plumbing system could also be used to design seismic experiments that might be able to image magma storages beneath the volcano, thereby providing a more precise basis for predicting future eruptions.

ORAL

FORECASTING HAZARDS FROM MOUNT TARANAKI USING TITAN2D

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Over the last c. 800 years at Mt Taranaki at least nine distinct eruption episodes occurred, all of which involved lava dome production and collapse. Each episode produced several Block-and-Ash Flows (BAFs) that were directed north-westward out of a breached crater wall. The latest dome-collapse in AD 1755 produced a deposit that covered an area of approximately 2.06×10^6 m^2 and reached up to 9.6 km from source. Future activity of this type could have a devastating effect on the Taranaki Region's communities, infrastructure and economy. For hazard planning purposes, a Volcanic Hazard map of Taranaki was created in 1996, with relative hazard zones relating to the frequency with which areas were inundated by volcanic flows in the past, with little consideration of present-day topography. If a similar sequence of events occurred today, what effect would current topography have on flow distribution? Additionally, would modelled flow inundation areas be similar to the mapped inundation zones based on past activity? A numerical geo mass-flow modelling approach is being used to answer these questions and to try constructing more-dynamic hazard maps that can take current topography into account. The Titan2D program (developed by the GMFG at SUNY Buffalo) is a "shallow water", continuum solution-based, granular-flow model. The program is adapted by the user for various flow mechanical properties by changing values for internal and basal friction as well as the dimensions of the initial pile. Before this model can be applied to Taranaki BAFs, we must evaluate the input parameters. For this we use the AD 1755 case-scenario, since initial collapse volume can be well constrained to the partially preserved summit dome. Internal and basal friction angles were evaluated through an iterative approach by broadly comparing modelled flow inundations with mapped AD 1755 BAF deposit boundaries (especially run-out). A range of possible input parameters were determined to produce a suite of potentially inundated areas under present-day terrain. This suite of around 10 forecasts from a uniformly distributed range was then analysed statistically to determine an overall map displaying relative probabilities of inundation by a future event of the same magnitude as AD 1755. Using this constrained the range of input parameters, future hazard forecasts for this scale and type of event can be undertaken using the present summit configuration, and altered to include any changes to topography in the future. This type of approach may also be adapted to developing appropriate models for other types and scales of mass flows possible on Mt Taranaki. Using this approach with outputs representing differing probabilities for each event modelled what methods can be applied to effectively and efficiently display the hazard and associated risk.

ORAL

PROGRESS REPORT: PALEOMAGNETIC ANALYSES OF KASTEN CORES FROM THE WAIPAOA BASIN, NEW ZEALAND

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U-channel samples were collected from several kasten cores in January 2005 from a research cruise (KM0502) as part of the Margins Source to Sink research programme in the Waipaoa Basin, New Zealand (http://www.margins.wustl.edu/S2S/S2S.html). Magnetic measurements of NRM intensity and direction, magnetic susceptibility (α) and treatments of AF demagnetisation, ARM and IRM have been performed. The results from these measurements are being used in studies to

determine a record of secular variation and paleointensity for New Zealand, and for an environmental magnetic study of the Waipaoa Catchment. Records of inclination of the geomagnetic field, NRM intensity and magnetic susceptibility are presented. Samples have low NRM intensities ($10^{-6} – 10^{-5}$ A/m) and similar mean destructive fields (MDF ~40mT), which indicate that the magnetic minerals have a fine grain size, are magnetically soft and easily demagnetised. IRM measurements indicate magnetite is the major magnetic mineral present in the cores. The prognosis for paleomagnetic applications to environmental and magnetic field studies is good as is the potential for the development of a high-resolution paleomagnetic age model for the cores. Samples are generally well behaved, with sufficient magnetic intensity and variations in inclination and magnetic susceptibility. NRM intensities appear to provide reliable estimates of relative paleointensity and variations in magnetic grain size, concentrations of magnetic grains and magnetic minerals are jointly indicated by α, MDF, ARM and IRM.

POSTER

THE OFFSHORE MORPHO-STRUCTURE OF THE SOUTHEASTERN VITI LEVU SEISMIC SOURCE REGION, FIJI

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SE Viti Levu is a seismically active intra-plate region of Fiji. The city of Suva (pop. ~150 000), in the SE coast of Viti Levu is vulnerable to the effects of potential offshore earthquakes and associated seismic hazards. Recently acquired SeaBat multibeam bathymetry and high resolution seismic reflection data reveals for the first time the physiography of the marginal slope of SE Viti Levu in unprecedented detail. The marginal slope is divided into five morphological domains, which are primarily influenced by the underlying geology and structure, and sedimentation from terrestrial sources. The eastern slope, an area between 178.2 and 178.4 E longitude and 18.2 and 18.4 S latitude, has had added influence from active tectonic processes and seismicity. The surface of this slope is scarred by linear submarine canyons, which are the surface expressions of faulted grabens. These submarine canyon faults extend onshore as fault valleys and structural lineaments and they collectively define continuous onshore/offshore fault zones. These fault zones form a complex network of faults, through which mesh style coseismic faulting is responsible for the diffused pattern of observed seismicity.

The submarine canyons are relict features from the Late Miocene/Early Pliocene that have developed primarily by downslope erosional processes. They have experienced several episodes of re-incision and infilling events, the latest occurring during the late Pleistocene period of lowered sea level and subsequent marine transgression. Presently, headward erosion of the canyons into the marginal shelf is occurring by seismically triggered basinward sliding of masses at the canyon heads. The head of these canyons indent the marginal shelf and they coincide with deep water passages that segment the barrier coral reefs protecting the inner lagoon and coastline. The canyon heads are positioned to act as sinks for the coastal sediment transport system. Steep slopes of the canyon heads are only marginally stable due to rapid deposition of carbonate sediments from the barrier reef fronts and outflowing lagoonal sediments through the reef passages. Slope instability is exacerbated here by slope oversteepening and undercutting by canyon currents. Submarine landslides at the canyon heads are initiated primarily by periodic short term stresses generated by earthquakes, which have induced destructive local tsunami in the past. The canyon heads, all of which are within 5 km of the coast, are potential local tsunami source areas that pose a substantial threat to the coast.

POSTER

NUMERICAL MODELLING OF SUBMARINE LANDSLIDE TSUNAMI AND THE LOCAL TSUNAMI HAZARD OF SUVA CITY, FIJI

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An important aspect of tsunami hazard assessment and mitigation is to produce predictive simulations of tsunami generation, propagation and run-up. Such simulations require accurate geological data on tsunami sources and a high quality computational grid, which is preferably based on high resolution bathymetry data. Predictive models used for simulations need to be tested and proven by running successful historical case studies. With a complete range of critical input datasets required for running predictive simulations, the coastal city of Suva in Fiji, provides a rare opportunity for assessing the tsunami hazard potential of submarine landslides. Suva City has experienced damaging historical earthquakes and associated submarine

landslide tsunami in the past. Recently acquired high resolution Reson SeaBat 8160 multi-beam bathymetry shows in unprecedented detail the locations and geometries of large slope failure scars off the coast of Suva. The destructive tsunami which followed the 1953 Suva earthquake provides a well documented account of a previous submarine landslide tsunami in the Suva area. Run-up data and arrival times from this event provide a benchmark for predictive models when creating tsunami hazard scenarios for Suva.

Using high resolution bathymetry data and historical records we define the source of the 1953 Suva tsunami as a ~3 x 10^6 m^3 submarine landslide at the head of the Suva Canyon, located 5 km SW of Suva. Geometrical parameters from this submarine landslide are used in the TOPICS/GEOWAVE tsunami initialisation and propagation model to successfully simulate observed run-ups and arrival times of the 1953 Suva tsunami at eight different locations along the coast of Suva and nearshore islands. The computational grid used in this simulation was adjusted to low tide to simulate sea level during the 1953 event.

The bathymetry data shows that the submarine landslide of 1953 is one of several failures that has occurred in this part of the Suva Canyon head in the past. These slope failures form a large retrogressive failure system that has been indenting the outer edge of the coral barrier reef. Two coral limestone boulder zones mapped on the reef crest represent tsunami deposits from the last two tsunami generating submarine landslides from this slope failure system. A set of curved fractures mapped on the barrier reef behind the headscarp of the 1953 failure is an indication of the likelihood of the next failure event and ensuing tsunami that will occur at this site. A predictive simulation of this future slope failure event was done using the source parameters similar to the 1953 landslide and with the computational grid adjusted to represent high tide, a potentially worse case scenario. The results of this simulation show maximum vertical run-up up to 4 m and maximum horizontal inundation up to 400 m at the Suva coast.

ORAL

GNS PALEONTOLOGICAL DATABASES PROGRAMME

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The New Zealand government, via FRST, recently increased available funding for designated Nationally Significant Databases and Collections, including the NZ Fossil Record File database (FRED) and the National Paleontological Collection (NPC). This has enabled GNS to set up, for the first time in the current funding regime, an explicit paleontological databases programme - formerly these activities were supported either through GNS's own resources or as small components of other FRST programmes. Aims of the new programme are to 1) develop and maintain comprehensive computer databases of fossil localities, collections, identifications, and paleontological interpretations; 2) provide easily accessible and useable database interfaces with extensive search and retrieval capabilities; and 3) attract routine participation (data provision and retrieval) by New Zealand and overseas researchers.

The NPC was initiated in 1865 by the Colonial Museum, and subsequently passed to the NZ Geological Survey and its successor, GNS. Collections represent over 55,000 localities, primarily from the NZ mainland, offshore islands, and submarine cores and dredgings from the NZ region. There are also important holdings from Antarctica and the SW Pacific, and global-scope reference collections of fossil and modern species. Collections include the gamut of animal, plant and trace fossils from Ordovician to Recent, but the main strengths are in macrofossil invertebrates, protist microfossils, and plant macrofossils and palynomorphs. Most NPC identifications are databased in FRED, but we plan to computerise physical collection records, type catalogues, etc. to streamline maintenance and extend the use of the collections. Much of the data will be publicly available online, and we also plan to make the facility and software available for use by other NZ institutions or individuals.

Over the last few years FRED has been transferred to a new database platform, with public Internet access for basic search and retrieval [http://data.gns.cri.nz/fred/]. This has been a challenging process, and further development of data entry and retrieval interfaces is planned within the new programme. New capabilities will include locality and fossil images, and sophisticated data manipulations (e.g., for research into biodiversity and statistical biostratigraphy). Following GNS-GSNZ consultation in May 2005, online registration of new localities, with continued participation of regional masterfile centres, is about to begin and this should ensure that new data is fed directly into the database. The backlog of existing locality records not yet in FRED will also be systematically entered through the new programme.

Within the programme we will also maintain and develop associated databases, such as the existing NZ Stratigraphic Lexicon [http://data.gns.cri.nz/stratlex/], and taxonomy-oriented databases such as the recently released NZ spore-pollen catalogue [http://data.gns.cri.nz/sporepollen]. Our aim is to integrate these with the NPC and FRED databases to provide a single "seamless" system.

ORAL

QMAP KAIKOURA: THE NEW 1:250 000 GEOLOGICAL MAP OF NORTHEASTERN SOUTH ISLAND

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A pre-publication version of the new 1:250 000 geological map of the Kaikoura region is presented. The map covers 18 100 km^2 of northeastern South Island, from northern Canterbury to southern Marlborough, including Kaikoura and parts of Buller and Nelson. The region straddles the Australia-Pacific plate boundary and the prominent Marlborough Fault System, incorporating the Alpine, Awatere, Clarence, and Hope faults amongst others, is a feature of the area. The map significantly refines the location of many of the known active faults and many new traces have been identified.

The basement rocks include parts of most New Zealand tectonostratigraphic terranes. North of the Alpine Fault the Buller and Takaka terranes occur in the far northwest of the map and are intruded by the granitic Karamea and Rahu suites. The Median Batholith to the east includes the mafic Rotoroa Complex and the dominantly felsic Tasman Intrusives and Separation Point Suite granite. Closer to the Alpine Fault are relatively restricted outcrops of the Brook Street and Murihiku terranes, and a wider exposure of the Dun Mountain-Maitai and Caples terranes. Southeast of the Alpine Fault, the Torlesse composite terrane dominates the map sheet area comprising greywacke of Rakaia and Pahau terranes in the west and east respectively. The Rakaia rocks of Triassic age are increasingly metamorphosed towards the west, up to greenschist facies, textural zone III schist near the fault. The weakly metamorphosed Late Jurassic-Early Cretaceous Pahau terrane greywacke is generally less structurally deformed than the Rakaia terrane apart from several zones of melange and broken formation. One of these, the Esk Head belt, occurs at the western edge of the Pahau terrane and is structurally discordant to the Rakaia terrane. The Esk Head belt also contains large areas of poorly bedded and structurally discontinuous sandstone.

The Late Cretaceous and Tertiary rocks of the region have been unified under a simplified stratigraphic schema using existing, established names. Where space on the map permits, local stratigraphic detail has been preserved to reflect the diversity of multiple depositional basins, particularly for the Late Cretaceous and Miocene rocks. These rocks are predominantly of marine origin but locally significant terrestrial and volcanic rocks occur. Igneous rocks are relatively abundant in the east of the map area. The most conspicuous of these is the Tapuaenuku Igneous Complex, a discrete mafic igneous pluton which intrudes Pahau terrane and is accompanied by an extensive, largely radial dike swarm. Time transgressive units such as the Amuri Limestone are another feature of the sheet.

Glacial till and associated outwash gravel in alluvial terraces dominate the widespread Quaternary deposits of the region. Scree, rock glacier and alluvial fan deposits are common in the mountains and raised interglacial beach deposits adjacent to the coast reflect Late Quaternary uplift. Many lakes in the region are dammed by landslide deposits, most of which are attributed to strong earthquake shaking.

POSTER

SOME LIKE IT HOT! CORE COMPLEX FORMATION IN THE CENTRAL AEGEAN SEA, GREECE, AND POSSIBLE IMPLICATIONS FOR THE PAPAROA CORE COMPLEX IN BULLER, SOUTH ISLAND, NEW ZEALAND

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Continental extension is very differently expressed and varies from rifting with little extension resolved on slowly displacing high-angle faults through core-complex forma-tion, which in extreme cases may accommodate more than 100 km of displacement with slip rates >10 km/Myr on the master fault. Numerical simulations suggest that the viscosity of the lower crust plays a fundamental role in the mode of continental exten-sion (Wijns et al. 2005). A high viscosity lower crust (and thus a small viscosity con-trast between the ductile lower and the brittle upper crust) during extension favours rift development. A lower strength of the lower crust, due to a low viscosity, favours a core complex mode of continental extension. Within the

core complex mode, temperature driven viscosity variations can determine whether the lower crust flows in a distributed manner or localisation occurs. This may allow a distinction between ‘cold’ or ‘strong’ core complexes and ‘hot’ or ‘weak’ core complexes. The latter develop when the lower crust has a markedly low viscosity. Hot core complexes in numerical simulations are characterized by large-scale normal faults with great slip and cooling rates and the de-velopment of an overall symmetric geometry expressed by a relatively late, secondary ductile shear zone with an antithetic movement sense caused by symmetric, plume-like extrusion of the hot and weak lower crust. In nature, hot core complexes may be ex-pressed by extension-related migmatite domes in their footwalls. Most core complexes worldwide appear to belong to the monovergent cold case. We report on a hot core complex exposed on the islands of Naxos and Ios in the Aegean Sea.

The Aegean Sea is an example of ongoing continental extension and core complex formation caused by the retreating Hellenic subduction zone. The extension-related migmatite dome on Naxos Island is characterized by cooling rates >100°C/Myr. Low-temperature thermochronology reveals great slip rates of ~10 km/Myr associated with the top-N Naxos detachment, which is the major detachment of the hot core complex. The secondary, antihtetic top-S normal fault is exposed on Ios Island some 40 km south of Naxos. Age data suggest that the top-S shear zone on Ios formed ~2-5 Myr after the Naxos detachment. These data are consistent with the numerical simulations of hot core complexes. Exhumation of hot footwall material on Ios did not expose magmatites but triggered anatexis in the lower crust producing syn-extensional S-type granites in the footwall. Naxos and Ios are presently situated in a central position above the retreating Hellenic subduction zone. We argue that asthenospheric flow associated with subduc-tion-zone retreat caused increased heat input in the center of the region affected by sub-duction-zone retreat causing the anomalous hot conditions on Naxos and Ios.

The Paparoa core complex in Buller, South Island, is a symmetric core complex (Tulloch & Kimbrough 1989) suggesting it fits the hot core complex case. High cooling rates of the Buckland granite in the footwall of the Paparoa core complex (Spell et al. 2000) are in line with this interpretation. In addition, the Paparoa core complex should have detachments with slightly different ages, with large displacements and high slip rates. Furthermore, high-grade rocks should occur in the footwall (White et al. 1994) and their peak metamorphism should be of Late Cretaceous age.

ORAL

PALAEOMAGNETISM OF VOLCANIC ROCKS IN WAITAKERE AND COROMANDEL, AND MIOCENE RECONSTRUCTION OF NEW ZEALAND

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Samples from 8 sites in the Waitakere Group, located to the west of Auckland, and 8 sites in the Coromandel Group in the Coromandel Peninsula have been studied palaeomagnetically using complete progressive af demagnetisation. The two Groups lie on opposite limbs of a gentle anticline, and the respective formation mean palaeofield directions become more consistent after unfolding is carried out on a regional basis. After unfolding, the palaeofield directions are 346.9°, -62.1°, 26.7° (as declination, inclination and $\alpha 95$) for the Waitakere Group and 347.5°, -57.9°, 14.1° for the Coromandel Group. Comparison of these results with palaeomagnetic data for other parts of New Zealand indicates that, relative to the southeast South Island and Chatham Rise, the Northern North Island has migrated northwards by an amount in the order of 1000 km and rotated by some 12° anticlockwise and since Miocene time. This is consistent with large scale dextral displacement of the Alpine Fault, compression in the Southern Alps and dilatation in the North Island. Anomalous clockwise rotation in the order of 15° to 45° which has been reported for the eastern North Island and Marlborough is attributable to dextral shear deformation in a zone incorporating the Hikurangi Trench system and likely extensions of the Alpine Fault.

ORAL

GEOCHEMICAL ASPECTS OF THE COROMANDEL VOLCANIC ZONE: TRACE ELEMENT AND RARE EARTH ELEMENT DATA

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Late Cenozoic volcanic activity in the North Island of New Zealand has been attributed to a series of volcanic arcs following the movement of the subduction zone boundary between the Pacific and Indo-Australian plates. The Coromandel Volcanic Zone (CVZ) is one such volcanic arc active from 18

Ma to 1.9 Ma that encompasses Coromandel Peninsula, the Kaimai ranges, Great Barrier Island, and the offshore islands east of the peninsula (except Mayor Island).

Volcanic rocks in the CVZ range from basalts, basaltic andesites, andesites, dacites, to rhyolites. Volcanic activity was initiated about 18 Ma along the western Coromandel Peninsula and Great Barrier Island, and involved basaltic-andesite, andesite, and dacite cone volcanism which built up a large portion of the peninsula. This phase of activity lasted until about 12 Ma, when eruptions shifted eastwards and changed to more silicic caldera-forming volcanism that continued until 1.9 Ma as arc volcanism moved from the CVZ to the active Taupo Volcanic Zone (TVZ).

Geochemical analyses of a representative suite of rocks from the CVZ by XRF (at the University of Waikato) and ICP-MS (at the University of Texas as Dallas) show that there is a continuous spectrum of compositions in CVZ. They have similar major and trace element compositions to TVZ, apart from the high-K rhyolites (up to 5.5 wt % K_2O) which are common as sanidine-bearing rhyolites in the CVZ, but rare in the TVZ. REE patterns in CVZ andesites and rhyolites have moderate slopes (La_N/ Yb_N average 4 to 8) and moderate Eu anomalies (Eu/Eu* average 0.6 to 0.95). The general geochemical similarities between CVZ and TVZ suggest that they had similar petrogeneses, with the difference that there is a greater proportion of mafic magma in CVZ.

ORAL

FACTORS INFLUENCING THE DISTRIBUTION OF SUBANTARCTIC DEEP-SEA BENTHIC FORAMINIFERA, SOUTH-EAST OF NEW ZEALAND

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In this study we investigate the combination of environmental factors that influence the distribution patterns of benthic foraminiferal tests (>0.63 μm) in a topographically varied region crossed by both the Subtropical and Subantarctic Fronts, south-east of New Zealand. Seafloor sample sites extend from outer shelf (50 m) to abyssal (5000 m) depths, are bathed by five different water masses, and receive phytodetritus from Subtropical, Subantarctic and Circumpolar surface water masses.

Eight mappable benthic foraminiferal associations are recognised by Q-mode cluster analysis of the census data (>63 →m, 214 species, 68 samples). Canonical correspondence analysis and a correlation coefficient matrix were used to relate the faunal data to a set of environmental proxies. These show that factors related to water depth (especially decreasing food supply with increasing depth) are the most significant in determining the overall foraminiferal distribution. Other contributing factors include surface water productivity and its seasonality, bottom water ventilation, energetic state of the benthic boundary layer and resulting substrate texture, and bottom water carbonate corrosiveness.

Three shallow-water associations (50-700 m), dominated by *Cassidulina carinata, Trifarina angulosa, Globocassidulina canalisuturata, Gavelinopsis praegeri*, and *Bolivina robusta*, occur in coarse substrates on the continental shelf and on the crests and upper slopes of four seamounts under well-oxygenated, high energy regimes, and high food input. Three mid-bathyal to upper abyssal associations (500-3300 m), dominated by *Alabaminella weddellensis, C. carinata*, and *Epistominella exigua*, occur in biopelagic sandy mud, beneath a region of strongly seasonal food supply, with composition influenced by total food flux, ventilation (Oxygen Minimum Zone), and bottom current strength. An unusual lower bathyal association (1200-2100 m), dominated by *T. angulosa* and *Ehrenbergina glabra*, occurs in a belt of coarser sandy substrates that runs along the crest of the submarine plateaux slopes beneath the strongly flowing Subantarctic Front. A deep abyssal association (3500-5000 m), dominated by *Epistominella umbonifera* and *Globocassidulina subglobosa*, occurs on the abyssal plain beneath oligotrophic Circumpolar Water south-east of the Subantarctic Front, and is strongly influenced by cold, carbonate-corrosive, lower Circum-polar Deep Water.

ORAL

PROVENANCE OF DEVONIAN BEACON SUPERGROUP SEDIMENTS IN SOUTHERN VICTORIA LAND, ANTARCTICA

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Conglomerate beds in the basal part of the Devonian Taylor Group (Beacon Supergroup) in southern Victoria Land provide valuable evidence of provenance and palaeoenvironment. The conglomerates occur within the Sperm Bluff Formation, a unit that overlies an unconformity truncating three plutonic suites of the Cambrian Granite Harbour Intrusives (Dry Valley 1a & 1b, and DV 2) and their metamorphic country rocks.

Provenance analysis was carried out on both sandstones and conglomerates using clast counts, petrographic analysis and U–Pb detrital zircon analysis. Conglomerates are dominated by silicic igneous clasts, mainly rhyolites, and fine-grained quartzites, both of which are unknown in outcrop in southern Victoria Land. Previously recorded granitoid clasts could not be found.

Rhyolite clasts have a geochemistry typical of highly evolved subduction-related rocks. Previous workers have dated rhyolite and tuff clasts at between 497±17 Ma and 492±8 Ma, ages that are within error of the Granite Harbour magmatic suites. This suggests that the volcanic clasts came from a co-magmatic volcanic arc rather than a northern Victoria Land source as tentatively proposed by earlier workers. Detrital zircon U–Pb ages for the quartzite clasts suggest derivation from the East Antarctic craton and that the sandstones had been deposited before the Ross/Delamarian Orogeny.

Sandstones in the Sperm Bluff Formation are arkosic to quartzose in composition but conspicuously lack plagioclase, indicating significant weathering of a continental source. Detrital zircon analysis gives a strong 500 Ma peak characteristic of Ross/Delamarian orogen magmatic rocks, and consistent with a local source.

Basin analysis of the six lithofacies comprising the Sperm Bluff Formation suggest foreshore–shoreface, shallow marine, estuarine and wave-dominated deltaic environments. A large delta, or fan-delta, composed partially of easterly-derived conglomerates, as indicated by palaeocurrent directions and channel orientation where the conglomerates are thickest, became buried by marine sandstones during a relative rise in sea level. The presence of pre-Ross quartzite clasts suggests that older continental rocks existed to the east.

Westward subduction during the Late Cambrian led to the emplacement of the Granite Harbour Intrusives and their superstructure of rhyolitic volcanoes (DV 1). Dry Valley Suite 2 intrusive rocks and associated volcanic rocks were probably emplaced slightly later in a downfaulted extensional intra-arc basin. This had the effect of preserving the volcanic superstructure in the downfaulted block while the volcanic rocks were being eroded from the upfaulted block to expose the much deeper Granite Harbour Intrusives. Basin inversion during the Devonian caused uplift of the preserved volcanic rocks, supplying rhyolitic and older quartzite clasts to the lower part of the new Beacon Supergroup basin. The basin inversion may have been a far-field effect of tectonic changes indicated by widespread mid-Devonian deformation (Tabberabberan Orogeny) and subsequent granite magmatism in Australia, New Zealand, northern Victoria Land and West Antarctica.

POSTER

LATE CRETACEOUS EUSTASY AND THE EAST COAST BASIN - THE BAD NEWS!

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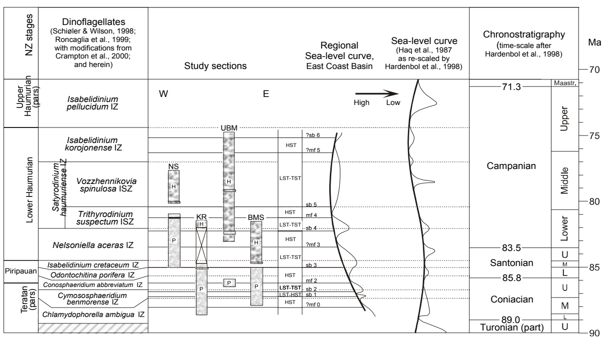
A palynofacies analysis of four sections through the Paton and Herring Formations of the East Coast Basin in southern Marlborough shows that the two formations were deposited in a marine environment with conspicuous input of plant material from adjacent land area. The Paton Formation was deposited on the inner to mid-shelf under oxic conditions and in proximity to a river delta. The deposition of the Herring Formation took place farther offshore, on the mid-shelf, in a mud-dominated environment under poorly oxygenated conditions at the sediment/water interface, following a landward shift of shoreline. A stratigraphic analysis of changes in palynofacies and lithology through the four sections allows a breakdown of the succession into seven depositional sequences, separated by unconformities or their correlative conformities. A regional sea-level curve for the Middle Coniacian–Upper Campanian in the East Coast Basin is proposed on the basis of the inferred sequences and chronostratigraphic control from dinoflagellate biostratigraphy. The sea-level cycles thus inferred for the East Coast Basin show a poor correlation with the re-scaled Haq cycle chart, suggesting that regional tectonics rather than eustasy controlled the East Coast Basin sequences.



Inferred regional sea-level curve for the East Coast Basin. Section abbreviations are: BMS=Ben More Stream tributary; KR= Kekerengu River, headwaters; NS=Nidd Stream; UBM=Ben More Stream, upper reaches. H=Herring Formation, P=Paton Formation, HST=highstand systems tract, LST= lowstand systems tract, TST=transgressive systems tract, mf=maximum flooding, sb=sequence boundary.

ORAL

PETROLOGY AND TECTONICS OF EASTERN FIORDLAND: SOME EARLY RESULTS

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The paleo-Pacific arc margin to Gondwana records a dynamic (500-100 Ma) history of regional plutonism, metamorphism and tectonic activity. The behaviour and timing of these events, however, remains poorly understood. From Eastern Fiordland, New Zealand, we present some early findings of an investigation into the Paleozoic and Mesozoic evolution of this arc, and in particular structures exposed in the Manapouri region that might clarify a complex period of Early Cretaceous tectonism.

The Grebe Shear Zone (GSZ) is a several hundred metres wide, steeply dipping, ductile, shear zone extending from south of Lake Hauroko at least 70km to Lake Manapouri, Fiordland. Mapping, geochemistry and petrography indicate that it forms a significant Cretaceous tectonic suture. Volcanogenic metasediments of the Jurassic Loch Burn Formation, and Paleozoic to Mesozoic diorite, gabbronorite and hypersolvus granite, crop out to the east of the GSZ. Early Paleozoic(?) psammitic and calc-silicate metasediments intruded by weakly deformed monzonites occur directly to the west.

During deformation, strain was largely partitioned into ~Late Jurassic- Early Cretaceous granitic bodies. Rotated K-feldspar porphyroclasts suggest sinistral oblique slip (lineations plunge ~45° southwards). Massive granites, of similar appearance and composition to the Early Cretaceous Separation Point Suite, cut the GSZ mylonitic fabric. Dating of these post-GSZ granitoids is in progress.

Moderately dipping (~30°) Tertiary unconformities on the eastern and southern limits of Fiordland suggest that the margins of the Fiordland block have been rotated from the horizontal since the Cretaceous. The extent of rotation in Central Fiordland is unknown, but is of fundamental importance to this study because two scenarios are implied. These are (1) with no block rotation the GSZ may have been an Early Cretaceous, ~vertical, oblique slip fault, active along the margin of Central Fiordland, or (2) back-rotating unconformities closest to the GSZ requires that in pre-Tertiary time the GSZ dipped (present-day) to the east, and therefore may have faulted Eastern Fiordland over Central Fiordland during the Early Cretaceous.

ORAL

MARINE TEPHROSTRATIGRAPHY, NORTHERN NEW ZEALAND: IMPLICATIONS FOR TAUPO VOLCANIC ZONE, MAYOR ISLAND AND WHITE ISLAND VOLCANOES

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Twenty piston cores were collected from depths of 600-3000 m from offshore of northern North Island, New Zealand. They contain tephra from 11 Okataina Volcanic Centre and 4 Taupo Volcanic Centre rhyolite eruptions during the last ~50 kyr that produce a tephrostratigraphic framework across a tectonically and volcanically complex region of southern Havre Trough, Alderman Trough and the Bay of Plenty continental shelf. This allows on-shore to off-shore correlations up to 200 km from source volcanoes, covering much of marine isotope stages 3 and 2. The framework temporally constrains poorly dated and newly recognised volcanic events. Macroscopic tephra layers from the peralkaline Mayor Island volcano are documented for the first time at pre-50 ka, post-50 ka, 39.6 ka, 36.3 ka, 21 ka, and 14.2 ka, in addition to the known 7 ka event. These represent some of the most explosive events from this volcano, and provide new marker horizons. They are dispersed up to 90 km north-east to east of the edifice. The tephra contain high SiO_2 (73-75.5 wt %) glass and subordinate basaltic components, and each represents a distinct magma batch that can be fingerprinted. They form two temporal trends toward less evolved magma compositions, punctuated by a large caldera-forming event at 36 ka. Minor tephra dispersal is also recorded at 17.7 ka, 25 ka, 35 ka and pre-50 ka. The historically active, andesitic White Island volcano has not widely dispersed tephra, and the oldest primary deposit found is ~20 ka. Five pre-50 ka rhyolite eruptions from an unknown Taupo Volcanic Zone source provide evidence for explosive activity in a time interval poorly documented on-land. The cores demonstrate the patchy and uneven preservation of large magnitude tephra falls caused by local bioturbation and ponding in bathymetrically complex regions. Reworked tephra layers are common and often lack indicative lithological features. Such units could easily be misinterpreted as primary events without micro-beam geochemical analyses of glass shards.

POSTER

3-D STRUCTURAL PERMEABILITY IN CONTRACTIONAL SETTINGS

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Fluid flow in the Earth's crust is influenced by anisotropic permeability as well as by hydraulic gradients in the crust. 2-D modelling of flow systems based on cross-sections drawn perpendicular to the strike of orogenic belts can be misleading when considering fluid redistribution during contractional orogenesis, because of the tendency to think of flow as restricted to the plane of the section. Topographically driven flow and flow in overpressured systems may both be affected by directional permeability parallel to strike. Bedding anisotropy and other forms of primary rock layering combine with stress/strain-controlled structural permeability, embracing systems of faults and fractures as well as fold closures, foliations, etc. In simple fold-thrust belts associated with accretionary prisms, collisional, and compressional inversion orogens, structural permeability is dominated by fold hinges and duplex structures, plus fault-fracture intersections aligned parallel to strike. In both active and ancient fold-belts, evidence exists for high levels of hydraulic communication extending along fold hingelines for kilometres to tens of kilometres along strike. Where convergence varies along contractional orogenic belts, fluid may thus be expelled laterally along this directional permeability from the regions of most intense shortening. The volume of fluid passing through a cross-strike section is then likely to be far greater than that inferred from considering fluid redistribution restricted to the plane of the section. Along the New Zealand plate boundary, 3-D structural permeability affecting fluid redistribution seems likely to be especially important within the dewatering accretionary prism of the Hikurangi Margin, and in areas of active compressional inversion (e.g. NW Nelson - Taranaki Basin).

ORAL

ACTIVE CRUSTAL FLUID FLOW AROUND THE NEW ZEALAND PLATE BOUNDARY – A RESEARCH FOCUS FOR THE 21ST CENTURY

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Crustal-scale fluid flow is a frontier area in Earth Science, critically relevant to exploration for, and future exploitation of, energy and mineral resources (oil, gas, geothermal power, hydrothermal mineral deposits). The New Zealand plate boundary (NZPB) is a geochemical factory where the interplay of tectonic and magmatic processes promotes fluid redistribution between the atmosphere, continental and oceanic rock assemblages, the ocean water mass, and the deep Earth. The diverse character of the boundary, comprising opposite-facing subduction zones along the Hikurangi and Fiordland Margins linked by an imperfect transform fault system, gives rise to an array of sites where aqueous and hydrocarbon fluids are being actively redistributed within the crust. These include:

i. active hydrothermal circulation coupled to magmatism in the Taupo Volcanic Zone (TVZ) (and its northeastward continuation along the Lau-Havre Trough);
ii. zones of sediment compaction and compressional 'squeegee' deformation with associated fluid loss along the Hikurangi and Fiordland subduction interfaces;
iii. areas of ongoing compressional inversion associated with hydrocarbon migration in the Taranaki Basin and in the northwestern and southern South Island; and
iv. topography-driven flow in the uplifted Southern Alps and other mountain ranges flanking the linking transform fault system, and around major volcanic edifices. Fluid redistribution is variously driven by topographic relief and precipitation, upwelling mantle and magmatic intrusion leading to convective circulation of hydrothermal fluids, compaction, deformation, and metamorphic dehydration of thick sedimentary sequences, and changes in the regional stress state. While flow in near-surface systems typically occurs under near-hydrostatic fluid pressure (the 'normal state'), fluids at depth may be structurally compartmentalised and overpressured well above hydrostatic values.

Flow systems are influenced by structural permeability and modulated by stress cycling which accompanies intermittent rupturing on faults, with coupled changes in fault-fracture permeability.

The NZPB thus provides a world-class natural laboratory where dynamic flow systems are accessible to investigation by geological, geochemical and geophysical techniques, both onshore and offshore, and by numerical modelling. Questions to be addressed for each of the tectonic domains include the fluid sources, the rates of flow, the degree of water–rock interaction along flow paths, the influence of structural permeability on fluid redistribution, and the total fluid budget. A Discussion Meeting and Workshop is proposed for late 2006, hosted by GNS Science at Avalon in Lower Hutt, to evaluate our present state of knowledge, define areas for future research, and devise research strategies to enhance understanding in this field of ever-increasing importance.

ORAL

SILICIC MAGMAS IN SUBDUCTION SYSTEMS

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A widely accepted paradigm is that continental crust is exclusively generated in continental subduction systems where large volume silicic magmas are produced by crustal anatexis. However, work in oceanic arcs suggests that this general conception is not valid. Although oceanic subduction systems mainly produce magma ranging from basaltic to basaltic andesite, silicic magmas can be locally abundant. For example, a feature of the Tonga-Kermadec oceanic arc is the abundance of silicic compositions typically associated with calderas comparable in scale to those of continental settings. In the thermal evolution of an oceanic arc system the processes of underplating, together with the continuous magmatic (and thermal) flux, can generate a crustal thickness in which dehydration melting of under plated arc material generates felsic magmas.

Oceanic arcs evolve through the following four stages:

1. Generation of subduction-related basaltic magmas initiates a volcanic system on oceanic crust. Under-plating magmas cool and crystallize and hydrothermal convection develops through the lower crust. At the top of the system relatively fractionated magmas begin to build a volcanic edifice.
2. During arc infancy (0.5-1.0 my) heat is transferred by convection to the lower arc crust. Hydration of crust through reaction of pyroxene $\pm$ olivine –bearing lithologies with hydrous fluids produces amphibole. Surficial eruption continues with eruption of basalt-andesite magmas.
3. A stage of arc adolescence (1-2 Ma) commences as the temperature of a significant volume of lower crust approaches the amphibole-saturated solidus at 850-950^{o}C. Dehydration melting fluxes the crust and melt volumes of a few km^3 to tens of km^3 are rapidly generated. A 20-30% melt fraction segregates from a granulitic residue and ascends to upper levels in the system. Triggering mechanisms include episodic transfer of extensional strain into the crust or a pulse of magma associated with a major recharge event. Felsic magmatic eruptive activity may be interspersed with continuing basaltic-andesitic activity.
4. Arc maturity (>3 Ma) sees a continuation of basaltic to andesitic activity. The lower crust having undergone dehydration melting is now anhydrous granulite significantly below its solidus temperature and it acts as a thermal insulator preventing convection of hydrothermal fluids. Further anatexis can only occur if appropriate source materials remain to participate in the hydration-dehydration cycle.

Work in andesitic volcanic systems shows that the composition of erupted magmas varies systematically with time a feature that is interpreted as increasing involvement of a crustal component as the isotherm rises in response to magmatic flux. By analogy with the proposed model for oceanic arcs rhyolitic magmatic systems in continental, subduction linked settings represent the end member state of this evolutionary spectrum of petrological processes where the crustal component has come to dominate.

ORAL

TRENDS IN RHYOLITE GEOCHEMISTRY, MINERALOGY, AND MAGMA STORAGE DURING THE LAST 50 KYR AT OKATAINA AND TAUPO VOLCANIC CENTRES

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During the past 50 kyr, rhyolitic volcanism at OVC and TVC caldera centres has been more frequent and voluminous than at any on Earth. The high frequency of episodes appears to reflect the thin crust, high heat flow, and active tectonic regime of the central North Island, New Zealand. The two contemporaneously active calderas, OVC and TVC, that have been active in the last 50 kyr display contrasting volcanic and magmatic histories. Following the last caldera-forming episode at ~50 ka (Rotoiti) from OVC, intra-caldera episodes have tapped progressively more evolved (~71- 77 wt % SiO_2), shallower (>400- 150 MPa), and cooler (940 -730°C) magmas. Directly following the caldera-forming episode, eruptions were rhyodacites and derived from deep, hot magmas, containing clinopyroxene. The most recent OVC eruption episodes (post-26.5 ka) were from shallow, cool magmas, and are dominated by hydrous mineral phases. In general, the frequency of episodes has decreased and volume of eruptions appear to have increased over time at OVC. At TVC, pre-26.5 ka eruption episodes were relatively infrequent, and were derived from shallow (~100 MPa), cool (~750°C) magmas, containing hydrous mineral phases. After the caldera-forming 26.5 ka Oruanui episode at TVC, initial eruption episodes were dacitic, infrequent, and derived from small volume, hot (>900°C), and possibly deep (~400 MPa) magmas. At 12 ka TVC rhyolitic activity re-commenced, episodes since have been more frequent, hotter (~790 -850°C) and it is likely that they progressively tapped deeper (~140 -300 MPa) magmas. Following caldera-formation, erupted magmas at both OVC and TVC were the least evolved, hottest (>900°C), and were likely from deep (~400 MPa) chambers. This suggests that these magmas rose rapidly after formation and exploited new conduits generated during the caldera collapse.

POSTER

VOLATILE AND TRACE ELEMENT CONCENTRATIONS IN MELT INCLUSIONS AND MATRIX GLASSES FROM POST-25 KA TARAWERA RHYOLITES, OKATAINA VOLCANIC CENTRE

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Three of the four rhyolitic episodes (21.4 ka Okareka, 17.7 ka Rerewhakaaitu, 13.8 ka Waiohau, and ~AD1315 Kaharoa) from Tarawera in the last 25 kyr have each tapped two or more rhyolite magmas. The relationships and properties of all these Tarawera rhyolites are being examined by ion-microprobe analyses (at University of Edinburgh) of the volatile contents and trace element compositions of quartz-hosted melt inclusions and their associated matrix glasses. The melt inclusions provide information on dissolved volatile concentrations, minimum pressures of crystallisation, and degassing processes in the pre-eruption magmas. The trace-element compositions of the inclusions and matrix melt can reveal magma variation and mixing processes. Very little was previously known about volatile abundances and trace elements in the melt phases of Okataina rhyolites.

More than 70 melt inclusions (>20 μm) have been analysed in this study. Volatile contents vary significantly between and within the magmas; the wide ranges indicating that inclusions were trapped at different stages of degassing-induced crystallisation. H_2O contents range from 0.7 to 5.4 wt %, and CO_2 concentrations between 30-660 ppm. Most of the CO_2 variation is seen between magmas, with typical variation within a magma <150 ppm. All the inclusions were trapped at pressures equivalent to depths <8 km, with most at about 4 km. These pressures agree with crystallisation closure pressures estimated by projecting matrix glass compositions onto a synthetic Qz-Al-Or-H_2O system. Li concentration correlates positively with H_2O, which suggests it was being partitioned into the vapour phase and lost from the melt during degassing. It appears that most of the Tarawera rhyolite magmas experienced a combination of open and closed system degassing.

Major element compositions of Tarawera rhyolite melts (determined by electron-microprobe at University of Auckland) are usually similar between inclusions and their associated matrix glasses. However, the trace element concentrations (by ion-microprobe) vary between the melt inclusions and matrix glasses, the amount of variation is different in each magma. Variations in ratios of incompatible trace elements (e.g. Nb/La) in the melt inclusions of some Tarawera magmas suggests that the trace-element variation is not just a function of crystallisation, and that some mixing of magmas must have occurred.

ORAL

GEOTECHNICAL INVESTIGATIONS AND GROUNDWATER MONITORING FOR WELLINGTON INNER CITY BYPASS

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The Wellington Inner City Bypass project involves developing an arterial route from the existing

Terrace Tunnel South Portal to the Basin Reserve, in Wellington City. The bypass is predominately at street level, but a section of the northbound lanes from Willis Street / Abel Smith Street intersection to Ghuznee Street involves construction of a depressed two-lane road. Opus International Consultants is Transit's consultants for this project from its inception to detailed design and currently construction management, and has developed innovative approaches to resolve the geotechnical challenges.

The depressed section will pass under a new bridge at Vivian Street and will require extensive retaining structures. The innovative trench design incorporates a propped reinforced trough structure and 200 m long soil nail retaining walls between the Terrace Tunnel portal and Abel Smith Street. The up to 7 m high soil nail walls are supported by a total length of about 7000 m of soil nails. This will be the largest soil nail wall in New Zealand.

Extensive geotechnical site investigations have been carried out to determine ground and groundwater conditions in the vicinity of the bypass route, particularly where the proposed road will be depressed below existing ground level, and adjacent to existing buildings. In the propped wall section, groundwater levels will be temporarily lowered during construction, then allowed to recharge. In the soil nail sections, groundwater levels will be permanently lowered. During construction a limited amount of excavation will be opened at any one time to minimise the amount of drawdown in groundwater levels. Artesian pressure relief wells are being drilled into bedrock to relieve groundwater pressures are underway. Building condition surveys, before during and after the construction are being undertaken.

A programme was developed to monitor the groundwater, ground deformation, and subsidence. Instrumentation comprises of piezometers, inclinometers and settlement stations which were installed prior to commencement of excavation. Multiple piezometers were installed in many of the boreholes to record and monitor the groundwater levels in different aquifers. Over 90 vibrating wire and standpipe piezometer combinations were installed in 41 different boreholes throughout the Wellington Inner City Bypass area, measuring a number of different aquifers. Vibrating wire piezometers were used at locations important for construction monitoring, as they respond more quickly to groundwater level changes that may occur during construction, especially in the bedrock aquifer that will be drawn down during construction of the walls.

The piezometers were installed in a number of site investigation stages. All 41 piezometer sets will be monitored regularly throughout the Wellington Inner City Bypass construction, a difficult undertaking in a dynamic urban environment, with traffic, vandalism, road maintenance, and urban development making continued monitoring challenging work.

POSTER

TRANSITION FROM SOFT-SEDIMENT TO WEAK ROCK DEFORMATION IN TURBIDITES OF THE MIOCENE WAITEMATA PIGGY-BACK BASIN, NORTHERN NEW ZEALAND

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The well known, spectacular shore platform and cliff exposures of the Miocene Waitemata Group on eastern Whangaparaoa Peninsula 50 km north of Auckland provide a world-class example of weak rock deformation, the neglected domain between soft-sediment and hard rock deformation. As a new convergent plate boundary propagated southwards through northern New Zealand in the Late Oligocene, the Northland Allochthon was emplaced. The allochthon subsequently formed a mobile base for the Waitemata piggy-back basin, resulting in a complex interaction between tectonic and gravity-driven shallow deformation. Quartz-poor clastic sequences of the Waitemata Group at Whangaparaoa display a protracted sequence of deformations: D1, syn-sedimentary slumping at the top of the sedimentary sequence and including seismites; D2, large scale deeper-seated sliding and extensional low-angle shearing, associated with generation of boudinage and broken formation; D3, contractional shearing at low angle to bedding associated with thrust faults and inclined folds, indicating transport mostly to the SE; D4, thrusting and folding in the opposite direction; D5, further folding including sinistral shear; D6, steep faults. The deformation sequence suggests continuous or intermittent southeast-ward transport of units with increasing sedimentary and structural burial. Phase D3 boudinage and broken formation are localised and, with a few exceptions, occurred by brittle deformation. Subsequent folds show little variation in bedding thickness around their hinges. By phase D3, the rocks had therefore passed from the soft-sediment state to low levels of consolidation. However, with a compressive strength of ~5 MPa they are weak rocks even today. These deformations, although more intensive than elsewhere, are typical for the entire Waitemata basin. Such weak-rock deformation must be important in other sedimentary basins, especially in those associated with active convergent plate boundaries and with immature source areas for their sediments.

ORAL

GEOPHYSICAL EXPLORATION OF THE ALPINE FAULT ZONE AND EVIDENCE FOR HIGH FLUID PRESSURE

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A fresh look at the problem of sustaining fluid pressures in active fault zones can be obtained by studying a major continental transform other than the San Andreas Fault. The Alpine Fault (AF) of central South Island is one such example. From a global perspective the AF is unusual as it is a continental transform where both strike-slip (~ 35 mm/y) and dip slip (~10 mm/y) movement take place on the same fault plane. Moreover, geophysical evidence shows this fault plane dips at 40 to 60^o from the Earth's surface down to a depth of at least 30 km where it soles out into what we interpret to be a decollement surface. Detailed analysis of seismic travel time anomalies and seismic reflection amplitudes show that above the dipping fault-plane is a banana-shaped region where seismic P-wave velocities are reduced by 6-10%. This low-velocity region has dimensions of roughly 20 x 40 km with the shallowest and deepest points being at ~ 8 and 35 km, respectively. A magnetotelluric study shows a low electrical resistivity zone in the crust that correlates closely with the region of low seismic velocities. Interconnected water at, or close to, lithostatic pressure is the physical condition that would give rise to both the low resistivity and low P-wave velocities. Corroborative geological evidence for high fluid pressures can be seen in the form of young, undeformed, quartz veins that are within freshly exhumed crust east of the surface exposure of the Alpine fault. The question then arises: how are high fluid pressures contained in the fault zone? A simple answer is that fluid is supplied to the root of the fault zone at a rate that is higher than it can be removed via porous flow through the crust. Greywacke-schist rocks that are transported into the fault zone are thickened as they travel down a decollement surface; this surface has been partially imaged with seismic reflection methods. As the crustal rocks are thickened water will be released (zeolite → amphibolite prograde metamorphism) at an estimated rate of 0.15 % wt per km of burial. On the basis of our seismic crustal structure models, and assuming a regular continental permeability of 10^{-17} m^2, we calculate that water is supplied to the root of the Alpine fault zone at a rate that is about 40 times greater than it can bleed off through crust of regular permeability.

For the majority of plate motion to be carried on a single inclined fault plane the fault itself is likely to be weak or of low friction. Most continental transforms with a component of convergence partition motion into a vertical strike slip fault and distributed thrust faults. Southern California is an example. We therefore argue that it is high fluid pressure, due largely to fluid-release from prograde metamorphism that reduces effective normal stresses in the Alpine fault zone. And it is possibly this reduction in normal stresses that allows plate motion to focus on a single inclined plane. In light of recently published findings of periodic slip and "slow" seismic tremor associated with fluid-saturated parts of other plate boundaries, it seems important to undertake long-term seismic and GPS monitoring of the central section of the Alpine Fault.

ORAL

SEISMIC HAZARD ANALYSIS IN NEW ZEALAND DURING THE LIFETIME OF THE GEOLOGICAL SOCIETY

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New Zealand sits astride the boundary of the Australian and Pacific Plates, where relative plate motion is expressed by frequent, and often damaging earthquakes. The Geological Society of New Zealand has been in existence throughout the evolution of earthquake hazard analysis in New Zealand, and many Society members have contributed to the associated advances in the science. The 1960s saw major contributions to understanding the patterns of seismicity in New Zealand, and the relationships between active faults and earthquakes. Prominent scientists such as the late Frank Evison and late Gerald Lensen were leaders in these efforts, along with Robin Adams, who showed the importance of parameters like tectonic setting, fault slip type and soil properties in the assessment of earthquake hazard. The USA-based formulation of probabilistic seismic hazard (PSH) methodology by Allin Cornell in the late 1960s led to the development of PSH models for New Zealand in the 1970s and 80s. These PSH models were often the combined products of engineering seismologists, seismologists and geologists, but largely limited to the historical record of seismicity. The well-known "Smith and

Berryman" model was used as the basis for Loadings Codes from the mid-80s almost to the present day. The growth and acceptance of paleoseismology as a discipline eventually resulted in PSH models that included active faults explicitly as earthquake sources in the 1990s, initially in regional studies, and eventually at a national scale. The most recent national PSH model includes over 300 fault sources, and incorporates the latest ground motion attenuation model for New Zealand. Multidisciplinary and multi-institutional collaborations are the basis for the new breed of models. Present efforts are focused on improving the fault and seismicity source input to the national model. The latest iteration of the model now includes an additional 100 fault sources largely from offshore, courtesy of the National Institute of Water and Atmospheric Research. Equally important are efforts focused on validating the national model against independent data, and relevant research into "time-varying" phenomena such as earthquake interactions in space and time, and elapsed time since the last earthquake.

ORAL

CRUSTAL EXTENSION AND THE MOHO IN THE CENTRAL VOLCANIC REGION

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Crustal thickness measurements in the Central Volcanic Region (CVR), the back-arc basin in North Island, show that here the crust has been thinned by at least 50 %. This wedge shaped segment of extended crust is the onshore continuation of the oceanic Lau-Havre back-arc spreading centre. A region of negative residual gravity anomalies clearly outlines the western and eastern margins of the CVR. Andesite arcs also define the boundaries of the CVR. An east moving and rotating subduction zone through time is reflected in an apparent fan like opening and migration of the volcanic arc from the ~ 4 Ma remnant western arc to the present day eastern arc. Despite the complex opening structure of the back-arc basin, evidence from offshore seismic data indicates the basement across the whole area has subsided by similar amounts and hence the region has undergone similar amounts of extension. Apparent extension strain rates in the back-arc are ~ twice that of most continental rifts, and the modes of extension are less clear. The accepted end member extension models of pure and simple shear are less applicable in a region of such high extension rates, where a significant amount of the extension is expressed by the intrusion of new material into the crust. What constitutes a Moho in this region of high extension rates and elevated heat flow is also less clear. Beneath the back-arc the most prominent boundary, from long-range refraction and reflection data, is between the extended and intruded upper crust, and a layer of new crust formed by underplating. From the top of the underplating, seismic velocities increase with depth, imply an increasingly mafic composition with depth. Mantle velocities and hence the base of the crust are reached at ~ 20 km depth. Thus the transition from lower crust to upper mantle is broad, and a conventional Moho does not exist beneath the CVR.

ORAL

THEN AND NOW - AND QUITE A BIT THEN AND NOW - AND QUITE A BIT BEFORE AND IN BETWEEN

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I present a personal view, starting by setting the scene over the 25 years before 1955, during which significant advances held out the promise of far greater understanding to be obtained by well focussed studies.

The next 50 years saw the New Zealand Geological Survey present a series of 1:250 000 maps for the whole of New Zealand, and become involved with both important industrial developments and with "Think Big" projects. It developed specialist sections in basin studies, engineering geology, earth deformation and computers, while retaining previous paleontology and petrology sections. It balanced application with research. When later the Survey was joined with DSIR's Geophysics Division and then subsumed into the Institute of Geological & Nuclear Sciences, much of the Survey's expertise remained relevant and the Survey's records have stood the new institute in good stead.

University geology staff numbers increased rapidly when the colleges of the University of New Zealand gained university status and then Massey and Waikato universities established departments in which geology was taught. The staff and the increasing numbers of research students began to put out many new data and interpretations. New ideas, for example plate tectonics in the late 1960s, were adopted and adapted to New Zealand by the universities, ahead of the Geological Survey. New techniques were commonly used as early as possible.

The new era of commercial viability, accountability and competitive funding led to the CRI model, and to significant impacts on universities. The pestilence of paper work and problems of keeping valuable projects going were balanced by increased flexibility in detailed expenditure and a valuable need to collaborate with other institutions. At present, many fields of research are moving forward, and the challenge now is to identify and tackle key problems in our geological history. Geology must also retain its relevance to the needs of the country.

ORAL

THE CENOZOIC SEQUENCE FROM A DRILLHOLE IN SOUTH CANTERBURY

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The Cenozoic sedimentary sequence in the South Canterbury basin has been widely studied and is considered to be of global significance. Unconformities, disconformities, paraconformities and variations in lithology within the basin have been variously attributed to changes in global climate, eustatic sea level and ocean circulation. However, the ability to correlate directly with other global proxies has been hampered by poor resolution of chronology and temporally limited outcrop patterns.

In association with the ANDRILL testing programme, the opportunity has arisen to recover a drillcore from the onshore part of the basin. This will provide a sufficiently long and continuously exposed section of the sequence for a chronological and environmental study of suitable resolution.

The drillcore record will be obtained from a site near Cave, on the Tengawai river and is expected to include ~500m of sequence ranging in age from ~40 to ~15Ma. This will include a variety of lithologies and incorporates a number of unconformities, including the "Marshall Paraconformity". By investigating the foraminiferal content, paleomagnetic record and other geochronological indicators, it will be possible to construct an age model. By acquiring a continuous core, a finer resolution of measurement can be made across the unconformities in the section to indicate their timing, duration and significance.

Drilling is scheduled to commence in October 2005 and we will present the preliminary results of the project, indicating how they relate to studies currently in progress on other South Canterbury sections.

POSTER

TERTIARY SKELETAL LIMESTONES AND CARBONATE DYKES ON CHATHAM ISLANDS

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Tertiary limestone occurrences on the Chatham Islands, 800 km east of South Island, are very limited in distribution but are diverse in age (Paleocene to Pliocene), fossil content, facies type, and diagenetic history. Their stratigraphy and general field features have previously been reviewed by Wood et al. (1989) and Campbell et al. (1993). During February 2005 we conducted detailed sedimentological field work on most of the main limestone sections cropping out on both Chatham and Pitt Islands. This poster reports, mainly through photographic images, some of the characteristics of the limestones in the field, and notes our intention to undertake detailed petrographic and geochemical studies of the limestones in the future, principally to assess their skeletal make-up and assemblages, their depositional paleoenvironments, and their diagenetic properties. Much of this work is presently underway, and other aspects will be included as part of the MSc study of the presenting author (JQT).

There are several unique aspects about the limestones on the Chatham Islands. First, they are temperate latitude limestones developed upon isolated oceanic islands far from mainland New Zealand, not upon extensive shelves or platforms. Second, oceanographically the islands straddle the late Tertiary position of the Subtropical Front bounding cool subtropical water to the north from subantarctic water to the south, which should be reflected in the development of distinctive limestone facies. Third, the wide spread of ages of the limestones throughout the Tertiary affords an excellent opportunity to compare biotic and facies changes over time. Fourth, stratigraphically these temperate limestones are intimately associated with coeval basaltic volcanic and volcaniclastic deposits that appear to have exerted a strong influence on their distribution and geometry, as well as on their facies associations and skeletal assemblages. Fifth, unlike many mainland New Zealand limestones, the carbonates have never been deeply buried, so that pressure-dissolution is unlikely to be a source of calcite cement. While many of the limestones are expectedly only weakly cemented, others are tightly cemented, implying either a marine or subaerial rather than burial origin like many other New Zealand limestone occurrences. And sixth, limestone dykes are associated with several of the Chatham limestone sections, seemingly as forceful downward fissure injections and veins into volcaniclastic substrates. Multiple episodes of injection are sometimes evident. All these aspects will be addressed and interpreted in our ongoing work and, where appropriate, comparisons will be made with age-equivalent limestone facies and associated deposits in mainland New Zealand.

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Wood, R. A. et al., 1989: Cretaceous and Cenozoic geology of the Chatham Rise region, South Island, New Zealand. NZGS, Lower Hutt, NZ.

ORAL

SOIL STRATIGRAPHY OF LOESSIAL SEQUENCES ON COASTAL MARINE AND RIVER TERRACES, NORTHEASTERN SOUTH ISLAND, PROXY RECORDS OF TECTONIC AND ENVIROMENTAL CHANGE

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In the late Pleistocene and Holocene, river aggradation and degradation in NZ has formed flights of fill, fill-cut and strath terraces. Soils and the soil stratigraphy of loess and tephra cover beds is used in this work-in-progress study to correlate fill terraces between catchments and to coastal marine terraces at three sites in northeastern South Island - coastal Kaikoura Peninsula and Kekerengu, and inland Charwell River.

At each of the three sites, the soil stratigraphy of the loess shows similar morphological features with the exception of texture, with the oldest loess at Kekerengu and Charwell, and all the loess on Kaikoura Peninsula having clay textures. Kawakawa tephra (c. 26.5ka) is disseminated within the youngest loess at all three sites, and an unidentified tephra occurs in the oldest loess at Charwell.

Kaikoura Peninsula has a sequence of five marine terraces. The distribution of loess on terraces is mapped and the soil stratigraphy of loess revised. Present age estimates indicate that three loesses overlying shallow marine deposits on the bedrock strath of the oldest terrace have accumulated since the last interglacial (OIS5). The loess - terrace relationships on the peninsula provide a local correlation with changes in sea level, and tectonic uplift since the last interglacial.

Coastal ekerengu terraces are remnants of alluvial fans and valley fills separated by low hills eroded from weathered conglomerates and marine rocks. A sequence of fill and fill-cut terraces is recognised, the youngest fill terrace with thin overbank but no loess cover and one, two and three loesses on the successively older terraces. Strongly weathered sandy clays, and/or sandstone conglomerates underlie the oldest terrace remnants. The presence or absence of loess, and the number of loesses on terrace remnants were used to map and correlate surfaces. The purpose of this mapping was to assess the late Pleistocene and Holocene movements on the Kekerengu Fault, which offsets the terraces. For example, a beheaded channel on a one-loess fan surface (correlated to OIS3) is offset from its likely Glencoe Stream source by c. 700 m, indicating a lateral slip rate of approximately 20 mm/yr.

Inland Charwell River terraces are underlain by gravelly alluvium deposited during five late Pleistocene depositional episodes. Fill and fill-cut terraces are formed in the four youngest aggradation gravels, with overbank and or thin loess on the youngest fill terrace and one, two and three loesses on the successively older fill terraces. The landform on the oldest loess mantled terrace has a low relief hilly topography with evidence of erosion and dissection of the terrace during and between episodes of loess accretion. Late Quaternary ecological and environmental changes are interpreted from phytolith analysis, soil chemistry and tephrochronology. A paired upbuilding – erosion loess record suggests that soil transport rates did not change significantly throughout the late Pleistocene-Holocene climate transition although soil transport mechanisms did. Ongoing work will develop a tephrochronological framework for loess accumulation and other environmental changes, and further explore the biogeomorphic effects of glacial-interglacial ecosystem changes.

POSTER

TECTONICS OF THE GALATEA BASIN USING GEOPHYSICAL TECHNIQUES

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Unusually deep basins can occur in regions subjected to both active extension and strike-slip. Such “pull-apart” basins are known to occur in Southern California, where they have been explored for more than 100 years. In New Zealand, examples of pull-apart basins include the Hamner Basin (Hope fault, Canterbury) and the Dagg Basin (Alpine fault, Fiordland). It is arguable that the dextral strike-slip Wellington fault also exhibits pull-apart character at eastward en echelon releasing steps as it passes through the Hutt Valley into the Wairarapa.

The Galatea Basin, located in southern Bay of Plenty, straddles the eastern margin of the extensional Central Volcanic Region and is juxtaposed against strands of Waiohau and Te Whaiti faults. These faults define the western limit of the North Island Dextral Fault Belt. Although part of a principally dextral strike-slip system of faults, motion on the Waiohau fault has been identified recently as being dominantly normal, with an average dip-slip rate of 0.6-0.9 mm/yr.

Over 170 new gravity measurements were acquired the Galatea Basin with the aim of better defining the dimensions of an associated Bouguer anomaly and determining the sub-surface structure of the basin. In addition, a single 5 km seismic refraction profile and a 2.5 km reflection profile were recorded along a line perpendicular to the Waiohau fault and strike of the Galatea Basin.

The residual gravity anomaly is –27 mGal at the centre of the basin. Results from ray-tracing have identified that the Waiohau fault dips in excess of 45° at depth, and, combined with other methods, we conclude that basin depth reaches at least 1000 m. Basin fill is Quaternary volcanics, including Matahina Ignimbrite and Rangitaiki Ignimbrite underlain by Pleistocene sediments including Lukes Farm Formation and possibly older Tertiary units.

The distinctly deep gravity anomaly combined with the steeply faulted eastern margin suggests a pull-apart origin for the Galatea Basin.

ORAL

CONSTRUCTING A BRITTLE–DUCTILE RHEOLOGICAL MODEL OF CONTINENTAL LITHOSPHERE

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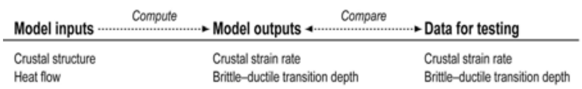
Idealised rheological models — elastic, ductile, viscoelastic etc. — provide physically reasonable, mathematically useful descriptions of the lithosphere’s large-scale mechanical characteristics in different circumstances. However, these models do not directly represent small-scale deformation mechanisms known to operate under particular geological conditions. In particular, the parameters describing common rheological models are not straightforwardly reconciled with the brittle and ductile modes of deformation thought to operate at shallow and deep levels within the crust and lithospheric mantle. Moreover, it is difficult to account for the vertical and horizontal distributions of crustal seismicity using existing rheological models in which the lithosphere’s mechanical properties are uniform.

In this presentation, I will discuss progress towards constructing a rheological model for continental lithosphere that combines geological evidence for brittle and ductile deformation mechanisms, and seismicity, with geophysical measurements of the lithosphere’s long-term, long-wavelength mechanical properties.

If the brittle–ductile transition in continental crust is controlled by the crust’s thermal structure and the ambient strain rate (e.g. Sibson, 1983), then the large-scale vertically averaged rheology of the lithosphere as a whole is temperature-dependent. Based on borehole observations indicating that the brittle crust is in a state of frictional failure equilibrium, Zoback and Townend (2001) hypothesized that the rate at which continental lithosphere deforms can be expressed in terms of heat flow if the total strength of the lithosphere is known. The corollary is that for a given crustal structure and heat flow, the corresponding lithospheric strain rate and the depth of the brittle–ductile transition (and the base of the seismogenic zone) can be estimated. In other words, any two of four key data sets listed in the schematic below can be used to compute the two others. All four data sets exist for California, providing a rare opportunity to test these ideas.



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POSTER

THE EARLY MIOCENE PLATE BOUNDARY IN MARLBOROUGH, NEW ZEALAND: THRUST FAULTING AND REGIONAL CLOCKWISE VERTICAL-AXIS ROTATION

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Plate reconstructions for the Early Miocene suggest that the Pacific-Australia plate boundary trended NW-SE and consisted of an array of thrust faults striking parallel to the paleo-Hikurangi margin. Parts of that subduction complex are preserved onshore in the Raukumara Peninsula, Wairarapa and Marlborough, where it was pinned at its eastern end by the Chatham Rise. The plate boundary zone in Marlborough has experienced a complex structural history, culminating in the late Neogene development of the NE-striking, dextral strike-slip Marlborough Fault System (MFS).

Inception of the Early Miocene plate boundary through New Zealand is recorded in Marlborough by development of the imbricate Flags Creek Fault System (FCFS) and coeval deposition of the (Otaian-Altonian) Great Marlborough Conglomerate. New structural mapping and analysis of folded thrust sheets in the FCFS has yielded a predominant in-situ SE vergence, which is strongly discordant to the inferred NW-SE strike and NE (seaward) vergence of the Early Miocene subduction complex.

Five new paleomagnetic samples from around the arcuate FCFS coupled with existing paleomagnetic data from coastal Marlborough suggest that the entire area has undergone clockwise vertical-axis rotation of at least 100º during the Middle and early Late Miocene [Vickery and Lamb 1995; Little & Roberts 1997]. Late Miocene to Pliocene clockwise vertical-axis rotation of up to 44º has affected coastal Marlborough to the north of the FCFS [Roberts 1995; Little & Roberts 1997]. Late Pliocene to Quaternary dextral shear strain within ~5 km of the active Kekerengu Fault has locally produced additional clockwise vertical-axis rotation (up to 45º) near Woodside Creek.

Restoration of strike-slip on the MFS and of the above-described rotations realigns the Early Miocene FCFS back to its original NW-SE strike and NE- (seaward-) vergent configuration. The proto-Clarence Fault (Flags Creek Fault) initiated as a NW-SE striking thrust within the Early Miocene subduction complex, and accrued >10 km of NE-vergent slip (with an additional 16 km of shortening within the FCFS) before being folded, strongly clockwise-rotated, and locally reactivated. Subsequently, oblique plate motion has allowed this and other faults in the MFS to remain active while transitioning from dip-slip to oblique- or strike-slip styles of deformation.

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POSTER

FABRIC TRANSITIONS IN THE ALPINE FAULT MYLONITES: VARIATION IN THE TEMPERATURE OF THE BRITTLE-PLASTIC TRANSITION DUE TO CHANGES IN STRAIN RATE

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The Alpine Fault is the major structure within the Australian–Pacific plate boundary and accommodates c. 25 mm/yr displacement. Due to the oblique convergence across it, mylonites formed by ductile shear at depth are exhumed in the hanging wall immediately east of the present fault trace. They grade from ultramylonite close to the fault to protomylonite adjacent to the Alpine Schist protolith c. 1 km to the east.

In order to gain further information about the distribution of strain and deformation conditions within the hanging-wall, Alpine Schist-derived Alpine fault mylonites, we have collected quartz crystallographic preferred orientation (CPO) data from mylonite samples along two transects perpendicular to the Alpine fault. Analyses were performed by the electron backscatter diffraction (EBSD) technique, using a Camscan SEM and Channel 5 indexing software.

Most crystallographic fabrics in the mylonite zone are characteristic of a high ratio of simple to pure shear. The most obvious trend in the <c> axis distributions is a transition from single Y-axis maxima and single girdles with marked rhomb <a>-slip peaks, to Type I and rare Type II crossed-girdle fabrics at a distance of approximately 400m from the Alpine fault. A transition from single maxima and single girdle to crossed girdle fabrics can occur due to a decrease in deformation temperature or a decrease in the rotational strain component of the deformation.

CPO patterns in high strain mylonites are likely to record only the latest stages of deformation due to destruction of previous fabrics by recrystallisation; hence the fabric transition observed at 400m from the fault is unlikely to result only from a variation in the total finite strain. The transition can therefore most easily be explained by a variation in temperature during the last increment of ductile deformation. In this scenario the CPO fabrics are 'frozen in' as the mylonites are exhumed through the brittle-plastic transition, which occurs at higher temperatures close to the Alpine fault due to the higher strain rate.

Subsidiary observations from the dataset include: (a) foliation-parallel quartz veins in ultramylonites have fabrics that are not easily related to the kinematics of the mylonite zone. These veins may have formed late in the deformation history and retain a growth fabric; (b) the presence of feldspar as a second phase mineral weakens the CPO fabric more than the presence of mica; (c) the CPO fabrics are asymmetrically distributed about the foliation plane, indicating that a previously occurring preferred orientation is selectively strengthened by the mylonitic deformation; (d) a fabric indicative of dominantly pure shear is attained close to the mylonite-schist transition, indicating flattening strain does occur during the initial stages of mylonitisation; (e) there is no systematic change in pattern or fabric opening angle within the protomylonite zone, indicating that there is no simple variation in temperature towards the fault in this zone. This may reflect an inhomogeneous distribution of the strain rate within the protomylonites.

ORAL

SIMILARITIES BETWEEN EARLY CRETACEOUS MAGMATIC BELTS IN QUEENSLAND AND NEW ZEALAND

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Mesozoic magmatism in NZ is dominated by the 800+ km-long Median Batholith. The main phase of magmatism spans 170-100 Ma with no significant arc-parallel age variation, and can be subdivided into two margin parallel-belts (Tulloch & Kimbrough 2003; GSA Sp paper 374, 275-95). A 130-100 Ma inboard belt is characterised by plutons with relatively high Na, Sr, Al and low Y (HiSY, for Sr/Y> 40; also known as adakitic or TTG-like); an older outboard belt has complementary LoSY chemistry. There is a rapid change from LoSY to HISY at ~130 Ma with HiSY magma flux rates ~ 5x greater than that of the preceeding LoSY belt. Several small bodies of A-type and peralkaline granite have ages of ~130 Ma. The HiSY magmas are likely derived from partial melting of basaltic continental lithosphere generated during preceeding LoSY arc magmatism. Shallowing subduction and pinching out of the mantle wedge may explain cessation of (LoSY) magmatism, and the inboard location of the HiSY plutons, but not the significant mantle heat input heat necessary for large scale crustal melting.

Early Cretaceous magmatism in eastern Australia is dominated by the ~132-95 Ma Whitsunday Volcanic Province. The 900 km long province ranges from basalt to high-silica rhyolite although the latter dominate. The rhyolitic rocks and some granites commonly have elevated Zr, Y (and thus hints of A-type geochemistry), and ages <125 Ma. Granitic rocks with HiSY and LoSY chemistry are also present but the HiSY rocks have not been directly dated. This magmatic belt has been interpreted (Bryan et al. 1997; EPSL 153, 85-102) as having been formed in an extensional environment related to 84-55 Ma Tasman Sea spreading. However, Allen et al. 1998 (AJES 45, 875-88) argue that the time lag of up to 50 Ma until ocean crust formation is too long for a causal connection.

Both the NZ and Queensland magmatic belts have a similar age span, and both contain a similar variety of distinctive rock types which are commonly regarded as atypical of subduction zones; e.g. HiSY (minor in Queensland, major in NZ) and rift-related/A-type igneous rocks (major in Queensland, minor in NZ). Both exhibit a major change in character at similar time (~125 Ma in Queensland, ~130 Ma in NZ). As such, the Early Cretaceous magmatic belts of NZ and Queensland can considered to be part of the same Gondwana-margin arc, crosscut by later continental rifting. The large volumes of A-type magmatism in Queensland may shed light on the significance of its apparently rare equivalent in NZ. Thus A-type magmatism at ~130 Ma in NZ may explain the sudden major HiSY flux as being due to heat associated with an otherwise largely unrecognised incursion of asthenospheric mantle-derived magmas, probably by slab rifting or roll back. In Queensland, by analogy, the "extension-related" magmatism may also have been "intra-arc", rather than strictly intracontinental.

ORAL

PROGRESS ON QMAP FIORDLAND

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Work on the Fiordland QMAP sheet has been under way for four field seasons with the southern two-thirds of Fiordland now largely mapped. Some of the more significant findings of the work to date are highlighted on this poster.

Schistose amphibolite facies metasediments, previously interpreted as the upper plate of a Western Fiordland Block, are now known to extend as far south as Chalky Inlet rather than terminating in Dusky Sound. These metasediments, and several younger granitoid units, strike across the mouth of Dusky Sound and indicate that the Dusky Fault does not extend out to sea as previously postulated. Movement is instead accommodated on a major SW-trending fault that crosses the coast near West Cape; consequently the Dusky Fault, previously thought to separate distinct Western and Southern Fiordland Blocks, appears to be of local rather than regional importance. Ordovician graptolitic shales and interbedded sandstone and quartzite previously included in a Southern Fiordland Block, as well as the schistose amphibolite facies rocks, are intruded by the Brothers and c. 350 Ma Evans Plutons, indicating that they have been in close proximity since the mid Paleozoic.

The c. 30+ granitoid plutons mapped show regional variations in composition and age across southern Fiordland. Carboniferous plutons are largely confined to the area between Dusky Sound and the Princess Mountains, and include at least 3 distinct groups, one of which correlates with the Ridge Orthogneiss on Stewart Island. Gabbroic, dioritic and related LoSY granodioritic rocks, c. 170-140 Ma old, similar to those mapped in northern Stewart Island and northeastern Fiordland, form a belt of heterogeneous variably deformed intrusions that extends from northeast of Lake Manapouri to the Princess Mountains. The presence of the c. 164 Ma Lake Mike Granite in SW Fiordland indicates this Jurassic plutonism locally extended further west. Younger HiSY plutons, correlated with the Separation Point Suite, form a narrow belt extending south from the western side of Lake Manapouri to Lake Poteriteri. Elsewhere in southern Fiordland, Cretaceous HiSY rocks are restricted to isolated plutons in the eastern Hunter Mountains and south of Dusky Sound. Numerous LoSY tonalitic to leucogranitic plutons, some dated at c. 130-135 Ma, occur in SW Fiordland; their affinity with other documented suites is not yet clear.

Cretaceous and Cenozoic sedimentary rocks had generally been mapped and described prior to the QMAP programme. However, newly discovered fossiliferous Pleistocene sediments that fill a submarine canyon east of Puysegur Point give valuable control on tectonic uplift rates for flights of marine terraces in SW Fiordland.

The Grebe Shear Zone, previously interpreted as the boundary between Eastern and Southern Fiordland Blocks, is cut by probably Early Cretaceous (Separation Point Suite) granitoids, implying correlation with the Gutter Shear Zone on Stewart Island. Innumerable brittle faults have been mapped; some offset the contacts of the Western Fiordland Orthogneiss. Demonstrable Late Quaternary faulting is rare.

POSTER

WORKING TOWARD A HIGH-PRECISION RECORD OF MT TARANAKI ERUPTIONS AND ASH FALLS, NEW ZEALAND

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A probabilistic assessment of eruption recurrence at any volcano requires quantification of the frequency and magnitude of each style of possible volcanic hazard. Existing eruption age data for frequency analysis at Taranaki is, as for many volcanoes, poorly constrained and relies on a few radiocarbon dates from widely distributed stratigraphic sections on and around the volcano. We have extracted what seems to be the highest resolution record yet of Taranaki volcanism from peaty lacustrine sediments within a small lake, 25km northeast of the volcano. Although not directly downwind of Mt Taranaki, this site holds >90 Holocene tephras, which have been sampled within the top 4 m of sediment. Ten new radiocarbon dates throughout the length of this core enable a very detailed sedimentation rate curve to be established and each individual tephra layer can be assigned an age based on its position within the core. This key site is correlated to syn-eruptive deposits in other locations, including those on the edifice, by physical and petrological characteristics as well as titanomagnetite mineral chemistry finger-printing techniques. By using these tephras as age horizons, other proximal eruption deposits which are not in the distal record can also be assigned a relative age and added to the event database. The new database will be used to develop the first comprehensive probabilistic eruption forecast for ash eruptions from Mt Taranaki.

A probabilistic temporal model is then required to handle the stochastic nature of the observed record, as well as the imprecision and inaccuracy inherent in the age data obtained via radiocarbon dating/sedimentation rates and that of the correlation uncertainties. Such models are usually assembled using techniques from renewal theory, (marked) point processes, or hidden (semi-)Markov models. Combining the resulting model with a quantitative assessment of the styles and properties of eruptions possible at Taranaki will allow the model parameters to be estimated, and the goodness of fit to the observed record assessed. A suitably well fitting model can then provide a probabilistic forecast of future eruptions at Taranaki.

POSTER

MASS TRANSFER IN SUBDUCTION ZONES: AN ELEMENTAL AND ISOTOPIC PERSPECTIVE

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Little doubt remains that subduction zone lavas contain elements recycled from the subducting slab. However, whether the key agents of this mass transfer are fluids, supercritical fluids or melts has major implications for the thermal structure of the mantle wedge. The evidence for contributions from both subducted sediment and altered oceanic crust are compelling and in most arcs their relative proportions vary inversely. Thus, so-called “fluid-rich” lavas with high Ba/Th and Sr.Th ratios have low $^{87}Sr/^{86}Sr$ and $^{10}Be/^{9}Be$ etc and the converse is true for the so-called “sediment-rich”lavas with elevated La/Sm. A complicating factor is that many individual arcs tend to be dominated by one end-member. Nevertheless, experimental partition coefficient data are consistent with the differences between the fluid and sediment components being formed in the presence of different residual mineralogies. Sediment fluids appear to be poor in incompatible elements, relative to those derived from altered oceanic crust and cannot easily replicate the sediment end-member. We suggest that subducted sediments dehydrate at relatively shallow levels and that these fluids are not strongly sampled by arc lavas. Altered oceanic crust may dehydrate more extensively and to greater depths and may be buffered against melting. Model melts of dehydrated sediment residues provide a much better simulation of the inferred sediment end-member but may require ~800 C at ~ 2GPa, consistent with recent temperature-dependant viscosity models. These general inferences are strongly supported by ^{10}Be and U-series isotope data which suggest that the sediment (melt) end-member is added 100’s kyr to several Myr prior to eruption whereas addition of fluid components continues until a few 1000 yrs prior to eruption. Thus, the fluid and sediment end-member contributions are separate in composition, space and time. These data argue strongly against the involvement of any single supercritical fluid.

ORAL

DEVELOPMENTS IN THE EAST COAST BASIN, NORTH ISLAND, NEW ZEALAND.

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The East Coast Basin saw oil production in the late 19th century from wildcat wells near oil seeps. By the mid-20th century, geology was being applied to oil exploration, but with little success. In the late 20th century seismic techniques were added to the exploration arsenal and several gas discoveries were made. At each stage it was recognised that exploration in this difficult but tantalising basin required more information than was available. Continuing work by exploration companies as well as by the Institute of Geological & Nuclear Sciences (GNS) has begun to reduce the risk of exploration. Source rocks have been identified and sophisticated thermal models show that petroleum is being generated and expelled from them as witnessed by the more than 300 oil and gas seeps onshore. Numerous reservoir facies have been recognised from outcrop studies and depositional models are being refined. All components of petroleum systems have been demonstrated to be present. The most important deficiency to date is the general lack of high-quality seismic data.

Recently, Crown Minerals, the New Zealand government group charged with promoting and regulating oil and gas exploration, commissioned a high specification regional 2D survey intended to address some of the main data gaps in the East Coast Basin. A broad grid was planned to be acquired with a 12,000 metre streamer. It was expected that the long streamer would increase resolution of Paleogene and Cretaceous units. Infill lines were to be acquired with a streamer 8000 metres long. The resulting 2,800 km data set consists of a series of northwest-southeast lines approximately orthogonal to the coast at a spacing of approximately 10 km as well as several long strike lines.

The new data set has confirmed the existence of a large, little-deformed basin to the north of North Island and the Bay of Plenty, it has elucidated the complex structure of a large part of the East Coast Basin and has enabled generation of a general sequence stratigraphic model which assists in delineating reservoir targets.

ORAL

PALEOCEANOGRAPHIC RESULTS FROM A MARINE SEDIMENT CORE NEAR LORD HOWE ISLAND, TASMAN SEA.

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Lord Howe Island (33°S, 159°E) is the eroded remnant of a basaltic shield volcano, approximately 500 km east of Australia and is situated in the path of an ocean boundary called the Tasman Front. This boundary marks the southern limit of the warm East Australian Current which flows from the Coral Sea down the east coast of Australia and across to New Zealand (between 30° and 35°S). The purpose of the study is to examine the influence of the shifting Tasman Front on the palaeoenvironment near an island setting.

A 2.8 m piston core was collected from 780 m water depth in a trough between Lord Howe Island and Balls Pyramid (a smaller island 25 km SSE of Lord Howe Island). Oxygen and carbon isotope analyses were conducted using the planktonic foraminifera *Globigerina bulloides* and *Globigerinoides* ruber and the benthic foraminifer *Uvigerina*. In combination with standard and AMS radiocarbon ages these analyses provide a temperature and productivity proxy for oceanographic conditions around the island for the Holocene and back to oxygen isotope stage 3. Component analysis was undertaken to assess the species composition and shifts in floral and faunal composition across this oceanographic boundary.

Preliminary analysis of the planktonic foraminifer data show three distinct changes related to different water masses coming in through the core. Compositional analysis of the whole core indicates that 2 distinct phases of deposition have occurred at the top (50 mm) and in the middle (1200 mm) of the core shown by a large decrease in abundance of the major components (foraminifera, corals, carbonate gastropods and ostracods) possibly relating to glacial periods and lowered sea level. One of the AMS dates places the top of the core at oxygen isotope stage 3. A complicating factor for the study is whether material eroded off the island and transported to the core site alters the preserved climatic signal. Another factor to consider is whether the presence of intermediate water masses has modified the sea surface temperature record found in the sediment around Lord Howe Island.

ORAL

BALANCING THE PLATE MOTION BUDGET IN THE SOUTH ISLAND, NEW ZEALAND USING GPS, GEOLOGICAL AND SEISMOLOGICAL DATA

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The landmass of New Zealand exists as a consequence of transpressional collision between the Australian and Pacific plates, providing an excellent opportunity to quantify the kinematics of deformation at this type of tectonic boundary. We implement an elastic, rotating block approach in the interpretation of GPS, geologic (fault slip rate and azimuth) and seismological (earthquake slip vectors) data to describe the active deformation in the South Island, New Zealand. This method concomitantly allows us to “balance” the Pacific/Australia relative plate motion budget in the South Island. Using this approach, we simultaneously invert the data for angular velocity vectors of rotating tectonic blocks and the degree of interseismic coupling on faults bounding the blocks. The data are fit to within error, indicating that the “elastic block” method is plausible for interpretation of geodetic data within this plate boundary zone.

Most of the tectonic blocks in the South Island have vertical axis rotation rates similar to the Pacific plate (~ 1 degree/Myr, counter-clockwise). This is in contrast to the North Island, where we have estimated high rates (2-4 deg/Myr) of clockwise tectonic block rotation. We also present estimates of the degree of interseismic coupling on the major South Island faults.

The kinematic block model predicts long-term rates of motion accommodated on some major faults zones in the South Island. With a few exceptions, the fault slip rates agree well with those estimated from geological studies. We estimate that 3-6 mm/yr of oblique convergence must occur to the east of the Southern Alps, and within Southland and central Otago. Our kinematic model requires 5-8 mm/yr of oblique shortening (right lateral) within the Porter's Pass fault zone, suggesting that geologic studies may have underestimated the amount of plate boundary zone deformation accommodated in the North Canterbury region. Up to 5 mm/yr of deformation may occur within the Main Divide Fault Zone, just to the east of the Alpine Fault.

Australia/Pacific relative motion is partitioned within the New Zealand plate boundary zone in a variety of ways. The role of block rotations in accommodating plate boundary deformation is more pronounced in the North Island than in the South Island. The southward migration of the Chatham Rise along the margin (relative to Australia) has a large influence on the evolution of the Hikurangi Subduction zone (North Island), the Marlborough Fault System, and the Alpine Fault.

ORAL

TORLESSE SEQUENCE STRATIGRAPHY AND FORMATIONS BETWEEN THE RAKAIA AND WAITAKI RIVERS

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The make-up of "Torlesse" rocks is analysed from my 1:50 000 mapping for 20 years. Most significant is the delineation of a narrow suture zone from the Waitaki to Rangitata Rivers, defined by schist and Cretaceous intrusions, and separating two basin complexes with different stratigraphic sequences. The interbasinal divide and major source rocks were geochemically like those of northern Queensland, and possibly detached from that region by strike-slip and sea-floor spreading. Later subducted, it provided the volcanics and intrusions of the Mt Somers region. To the east, rocks of Carboniferous to Triassic age involve limestone, chert, clastics and scattered ocean-floor lavas, with rare conodonts, folded and refolded, but without thrusts. West of the suture, the bulk of rocks is Triassic, in three associations. The Otematata and Balmacaan Groups (Retallack 1979, Oliver & Keene 1990) are estuarine and subdeltaic, judged from plant remains, coal, conglomerate and marine fossils, and overlain by the Jurassic substantially non-marine Clent Hills Group. Westwards lies transitional or submarginal facies, mostly the Acolyte Formation of some 6-9 transgressive and recessive units of sandstone and shallow-water black shale. These are overlain by continental slope deposits of the Fingers, Onslow and Baker Formations. Rarely, Acolyte equivalents include plant fossils and detached coal blocks, as at Tank Gully, Clyde River, followed by shallow-marine Mt Potts Group (Campbell & Force 1972). Still further west are found deep-water trough and outer slope turbidtes, extending as far as the Alpine Fault, and ranging north into Wellington. Several sequences may be recognised, with estuarine-subdeltaic unconformities at ?Late Permian, ?Scythian, early Ladinian or late Anisian (Etalian-Kaihikuan), and Late Triassic, as well as Jurassic levels. Some unconformities persist into the marginal facies, and in the trough facies, correlative conformity levels may be tentatively indicated. Permian rocks of this basin are readily distinguished from Triassic and from easterly Permian by their greenish colour, presence of basic minerals and less quartz, and widespread occurrence of red argillite, green siltstone and pillow lava with some limestone. The rocks seem likely to be related to those of the Wakatipu lithologic association. No Carboniferous is known, and the presence of Jurassic possible, but not yet established.

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ORAL

COASTAL DUNE RIDGE SYSTEMS AS CHRONOLOGICAL MARKERS OF PALEOSEISMIC ACTIVITY – A 600 YEAR RECORD FROM SOUTHWEST NEW ZEALAND

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A study of five shore-parallel dune ridge sequences in southwest New Zealand shows that tectonic activity has been the primary controlling influence in their formation since at least AD 1450. The timing of dune building episodes at the mouths of the Haast, Okuru, Waiatoto, Arawhata and Awarua Rivers was determined using the ages of colonizing trees. Episodic dune formation was indicated by clear discontinuities in tree ages, with distinct cohorts having colonized successive, newly-formed, dune ridge-swale units. At Haast and Okuru, four dune ridge-swale units have formed since AD 1460, with each unit closely post-dating an Alpine fault rupture (c. AD 1490, c. AD 1615, AD 1717, AD 1826). At Waiatoto, Arawhata and Awarua, three dune-swale units have formed since AD 1490 and each of these also closely post-dates an Alpine fault rupture (c. AD 1490, AD 1717, AD 1826). Colonizing cohorts of trees started growing within 17-47 years after an earthquake, and at all five sites all known major regional earthquakes that affected each site since AD 1460 had resulted in a dune building episode at that site. No other dunes are present at any site.

Progradational coastal dune systems have potential as a tool for paleoseismic studies. In regions with high background levels of sediment delivery to limit erosion/burial of dunes and with little coseismic subsidence, dune systems may offer a near-complete, spatially discrete record of earthquake-induced sedimentation events over the last 6500 years or so. Earthquakes are a key driver of paleoenvironmental change and coastal plain development in this tectonically active region.

ORAL

MECHANISMS OF LATE QUATERNARY FOREARC UPLIFT: A CASE STUDY OF THE NORTHEASTERN RAUKUMARA PENINSULA, NEW ZEALAND

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On the northeastern Raukumara Peninsula at Hicks Bay and Te Araroa, we have investigated Holocene landforms and coastal stratigraphy with the aim of documenting coastal uplift mechanisms. Drill cores of incised-valley infill sediments at Hicks Bay show apparently continuous estuarine sedimentation at intertidal elevations throughout the early Holocene. Radiocarbon ages allow comparisons between the thickness of sediment preserved and the amount of accommodation space expected to have been created within the estuary due to eustatic sea level rise. Accommodation space deficits indicate tectonic uplift did take place during deposition of the sequence, yet the continuity of estuarine sedimentation implies this tectonic uplift was relatively gradual and continuous as opposed to the sudden and infrequent uplift characteristic of earthquakes.

Raised beach ridges at Te Araroa, ~ 8 km southeast of Hicks Bay, display a seaward-sloping, stepped morphology. The seaward slope indicates that gradual tectonic uplift continued through the mid-late Holocene. The beach ridge steps have an amplitude of <1 m and may have formed due to sudden uplift events. Additional evidence for sudden uplift events in the region is the sequence of raised mudstone platforms on the coast between Te Araroa and East Cape.

Radiocarbon ages from estuarine sediments at Hicks Bay yield early Holocene uplift rates of 1.6 ± 0.2 mm yr^{-1}. Raised beach ridges at Te Araroa indicate average mid-late Holocene uplift rates of 2.5 ± 0.2 mm yr^{-1}. These rates indicate back-tilting approximately normal to the strike of the subduction zone. This is mirrored by the Pleistocene marine terraces. The most widespread of these decreases in elevation from 200 m at Te Araroa to 130 m at Hicks Bay with a distance between them of 12 km. The terrace was previously estimated to be the Marine Isotope Stage 5e terrace, but an OSL date collected by us yielded an age of 68.7 ± 5.6 ka. This age suggests terrace formation during Stage 5a. Uplift rates calculated from this terrace assuming a Stage 5a age are 1.6 ± 0.2 mm/yr at Hicks Bay and 2.5 ± 0.2 mm/yr at Te Araroa. The remarkable consistency between these short- and long-term uplift rates implies an uplift mechanism operating uniformly over the past 80 ka at least.

In summary, the dominant uplift signal in the Hicks Bay – Te Araroa region is one of gradual uplift. This may be driven by sediment underplating on the subduction interface which is ~20 km beneath the coastline. Sudden uplift events comprise a weaker, secondary uplift signal and may have been generated by interface rupture or on an unidentified offshore thrust fault.

POSTER

TECTONIC AND NON-TECTONIC CAUSES OF EARLY HOLOCENE RELATIVE SEA LEVEL CHANGE WITHIN A TRANSGRESSIVE ESTUARY ON A SUBDUCTION MARGIN, PAKARAE RIVER, NORTH ISLAND, NEW ZEALAND.

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The highest Holocene marine terrace at Pakarae, North Island, New Zealand, corresponds with the maximum Holocene marine flooding surface. This terrace is underlain by a sequence of estuarine, fluvial and marine sediments that were deposited under rising eustatic sea level (SL) conditions. These sediments are presently exposed at elevations up to 20 m above modern mean SL as a result of tectonic uplift. This sedimentary sequence provides an opportunity to study the paleoenvironmental development of incised valleys under conditions of rising SL and tectonic uplift. The stratigraphy is valuable for comparison with traditional facies models of incised valley infills, which were developed exclusively from studies on stable coasts. We use sedimentology, macropaleontology and micropaleontology (benthic foraminifera) to reconstruct the paleoenvironments that accompanied infilling of Pakarae valley and to estimate the frequency, magnitude and timing of uplift events that occurred during the depositional period (c. 10,500 – c. 7,000 cal. yrs BP).

We divide the Pakarae valley infill sequence into eight bio-lithofacies, each relates to a particular paleoenvironment. These are grouped into four paleoenvironmental facies: barrier, estuarine, estuary-head delta and fluvial. The basal fluvial facies, the immediately overlying estuary-head delta facies, and the capping barrier facies correlate well with models of incised valley infill from stable coasts and indicate that the complete sequence of valley infill is probably present within the Pakarae outcrops. However the middle section of the Pakarae stratigraphy displays alternations of estuarine and fluvial facies. This contrasts both with models of incised valley infill and with individual estuary infill studies; which predict that only central estuary basin sediments should be present between the transgressive estuary-head delta and the barrier facies.

The whole Pakarae sequence is compressed relative to the amount of accommodation space estimated to have been created by eustatic SL rise during the depositional period. Only a small proportion of this can be explained by compaction, most of this important difference is the result of tectonic uplift during deposition. Supplemented by detailed microfossil studies and radiocarbon dates, we identify which facies transitions within the middle section are tectonic and non-tectonic in origin. One uplift event of at least 2 m occurred between 8695 – 8376 cal. yrs B.P. One or two uplift events occurred after deposition of the Rotoma tephra at ~ 9500 cal. yrs B.P and before 9255 – 8990 cal. yrs. B.P. Our data extends the paleoseismic history of this important location which has one of the highest uplift rates along a subduction margin without an historical record of subduction earthquakes.

ORAL

IMPACTS OF TEPHRA FALL ON A DAIRY FARMING OPERATION AT REREWHAKAAITU, EASTERN TAUPO VOLCANIC ZONE, NEW ZEALAND

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Much of New Zealand's dairy farming industry, central to New Zealand's economy, is based in the central North Island, in or near the Taupo Volcanic Zone, and is highly vulnerable to tephra fall.

A vulnerability analysis was undertaken of, 'Tulachard' a study farm at Rerewhakaaitu, eastern Taupo Volcanic Zone, to assess the susceptibility of dairy farm's infrastructure and operational processes to tephra fall. 'Tulachard' was particularly appropriate as it is close to Tarawera Volcano. Power supply, water supply and ability to use the tractor were identified as the most vulnerable elements to 'Tulachard's' ability to respond and recover from tephra fall. One of the most vulnerable components of a milking shed is the condenser used for cooling milk because of its exposed nature and requirement for circulating outside air. An air conditioning condenser, similar to condensers used in milk cooling systems, was laboratory tested where it performed moderately well when inundated with dry tephra, but rapidly failed with wet tephra.

A telephone survey of the Rerewhakaaitu dairy farming community established their perceptions of the risks faced from volcanic hazards. Although all respondents were aware of volcanic hazards, over half did not believe their farm would be affected by a volcanic eruption in their lifetime. None had prepared for a future volcanic eruption. This has important education implications for key organisations that would be affected if dairy farms were affected by eruptions.

Generic recommendations are presented for measures that will decrease the vulnerability of dairy farms to tephra fall hazards. These include a modern, well maintained electrical power supply, large covered water storage capacity, reserves of supplementary feeds, tractor with bucket or grader blade attachments, spare air and oil filters for engines, air compressor for blowing tephra out of machinery, and appropriate knowledge of rehabilitation strategies for pastures covered with tephra.

POSTER

TAPHONOMY OF A HOLOCENE MOA FEN DEPOSIT, STYX VALLEY, CENTRAL OTAGO

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Significant deposits of bones from large, extinct, flightless birds, predominantly moa (Dinornithiformes) and New Zealand goose (*Cnemiornis*), occur in alkaline mires (fens) throughout New Zealand. Discovery of these sites is usually associated with the digging of drainage ditches, which causes major disturbance to the deposits. As a result, past scientific excavations have tended to be haphazard, and little taphonomic or orientation data is associated with historic collections. Results are presented for a newly discovered, undisturbed moa fen deposit near Paerau in Styx Valley, Central Otago, where 3-dimensional long bone position and orientation data was recorded during excavation of a 1 x 2m L-shaped test pit. The age of the deposit is currently being determined but it is likely to be contemporaneous with a similar mid-late Holocene deposit 5km to the east. Bones were generally in poor condition due to infiltration by fine grass roots. The collected assemblage consisted of heavy-footed moa (*Pachyornis elephantopus*) (Minimum Number of Individuals (M.N.I.) = 11), stout-legged moa (*Euryapteryx geranoides*) (M.N.I. = 1), South Island giant moa (*Dinornis robustus*) (M.N.I. = 1), eastern moa (*Emeus crassus*) (M.N.I. = 2) and South Island goose (*Cnemiornis calcitrans*) (M.N.I. = 1). Long bones were mostly lying horizontal, as was found in a moa fen excavation at Glencrieff, Canterbury (Worthy & Holdaway 1996), but showed no apparent preferred alignment with respect to compass bearing. Bones were encountered at depths of 200-800mm, but were most abundant from 500-600mm. No articulated bones were found, although bones from individual birds were found in close association. Common quartz and schistose moa gizzard stones were associated with the bones. Some of these are the largest recorded moa gizzard stones, up to 110mm long, and weighing up to 217g. The content of one gizzard included 2.25kg of stones, and clipped twigs of lacebark (*Hoheria sp.*) and tree daisy (*Olearia sp.*), up to 16mm diameter.

ORAL

ANAGLYPHS AS A TOOL FOR VIEWING TAPHONOMY: AN EXAMPLE FROM A HOLOCENE MOA FEN DEPOSIT, STYX VALLEY, CENTRAL OTAGO

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Coloured stereograms, or anaglyphs, are examined as a tool for gaining an overall perspective on the taphonomy of a fossil deposit. The method was trialled using the excavation of a Holocene moa fen deposit, Styx Valley, Central Otago. 3D orientations were recorded for 63 moa leg bones by measuring X,Y,Z coordinates for the proximal end of each bone, bearing and inclination to the distal end of the bone, and bone length. Trigonometry was used to find X,Y,Z coordinates for the distal end of the bone. Proximal and distal coordinates were used to create points in 3D space using the GIS program ArcGIS. Points from the same bone were joined using a purpose-built script (supplied by Susan Jones, Eagle Technology Group Ltd.). The ground surface and edges of the excavation pit were symbolised and displayed along with the bones (symbolised as simple 3D tubes) in different perspective views. Selected views were then converted to anaglyphs using an inbuilt application of ArcGIS. This provided a useful way of representing bone orientation data, and may have applications for other paleontological researchers.

POSTER

SEDIMENT DISPERSAL AND DEPOSITION ON A MUDDY CONTINENTAL SHELF AT THE ACTIVE HIKURANGI MARGIN, POVERTY BAY, NEW ZEALAND

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The continental shelf of the Poverty Bay margin is characterised by very high sediment delivery by the muddy Waipaoa River, which is among the largest in New Zealand in terms of suspended sediment load. This situation reflects favourable geological, tectonic and climatic conditions as well as the effects of human settlement and land-use (Foster and Carter, 1997). The Waipaoa provides an opportunity to study how such high discharge systems interact with the marine environment. The main research objective is to determine the spatial distribution of modern sediment on the continental shelf of the Poverty Bay margin, and to understand how the pattern of various seafloor facies have been affected by the hydraulic regime (waves and currents), shelf morphology (including the Lachlan and Ariel anticlines), and sediment supply. This study has been carried out within the research objectives framework of the Margins Source to Sink (S2S) Initiative and this presentation represents an early stage progress report.

The study relies on the integration of geophysical data collected on various research cruises, recently collected physical samples and existing environmental databases. A suite of sediment samples, representing the top 1cm of 87 box cores are analysed for grain size distributions. Contour mapping a number of sedimentary parameters, including % mud and mean grain size, constrains the position of various sedimentary facies across the shelf. Preliminary results suggest that terrigenous organic carbon-rich fluid muds predominate in mid-shelf basin depocentres and are likely to represent recent flood deposits. Samples from the landward limb of the Lachlan Anticline are typically sandy shell hash with associated pebbles. This situation reflects the seafloor outcrop of Neogene strata and potentially the winnowing action of ocean currents. Contour mapping of carbon/nitrogen ratios of the sediment will show the varying influences of marine and terrestrial carbon within the shelf sediments, and highlight sediment pathways and depocentres from river plumes.

An acoustic facies classification scheme for the shelf is proposed, based on the type of seafloor surface seismic response (diffuse/distinct/hyperbolic), and the degree of seismic subsurface penetration, as shown in 3.5kHz and ‘chirp’ FM pulse (0.5-7.2kHz) seismic profiles. Gas-masking of the subsurface is prevalent across much of the mid-shelf basin. Significant influence of non-tidal currents may be represented by moating of sediments against the western limbs of the growing anticlines of the shelf break. Further mapping work will include seafloor textural mapping from a side-scan sonar and multibeam backscatter datasets. Wave and wind regime datasets and existing knowledge of ocean currents will be integrated with satellite imagery to develop a model to explain sedimentation in both normal and storm conditions, and the timing of muddy flood deposit resuspension events.

POSTER

HOW STRONG IS THE ALPINE FAULT? EVIDENCE FROM FLUID FLOW AND DEFORMATION PARTITIONING IN THE PACIFIC PLATE HANGING-WALL

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An array of near-vertical backshears in the central Southern Alps are interpreted to have formed sequentially in an escalator-like fashion and to play an important role in channelling the upward flow of metamorphic fluids through this active orogen. The 1-2 km-wide array of backshears is exposed only in the central region of the Southern Alps around Fox and Franz Josef glaciers. There, fluid inclusion, stable isotope, and thermochronometric data indicate shear failure of a transiently embrittled lower crust down to depths of >20 km. In quartzofeldspathic schist, the shears initiated and accumulated slip brittlely (but probably steadily and aseismically) but ductilely in weaker, pre-existing quartz veins that were subject to finite shear strains averaging 4.8 ± 0.8. Blunting of the brittle crack-tips into the coherently deformed quartz veins suggests that ductile flow was the rate-controlling factor during backshear deformation. The backshears are systematically spaced (53 ± 4.7 cm), with an average slip of 14.1 ± 1.2 cm in a direction pitching 36°SW and are dextral-oblique. Relative to plate motion, they accommodated an excess of margin-parallel dextral-slip. This situation implies some partitioning of oblique motion components between the Alpine Fault and its dextrally wrenched hanging-wall to the east. A corollary to this is that the Alpine Fault, despite its inferred thermally induced weakness, was not weak enough to accommodate perfectly plate motion-parallel slip at the time when the shears were active.

We infer that presence of fluid in the Pacific Plate crust was integral to the formation and accumulation of shear along these structures. Near-lithostatic fluid pressures were a chief agent that originally triggered deep embrittlement and shear failure at the lower crustal depths. After formation, hydrolytic weakening due to high water fugacity allowed deformation in the fluid-weakened quartz veins to accrue at high strain-rates but without sufficiently high differential stresses to cause their brittle failure. As the strength of these veins controlled that of the backshears terminating into them, this process may have significantly weakened the bulk strength of the Pacific Plate crust above the Alpine Fault ramp. The shears also provided a means for suprahydrostatic metamorphic fluids to escape upwards, acting as a closely spaced array of planar, vertical conduits cutting across the otherwise low permeability (1 x 10^{-18} m^2) schist. We calculate that an aqueous fluid volume of 5.6 x 10^{10} m^3 was required to deposit the 1-3 mm thick veins that currently seal the backshears throughout the 30 km-long by ~2 km-wide array, equivalent to an integrated fluid flux of 486000 m^3/m^2. Upward draining of this metamorphic fluid into the hanging-wall would have left the underlying source region near its base residually drier. Fluid expulsion may thus have accomplished a net devolatilisation and rheological strengthening along the Alpine mylonite zone at depth at the same time that hydrolytic weakening softened structurally higher rocks in the hanging-wall. These fluid-related strength changes may have limited the degree to which the Alpine Fault could slip in the plate motion direction without some partitioning of deformation into its hanging-wall.

POSTER

COLLAPSE AND RE-GROWTH OF MONOWAI SUBMARINE VOLCANO, KERMADEC ARC, 1998-2004

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Monowai submarine volcano is located at 25°53.5'S/177°11.1'W, about 1400 km NNE of New Zealand along the Kermadec arc, and consists of a shallow symmetrical cone with a summit depth of ~100 m. Monowai is one of the most active submarine volcanoes in the Kermadec arc, based on visual reports from overflights, oceanographic surveys of hydrothermal plumes, and seismoacoustic monitoring from French Polynesia and elsewhere. Since the late 1970's, Monowai has been the source of frequent swarms of acoustic T-wave events every few years. On 24 May 2002 there was a particularly large seismoacoustic event with a duration of 6-8 minutes and an exceptional amplitude that was 4-5 times larger than any other T-wave signal recorded from Monowai. Bathymetric surveys of Monowai that bracket this event were collected with multibeam sonars in 1998 and 2004 by *R/V Sonne* (Hydrosweep) and *R/V Tangaroa* (EM300), respectively. A new collapse feature is apparent on the SE side of the volcano in the 2004 bathymetry. The two surveys were compared using a quantitative technique that has been used for documenting depth changes due to volcanic eruptions on mid-ocean ridges. The results of this comparison show that the summit depth of Monowai changed from 69 m below sealevel in 1998 to 135 m in 2004, a difference of -66 m, and the location of the shallowest point moved ~200 m to the NNW. However, the maximum depth change between the surveys is -105 m and is located near the 1998-summit, which in 2004 is south of the new headwall scarp on the SE flank of the volcano. The total area of significant depth change is 1.26 x 10^6 m^2, and the decrease in volume is 6.12 x 10^7 m^3 (or 0.06 km^3). From the distribution of the depth changes it is also clear that four things occurred between the surveys: removal of volume from slope failure, the subsequent addition of volume from an eruptive vent within the new slide scar, the removal of part of that additional volume by a further slope failure, and the addition of more volume within the eruptive vent. Therefore, the volume removed by slope failure was probably closer to 0.1 km^3 whereas the volume added back by eruption is approximately 0.03 km^3. It is not known whether the slide triggered the eruption or visa versa, but the recent history of frequent volcanic activity at Monowai suggests that an eruption-triggered slide may be more likely.

POSTER

FINGERPRINTING SLAB–DERIVED AQUEOUS FLUIDS IN THE MANTLE SOURCES OF ARC LAVAS: AN EXAMPLE FROM THE SOUTHERN KERMADEC ARC

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Convergent margins, where oceanic lithosphere is subducted back into the mantle, form the key interface for large–scale element recycling between ocean, crust, mantle, and atmosphere. Recycling of elements in occurs as sediments and altered oceanic crust (AOC) in the subducting slab dehydrate and/or melt, releasing water and mobile elements into the overlying mantle wedge, initiating melting and the generation of arc magmatism. The composition of arc magmas reflects these multiple sources and is further complicated by assimilation of arc crust and hydrothermal fluids and brines as the magma ascends. Deconvolving the origin and transport mechanism of slab fluids and melts in subduction zones requires identifying tracer elements specific to a source and/or mechanism.

Fluid-mobile elements such as Cl, Ba, and Pb provide the potential to investigate the composition and source of aqueous fluids derived from the subducting slab in arc systems. In the southern Kermadec arc – Havre Trough (KAHT) pillow-basalt glasses have water (~1.5 wt.%) and carbon (<16 ppm C) contents consistent with degassing to their pressures of eruption at 3000m bsl. By contrast, Cl contents show strong correlations with fluid mobile elements (e.g. Pb and Ba) and commonly used indices of aqueous fluids (e.g. Ba/La). Simple modeling indicates that in excess of 80% of fluid mobile components in the mantle wedge are derived from addition of <1.5 wt.% of an aqueous fluid from the descending slab. The proportion of aqueous fluid added to the mantle wedge decreases westward into the back arc, consistent with the increasing volume of the depleted mantle wedge. Correlations of aqueous fluid indices with Pb isotopic compositions indicate a sediment rather than AOC source for the fluids in the southern KAHT, although in sediment-starved areas such as the northern KAHT, fluids are probably derived from AOC.

We propose a single reservoir for the aqueous fluid source of the arc magmas. This reservoir is most likely to be hydrated serpentinite formed above the subducting slab by fluids derived from subducting sediment and/or altered oceanic crust. Dehydration of the serpentinite occurs as it descends into the mantle, transporting fluid mobile elements into the overlying mantle and triggering partial melting. The similarity of aqueous fluid compositions derived for other oceanic arcs suggests that this process may occur in arc systems worldwide, with the origin of aqueous fluids dependant on the volume and composition of the sedimentary pile.

ORAL

CYCLIC GROWTH AND DESTRUCTION OF STRATOVOLCANOES

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The last 150,000 years of volcanic activity of Mt Taranaki are characterised by a series of alternating phases of edifice construction and collapse, with the latter often producing catastrophic debris avalanches. Repeated debris avalanche events from unstable volcanic edifices have been inferred from a number of long-lived stratovolcanoes, e.g. Mt Rainier, Colima, Shiveluch, and St. Augustine. However, in many of these locations it is impossible to study the oldest units because they are deeply buried by more-recent volcaniclastic deposits. Unusually, at Mt Taranaki an almost complete stratigraphic record of distal ring-plain successions is exposed due to continuous coastal erosion of the tectonically uplifted areas of southern Taranaki. This allows a detailed analysis of the processes that are behind Mt Taranaki's evolution and apparent cycles in behaviour.

Previous work had split the volcaniclastic succession into an inferred edifice-construction sequence (Opunake Fm; 48-20 ka BP) and a sequence representing destruction (Stratford Fm; 80-48 ka BP). However, more detailed mapping now reveals a greater complexity of packages of deposits representing higher frequency cycles of growth and destruction, including two previously unrecognised debris avalanche events between 23-29 ka BP. Accumulation during constructional phases is marked by massive sequences of predominantly monolithologic lahar and hyperconcentrated flow deposits with intercalated andesitic Taranaki and TVZ tephra beds. Intervals of quiescence separating these eruptive periods are represented by paleosols and complex channels of reworked volcaniclastic sediments formed by intense fluvial erosion. In contrast, destructional episodes are represented by coarse polylithologic debris flow and debris avalanche deposits which form due to partial or complete failure of the edifice. Major debris avalanches bury extensive areas of the ring plain and reshape the landscape, while those related to small events are confined to channels.

A general model of a cycle begins with edifice destruction, which is followed by long-term production of ash - reflected in the formation of thick paleosols or tephra layers within lignites at distal locations. This period represents the time taken for the cone to grow to a size at which pyroclastic activity starts generating long-runout massflows. Edifice growth is ultimately limited to a critical point at which it fails. Past cones were probably similar to the current edifice, built primarily from voluminous unconsolidated pyroclastic deposits, making them susceptible to large-scale, deep-seated failures. Currently we appear to be near the end of the edifice growth phase.

Understanding the cyclic nature of this record, including redefining the number of cycles will be critical for developing realistic probabilistic hazard models. Forecasting models can be refined by considering not just return periods of debris avalanches but also the preconditioning of the edifice to failure, and the type and nature of other hazards at different parts of the cycle.

ORAL

Author Index