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ABSTRACTS

(Oral, plenary and poster)

(ORAL)

STRANGE PROVENANCE FOR JURASSIC SANDSTONES OF THE CLENT HILLS GROUP, CANTERBURY, NEW ZEALAND

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U-Pb ages for rims and cores of detrital zircons (n=70) from Late Jurassic fluviatile sandstones in Clent Hills Group at Haast Creek, Canterbury, reveal a strange pattern which is dominated by two components. The major component, c. 50%, forms a latest Carboniferous to Permian set at 310-250 Ma. However, there are no Carboniferous or Permian rocks in the immediate vicinity. Rather, the Clent Hills Group is, in most places, surrounded by Triassic Torlesse Supergroup sedimentary rocks, yet virtually no (<3%) Triassic zircons, 210-235 Ma, so characteristic of such greywackes, are present in the Clent Hills sample. There are no Jurassic zircons in the sample either, although they are a major component of Late Jurassic greywackes in the Pahau Group (Pahau Terrane) not far to the north. These features emphasize the isolation of the Clent Hills Group, having a provenance not shared with surrounding rocks, and strongly support the evidence for a tectonic contact, possibly quite major, with them. The minor component, c. 33%, is late Neoproterozoic-Ordovician, 650-450 Ma, a component frequently observed in Torlesse Supergroup greywackes, but typically forming a far smaller proportion, <10%. The origin of this zircon component is uncertain; the Cambrian-Ordovician part might be derived from the Ross-Delamerian Foldbelt of Antarctica and Australia, although achieving the unusual proportions, in relation to Torlesse neighbours, would be difficult. The absence of any Late Devonian-Early Carboniferous zircons, that might be derived from the intervening Lachlan Fold Belt, is also very surprising. The fluviatile character of the Clent Hills sediments, with tree-size logs and delicate leaf fronds suggests a very local provenance, and thus an easterly source, from the Campbell Plateau basement, is an interesting alternative possibility.

(PLENARY)

INTERPRETATION OF THE RADIOLARIAN FAUNAS WITHIN THE ACCRETIONARY PRISM OF THE WAIPAPA TERRANE, NEW ZEALAND

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The Waipapa Terrane is dominated by terrigenous greywackes with thin sequences of radiolarian cherts and hemipelagic green argillites, basaltic rocks and minor limestones representing an accretionary complex formed along the margin of Gondwanaland. A complete "oceanic plate stratigraphy" (Matsuda & Isozaki, 1991;Isozaki, 1996) of basaltic rocks, overlying pelagic cherts and hemipelagic siliceous mudstones, followed by trench-fill turbidites and/or sandstones is preserved in some of the imbricated slice packets of the terrane. Detailed dating of the cherts and hemipelagic green argillites provides information on age of the ocean floor and time of accretion.

A Japan / New Zealand collaborative group has been doing long term research (1995-2003) to clarify the facies, structure and ages of accretionary sequences of the terrane and establish faunal and stratigraphic correlations between terranes. Important new microfossil (radiolarian and conodont) faunas from the oceanic plate stratigraphy have been found at many localities in the Waipapa Terrane.

In the north, Mahinepua Peninsula and Arrow Rocks (Whangaroa Bay area, Northland) have yielded excellent radiolarian bearing sequences. Mahinepua section, which preserves the ocean floor stratigraphy, covers a sequence from pelagic (bedded chert) to hemipelagic facies (green and blue argillites) sediments, with overlying unfossiliferous clastics (massive sandstones). Pelagic bedded cherts are Late Permian to Early Triassic in age, whereas diverse, well-preserved radiolarian faunas from phosphatic concretions within the hemipelagites indicate a Middle to Late Triassic age. The Middle Triassic hemipelagic green argillites contain endemic high latitude faunas dominated by abundant species of the genus *Glomeropyle*. Manganese carbonate concretions from Middle Triassic maroon chert and siliceous mudstone of the Arrow Rocks section have also yielded well-preserved *Glomeropyle*-bearing faunas.

In the south (Auckland area) , ocean plate sections display analogous features. Late Triassic to Early Jurassic radiolarian faunas from bedded cherts at Waiheke Island, Kawakawa Bay and Pakihi Island are Tethyan (= low latitude affinity). On the other hand, Middle to Late Jurassic radiolarian faunas in green argillite successions at Kawakawa Bay and Ponui Island are dominated by high latitude radiolarians (genera *Stichocapsa*, *Obesacapsula* and *Spongocapsula* associated with Praeparvicingula).

In the Waipapa Terrane, paleobiogeographic affinities of green argillite radiolarians indicate high latitude conditions from Middle Triassic to Late Jurassic time. They also suggest that accretionary setting in the north and south are essentially similar. However, the accretion in the north is older (Late Triassic) than that in the south (Late Jurrassic).

(POSTER)

TAXOMORPH – AN INTERACTIVE CD-ROM FOR THE IDENTIFICATION OF RECENT SOUTH-WEST PACIFIC FORAMINIFERA

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A CD-Rom has been prepared to assist anyone wishing to identify modern foraminifera from the South-west Pacific region. At this stage it mostly includes shallow-water

(<200 m) taxa from New Zealand and eastern Australia, with fewer records from Antarctica and the tropical island groups. The first edition, now available, contains full information on 629 species. Data presented includes synonymies, classification, description, references, and notes on habitat, geographic and stratigraphic range. Every species has at least one quality SEM or light microscope picture, with more than one illustration for many species. The known geographic distribution of each species is shown on separate maps of Australia, New Zealand and the islands.

The database is fully searchable by author, genus, species or synonym name, but perhaps the most useful window is that which aids in the identification of species. Here the user has the option of choosing any combination of a number of shell features to produce groups of species to examine more closely before deciding upon an identification. Habitat and geographic choices can be included to assist in reducing the size of the resulting groups.

(ORAL)

HOLOCENE VEGETATION CHANGE AND ESTUARY INFILL IN WHANGANUI INLET, NORTHWEST NELSON, SOUTH ISLAND

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Whanganui Inlet, in north west Nelson, is an enclosed drowned river valley that has remained tectonically stable throughout the Holocene. The Inlet is 13 km long and 1-2 km wide and is characterized by an expanse of tidal flats that is exposed at low tide, therefore meaning there is little vertical accommodation space. The Inlet is relatively pristine with little human modification. This research aims to document the Holocene vegetation change and sediment infill during the evolution of Whanganui Inlet.

Seven vibrocores were taken from the **s**outhern half of the inlet, penetrating to a maximum depth of 5 m. Subsurface sediment is dominated by mud interspersed with layers of coarse sand and shells. Radiocarbon dating suggests that little sediment has accumulated during the Holocene with material at 2 m below the surface dating at 7 ka. Conversely two peat cores extracted from Mangarakau Swamp, adjacent to the inlet's southern margin, record more rapid accumulation with material at 7 m depth dating at 5.7 ka.

Pollen is well preserved in both the estuary and the swamp and records two scales of vegetation change. It is assumed that ~90% of pollen extracted from the vibrocores is stream borne (Peck, 1973). Hence changes in this pollen spectra represent changes in the inlet's hinterland. Peat cores however, record more local vegetation change around Mangarakau Swamp. Beech occurred adjacent to the inlet 5 ka but was present earlier in the hinterland 7 ka. Increases in beech correspond with declining rimu and matai forest. Peat cores record a dominance of wetland taxa, kahikatea, *Cyperaceae,* and manuka/kanuka, which is not registered in the inlet cores. From 5.7 – 3 ka a transitional zone between forest and swamp facies is present, which is represented by a high number of shrub and small tree taxa. Tree ferns are over-represented in the vibrocores and the quality of palynomorph preservation is less. Exotic pollen taxa are not found in the peat cores; however, vibrocores document the presence of pine in the modern pollen rain. A clear signature of human modification is not evident from the pollen record in either swamp or inlet cores.

References:

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(ORAL)

DEEP MAGMATIC PROCESSES IN SUBDUCTION SETTINGS: THE EXAMPLE OF A XENOLITH- AND GARNET-BEARING ANDESITIC SYSTEM IN NORTHLAND, NEW ZEALAND

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Andesite generation is one of the most complex petrological processes at convergent margins, and is an important contributor to the growth of the continents and the overall chemical differentiation of the Earth. An understanding of andesite genesis involves elucidation of the relative roles played by the subducted lithosphere, overlying mantle and continental crust. This study investigates the rare occurrence of the Miocene xenoliths- and garnet-bearing metaluminous volcanic suite of the Northland arc best preserved at the Whangarei Heads and in Taipa. The suite comprises calc-alkaline high-MgO pyroxene- and hornblende-pyroxene andesites (HMA), low-MgO hornblende and biotite-hornblende andesites (LMA), and dacites. These rocks carry tholeiitic gabbroic xenoliths of high-MgO pyroxenites, hornblendites and pyroxene-hornblende gabbros (HMG) as well as of high-Al_2O_3 hornblende-, garnet-hornblende gabbros, garnetite lenses and anorthosites (HAG). Garnet and gabbroic xenoliths reveal a P-T environment of 10 kbar and 700-1000ºC, and thus provide an unique window into deep magmatic processes in a subduction setting.

The xenoliths provide an exceptional opportunity to study deep arc processes in an add-on approach from the bottom to the top of a subduction zone revealing three sequential petrogenetic processes that took place in the mantle wedge during the initiation of subduction. These are, (1) Primary melt generation through 10-15% partial melting of a hydrous, depleted spinel-lherzolite, induced by slab metasomatism (2) Magmatic underplating of a medium-K, Nb-enriched, high-MgO, Si-saturated arc tholeiite enriched in sediment-slab-fluid-derived Li, Pb, U, Ba and K at the mantle-crust interface (10kbar), and isobaric high-pressure fractionation leading to the suppression of olivine and plagioclase crystallization and the formation of HMG pyroxene-rich cumulates and garnet-bearing HAG derivative melts (3) a change of sediment-fluid-slab-flux into a sediment-melt-slab-flux causing infiltration metasomatism, mixing and hybridization within the underplating gabbroic sequence.

The andesites are a result of a progressive mixing between the fractionated HMG and HAG and the sediment-dominant slab-melts characterized by high Th and LILE. They form a "high-Th metasomatic forearc series" and share many petrological similarities with adakites and alkaline low-Ca boninites. However, they differ in the fact that the slab component did not interact with the primary mantle melt but with fractionated derivatives of such primary melts. A petrogenetic model for the deep arc crustal magma genesis of the Eastern Northland arc is proposed that involves an initial subduction of a young/hot oceanic crust with a strong sediment component.

(POSTER)

MAJOR- AND TRACE ELEMENT VARIATIONS IN MAGMATIC GARNETS: IMPLICATIONS FOR PETROGENETIC PROCESSES AT THE BASE OF THE MIOCENE NORTHLAND ARC IN NEW ZEALAND

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Rare high P-T garnets occur in the Miocene metaluminous xenolith-bearing andesite suite of the eastern Northland arc in New Zealand. Previous studies on selected andesite units described the garnets as cognate phenocrysts (Day et al., 1992). However, detailed re-investigation of the relationship between xenoliths, garnets and andesites of the entire andesite suite reveals that the garnets are xenocrysts and derived from the associated gabbroic xenoliths and garnetite lenses carried by the andesitic hosts.

Major- and trace element compositions of the garnets and related P-T estimates rule out both, a direct mantle and metasedimentary source. Instead, garnets are part of a high-Al_2O_3 gabbroic sequence (HAG) that is derived from underplating and fractionating hydrous, high-MgO arc tholeiite at the mantle wedge/lower crust interface during subduction initiation. Garnet crystallization was favored by a sediment-rich slab-flux into a shallow hydrous mantle wedge together with the successive high-pressure isobaric pyroxene crystallization from a hydrous, Si-rich shallow mantle melt that resulted in the generation of garnet-bearing HAG.

Major- and trace element variations in garnets reflect complex petrogenetic processes that took place within the HAG magma column at the base of the Northland arc prior to the development of the subduction system that produced the andesites. Four magmatic garnet types and their zoning pattern record (1) an isobaric fractionation process at 10 kbar and 800-1100ºC (type1 and type2 garnets), (2) an infiltration metasomatism at 10 kbar and 700-800ºC (oscillatory zoned type3 garnets), (3) resulting isobaric magma mixing within HAG as evidenced by composite garnets involving type1, 2 and 3 garnet compositions and (4) a subsequent mixing of the hybrid gabbros with more fractionated magmas at higher crustal levels at 8 kbar and 600-700ºC (type4). Composite garnets with type4 overgrowth on HAG derived type1, 2 and 3 garnets postdate the isobaric fractionation, infiltration and mixing processes that took place at deeper levels within the arc.

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(POSTER)

ONGOING STUDIES OF PLIOCENE SEDIMENTOLOGY IN THE HAWKE'S BAY REGION

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For the past four years the Department of Earth Sciences at the University of Waikato has been involved in studying the sedimentary record and diagenesis of the mixed siliciclastic-carbonate late Neogene rocks in the East Coast Basin, concentrating initially on the Pliocene deposits in the Hawke's Bay region.

A key aim of the project is to simplify the often complicated and over-subdivided nomenclature of the stratigraphy in this basin. This is being achieved through detailed geological mapping of different areas, linking key outcrop sections described by previous workers (e.g., Haywick 1990; Beu 1995), as well as petrographic analysis of selected sections.

Detailed analysis of the sequence stratigraphy of the Pliocene limestones and the associated thick sections of siliciclastic-dominated rocks, along with high-resolution studies of limestone diagenesis, have been undertaken by Vincent Caron (2002) in southern Hawke's Bay, and remain underway by Arne Pallentin in northern Hawke's Bay (in prep.; see Pallentin et al., this volume). From the detailed petrographic work, new ideas have emerged concerning the origin and depositional controls of these limestones in relation to global relative sea-level changes (Caron 2002; Caron and Nelson in press).

As part of their MSc theses, Bland (2001) and Graafhuis (2001) have studied and mapped the Pliocene strata in the Esk and Waikoau/Waikari River catchments in an attempt to resolve the stratigraphy in this remote part of central Hawke's Bay. For the past year, Kyle Bland has been expanding on the work by Bland (2001), Graafhuis (2001), Caron (2002) and Pallentin (in prep.) as part of his PhD project, and is mapping the Pliocene successions throughout the wider central and southern Hawke's Bay area (see Bland et al., this volume).

The Pliocene sedimentology project continues this year with two new MSc students, Rachel Baggs and Sarah Dyer, who aim to document the evolution, and map outcrop patterns, of Nukumaruan (Late Pliocene) limestone units in the region west and south of Napier and

Hastings cities. An important aspect of their work will be to try to resolve discrepancies in nomenclature between the limestone beds cropping out north and south of the Ngaruroro River.

(ORAL)

TRANSITIONAL EXTENSIONAL-CONVERGENT MAGMATISM AT REEVES BLUFF, SOUTHERN VICTORIA LAND, ANTARCTICA

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The Precambrian-Ordovician Ross Orogen at Reeves Bluff, southern Victoria Land, Antarctica, is characterised by predominantly subduction-related calc-alkaline plutonism, with subordinate adakitic and minor A-type magmatism. A similar style of plutonism is also recognised nearby in the Brown Hills area, although here subduction-related magmatism is 'calcic', rather than 'calc-alkaline'. This style of magmatism is markedly different to that observed to the north in the Koettlitz Glacier Alkaline Province (KGAP) between the Royal Society Range and Skelton Glacier, where predominantly alkaline magmatism, including A-type granitoids, nepheline syenite, and carbonatites were emplaced between 517 and 551 Ma. The KGAP suggests an extensional rather than compressional tectonic regime.

Calc-alkaline granitoids in Reeves Bluff are generally non-foliated, equigranular, biotite granites, although two smaller plutons of coarse-grained, biotite-hornblende granite and a granodioritic pluton are also recognised. Equigranular granodiorites with high Sr/Y contents, typical of adakite, occur on the eastern side of Reeves Bluff, and are interpreted to be the northern extent of the 515 Ma Cooper Granodiorite recognised in the Brown Hills area. Sporadic occurrences of a leucocratic granite showing weak A-type characteristics including high SiO_2, Na_2O+K_2O, Fe/Mg, Ga/Al, high field strength elements (HFSE), and low CaO, Ba and Sr, occur in two nunataks immediately northeast of Reeves Bluff. These rocks are interpreted to belong to the weakly A-type Foggydog Granite suite of the Brown Hills area, which has an age of 536 Ma, coeval with KGAP magmatism.

An age of 538 Ma was obtained for a calc-alkaline granodiorite at Reeves Bluff using (ELA) ICP-MS microbeam analytical techniques from 27 individual zircons. Subduction-related magmatism in this area is therefore coeval with extensional magmatism in the KGAP, and predates by 30-35 Ma the main pulse of subduction-related calc-alkaline magmatism in the Dry Valleys (DV1a) over 200 km to the north. Calc-alkaline magmatism between 521 and 542 Ma also occurs further south in the Central Transantarctic Mountains, which is consistent with the age obtained from Reeves Bluff. Further work is required to determine whether A-type magmatism in Reeves Bluff is related to the KGAP. Perhaps the shift from predominantly alkaline magmatism in the KGAP to predominantly calc-alkaline magmatism in Reeves Bluff marks a transitional zone between the southern extent of the KGAP and typical convergence-related magmatism typical of the Dry Valleys.

(ORAL)

SHORE PLATFORM DEVELOPMENT AROUND THE MIRAMAR PENINSULA, WELLINGTON

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The role of wave action, subaerial weathering and rock structure in platform development was investigated around Miramar Peninsula, Wellington. In Wellington platform morphology and width along the harbour and open coast are strongly controlled by wave action, with the widest platforms occurring on the more exposed sections of coastline. For example Shark Bay within the harbour has an average platform width of 14.59m, compared with 38.79m at Flax Bay on the open coast. The slope of the platforms can be directly related to the dominating formative process as no earthquake induced tilting has occurred on the Miramar Peninsula in the last few thousand years. Sixty four percent of the platforms had a seaward slope, indicating a dominance of wave action. Thirty one percent of the platforms were sub-horizontal implying that either subaerial weathering and wave erosion were having an equal effect on platform development, or another process such as platform orientation to dominate wave approach was occurring. The remaining five percent of the shore platforms has a landward slope, indicating that subaerial weathering was dominating the development of these platforms. However when inter-site variations over scales of 100's of metres were investigated it was found that platform widths are controlled by site specific factors such geology, rock structure and platform alignment to dominant wave approach. Shore platform development in Wellington is unique in that they have not developed from the continued erosion of a cliff face but instead have eroded horizontally and vertically into bedrock uplifted during earthquakes. The width of the contemporary platform is then able to expand through the continued erosion of the seaward edge of the older uplifted platform.

(ORAL)

LOOKING INSIDE QUARTZ: DEVELOPING SEM-CL AS A TOOL FOR PROVENANCE ANALYSIS

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Provenance analysis of detrital sediment is a key-method for tectonic reconstructions and basin interpretations, by identifying the sources of sediments preserved in basins, and linking sediments to sources that may now be fully eroded and removed by large-scale displacement and exhumation. Conventional provenance analysis includes petrologic composition of sediments, heavy mineral assemblages, and dating of detrital minerals. A relatively new tool in provenance analysis is Scanning Electron Microscopy cathodoluminescence (SEM-CL), which is an established mineralogic technique in the geological sciences. SEM-CL can be used on poorly luminous minerals such as quartz, which is the most common detrital mineral. So far SEM-CL in sedimentary petrology has mainly been used to distinguish between detrital quartz and authigenic quartz overgrowth in diagenetic studies. SEM-CL is different from conventional colour CL by providing high-resolution grey-scale images that allow identification of features that might be obscured in colour CL.

In the past detrital quartz has been of little use for sedimentary provenance studies. Standard petrographic microscopy allows the identification of quartz in igneous, metamorphic or sedimentary rocks, but does not easily provide information about internal structures of quartz grains or crystals except for differences in extinction (straight versus undulatory) and re-crystallization (mosaic quartz). Nevertheless, information about internal structures is available, using SEM-CL. Even if quartz is a low-luminescent mineral, SEM-CL can be used to identify internal structures in quartz like healed fractures, zoning, deformation, and various other patterns. Attempts to use colour CL of quartz for provenance analysis have been semi-successful in the past. Currently we are establishing an image data base of quartz SEM-CL images from a large variety of different rocks to characterize internal structures in specific lithologies. Of interest are not only quartz crystals from acid plutonic (granite, granodiorite etc) and volcanic rocks (rhyolite, dacite, ignimbrite etc), but also from metamorphic rocks with various degrees of deformation (schist, gneiss, mylonite). Similar lithologies are collected from different locations for comparison. Ultimately this information will be used for provenance analysis of detrital quartz grains in siliciclastic sediments and sedimentary rocks from unknown settings, in order to aid the interpretation of basin history and economic potential, especially of placer economic deposits.

(POSTER)

SEM-CL OF QUARTZ FROM THE HOHONU BATHOLITH, WESTERN PROVINCE, NEW ZEALAND

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Scanning Electron Microscopy cathodoluminescence (SEM-CL) can be used on minerals with relatively low luminescence, such as quartz, to reveal internal structures like deformation, zoning, fractures, and other patterns, which might not be visible with a standard petrologic microscope. We try to establish SEM-CL as a tool for provenance analysis, by identifying internal structures of quartz in specific source rocks.

First results are presented from a preliminary study of a suite of samples from the mid Cretaceous Deutgam Granodiorite. The Deutgam Granodiorite is part of the larger Hohonu Batholith that intruded Greenland Group rocks of the Buller Terrane in the Western Province of the South Island of New Zealand. Today the Hohonu Batholith forms an uplifted basement block adjacent to the Alpine Fault. The lithology is relatively homogenous throughout the Deutgam Granodiorite, but the rocks suffered differential amounts of deformation, depending on proximity to the Alpine fault. We analyzed a suite of samples that was collected across the intrusion. Samples collected in the NE, near Lake Brunner, show no macroscopic signs of deformation while samples from the SW end of the intrusion are distinctly foliated. This trend is reflected by quartz crystals showing straight or only slightly undulatory extinction in the NE of the intrusion, while quartz crystals are re-crystallized, mosaic, and elongated with sub-grains in the SW section of the intrusion, closer to the Alpine Fault. SEM-CL analysis of the same samples reveals that quartz crystals in the un-deformed part of the Deutgam Granodiorite show two generations of healed fractures. With increasing degree of deformation the fractures partly disappear, while some samples in the intermediate range show indication of shear. In re-crystallized quartz patchy CL patterns become more prominent, which are independent of the mosaic texture of re-crystallized quartz. Sub-grain boundaries are visible with SEM-CL, but the overall CL properties do not change considerably between sub-grains. Re-crystallization seems not to introduce a major chemical change in the quartz crystals as their luminescence depends on trace element concentrations in the crystal structure, and the overall luminescence does not change considerably. On-going research will address this and other aspects in more detail.

(ORAL)

CRETACEOUS – MID TERTIARY BASALTIC VOLCANISM IN NORTHERNMOST NEW ZEALAND.

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Basaltic volcanism is a dominant feature of the Cretaceous – Mid Tertiary geology of Northland. Tangihua pillow lava complexes enclosed in the Northland Allochthon form massifs covering much of north and central Northland. In the "Far North" pillow lava sequences form a major component of the Three Kings Islands and other islands now joined by tombolos to the Northland Peninsula.

Studies of individual pillow lava massifs show a range of geochemical affinities. The basaltic lavas of the Tangihua Complex are relatively homogeneous dominantly tholeiitic basalts with lesser calc-alkaline and minor alkaline affinities; lavas with both arc and back-arc signatures are present in the complex. Equivalent geochemical data from basaltic complexes in the Far North**,** have shown them to be distinct from the Tangihua Complex rocks and the Far North pillow basalts also appear to be para-autochthonous.

Individual pillow basalt "islands" outcropping along the Far North tombolo and on Three Kings Islands cluster into two geochemical groups. One of these groups is the basaltic pillows in the Mt Camel terrane, a quasi-conformable continental shelf sedimentary sequence ranging from Cretaceous to early Tertiary. Mt Camel terrane basalts have a distinct geochemistry with a clear continental arc signature. Other Far North pillow complexes also have subduction signatures but differ in their minor element geochemistry from both the Mt Camel and the Tangihua basalts.

Early workers in the region (eg Hay) considered the pillow basalts in the Far North to be different to those elsewhere in Northland and mapped them as different units. However, more recent workers have assigned all the Northland pillow basalt complexes to one unit: the Tangihua Volcanics. Our work suggests that the Far North pillow complexes are indeed distinct and should not be assigned to the allochthonous Tangihua Complex. However, there are several petrogenetically distinct types (and ages) of Cretaceous – early Tertiary basaltic volcanics in the Far North. While some should be assigned to the Mt Camel terrane others probably represent on land examples of the complex volcanism recorded by dredging from the Three Kings Ridge and the area immediately north of New Zealand.

(POSTER)

NEOGENE SEDIMENTOLOGY OF HAWKE'S BAY BASIN

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Traditional geological maps are paper-based physical products limited in the information they can portray by the scale of the map. They summarise the basic structure and distribution of Earth materials and the resources they contain. Geographic Information System (GIS) technology allows for more comprehensive and flexible data management, and for the representation of a multitude of individual or collective properties in either digital or printed forms at various scales.

This PhD project (K. Bland) aims to document the sedimentary and subsidence history of the Hawke's Bay forearc basin. The study has a wide range of input data sources, covers a large geographical area and requires a high level of data organisation and analysis. These requirements are most effectively achieved through the utilisation of digital Geographic Information Systems.

Data for this project are being collected through intensive fieldwork in Hawke's Bay. Numerous sections are being stratigraphically logged and fossil and rock samples are collected where possible. While a facies approach to geological mapping is being employed, the identification and mapping of cyclothemic strata is being undertaken where possible.

The database model used in this study is aligned with the one used by the QMap programme at IGNS (Rattenbury *et al.* 1994, *IGNS science report 94/42*; Rattenbury and Heron 1997, *IGNS science report 97/3. 52p*). Additional features have been added to accommodate data specific to this project. The PhD database will be able to be incorporated into the IGNS QMap database, from which the new 1:250 000 scale Hawke's Bay geological map sheet will be derived as one output.

All data pertinent to this project are stored in a Personal Geodatabase using ARC/INFO 8.2 which organises data into a hierarchy of objects. This database contains Feature Datasets which group features with the same spatial reference and with similar themes (for example "Geology"). Each Feature Dataset contains a number of Feature Classes (e.g. "Geological Units"), which are collections of features with the same type of geometry and attributes.

The most significant output from this project will be the GIS database. It will be able to be extended in the future and used for all types of geological analysis, including the representation of specific features on paper-based maps or in digital form at various scales for a multitude of purposes. The power of producing a database such as this one lies in the many derivative products and analyses that will result from it.

(ORAL)

SEDIMENT GEOCHEMISTRY OF THE WAIHI MINING DISTRICT, WAIHI, NEW ZEALAND

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The former Golden Cross Mine (located 8 km NW of Waihi, Coromandel, NZ) was a gold mining operation that placed significant emphasis on environmental management over its seven years of operation. An assessment of the influence of mining on stream sediment chemistry has been conducted in the drainage catchment: the Waitekauri Valley. Trace metals analysed include Fe, Mn, As, Cu, Pb, Zn, Cr, Cd, Ni, Ag, and Se.

Trace metal concentrations within the Waitekauri Catchment generally fall below the ANZECC and ONTARIO sediment quality guidelines. However, elevated As levels have been recorded in the Upper Waitekauri River and Battery Stream, exceeding guideline values. Elevated levels of Cu, Pb, Zn and Cd were found in the Huanui Stream, a tributary of the lower Waitekauri River. The presence of these metals reflects the influence of past mining operations within the valley, spanning the last 100 years, and active or recent drainage from old mine adits and portals. At a number of sites Mn concentrations also exceed sediment quality guidelines, which may be due to drainage from the remediated site but this has yet to be confirmed.

The Golden Cross Mining Project does not appear to have increased stream sediment contamination levels. An overall decrease has occurred in the concentration of most metals in sediments of the Upper Waitekauri Valley, since 1987. This is believed to reflect one or all of the following factors:

1. Effective site discharge control while the mine was operational
2. Dewatering of the Golden Cross Project area reducing flows from old workings
3. Flash flooding events acting as a 'flushing' mechanism for the catchment

Slight differences in analytical methodology employed for the 1987 and 2002 surveys may also be a contributing factor.

(ORAL)

WHERE DO I COME FROM? FOURIER ANALYSIS OF AN EVOLUTIONARY LINEAGE OF LATE JURASSIC RETROCERAMIDS FROM AWAKINO TO PORT WAIKATO

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A morphologic study of variation utilising outline shape analysis is being used to infer taxonomic groupings among the *Retroceramus* species *R. galoi*, *R. haasti* and the forms that fall stratigraphically between, which have been variously identified in the past as *R.* cf./aff. *subhaasti*. Traditional palaeontological analysis has been conducted by way of visually assessing the specimens and defining the characters for species separation. Upper Jurassic retroceramids from the Awakino to Port Waikato area lack landmarks and other discrete characters, causing confusion in species separation. Because of this, classification must be based on characters that display continuous variation in many dimensions, such as shape and shell sculpture. Employing Fourier shape analysis, the study has attempted to quantify the differences between the two known species and establish groupings for the poorly understood intermediate forms.

Fourier shape analysis utilises the Fourier decomposition of the shell outline (as viewed in lateral projection) to produce a suite of independent variables that are agreeable to statistical analysis. The study focuses upon morphologic separation into broad groupings using shape analysis and then into finer groupings based upon rib spacing and changes with distance from beak. Statistical methods are employed to examine variation within and between stratigraphically and geographically discrete populations.

Results from the examination will enable future studies to determine if the intermediate forms are best grouped as one or more species, and in turn provide a better basis for Late Jurassic correlation, both locally and globally, as the ammonite fauna of the area is sparse.

(POSTER)

RESERVOIR PROPERTIES AND SEDIMENTARY FEATURES OF MT. MESSENGER FORMATION BASIN FLOOR FAN LITHOFACIES, NORTH TARANAKI

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Late Miocene (Tongaporutuan) Mt. Messenger Formation sediments are well-exposed in coastal cliffs of North Taranaki. Hydrocarbon production from sandstones of the Mt. Messenger Formation in the Kaimiro, Ngatoro, and Goldie fields to the south make the coastal section a useful analogue to study stratigraphic architecture, sedimentary features, and reservoir attributes.

Coastal sections at Tongaporutu and Mohakatino expose thick- and thin-bedded sandstone with interbedded thin siltstone. Foraminiferal faunas indicate deposition in lower to mid-bathyal settings. Sandstone is the dominant lithofacies, typically as amalgamated massive beds, with less abundant horizontal and ripple lamination. Outcrop and subsurface samples are moderately well sorted, fine- to very fine-grained sandstones, with porosities between 20-35% and permeabilities of 20-1230 mD. In both outcrop and subsurface settings the sandstones are feldspathic litharenites to litharenites. Sandstones have abundant primary intergranular porosity, and pores show little secondary clay. Diagenetic alteration is minor due largely to the degree of burial experienced by the formation.

Variable sand-silt proportions and sandstone bedding thickness, lateral continuity changes, and contrasting degrees of channelling characterise the outcrop. Texturally the sandstones are argillaceous and can be classified as clayey sandstones, muddy sandstones and silty sandstones. Thick-bedded successions display better communication than thin-bedded sandstone outcrop sections, where interbedded siltstones provide greater seal rock attributes. Broad channels occur in all sections, involving incision depths of several metres over lateral distances of tens of metres. In rare, but possibly significant cases, deep pipe-like features occur, which we suspect are at least in part seismically triggered extensional features.

Basin floor fan sandstones are interpreted as broad lobate sheet sandstones that represent deposition from a range of high-density sediment gravity flows. Thick-bedded sandstones are interpreted as the centralised portions of these lobes; and thin-bedded equivalents interpreted as lobe fringe facies. To date, production in Kaimiro and Ngatoro fields has not been from thick-bedded sandstones, though they display excellent reservoir qualities (sorting, porosity, permeability). The likelihood of prospective basin floor fan sandstones elsewhere however remains a distinct possibility.

(ORAL)

SILICIC-DOMINATED LARGE IGNEOUS PROVINCES AND VOLCANIC RIFTED MARGINS

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Large igneous provinces are commonly thought to represent short-lived (< 5 m.y.), high rate (0.1 - >1 km^3/yr), large volume (≥1 x 10^6 km^3) mafic eruptive events, related to continental break-up. Silicic volcanic rocks are associated with most, if not all, continental flood basalt provinces and volcanic rifted margins where they can form substantial parts of the eruptive stratigraphy and have eruptive volumes >10^4 km^3. However, there are examples of large igneous provinces that are silicic-dominated with low proportions of basalt expressed at the surface, and volumes comparable to that of mafic large igneous provinces. These silicic large igneous provinces are volumetrically dominated by ignimbrite and active over prolonged periods (up to 40 m.y.). The volcanic rocks typically show calc-alkaline affinities that resemble modern destructive plate margin volcanic rocks rather than bimodal or alkalic volcanism associated with continental flood basalts and continental rifts. Some silicic large igneous provinces are associated with continental break-up and followed by intraplate magmatism (e.g., Jurassic Chon Aike Province of South America, the Early Cretaceous Eastern Australian margin), whereas others are tectonically and geochemically associated with back-arc environments (e.g., Sierra Madre Occidental). Silicic volcanic rocks formed in these two environments are similar in terms of total eruptive volumes, dominant lithologies and rhyolite geochemistry, but show fundamental differences in tectonic setting and basalt geochemistry.

Large volume ignimbrites are the dominant silicic volcanic rock type of both mafic and silicic large igneous provinces. Individual silicic eruptive units can have thicknesses, areal extents and volumes that are comparable to, or exceed the most voluminous flood basalt lavas. Caldera complexes, with diameters typically 10-30 km, represent the main eruptive sources for the large volumes of silicic magma, and may range from regional sag structures to complex volcano-tectonic collapse structures controlled by tectonic stresses and pre-existing crustal architecture.

The largest volume silicic igneous provinces occur along accreted continental margins, in contrast to continental flood basalt provinces that have been emplaced on or adjacent to Archean cratons. Large volume silicic igneous provinces ultimately reflect large scale crustal melting processes in response to lithospheric extension and high thermal (± mass) input from underlying hot mantle. Partial melting of hydrous, mafic-intermediate composition (amphibolite) crust is critical in generating the large volumes of predominantly I-type silicic igneous melt. In these cases, subduction up to 100's m.y. prior to the emplacement of the silicic igneous province, seems crucial in producing a hydrous lower crustal source receptive to melting.

(POSTER)

REVISED MIDDLE TO LATE PALAEOZOIC TECTONIC EVOLUTION OF THE NORTHERN NEW ENGLAND FOLD BELT, QUEENSLAND

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The tectonic evolution of the New England Fold Belt (NEFB) during the Middle to Late Palaeozoic has previously been viewed as having persistent supra-subduction zone arc magmatism, such that the location of these magmatic arc belts have been an important reference frame for tectonic reconstructions. Our research, however, finds no evidence for arc magmatism within the northern NEFB except at the end of this period. In contrast, we recognise three main episodes of extension-related magmatism and accompanying sedimentation: 1) ~380-365 Ma; 2) ~360-340 Ma; and 3) ~320-280 Ma. Magmatism and sedimentation occurred in a broad 'back-arc' region, with any arc magmatism located further east, and at least during the Late Carboniferous-Early Permian, east of the present Queensland coastline.

In our model, Middle Devonian silicic-dominated magmatism preceded back-arc basin development along the continental margin. Magmatism varied from low-K+Al trondhjemite/rhyolite in the east (e.g., Mount Morgan), to medium- to high-K, I-type granitoids ~350 km to the west (Retreat Batholith). Mafic, effusive and hydroclastic volcanism then developed within the Yarrol Basin in eastern Queensland, previously regarded as a fore-arc basin. Mafic rocks range from basalt to basaltic andesite and vary in composition from N-MORB to crust-contaminated, 'arc-like' low-K tholeiites, being most similar to basalts associated with intra-continental rifting and back-arc basins. Dyke orientations and palaeocurrent data suggest that rift basins (Yarrol & Campwyn) developed along the plate margin were northeast-trending.

Renewed, silicic, to weakly bimodal magmatism ~360 Ma was related to the opening of the Drummond Basin, and was more voluminous and widespread, extending >400 km inboard of the present coastline. Extrusive volumes were >100,000 km^3. Rhyolite to high-silica rhyolite ignimbrites/intrusions are volumetrically dominant, with subordinate low-Ti basaltic and andesitic lavas/intrusions occurring along the northern and eastern margins of the Drummond Basin. The rhyolites are transitional in composition between destructive plate margin and within-plate magmas, similar to trends observed in other rift-related silicic igneous provinces (e.g., Whitsunday & Chon Aike provinces).

A voluminous, silicic-dominated magmatic and thermal event during the Permo-Carboniferous preceded the opening of the Bowen-Sydney Basin system. Silicic igneous rocks define a belt >1900 km long and ≥300 km wide, with extrusive volumes ≥500,000 km^3. Volcanic rocks are dominated by dacite to high-silica rhyolite ignimbrite related to a major continental caldera system. An extensive granitic batholith belt is preserved in central and northern Queensland, and dyke swarms developed over a distance of ≥1000 km along the margin. Igneous compositions become bimodal up-sequence with Early Permian mafic lavas including basalts with intraplate signatures.

Extension terminated with the Permo-Triassic Hunter Bowen Orogeny, which was accompanied by the first evidence for supra-subduction zone magmatism.

(ORAL)

EARLY CAINOZOIC HEXACTINELLID SPONGES (PHYLUM PORIFERA) FROM THE TUTUIRI GREENSAND, CHATHAM ISLAND, NEW ZEALAND

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Little is published on the fossil poriferan fauna of New Zealand. Although some sponge-like taxa are known from the Palaeozoic, there is still uncertainty about their taxonomic location. Several sponge body fossils have been recorded from the Chatham Islands, West Auckland and Port Waikato, although only one fossil sponge (*Pleroma aotea* Kelly, from the mouth of the Kakanui River in the South Island) has been formally described, and this is a lithistid (Kelly et al., in press).

The earliest record of sponges from New Zealand is by Hinde and Holmes, who in 1891 described an extensive fauna of spicule microfossils from Oligocene sediments near Oamaru. Similar fossils have since been described from the Tutuiri Greensand (Teurian – Waipawan) outcropping on the north coast of Chatham Island (Buckeridge, 1993). The majority of these are hexactinellids, comprising extremely delicate siliceous networks embedded in a friable or cemented brown-green grits and sandstones. The grit within and surrounding these skeletons contains numerous siliceous demosponge spicules but these spicules represent only a subset of the taxa described from the Oamaru district. Some of the spicules are extremely well preserved, and in those in which clear silica remains, inception canals are visible. Unfortunately many of the spicules have become opalised and these finer details are obscured.

The Tutuiri collection is remarkable in that the body skeletons are exclusively those of hexactinellid sponges. Further, the taxa are very similar to those living on the Chatham Rise at depths of between 200-2000m. This depth is not incompatible with the inferred depositional environment for the Tutuiri Greensand, which based upon foraminiferal and sedimentological data, is concluded to be mid to inner shelf (Campbell et al., 1993). What is significant here is that late Palaeocene hexactinellids and lithistids, unlike some other invertebrate groups such as barnacles, have not significantly changed habitat during the Cainozoic.

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(ORAL)

THE NELSONIAN STAGE: A NEW EARLY TRIASSIC LOCAL STAGE FOR NEW ZEALAND?

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It is proposed that a new stage, the Nelsonian Stage, be introduced for New Zealand sequences of Early Triassic age. The base of the Nelsonian Stage would be defined by the first appearance of the ammonoid *Durvilleoceras* within sequences of the Maitai Group that are exposed in the Nelson and Southland regions of the South Island of New Zealand.

The present 1:250,000 geological mapping of New Zealand in the Qmap Programme and the Geological Timescale Programme (Institute of Geological and Nuclear Sciences; GNS), have generated renewed attention to the definition, retention and use of time-stratigraphic units (stages). Consultation within GNS and the wider geological community indicates continued interest and support for local stages on the grounds that they are practical mapping units, based on sufficiently abundant locally occurring fossils (whose global correlation may remain imprecise). Accordingly, a new Early Triassic stage is deemed desirable.

The Nelsonian Stage would include sparsely fossiliferous New Zealand Triassic sequences that are correlated with middle Induan to earliest Anisian age. This represents a period of about 5 million years, taking the middle Induan at 248 m.y. and earliest Anisian at 243 m.y. In terms of local New Zealand stages, the Nelsonian Stage would occur above the Makarewan Stage (D'Urville Series) and below the Malakovian Stage (Gore Series). The Nelsonian Stage would be attributed to the exclusively Triassic Gore Series. The base of the Nelsonian would be defined by the first appearance of *Durvilleoceras* within a type section located at Iron Pot Point, western coast of D'Urville Island. This section is located within Greville Formation, Maitai Group, Dun Mountain – Maitai Terrane. *Durvilleoceras* is known from four different sections within Greville Formation thus far. The Nelsonian Stage would be represented by sequences within at least six tectonostratigraphic units in New Zealand: the Western Province (Parapara Group), and the Rakaia, Caples, Waipapa, Dun Mountain - Maitai and Murihiku Terranes of the Eastern Province.

In terms of scientific language, the Nelsonian Stage would provide appropriate recognition of the presence of a significant succession (>2,500 m) of marine sedimentary rocks in New Zealand that are representative of Early Triassic time.

(ORAL)

TRANSFORMATIONS IN THE TEXTURE AND MINERALOGY OF SILICEOUS SINTER DURING ITS MATURATION, NORTH ISLAND, NEW ZEALAND

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The Taupo, Northland and Coromandel regions have recorded surface manifestations of geothermal systems since the Miocene. In particular, more than four dozen siliceous sinter deposits are known. A preliminary study of low-temperature sinter facies from global locations allowed construction of a sinter aging model, showing concomitant changes in both mineralogy and textures (Herdianita et al., 2000). Specifically, silica phase transformations of sinter follow those reported for wood petrification and diagenesis of siliceous marine sediments: noncrystalline opal-A transforms to paracrystalline opal-CT and/or opal-C, and then to microcrystalline quartz plus moganite. This transformation requires moisture, and is affected by factors such as the presence of other minerals, organic matter, heat, and time. Unassisted, the complete change appears to be accomplished within 30,000 to 40,000 years.

Subsequent detailed studies of specific New Zealand sinter deposits along faults and in drill-core show the same pattern, with mineralogic transformations captured “frozen” in stratigraphic succession. Increases in structural ordering of silica during sinter diagenesis, revealed by X-ray powder diffraction (XRPD), are accompanied by progressive reductions in porosity and water content, and an increase in particle density. Textures change at a micro-scale from an initial starting point of freshly deposited, noncrystalline, smooth spheres of opal-A to paracrystalline, opal-CT bladed lepispheres. Paired SEM/XRPD observations indicate that the spheres undergo dissolution, micro-hole development, and subsequent unfolding. The sphere remnants then fragment and collapse into sub-horizontal piles of hexagonal silica platelets. These platelets subsequently gather into more closely packed blades situated sub-normal to surfaces, and arrange themselves into typical opal-CT bladed lepispheres. The next steps in sinter maturation, from opal-C to microcrystalline quartz, occur along either fibrous or granular morphological pathways. Biotic and abiotic inclusions (e.g., microbial filaments, plant moulds, sinter fragments, peloids, pisoids) are commonly well-preserved in sinters of varying ages, although patchy obliteration of primary textures has occurred in post-depositional fabrics, such as massive, mottled, diffusely layered, quartzose sinter. Consequently the aging of silica sinter recorded in the North Island’s geothermal areas provides a series of taphonomic windows within a continuum of mineralogic and textural change.

This type of paleoenvironmental-diagenetic approach is useful for reconstructing biogenic vs. abiogenic signals in these and other extreme environments in the geologic record.

(ORAL)

PREDICTING PATHWAYS AND TIMING OF CARBONATE DIAGENESIS IN NON-TROPICAL LIMESTONES IN RELATION TO PATTERNS OF RELATIVE SEA-LEVEL CHANGES

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Vertical changes in thickness and depositional facies through Pliocene non-tropical limestones in eastern North Island (Hawke’s Bay), and fundamentally the position and nature of internal bounding discontinuities, have enabled identification of transgressive (deepening-upwards) and transgressive-regressive (deepening- then shallowing-upwards) sequences within the studied deposits.

These variably consolidated carbonates bear a remarkable array of diagenetic features that are assigned to a wide spectrum of environments involving marine, meteoric, and burial influences.

The Pliocene limestones in central Hawke’s Bay serve to introduce some properties of diagenetic processes and their products in cool-water, predominantly calcitic, carbonate systems, and to illustrate the potential of such systems to translate regional and more global environmental changes, which also control the formation of sedimentary sequences, into distinct diagenetic patterns.

Thus, we demonstrate that vertical changes in the type and degree of diagenesis through discontinuity-bounded sediment piles outline patterns of pre-compaction (i.e., prior to burial at depths triggering mechanical compaction) diagenetic suites that relate intimately to patterns of vertical depositional facies trends, hence providing the opportunity to integrate the diagenetic evolution of cool-water carbonates into a scheme of relative sea-level changes.

We present a series of predictive sequence stratigraphic-based diagenetic models that should be useful to assess the timing of diagenetic processes resulting in porosity alteration, and both their relation and contribution to the building-up of sedimentary sequences, and their internal components (i.e. systems tracts).

(ORAL)

NEW ZEALAND'S OCEAN IN A WARMING WORLD - 21,000 B.P. TO 2100 A.D.

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Since the last glacial maximum (LGM), the circulation and water mass structure around New Zealand has responded to climatic and oceanic changes at time scales of millennia to years. As climate warmed and sea level rose, the coastal current system reorganized. Along-shelf currents moved shorewards, tidal raceways formed through the drowned Cook and Foveaux straits, and wind-forced coastal currents weakened with the ameliorating climate. In the open ocean, subtropical waters and the bounding

Tasman and Subtropical fronts shifted south by as much as 5^0 latitude. The Tasman Front migration enhanced the warm inflow along eastern North Island, and ~ 8 ka, subtropical waters became the dominant water mass north of Chatham Rise. The Subtropical Front also migrated ~ 4-5^0 down western South Island, but in the east its movement was restricted to within 1-2^0 of Chatham Rise by currents along the rise flanks. In Subantarctic reaches, the reduced windiness of the deglaciation is reflected by a less energetic Antarctic Circumpolar Current, and reduced inputs of cold Subantarctic waters and icebergs to central New Zealand. Ocean warming and sea level rise were not steady linear processes, but were punctuated by major pauses and reversals, one of which correlates with the Antarctic Cold Reversal of 14.5-12.5 ka. A further change in shelf sedimentation around 4-3.5 ka, is interpreted as response to increased storminess, possibly under renewed ENSO activity.

With these past changes in mind, how is the New Zealand ocean expected to behave in a rapidly warming world? Over the past century, the global average increase in sea surface temperature was 0.6^{0}C. A similar change is recorded off New Zealand, but it is masked by strong oscillations associated with ENSO events. Warming fluctuated with steep rises punctuated by cooling phases such as occurred between 1978-1995 - a period of strong ENSO. Models predict ENSO to continue at present or slightly higher levels into 2100, although such activity may be modified by the 20-30 year Interdecadal Pacific Oscillation. Such strong west (El Niño) and east (La Niña) signals will also influence coastal currents, ocean productivity, and the inputs of freshwater and sediment to the shelf. Models also suggest faster warming in the north than south of New Zealand that will cause a general increase in westerly winds. Although masked by a strong variability, sea level has risen by 1-2 mm/yr over the last century, and is predicted to rise 3-5 mm/yr into 2100.

(ORAL)

THE MID-TERTIARY TE KUITI GROUP IN THE VICINITY OF AOTEA HARBOUR: UNRAVELLING LITHOSTRATIGRAPHIC RELATIONSHIPS

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The mid-Tertiary Te Kuiti Group (TKG) comprises predominantly carbonates and mixed siliciclastic-carbonate facies presently assigned to 9 formations and 23 members in western North Island, cropping out from Port Waikato in the north to Mokau in the south. From a formational viewpoint the region can be divided into three zones based on geographical and lithological characteristics. The Aotea region lies within the central zone which has been acknowledged by several workers to be the transitionary link between distinctive northern and southern stratigraphies.

Excluding localised basal coal measures, the overall transgressive sequence involves low- to high-energy shelf deposits having temperate-latitude skeletal attributes. Sedimentation continued for about 13 million years throughout the Oligocene (Whaingaroan [Lwh] and Duntroonian [Ld]) into the earliest Miocene (Waitakian [Lw]). Equivalent strata crop out in Northland, Coromandel, Northwest Nelson, West Coast, Canterbury-North Otago and Southland. Offshore equivalents (Taimana, Tikorangi, Otaraoa and Tangaroa formations) are locally important reservoirs within the Taranaki oil field.

The regional lithostratigraphy of the TKG has been addressed by at least 18 workers, beginning with Hochstetter (1864). Up until the 1950 classifications were restricted to nine members within established geographical locations, examples being “Whaingaroa Claystone” and “Aotea Sandstone”. Early attempts were made to correlate lithologies throughout the extent of the TWG, forming the foundation of present-day nomenclature.

More recent studies [e.g., Kear & Schofield (1959), Nelson (1978), Kear (1966), Waterhouse (1978), White & Waterhouse (1993)] have resulted in the present lithostratigraphic classification wherein many of the original units have been designated formation status to which 23 members are assigned. However, all of these researchers acknowledge on-going problems concerning our understanding of depositional systems and litho-correlations for the TKG.

Likewise, fieldwork in this study identified ambiguities within published stratal correlation schemes. Certain units, having been assigned a particular name on the basis of field characteristics, are variably diachronous and do not conform to straightforward stratigraphic positioning throughout the TKG region. Techniques utilised to help resolve these problems have been detailed section logging, mapping, textural analyses and dating of key units.

This presentation describes the lithostratigraphy, chronostratigraphy and allostratigraphy of the TKG within the Aotea Harbour region. Key lithologies are described along with the problems and difficulties associated with stratigraphic correlation within the TKG basin. A review of TKG nomenclature evolution and its compliance with international stratigraphic codes is also mentioned.

(ORAL)

CLIMATIC YO-YO-ING OF THE SUBTROPICAL FRONT, 0-0.38 MA: ODP SITE 1119, SOUTHWEST PACIFIC OCEAN

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ODP site 1119 is located at water depth 396 m near the subtropical front (STF), and just downslope from the shelf edge of eastern South Island, New Zealand. The site contains an expanded stratigraphic record of Southern Ocean Quaternary oceanographic change, the younger part of which correlates closely with the climatic history contained within the Vostok ice core. Four palaeoceanographic proxy measures vary in consonance with the main lithological glacial-interglacial cyclicity at the site. Interglacial intervals are characterised by high □^{13}C and colour reflectance (a proxy for carbonate content), and low γ-ray (a proxy for clay content) and δ^{18}O; conversely, glacial intervals exhibit low δ^{13}C and reflectance, and high gamma ray and δ^{18}O. Early interglacial intervals are represented by silty clays which enclose intervals of 10-65 cm thick, sharp-based, *Chondrites*-burrowed, shelly, graded, very fine sands. The sands are rich in foraminifers, including species of warm water affinities, and were deposited distant from the shoreline under the influence of longitudinal flow in relatively deep water, as the palaeo-STF passed shorewards across the upper slope. The enclosing glacial units, which comprise mostly micaceous silty clay, though with some thin (3-25 cm thick) sands present also at peak cold periods, contain the cold-water scallop *Zygochlamys delicatula*.

The 1119 core records the seaward movement of the STF during glacial periods, accompanied by the incursion then of warmer subtropical water (STW) above the site, and landward movement during interglacials, resulting in a dominant influence then of colder subantarctic surface water (SAW). Intervals of thin, sharp-based, graded sands-muds occur within cold periods MIS 2-3, 6.2 and 7.4. These sands indicate the onset of intermittent bottom currents at times of peak cold, caused by strengthened frontal flows along an STF which lay east of site 1119, in relatively close proximity to seaward-encroaching subantarctic waters within the Bounty gyre. An important sequence stratigraphic implication of these data is that packets of sediment deposited below the lowstand shoreline are not necessarily separated by correlative conformities.

(ORAL)

CENOZOIC GEOLOGICAL EVOLUTION OF THE CENTRAL-EASTERN (TAUMARUNUI) PART OF KING COUNTRY BASIN

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The central-eastern part of the King Country Basin in the Taumarunui region contains an 800 m-thick sedimentary succession (Otaian to Tongaporutuan) that accumulated during several sedimentary regimes. Geological mapping at a scale of 1:50 000 has been completed and the distribution of four sedimentary formations and five ignimbrite units has been established. Map production is being undertaken on a GIS platform. The Early Miocene Mahoenui Group includes the basal Pungapunga Formation (new), Taumatamaire Formation and Taumarunui Formation. The Middle to Late Miocene Whangamomona Group is represented by the Otunui Formation in the field area.

Sedimentary analysis has identified 15 lithofacies types associated in 5 facies assemblages. Mudstone facies have accumulated at slope and bathyal paleoenvironments. Siltstone facies have accumulated in marginal marine, inner shelf and slope depths. Sandstone facies were deposited in marginal marine, shoreface and inner-mid shelf depths. Conglomerate facies are dominantly inner shelf and shoreface, while carbonate facies are solely inner shelf. The greatest range of lithofacies is present within the Pungapunga Formation and these can occur together or separately; however, the thickness of the formation never exceeds 20 m. This lithologic diversity in the Pungapunga Formation is due to the rapid transgression of the Otaian sea across an irregular landscape cut upon Mesozoic basement rocks.

Broadly there are two sedimentary megasequences present within the study area. Formation of the Australian-Pacific plate boundary during the Early Miocene resulted locally in the subsidence of the central-eastern King Country Basin and subsequent rapid transgression. Reverse faulting contemporaneous with movement on the Ohura Fault during the Altonian resulted in uplift, deformation and subsequent subaerial exposure and erosion of the Mahoenui Group, sourcing sediments to the Mokau Group in the west. Basin subsidence again occurred during the Middle Miocene with deposition of the Otunui Formation. Reactivation of faults with reversal of movement, now involving normal throw, probably occurred during the Late Pliocene. The Hauhungaroa Fault is the most prominent of these faults, with about 500 m of vertical throw. Several ignimbrite flows sourced from the TVZ have been deposited since about 1.6 Ma, capping hills (Ongatiti Ignimbrite) at 1000 m elevation and giving useful constraints on rates and volumes of Quaternary landscape erosion.

(ORAL)

THE NATURE AND DYNAMICS OF EXPLOSIVE ERUPTIONS AND ASSOCIATED CRATER FORMATION AT TAMA LAKES, TONGARIRO VOLCANO

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Tama Lakes, on the southern flank of Tongariro volcano, occupy craters thought to have formed in explosive eruptions about 10,000 years ago. Evidence for these eruptions can be found in three main deposit types; 1) a low, strongly asymmetric tuff-ring around the Lower (southern most) Tama craters, 2) a more widely dispersed thin sheet of tephra variably preserved over much of the national park area, and 3) a coarse ballistic block field around Upper (northern most) Tama Lake/crater. The aim of this research has been to determine in detail the nature and dynamics of the Tama eruptions, and establish the sequence of events involved in the formation of the Tama Lakes craters.

Detailed field and laboratory analysis has been undertaken on the complex sequences of pyroclastic deposits in the Tama Lakes area, including measurements of the size, density, composition and distribution of the ejected material. Two contrasting depositional facies have been identified at proximal localities. Fines-rich, lithic-poor units commonly exhibiting cross-bedding and low angle truncations are the dominant products from the earliest phases of the eruptions. These surge-deposits are overlain by clast supported, lithic breccia units containing dense, angular blocks up to 3 m in diameter. Individual blocks often display spectacular asymmetric impact structures up to 1 m deep. Contacts between the two facies are very sharp and typically planar.

The surge facies is interpreted as representing vigorous, dominantly phreatomagmatic activity from multiple, closely-spaced vents. The low wallrock lithic content of this facies shows the level of magma-water interaction had to have been very shallow, and this feature, along with the 'wet' character of the surge facies beds, suggests the involvement of initially abundant surface water.

The lithic breccia facies records significant changes in the nature and dynamics of the Tama eruptions. Beds of this facies are the product of deeper interaction involving a retreating magma column and limited ground water. Steam explosions quarried out country rock, ejecting material on ballistic trajectories, and contributed significantly to crater development.

Further analysis and interpretation of the deposits aims to determine more precisely the changes in water: magma ratios during the eruptions, and establish the timing and mechanisms of crater formation and modification.

(ORAL)

BURIED LAKE SEDIMENTS IN A NICKEL MINE, SOROWAKO, SULAWESI SELATAN, INDONESIA

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Geotechnical borehole investigations and mining excavations have revealed a buried sequence of alternating alluvial and lacustrine sediments within a nickeliferous laterite soil profile adjacent to Lake Matano in Sorowako, Indonesia. The sediments, previously undocumented, are significant in the understanding and assessment of stability of man-made and natural slopes. The deposits encountered were >30 m thick and irregularly distributed across the mine site both laterally (5 km) and vertically.

The sequence comprises a basal alluvial conglomerate, derived from several peridotite sources. The conglomerate grades into a finer grained sequence of interbedded sandstones and siltstones, which in turn grade into a lacustrine sequence comprising multicoloured thinly-bedded, highly fissile, fossiliferous muds, and peat lenses. The muds are overlain by a coarsening- upwards layer of crossbedded silts and sands, and a polymict conglomerate derived from a catchment area with a wider diversity of lithologies than that of the lower peridotite conglomerate.

A sequence of residual soil cover overlie these deposits (up to 30 m thick), and resembles a typical laterite soil. Only through subtle colour changes within the soil in an openly excavated setting can one distinguish between a colluvial soil, typical laterite soil, and a sedimentary-derived soil.

The peat lenses within the lacustrine sediments lie beyond the range of carbon dating. The units were therefore only tentatively dated from residual soil cover calculations as about 1 Million years.

At present, several small lakes lie within down-faulted depressions, possibly controlled by offsets from the locally active Matano Fault, which forms the nearby Lake Matano. These lacustrine and alluvial sediments occur intermittently across the mine site. Those within the Anoa North mining-disposal area are considered to be derived from a small lake and are inferred to have formed as a result of localised tectonism.

Groundwater within the residual soils overlying the lacustrine sediments is perched. This contrasts with adjacent areas where residual soils were typically free-draining into the underlying rock. The sedimentary sequence and associated perched groundwater table have significant risks for stability of cuts and stockpiles at the site.

(POSTER)

NEW ZEALAND QUARTZ ARENITES: OUR OWN PRIVATE MYSTERY

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The internationally accepted view of the formation of quartz arenites is often problematic when attempting to apply the same processes to their New Zealand equivalents. Quartz arenites are generally considered to originate from cratonic provinces or recycled orogens, yet New Zealand had neither of these tectonic regimes during the late Mesozoic to mid Cenozoic, when most of New Zealands quartz arenites were deposited. There is little published about New Zealand quartz arenites, but considering our lack of cratonic or recycled orogenic sources prior to the Miocene, we are more likely to have 1st or 2nd cycle deposits. Many New Zealand quartz arenite deposits are associated with coal measures, which could provide the intense chemical weathering necessary to remove most of the feldspar. Coal measures are relatively common in New Zealand from the Late Cretaceous to Miocene and a link between peat bogs and quartz arenite formation is logical.

Generally, quartz arenites are considered texturally mature, enriched in monocrystalline, non-undulose quartz, well rounded, well sorted and containing sedimentary structures. The Oligocene Coleridge Formation sandstone presents a provenance and depositional challenge, as it is not a typical quartz arenite by that definition. The Coleridge Formation is a member of the Porter Group, located west of Christchurch. It comprises a white, massive (only two examples of vague, low angle cross bedding), moderately sorted, rounded to angular grained, marine quartz arenite, with one metre thick muddy units at irregular intervals. Analysis has shown the majority of grains to be monocrystalline undulose quartz, with 2-4% polycrystalline, both indicative of a metamorphic source. Feldspar analysis shows ~5% alkali feldspar with 1-2% plagioclase feldspar; microcline and orthoclase dominate with minor amounts of albite (untwinned and unzoned). Both types of feldspar are found in metamorphic rocks, particularly untwinned, unzoned plagioclase, however, both may also be found in plutonic and volcanic rocks. Lithic grains often provide conclusive provenance data, as they are intact fragments of the source rock. The Coleridge Formation contains trace amounts of chloritic schist. Glauconitic grains are scattered throughout the Formation, which previous researchers suggested were reworked from the underlying Ironcreek Greensand. Thus two sources are indicated, a 1st cycle metamorphic source and 2nd cycle source from reworked underlying formations. Grain textural analysis also supports two separate source areas, one supplying a distinct population of coarse, rounded quartz grains.

Provenance analysis studies of quartz arenites in New Zealand need to consider the lack of a cratonic or recycled orogenic source area during a large part of its history, and look more closely at environments that can produce intense chemical weathering. The acidity in peat bogs can produce the chemical weathering required to form 1st cycle quartz arenites, possibly in a relatively short time span. However, the Coleridge Formation sandstone is difficult to explain by these methods, as it is marine in origin, as evidenced from scattered microfossils. Lack of sedimentary structures and moderate sorting makes the depositional environment difficult to place, but an inner to mid shelf setting is considered likely. The quartzose nature of the Coleridge Formation suggests that both textural elements involved intense chemical weathering between source and deposition.

(POSTER)

NEOGENE PALAEOCEANOGRAPHY BASED ON STABLE ISOTOPE STRATIGRAPHIES FROM THE SOUTHERN TASMAN SEA (SITE 593), SOUTHWEST PACIFIC

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Climate change and its effects on ocean circulation can only be monitored in ancient sediments using proxy parameters. Stable oxygen and carbon isotopic records for benthic and planktic foraminifers are presented from DSDP Site 593 to illustrate major palaeoceanographic changes in the southern Tasman Sea over the past 19 m.y. The Neogene core sediment comprises mainly nannofossil ooze from 19-5 Ma, and foram-bearing nannofossil ooze with occasional tephra layers from 5-0 Ma.

Presently the Site 593 seabed is bathed by Antarctic Intermediate Water, with the benthic *Cibicidoides* and *Uvigerina* data recording its Neogene equivalent, Southern Component Intermediate Water (SCIW). The planktic *Globorotalia miotumida* record is interpreted as a mode water signal (Southern Component Mode Water - SCMW), and the *Globigerina bulloides, Globigerina woodi*, and *Orbulina universa* records as surface water signals, equivalent to modern Cool Subtropical Water (CSTW).

The benthic δ^{18}O record contains the globally-recognised extreme glacial episodes, Zones Mi1b to Mi6, identified for the first time in intermediate water data. These events are also recorded in the planktic records, a covariance that indicates both surface and intermediate waters were responding to global climatic cooling and ice volume increases. Middle Miocene Zones (Mi2 to Mi5) indicate the SCIW response to these glacials was a combination of initial ice volume increase with some associated cooling. Unlike other records, the plateau-like nature of these Zones indicates that the SCIW maintained comparable cooler water temperatures prior to the next Mi glacial event. However, Zone Mi6 appears as a single-point event. The interval from 5 to 3.8 Ma exhibits reduced amplitude fluctuations, related to the Early Pliocene Warm period. From 3.5 to 0 Ma δ^{18}O amplitudes increase, interpreted as the result of Northern Hemisphere ice sheet development.

Early to Middle Miocene globally-recognised carbon maxima (CM) events CM1 to 7 are evident in the records, associated with the Monterey Excursion. The δ^{13}C data indicate that the CM events correspond with Mi glacials, except Mi6 which is associated with a carbon minima. The Messinian Carbon Shift is tentatively placed ending at c. 6.45 Ma, in keeping with other records from the southwest Pacific. The high absolute benthic δ^{13}C values are linked to thermodynamic tagging of the Antarctic surface water, from which SCIW is derived.

(ORAL)

SEDIMENTARY FACIES, PETROGRAPHY AND DIAGENESIS OF THE KAPUNI GROUP RESERVOIR SANDSTONES IN THE KAPUNI FIELD, TARANAKI, NEW ZEALAND

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Sandstone facies in the Mangahewa and Kaimiro Formations (Kapuni Group) provide the main reservoir units and still remain the principal exploration targets in Taranaki Basin wells. The potential of these sandstone facies to act as hydrocarbon reservoirs can be attributed to changes in environments of deposition and diagenesis with both time and space in the basin. To gain a better understanding of the reservoir architecture in the Kapuni gas/condensate field an integrated sedimentary facies (using core and well log data), petrographic and diagenetic model of the sandstone reservoirs has been developed.

Five lithological facies and twenty-four subfacies are identified in core available from the Kapuni Field. These lithological facies were then related to their corresponding log patterns and then extrapolated to uncored sections of the Kapuni Group. Based on core and log motifs a depositional environments model has been devised. The model demonstrates deposition of the sandstone reservoir facies in tidally influenced upper deltaic plain to lower deltaic plain settings within an overall transgressive sequence, during which changes in sea-level cause pronounced effects in displacing environments in either a landward or a seaward direction.

Petrographic studies of core samples from the various lithofacies show that reservoir quality variations in the sandstones are directly related to the diagenetic processes that have controlled porosity reduction and enhancement. Porosity has been reduced mainly by compaction, clay neoformation, pyrite cementation, carbonate cementation, quartz and feldspar overgrowths and enhanced primarily by grain dissolution and subordinately by clay and carbonate dissolution. The paragenetic sequence and timing of diagenetic events is complex in the Kapuni Group sandstone facies and involves multi stages of clay neoformation, feldspar dissolution and carbonate precipitation and dissolution. Provenance studies suggest that the Kapuni Group sediments were derived primarily from a granitic source with minor schist and altered acid volcanic source rocks also contributing. The most likely source is from the plutonic and metamorphic rocks cropping out in the Nelson area.

(ORAL)

LATE TRIASSIC STRATA FROM EAST TIMOR: - STRATIGRAPHY, SEDIMENTOLOGY, AND HYDROCARBON POTENTIAL

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Flysch-like facies rocks of Late Triassic age have been mapped in East Timor. Graded bedding, parallel and cross laminations, and scoured bedding surfaces are common in the interbedded alternating sandstone and shale succession, which forms the lower part of the sequence. Calcarenites, massive sandstone bodies of up 7 metres thick and polymict conglomerates become dominant in the upper part of the sequence. Extensive bioturbation and trace fossils (cf. *Chondrites* and cf. *Scalarituba*) are associated with these deposits.

Late Triassic rocks are included in the Aitutu and Wailuli Formations. The former is predominantly limestone (calcilutite) facies with minor shale-sandstone, whilst the latter is dominated by shale-sandstone with fewer marl-limestone and polymict conglomerates. Locally (northern limb of Aliambata and Bazol Anticlines), the Wailuli Formation extends down into the Late Triassic, but this name has been mainly applied to rock units of Early-Middle Jurassic age based on a sparse assemblage of ammonites and belemnites.

New evidence, however, indicates that much of the Wailuli Formation is of Late Triassic age on the basis of dinoflagellates and foraminifera, and macropaleontological studies. Ammonites, e.g., *Dimorphites fissicostatus timorensi*s (Welter), *Juvavites* sp., and *Anatomites* cf. *brochiiformis* (Welter), and halobias, e.g., *Halobia comata*, *Halobia* cf. *cassiana*, and *Halobia charlyana,* indicating a Carnian- Norian age have been recovered from marls and limestones. Consequently, we conclude that the Babulu Formation, which has been defined in West Timor as a flysch-like facies unit of Late Triassic age can be extended into East Timor to cover most of the rocks previously mapped as Wailuli Formation.

Sedimentology and geochemical studies indicate an abundance of organic matter that could be a source for hydrocarbons. Analysis of known surface oil seeps, both those oozing from outcrops of Triassic-Jurassic formations and from Tertiary-Quaternary units, suggests a marine organic source. The thick massive sandstones may be potential reservoirs.

Deformation associated with the collision between the Australian continental plate and the Banda Arc in Timor has extensively affected the strata. Fractures across bedding planes are very intense and could have acted as conduits for hydrocarbon fluid migration. Syn- and post-orogenic sequences and subsequent Late Neogene to Quaternary deformation and block faulting may have also produced stratigraphic and structural hydrocarbon traps.

(ORAL)

DATING A DINOSAUR: THE TIMES THEY ARE A-CHANGING!

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The New Zealand Geological Timescale Project was initiated by the Institute of Geological & Nuclear Sciences in 1995 and aims to achieve precision and accuracy in the definition, calibration and international correlation of the New Zealand geological timescale using as wide a range of techniques as possible. This project is now drawing to a close and it is time to take stock of progress made and challenges remaining. This talk will focus on the Cretaceous Period, but will touch on many issues common to the timescale as a whole.

Subdivision of geological time in New Zealand is still based on a sequence of local series and stages. Despite the oft-debated merits of abandoning these local units, they represent most natural divisions of New Zealand strata and remain the most useful tools for dating and correlating *local* events in *local* rock successions. In addition, however, it is clearly very important to identify biological, geochemical and geophysical markers in the local succession that can be used to correlate the New Zealand and international timescales.

The New Zealand Cretaceous timescale has been improved and updated using a range of techniques and approaches. For the late Early and Late Cretaceous, biostratigraphic resolution has been improved by between two and nine times through detailed studies of particular fossil groups and, in particular, the integration of data from different groups. The definitions of all local stages have been revised using this new biostratigraphic information and the stages have been correlated with the international timescale using new paleomagnetic data and radiometric dates. Attempts to use geochemical means of correlation (^{87}Sr) were unsuccessful. Lastly, highly resolved biozonations for the Late Cretaceous have been calibrated using quantitative biostratigraphic methods to yield a robust, quantitative subdivision of the interval from 85 to 65 Ma.

Despite all these advances, much of the Cretaceous timescale in New Zealand is understood at little more than reconnaissance level and there remains much scope for further study.

(ORAL)

BIOTIC CHANGES WITHIN AN EARLY CENOZOIC GREENHOUSE CLIMATE

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The early Cenozoic represents the longest period of global warming in the last 70 Ma and provides excellent opportunities to examine the short- and long-term consequences of greenhouse warming for biodiversity and biogeochemical systems. The Paleocene-Eocene boundary, at 55 Ma, is marked by a rapid and extreme episode of climatic warming during which deep ocean and high latitude surface temperatures warmed by 6 to 8°C. Referred to as the Paleocene-Eocene thermal maximum (PETM), this climatic aberration is thought to have been caused by abrupt release into the ocean-atmosphere reservoir of ~2000 gigatons of isotopically-light carbon derived from submarine methane hydrates. Associated with the PETM are numerous biotic changes, including a significant benthic foraminiferal extinction event[s]and notable diversification of planktonic foraminifera, calcareous nannoplankton and terrestrial mammal orders.

The research to be discussed in this presentation focuses on the response of surface-dwelling marine algae and terrestrial vegetation, as represented by dinoflagellate cysts (dinocysts) and spores and pollen, in the New Zealand region to this interval of extreme global warming. Profound changes in dinocysts during the Paleocene-Eocene transition involved one particular genus, *Apectodinium*. Coincident with the beginning of the PETM, *Apectodinium* species underwent a widespread proliferation and suddenly became dominant in dinocyst assemblages worldwide. This unparalleled marine algal event indicates a special set of environmental conditions involving elevated sea surface temperatures and nutrient availability. By contrast, initial records suggest that terrestrial vegetation in New Zealand was relatively unaffected by the intense warming and excess carbon of the PETM. Detailed records of the biotic response of primary producers, such as dinoflagellates and land plants, can provide further insight into the mechanisms and underlying causes of environmental change during this unique time interval.

(PLENARY)

SUBMARINE HYDROTHERMAL VENTING RELATED TO VOLCANIC ARCS

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Volcanic arcs that have a submarine component (n = 21) include both intra-oceanic and island arcs that combined total almost 22,000 km with ~93%, or just over 20,000 km, occurring in the Pacific region. We estimate the number of volcanoes known to occur along these arcs to be 693, with at least 206 (29%) being submarine. Less than 5% of arc length has been systematically surveyed for seafloor hydrothermal emissions. Submarine hydrothermal venting along these arcs therefore remains overwhelmingly undetected.

Plumes and vent fluids from arc sites are chemically heterogeneous in nature and in some cases highly enriched compared to MOR sites. They include liquid-plus gas-rich to liquid-poor but gas-rich types. Evidence for a magmatic component in arc vent systems is given by the nature and concentrations of various gases and iron.

The Kermadec arc extends for ~1,200 km northeastwards from New Zealand and forms the southern part of the ~2,500-km-long Tonga-Kermadec intra-oceanic arc system. At least 33 volcanoes occur along the Kermadec arc with all but one (Raoul Island) being submarine. The combined NZAPLUME I and II cruises of March 1999 and May 2002, respectively, have systematically surveyed ~840 km of the Kermadec arc including 26 major volcanoes and 8 smaller volcanic edifices. Ten of the volcanoes (38%) host active vent fields with Brothers and Healy each hosting two separate sites. In addition, both Curtis and Raoul islands host subaerial geothermal systems. Combined, this equates to a 'vent field' every 70 km of arc length.

Our surveys show, however, that venting is not distributed evenly along the Kermadec arc. For example, the southern 260 km of the arc hosts about one vent site every 33 km, while the next 520 km has none. Thereafter, the following 60 km of arc is host to 3 submarine vent sites and the subaerial geothermal system on Curtis Island. If we extend this another 110 km to include the geothermal system on Raoul Island, this mid-part of the arc also hosts one 'vent' site about every 34 km. At present it is unclear why parts of the arc are active and others are not, although this may relate to magma supply rates?

If the frequency of venting for the presently surveyed part of the Kermadec arc is projected worldwide for all known submarine arc volcanoes, this equates to 78 hydrothermally active vent sites. Considering the number of sites still to be discovered, this makes submarine arcs a potentially a very rich source of hydrothermal fluids and minerals.

(ORAL)

THE JUNCTION MAGNETIC ANOMALY IN THE AUCKLAND REGION

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The Junction Magnetic Anomaly (JMA), attributed to the Dun Mountain Ophiolite Belt at the junction of Murihiku and Caples/Waipapa basement terranes, is an important tectonic marker in New Zealand. Substantial sedimentary cover in the Auckland Region means basement composition and structure are poorly defined. A recently completed aeromagnetic survey of the Auckland Region, collected at an elevation of approximately 430m and with flightline spacings of between 0.25-1 km extends 50 km north - south across the Auckland Region. These relatively high resolution data allow better definition of the JMA and other magnetic anomalies in the Auckland Region. This study aims to constrain the structure, location and nature of the JMA source body in the Auckland Region and hence to interpret tectonic evolution of the Auckland region.

Data processing such as spectral filtering were used remove noise from the data and techniques such as a vertical derivative were used to resolve short wavelength features. One particular challenge is the separation of the JMA from anomalies associated with the Auckland Volcanic Field as both a spatial and spectral overlap occurs. Image processing techniques are used to enhance images produced and emphasise important features. The JMA is complex in the region, with a sinistral bend or offset, and consists of multiple lineaments.

Ground based magnetic and gravity data and physical properties of possible source material (Wairere serpentinite and xenoliths from St Heliers Volcano which have induced magnetic intensities in the ranges of 0.02-2.2A/m and 0.02-0.2A/m respectively) have been used to constrain 2.5D modelling of aeromagnetic data. Possible structural interpretations of the JMA in the Auckland region, including tectonic imbrication of magnetic material (the Dun Mountain Ophiolite Belt and ocean floor material within the greywacke terranes) and the role of basement faulting in the Auckland Region will be discussed.

(POSTER)

TOWARDS A DETAILED HISTORY AND PALAEOGEOGRAPHY OF THE ROTORUA BASIN

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The Rotorua Basin formed during and immediately after the eruption of the Mamaku Ignimbrite at c. 225 ka. Caldera-related faulting apparently ceased soon after effusion of intra-caldera rhyolite lava domes. Evidence for the oldest ancestral lake in the Rotorua Basin is found in borehole data and as localised outcrops in the Rotorua Geothermal Field where silicified lake, fluvial and carbonaceous sediments occur interbedded with at least two small-volume ignimbrites. Huka Group diatomaceous silts of younger age crop out in the Utuhina and Paradise valleys, in the north of the Basin, and on the south shore of Lake Rotoiti, and may represent beds deposited in earlier large lakes that extended throughout central Taupo Volcanic Zone. These early Rotorua lakes reached elevations of c. 350 m asl, i.e., c. 70 m above the present level of Lake Rotorua at c. 280 m asl.

Subsequent NNW-trending faulting allowed short-lived geothermal activity to begin in the Utuhina Valley and other regions to the south. NE-trending faulting then tilted sediments north of Paradise Valley. Tikitere Graben subsided and allowed the ancestral Rotorua lake to discharge to the north; associated peats were formed at elevations of c. 260 m asl.

Rotoiti Ignimbrite erupted at c. 55 calendar (cal.) ka, and covered most of the Rotorua Basin, blocking the lake's northerly drainage. Earthquake Flat Ignimbrite erupted immediately after, or contemporaneously with, the Rotoiti event and entered the Utuhina Valley from the south. The deposition of both ignimbrites, together with two major earthquakes, contributed to massive rates of sedimentation as Lake Rotorua rose to c. 380 m asl. Surface geothermal activity at Whakarewarewa and Lake Rotokawa began at about this time.

Lake Rotorua drained underground, its surface elevation being below 280 m asl, shortly before the eruption of Hauparu Tephra (?Unit F) eruption at c. 40 cal. ka, accompanied by a major hydrothermal explosion at Tikitere. Lake level then rose slowly, but was still below c. 320 m asl when multiple flow units of the Mangaone Tephra (Unit I) at c. 36 cal. ka entered the east of the basin. NNW-trending faulting resumed at this time, and still influences geothermal activity. Terraces east of the lake basin are constructed mainly of fluvial sediments derived from reworked Mangaone Tephra. Lake Rotorua briefly returned to an elevation of c. 380 m and extended about 8 km south of Hemo Gorge. The northern barrier failed shortly before distal Oruanui Ignimbrite entered the Basin at c. 26.5 cal. ka. Lake level then dropped below 270 m. Major NE to ENE faulting occurred in the west of the Basin, and accompanied extensive sedimentation of the Hinuera Formation during the Last Glacial Maximum (c. 25–16 cal. ka). The lake level rose and cut a cliff at c. 290 m when the drainage to the NE was blocked by lavas of the Rotoma (c. 9.5 cal. ka) and Mamaku (c. 8.1 cal. ka) eruptive episodes. Lake levels have since declined to the present at c. 280 m asl.

(POSTER)

STRATIGRAPHY AND SEDIMENTOLOGY OF THE EARLY-MID MIOCENE SEQUENCE, KING COUNTRY BASIN, NEW ZEALAND

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This MSc. thesis project aims to map the geology of part of the King Country Basin, and to describe the stratigraphy and depositional history within this field area. The study area encompasses parts of NZMS 260 S18 and R18 map sheets, with the western boundary being the Waitewhena

Valley Road, and the eastern boundary being State Highway 4. This field area is on the southern margin of the new Waikato QMAP Sheet, due for publication in 2005.

The application of a Geographic Information System (GIS) allows large amounts of data to be managed easily and effectively, and also allows for the representation of a large number of individual or group properties (geology, roads, site localities etc) to be displayed and relations between various properties to be shown. The geological mapping in this project is being undertaken in a GIS environment. Data are stored in a Personal Database using ARC/INFO 8.2, which will be incorporated later into the IGNS QMAP database, from which the new 1: 250 000 scale 'Waikato' geological map sheet will be derived as one product. The major part of this project is the production of the geological map and also the construction of the GIS database. This database will be able to be amended easily if needed, and will also enable quick and effective digital access to the geological data.

No basement is exposed in the field area, which lies wholly in early Miocene (Otaian Stage) Mahoenui Group, Mangarara Formation, and Otunui Formation, the latter two being of middle Miocene age. The Mahoenui Group comprises the Taumarunui Formation, characterised by flysch deposits, and the Taumatamaire Formation, which is a massive mudstone and overlies the Taumarunui Formation. These deposits represent rapid subsidence and basin formation, with accumulation in outer shelf to bathyal environments. The Otunui Formation conformably overlies the Mangarara Formation, which itself is unconformable on the Mahoenui Group. The Mangarara Formation is essentially an onlap transgressive succession, which deepens upwards into shelfal Otunui Formation. Quaternary Ignimbrites have a scattered distribution on hill tops in the study area.

(ORAL)

STRAIN DIRECTIONS AND HYDROCARBON RESERVOIR POTENTIAL, EAST COAST

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Stresses associated with the development of the Hikurangi subduction margin have produced fractures in lithologies with otherwise low permeability. Such rocks can form fractured reservoirs. Knowledge of the orientations of fractures with respect to present-day strain fields can help predict whether fractures are likely to be open at depth in exploration wells. Studies of East Coast fractures and strain directions will help us to model volumetrics and flow rates of local reservoir prospects and plays.

Image logs from petroleum wells can provide data on fracture types and orientations. In addition, the trend of borehole breakout strain as observed in image logs is likely to be orthogonal to the orientation of the principal horizontal stress axis at the borehole. Formation microresistivity image (FMI) logs from the Kauhauroa field near Wairoa show fractures in Early Miocene limestone that mainly strike NE and borehole breakout trending NW. The FMI log from Titihaoa-1 (offshore Wairarapa) shows fractures which strike NNE and borehole breakout trending NE. The present-day principal horizontal strain (PHS) direction is inferred to be orthogonal to the trend of borehole breakout, and should trend NE-SW at Kauhauroa and NW-SE at Titihaoa.

The present-day strain field from published earthquake focal mechanism data and GPS studies is, in plan view, similar to strain data from the two wells and supports a model of two stress domains. In the northern domain, which is north of Hawke Bay, the PHS axis trends approximately NE. In the southern domain the PHS trends SE.

Outcrop measurements show fractures in Early Miocene limestone strike in the NE quadrant in the north and mainly SE in the south, in both cases sub-parallel to the inferred PHS direction. As fractures parallel to the PHS direction are likely to remain open to greater depths than fractures striking at a high angle to the PHS direction (provided they are not filled by, for example, mineral cement) they potentially increase reservoir capacity and fracture permeability.

(ORAL)

THE MAIN DIVIDE FAULT ZONE AND THE CENOZOIC KINEMATICS OF NEW ZEALAND'S SOUTH ISLAND SECTOR OF THE AUSTRALIAN-PACIFIC PLATE BOUNDARY

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The Main Divide Fault Zone (MDFZ) , Mt Cook, is alleged to be the contemporaneous backthrust of the Alpine Fault. The Alpine Fault's palaeostress fingerprint is well-defined and may be compared with that of the MDFZ. For the Alpine Fault, σ_1 should trend about 110-290°, plunge very shallowly and it and the calculated σ_3 should define an M - plane dipping 40-50° north.

472 small-scale faults in and adjacent to the MDFZ define a best-fit girdle (M-plane) dipping 25-35° to 105°. This by no means matches the M-plane for the Alpine Fault. Thus the MDFZ is incongruent to the Alpine Fault and therefore the MDFZ did not form an original part of the kinematic system of the Late Miocene-Present Alpine Fault. However, the MDFZ could well have been part of a fault system preceding the Alpine Fault and may have been reactivated during Late Miocene-Present development of the Alpine Fault to produce compatible movement and structures.

Palaeostress analyses of small faults in the hanging wall and footwall of the MDFZ confirm three trends for σ_1 : 045°, 070-090°, and 110-120°. Recent palaeomagnetic studies confirm these as consistent with systematic rotation of the convergence vector of the Pacific Plate from a southwesterly trend, through a westerly trend, to the present trend.

The 045° trend for σ_1 is incompatible with either dextral strike-slip or reverse motion on the Alpine Fault, but is compatible with dextral strike-slip in the MDFZ and formation of the extremely large, steeply plunging, dextral mega-kinks of the Mt Cook region. This leads to the interpretation of the MDFZ as a dextral Riedel R Shear within a very broad, northnortheast-trending, Early to Middle Tertiary displacement zone along the then coupled Australian-Pacific plate boundary.

The 070-090° trend for σ_1 is consistent with reverse slip on the MDFZ in a dextral strike-slip regime and the contemporaneous production of the westsouthwest trending folds and dated Oligocene high-strain zones in the Alpine schist.

The 110-120° trend of σ_1 fits the Alpine Fault's geometry and the present convergence vector of the Pacific Plate in South Island. It is similar to the results from splays of the Alpine Fault in Marlborough; is consistent with formation of the Alpine Fault as a linear discontinuity between 8 and 2my ago; and fits the evidence for sinistral reverse slip in the MDFZ.

(POSTER)

PALAEOSTRESS, GEODETIC AND SEISMIC DATA CONFIRM SYN-COLLISIONAL, 3-DIMENSIONAL STRESS- AND STRAIN-PARTITIONING IN THE CENTRAL REGIONS OF PAPUA NEW GUINEA

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Papua New Guinea lies on the collisional boundary between the Australian plate, here moving NNE, and the Pacific plate, here moving westward.

Palaeostress data from a cross-section of the Eastern Highlands and Morobe Provinces, PNG, indicate that from N to S across central PNG there is: (1) a shallowly N to NE plunging σ_1 which may be associated with the post-800 000 years to Present thrusting and uplift of the Finisterre Mountains; and (2) a shallowly E-W to SSE NNW plunging σ_1 at the post-Pliocene Sunshine Fault of the Bulolo region, in the Menyamaya district, and at the Koki Thrust Zone in Port Moresby; that is, the stress tensor is similar to that of the Port Moresby earthquake in 1979.

As both orientations of σ_1 are contemporaneous, it confirms modern stress partitioning on a regional scale.

Geodetically measured strains, which indicate shortening on a NE axis occurring at the thrust front of the Finisterre Mountains and E-W shortening at the Owen Stanley Fault in eastern Morobe Province, confirm regional strain partitioning.

The earthquake data of last the 40 years from the Finisterre Mountains also show simultaneous but mutually orthogonal compression axes, except that depth and not surface location controls the distribution of the different orientations. Above 70 km depth, the compression axes follow the orientation of σ_1 derived from the young faults, whereas below 70 km depth the orientation of the compression axes matches the E-W palaeostress determined from faults well south of the mountains and at Port Moresby. A similar feature is indicated by earthquake data from the Kubor Anticline of the central PNG Highlands.

It is clear that these data indicate widespread contemporaneous crustal decoupling in three dimensions in mainland PNG, despite the apparent simplicity of structures such as the Papuan Fold Belt, and the simple history of tectonic convergence between the Australian and Pacific plates. Thus the Recent palaeostress, and modern geodetic and seismic data from this classic collisional plate boundary region are clear confirmation of the true complexities attending even apparently simple continental/island-arc plate collisions.

(ORAL)

GEOPHYSICAL AND GEOCHEMICAL CHARACTERISATION OF TWO MAARS WITHIN THE AUCKLAND VOLCANIC FIELD

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The Domain Volcano and Pukekiwiriki Volcano are two basaltic maars within the monogenetic Auckland Volcanic Field. Both consist of a low angle tuff ring and central crater; the craters have been excavated below the pre-volcanic surface and infilled with Quaternary alluvium. The Domain Volcano has a scoria cone within the central crater and there is historical evidence for another cone located on the southwestern tuff ring, Outhwaite Park. There are no lava flows currently exposed at the Domain Volcano but borehole evidence and previous investigations have shown there is a significant basalt volume beneath the southwestern tuff ring. Pukekiwiriki Volcano has no present day or historical evidence of a scoria cone or associated flows.

Recent geophysical surveys have shown both volcanoes are associated with substantial gravity and magnetic anomalies. The Domain Volcano is characterised by a +3.2mgal gravity anomaly centred approximately 300m southwest of the present day scoria cone. A corresponding aeromagnetic anomaly of approximately 350nT is also centred to the west of the scoria cone. Pukekiwiriki has a elongated, sub-circular gravity anomaly of +1mgals that is centred over the crater and a corresponding aeromagnetic anomaly which peaks at approximately 150nT. These anomalies indicate substantial, dense sub-surface basalt bodies must occur at both volcanoes, as indicated by borehole evidence at the Domain Volcano. 3D models of the sub-surface structure of each centre, developed from the potential field data and constrained by known geology and borehole data, have been interpreted in terms of eruptive history.

Nepheline basanite bombs from within the tuff ring of the Domain Volcano have previously been identified(Marshall, 1912; Searle, 1961). 20 samples from within the central tuff ring and from the southwestern tuff, in the area surrounding Outhwaite Park, been analysed in terms of petrography and whole rock geochemistry. Preliminary results indicate that the rocks were sourced from a single magma batch. Four samples collected from Pukekiwiriki Volcano have also been analysed in terms of petrography and whole rock geochemistry.

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(PLENARY)

THE NEW ZEALAND GEONET PROJECT: THE FIRST YEAR

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New Zealand sits astride the Pacific-Australia plate boundary and is thus prone to earthquakes, volcanic eruptions, and landslides. In recognition of the need to mitigate the geological risk the Earthquake Commission (EQC) is providing core funding of a real-time hazard monitoring and data collection system (known as GeoNet) for on-going research into earthquake, volcano, and other geological hazards. The decision to fund this undertaking came after several years of inter-agency consultation and review by both New Zealand and international experts. Almost all of the components of the GeoNet system had been trialed in pilot projects in the five years preceding the GeoNet investment by EQC.

The New Zealand GeoNet will consist of a backbone seismograph network throughout the country, dense regional networks (both weak motion and volcano-seismic) and continuous GPS networks in some areas of higher hazard, an upgraded accelerograph network (strong ground motion) and two independent data centers. A boost for gas chemistry is also included to enhance surveillance capabilities at selected volcanoes. The direct investment in GeoNet emphasizes geophysical monitoring over periods of a few tens of seconds (seismometry) to a few months or years (chemistry and geodesy). The geological dimension of hazard assessment has also been enhanced through re-allocation of some of the Public Good Science & Technology funding that previously supported the operation and maintenance of the geophysical network.

The GeoNet programme for the first year concentrated on upgrading the national seismograph and strong motion networks, the specification of new volcano geochemistry equipment and the "hardening" of existing systems. Detailed planning and design work for the regional networks (seismograph and GPS) also started. Over 100 new strong motion recorders with dial-out capability have now been deployed, as well as the infrastructure for 13 six-component (broadband and strong motion) National Seismograph Network stations with satellite telemetry. This is already having a positive impact on our ability to respond quickly to felt earthquakes. For example a recent felt earthquake (M_L 4.6) in the Wairarapa region produced 20 strong motion records which where available within three minutes of the earthquake occurring.

The GeoNet project is pursuing a best practice approach to instrument and system design, together with a vigorous outreach program to promote utilisation of research data and knowledge for emergency management. GeoNet information and data are available via a robust web site (www.geonet.org.nz) where information is published soon after events occur.

(ORAL)

MUDDYING THE WATERS - BENTHIC FORAMINIFERA FROM OFFSHORE TARANAKI

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Four benthic foraminiferal associations are recognised and mapped in the offshore Taranaki region (0-2150m) based on cluster analysis of census data (231 species, 39 samples). Canonical correspondence analysis and correlation coefficients suggest that the distribution patterns are strongly depth-related.

Comparison of the Taranaki foraminiferal data with a similar data set from off the east coast of New Zealand indicates considerable differences in composition, relative abundance levels, and depth ranges of common species that appear to be a result of differences in primary productivity, translated into organic carbon flux (food). Since the flux reaching the seafloor decreases progressively with increasing water depth, this is inferred to be the major factor producing the strong depth-related distributional pattern of deep-sea benthic foraminiferal faunas observed around New Zealand. Thus highly accurate estimates of paleobathymetry are unlikely using benthic foraminifera, unless organic carbon flux has remained unchanged.

Bathyal and abyssal estimates currently used to understand the geological history of New Zealand's most important hydrocarbon-bearing sedimentary basin, the Taranaki Basin, have large ranges of uncertainty. These might be improved using knowledge of the depth distribution patterns of Recent deep-sea benthic foraminifera from the same region.

Notwithstanding the differences between the west and east coasts, there are sufficient bathymetrically consistent similarities and trends that would be useful in improving paleobathymetric estimates. These include, in decreasing order of reliability: upper depth limits of key species; recognition of foraminiferal associations; and relative abundance of planktic foraminifera.

(ORAL)

THE 2000 NEVIS BLUFF ROCKFALL, SH6, QUEENSTOWN

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A rockfall blocked the state highway to Queenstown at the Nevis Bluff in September 2000. A number of people observed the collapse, and one took a video showing a side- on view of the fall. The film provides a rare opportunity to study the sequence of events in a major rockfall.

The Nevis Bluff is 100m high and has a 60 degree face, steepened in the lower slopes by road widening in the 1970s. The rock is predominantly quartzofeldspathic schist (TZ IV), dipping into the slope at 40 degrees. A number of crush[ed] zones and foliation shears (minor crushed zones parallel to foliation) are present, and two intersecting joint sets dipping at approximately 60 degrees provide potential release surfaces for wedge failures. A previous collapse of another section of the bluff blocked the highway in 1975.

Examination of the face marginal to the failure shows an outer layer of dilated schist with open [–cavernous] joints. Dilation appears to be due to stress relief and incipient toppling of schist blocks. It is likely that the section of the rock mass that collapsed was in a similar condition.

The earliest indication of failure was a minor fall that deposited debris on the highway and caused a group of motorcyclists and several motorists to stop. The first event observed was toppling of a schist block from the crest of the bluff. Falling material appeared to trigger secondary releases from the face, producing several surges of debris down the slope. The total volume is estimated to be some hundreds of m^3. This initial phase took about 20 seconds, and was followed by a pause in activity for about 8 seconds.

The main failure then broke out at mid-height in the slope, with a large volume rapidly spilling forward over the bluff. After about 6 seconds, translational sliding of an area of rock at the head of the slope commenced, producing a pulse of debris as it broke up. The main failure phase lasted a total of 16 seconds and released approximately $10{,}000m^3$ of rock.

It is thought that the main failure was probably triggered by the impacts from the initial fall. After a short delay, possibly due to the propagation of cracking, the lower part of the slope underwent a brittle sliding failure, and disintegrated into debris. This movement undermined the upper slope, causing the head region to fail retrogressively, initially as a coherent block.

Helicopter inspection immediately after the failure revealed wide open tension cracks extending behind an adjacent section of the face. Because of the danger of this area also falling, it was necessary to remove it before the road could be reopened. Initial attempts to bring it down by using helicopter monsoon buckets to charge tension cracks with water were unsuccessful, and the material had to be removed using explosives. These were placed on the slopes by helicopter, and triggered using an aerial blasting technique developed for avalanche control.

(POSTER)

MARINE PALYNOLOGY OF THE CAPE ROBERTS DRILLHOLES, VICTORIA LAND BASIN, ANTARCTICA.

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The composite core recovered from the three Cape Roberts drillholes (CRP –1, CRP-2/2A and CRP-3) was sampled for marine palynomorphs. Samples from the Quaternary section contain rare marine palynomorphs, most of which are reworked from older underlying strata. Diverse marine palynomorph assemblages were recovered from the older (Miocene and Oligocene) sediments in CRP –1 and CRP - 2/2A). Similar assemblages continued in the top 162 m of CRP –3. Below this level most samples are either barren or yielded only sparse floras. One exception is a spike of increased productivity between 781.36 – 788.69 mbsf.

- Three broad taxonomic groups can be recognised: Prasinophyte algae, predominantly *Cymatiosphaera.*
- Acritarchs, dominated by species of *Leiosphaeridia,* with the fusiform acritarch *Leiofusa* being an important component of the assemblages in the bottom part of the CRP-2/2A and the upper part of CRP –3.
- Dinoflagellate cysts (dinocysts), both *in situ* and reworked. The *in situ* forms increase in diversity down hole in CRP-1 and maintain this level to the bottom of the productive assemblages in CRP –3. More than 20 new species of dinocysts, including several species of *Lejeunecysta*, have been recognised and are currently being analysed.
  Many reworked species are attributable to the well known Paleogene Transantarctic Flora, an assemblage which includes species originally described from the McMurdo Sound area. The absence of *in situ* taxa from this assemblage is thought to have time significance, restricting the maximum age of the base of the sequence to earliest Oligocene or ?latest Eocene.

Several marine palynomorph species recovered are new and remain undescribed.
The suite of marine palynomorph assemblages documented in the Cape Roberts Core represents an opportunity to develop a new robust biostratigraphy for southern high latitudes. The marine palynomorph flora is often the dominant microfossil group present in the cores and well preserved floras were recovered from most facies, usually with a significant yield. A preliminary biostratigraphic scheme has been developed. Seven biozones cover most of the Oligocene – Miocene strata and are based largely on *in situ* dinocysts . Species of *Lejeunecysta,* which are used in the definition for six of the biozones, are particularly significant.

(POSTER)

ILLITE CRYSTALLINITY AND PALEO-GEOTHERMAL STRUCTURE FROM ON-LAND ACCRETIONARY COMPLEXES: AN EXAMPLE OF THE JURASSIC CHICHIBU AND CRETACEOUS SHIMANTO COMPLEXES, CENTRAL JAPAN

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The illite crystallinity (IC, Kubler index) is a useful method for estimating the thermal maturity of low-grade metamorphism. For the IC analysis in an accretionary complex, the errors and its factors are inspected with regard to argillaceous rock samples (black shale and melange-matrix) collected from the Jurassic Chichibu complex, central Japan.

Machine errors by XRD and intra-sample errors by making slides are estimated about 1.5% together. The IC values of black shale have the intra-outcrop errors of 4.6%, and also the intra-area (2km×2.5km) variations are within 9%. The intra-area variations decrease to approximately 6% except for samples near major faults bounding tectonostratigraphic units. The IC values of melange-matrix show the intra-outcrop error of 11%, which are much larger. These data show that total of the IC value errors is estimated below 10% in our method, and most of the errors are caused by structural and lithological factors. The CIS (Crystallinity-Index Standard) as standard samples have been proposed and supplied for inter-laboratory calibration of the IC by Warr and Rice (1994). The comparison between the CIS and our IC values results in the following equation: IC(CIS)=1.55IC(GSJ)-0.77 (R=0.99). The anchizone (0.25-0.42 Δ˚2Ø) measured in our laboratory corresponds to a range from 0.21 to 0.32 Δ˚2Ø in the CIS values. The lower limit of anchizone indicates a similar value, however the upper limit shows a lower value than the CIS value.

After the estimation of the IC errors and CIS standardization, the IC technique has been applied to the Jurassic Chichibu and Cretaceous Shimanto complexes in the Kanto Mountains. As a result of the IC analysis for 168 argillaceous rocks samples, the IC values of both complexes are characterized by the same tendency that gradually decreases toward the northwest from 0.60 to 0.22 Δ˚2Ø, without significance gap across the boundary fault of both complexes. The features of the IC values suggest that the Chichibu and Shimanto complexes have the thermal history and uplift process in common. Namely, the thermal event causing the geothermal structure occurred after thrusting of the Chichibu complex over the Shimanto complex seaward. After this, both of the Chichibu and Shimanto complexes were uplifted in association with southeastward tilting process, probably caused by collision of the Izu-Mariana Arc to the Japanese Island Arc during the Miocene.

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(POSTER)

IS IT PLANT OR IS IT ANIMAL? ENIGMATIC LATE JURASSIC CARBONACEOUS OBJECTS FROM PORT WAIKATO

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A series of large (70-90 X 35-50 mm). flat (c. 1mm), oval, carbonaceous bodies comes from carbonaceous sandstone at three separate localities in the latest Jurassic Huriwai Measures southwest of Sunset Beach, Port Waikato. Some show a transverse structural pattern, perhaps associated with post-depositional tectonism but little or no other internal structure. The external surface seems to have been essentially smooth.

The entire, unbroken margin on each indicates that the objects were not rigid 3-dimensional structures when subject to post-depositional compression, and that they were instead more likely to have been originally flattened-ellipsoidal in form, or else soft and compressible. Their relatively consistent form leads us to accept an organic origin, but the nature of these objects is entirely conjectural, and suggestions are eagerly sought!

From their general similarity and lack of internal structure they are unlikely to be stream-abraded wood fragments or cones. They lack the midrib, venation, and petiolar attachment of a leaf, and in life were probably too thick. They are too large to be Mesozoic seeds and, more significantly, lack any indication of attachment to cone or stalk. Similarly, they are too large and of the wrong shape to be cone scales.

Flattened coal balls or tar balls are also rejected because of their entire outline, carbonaceous content, and lack of adherent material.

So much for plant debris!

As for animals, lack of any indicative structure rules them out from being complete individuals. To us, the only remaining possibility is that they are coprolites, deposited in still water on the Huriwai braid plain by passing relatively large vertebrates. The first-collected specimen shows faint, questionable comminuted plant debris and possible small seeds on the broken internal surface, and these, if confirmed, would support the interpretation of a herbivore origin. So, perhaps, dinosaur coprolites!

This explanation would account for the size and shape variation. Such objects deposited in water could retain their outline intact when compressed, if originally sufficiently soft. Their fine-grained matrix and rarity of coarser debris is a problem in a herbivore of the size implied (perhaps 3-4 m long?), however.

Your views will be greatly appreciated. What do you think?

(ORAL)

THE WORLD'S MOST MISIDENTIFIED FORAMS - MORPHOLOGICAL DISCRIMINATION OF MOLECULAR TYPES IN *AMMONIA*

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Ammonia was the first genus described from the Phylum Foraminifera and is one of the two most abundant foraminiferal genera world-wide. It mainly occurs in sheltered, shallow marine, especially intertidal environments, both at present and in the Neogene. Its high morphologic variability has led to considerable difficulties in species identification and although more than 40 taxa of Recent *Ammonia* have been described world-wide, many workers lump them into two or three morphologically-variable taxa. Today the taxonomy of *Ammonia* is in a chaotic and confused state.

Phylogenetic analysis of 267 partial LSU rDNA sequences, obtained from 202 living *Ammonia* specimens, sampled from 30 different localities world-wide is used to distinguish 13 different molecular types. Multivariate morphometric analysis, based on measurements of 37 external test characters in SEM views of 178 specimens, suggests that each molecular type can be distinguished morphologically and can be recognised as a separate, at times rather cryptic, species. We are aware of at least 9 more, as yet unsequenced, distinctive morphotypes and thus we infer that the total number of genetically distinct and morphologically separable living species of *Ammonia* is likely to exceed 25-30.

These results imply that the current widespread practice of lumping most species of *Ammonia* together should be abandoned. The most commonly used name, *Ammonia beccarii*, is not known beyond its type locality in the Adriatic Sea and should be restricted to a large, compressed, highly ornamented species. This work indicates the presence of one cosmopolitan species, several globally distributed tropical species, and other species with distribution patterns limited to the northern or southern hemispheres, or parts thereof.

(POSTER)

FROM SOURCE TO SINK – LINKING SHELF AND SLOPE BIOCLASTIC DEPOSITS IN THE LATE MIOCENE-EARLY PLIOCENE RECORD OF WANGANUI AND TARANAKI BASINS, NEW ZEALAND

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Shell beds are conspicuous components of shelf-slope sedimentary successions in the late Miocene to early Pliocene Whangamomona Group (Matemateaonga, Kiore, and Urenui Formations) of Wanganui and Taranaki Basins in the North Island of New Zealand. The Matemateaonga Formation is a cyclothemic unit that represents shelf sediments (topsets) of a prograding continental margin. It is characterized by the occurrence of uniformly thick (2-6 m) and laterally continuous shell beds, separated by 10-90 m thick successions of siliciclastic sediments. These shell beds represent the transgressive systems tracts of 6th-order depositional sequences. The Kiore and Urenui Formations represent slope deposits (slope-sets), and occur geographically and stratigraphically adjacent to the Matemateaonga Formation. The Kiore Formation is inferred to have formed in upper slope paleoenvironments and is characterized by a succession of laminated mudstone and sandstone, punctuated by laterally discontinuous, conglomerate- and bioclast-filled channels. The Urenui Formation accumulated in an upper-mid slope paleoenvironment and comprises massive to laminated mudstone with large allochthonous bioclast- and conglomerate-filled channels or canyons.

The concentrated and transported skeletal material observed in channels of the Kiore and Urenui Formations is inferred to have originated from the same inner shelf fauna that contributed to the contemporary autochthonous shelf shell beds of the Matemateaonga Formation. As the supply of concentrated skeletal material on the shelf is determined by the state of sea level (i.e. during transgressive systems tracts), the sequence stratigraphic framework established for the shelfal Matemateaonga Formation can be extended off the shelf and onto the slope.

(PLENARY)

THE PACIFIC MARGIN OF NORTHWESTERN NEW ZEALAND

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The Pacific-facing continental margin from New Zealand to New Caledonia has undergone multiple tectonic and volcanic episodes. The most recent episode is recorded in the margin of northwestern New Zealand, which was active in the Late Oligocene and Early Miocene, and was the site of the Northland volcanic arc. Two back-arc basins, the South Norfolk and southern South Fiji basins, opened to seaward around this time, and part of the margin sequence, including basaltic crust, was obducted landward as the famous Northland Allochthon.

Striking differences in the continental margin facing these two basins are critical to understanding the evolution of the greater region. Although New Zealand and international regional surveys provide important new leads and constraints, no unifying model yet satisfactorily explains these contrasting margins.

The margin facing the Norfolk Basin is interpreted as a dextral continent-ocean transform. The continental side of the transform is a transpressional ridge, the Reinga Ridge, with left-stepping relays deforming the inboard sedimentary sequence. The oceanic side is an escarpment complex consisting of transtensional fault scarps and detached blocks. The timing of movement is reasonably well constrained by seismic stratigraphy and radiometric and biostratigraphic dates to Late Oligocene to perhaps early Middle Miocene. Cataclasites are common on the scarp.

The margin facing the southern South Fiji Basin has neither an obvious transform nor an obvious subduction zone. The continent-ocean boundary might be at a linear magnetic and gravity lineament 100 km beyond the continental shelf under the mid-slope Northland Plateau. Seaward of the lineament, a positively magnetic volcanic field could be continuous with the Three Kings Ridge or the southern South Fiji Basin or both. Dredged volcanics in all three areas are mainly subduction related and 17-23 My old, much like the Northland Arc, with few MORB-like rocks sampled so far. Landward, a linear basin contains Waitemata equivalent sequences and, unconformably beneath them, what appear to be parts of the allochthon and its sources. Flat tops and shallow water rocks show that the latter were once above sea level. High-temperature metamorphic rocks indicate locally extreme uplift in the basin between 24 and 20 million years ago, a time that coincides with allochthon obduction and early volcanic arc activity.

(ORAL & POSTER)

THE FAUNA AND BIOSTRATIGRPAHY OF THE JURASSIC LATADY FORMATION, ANTARCTIC PENINSULA

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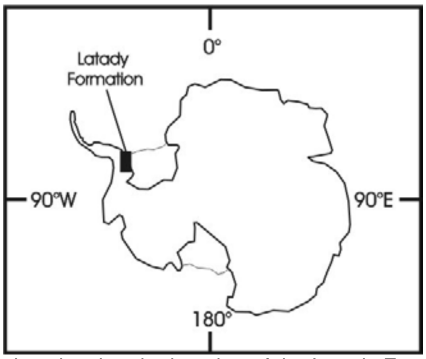
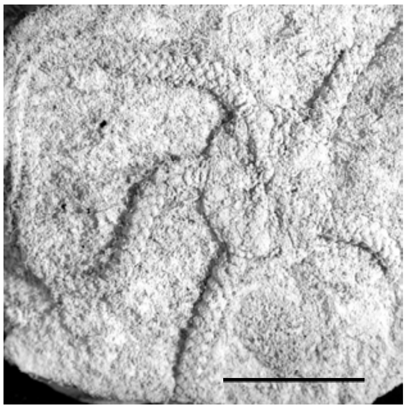
The Antarctic Peninsula represents the only remaining piece of the paleo-Pacific margin of Gondwana that is still adjacent to the core of the former supercontinent. Gondwana began to break-up c.199 Ma, and was completely fragmented by the mid-Cretaceous. The Jurassic Latady Formation was being deposited throughout much of the break- up. It is a thick sequence of predominantly marine black and grey shale and siltstone, with subordinate sandstone and conglomerate, and sparse thin coal and limestone with locally interbedded volcanic rocks. It occurs in an area that extends more than 700 km, and possibly as much as 1000 km, along the Weddell Sea coast of the southern Antarctic Peninsula, and inland as much as 200 km (Fig. 1).

Initial paleontologic evidence from earlier studies, indicated that most of the Latady Formation is of Late Jurassic (Kimmeridgian-Tithonian) age, with Middle Jurassic beds restricted to the Behrendt Mountains. However, preliminary results from this study suggest that Middle Jurassic (Bajocian) strata are more widespread than originally believed. Faunal assemblages, sediments and sedimentary structures suggest most of the Latady Formation was deposited in marine shelf environments. The Middle Jurassic is represented by low energy anoxic deposition, probably with restricted circulation.



Antarctica showing the location of the Latady Formation


An ophiuroid (scale bar 1cm).

Faunal assemblages, sediments and sedimentary structures suggest most of the Latady Formation was deposited in marine shelf environments. The Middle Jurassic is represented by low energy anoxic deposition, probably with restricted circulation. Higher energy facies predominate in the late Middle to Late Jurassic in a larger depositional basin. The youngest strata of latest Jurassic age occur at the present day coast and represent deeper water, marine anoxic environments. Terrestrial and nearshore marine environments are represented in the interior of the southern Antarctic Peninsula. The affinities of the faunas are overwhelmingly with those of coeval New Zealand assemblages (Murihiku Supergroup) and also with South America.

The aim of this study is to determine the fauna of the rocks in the Latady Formation, including known taxa and a description of new forms. This will allow the biostratigraphy, precise age and finer correlation with faunas in other regions to be determined. Substantial collections were made, which included retroceramids, ammonites and belemnites, all groups used in local New Zealand biostratigraphy. Simple correlation with New Zealand stages is not possible, as it appears that the retroceramids are different to those known in New Zealand and South America. Of note is the relatively diverse echinoderm fauna that comprises cidaroids, crinoids and ophiuroids.

(ORAL)

TAPHONOMY OF A REPTILE-BEARING CONCRETION

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The preparation of marine reptile remains enclosed in a concretionary mass has allowed consideration of the processes leading to the fossilization of the specimen. These can be divided into pre-burial processes – necrolysis and biostratinomy, and post-burial processes - compaction and diagenesis.

Canterbury Museum fossil reptile specimen Zfr 145 represents a nearly completely disarticulated partial skeleton of a large elasmosaurid plesiosaur. Although lacking the neck and skull, the specimen includes many diagnostic elements in association. Among the scatter of bones are vertebrae from the mid-dorsal region to the caudal region of the spine, one forelimb, one hind limb, most of the large bones of the pelvic and pectoral girdles, ribs and gastralia. The bones are preserved in an approximately 10 tonne concretion, discovered in two pieces, on the left bank of the Waipara River about one kilometre above the old Laidmore Bridge.

The cause of death of the animal can only be surmised but the state and distribution of the bones permit inferences to be made about the pre-burial history of the remains. The preserved bones are scattered over an area of about 4 m^2; disarticulation is almost complete with only a few dorsal vertebrae retaining any original association. The bones are generally well preserved with very little evidence of fragmentation or abrasion, suggesting a minimum of transport by current activity. However, several articulation surfaces, such as the capitulum of both the femur and humerus, and a number of vertebral centra show marked degradation. Whether this is the result of chemical attack or bioerosion is difficult to determine, but it suggests that the bones were at least partially exposed for some time on the sea floor prior to burial.

Once buried, the bones became encased in a carbonate-cemented concretion. The lack of significant compaction of the bones suggests that concretion formation took place early in the diagenetic history. Microbial decay of organic matter resulted in carbonate supersaturation, but the contribution of soft tissues associated with the bones is likely to have been limited and the abundant plant remains found in the concretion are thought to have been primarily responsible for carbonate precipitation. Concretion formation requires that the bones resided for sufficient time in the zone of maximum carbonate precipitation. This suggests either a break in sedimentation or very slow sedimentation rates. The pervasive bioturbation of the Conway Formation sediments certainly indicates the latter.

(ORAL)

USING U-TH-RA DISEQUILIBRIA TO CONSTRAIN MAGMATIC PROCESSES OF THE 1945-1996 RUAPEHU ERUPTIONS

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Short-lived U-series isotopes provide information about the timescales of magma differentiation processes for young eruptions. Immediately following a melting event that generates isotopic disequilibrium, radioactive decay begins to drive a return to secular isotopic equilibrium so that the amount of U-series disequilibrium reflects time elapsed between melt extraction and eruption. Major and trace element and Sr-Nd isotopic data for Ruapehu eruptives are consistent with processes involving injection and mixing of small-volume, short-lived magma batches in complex plumbing systems. The timescales involved in such processes can be investigated using U-Th-Ra disequilibria. If magma compositions are repeatedly modified by influxes of new magma then the Ra-Th disequilibria should show evidence of repetitive disturbance or resetting.

U-Th disequilibria data are presented for 14 historical Ruapehu samples spanning the entire historical eruptive period from 1945 to 1996 and Ra-Th disequilibria data have also been obtained for 9 of these samples.

With increasing SiO_2, U (1.12-2.30 ppm) and Th (4.00-8.07 ppm) concentrations increase. U/Th ratios are relatively constant, (0.27 to 0.29). SiO_2 abundance does not correlate with U/Th, and U and Th bearing phases (e.g. apatite or zircon) are absent so significant fractionation of U and Th during differentiation can be disregarded.

As for other subduction-related volcanics, all the samples show U excesses (7-15%), which are usually attributed to mobilisation of U in fluids derived from the subducted slab. On a ($^{230}Th/^{232}Th$) versus ($^{238}U/^{232}Th$) diagram the historical Ruapehu data scatter to the right of the equiline, rather than falling on a tightly constrained linear trend. Data for prehistoric Ruapehu lavas plot closer to the equiline than those for historical lavas.

Ra-Th isotopes are best used on historical eruptions. The historical samples exhibit Ra excesses of up to 10% and show non-systematic variations of ($^{226}Ra/^{230}Th$) over time that are inconsistent with evolution of a single magma body. Instead the isotopic system appears to have been disturbed and reset repeatedly, consistent with frequent influx and mixing between new magma batches. Notable reversals in ($^{226}Ra/^{230}Th$) have been identified as occurring in 1966, 1975 and 1996 and these may be linked to influxes of fresh magma.

To assess the impact of mixed crystal populations and crustal xenocrysts on measured Ra-Th disequilibria, groundmass separates from two samples were analysed. These preliminary data show significant Ra-Th differences between whole rock and groundmass, but more groundmass analyses are needed to establish the relationship.

(ORAL)

HIGHLIGHTS FROM FERDINAND HOCHSTETTER'S 5TH AND ONLY SURVIVING NEW ZEALAND DIARY OF HIS VISIT TO THE NELSON AREA (6TH SEPT. - 2ND OCT. 1859)

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Hochstetter's 5th diary covers the last month (6th Sept. - 2nd Oct. 1859) of his nine-month long visit to New Zealand and records the latter part of his pioneering geological explorations in the Nelson Province. It overlaps with Sir David Monro's diary (Fleming 1959), a record of a leading Nelson settler who had many contacts with Hochstetter. Hochstetter's 5th diary contains observations and thoughts on the Nelson Boulder Bank, first impressions of the monotis-bearing sandstones at Richmond, trips up the Wairoa and Wangapeka valleys and an expedition to Lake Rotoiti. Hochstetter had already spent two months in the Nelson area and a further month was added, so that more ground could be covered. His friend and companion Julius Haast helped Hochstetter by investigating separately Queen Charlotte Sound, the Wairau and Awatere valleys. Haast reported his observations back to Hochstetter who noted them down in his diary. Hochstetter left on the 2nd October 1859 on the Steamer Prince Alfred bound for Sydney, where he spent another four weeks before returning to Vienna. His visit to Australia is also recorded in this diary and has been published by Darragh 2001. A translation of the New Zealand part is to be published in full shortly (Hoke and Schedl in prep.).

Highlights from Hochstetter's 5th diary include his thoughts and discussions on the origin of the Nelson Boulder Bank. They are much more fully explored in this diary than in any of his subsequent publications. His observations and sketches from what today is called the Spooners Saddle demonstrate Hochstetter's quick grasp and approach to understanding the complex regional geology. The notes on earthquake damage along the Awatere and Wairau valleys, reported to him by Julius Haast suggest that the Berefelds Pass fault trace is probably related to the 1855 earthquake rather than the 1848 one (Grapes and Downes, 1997, p 336). Hochstetter's concluding thoughts of his New Zealand experience round off the New Zealand part of the diary.

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(POSTER)

K/T BOUNDARY ASTEROID IMPACT CAUSED PROLONGED DISRUPTION TO NEW ZEALAND'S TERRESTRIAL AND OCEANIC ECOSYSTEMS

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New Zealand's record of the (Cretaceous/Tertiary) K/T boundary event indicates that the impact of a giant asteroid caused catastrophic, prolonged disruption to primary production, biogeochemical cycles and climate. We have studied six well-delineated sections that represent a continental margin transect from terrestrial mire to pelagic basin, with four of the sections transecting an upwelling system. Paleoenvironmental trends drawn from palynomorph and siliceous microfossil censuses and geochemistry are divided into six phases over ~1.5 Myrs: (1) pre-impact conditions, (2) K/T event, (3) initial recovery (~50 kyrs, (4) greenhouse warming (~50 kyrs), (5) climatic deterioration (~1.4 Myrs), and (6) climatic amelioration.

In nonmarine Moody Creek Mine and marine mid-Waipara sections, these phases are recorded by abrupt replacement of a mixed forest palynomorph assemblage by one dominated by ground ferns (Phases 2-3), expansion of tree ferns (Phase 4), expansion of conifers (Phase 5) and a return to a mixed forest assemblage (Phase 6). In the Marlborough upwelling system, the phases are recorded by an abrupt cessation in carbonate production and increase in terrigenous input (Phase 2), initial recovery of carbonate production and increasing biosiliceous production (Phases 3-4), a decline in carbonate production and a marked increase in biosiliceous production (Phase 5), and final full recovery of calcareous plankton, with decreasing in biosiliceous production and terrigenous input (Phase 6).

Post-impact expansion of biosiliceous facies in Marlborough signals intensification of upwelling, first in the upwelling system's core (Branch and Mead Streams), next in the distal part (Flaxbourne River) and finally at the margin (Woodside Creek). Similarly, final recovery of calcareous plankton occurs earliest at Woodside and latest at Branch. High biosiliceous production at Branch spans a 1.5-Myr interval in which carbonate flux was very low in most ocean basins, high-amplitude climate cycles occurred in the South Atlantic, and cool temperate conditions are inferred from austral terrestrial floras. Although climate was relatively stable through the first 2-3 Myrs of the Paleocene in the Northern Hemisphere, peak biosiliceous production in the Marlborough upwelling system (~64.3 Ma) corresponds with a cool water incursion in the North Pacific.

We speculate that a massive increase in pCO2, following vaporisation of carbonate target rock and greatly reduced photosynthetic uptake, had long-term impacts on global climate and ocean systems, with loci of productivity shifting from the open ocean to continental margins and, while warm climate prevailed in the Northern Hemisphere, climatic cooling and high amplitude climate oscillations occurred south of ~40°S.

(ORAL)

EARLIEST EOCENE RADIOLARIAN BLOOM AT MEAD STREAM, MARLBOROUGH, SIGNALS A MAJOR CHANGE IN SW PACIFIC OCEAN CIRCULATION

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Mead Stream section, northern Clarence Valley, is one of the most complete Paleocene-Early Eocene records of pelagic sedimentation in the South Pacific Ocean. Integrated studies of sediments, siliceous and calcareous microfossils and stable isotopes reveal that major global climate events are recorded by distinct changes in lithofacies and biofacies. Two episodes of global warming in the Early Eocene are associated with a switch from limestone-dominated to marl-dominated sedimentation: (1) the Paleocene-Eocene thermal maximum (PETM, 55.5 Ma) is recognised by abrupt extinction of benthic foraminifera and a 1-2‰ negative $\delta^{13}C$ excursion in bulk carbonate within a 2 m-thick recessive marl; (2) the interval correlated with the Early Eocene Climatic Optimum (EECO, 53-50 Ma), primarily based on radiolarian biostratigraphy, corresponds to deposition of a 100 m-thick marl-dominated unit ("Lower Marl" of the Amuri Limestone; correlated with radiolarian zone RP8 = 53-50 Ma).

The persistent and often abundant occurrence of siliceous microfossils in the section provides a rare opportunity to undertake quantitative analysis of radiolarian population changes across the PETM and into the EECO. Late Paleocene assemblages are dominated by spumellarians, with abundant Amphisphaera and Buryella spp. Radiolarian abundance and diversity increase markedly in the 2 m-thick PETM interval and remain high over a further 16 m, corresponding to ~2 Myrs (nannofossil zones NP9b-10). The PETM is marked by an abrupt decline in spiny spumellarians, high-latitude nassellarians (Buryella granulata-foremanae-tetradica complex) and diatoms; a concomitant increase in smooth-shelled, robust spumellarian taxa (Haliomma, Periphaena, spongurids and spongodiscids), and the first appearances of several low-latitude or North Atlantic radiolarian species (e.g. Amphicraspedum prolixum s.s., Bekoma bidartensis, Podocyrtis papalis, Theocyrtis phyzella). Above this 18 m-thick interval, radiolarian abundance declines progressively, falling to <10 individuals per gram in the Lower Marl.

These trends in siliceous microfossil populations signal a major change in watermass characteristics along the northeastern New Zealand margin in the earliest Eocene. Assemblages typical of cool, eutrophic, watermasses dominate the Marlborough Paleocene. In the earliest Eocene, they are abruptly replaced by radiolarian assemblages dominated by taxa affiliated to modern symbiotrophes, which inhabit oligotrophic, stratified, subtropical-tropical watermasses. The incursion of warm subtropical waters is also indicated by the appearance of several low-latitude species. A marked decline in radiolarian abundance associated with the EECO suggests increasingly warm, oligotrophic conditions, favouring calcareous over siliceous plankton.

(ORAL)

MAWSON FORMATION VENT CHARACTERISTICS, ALLAN HILLS, SOUTHERN VICTORIA LAND, ANTARCTICA

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Prior to Jurassic effusion of the Kirkpatrick flood-basalts, explosive volcanism occurred along the length of the Transantarctic Mountains. Evidence for this explosive activity, the Mawson Formation, which is part of the Ferrar Supergroup together with intrusive dolerites and the overlying flood basalts, is well exposed in the Allan Hills, southern Victoria Land. The volcaniclastic Mawson Formation and correlatives along the Transantarctic Mountains have previously been interpreted as being part of a regional lahar field. Variations of the mode of deposition of the Mawson Formation tuff breccias in the Allan Hills can be seen by the different structural relationships between tuff breccia units, and varying incorporation of juvenile material and accidental lithics. This study documents the characteristics of a small part of the Mawson Formation in the Allan Hills.

Detailed field mapping of Mawson Formation tuff breccias reveals a small, well preserved diatreme-like vent structure having steep, near vertical contacts with the host tuff breccia, also of the Mawson Formation. Well indurated intra-vent tuff breccia dominantly comprises randomly orientated sandstone and coal clasts derived from the underlying and adjacent country rock, the Beacon Supergroup, along with dolerite and rare granitoid clasts with varying amounts of fluidal juvenile clasts. Thorough mixing of fluidal juvenile material and Beacon sandstone and coal has occurred, with the vent's tuff breccia matrix dominantly consisting of sand grains, which are sometimes incorporated within juvenile fragments. Incorporation of large blocks of the host Mawson tuff breccia within the vent breccia is indicated by varying amounts of fluidal juvenile material and accidental lithic clasts throughout the exposed vent tuff breccia. Evidence for heating of accidental lithics is given by vitrinite reflectance data for coal incorporated within the vent breccia. The occurrence of magma-water interaction is indicated by abundant peperite fragments, and by peperitic margins on dykes cutting the intra-vent tuff breccia. This vent feature is representative of many similar structures throughout the area that were formed within a large volcanic complex.

(ORAL)

DOLOMITISATION IN AN OLIGOCENE CARBONATE RESERVOIR, TARANAKI BASIN, NEW ZEALAND

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The Tikorangi Formation is a non-tropical, totally-subsurface, carbonate-rich, fracture-producing oil reservoir in Taranaki Basin. Unlike most New Zealand limestones, where dolomite is rare or absent, the Tikorangi Formation is distinctive because it includes up to 20%, and locally up to 55%, of silt-sized (20-90µm), scattered, free-floating, euhedral dolomite rhombs, occasionally forming pervasive planar-e (idiotopic) fabrics. The occurrence of dolomites can be of economic significance as they fracture more easily than limestones and make superior fracture reservoirs. Consequently the delineation of dolomite-rich facies may have implications for predicting the occurrence of key fracture systems within a formation. This paper investigates the origin of dolomite in the Tikorangi Formation.

Detailed petrographic study of core material from seven onshore wells has focused on the cathodoluminescence (CL) patterns in dolomite crystals together with XRD and bulk trace element analysis. Rhombs have dull luminescent Fe-rich cores, and often oscillatory bright and dull concentric outer zones. The fine-grained dolomites are invariably poorly-ordered non-stoichiometric calcian-rich (av. 58 mol% $CaCO_3$) and highly ferroan (av. 13 mol% $FeCO_3$) varieties. Dolomite has resulted in elevated trace element concentrations in the Tikorangi Formation carbonates in comparison with wholly calcitic cool-water equivalents, giving them bulk geochemical affinities more in common in with tropical carbonates.

Dolomite characteristics are interpreted in terms of pore fluid chemistries and associated diagenetic environments. The petrography and geochemistry of the dolomite, combined with inferred tectonic and burial histories of the rocks, enables an assessment of the physical and geochemical conditions of dolomitisation, including depth, timing, temperature, and fluid nature. Dolomitisation is consistent with a burial diagenetic origin and occurred in a closed chemical system without any secondary porosity development at depths and temperatures of ~1.0 km and 36-50℃. Dolomite formed from warm saline-enriched marine-modified formation waters with relatively low levels of dolomite supersaturation but with sufficiently elevated Mg/Ca ratios derived from Mg-rich intergranular micrite/matrix/clay material and by the removal of some Ca by precipitation of LMC cements. Dolomitisation occurred by simultaneous localised micro-scale dissolution of calcite and replacement by inclusion-rich dolomite rhombs resulting in mimic non-pervasive and fabric-selective replacement of interparticle, and rarely intraparticle, micritic/clay-rich matrix without affecting more coarsely crystalline skeletal grains.

(POSTER)

MAGNETIC MINERALOGY AND REMANENCE ACQUISITION IN THE EOCENE/OLIGOCENE SEDIMENTS AT CAPE FOULWIND, NEW ZEALAND

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The 90m thick sequence of silty mudstones exposed in the cliff section at Cape Foulwind, 12 km west of Westport, is important because it spans both the Runangan/Whaingaroan stage boundary and the Eocene/Oligocene transition. The lowermost 55m consists of the massive Kaiata Member, which is overlain by the rhythmically banded Port Elizabeth Member. The accompanying poster by Michalk et al. reports a detailed magnetostratigraphic study of the section in which the location of the Eocene/Oligocene boundary is established. However, the natural remanent magnetization (NRM) of the sediments is very weak and its interpretation is hampered by secondary components of magnetization, thought to be of diagenetic as well as thermoviscous origin. This study addresses the nature and origin of the remanence bearing magnetic minerals through measurements of magnetic susceptibility, isothermal remanent magnetization and magnetic coercivity, as well as electron microprobe analyses of atom ratios in selected opaque grains.

All magnetic properties are characteristic of low-coercivity ferrimagnetic minerals such as the spinel-structured titanomagnetites and greigite (Fe_3S_4) or monoclinic pyrrhotite (Fe_7S_8 – Fe_9S_{10}). Electron microprobe analyses of opaque grains give Fe:S ratios between 1:1.10 and 1:2.00, consistent with pyrrhotite (1:1.11 – 1:1.14), greigite (1: 1.33) and pyrite (1:2), as well as intermediate compositions. Also probed were grains with Fe:Ti ratios of about 1:1, consistent with ilmenite. In a total of 126 analyses, only one grain gave an Fe:Ti ratio high enough for a stoichiometric ferrimagnetic titanomagnetite.

Greigite, pyrrhotite and titanomagnetites with Fe:Ti > 4:1 are ferrimagnetic at room temperature. Stoichiometric pyrite and ilmenite are paramagnetic, and so cannot contribute to a remanent magnetization.

Greigite is observed to occur in framboidal clusters of sub-micron grains, or as individual cubic grains, growing on, or associated with, larger host grains. The greigite is therefore assumed to be authigenic, and to be carrying a secondary component of magnetization. The host grains, which are detrital in appearance, also yield atom ratios that are consistent with compositions between greigite and pyrite: sulphides, which are most likely authigenic. However, most specimens analysed palaeomagnetically appeared to retain at least some vestige of a detrital remanent magnetization. It is suggested that detrital titanomagnetite grains supply the iron necessary for diagenetic sulphidization: resulting in the formation of both framboids and cubic crystals of greigite and a surface coating of pyrite composition. Beneath this surface layer, we suggest remains a core of iron-depleted (titano-) magnetite, still bearing the weak vestige of a detrital NRM.

(ORAL)

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25 year old Davis was the only staff member of the NZ Geological Survey (1865-1990) to die while on duty. After schooling in Lancashire, Davis was employed in his father's iron mines in Cumberland before graduating with distinction in chemistry, mineralogy and geology from the School of Mines, London. A fellow of the Chemistry and Geological societies, he was for two years a chemist to the Portugal Iron and Steel Company but returned to England when the company collapsed. In 1867 he married Lucy Charlotte Wright before they moved to Colombia where he was chemist to a gold mining company. The tropical climate and arduous work affected his health and partly to recuperate he came to New Zealand to assess, on behalf of his father, the Taranaki iron sands. In Auckland in April 1870 Davis met James Hector and was temporarily engaged to work at Thames. On 6 July 1870, he was appointed Assistant-geologist. In October and November 1870 Davis examined the Dun Mountain, Collingwood and Wangapeka districts of Nelson. The Dun Mountain Company had been advised by its former manager, Thomas Hacket, that the Gympie Gold Field had close similarities with east Nelson and that finely disseminated gold might occur in the serpentinite, which he interpreted as a sedimentary rock. In addition Hector and Hacket had noted that Dun Mountain and Thames appeared to be similar. In early 1871 Davis surveyed the Brunner Mine and on 9 February 1871 was swept off his horse at Ten Mile Creek north of Greymouth and was drowned. His funeral in Wellington was attended by most of the civil service.

Davis was very talented, being a chemist, geologist and mineralogist as well a good observer. He demonstrated that the Nelson rocks were not the same as those at Thames and he recognised the synclinal nature of the Maitai Group. His conclusion that the serpentinite was older metamorphosed Maitai sediments was not inconsistent with the latter being unconformable on the former. While he did not recognise the Waimea and Flaxmore faults, the nature of the contacts between what are now mapped as terranes puzzled him. However, he was reluctant to "fill in" areas where the geology could be reasonably inferred. In Collingwood he noted that the Perseverance Reef was between different rock types along what is now mapped as a thrust separating Cambrian and Ordovician rocks. The gold he attributed to precipitation by graphite. If Davis had survived it is interesting to speculate how his career would have developed. He got on well with Hector and as a large part of the Geological Survey's work was assessing mineral deposits Davis would have fulfilled this role admirably. Despite poor health, he did not shirk from fieldwork but he was accident-prone. In retrospect it seems that had he survived, Davis would not have been the equal of Hector, Hutton, Cox or McKay.

(POSTER)

CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY THROUGH THE PALEOCENE-EOCENE TRANSITION, CLARENCE VALLEY, NEW ZEALAND

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Stratigraphic sections exposed in north-western tributaries of the Clarence River represent a record of hemipelagic-pelagic sedimentation across a terrigenous sediment-starved continental margin from Late Cretaceous to Middle Eocene. The sediments consist of chert, siliceous limestone, nonsiliceous limestone and marls of the Mead Hill and Amuri Limestone Formations (Muzzle Group). Through the Paleogene interval, marly interbeds or marl-rich intervals yield poorly preserved nannofossil assemblages, which contain sufficient identifiable index species to provide critical age constraints in four key sections: Bluff, Muzzle, Dee and Mead Streams.

In an integrated biostratigraphic and paleoenvironmental study of the Paleocene-Eocene transition, the following key nannofossil events have been identified: first occurrences of *Prinsius martinii* (base of nannoplankton zone NP4), *Fasciculithus tympaniformis* (base of NP5), Heliolithus kleinpelli (base of NP6), *Discoaster multiradiatus* (base of NP9), *Tribrachiatus orthostylus* (Base of NP11) and *Discoaster lodoensis* (base NP12); and the last occurrence of *F. tympaniformis*, which is tentatively correlated with the base of NP10.

Nannofossil biostratigraphy indicates that a complete Late Paleocene to Early Eocene (N4-5 to NP12) sedimentary record may be present at Mead and Dee Streams. At Mead Stream, a basal Eocene marl-rich unit, which carbon isotope data identify as the Paleocene-Eocene Thermal Maximum (PETM), is associated with a short-lived influx of a distinctive ten-rayed *Discoaster* sp. Nannofossils indicate that latest Paleocene and Early Eocene (NP5-8 to NP10) strata may be also preserved at Muzzle Stream. However, only Eocene (NP10 to NP12) strata are preserved at Bluff Stream. In both Muzzle and Bluff sections, the basal Paleogene unit is a calcareous greensand (Teredo Limestone Member of Amuri Limestone) that unconformably overlies Late Cretaceous Mead Hill Formation.

(POSTER)

RATITE EGGSHELL FROM EARLY – MIDDLE MIOCENE AGE MICROVERTEBRATE SITES, MANUHERIKIA VALLEY, CENTRAL OTAGO, NEW ZEALAND

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The recent discovery of a diverse microvertebrate assemblage in Early-Mid Miocene fluvial - lacustrine Manuherikia Group sediments in Central Otago are providing an opportunity to examine New Zealand's pre-Quaternary non-marine vertebrate record. The authors collected an extensive volume of microvertebrate material using wet sieving techniques from 3 sites in the upper part of the Manuherikia Valley.

The material picked from the washed residue is dominated by fish bones representing an as yet unidentified fish taxon, with small but significant numbers of bird bones, representing 5 species of Anatids (ducks), 4 species of passerines, 2 species of Charadriiformes (waders), 1 species of Rallidae (rail), 1 species of Psittacidae (parrot). Unexpected taxa represented in the material by very rare fragments include a crocodile, a snake, 2 species of bat, and a possible sphenodontid (Tuatara). There is also a significant amount of moderately well preserved calcified eggshell present, which is the topic of this presentation.

Two distinct eggshell morphotypes have been identified on the basis of shell thickness, pore canal morphology and shell ultrastructure examined in thin section and with S.E.M. Morphotype I is smooth, less than 0.5 mm in thickness with small, simple circular non-branching pore canals spaced 1-2mm apart. The shell in cross-section consists of three ultrastructure zones; a zone of wedges on the internal surface, a spongy layer and an external planar zone. This structure is identified as ornithoid type (sensu Mikhailov 1991) and is typical of neognathous birds. This morphotype includes most (>90%) of the eggshell present and is probably associated with the waterbird fauna.

Morphotype II, represented by only a few specimens is also smooth but much thicker (>1mm), with elongate branching pore canals approximately 0.4mm in length, spaced approximately 2-3 mm apart. The structure of morphotype II in cross-section comprises only two zones, a basal zone of wedges and a relatively thick spongy layer, the external planar layer is absent. Shell thickness >1mm, pore canal morphology, and an expanded undifferentiated spongy layer are typical of ratite eggshell. However the lack of an external layer is unique to Moa (Dinornithiformes) (Mikhailov 1992).

The presence of thick eggshell that has this type of ultrastructure suggests that Moa were present and that they were probably large and flightless. This is the earliest evidence yet of Moa in New Zealand and extends their fossil record back to at least the Middle Miocene.

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(POSTER)

A NEW FOSSIL LITHISTID SPONGE FROM SOUTHERN NEW ZEALAND: PALAEOECOLOGY AND EVOLUTIONARY LINKS

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Numerous remarkably well-preserved lithistid sponges recovered from the late Eocene - early Oligocene Ototara Limestone at Kakanui in the South Island of New Zealand, represent the first sponge body fossils to be described from the New Zealand Cainozoic. The sponges are scattered throughout a 1-3 m thick volcaniclastic limestone horizon immediately overlying the Kakanui Mineral Breccia. The sponge fossils are now solid calcite, the former siliceous skeleton having been replaced by calcite during diagenesis. The fossils are morphologically indistinguishable from a new species of living *Pleroma* ('Order' Lithistida: Family Pleromidae) from deepwater seamounts and banks off northeastern New Zealand. The present day limited distribution of this new species of *Pleroma* to silica-rich deeper waters is in marked contrast to the relatively shallow warm water volcanic environments occupied during the Palaeogene. This restriction, and that of related lithistid sponges to silica-rich deeper waters off northern New Zealand, is paralleled in other demosponges and several non-siliceous invertebrate groups such as barnacles, bryozoans, and crinoids.

(ORAL)

AN EVOLUTIONARY MODEL OF FRINGING REEF GROWTH AND IMPLICATIONS FOR FUTURE REEF DEVELOPMENT

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Fringing reefs are often described as simple veneers of coral growth along tropical shorelines and although their surface morphology may appear simple they in fact develop in a complex variety of ways. The growth pattern of these reefs is primarily related to the available accommodation space. This in turn is influenced by sea level and associated non-reefal sedimentation. From analysis of the morphology and chronostratigraphy of a range of Holocene fringing reefs a series of growth patterns can be identified. Fringing reefs may be established at depth and primarily grow vertically, or establish at sea level and grow laterally. If there is ample sediment supply the reef may prograde over a non-reefal sediment wedge. Growth can also be distinguished by episodic lateral and vertical growth where the reef front is characterized by a stepwise progradation. A seaward reef framework behind which unconsolidated sediments accumulate characterizes the remaining models. Here the reef crest may form a barrier, composed of either reef matrix of storm-rubble accumulation, leading to the development of a backreef lagoon.

These models provide a basis for investigation of the evolutionary history of coral reefs. Each different mode of growth produces a different chronostratigraphy and also provides a series of scenarios that may enable reef managers to forecast the likely sensitivity and trajectory of fringing-reef response to global climatic change.

(ORAL)

THE MULTI-PHASE ROTORUA ERUPTIVE EPISODE FROM OKAREKA EMBAYMENT, OKATAINA CALDERA

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The ~15.7 cal ka Rotorua eruptive episode involved a series of explosive and effusive episodes from the Okareka Embayment of Okataina caldera. Two distinct phases (A and B) have been determined according to re-evaluation of the stratigraphy, mineralogy and geochemistry of the eruptive products.

Phase A involved an initial large scale explosive episode that produced a widespread plinian fall deposit (tephra volume 1.61 km^3), dispersed predominantly to the NW. This was followed by a long-lived effusive phase that resulted in growth of Eastern Dome (0.75 km^3), which occupies a large portion of the Okareka Embayment. Previous work has indicated Eastern Dome to be a much older feature, but new stratigraphic evidence suggests post-plinian emplacement and geochemical analyses show Eastern dome lava and the plinian pumice are of very similar compositions (72-74 wt% SiO_2).

Phase B involved dominantly lava dome growth and associated minor explosive activity, and it was during this episode that Trig 7693 and Middle domes (0.36 km^3 and 0.26 km^3, respectively) were constructed. Associated with dome formation were a series of small to moderate pyroclastic eruptions (previously termed 'upper Rotorua Tephra') with local dispersal of concentrated density currents and ashfall to the south and east.

The Phase-B materials (75-76 wt% SiO_2) have a distinctly different mineralogy, crystallinity and geochemistry compared with Phase-A pumice and lava. The significant contrast in isotopic and bulk chemistry of the Rotorua A and B phases indicates that each phase tapped a discrete magma batch. The lack of paleosol development or significant weathering between the Rotorua A and B pyroclastic deposits indicates the transition period between phases was no longer than several years. Lava volumes and eruptive rate considerations suggest that dome construction may have taken place over 5-8 years.

(POSTER)

ILLITE CRYSTALLINITY FROM THE TORLESSE TERRANE IN NORTH CANTERBURY AND WELLINGTON: IMPLICATIONS FOR ACCRETIONARY TECTONICS

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In the South Island the Torlesse Terrane is subdivided into the Rakaia, Esk Head, and Pahau subterranes (Bradshaw et al., 1980). On the Wellington coast, North Island, a similar subdivision of the Torlesse Terrane has been reported by Begg & Mazengarb(1996). The accretionary process and the juxtaposition of these subterranes have been hitherto problematic. Paleogeothermometry may help to solve these problems.

In order to reconstruct the paleogeothermal structure across the eastern Rakaia and Esk Head subterranes, illite crystallinity (IC; Kubler index) of 50 samples of argillaceous rocks was measured from both north Canterbury and the Wellington coast. Each subterrane consists of two lithotetonic units, that is, coherent-broken and mélange units, bounded by faults. The summary of IC analysis is shown in Fig. 1 and the tectonic interpretation is summarized in the following:

1. IC values tend to be lower in Wellington coast than in North Canterbury. It is probably related to the difference of the distance from the Haast Schist and the equivalents to both the survey areas.
2. IC values are always higher in the melange unit than in the coherent-broken unit within each subterrane, indicating that the mélange unit was buried deeper than the coherent-broken unit during the metamorphism. It is supported by the development of pervasive bedding-parallel S1 foliation and dynamic recrystallization of quartz in the mélange unit except that of the Esk Head subterrane in north Canterbury.

3. IC values show large gap across the boundary fault between the mélange unit and the coherent-broken unit on the east side, while appearing to increase gradually from the mélange unit to the coherent-broken unit on the west side. It suggests that the mélange unit has thrust over the coherent-broken unit to the east, truncating the normal gradient of geothermal structure, after the accretionary process of the coherent-broken unit structurally underlain by the mélange unit, followed by the metamorphism.

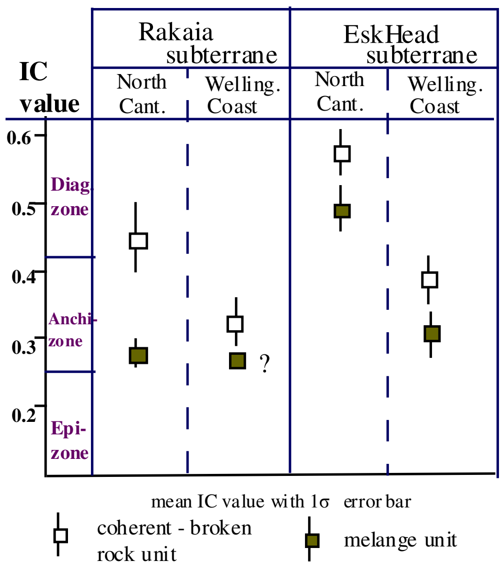

Fig. 1 Summary of IC values

(POSTER)

HAZARD ASSESSMENT OF SH 31 RS 31 (KAWHIA ROAD)

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The 31 RS of SH 31 is notorious for its susceptibility to natural hazards, particularly extreme weather, inducing mass movement and flooding. Transfield Services (NZ) Ltd. is interested in the effect these natural hazards have on the road network in the area. The area is sparsely populated, therefore the risk to the population is minimal, however the threat to the infrastructure is high.

Every winter excessive rainfall causes slips along the highway reducing the stability at the road surface, and often causing failure of the highway. The main kinds of failures are shallow translational and simple washouts, caused by a concentration of rainfall runoff. The geological materials in the area are also a major control on the location of these failures. The distribution of materials is indicated in the geomorphology, which also helps to indicate those areas more susceptible to failure due to past movement.

In this area the quick rise in elevation initiates orographic rainfall, which is the main triggering factor for these failures. Slope stability analyses have shown some areas to be particularly susceptible to failure when the water table rises saturating the altered Pirongia deposits that overly the Te Kuiti group.

The dual purpose of this study is to propose a preventive maintenance solution to reduce failures in the area and as the water runoff is the major triggering factor, improving the overall drainage of the highway will prove to be the simplest, cheapest option. Other options involve major works, such as lowering or deviating the road.

(ORAL)

EVIDENCE FROM THE SHELF FOR PASSAGE OF THE SEAMOUNT THAT CREATED THE RUATORIA INDENTATION AND GIANT AVALANCHE

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The Ruatoria Margin Indentation near East Cape has been inferred to be a result of destabilisation of an already unstable margin by oblique subduction of a large seamount (Collot et al. 2002). The seamount, which may have been similar to the yet-to-be subducted Mahia and Gisborne Seamounts, pushed margin material with it into the subduction zone and left in its wake a collapse trough obliquely across the margin. Between the collapse trough and the slope-toe deformation front, a huge triangle of oversteepened continental margin, which included allochthonous sheets and smectite clays with high fluid pressures, was further destabilised by peripheral fracturing associated with passage of the seamount. The unstable triangle collapsed to form the Ruatoria Giant Avalanche deposit, leaving the southern half of the Ruatoria Indentation behind it.

Despite the plausibility of the hypothesis, there has been little other evidence to support the passage of a large seamount beneath the margin. Various geophysical anomalies beneath land and margin seem to be in the wrong places to represent the seamount that carved the northern part of the Ruatoria Indentation. Sand box modelling experiments and observations of other margins suggests that subduction of a large seamount can leave characteristic patterns of deformation ahead of its wake-collapse trough. In some circumstances, these can indicate the location of the seamount even beneath thick margin cover. New multichannel seismic data from the head of the Ruatoria Indentation provide tentative support for passage of a large seamount beneath the continental shelf.

The continental shelf and upper slope around the head of the Ruatoria Indentation is underlain by Miocene to Recent basins aligned slightly oblique to the coast and margin. The basins are a product mainly of the component of compression associated with oblique plate convergence. One basin underlies the shelf landward of the Ruatoria Indentation, its seaward edge having collapsed into the indentation. This basin is also characterised by numerous diapiric intrusions suggesting escape of mobile fluids associated with fracturing at depth.

Its northern part is also characterised by a margin-transverse graben of slumping and transverse faults that extrapolate the previously inferred path of the seamount. The transverse zone of collapse indicates that a seamount has already passed beneath the shelf, and may underlie rising coastal hills near East Cape. Sequence stratigraphy of shelf deposits suggests that collapse occurred across the shelf immediately before and during the last interglacial age.

(ORAL)

DISTRIBUTION, ELEVATION, AGE, AND INCISION OF THE OHAKEAN RIVER TERRACE IN THE EASTERN NORTH ISLAND

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Aggradation river terraces, formed during glacial periods in response to increased sediment supply from periglacially stripped slopes, are preserved throughout the eastern North Island. The most widespread aggradation terrace is that formed during the most recent glaciation (Otiran), the Ohakean terrace, first described in the Rangitikei River catchment by Milne (1973).

New mapping at 1:50 000 scale is being compiled with unpublished data for 11 eastern North Island river catchments. The Ohakean terrace is variably preserved in each catchment, the broadest terraces occur within the Wairarapa Valley and the Heretaunga Plains (southern Hawkes Bay), whereas in the Mohaka, Waipaoa and Waiapu catchments to the north, Ohakean terrace remnants are small.

Elevation of the terrace tread above the modern river is measured along each of the major trunk rivers by GPS, and longitudinal profiles constructed along smoothed profile lines. Examination of these profiles shows a variable relationship between the Ohakean and modern river profiles; in some the Ohakean profile is steeper, in others they are sub-parallel. Various ways of projecting the profiles for margin-parallel comparison are currently being examined.

Preliminary incision rates, using an age of terrace abandonment of 18 +/- 2 ka, based on tephrochronology in the north (Hammond 1997; Eden et al. 2001) and luminescence ages in the south (Wang 2001; Formento-Trigilio et al. 2002), range from 0 to 11 mm/yr. The highest rates occur along the Mohaka River, with slightly lower values in the upper Ngaruroro and Waipaoa catchments. Plotting mean incision rates in map view allows the identification of regional-scale patterns, as well as comparison with possible factors driving incision such as rainfall, lithology, and tectonics.

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(ORAL)

LANDSLIDE DEPOSITS AT THE MARGIN OF A LARGE BASALTIC VENT COMPLEX, MAWSON FORMATION, FERRAR SUPERGROUP, ALLAN HILLS, ANTARCTICA

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In the Allan Hills, Victoria Land, Antarctica, Beacon Supergroup sedimentary rocks are juxtaposed with volcaniclastic rocks of the Ferrar-age Mawson Formation. The Mawson Formation and its correlatives along the Transantarctic Mountains contain an abundance of chaotic rocks consisting of once-glassy, juvenile basaltic grains mixed with broken country rock from the Beacon. Many of these rocks, including those at Allan Hills, have previously been interpreted in terms of a regional lahar field that formed in advance of Kirkpatrick flood basalt eruptions of the Ferrar large igneous province.

Near Watters Peak, the Mawson Formation at Allan Hills can be divided into two units. One unit ("Mawson A") contains fragmented Beacon strata, with little or no juvenile basaltic material, and is the focus of this presentation. "Mawson B" is more typical Mawson Formation tuff breccia, containing a variably high concentration of juvenile material; it forms most of the Allan Hills and much of nearby Coombs Hills.

Mawson A is further subdivided into two facies. The lower facies (MA1) consists entirely of blocks of medium-coarse sandstone from the immediately underlying Beacon strata. Nearest the contact, blocks are of decimeter scale, with block size decreasing exponentially to less than 5cm towards Mawson B. Thin seams of sand matrix separate the blocks; the matrix consists of the same grains as the sand comprising the blocks. The blocks dip to the south, towards the vent system. The upper facies (MA2) is more chaotic in appearance, and comprises predominately medium grained sandstone along with blocks of siltstone, coarse grained pebbly sandstone conglomerate, coal, and rare juvenile material. Clasts are randomly orientated and no internal structures are visible.

MA1 is interpreted to have formed on a peripheral ring fault surrounding a maar-diatreme system. As magmatic support within the vent system was withdrawn, downsag features formed causing the beds to dip into the vent and fragment. Fragmentation of the blocks due to eruptions within a growing vent would fragment the rock further causing the stratification seen. MA2 is the result of a debris avalanche, created by continued volcanic activity causing instability of country rocks and failures.

(POSTER)

AN ASSESSMENT OF THE MATURATION TRENDS AND IMPLICATIONS FOR THE KAITANGATA COALFIELD, OTAGO, NEW ZEALAND

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The Kaitangata Coalfield, South Otago, New Zealand occurs over 45 km^2 and is located on the Western boundary of the Great South Basin. It is comprised mostly of conglomerate, sandstone, mudstone and coal belonging to the Cretaceous aged Taratu Formation. The Taratu Formation contains in excess of 17 coal seams, many of which are economically significant. Coal seam thickness ranges from 5-20m and show a distinctive rank trend from the North East to South West. The aim of the research has been to assess the relative influence of the following factors on coal rank trends. These include facies relationships, burial depth, syndepositional and postdepositional faulting, and the later intrusion of the Miocene Dunedin Volcanics.

By combining coal analyses with detailed mapping of facies architecture, it has been possible to depict lateral and vertical variations in coal maturation as well as refining the understanding of sedimentary basinal relationships. The Castle Hill fault is a major structural feature of the Kaitangata basin. Cross-sectional analysis shows that the fault was syndepositional with adjacent facies strongly related to fault movement. This relationship can be seen as coal formation during fault quiescence succeeded by fanglomerates during fault activation. This may have had not only a strong control on coal distribution and thickness but also an impact on coal quality and later maturation.

Reconstructing basin architecture via cross-sections aids in sampling methodologies by delineating targeted seams in terms of coal distribution and thickness. Most coal sample analysis will include the following: (a) vitrinite reflectance, (b) rock evolution, (c) volatile matter/fixed carbon, and (d) C, H, N, O Analysis. This will provide information on the composition of the coal as well as the degree of thermal alteration that the coal has undergone. By combining this data with facies architecture, a coal maturation map for the Kaitangata basin can be constructed identifying the primary causal influence of coal rank trends in the basin. So far, burial depth seems to be the most important causal factor. However, with the results of some coal analysis pending it is too early to determine the importance the intrusion of the Dunedin Volcanic Group or the faulting relative to the other causal factors in coal maturation within the Kaitangata Coalfield.

(POSTER)

LATE QUATERNARY ENVIRONMENTAL CHANGE FROM LAKE OMAPERE, NORTHLAND, NEW ZEALAND

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We provide a record of environmental change from L. Omapere, a 12 km^2 shallow eutrophic lake in northern Northland, based on palaeolimnological analysis of a 7-m-long core spanning the last c. 80 cal. ka. The chronology was developed using tephrochronology, palaeomagnetism, and ^{14}C dating plus climato- and palyno-stratigraphy. Two of 14 tephra layers provide key markers for correlating the record with other N.Z. terrestrial and marine sequences and with Marine Isotope Stages (MIS): Tephra-13 (c. 74 cal. ka) was deposited near the MIS 5a–4 boundary, and Rotoehu Ash (c. 55 cal. ka) was deposited early in MIS 3. Pollen, diatom, palaeomagnetic, sedimentologic and pigment analyses show that L. Omapere, currently c. 2 m deep, has had a discontinuous history. Occupying a shallow basin perched partly within old basalt lavas, the initial (alkaline) lake formed c. 80 cal. ka, presumably because of blockage (not by lava flows) of local drainage of a paludal floodplain, inundating peat and forest trees, including kauri. The lake filled rapidly to a level c. 1–2 m above that at present. Such filling was probably unrelated to climate but the subsequent phase of variable but generally falling lake levels and increasing dystrophy may have been climatically controlled. The lake became swampy or dry early in MIS 3, soon after Rotoehu Ash fell. The longest periods of non-deposition (or non-preservation) were during most of MIS 3, all of MIS 2, and probably for most of MIS 1 until formation of the modern lake c. 700 cal. years ago, or soon after, as indicated by the presence of Kaharoa Tephra (AD 1314 ± 12) near the top of the core. This tephra also provides a maximum date for Polynesian settlement in the region, shown palynologically by initial forest clearance soon after its deposition. The modern lake originated possibly through damming of the western outlet as a consequence of Polynesian deforestation by burning, an interpretation supported by Nga Puhi oral narratives. Lowered by c. 1.4 m in 1922 to reduce local flooding, the lake may now be in danger of drying out unless pre-1922 levels are restored.

Except for the human era, forest appears to have been continuously dominant near L. Omapere. However, major time gaps occur in the record, not only during MIS 2 but also in MIS 3 and 1. *Nothofagus* (presumably *N. truncata*) was much more common in Northland during the Last Glacial (LG) and the relative abundance of *Nothofagus* vs. *Agathis* pollen may provide a better indicator of cooler vs. warmer intervals during the Quaternary than the ratio of tree to non-tree pollen. However, moisture balance was probably a more critical factor than temperature in vegetation composition and distribution, particularly during MIS 2. Several tree species (*Halocarpus bidwillii, H. biformis, Phyllocladus alpinus*) occurred about 2° latitude further north and at much lower altitudes than their current limits during cooler or drier phases of the LG. A temperature depression in Northland of 4^{o} C at various times during the LG is inferred from these range expansions. Nevertheless, the persistence of widespread forest cover suggests that L. Pleistocene climates of Northland were less severe than for most of the rest of N.Z. and strengthens the argument for a heightened latitudinal temperature gradient across northern N.Z. during MIS 4–1.

(ORAL)

IRONSAND MINERALOGY AT THE WAIKATO NORTH HEAD AND TAHAROA DEPOSITS, NEW ZEALAND

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The Waikato North Head and Taharoa ironsand deposits are located on the west coast of the North Island of New Zealand. Waikato North Head occupies the southern-most tip of the Awhitu Peninsula 50 kilometres southwest of Auckland and is the largest producer of iron ore in New Zealand. The Taharoa deposit is the only other iron ore producer in New Zealand, and is located 144 kilometres south of Auckland on the southern tip of the Kawhia Harbour.

Four Quaternary stratigraphic units are present at the Waikato North Head deposit, the Mitiwai, Bothwell, Hood and Awhitu sands. The Mitiwai and Hood sands contain the highest concentrations of magnetic minerals. These units have significant mineralogical differences, which we quantified by point counting a total of 2400 grains from twelve polished mounts, with four mounts from each of the Mitiwai, Hood and Nukumiti sands. This method concentrated on the homogenous magnetite grains and the magnetite grains containing exsolution lamellae of ilmenite. For the purpose of this exercise all other grains were ignored.

The Mitiwai Sands are the youngest unit present at Waikato North Head, and contain an average magnetic mineral content of 14 percent. The magnetic fraction of this unit contains predominantly homogenous magnetite grains. Twenty to 34 percent of the magnetite grains contain exsolution lamellae of ilmenite. At Taharoa the only exposed unit of the Mitiwai Sands is the Nukumiti Sands Member. These are the youngest aeolian sands of the Taharoa deposit and contain an average magnetic mineral content of up to 70 percent. The magnetic fraction of this unit also contains predominantly homogenous magnetite grains. However, 24 to 27 percent of the magnetite grains also contain exsolution lamellae of ilmenite. The Waiuku Black Sand, which is a member of the Hood Sands, is the highest grade unit at Waikato North Head, containing up to 70 percent magnetic minerals mostly as homogenous magnetite grains. Ten to 17 percent of these magnetite grains contain exsolution lamellae of ilmenite.

The Mitiwai Sands at Waikato North Head and Taharoa contain approximately equal amounts of magnetite grains with exsolution of magnetite lamellae of ilmenite (average 26 percent). However, the Hood Sands contain a lesser amount of magnetite grains with exsolution lamellae of ilmenite (average 12 percent). The Hood Sands are older than the Mitiwai Sands, which may indicate that younger sands are derived from a provenance with higher proportions of magnetite with ilmenite lamellae. Alternatively, this difference may indicate that the older sands were transported for longer distances and that magnetite grains with ilmenite lamellae selectively degraded during transport. Additional petrographic work of oxide minerals in the possible source terrains would help distinguish between these possibilities.

(ORAL)

VOLCANISM VS TECTONISM: IMPLICATIONS OF INTRACALDERA PALAEOSHORELINES AT LAKE TAUPO

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The Taupo Volcanic Zone is a region of ongoing active volcanism, deformation, and seismicity in the central North Island of New Zealand. At Taupo Volcanic Centre, a major young caldera system is superposed on the Taupo Fault Belt, a zone of Late Quaternary extensional normal faulting accompanying intra-arc rifting. Intracaldera Lake Taupo forms a highly sensitive datum against which to measure active deformation trends around the margins of the lake as part of ongoing monitoring and surveillance of the active volcanic system. Modern short-term (< 20 years) vertical deformation rates measured using geodetic and lake-levelling techniques reveal complex and episodic deformation trends related to active faulting and seismicity, overlaying a broader regional pattern. In contrast, warped and offset palaeoshorelines formed at 1.8 and 26.5 ka following major explosive eruptions reveal differences in medium- and long-term patterns. While relative vertical displacements of the post-1.8 ka marker are broadly similar to historic patterns, warping and offsetting of a high-stand shoreline developed ~140 m above modern lake level in the immediate aftermath of the 26.5 ka Oruanui eruption are only double those of the 1.8 ka shoreline, despite it being 15 times older, except where displacement has been concentrated on the highly active Kaiapo Fault. Furthermore, the 26.5 ka shoreline reaches its highest elevation in the middle of an inferred graben in the Taupo Fault Belt: extrapolation of modern deformation rates at this site would place it *below* modern lake level.

These observations, coupled with geomorphic and stratigraphic data, indicate that much vertical deformation at Taupo is episodic and intimately related to major volcanic eruptions. At other times, rifting is apparently occurring without the accumulation of long-term vertical offsets and net subsidence on caldera-adjacent normal faults of the TFB, possibly because of compensation by magma accumulation in the crust. Careful assessment of short-term, fault-related, deformation trends and seismicity at Taupo is therefore needed in order to distinguish elastic responses to long-term horizontal extension from deformation with a magmatic component that may be a prelude to an eruption.

(POSTER)

SEISMIC NET CATCHES A FALLING STAR: THE 7TH JULY 1999 HAWERA FIREBALL

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At approximately 4.10 pm (04:10 UTC) on 7th July 1999 a meteor weighing between 1 and 10 tonnes entered the Earth's atmosphere to the north west of New Zealand. Visual observers between Whangarei and Timaru reported the path of the fireball across the sky, before it exploded 32 km above the small Taranaki town of Hawera. The terminal detonation produced an atmospheric shock wave that weakly coupled with the ground, generating a signal that was recorded on 18 seismograph stations that form part of the geological hazards monitoring network operated by the Institute of Geological and Nuclear Sciences. Modelling of arrival times of the sonic boom at a subset of stations constrain the point source location to 39.45° S, 174.45° E at an elevation of 32 km, which places the explosion 20 km northeast of Hawera. Source energy of the terminal blast, detected at 04:14:42 UTC by U.S. Department of Defence satellites, is estimated at c. 0.3 kilotons from inversion of the heard radius of the explosion. Although optimised for the monitoring of terrestrial geohazards, New Zealand's seismic stations have also shown their utility in detecting extra-terrestrial hazards.

(POSTER)

VERTICAL DENSITY CURRENTS AND THEIR ROLE IN THE FORMATION OF DEEP-SEA ASH BEDS

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Volcanic ash layers form important chronostratigraphic markers in the geological record, in addition to providing information on eruption dynamics and chronology. Although the atmospheric transport and fall-out of tephra is relatively well-understood, little attention has been paid to the mechanisms of tephra delivery to the deep oceans. Early work assumed that on crossing the air-water interface, sedimentation occurred by Stokes Law settling of individual particles, but many of the features of deep-sea ash beds contradict such a process. More recently, theoretical studies and laboratory experiments have demonstrated the potential of vertical density currents (VDC's) in the rapid transport of fine particulate material through water columns, while data collected from the deep sea during and after the 1991 eruption of Pinatubo has provided independent evidence for the vertical transport of tephra at velocities 1 to 3 orders of magnitude faster than possible by Stokesian settling.

Fluid dynamic and plume theory applied to VDC's generated by the gravitational instability of a particle-laden surface layer of water produce some surprising results:
The overall properties of the buoyancy field are more important than those of the individual convection elements that make it up.
Mixing and dilution with ambient seawater only occurs at the plume fronts; lateral mixing is with adjacent plumes of equivalent density.
Vertical transport velocities are proportional to tephra fallout rates only, not particle grain-size.
Some vertical size sorting occurs in mid-water due to incomplete turbulent mixing in the descending plumes.

This theoretical model reproduces all of the features demonstrated by deep-sea ash beds and the Pinatubo observations. Deposition of deep-sea ash layers is a hybrid process, involving both Stokesian settling of individual coarse/dense particles through the entire water column, and suspension settling from a polydisperse turbid layer delivered to the ocean floor by VDC plumes. This turbid layer may itself passively settle out, become entrained by a deep-water thermohaline current, or, if it becomes sufficiently thick and/or dense on a sloping substrate, self-mobilise as a nepheloid current. Regardless of additional complications arising from post-depositional reworking, deep-sea ash beds may not therefore directly reflect either an eruptive signal, or record the order, rate, and location of the arrival of ash particles at the ocean surface.

(ORAL)

ANOTHER COUNTRY? A PALEONTOLOGIST FROM THE SOUTHERN LAND LOOKS AT NORTHLAND

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Early to mid-Cenozoic molluscan faunas from the southern South Island are compared with those from Northland. About 1000 species are recorded from the Paleogene of South Canterbury/North Otago, but Northland Paleogene faunas are poorly preserved, of low diversity or non-existent. The richest (c. 45 spp) is from Pahi (Bortonian, Middle Eocene), and its composition suggests marine temperatures may have been similar over much of New Zealand at this time.

In contrast, the Northland Otaian/Altonian (Early Miocene) fauna (> 800 spp) is not only much richer than the South Canterbury/North Otago fauna (c. 570 spp), but differs markedly in composition, particularly at the species level where the Simpson Similarity Index for marine bivalves, scaphopods and gastropods is only 6.4, compared with 49.7 for the modern Aupourian and Forsterian "provinces". Possible reasons for this disparity include:

1. The greater latitudinal spread (2° 30') for Northland compared with South Canterbury/North Otago (1° 05').

2. The wider range of facies represented in Northland. The southern localities are mostly of shelf facies, whereas the Northland fauna includes rocky shore, subtidal, shelf and bathyal assemblages. Some noteworthy Northland faunules are mixed, e.g. Hollands Point, Pakaurangi, the richest molluscan fossil locality in New Zealand (398 species.) Besides benthic molluscs it includes abundant pteropods and very rare land snails (which have important implications for paleogeography.) Northland geography was considerably more complex and had greater habitat diversity than eastern South Island, and included numerous volcanic seamounts (although shoals or islands were present in the Oamaru district at this time). Upwelling of nutrient-rich waters may have formed biodiversity "hot-spots" in both regions.

3. Temperature differences between Northland and eastern South Island. Many warm-water molluscan taxa are recorded from the Early Miocene of Northland but not from South Canterbury/North Otago. (Several, however, occur in the Late Oligocene of South Canterbury/North Otago - possible evidence for a cooling episode at or near the end of the Waitakian. Some are present in the Altonian at Clifden, suggesting a relatively open seaway between Southland and Northland).

It seems unlikely geographic and climatic barriers alone can explain the disparity. A possible explanation - supported by the considerable number of molluscan genera that are first recorded from the Early Miocene of Northland - is that a significant portion of the fauna arrived at about this time by island-hopping along the Norfolk Ridge, or are descended from species emplaced with the Northland Allochthon during the Late Oligocene.

(ORAL)

THE GEOCHEMICAL TRENDS OF RECENT TEPHRA ON EGMONT VOLCANO, TARANAKI, NEW ZEALAND

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The aim of this study is to analyse the mineral chemistry and petrology of recent tephra units on Egmont volcano, younger than 6000yrs B.P. and will further document the geochemical trends that exist on the cone. The fieldwork involved collecting samples from individual ash and lapilli beds for chemical analysis. Individual phenocrysts from samples were analysed by microprobe and pumice and lithics were analysed by XRF and ICP. The main phenocryst assemblage within tephra (in order of abundance) is plagioclase, augite, hornblende and titanomagnetite with some tephra containing olivine or biotite. Microprobe results showed no significant chemical variation in phenocrysts between tephra, however there are significant differences in plagioclase and augite between tephra from the main cone of Egmont Volcano and Fanthams Peak. Within the plagioclase phenocrysts, there is a strong positive correlation in K_2O and Na_2O compared to SiO_2, whereas FeO and MgO show a negative correlation with SiO_2. Major element data from glass fragments have a similar trend with Al_2O_3, FeO, CaO and MgO showing a negative correlation with SiO_2 and K_2O a positive correlation with SiO_2. There is also a clear separation between the glass chemistry of tephra from Fanthams Peak and the main cone. Whole rock chemical data from pumice clasts show a positive correlation of K_2O and Na_2O with SiO_2 that contrast with a negative correlation of FeO and MgO with SiO_2. There is also a clear variation of major elements between the tephra units. From whole rock chemical data three main stages in the chemical evolution of the Egmont Volcano magmatic system between 5300 and 347 yrs B.P are apparent. The first stage shows an increase in the major elements SiO_2, K_2O and Na_2O and a decrease in FeO and MgO due to fractionation. The second stage can be divided into two parts with an initial decrease in SiO_2, K_2O and Na_2O and an increase in FeO and MgO caused by an injection of fresh magma. In the second half of stage two the reverse effect occurs caused by fractionation. The third stage, represented by the most recent tephra, is similar to stage two but occurs over a smaller time frame and corresponds to another magma injection event and subsequent fractionation. The discriminant analysis showed no overlap between tephra and lava chemical data suggesting there is no correlation between lava and tephra from the same eruptions, this result maybe due to eruption processes.

(POSTER)

MAGNETOSTRATIGRAPHY AND LOCATION OF THE EOCENE/OLIGOCENE BOUNDARY IN THE CLIFF SECTION AT CAPE FOULWIND, NEW ZEALAND

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A magnetostratigraphic record has been developed for the ca. 98m thick sequence of silty mudstones exposed at Cape Foulwind, 12 km west of Westport. Approximately 180 oriented samples were drilled from the lower, massive Kaiata Member and the overlying, rhythmically banded Port Elizabeth Member. The natural remanent magnetization (NRM) is very weak throughout the section, and thermal demagnetisation is impractical above about 300°C, due to thermal alteration of the magnetic minerals. The Kaiata Member carries a normal-polarity thermoviscous component of magnetization, overlying a characteristic remanent magnetization (ChRM) that is interpreted to be detrital in origin. The NRM of the Port Elizabeth Member is complicated by diagenesis which seems to result in a high unblocking temperature secondary component that partly masks the ChRM. Directions and/or polarities of the ChRM were estimated for 78% of the 180 samples analysed.

The lower part of the section is entirely of reversed polarity, with a R-N transition occurring 14.5m above the Kaiata/Port Elizabeth contact. This is interpreted as the C13R/C13N transition (33.545Ma) on the basis of the LO of *Globilerapsis index*, which defines the Runangan/Whaingaroan Stage Boundary, 14m below the contact (Morgans, pers. comm.) The identification of the predominantly normal interval from 61m to at least 80m above the Kaiata/Port Elizabeth contact as C13N is further supported by the highest occurrence of *Pseudohastigerina micra* at ca. 30m. The LO of *Pseudohastigerina micra* occurs in C12R. The Eocene/Oligocene Boundary is conventionally placed at 33.7Ma, 0.155 My before the C13R/C13N transition (Berggren *et al.* 1995) and is accompanied by a global rise in the $\delta^{18}O/\delta^{16}O$ ratio (Zachos et al., 2001). Such a rise in $\delta^{18}O$ was recorded 5 - 10m above the Kaiatan/Port Elizabeth contact at Cape Foulwind, by Burns and Nelson (1981). This is very close to our estimated position of the Eocene/Oligocene transition. Rock magnetic studies by Hüsing et al. also show a marked drop in magnetic mineral concentration at this level, indicating a sudden change in the depositional environment.

(PLENARY)

QUARRYING IN KARST: APPLIED GEOLOGY AT WILSONVILLE QUARRY, NORTHLAND

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Wilsonville Quarry is operated by Golden Bay Cement and supplies high-grade limestone to the Portland cement works near Whangarei. The quarry is situated within a deposit of highly corroded Whangarei Limestone. It overlies an abandoned coal mine in Kamo Coal Measures and is in turn partially overlain by very weak Northland Allochthon material. This unusual geological setting affects the operation and planning of the quarry, requiring ongoing geological and hydrogeological investigations.

Groundwater ingress is significant as conduits and cavities make the limestone highly permeable. Water is inferred to travel underground from a number of sinkholes located well beyond the quarry's topographic catchment. Water quality analyses also indicate a hydraulic connection with the underlying flooded coal mine. Ongoing investigations include dye tracing to identify sinkholes that contribute water and detailed monitoring of groundwater levels in the area.

Drilling has shown that allochthon sediments are highly variable over short distances. Mudstones currently exposed around the quarry are very weak and are believed to have resulted from recent remobilisation of the sediments, possibly when Hikurangi Swamp water levels were higher. For this reason the base of the mudstone may not represent the allochthon emplacement surface, but a more recent surface in which limestone pinnacles formed in a sub-aerial weathering environment. Considerable corrosion of the limestone has also occurred following burial however, with rain water solution features being removed.

(ORAL)

PHYTOREMEDIATION OF Hg-CONTAMINATED MINE TAILINGS BY INDUCED HYPERACCUMULATION

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The success of a phytoremediation operation is dependent on the availability of the target metal in soil for plant uptake (Anderson, 2000). In most contaminated soils and mine tailings, mercury (Hg), one of the most toxic metal pollutants, has limited solubility and thus low availability for plant uptake (Kabata-Pendias, 2000).

A strategy for inducing Hg mobilisation in soils to increase accumulation potential in plants was investigated by combining studies on the geochemistry of Hg in the Tui mine tailings (Te Aroha, New Zealand) with pot trials carried out in a greenhouse. Induced hyperaccumulation of Hg was tested in *Brassica juncea* and *Lupinus* sp. grown in pots using Tui mine tailings treated either with ammonium thiocyanate supplemented with hydrogen peroxide ($SCN+H_2O_2$), ammonium thiosulphate (S_2O_3) or thiourea.

The addition of S_2O_3 to tailings mobilized Hg in substrates and caused a significant increase in the Hg concentration in shoots of *B. juncea*. Conversely, Hg translocation to *Lupinus* sp. shoots was significantly reduced in the presence of this ligand. The Hg concentration in leachates collected from pots of both species was significantly enhanced in the presence of $SCN+H_2O_2$ and S_2O_3. Mass balance calculations revealed a significant fraction of Hg was lost from the system. This unaccounted Hg may indicate Hg volatilization from plant leaves or rhizosphere microbes.

The results indicate that there is potential to induce Hg hyperaccumulation for phytoremediation of Hg-contaminated sites. However, issues of Hg leaching and volatilization need to be addressed before this technology can be implemented in the field.

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(POSTER)

HAROLD WELLMAN: HIS EARLY CAREER WITH NEW ZEALAND GEOLOGICAL SURVEY

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Harold Wellman was the most influential New Zealand geologist in the middle part of the twentieth century. Although he is remembered today mainly for his discovery of the Alpine Fault (and his subsequent recognition of a 300-mile offset along it), he had an extraordinary range of achievements during his period with the New Zealand Geological Survey, DSIR (1938-56), including:

- Geophysical investigations (including the Cobb Dam site)
- Economic mineral investigations during World War II
- Unravelling Tertiary stratigraphy and paleogeography
- Developing a relationship between coal rank and depth of burial
- Distinction between the Alpine and Hokonui facies
- Recognition and mapping of active faults
- Analysis of past earthquakes from faulted terrace sequences (Paleoseismology)
- Cretaceous stratigraphy and paleontology

I am currently working on a biography of Harold Wellman, and am keen to talk to people who have memories or records of his work (especially including photographs).

(ORAL)

FORAMINIFERAL DISTRIBUTION AS A RESPONSE TO OCEANOGRAPHIC REGIMES

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Paleoceanographic reconstructions are only as good as the understanding of foraminiferal biology. Planktic foraminifera form a major component of the open ocean plankton; hence their modern abundance and flux can give insight into proxy interpretations. Deep-sea sediments are supplied with a constant 'rain' of the inorganic carbonate tests of planktic foraminifera, with nearly half the ocean floor covered by ooze composed predominantly of these tests. Any changes in the spatial distribution of specific species may reflect significant oceanographic change, and needs to be considered when making paleoceanographic interpretations.

Vertical distribution of planktic foraminifera within the water column is assumed to be controlled by three major factors: (1) the physico-chemical conditions of the photic zone dictate planktic foraminiferal population abundance and composition; (2) species are vertically stratified within the photic zone according to their temperature and reproductive preferences; and (3) the zone of maximum chlorophyll concentration is a major source of food which is preferentially exploited by foraminifera.

The supply of biogenic material to the seafloor has become the subject of active research in New Zealand in recent years. Here we address the relationships between living planktic foraminifera in the upper 800m of the water column, and the tests collected in sediment traps and deep-sea sediments over Campbell Plateau. We assess the reliability of planktic foraminiferal assemblages and oxygen isotopes for utilization as surface water mass indicators, and for selected species we assess the calcification depths from oxygen isotopes. Plankton tow data provides insights into the relationship between hydrographic (temperature and salinity) and biological (nutrients, oxygen and light) factors, which may control the abundance, size, and/or isotopic composition of specific foraminiferal species. As snap-shots, tow data can be impaired by patchiness and seasonal and interannual variations. However, these variations can be assessed from time-sequenced sediment trap data. This comparison will improve our knowledge of the ecology, life cycle, surface and vertical distribution of the modern fauna thus improving paleoceanographic reconstructions using the sediment records.

(ORAL)

PETROGENESIS OF MID-TERTIARY LIMESTONES IN EASTERN NORTHLAND, NEW ZEALAND

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Oligocene-earliest Miocene (Whaingaroan-Waitakian) limestones within eastern Northland include the coarse-grained, autochthonous Whangarei Limestone and Onemana Formation, and the fine-grained, allochthonous Mahurangi Limestone. Based on field and petrographic attributes, a total of 11 facies (A to K) accounts for most of the lithologic variation within these deposits. The carbonates formed at a range of depths and energy conditions across an island-dotted shelf platform, on the bounding slope and in more distant oceanic basin environments. Bryomol, echinofor, rhodechfor, and nannofor skeletal assemblages dominate, all typical of non-tropical carbonate deposits. Regional facies relationships suggest generally shallower depositional sites to the north than the south, related to initial differences in elevation of platform paleotopography. With time, depositional water depths gradually increased, associated with regional submergence consequent upon post-breakup thermal relaxation of the wider New Zealand subcontinent, before a significant shallowing event, possibly related to propagation of a "wave-form bulge" ahead of the advancing Northland Allochthon, affected the northern area only with the formation of hardgrounds and, in places, erosion with relief up to a few metres. Following this shallowing event, the entire region deepened rapidly due to drawdown associated with the evolving subduction plate boundary to the east, with widespread deposition of planktic-foraminiferal carbonate facies. Subsequent local occurrences of Onemana Formation above the Whangarei Limestone in the southeast accumulated under relatively shallower water conditions, as evidenced by the presence of prominent traction-current structures and hummocky cross-stratification within the carbonate successions. The presence of a thick tuff bed within the Onemana Formation might link the shallowing to the onset of local dacitic volcanism in the area. This formation also includes a wedge of allochthonous material which may have broken off the front of the advancing Northland Allochthon, which includes the Mahurangi Limestone and sits with sheared contact above all facies of the Whangarei Limestone and Onemana Formation.

Petrography and geochemistry demonstrate the Northland limestones are dominated by sequences of burial cements of equant and microequant non-ferroan calcite composition. Consequently, pressure-dissolution features are widespread and flagginess is typical of many facies in the field. However, facies including marine cements are rather more common than in many other New Zealand mid-Tertiary limestone sections and, together with some stable oxygen isotope data, are suggestive of a locally strong marine influence during limestone diagenesis, possibly related to the more northerly latitude and more persistently warm temperate marine climate of the Northland region in the Oligocene.

(ORAL)

LANDSLIDING ON THE PAEROA FAULT AT TE KOPIA

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The Te Kopia geothermal field is bisected by the north-east striking, active Paeroa Fault. Maximum vertical expression of the scarp is 524m. Three rhyolitic ignimbrites from the Whakamaaru Caldera are exposed, dated at 0.34 - 0.32 my. These are the source rocks for numerous debris flow deposits within a hummocky, sloping apron at the base of the scarp. Identifiable tephra layers within the apron provide age control for these deposits. Clay (illite and smectite) and zeolite (mordenite) alteration dominate these thick, clast supported deposits. This alteration is characteristic of warm (<120°) near neutral pH heated groundwater proximal to a geothermal field. Distribution of clast alteration within several debris flow deposits does not, however, match the present boundary of the geothermal field, suggesting hydrothermal activity was once more widespread.

Other slope deposits are thinner, matrix supported, and dominated by angular tabular clasts of silicified tuffaceous sediment of the Huka Falls Formation. Circular features nearby suggest that these deposits are hydrothermal eruption breccias.

Different types of landslide movement are recorded at Te Kopia, and their deposits show different spatial and temporal distributions. Debris flow deposits are the most widespread. Rockfall is common, easily identified, and generally constrained to specific areas along the scarp. Block slide deposits are rare and occur as isolated hills and benches within the scarp. Earth flows have left scars all along the scarp, but no obvious deposits, and are present both inside and outside the thermally active area.

Landslide failure within the area can be attributed to several different factors. Acid steam condensate alteration is likely to promote widespread debris flow failures, especially during intense rainfall and earthquakes. Rockfall is a function of defects and oversteepening along the scarp. Infrequent earth flow deposits at the base of the fault scarp indicate a saturated condition when deposited. The scarcity of earth flow debris also suggests low mass volumes. Block slide failure is assumed to have some structural control in the rock mass. The presence of hydrothermal eruption breccias within landslide deposits may indicate that these events have a direct causal relationship with landsliding.

(ORAL)

RESEDIMENTATION OF THE 1800A TAUPO IGNIMBRITE ALONG THE RANGITAIKI RIVER CATCHMENT, NORTH ISLAND, NEW ZEALAND

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Volcaniclastic material from the 1.8 ka Taupo eruption (central North Island, New Zealand) was widely remobilized in the months to years after the eruption. The potential for generation of dangerous and damaging lahars and floods in response to tephra deposition from the Taupo caldera still exists along river catchments draining the Taupo caldera, were it to erupt again. Studies of the style and tempo of the response to the 1.8 ka Taupo eruption provide information for hazard assessment for the North Island and other areas where explosive and voluminous rhyolitic eruptions will occur in the future. For the 1.8 ka Taupo eruption, earlier studies have addressed intracaldera response and extra-caldera re-establishment of three main drainages of the Taupo caldera. The topography of the upper Rangitaiki catchment, the subject of this study, is unique in that the Taupo ignimbrite buried an essentially flat land surface inherited from a 320 ka welded ignimbrite sheet. Previous researchers have inferred that the Rangitaiki River was immediately re-established as a meandering stream, implying sediment loading and transport rates similar to those of the present. My mapping in contrast reveals that a low gradient area of hundreds of square kilometres was initially flooded and washed by hyperconcentrated and sheet flows, resulting in shallow but widespread reworking. In higher gradient areas, re-integration of drainage systems was accompanied by incision of deep channels and gullies, interspersed with ephemeral lakelets formed in response to localised damming by pyroclastic material. Ephemeral braided streams and meandering rivers eventually developed as stable rill and gully systems were established and overland flow across the remaining unconsolidated deposits diminished. This pattern of landscape response has implications for the timing and nature of the remobilised pyroclastic flux to downstream depocentres and the Bay of Plenty coast more than 100 km to the north.

(ORAL)

EPIDIASCOPE TO POWERPOINT: VISUALISING NEW ZEALAND GEOLOGY

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No modern geological seminar or published paper is complete without its supporting illustrations. In some recent papers over 60% of the space is taken up by images with every one no doubt worth a 'thousand words'. Poster sessions are based on the idea of images supported by text rather than the other way around.

Visual representations of data and interpretations are essential tools of communication for geologists, who expect to see well-designed illustrations that complement and illuminate the words, but 'if a writer cannot make himself clear by the aid of words, all the illustrations in the world will not retrieve the position' (Smith 1951). Conference talks and posters are crammed with visual images that are now constructed, coloured and displayed using computer technology entirely. In contrast, historians and philosophers who write about science rarely use images and pay little attention to the significant presence and role of visual representations especially those used by geologists (Rudwick 1976).

The way in which visual images are used to describe, analyse and explain geological phenomena in New Zealand will be reviewed, beginning with Stutchbury's Bay of Islands section of 1826. Photographs, microphotographs and movies constitute the most realistic field descriptions while field sketches and drawings, graphs, diagrams, charts and stereonets involve considerable analysis, interpretation and abstraction. Geological maps play a fundamental role in geoscientific research, and all images can be regarded as data repositories. Graphical methods can even be used to trace the emergence of a new sub-field, such as terranes, and the growth pattern of the subject of geology in New Zealand by analysing the publication rate of articles, books and maps about New Zealand geology.

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(ORAL)

EPISODIC FAULT MOVEMENT IN THE OTAGO RANGE AND BASIN PROVINCE: SOME PRELIMINARY SPECULATIONS

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Otago is characterised by a sequence of NE-trending ranges formed as fold-thrust structures above a set of parallel reverse faults. Approximately 10 major structures occur between the Cardrona Valley in the west and the Otago coast. The various fault-fold segments range from 15 to 20 km in length and the spacing of the major structures is in the range 15 to 25 km. The total amount of strain currently being accommodated by these structures is uncertain, but is likely to be small. The Late Cenozoic vertical displacement on all the structures sums to c. 10 km. Assuming an average dip on the faults at depth of 45°, the vertical offset will approximate the horizontal shortening. If this has largely accumulated during the Quaternary, an average shortening rate of 4 mm/yr across the whole area is derived. The amount of shortening is largest in the west and diminishes eastwards. Whether this is because the rates are highest in the west, or the time of accumulation there has been longer is uncertain.

Paleoseismic studies of the Pisa and Dunstan faults by Beanland and Berryman (NZ Journal of Geology and Geophysics, 1989, v. 32, 451-461) led them to suggest that displacement on these two structures was episodic, with periods of frequent ruptures separated by long periods of quiescence. They went on to propose that episodic displacement may be characteristic of the Otago faults and that these faults form a linked system. More recent work by Litchfield (NZ Journal of Geology and Geophysics, 2001, v. 44, 517-534) and Litchfield and Norris (NZ Journal of Geology and Geophysics, 2000, v. 43, 405-418) supports this concept by showing that the Titri and Akatore faults have had periods of activity interspersed with long periods of quiescence. Cosmogenic dating of fault propagation at the end of South Rough Ridge (Jackson et al., Earth & Planetary Science Letters, 2002, v.195, 185-193) also suggests episodic displacement and range growth.

Simple models have been investigated in which the probability of an individual fault within a set of parallel faults rupturing is increased after a previous rupture. As the weighting for this effect is increased, fault ruptures change from a random to a clustered pattern, with sequences of consecutive ruptures separated by periods of inactivity. Calibration of this model using paleoseismic data may be useful in providing a better hazard model than by assuming a random distribution of ruptures.

(ORAL)

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

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The Rennick Glacier is a major regional outlet of the East Antarctic Ice Sheet. It drains from the Talos Dome, a small coastal sector of the ice sheet, and unlike other glaciers in the region flows into the Southern Ocean rather than the Ross Sea. As a consequence of its more maritime location and in the absence of the buffering effect of the Ross Ice Shelf, it should respond more sensitively to global climate fluctuations. Since the upper reaches of the glacier fluctuate in response to changes in source ice levels, the history of the upper Rennick Glacier, recorded by glacial moraines and drift sheets, should reveal a pattern of changes in the thickness and extent of the Talos Dome itself.

Surface exposure dating using the cosmogenic nuclides ^{10}Be and ^{26}Al is being used in the present study to ascertain the timing of fluctuations in the upper Rennick Glacier. Relative age assessment of the mapped moraines and associated drift sheets has also been undertaken using the morphostratigraphic and post-depositional weathering criteria. In addition, the moraines can be correlated or differentiated on the basis of the proportion of the various clast lithologies that make up the till. XRF analyses have also been performed on granitic till and bedrock in order to determine till provenance to reveal any changes in source rock materials that may result from major changes in glacier flow direction.

Preliminary investigation of the moraines and drift sheets appeared to indicate a simple pattern of reducing glacier level with each subsequent Rennick Glacier fluctuation. Weathering states increase with altitude, with a significant increase in weathering between the highest and lowest moraines. The weathering analyses combined with morphostratigraphic criteria and analysis of clast lithologies reveal a probable correlation between moraines across the upper Rennick Glacier system. Furthermore, the mapping, relative age discrimination and correlation of the moraines has created a framework within which the cosmogenic nuclide exposure ages can be placed and assessed, and will allow us to develop a reliable framework for the interpretation of the late Cenozoic glacial history of the Rennick Glacier system.

(ORAL)

QUANTIFYING DEPOSITION FROM THE VERY MUDDY WAIPAOA RIVER ON THE POVERTY SHELF AND MARGIN RE-ENTRANT, EAST COAST NEW ZEALAND

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The East Coast margin is characterised by high terrigenous sediment flux, dramatic effects of land-use changes, and by complex sediment-tectonic interactions on a steep and unstable continental slope. Post-glacial output from the Waipaoa River has been largely trapped on the shelf and slope. An estimated 18 km^3 of sediment has been deposited in an actively subsiding mid-shelf basin and outer shelf apron since 18 ka BP, with a maximum thickness of ~45 m. The shelf is bordered along its seaward edge by two growing anticlines, but a significant component of the sediment leaks through a 13 km-wide gap between the anticlines and cascades into a large structural re-entrant that is heavily incised by the Poverty submarine canyon system. ^{210}Pb mass accumulation profiles indicate that the modern post-settlement sedimentation rate of around 0.9 cm yr^{-1} on the outer shelf is double that recorded at the mid-shelf. Hence, the modern sediment accumulation is inconsistent with the post-glacial sediment thicknesses, which show the largest volume has accumulated on the mid-shelf. This may suggest an increasing frequency of Waipaoa-derived hyperpycnal flows with the ability to transport sediment seawards, or a change in the storage pattern within Poverty Bay. Accumulation rates on the slope are an order of magnitude less, around 0.1 cm yr^{-1}.

Cores and multibeam images suggest that Poverty Canyon is inactive as a modern sediment pathway. The mouth and floor of the canyon are composed of stiff Pleistocene mud, overlain by a thin drape of unconsolidated mud. The seabed at the canyon mouth is highly reflective, deeply scoured, and lacks a fan. These features indicate little or no sediment flux. During lowstand, the ancient Waipaoa River is likely to have been in the gap between the anticlines, and turbidites in one upper slope canyon suggest it could have tapped into the lowstand riverine sediment supply. Most of the lowstand sediment was apparently captured on the shelf and in the mid-slope re-entrant. Aggradation on the subsiding coastal plain (now the mid-shelf basin) may also have occurred. Accepting near-full capture of riverine-derived sediment on the shelf and slope, accumulation rates indicate that the modern (post-settlement) sediment yield from the Waipaoa River is almost an order of magnitude higher than the average for the Holocene. This is broadly compatible with accelerated rates of landscape erosion measured onshore.

(POSTER)

PETROGRAPHIC FEATURES OF PLIOCENE MIXED SILICICLASTIC-CALCAREOUS ROCKS IN NORTHERN HAWKE'S BAY

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Pliocene sediments in the East Coast Basin have been researched in a number of studies over the past decade, including a comprehensive biostratigraphy of the limestones by Beu (1995) and a petrographic and diagenetic study of the limestones in southern Hawke's Bay by Caron (2002). Compared to the latter work, the Pliocene deposits in northern Hawke's Bay include significantly increased contents of mixed siliciclastic-carbonate and siliciclastic rocks, being studied in a PhD project by Pallentin (in prep.), and the petrographic description and classification of these mixed lithologies are less straightforward.

Results from point-count and grain-size analysis have been used in various plots and statistical tests, including skeletal cluster analysis following Hayton et al. (1995), to characterize the petrographic features and the possible relationships between the siliciclastic and calcareous components.

Lithologic transitions between dominantly calcareous rocks and dominantly siliciclastic rocks have to date received little attention in the literature, and then only for tropical settings (Mount 1984; Dorsey & Kidwell 1999). Following the field-based description of the spatial relationships of some of the carbonate-dominated rock units in northern Hawke's Bay (Pallentin & Nelson 2000), analysis of petrographic features and statistical tests of principal components are the next step to investigating the diagenesis of these rocks.

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(POSTER)
ENGINEERING GEOLOGY AND COASTAL CLIFF STABILITY OF TAKAPUNA

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The actively eroding coastal cliffs of Takapuna, on Auckland's north shore, are the location of some of the most expensive properties in New Zealand. The cliffs are comprised predominantly of alternating very weak and weak sandstones and mudstones (often also classified as siltstones) of the Miocene age. Stronger and more resistant Parnell Grit and limonitic sandstones form headlands and reefs on the otherwise linear coastline. Weathering towards (extremely weak) soil, these East Coast Bays Formation lithologies are overlain in places by younger Quaternary deposits.

Petrographic examination showed that the rocks were clay matrix supported. Strength testing indicates the mudstone is not as weak as previously suggested and is as strong as the sandstone. The mudstone has a low density and a high porosity. However, it is unlikely to transmit much water. The sandstones and particularly the mudstone are prone to slaking when immersed in water with the mudstone rapidly forming loose curved chips that can be easily removed from the cliff face. This undercuts the sandstones, which have two perpendicular joint sets, resulting in block fall.

Local folding has produced varying dip direction, which has a significant control on slope stability, with failures occurring in extremely weathered rock or residual soil on beds dipping between 30˚ and 60˚. Joint sets show a strong trend into the cliff face while several continuous faults can be seen parallel to the cliffs in the shore platform. Faults running perpendicular to the cliff face form coves and gullies as fault gouge is eroded while other faults form caves. Gradual erosion of the cliffs by processes such as wave action is ongoing. This destabilises the cliff and promotes mass movements in the form of falls (e.g. slabbing) and slides in the residual soil or as wedge failures along intersecting defects.

Erosion rates between 2.7m and greater than 12.7m per hundred years have been recorded. Groundwater, vegetation (especially the pohutukawa), and humans all have the ability to impact on overall cliff stability and erosion. Remediation measures need to strike a balance between reducing risk and preserving the landscape. Defects pose the highest hazard in regard to cliff stability and this has been recognised in delineating a proposal for a hazard zone scheme for consideration and discussion.

(PLENARY)
TECTONICS AND STRUCTURAL GEOMORPHOLOGY IN THE PLATE BOUNDARY TRANSFER ZONE, NORTHEAST SOUTH ISLAND

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In NE South Island the southward transition from subduction to oblique continental collision is associated with tectonic shortening and rotations, crustal thickening and uplift. Landforms reflect the ongoing nature of this active earth deformation, and also reveal that the Australia-Pacific plate boundary zone has rapidly widened during the Late Quaternary. The upper crustal geological structure of the north Canterbury region is dominated by a complex array of N and NE trending active faults and folds accommodating the transfer of the relative plate motion, with structural deformation grouped into five structural domains, defined in terms of their tectonic setting, style, geometry and rates of deformation. Faults and folds in adjacent structural domains commonly vary in strike and accommodate oblique slip.

The complexities of present-day structural styles are attributed to three factors, including: i). temporal increase in the oblique plate convergence vector during the Plio-Pleistocene; ii). the inherited less favourably oriented major faults in basement being reactivated by present-day deformation; and (iii) the role of topographic loading on the evolution, geometry and slip behaviour of active faults.

Oblique-slip has modified many early stage conventional strike-slip structures (restraining and releasing bends and step-overs), and also range-front reverse/thrust faults and related fault-propagated folds, into complex geometries indicative of oblique-slip motion. Temporal and spatial variations in topographic loading are directly related to the near-surface stress field perturbations that control fracture propagation and orientation, as well as fault zone behaviour and evolution. While some end-member styles of transpressional deformation are well documented by laboratory modelling and from field examples, fault-slip is often complex, and invariably accompanied by progressive uplift and mountain building. There are few well-constrained field studies documenting the critically dependent interactive relationship between fault zone evolution and the tectonically-driven mountain building. A key question that remains to be addressed is how does the geomorphic evolution of fault-driven landscapes (including valley incision and large-scale deep-seated landsliding) influence upper crustal fault zone architecture and visa versa.

We have developed a number of structural models based on detailed field observations which typically form at major segment boundaries as well as at internal variations in segment geometry. These models illustrate the interaction between geologic structure and topography, and the way that slip is partitioned in a complex 3D deformation. The relationship between structural geometry and geomorphic evolution highlights the necessity of integrating these disciplines in the analysis of tectonically active regions.

(POSTER)

DEPOSITIONAL ENVIRONMENT AND AGE OF THE BEACON SUPERGROUP AT THE ALLAN HILLS IN THE TRANSANTARCTIC MOUNTAINS.

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The Allan Hills are located on the edge of the polar plateau, in Central Victoria Land. The sedimentary strata at the Allan Hills consists of Permian and Triassic sandstone, shale, and coal, deposited by braided and meandering rivers, and has been described by Balance (1977). Three formations, The Weller Coal Measures, the Feather Conglomerate, and the Lashly Formation, recognised in other parts of the Transantarctic Mountains, were described and mapped in central Allan Hills.
Member 'C' of the Weller Coal Measures is ~80m thick, and consists of 8-10 fining upwards cycles. A typical cycle has an erosional base capped by coarse, pebbly sandstone, which fines up to a medium sandstone, both of which contain trough and planar cross-bedding. This fines up to a carbonaceous shale, occasionally capped by a layer of coal. This is interpreted to have been deposited on a fluvial outwash plain, by a braided river, with swamps distal to the flow.
The Feather Conglomerate is a coarse grained sandstone. It contains large scale hyphonate? trough cross beds, Skolithos burrows, and is ~120m thick. The upper 30m consists of fining upwards hyphonate? cycles, that characterise the Fleming Member. The Feather Conglomerate was deposited by a large braided river system, with rapid, though sporadic deposition.
Only the lowest 30m of the Lashly Formation was observed in Trudge Valley, although >250m are present in the northern part of the Allan Hills. The Formation consists of 3-5m thick layers of massive fine sandstone, with layers of medium sandstone between, which contain coal rip-up clasts.
Pollen was extracted from the carbonaceous layers of the Weller Coal Measures. Pollen preservation was extremely poor due to Jurassic volcanic intrusions, but seven taxa were identified, including *Allosporites tenuicorpus, Cycadopites follicularis, Marsupipollenites tradiatus, Protohaploxypinus limpidus, and Sulcatisporites ovatus.* These taxa link the assemblage found in this study to the *Protohaploxypinus* zone of Kyle (1977), which has been dated by reference to Australian taxa. Member 'C' of Weller Coal Measures at the Allan Hills is of Middle Permian age.

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(ORAL)

PHYTOLITHS FROM THE PERMIAN BEACON SUPERGROUP, ANTARCTICA.

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Phytoliths have been reported in the Permian Beacon Supergroup rocks in the Transantarctic Mountains by Carter (1999). Closer sampling of the Mid-Permian to early Triassic strata at the Allan Hills has revealed six distinct shapes of opaline silica: polyhedral (etched and smooth), elongate, spherical, opaque and round layered. All of the shapes identified, except 'round layered', have also been observed in extant plants that had close relatives alive in the Permian.

A botanical origin is inferred for the spherical, elongate, opaque, and some of the polyhedral forms. Work by J. Carter on Southland loess suggests that some polyhedral forms are redeposited silica, and not phytoliths (J. Carter pers comm. 2002). This is inferred by the presence of polyhedral forms deeper than 2-3 m at loess sections, the upper parts of which are rich in phytoliths. Round layered forms have not been reported as modern phytoliths - this form is thus far unique to the Weller Coal Measures of the Victoria Group.

Opal forms considered to be phytoliths have been found in the Weller Coal Measures, the Feather Conglomerate, and the lowest Member of the Lashly Formation. The presence of phytoliths in the lower part of the Feather Conglomerate may be useful, as the formation is barren of pollen and other fossils. Study of opaline silica from other strata, which are richer in other types of fossils, must be conducted before the phytoliths in these rocks can be used for paleoenvironmental reconstruction.

Opal is an unstable form of silica - over time it tends towards a more stable, crystalline, form. This has happened in sections of the opal found at the Allan Hills. This recrystallisation, and the reduced temperature due to the polar location of the strata, are possible mechanisms that would promote opal preservation.

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((ORAL))

NEW SHRIMP ION PROBE ZIRCON GEOCHRONOLOGY FOR SOUTHERN LONGWOODS AND BLUFF PENINSULA INTRUSIVE ROCKS OF SOUTHLAND, NEW ZEALAND.

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The Longwoods Complex is one of a series of complex South Island batholiths grouped under the name of the Median Batholith (Mortimer et al., 1999) and ranging in age from Carboniferous to Cretaceous. Inland, the complex is poorly exposed but coastal outcrops between Colac and Te Waewae Bays provide an excellent E-W section. Mortimer et al. compiled geochronological data for Longwoods rocks and used this information to distinguish two distinct suites of differing age; an eastern Permian aged and dominantly gabbroic suite interpreted to be part of the Brook Street Terrane and a western Middle Triassic to Early Jurassic suite containing rocks ranging from ultramafic compositions through gabbros and diorites to tonalites. These age distinctions are confirmed by new SHRIMP zircon data. Zircons from a gabbro from Oraka Point on the eastern end of the coastal section give an age of 245.0±4.3 Ma and show virtually no evidence of any inheritance. Zircons from rocks to the west show more variability with some indications of inheritance and emplacement ages ranging from 203 to 227 Ma. A leucogabbro from Pahia Point yields a zircon population indicating an emplacement age of 142.4±2.3 Ma, similar to ages obtained from the Anglem complex on Stewart Island (Kimborough et al., 1994).

The Flat Hill complex is one of a series of intrusions exposed within the Brook Street Terrane on the Bluff Peninsula, east of Invercargill. Zircons in a quartz diorite from the complex yield an age of 259.1±4.4 Ma, consistent with conventional U/Pb zircon and Rb/Sr and K/Ar mineral ages.

The Median Batholith includes intrusive complexes of different age and composition indicating a pattern of successive emplacement of subduction related arcs along the Gondwana continental margin over a very long period, from late Palaeozoic to Cretaceous times. Intrusive rocks of the Brook Street Terrane and the western Longwoods appear to represent successive events in this pattern. The term “Median Batholith” may be too much of a generalisation obscuring rather than emphasising important detail.

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(POSTER)

FAILURE IN COMPLEX VOLCANIC TERRAIN, TAHANGA HILL NORTHERN COROMANDEL

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The Ohinau Drive slope failure occurred at Opito Bay, Coromandel Peninsula. It occurred at the northern base of a basalt to basaltic andesite cone (Tahanga Hill) and within older extensively hydrothermally altered andesite lavas. The failure affected a recent subdivision on Ohinau Drive situated on the lower slopes of Tahanga Hill immediately adjacent to the hill.

Mapping of exposures and subsurface investigation associated with the subsequent geotechnical investigation revealed complex volcanic and sedimentary deposits underlying the site.

At the site 8.9±0.5ma Tahanga Hill eruptives (Mercury Basalts) comprising basalt to basaltic andesite lavas unconformably overlies 11.5±0.5ma deeply hydrothermally altered and weathered andesite (Mahinapapa Andesite) and lacustrine sediments. Geochemistry indicates these volcanic rocks indicates they are subduction related.

The failure extends a distance of 170m from head scarp to toe with an estimated maximum width of 130m. It comprises both shallow seated and deep seated failure mechanisms to a maximum depth of approximately 20m.

The shallow failure extends to an inferred maximum depth of 12m and generally involves surficial basaltic debris previously slumped from the basaltic-andesite Tahanga Hill volcanic centre. The deeper failure encompasses both basalt and andesite lava flows riding up over younger lacustrine deposits at the toe.

Investigation findings indicate that the slump is a reactivation of an ancient slope failure most likely initiated by recent earthworks and sub-basal artesian water pressures.

Computer based stability analyses were undertaken with target groundwater levels determined to achieve a satisfactory Factor of Safety to allow future subdivision development. Drainage installation and monitoring is yet to be established following liaison with Council.

(ORAL)

NEW REVISIONS IN THE AGE OF THE VOLCANIC STRATIGRAPHY OF THE SOUTH EASTERN FLANK OF RUAPEHU VOLCANO.

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A detailed study was made of the Wahianoa Formation volcaniclastics that comprise the planeze (here termed the Rangipo Planeze) located between the Wahianoa and Whangaehu Rivers on Mt Ruapehu. The volcanic rocks of the area are typical of the effusive and explosive activity that has taken place at Ruapehu volcano over the Quaternary. The area is dominated by blocky, andesitic lava flows and associated autobreccia. Pyroclastic deposits, identified as being of both block and ash flow and tephra origin, can be found but are confined to small areas, while cemented pumiceous volcaniclastic diamictons are also present lower in the stratigraphic sequence. These mantle the topography and form valley fills.

The volcaniclastic diamicton deposits found exposed on the Rangipo Planeze are quite distinctive and are unlike the lahar deposits found on the ring plain. However, two volcaniclastic diamictons can be correlated to the two lahar units, R11 and R12, identified by Cronin (1996) in the Waikato Stream. Interbedded, dated rhyolitic tephras show that the lahar units were emplaced between 22,590 to 23,000 (R11) and 28,200 to 35,870 (R12) yrs B.P. These dates, together with the stratigraphic position and relationship of lateral moraines deposited during the last two stadials of the last glaciation (McArthur and Shepard, 1990), imply that a large part of the Rangipo Planeze was constructed between 22,000 and 35,870 yrs B.P. The earliest volcaniclastic diamicton unit has also been found to cover a large portion of the eastern flank of Ruapehu.

This information, combined with GIS and DEM data, show that the lahar hazards on Ruapehu Volcano estimated in Neall et al. (2001) need to be adjusted to account for the number of events and the topography found on the Rangipo Planeze.

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(POSTER)

QMAP – HALFWAY HIGHLIGHTS

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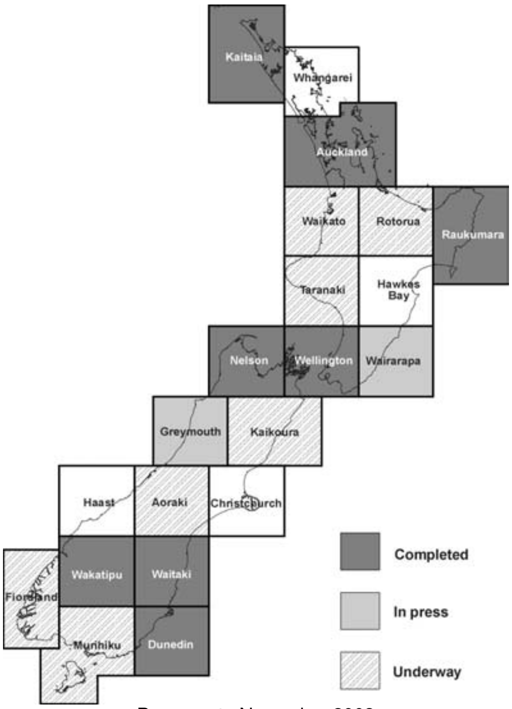
QMAP, the PGST-funded revision of the 1:250 000 Geological Map of New Zealand, has had a burst of publication in the last 2 years with the release of the Wellington, Wakatipu, Raukumara, Auckland, and Waitaki sheets. With the imminent publication of the Greymouth and Wairarapa sheets, QMAP is now halfway through. Furthermore a number of other sheets are in advanced stages and the digital data coverage country-wide is even greater. There have been a number of geological highlights and advances in understanding with each of the completed sheets and there are a number of challenges ahead for the remaining sheets.

Some of the recent highlights include:
QMAP Wellington Linking the North and South Island geology through Cook Strait and the identification of many new active faults.
QMAP Wakatipu Delineation of the late Paleozoic-Mesozoic central arc terranes and the schist transition in the Caples/Torlesse.
QMAP Raukumara Rationalisation of the complex East Coast allochthon with the extensive Late Cretaceous and Cenozoic convergent margin geology.
QMAP Auckland Integration of the Northland Allochthon with the mid Tertiary Waitemata Group and Te Kuiti Group geology, as well as the Miocene-Pliocene volcanic geology of Coromandel Peninsula.
QMAP Waitaki Extension of textural zone mapping into the Caples and Torlesse-derived schist and semischist.
QMAP Greymouth Subdivision and delineation of Mid Paleozoic and Early Cretaceous the Western Province plutonic, and identification of structural/metamorphic zones within the Torlesse terrane rocks.
QMAP Wairarapa Recognition and delineation of Late Cretaceous-Tertiary melange belts

Some of the challenges being addressed include:
QMAPs Rotorua/Waikato Association and portrayal of the Taupo Volcanic Zone volcanic geology and the associated ignimbrite and tephra deposits.
QMAP Aoraki Unravelling the complex interaction of Quaternary collision tectonics on an already multiply-deformed Mesozoic Torlesse greywacke schist assemblage.
QMAP Kaikoura ntegration of the Late Cretaceous-Tertiary stratigraphy, and defining the boundaries of the Esk Head and other melange zones.
QMAPs Murihiku/Fiordland Differentiating the granitic and gneissic rocks, and in particular identifying the Mesozoic versus Paleozoic components.
QMAP Taranaki Portrayal of the gently dipping Late Cenozoic sequence stratigraphy units and the Mt Taranaki volcanic deposits.

The QMAP sheets are produced from a digital Geographic Information System (GIS) map database using ArcInfo software. The database despite being incomplete is already undergoing revision in the Dunedin sheet area. The ability to update the digital geological data when new information becomes available is a major advantage of using a GIS. The published sheets have a limited currency and will quickly be superseded by the digital map version. The digital map version, however, will be increasingly accessible to the wider geological community.



Progress to November 2002

(ORAL)

ADVANCES IN THE PHYTOREMEDIATION OF HEAVY-METAL CONTAMINATED SITES RESULTING FROM THE MINING INDUSTRY

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The growing global economy requires an ever-increasing supply of mined-metals. This combined with a political shift towards environmentally friendly practices has placed pressure on mining companies to find low-cost technologies for complying with government regulation.

Phytoremediation is the use of plants to improve degraded environments. In its early stages the technology focused on using plants that accumulate inordinate amounts of heavy-metals. These plants were named *hyperaccumulators* by the pioneering scientist Robert Brooks in 1977 at Massey University. The initial concept was to use such plants to remove metals from a contaminated substrate and store or recycle the metals contained in the plants biomass. Although based on a sound scientific foundation, no commercial phytoremediation operations using this method were undertaken until 1999.

The current view is to think of hyperaccumulation in a broader sense. Plants will remove water from soil, assist the breakdown of organic contaminants and stabilise barren land as well as remove metals. Planting strategies that are based upon traditional mine-revegetation techniques can also be described as phytoremediation. The success of this technology can be greatly enhanced by judicious species selection, soil amendments and site monitoring. The technology has particular relevance in developing countries, where lack of funds and government regulation has resulted in large-scale environmental degradation due to mining. Phytoremediation may provide a low-cost and permanent means of environmental restoration using local resources and labour.

This paper investigates, using case studies, the advances in phytoremediation technology for the amelioration of specific problems associated with sites contaminated by mining. Particular focus is made on the Tui mine tailings, Mt Te Aroha in the Coromandel and the potential of technology transfer to improve the environment in developing countries.

(ORAL)

PLANKTIC FORAMINIFERAL EVIDENCE OF PALEOCEANOGRAPHIC CHANGES ACROSS THE SUBTROPICAL FRONT DURING THE LATE PLEISTOCENE

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Planktic foraminiferal census counts were compiled for 78 samples from ODP Site 1125, located on the northern slope of the Chatham Rise, east of New Zealand. Site 1125 was chosen primarily as a counterpart for DSDP 594, located south of the Chatham Rise, to investigate paleoceanographic changes across the Subtropical Front (STF) that is currently locked to the crest of the Rise. An age model for the 9.9m late Pleistocene core section was constructed by correlating the reflectance curve of the studied interval with the tuned curve at nearby ODP Site 1123. Sea surface temperatures (SST's) were generated for each sample depth at Site 1125 using the Modern Analogue Technique (MAT) and the combination of these results with SST data from R657 allowed the construction of a 600 k.y. paleotemperature record. The minimum temperature estimates that were recorded in each of the cooler glacial periods of the late Pleistocene varied by nearly 5°C, with the coldest SST estimate of 8°C recorded during Marine Isotope Stage (MIS) 6.1. The maximum SST estimates generated for each of the corresponding warm interglacial periods display a temperature range of only 1°C over the last 600 k.y, excluding the cool interglacial stage MIS 3, with the highest temperature of 19°C recorded in MIS 5.5.

Large temperature differences of up to 12°C between 1125 and 594 are evident in the glacial periods, based on the planktic foraminiferal assemblage data, confirming that the intense temperature gradient in MIS 2 was repeated in earlier glacial stages back to MIS 14. These temperature differences are significantly larger than those determined from alkenone based SST estimates for MIS 2, and may reflect changes in the stratification of the water column, possibly linked to increased upwelling of cooler subantarctic waters in these glacial periods. However, the temperature estimates generated for the interglacial peaks of MIS 11, 5.5 and 1 vary by less than 2°C between the two sites suggesting that the STF may have migrated south of the Bounty Trough in these intervals. Canonical Correspondence Analysis identified three major groups of samples within the studied section. The primary influence on the faunal composition of the samples in each group was age within the studied interval, with changes in the abundance of several taxa evident through time.

(ORAL)

MAGMA-WATER INTERACTIONS IN A GEOTHERMAL ENVIRONMENT, THE 1886 ROTOMAHANA ERUPTION

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The eruptive process of a hydrovolcanic phenomenon is affected by the physical configuration of the magma and water interaction, and by different intrinsic characteristics of the materials involved, i.e. the thermodynamic state of the water and the various impurities and dissolved products it carries, or the rheology of the magma. An active geothermal area presents many particularities that would influence the behaviour of an eruption occurring in this setting.

On 10th June 1886, Tarawera and Rotomahana (Okataina Volcanic Centre, Taupo Volcanic Zone) erupted in New Zealand's largest historic volcanic event, opening a fissure 7 km long across Tarawera mountain and extending along 8 km across Rotomahana basin to Waimangu valley, through a former very active geothermal system, destroying the internationally known Pink and White silica terraces. Therefore, the deposits of this eruption, and inferences on the characteristics of geothermal areas and eruptive processes, illustrate the mechanisms of hydrovolcanism and the variations imposed by the geothermal environment. A plinian plume deposited Rotomahana mud over a wide area, with turbulent pyroclastic density currents extending as far as 6 kilometres from the eruptive centre.

The study of outcrops distributed along the fracture on the shore of the modern Lake Rotomahana, from the area affected by the geothermal system up to the southernmost crater of Tarawera, show extreme variation in the clast composition, texture and proportion of various components. The outcrops also show intermingling of materials of different origins. Basalt is pervasive through the whole deposit, in various percentages, showing a diversity of shapes, densities and textures. Numerous basalt bombs, present features characteristic of phreatomagmatic processes.

The complexity of the deposits reflects the simultaneous occurrence of different processes within different zones of the fissure. The rupture of the geothermal system probably involved a phreatic component, but the overall eruption was phreatomagmatic in the Rotomahana area, with Molten Fuel-Coolant Interactions likely to have occurred. The study of the whole complex, structure and deposit, along with thermodynamic calculations and assumptions, allow assessments on the behaviour of the plumes, and on the contribution of the geothermal system to the process.

(ORAL)

MIDDLE PLEISTOCENE PALEOCEANOGRAPHIC RECORD DETERMINED FROM PLANKTONIC FORAMINIFERAL ASSEMBLAGES FROM THE CHATHAM RISE (ODP SITE 1125)

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The Mid-Pleistocene Climatic Transition (MPT) dated at ~1.0-0.6 Ma marks the global climatic shift from a dominant 41-kyr cyclicity of obliquity towards a dominant 100-kyr cyclicity of eccentricity that is characteristic of the late Pleistocene. While this transition is observed in global climate proxy data, until recently, high-resolution foraminiferal MPT studies for the Southwest Pacific Ocean did not exist and this study helps address this.

Site 1125 lies within the northernmost margin of the Subtropical Front (STF) on the northern slope of the Chatham Rise and underlies the south-eastward flowing East Cape Current. The chronological framework is based on carbonate reflection correlation with orbitally tuned Site 1123 nearby. The latter contains two tephra layers (0.92 and 0.83 Ma) which provide a reliable age correlation with Site 1125. Three biostratigraphic events at 0.98, 0.85 and 0.8 Ma as well as the coiling ratio record of *Truncorotalia truncatulinoides* were used to develop the age model. The Modern Analogue Technique was used to calculate sea surface temperature (SST) estimates from planktonic foraminiferal census data in 70 samples through the middle Pleistocene of ODP 1125.

Summer SSTs during all interglacial peaks (except MIS23) were 19-20 ºC, similar to the present-day. Summer SSTs during peak glacials were mostly 16-18 ºC, 2-4 ºC warmer than the peak of the Last Glacial. Three glacial periods (MIS 26, 20, 16) have SST estimates of similar severity to those recorded in the late Pleistocene, and may indicate intervals when cool Subantarctic Surface Water was jetting through the Mernoo Gap and mixing with warm Subtropical Surface Water as it moved eastwards along the north side of the Chatham Rise. A trend of increasingly severe of glaciations at 1125 coincides with the global MPT trend, while interglacial temperatures remain steady throughout the period.

A comparison of the mid Pleistocene SST estimates for 1125 with similarly derived SSTs from DSDP 594 to the south, indicates that the STF was located between the two sites along the Chatham Rise throughout this interval. During interglacials the foraminiferally-determined temperature gradient across the Chatham Rise was 8 ºC, and during glacials 9-14 ºC. This is similar to previous findings for the Last Glaciation and the previous Interglacial and may imply that the Subantarctic Front migrated northwards and coalesced with the STF along the Chatham Rise during glacial periods. An alternative explanation (supported by alkenone-based SST estimates for the Last Glacial) is that the surface waters over 594 were not as cool as the foraminiferal data indicate during these glacial intervals, but that increased upwelling changed the thermal stratification of the subsurface water layers in which the foraminifera lived.

(PLENARY)

MAAR DRILLING PROVIDES NEW INSIGHTS INTO LATE QUATERNARY VOLCANISM AND PALEOCLIMATE IN AUCKLAND

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Deep volcanic explosion craters (maars) provide an ideal trap for eolian material including tephra and pollen, allowing the history of both local and distal explosive volcanism, and paleoenvironmental changes to be reconstructed. Crater fill of basaltic craters in the late Quaternary Auckland Volcanic Field (AVF) has been the focus of deep drilling initiated by University of Auckland researchers in 1997, and later joined by Victoria University of Wellington and University of Canterbury workers in 2001.

In 2000/2001, a long paleolake record representing c.9.5 to 250 ka was recovered from Onepoto Basin. Eighty tephra beds were identified, and their known source include Taupo (4), Okataina (14), Taranaki (40), Tongariro (3) and AVF (8). The record greatly extends the known dispersal of many deposits such as those of the Mangaone Subgroup. It also provides evidence for 4 previously unrecognised rhyolitic events between c. 50 and 28 ka. Ten rhyolitic tephra pre-date the Rotoehu eruption (c. 50 ka) and some of these older tephra were produced by large magnitude events, however their source within the Taupo Volcanic Zone remains unknown. The abundant Taranaki-sourced tephra provide a new perspective on the geochemical evolution of the volcano and its ability to widely disperse ash.

The AVF is poorly dated and was considered to date back to c. 140 ka. An^{40}Ar^{39}Ar step-heated age of c. 250 ka on basaltic lapilli from the base of the Onepoto core indicates that activity extends back considerably further in time. However, there is also evidence for frequent recent eruptions. By combining the 2001 Onepoto and 1997 Pukaki core tephra records, 15 AVF basaltic fall events are constrained at: 34.6, 30.9, 29.6, 29.6, 25.7, 25.2, 24.2, 23.8, 19.4, 19.4, 15.8, and 14.5 ka, plus 3 pre-50 ka events. This provides some of the best age constraints for the AVF, and the only reliable data for hazard frequency calculations. The minimum frequency of fall events have been estimated and they demonstrate Auckland City is frequently impacted by ash fall from many local and distal volcanoes.

A significant problem in tephrochronology is the uncertainty in age of the regional marker Rotoehu tephra variously dated at 45-65 ka (marine isotope stage - MIS 4 and early 3). This period also lacks continuous paleovegetation records. New palynological work from Onepoto by Anna Sandiford reveals MIS 4 as a shrub land-dominated cold period that occurs prior to the eruption of Rotoehu. This is succeeded by the rapid expansion of rimu forest followed by beech forest, indicative of a cool, wet phase at the beginning of MIS 3. Rotoehu tephra was emplaced following a replacement of rimu-matai forest with beech forest during the thermal decline of MIS 3. Extrapolation of sedimentation rates gives an age of c. 44 ka for the eruption. This age implies a shorter duration but higher tempo for the present phase of volcanic activity at Okataina and Taupo.

(POSTER)

PRELIMINARY RESULTS FROM A NEW GRAVITY STUDY, AND RE-ASSESSMENT OF AEROMAGNETIC DATA FROM THE WAIHI REGION, SOUTHERN COROMANDEL, NEW ZEALAND

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The Waihi region of the Coromandel Volcanic Zone (CVZ) contains andesites and dacites of Miocene or younger age that overly Jurassic-age greywacke basement of the Manaia Hill Group. Volcanism during the Late Miocene (c. 9 to 4 Ma) was dominated by eruptions of andesites and subordinate dacites of the Coromandel Group. In the Pliocene (c. 4 Ma), volcanism shifted from the west to the east-central sector of the peninsula, and changed to rhyolitic volcanism of the Whitianga Group. The CVZ hosts the Hauraki Goldfield, a gold-silver province that contains over 50 separate low sulfidation epithermal gold-silver deposits. Gold-silver mineralization occurs in steeply dipping quartz veins that fill extensional fractures hosted mainly within andesites and dacites of the Coromandel Group.

Existing geophysical data of this region consists of a regional gravity survey completed by IGNS, and a high resolution (500m line spacing) aeromagnetic survey completed by AMOCO in 1978, as well as several small-scale very high resolution (150-200m) aeromagnetic surveys by various companies. These aeromagnetic surveys have revealed several interesting features including a large bi-polar anomaly south of Waihi which may represent a substantial buried intrusion. This hypothesis, however, has not been tested by detailed study and modelling. The gravity data, although of poor resolution, revealed several anomalies, including a poorly defined 10mgal, 10 km diameter feature south of Waihi, which has previously been interpreted as a caldera structure.

New gravity data have been collected at higher resolution over the Waihi region, which map the known anomalies in greater detail. Existing aeromagnetic data have been analysed and correlated with known geology and new gravity data to identify and investigate major structural and volcanic elements, which may relate to or control the extent of hydrothermal alteration and potential epithermal mineralisation.

(POSTER)

HYBRID PROCESSES OF PRIMARY DEPOSITION DURING A PHREATOPLINIAN ERUPTION

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The Rotongaio Ash is a widespread, very fine-grained phreatoplinian fall deposit erupted during phase 4 of the 1.85 ka Taupo eruption. An unusual and previously undescribed feature of this unit is the occurrence of primary cross-stratified beds within medial and distal parts of the finely laminated fall sheet. These intervals have many features in common with archetypal surge deposits, but all occurrences are greater than 15 km from source and cannot be directly associated with any conventional vent-derived phenomenon.

These surge-like intervals are of two distinct, but apparently related types. The most common type consists of very fine (clay grade) ash with foreset-type cross bedding defined by single clast trains of medium to coarse ash. In areas of some underlying relief these cryptic fines-rich layers transition into well-sorted, dune bedded layers of medium to coarse ash that are confined to depressions. Both of these cross-bedded variants appear primary and are unlike any fluvially reworked or other secondary facies that are common within the Rotongaio medial stratigraphy. Under SEM, clasts from these surge-like layers have identical morphologies to those of the bounding, planar-bedded fall units.

The nature of these beds implies a significant horizontal component during a dynamic process of emplacement, which is at odds with a simple convective fallout origin. The few published studies of hybrid pyroclastics have involved lapilli fall beds and models for these include contemporaneous reworking by strong crosswinds and settling of fall through dilute surge clouds. The Rotongaio beds differ from these in that the beds are not hybrid in character (having few features in common with archetypal fall), but they are interpreted as the product of some hybrid process of pyroclastic deposition involving modification of normal fallout by strong whirlwinds. Observations of historic surtseyan eruption plumes suggest that strong downbursts and whirlwinds from the umbrella region may be an inherent part of 'wet' plume dynamics, and such hybrid phenomena may have been an integral part of the medial emplacement of Rotongaio tephra.

(ORAL)

MAGMAS IN COLLISION: AN EXAMPLE FROM OKATAINA VOLCANIC CENTRE

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Geochemical variation has been observed in the deposits of many large rhyolitic eruptions, especially those from large, caldera-forming eruptions in North America, where voluminous eruptions occur at long intervals from a thick crustal environment (Hildreth, 1981). In contrast, Okataina and Taupo rhyolite eruptions during the last 50 kyr have been of smaller volume but more frequent in occurrence, so that their magma batches cannot have resided in the crust for long periods of time. This inhibits the formation of significant magmatic gradients. Alternative models to explain compositional variation include the mixing or collision of discrete magma batches (Hervig and Dunbar, 1992; Eichelberger *et al*., 2000). We demonstrate that partial mixing or interaction of different magma batches prior to eruption better explains the geochemical variation observed in some Okataina rhyolites.

The Rotorua eruptive episode occurred at 15.7 cal ka from multiple vents in the Okareka basin on the western margin of the Okataina caldera (Nairn, 1980; Kilgour and Smith, 2001). Based on whole-rock data, Kilgour and Smith (2001) suggested the eruption tapped a thermally and compositionally zoned magma reservoir. However, our detailed sampling and analyses of the deposits has shown that two chemically distinct homogeneous magma batches were tapped. Early plinian falls that are mostly dispersed to the northwest are composed of crystal-poor, rhyolite containing orthopyroxene, hornblende and clinopyroxene phases. This magma is characterised by SiO_2 contents of 73-74 wt.% in the whole-pumice and K_2O contents of 2.9-3.3 wt.% in the glass phase, Ca-rich feldspars (Ab_{51}-Ab_{60}), and magnesian rich hornblendes (MgO: 13.75-15 wt.%; FeO: 12-14.75 wt.%). Temperatures of 830^{o}C are estimated from Fe-Ti oxide pairs and hornblende-plagioclase equilibrium. Toward the end of the plinian sequence, an increasing proportion of biotite-bearing ejecta was emitted. This second type of magma was crystal-rich with a ferromagnesian mineral assemblage containing almost only biotite. It is characterised by SiO_2 contents of 74.5-75.5 wt.% in the whole-pumice and K_2O contents of 4-4.7 wt.% in the glass phase, Na-rich feldspars (Ab_{69}- Ab_{74}), and Fe-rich hornblendes (FeO: 16.5-19 wt.%; MgO: 11-12.25 wt.%). Temperatures of 750^{o}C are estimated from Fe-Ti oxide pairs and hornblende-plagioclase equilibrium. This second type of magma dominates the late fall sequence and the subsequent dome building stage.

We infer that the biotite-bearing magma resided beneath the conduit and then interacted with a hotter, more buoyant orthopyroxene, hornblende and clinopyroxene bearing magma. This hotter magma rose through the biotite-bearing one with minimal mixing and was erupted first. However, there is some evidence for limited mingling, as rare individual pumice clasts contain zones of both magma types. The contrasting physical properties of the magmas inhibited complete mixing and hybridisation.

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(ORAL)
VOLCANICLASTIC DEPOSITS OF THE NORTHERN TONGARIRO VOLCANIC CENTRE, NORTH ISLAND, NEW ZEALAND
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This study examines the stratigraphy of the northern Tongariro Volcanic centre (TgVC) to determine the origin, mode of emplacement and age of volcaniclastic deposits mapped within the northern ring plain of Mt Tongariro and the Kakaramea –Tihia massif.

Brecciated deposits containing jig–saw fractured andesitic clasts, some exceeding 4 m in diameter, are exposed in road cuts east of Papakai along State Highway 47a, Tongariro National Park. These deposits are clast–supported, show a variable degree of hydrothermal alteration, and have a coarse-grained, hydrothermally altered matrix. They could represent debris avalanche deposits and be correlatives of the Te Whaiau Formation. This would greatly extend the known distribution and increase the volume of this catastrophic collapse event.

The stratigraphy of the northern ring plain suggests that these deposits were emplaced prior to the Oruanui Formation (26.5 ka). Although an age limit for the base of the deposits is not certain, aerial photograph interpretation indicates that these deposits are underlain by lava flows, potentially providing a lower age limit for the volcaniclastic units.

Comparison is made to previously undocumented volcaniclastic deposits along the Te Ponanga Saddle Road. These also display distinctive jig–saw fractured andesitic clasts within a typically clast-supported, hydrothermally altered deposit. The Oruanui Formation has been found to be present within a constituent mega clast and the Rotoaira Formation overlies the deposit. Therefore, the age of these volcaniclastic deposits is constrained to between 13.8 ka - 26.5 ka. These deposits illustrate that the Kakaramea massif has undergone large–scale collapse events in recent times. Geothermal activity on the massif would promote weakening of the lava and pyroclastic material. Thus, there is a potential for future debris flows and avalanches in this region.

(ORAL)
PERVASIVE CATACLASTIC FAULTING IN "NGATUTURI CLAYSTONE" AT ALGIES BAY: EVIDENCE FOR COMPLEX MOVEMENT OF THE NORTHLAND ALLOCHTHON
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Monotonous siliceous mudstones of the Late Cretaceous/Early Tertiary Whangai Formation are well exposed in the headland between Algies Bay and Snells Beach. They are unconformably overlain by complexly folded Miocene Waitemata Group. In the claystones, bedding is sporadically visible as fine laminations. Bedding-controlled ferro-carbonate concretions provide markers for localised structural analysis. Dips are uniformly steep, with a NW-SE strike direction being most common. Localised swings in strike indicate the presence of steeply plunging folds. So far it has been impossible to determine any younging directions of bedding.

Spectacular networks of black cataclasite seams ranging from sub-millimetre to a few centimetres in thickness are so dense that it is practically impossible to collect a 3x3x3 cm sample of the mudstone without any seams. Major fault zones are accompanied by "consolidation zones" of particularly dense fault networks which form fold-like patterns on the shore platforms. The cataclasites predate deposition of the Waitemata Group and are postdated by thick breccia zones and a few non-cataclastic, post-Waitemata faults. Slip vectors of some of the faults can be determined from the geometry of conjugate faults, Riedel shear patterns and offsets of differently oriented older faults.

Although there has been multiple reactivation of faults, it is possible to establish the following generalised sequence of deformation: **1.** formation of steeply plunging folds; **2.** top-to-East ductile shearing on sub-horizontal surfaces ; **3.** N–S shortening along bedding; **4.** E–W striking normal faults; **5.** formation of consolidation zones; **6.** strike slip faulting with N–S shortening. **7.** formation of breccia dikes. **8.** formation of Waitemata-filled clastic dikes. **9.** sinistral strike slip movement on N-S trending steep faults (part of complex folding in surrounding Waitemata Group?)

It is not yet certain whether the steeply plunging folds were formed in their present attitude or were tilted from horizontal. Either scenario requires another, earlier phase of deformation and fundamental re-orientation of tectonic axes. This and the complexity of the subsequent phases indicates that the movement directions in the Northland Allochthon were complex even before its reactivation during the Miocene ("Onerahi Chaos") phase. Cataclasite-seamed "Ngatuturi claystone" is quite common in the

Northland Allochthon and may indicate megascopically ductile deformation of a mechanically homogeneous but anisotropic rock mass accommodated by slip on closely spaced mesoscopic brittle faults. These structures may be similar to the "web structures" in the broken formations and melanges of accretionary complexes.

(POSTER)

ADVENTURES IN MICROSTRUCTURAL GEOLOGY: FOLIATION DEVELOPMENT AND FOLD MECHANISMS IN SCHISTOSE ROCKS

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Three case studies are presented that document the use of microstructures in understanding processes of foliation development, folding, and garnet growth in schistose rocks.

In the first study, compositional analyses of garnet porphyroblasts are used to test a previously published microstructure-based model of episodic garnet growth in the Fleur de Lys Supergroup, Canada. Pronounced compositional anomalies are coincident with microstructural truncations and changes in inclusion assemblage at the margin of the first stage of garnet growth (G_1). The G_1-G_2 boundary is thus interpreted to represent a hiatus in garnet growth, possibly accompanied by garnet consumption. During this pause in growth, changes occurred in the dominant mineral-forming reactions, *P-T* and kinematic conditions. In contrast, the G_2-G_3 boundary is marked by subtle zoning anomalies or uninterrupted zoning, suggesting either continuous garnet growth or a relatively brief intra-orogenic pause in growth.

The second case study reports the results of 3D numerical simulations of the development of spiral-shaped inclusion trails in porphyroblasts. The simulations were conducted in order to test the proposals that (a) 3D spiral geometry differs between the rotation and non-rotation end-member models of spiral formation proposed in the literature, and (b) 3D spiral geometry can be used as a criterion to distinguish between the two end-member models in rocks. There are four principal differences between the two sets of simulations: smoothness of spiral curvature; spacing of foliation planes; alignment of individual foliation planes either side of the sphere representing the porphyroblast; and spiral asymmetry with respect to matrix shear sense. Of these differences, only spiral asymmetry and possibly the alignment of individual foliation planes are diagnostic criteria for distinguishing between the end-member models.

In the third case study, fold mechanisms operating in the Canton Schist, Georgia, USA, have been resolved using the geometric relationship between folds and spiral inclusion trail geometries. Of the four end-member fold mechanisms, tangential-longitudinal strain folding and slip folding are unable to produce the observed geometries, but a combination of flexural flow and pure shear folding is consistent with the data. The maximum flexural flow component during each fold event was determined from the geometric data. During F_3 and F_4, flexural flow produced ≤ 27% and ≤ 37% of measured limb rotation respectively, which corresponds to a maximum of 24˚ limb rotation by flexural flow. The remainder of limb rotation is a product of pure shear folding.

(ORAL)

LINKING METAMORPHIC TEXTURE, STRUCTURE AND MINERAL COMPOSITION: PRELIMINARY DATA FROM THE OTAGO SCHIST

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The aim of the current research is to investigate aspects of the textural, mineralogical and structural changes that accompany progressive metamorphism, as well as the processes responsible for these changes. In this report, we summarise the problems of interest, the methods of analysis, and we present preliminary data.

We seek to analyse samples of varied textural development across the Otago Schist, and describe shape- and lattice-preferred orientation of quartz and sheet silicates, mineral composition (spot analyses and compositional maps), and structural features. These data will allow us to make statements concerning the nature of such processes as schistosity formation, patterns of dissolution and recrystallisation, mechanisms of shape- and lattice-preferred orientation (e.g. growth vs rotation origin), patterns of porphyroblast nucleation and growth, and deformation partitioning.

Following this, we aim to study in detail the fold mechanisms of a number of outcrop-scale folds, and examine the influences of lithology and metamorphic grade on fold mechanisms. This also involves investigation of the following: reactivation during folding, comparison of the fabric and structure of Q- and M-domains, structural controls on dissolution and nucleation of grains, and the development of axial plane foliation. A related topic of study will be the progressive development of crenulation cleavage, in particular examining the roles of mass transfer, shear on cleavage planes, and the deformation and reactivation of pre-existing cleavage seams, and also how crenulation cleavage provides preferred nucleation sites and controls the LPO of new minerals.

(ORAL)

EARLY TRIASSIC RADIOLARIANS FROM ARROW ROCKS, WAIPAPA TERRANE, NEW ZEALAND

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A distinct radiolarian faunal change occurred across the Permian/Triassic boundary. However, the nature of this change is obscure because of the very limited knowledge of Early Triassic radiolarians. The very first records of Early Triassic radiolarians globally are those described by Kozur et al. (1996) and Sashida et al. (1998) from Dienerian (late Induan, Early Triassic) sequences in Turkey and Thailand respectively. No radiolarian chert of earliest Triassic age is known in the Northern Hemisphere. Accordingly, radiolarian-bearing P-Tr boundary sequences in the Southern Hemisphere, and specifically New Zealand, are of immense international interest.

Arrow Rocks is an islet within Whangaroa Bay in Northland, New Zealand, situated in the northern part of the Waipapa Terrane. The Arrow Rocks sequence consists of basalt with limestone layers, bedded chert, black shale and red, maroon and green siliceous mudstone in ascending order. This sequence is almost continuous and has been described in terms of eight lithologic units (Unit 1 to 8, Takemura et al., 1998). Well-preserved radiolarians have been obtained from four horizons in this section, from Middle-Late Permian in Unit 1 to early Middle Triassic (Anisian) in Unit 7 (Takemura et al., 2002). The age of Units 3 to 6 is determined by conodonts as Induan to Anisian.

To date, detailed observations and sampling of the Arrow Rocks sequence have been carried out along eight measured sections that are referred to as ARA to ARH. These sections are geographically distinct but their stratigraphic location within the sequence is not so obvious.

Here we report on the occurrence of radiolarian faunas from three of these sections: ARD, ARE and ARF. These sections are composed mostly of pale green, black, grey and red bedded cherts, with occasionally intercalated thin black shales and tuffs. Lithologies of these sections can be correlated with those of Units 2 to 4. Induan (Dienerian) conodonts occur in a number of horizons within these three sections and support the lithostratigraphic correlation.

Most species of these faunas are new. Late Dienerian faunas from ARD and ARE sections include palaeoscenidiids and primitive nassellarians, which are considered to be the oldest Mesozoic-type radiolarians. Early Dienerian faunas from ARF section, on the other hand, are composed mostly of spherical and triangular forms and include no Mesozoic-type forms. This suggests that a significant radiolarian faunal change occurred during Dienerian time.

(POSTER)

GEOCHEMISTRY OF THE LATE PLEISTOCENE ALKALI BASALTS, SOUTHEAST QUEENSLAND, AUSTRALIA

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The geochemistry of mafic volcanic rocks erupted in continental areas can potentially yield valuable information about the nature of large parts of the Earth's interior that are otherwise inaccessible. In the northern New England Fold Belt, east and northeast of Gayndah the Late Pleistocene Barambah basalts near Ban Ban Springs, Degilbo and along the Burnett river include alkali basalt and basanite lava flows. Wellman (1978) has dated the Barambah basalt as Late Pleistocene (600 000 years). Until now there has been no geochemical study of these basalts.

The Barambah basalts range in composition from alkali basalts to basanites corresponding to CIPW-normative nepheline contents (ne) from 3% to 8%. These rocks show relatively primitive compositions as indicated by their high Mg#s (63-67), and Ni and Cr contents. Compositional variations can be explained by olivine and clinopyroxene fractionation probably in a high-level magma chamber.

Primitive mantle-normalized incompatible trace element patterns of the Barambah basalts exhibit similarities with ocean island basalts. In addition, ratios of selected incompatible trace elements (e.g. Ce/Y, La/Ba, La/Nb and Zr/Ba) are comparable to those of OIB. The Barambah basalts are enriched in highly and moderately incompatible trace elements (Rb, Ba, Th, Nb, La, Ce, Sr, Nd and Zr), a feature characteristic of within-plate alkali basalts which distinguishes them from basalts of other tectonic settings. Furthermore, on the diagram of Zr vs Zr/Y, the investigated basalts plot in the within plate basalts field.

The chondrite-normalized REE patterns are steep with a distinct LREE enrichment and fractionation of HREE. Highly fractionated REE patterns ($(La/Yb)_{CN}$ = 16 - 19) with no Eu anomaly are the main features of these basalts and are comparable to alkaline volcanism in continental rift zones. This could be due to melting of metasomatised mantle.

In the Barambah basalts, strongly differentiated REE patterns and smooth profiles on multi-element primitive mantle-normalized diagrams resemble those either of continental intraplate alkali basalts free of crustal contamination effects or of OIB. Overall, the geochemistry suggests that the Barambah alkali basalts and basanites are derived from an enriched asthenospheric mantle source in response to lithospheric extension in the Late Pleistocene and have experienced slight fractional crystallization and negligible or no crustal assimilation during their ascent to the surface.

Acknowledgement: I would like to thank Paul M. Ashley for introducing me to the Barambah basalt in the field.

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(POSTER)

ORIGIN OF LOW-Ti-P-K BASALTS FROM THE MAHAKOSHAL GREENSTONE BELT, CENTRAL INDIA

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It has long been recognized that continental rifting is associated with a compositional spectrum of igneous rocks. Rifts can be characterized by crust about 25-35 km thick with significant thinning taking place in the lower part of the crust. Active rifts are associated with the active rising of asthenosphere by starting plumes which cause regional crustal doming and subsequent fracturing of the crust. In the passive rift setting, large-scale stresses exert force upon the lithosphere, causing it to fracture and allowing the passive up rise of asthenosphere. Compared to active rifts, passive rifts produce only small volumes of magma.

The Mahakoshal Greenstone belt in central India is an example of Late Archaean, passive, intra-plate rifting. The ~500 km long, ENE-trending Mahakoshal Greenstone belt is composed of metavolcanic-sedimentary sequences and a wide spectrum of magmatic rocks. Magmatism is represented by four phases: komatiites, basalts, rhyolites and alkaline rocks (Talusani, 2001). This contribution presents geochemistry of low-Ti-P-K basalts from the Katni area of the Mahakoshal Greenstone belt.

In general, the Katni basalts are similar in their major and trace element compositions to mid-oceanic ridge basalts. They are low Ti-P-K tholeiites with TiO_2 = 0.94-1.12%, K_2O = 0.29-0.45% and P_2O_5 = 0.084-0.103% and Ti/Zr ratio ranges from 93-102 which is comparable with Ti/Zr = 109 in mid-oceanic ridge basalts. All the analyzed basalts have restricted range of major element compositions with SiO_2 = 49.17-50.44% and MgO = 6.18-7.64%, and show evidence of moderate amounts of fractionation (Mg#s = 56 to 62) of mafic phases such as olivine and pyroxene. Removal of mafic phases is also indicated by the rapid decrease in Ni and Cr contents with decreasing MgO.

The Zr/Y and Ti/Y ratios of the Katni basalts are similar to those of primitive mantle and many oceanic basalts. Furthermore, on the binary diagram of Zr vs Zr/Y, all the samples plot in the mid-oceanic ridge basalts field. A distinctive feature of Katni basalts is that they have negative Nb and P anomalies on mantle-normalized diagrams, compared with oceanic basalts. Since such negative anomalies are not a feature of oceanic basalts, they are inferred to reflect contributions from the continental lithosphere. The Katni basalts show near horizontal REE patterns similar to those of MORB with $[La/Sm]_{CN}$ = 1.3, $[Tb/Yb]_{CN}$ = 1.09 and $[La/Yb]_{CN}$ = 1.7. Overall, the geochemistry suggests that the convecting MORB type asthenospheric mantle is the predominant source of the Katni basaltic magmas.

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(ORAL)

A HIGH-ENERGY WAVE DEPOSIT ALONG THE OTAGO COASTLINE

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New Zealand is particularly susceptible to locally generated and far field tsunami because of its tectonic setting on a plate margin and the unimpeded fetch across the Pacific. Historical tsunami are well documented, however sedimentological evidence from Shag Point suggests larger events may have occurred in the past. This paper describes possible high-energy tsunami deposits at one site along the Otago coastline, South Island. Imbricated boulders up to 2.5x1.7x1 m occur on a Pleistocene erosion surface 5 m above mean sea level, buried under late Quaternary loess. Calculations derived from published work indicate a high velocity wave, most probably tsunami related, would have been needed to transport them. There are no contemporary examples of these deposits on the modern-day beach, which would suggest that the boulders are a result of a low-frequency catastrophic event.

(ORAL)

PALEOENVIRONMENTS OF NEOGENE STRATA AT TE ARAROA, EAST CAPE: TRACE FOSSILS AND EVENT STRATIGRAPHY

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A shallowing marine sequence of Tongaporutuan (Late Miocene) to Kapitean (Early Pliocene) age strata is spectacularly preserved and exposed along the coastline between Te Araroa to East Cape in the Eastern North Island of New Zealand. Sedimentation on this active continental margin was dynamic with a succession of sands and muds deposited in a shelf/slope setting. The sequence contains numerous event beds including: sediment gravity flows, shell concentrations and an olistrosome unit. Throughout the sequence, ash beds are common. Thin ash beds punctuate background sedimentation, many are primary fallout tephra, while reworked beds are graded and show characteristic turbidite features. The source of volcaniclastic material throughout the sequence is considered to be the Coromandel Volcanic Arc, active during the Miocene-Pliocene. Sub-spherical and cylindrical concretions from (10 cm to 3 m diameter) are common mid-sequence. Many exhibit a hollow central tube and are considered to be evidence of post-depositional fluid expulsion structures.

Virtually the entire sequence has been thoroughly bioturbated. Many, if not most, small-scale sedimentary structures have been destroyed, including some thin event beds. In some parts of the section, discrete traces are not visible and repeated overprinting is evident. Taylor and Goldrings's (1992) ichnofabric analysis method is utilised in this study, which includes ichnotaxon identification, burrow size and extent (bioturbation index), colonisation order and tiering, in combination with sedimentary structures that can show ichnofaunal response to events. Droser and Bottjer's (1986) ichnofabric indices were not useful when applied to this suite of rocks. Preliminary results reveal that ichnofaunal diversity and bioturbation intensity increase with the frequency of small-scale events. Comparison of ichnofabrics throughout the sequence reveals background hemipelagic sedimentation punctuated by numerous event beds.

In the shelf environment of the sequence, shell material is abundant and ichno-assemblages are dominated by *Asterosoma* and *Thallasinoides*. In the slope environment, ichno-assemblages are diverse with recurrent *Zoophycos*, *Teichichnus*, *Chondrites* and *Phycosiphon*, and occasional scattered macrofossils. Ash event beds are dominated by *Scolicia* traces. *Helicodromites* and sub-horizontal rind burrows are occasionally encountered in the slope setting of the sequence.

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(POSTER)

DRIFTING AND LODGEMENT OF GIANT FLOATED PUMICE BLOCKS FROM THE 1.8KA ERUPTION, LAKE TAUPO

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At the close of the 1.8ka Taupo eruption, degassing remnants of magma were extruded as a dome(s) beneath Lake Taupo. Blocks broke loose from the dome(s) and floated to the surface, and many washed ashore around the northeastern part of the lake. Larger blocks would, on the basis of cooling models and likely rates of wind-drifted transport to shore, have still been hot as they were stranded, but few show evidence for significant heat retention at the time of their final encasement in sediment during lake filling and shoreline transgression. From this we infer that most clasts cooled while lodged, but before final burial.

Four thousand m^3 of grey pumice clasts are identified between Te Kumi Bay and Motutere, lying predominantly between western Five Mile Bay Reserve and Otene Road. Two populations of grey pumice are present. The first are giant floated pumice blocks, and the second are small pumice that spalled off the giant blocks. Both types of clasts occur in shoreface and nearshore lacustrine gravels and sands, and commonly overlie laminated and rippled sands. There is very little or no erosion or deformation seen in the sediments underlying the grey pumice, suggesting that they did not sink rapidly into place. The lack of deformation also implies that they must have been almost neutrally buoyant when stranded, a contention supported by unusual "standing pebble" fabrics developed beneath some of the larger blocks. Some smaller clasts, <5cm in diameter, occur slightly higher in the transgressive sequence in deposits of the shoaling and oscillatory wave zone.

The grey pumice ranges from 2mm to 20m in diameter, with a mean of ~20cm. Most are angular and blocky, especially the smaller clasts. All grey pumice clasts >0.5m show radial cooling joints.

Grey pumice clasts have a non-homogenous distribution of mostly elongate vesicles (50 – 80%). Clasts >2m show a distinct distribution of vesicles with dense rims (av. density 917kgm^{-3}) and a more vesicular interior (av. density 815kgm^{-3}). A transition area (av. density 44kgm^{-3}) usually exists between the rim and interior.

A detailed GPS survey of the base height of the grey pumice clasts within the sediment shows a vertical range of 3.3m. Rates of accumulation around the lake varied, with relatively high rates inferred for the Five Mile Bay area. Considering a maximum rate of 5myr^{-1}, the burial of the grey pumice within the sediment would have taken about 7 months after final stranding.

(POSTER)

MATEMATEAONGA FORMATION, EASTERN TARANAKI PENINSULA: GIS MAPPING AND STRATIGRAPHIC CORRELATIONS

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The stratigraphic development of eastern Taranaki Peninsula through the late Miocene and early Pliocene is best understood in terms of it being part of a progradational continental margin, which has been subsequently uplifted, tilted to the southwest and partially eroded. This succession comprises the Whangamomona Group, which is a 2nd order megasequence of middle Miocene to early Pliocene age. The Matemateaonga Formation makes up the uppermost and shelfal component of this megasequence.

The Matemateaonga Formation (late Kapitean to early Opoitian; c.5.5 - 4.7 Ma) comprises a 1000 m-thick succession characterised by the cyclical repetition of lithofacies (sequences) driven by 6th order glacio-eustatic sea-level oscillations. Each sequence comprises transgressive (TST), highstand (HST) and regressive (RST) systems tracts. Most sequences contain onlap and backlap shellbeds, which are often superimposed to form compound shellbeds. These are typically overlain by massive aggradational siltstone (HST) and regressive sandstone (RST). Most of the sequence boundaries are unconformable. Individual sequences or groups of sequences in the Matemateaonga Formation have been geologically mapped across eastern Taranaki Peninsula.

The stratal geometry of the Matemateaonga Formation is tabular and continuous. The mapping area lies on the western flank of the southward plunging Whangamomona Anticline, with Matemateaonga Formation strata striking 100 to 150°, with dips of 2-4° to the southwest. Northeast-southwest trending faults offset Matemateaonga Formation and are relatively common throughout the Taranaki hill country. Faults can have normal offsets of up to 50 m but the majority of offsets are less than 10 m. Twenty eight sequences have been identified and a composite stratigraphic column has been constructed from numerous measured sections throughout the mapping area.

The geophysical wireline log record for the recently drilled Makino-1 exploration hole, located down-dip from the outcrop area, has been analysed and interpreted. This interpretation, in particular the identification of 6th order sequences in Matemateaonga Formation, has been made possible by a wireline log model developed for the continuously cored Manutahi-1 well, which lies some 30 km to the south. The Makino-1 well has provided a complete section of Matemateaonga strata with which the outcrop sections have been correlated.

Geological mapping is done using ESRI's ArcGIS 8.2 software which provides the platform in which to integrate multiple sources of spatial data. The resulting geodatabase produced has a structure and functionality similar to that described by Bland *et al.* (this volume).

(POSTER)

NATURAL HAZARD ANALYSIS IN URBAN AREAS USING HIGH RESOLUTION DIGITAL DATA – THE MASTERTON FAULT MAPPING PROJECT

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In March 2002, Ian R Brown Associates Ltd (IRBA) was contracted by Masterton District Council and Wellington Regional Council to provide a survey accurate map of the Masterton Fault and related landform features within the Masterton urban area as an input to natural hazard planning.

IRBA compiled a database of existing high-resolution digital data to undertake this project. Data included orthophotographs, cadastral (property outline) data, road and river polygons and 1m contour topographic data. We assembled a digital terrain model (DTM) with 10x10m cells to facilitate construction of cross-sections and slope-gradient maps. Landform mapping was undertaken at a scale of 1:5000.

We located the position of the Masterton Fault scarp by identifying breaks in slope across the late Quaternary Waiohine Surface. No actual trace of the fault was observed. At numerous sites, the scarp has been modified by roading, land development and natural erosion. There is one instance of alluvial fan deposition across the scarp. In the Hillcrest St / Pownall St area, the fault scarp bifurcates eastwards and assumes a more easterly strike. Ponding and back-tilting adjacent to the eastern fault segment indicate greater extension across the eastern segment than the western segment. The faulting mechanism is dominantly normal, with a minor right lateral component.

Near the town centre, the Masterton Fault scarp has been removed by the 1300m wide floodplain of the Waipoua River. The Waiohine Surface has been eroded by at least 4m, however the modern floodplain has a convex-upwards topographic profile indicating accretion. Mapped floodplain width is consistent with historical flooding records.

After completion of geomorphic mapping, we recorded profiles across the fault scarp with differential GPS surveying. There is good correspondence between the position of landform features as recorded by the DTM, GPS profiles and orthophotography. However, there were minor differences in relative elevation between the DTM and GPS data which we were unable to resolve. The position of the Masterton Fault trace was estimated from our mapping of the fault scarp, and a 20m wide setback zone on either side of the fault was calculated as the fault hazard zone.

Availability of a high resolution DTM and associated data for Masterton enabled mapping of tectonic and fluvial landform features to a precision which was sufficient for planning purposes. Similar data are available for many urban areas in New Zealand, and should be used where possible as a basis for urban natural hazard investigations.

(ORAL)

GEOPHYSICAL AND STRUCTURAL INVESTIGATION OF BASEMENT GREYWACKE IN THE AUCKLAND REGION

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The Bouguer gravity field across the Auckland region can be described in terms of a broad gravity decrease from east to west with an average gradient of ~0.6 mgal km^{-1}. This gradient steepens to ~2 mgal km^{-1} over a zone about 5 km wide, running NW-SE through central Auckland. Superimposed on these broad features are shorter wavelength features including a notable gravity peak in the east. The east-west gravity gradient has previously been interpreted as resulting from a dipping greywacke basement, however deep boreholes in the area show that the contact between the basement and the overlying

Waitemata rocks is relatively flat-lying. Therefore this gradient must result from density variations within or below the greywacke.

Studies to define the gravity expression directly on the nearby greywacke basement in the adjacent Hunua range (Hunua Facies, Waipapa Terrane) reveal complex patterns. The Hunua block east of the Wairoa Fault is characterised by high gravity values while the block west of the Wairoa Fault is characterised by values that reflect the broad wavelength gradient. Laboratory density measurements were taken on sandstone and argillite samples sourced from greywacke sequences of both the Murihiku Terrane in the west and the Waipapa Terrane in the east. Results show that the greywackes of the Waipapa Terrane have an average density of 2.69 Mgm^{-3} $\pm$ 0.007 and in contrast, the greywackes of the Murihiku Terrane have an average density of 2.59 Mgm^{-3} $\pm$ 0.016.

Preliminary modelling suggests that the steepest segment of the broad wavelength east-west gravity gradient across Auckland can be largely attributed to the density contrast of 0.1 Mgm^{-3} between the two basement terranes. No significant density variation was identified in samples sourced from within the Waipapa Terrane (Hunua Facies) that may account for the observed complex anomalies in the Hunuas.

(ORAL)

PALEOCEANOGRAPHY OF THE CANTERBURY BIGHT: PLANKTIC FORAMINIFERAL EVIDENCE FOR THE LAST 1 MILLION YEARS FROM ODP 1119

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ODP 1119, drilled on the upper continental slope of the Canterbury Bight, displays clear sedimentary oscillations, which document the oceanic history of the last 1 myrs. Glacial periods have thick beds of muddy, micaceous sediment, reflecting an increase in fluvial sediment derived from the glaciated Southern Alps and the narrowing of the continental shelf. Interglacial periods have thin beds of sandy biogenic sediment. Fluctuations of sea surface temperature, carbonate, natural gamma and oxygen isotopes (Carter and Gammon, unpubl.) have been used to correlate ODP 1119 stratigraphy with the Marine Isotope Stages (MIS) and suggest that the upper 233 metres of the core dates back to MIS 23.

ODP 1119 provides clues to understanding the movement and character of the Southland Current and Front during glacial and interglacial cycles over the last 1 myrs. Planktic foraminiferal assemblages have been used to estimate sea surface temperatures (SST). Summer SSTs in most interglacials range between 10° and 13°C (slightly cooler than the present day 14° C for this site). Interglacial SSTs indicate an overall warming trend of about 2°C through the Mid Pleistocene Climatic Transition (~0.9 – 0.6 Ma), similar to that observed in DSDP 594, which lies in deeper water to the east. SSTs suggest that during most interglacial high sea level intervals the Southland Front was landward of ODP 1119 and that both 1119 and 594 were bathed by cool Subantarctic Surface Water. One major exception to this was during MIS 11 (400 ka) when both sites have summer SSTs of 16°-18° C. This indicates that the Subtropical Front (STF) had probably detached from the Chatham Rise and migrated south of the Bounty Trough.

In contrast, glacial SSTs in ODP 1119 (summer SSTs 7-8°C) are mostly 3-4°C warmer than DSDP 594, indicating that the Southland Front moved seaward and lay between the two sites during these intervals of lowered sea level, with 1119 beneath the warm Southland Current. One exception is seen during MIS 20 (850 ka), when both 1119 and 594 had similar SSTs of 3-4°C. This suggests that the Southland Current did not exist at this time and that the Subtropical Front did not pass around the southern end of NZ. These low SSTs suggest that even the Subantarctic Front may have migrated northward of 1119 and 594 and coalesced with the STF, which was locked to the Chatham Rise.

(PLENARY)

THE EARLY-MIOCENE (15-20MA) MANUHERIKIA GROUP REVEALS NEW ZEALAND'S FIRST DIVERSE TERTIARY TERRESTRIAL FAUNA

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New Zealand was once part of Gondwana, but has been an archipelago since its separation from Australia and Antarctica around 82 Ma. Some 245 breeding species of bird and lizards (Scincidae, c.35 spp; Gekkonidae , c.29 spp) dominate the Recent vertebrate fauna, with land mammals represented only by 3 species of bats. While New Zealand has a very rich late Quaternary terrestrial fossil vertebrate record, it boasts one of the world's poorest pre-Quaternary records. Between the fragmentary Late Cretaceous (80-71 Ma) dinosaur record and isolated moa bones from marine sediments, up to 2.5 Ma, the terrestrial record is largely limited to a single fauna from the Manuherikia Group. This was known to have two undescribed anatids and undetermined fish discovered in 1978, and a single crocodilian angular discovered in 1989. The Manuherikia Gp sediments near St Bathans in central Otago comprises quartz gravels, carbonaceous mudstones, thin silts and clays deposited in a lake and river system approximately 15-20 m.y.a. We have recently begun a reinvestigation of the Manuherikia Gp sediments in search of fossil vertebrates and report here the preliminary results of fieldwork from 3 sites.

Fish bones are abundant and represent small (up to 30 cm long) fish that appear to belong to a single taxon. The family to which this taxon belongs is unidentified, but appears to be unrepresented in New Zealand freshwaters now. No bones of the present dominant galaxiid group were identified.

Reptile bones are rare. A single fragment of tooth row is the first pre-Holocene fossil record for sphenodontids in New Zealand. Crocodilian remains include 3 teeth and 2 scutes, and indeterminate fragments. Two fragments of tooth bearing bones indicate the first fossil occurrences of a snake in New Zealand.

Bird bones dominate the terrestrial fauna, with at least 300 bones identifiable to a taxon level. Most bones are anatids (c. 5 spp.). The largest is the size of Tadorna, and one common taxon is a diving duck, but none are described. Waders (Charadriiformes) are represented by c. 2 spp., rails (Rallidae) by many bones of 1 sp., parrots (Psittacidae) by 1 sp., and passerines by c. 4 spp. Other than these, fragments of longbones indicate at least one goose-sized species. Eggshell of several thicknesses is abundant and is assumed to be mostly anatid, however, shell c. 1.5 mm thick is as thick as that of Emeid moa, and if confirmed as ratite indicates that moa ancestors were large and flightless at this time. Thus a minimum of 15 avian taxa are represented.

Mammals. A single symphysis of a mandible and a proximal portion of a metacarpal are from two bat species that appear to be related to the mystacinids, recently endemic to New Zealand and with a Miocene presence in Australia.

The Manuherikia Gp sediments provide the first terrestrial vertebrate fauna of Tertiary age for New Zealand. They allow a glimpse of the fauna living in New Zealand after the Oligocene submergence, when land area was reduced to about 20% of present. This event is hypothesised to have been a bottleneck to species diversity based on DNA divergence dates for various taxa. Although preliminary, our results show that some previously undetected taxa survived on New Zealand after separation from Gondwana, and that there has been substantial changes to New Zealand's vertebrate community since the late Early Miocene.

(ORAL)

EVOLUTION OF THE MACAULEY VOLCANO AND ~6300 YEAR OLD CALDERA: NEW EVIDENCE FROM EM300 MULTI-BEAM SEAFLOOR MAPPING

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Macauley Island is the emergent summit of the submarine Macauley volcano, which is part of the Kermadec arc. The island is a small remnant left when the volcano partly collapsed during the formation of Macauley caldera. This caldera-forming eruption is the inferred source of the ~6300 year-old Sandy Bay Tephra (SBT), a thick pyroclastic sequence of dacitic pumice with a possible eruptive volume of 50–100 km^3 (Lloyd et al., 1996).

New EM300 multi-beam seafloor mapping (with a grid resolution of 15 m and vertical resolution of <2 m), together with multi-channel seismic reflection lines, provide new insight into the evolution of the volcano. They reveal a complex 35x40 km volcanic massif with several satellite cones. The large centrally-located Macauley caldera (10.8 km long, 8.2 km wide, and ~500 m deep with the caldera rim at 400–700 mbsl) is host to an active cone, while the caldera rim and outer flanks are dotted with >150 small cones that form distinct lineations and vent fields.

A dramatic and extensive set of concentric faults on the volcano flanks, with seafloor displacements of 20–120 m, record the foundering of the edifice contemporaneous with the main caldera-forming eruption(s). Multi-channel seismic reflection data image a semi-acoustically transparent unit 100–200 msec-thick (two-way travel time) that thins away from the caldera rim. This unit has complex bedding and displacement relationships with the flanks concentric faults, and is the inferred marine correlative of the SBT. A thickness of 80–160 m (assumed seismic velocity of 1.6 km s^{-1} for saturated pyroclastic deposits) is comparable to the maximum SBT thickness of 100 m on Macauley Island. The caldera-forming eruption(s) are interpreted to be large – a minimum unfilled caldera collar volume of 17.5 km^3 plus a comparable ~15 km^3 volume of caldera fill yields, at an assumed at 70 % vesicularity, a minimum erupted volume of ~77 km^3. Resurgent mafic volcanism was pervasive, with >50 vents erupting on the caldera rim and flows of aphyric basaltic andesite descending both the inner and outer caldera flanks. A recent phase of normal faulting, orientated NE–SW, displaces the post-caldera lavas.

(POSTER)

KERMADEC SUBMARINE ARC VOLCANISM: NEW DISCOVERIES USING EM300 MULTI-BEAM SWATH MAPPING BETWEEN 30°–35°S

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New EM300 seafloor swath mapping provides the first definition of the submarine Kermadec volcanic arc at 30°–35°S. The mapping, acquired by *RV Tangaroa* in April–May 2002, covers ~14,800 km^2, equivalent to ~6 % of New Zealand's land area. Apart from the discovery of 13 volcanoes ≥10 km in diameter (the largest being 25 km-wide, 2100 m-high, and comparable to Ruapehu / Taranaki in size), and a further 30 volcanoes comparable to Rangitoto, the research provides insights into fundamental processes of submarine arc volcanism.

The present-day arc is built atop an extended back-arc basin basement, with this fabric and its conjugate orientation controlling the structure and morphology of the arc volcanoes. The simplest explanation is that the present arc was established after the Havre Trough began to open. The arc has now been mapped from its southern termination near 36.4°S (Clark volcano) to Raoul Island, a distance of 890 km. This segment contains 27 major volcanic massifs (>1000 m relief) at an average spacing of 33 km, together with numerous smaller edifices. Taking all volcanic constructs, and assuming the present-day arc is <1 Ma old, the edifice construction rate is at least 17

km^3/km/Ma. The magma production rate will be higher needing to incorporate the volume of sector collapses, diffuse volcanism and sub-volcanic intrusions.

Silicic volcanism and associated caldera-forming eruptions are a major component of the Kermadec intra-oceanic arc, supporting recent discoveries at the comparable Izu-Bonin arc. At least 13 volcanoes from 29.3°–36.4°S have erupted dacite or dacitic pumice, representing ~38 % of the 34 volcanoes with ≥5 km basal diameters. Seven of these 13 have calderas ≥3 km in diameter. The caldera-forming eruptions are not restricted to the volcanic front, nor must they terminate silicic volcanism.

A variety of edifice destruction and modification processes are observed, including sector collapse, tectonic dissection, caldera collapse, and the post-collapse re-growth of volcanic cones. Preliminary analysis shows that individual sector collapses can have volumes of at least 4.4 km^3. Further research is aimed at establishing the timing and frequency of edifice failure.

(ORAL)

GEOTECHNICAL ENGINEERING WITHIN THE NORTHLAND ALLOCHTHON

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Northland is fast becoming a sort after place to live. But residential, industrial and commercial development and infrastructure within the area is commonly plagued by the widespread presence of the Northland Allochthon and all its inherent difficulties, mainly relating to slope instability. It is a particularly troublesome group of materials in terms of geotechnical engineering. The objective of this paper is to present a summary of key aspects of geotechnical engineering within the Northland Allochthon gained from numerous projects within the Northland area. The principle engineering geological characteristics of the main units within the Allochthon are described, including the close correlation between geomorphology, lithology, and rockmass strength. An understanding of this simple correlation is paramount to understanding the nature of the land, especially for engineering purposes. The hydrogeological characteristics of the main Allochthon units are also described, including the "Reverse groundwater model", which is typically observed. Slope movement styles and mechanisms are described, as are stabilisation of the slopes and the difficulty in doing so. Cut slope gradients are summarised, as are other geotechnical aspects, such as foundation depths to avoid shrink-swell effects, and effluent disposal techniques and problems.