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FIELD TRIP GUIDES

Edited by
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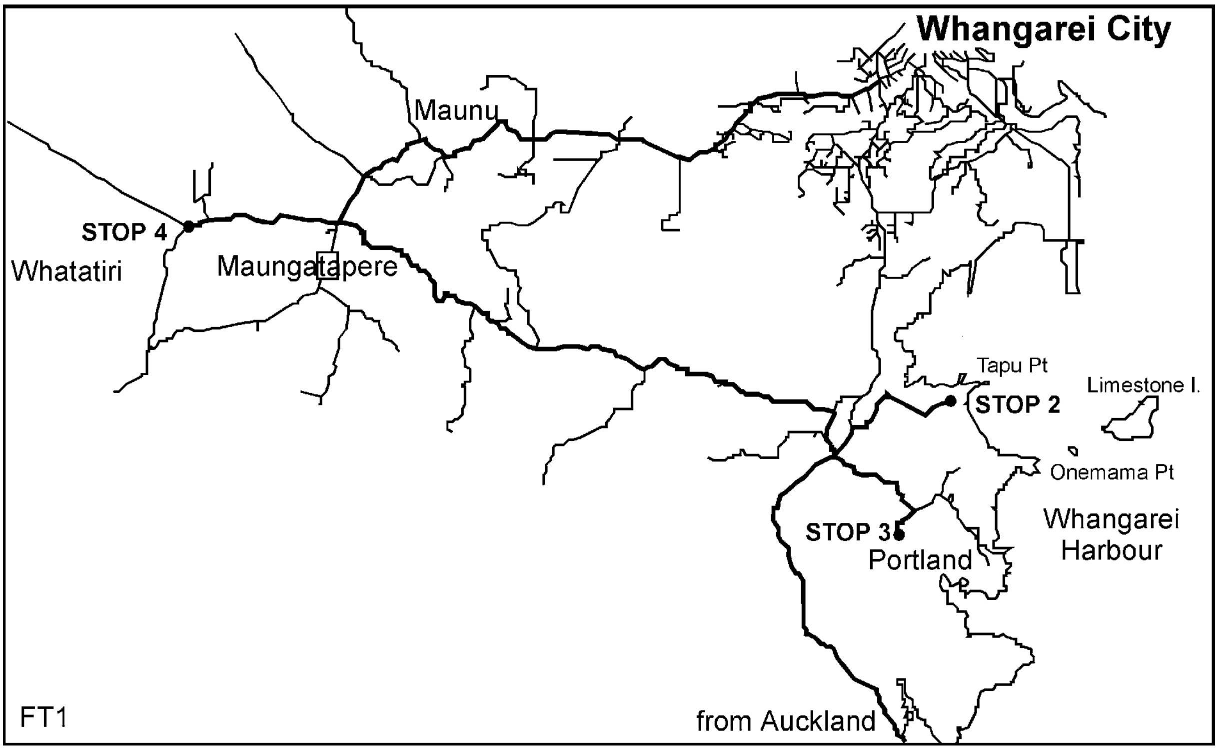

Route guide for field trip 1 around Whangarei.

Field Trip 1

Northland Allochthon emplacement, South Whangarei Harbour

Bruce Hayward, Bernhard Spörli and Mike Isaac

0 km **LEAVE AUCKLAND**

North side of Albany Hill, southernmost limit of Northland Allochthon outcrops. Note the different topography between early Micoene Waitemata Group hills and Dairy Flat-Silverdale lowlands (mostly allochthonous Mahurangi Limestone).

Return of Waitemata hill topography near end of motorway at Orewa.

Waitemata Group all way to Warkworth, where there are windows of Northland Allochthon (Mahurangi Limestone, greensand etc).

Volcanic-rich, thick-bedded Waitematas (Pakiri facies) through Dome Valley

Southern toe of main Northland Allochthon outcrop overthrusts Waitemata Group at Hoteo River.

102 km Toilet stop (at Kaiwaka on side road on right, side of hall)

North of Kaiwaka, a group of early Miocene dacite domes and associated altered tuff (Pukekaroro Dacites, Bowen 1966) form dome-like hills protruding above the soft Allochthon lithologies. These outcrop along the Brynderwyn Fault and an apparent WSW-trending splinter fault to the south of it (Fig. 1.1). The Pukekaroro domes intrude and overlie Northland Allochthon rocks and on the coast also intrude early Miocene Waitemata Group marine sedimentary rocks (Isaac et al. 1994). Five K-Ar ages give a total acceptable age of latest Otaian-early Altonian within the range 19.3-18.2 ± 0.5 Ma (Stipp & Thompson 1971, Hayward et al. 2001).

Climb southern front of Waipu greywacke Block, up Brynderwyn Fault.

116 km **STOP 1: BRYNDERWYN SUMMIT**

Turn left and up into carpark in front of Skyline Café at top of Brynderwyns.
Spectacular views of:

(a.) Whangarei Heads and Hen Island (eroded remnants of early Miocene andesite stratovolcano, Fig. 1.1)

(b.) Chicken Islands composed mostly of Waipapa Terrane greywacke.

(c.) Waipu basement blocks with Te Kuiti and Waitemata Group cover sequence.

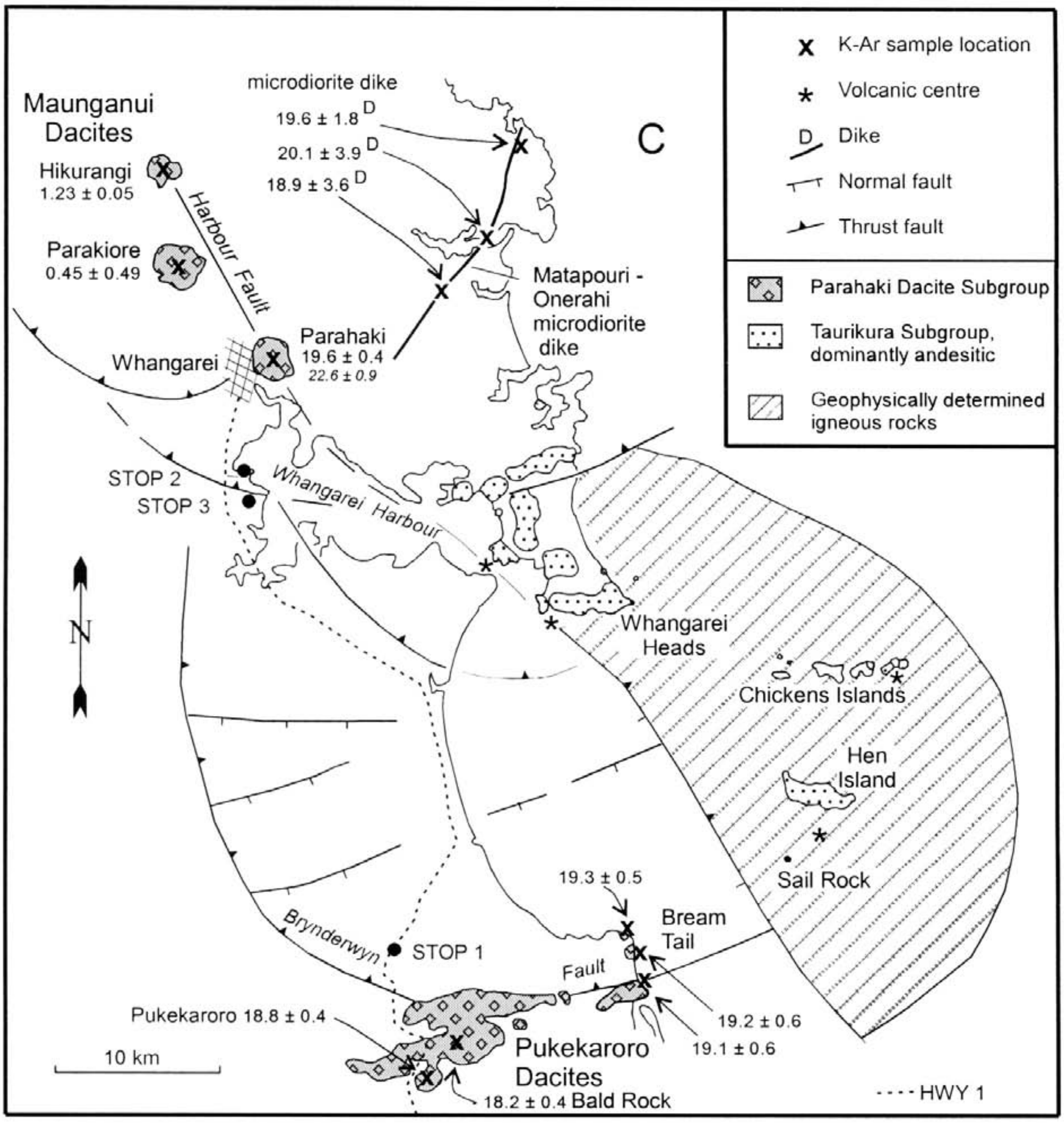

Fig. 1.1: Map showing the distribution of early Miocene volcanic rocks and inferred centres in the Whangarei-Brynderwyn area. K-Ar ages for the dacites are shown (from Hayward et al. 2001).

Waipu basement block
The Waipu block comprises an up-faulted and mostly high standing block of possibly allochthonous, basement greywacke, overlain by a mid Tertiary sedimentary sequence. It extends from the Brynderwyn Fault in the south to the shore of the Whangarei Harbour in the north (Fig. 1.2). It is bounded to the west by an arcuate extension of the Brynderwyn Fault. The eroded remnants of the eastern half of the Waipu block can be recognised beneath the seafloor of Bream Bay.

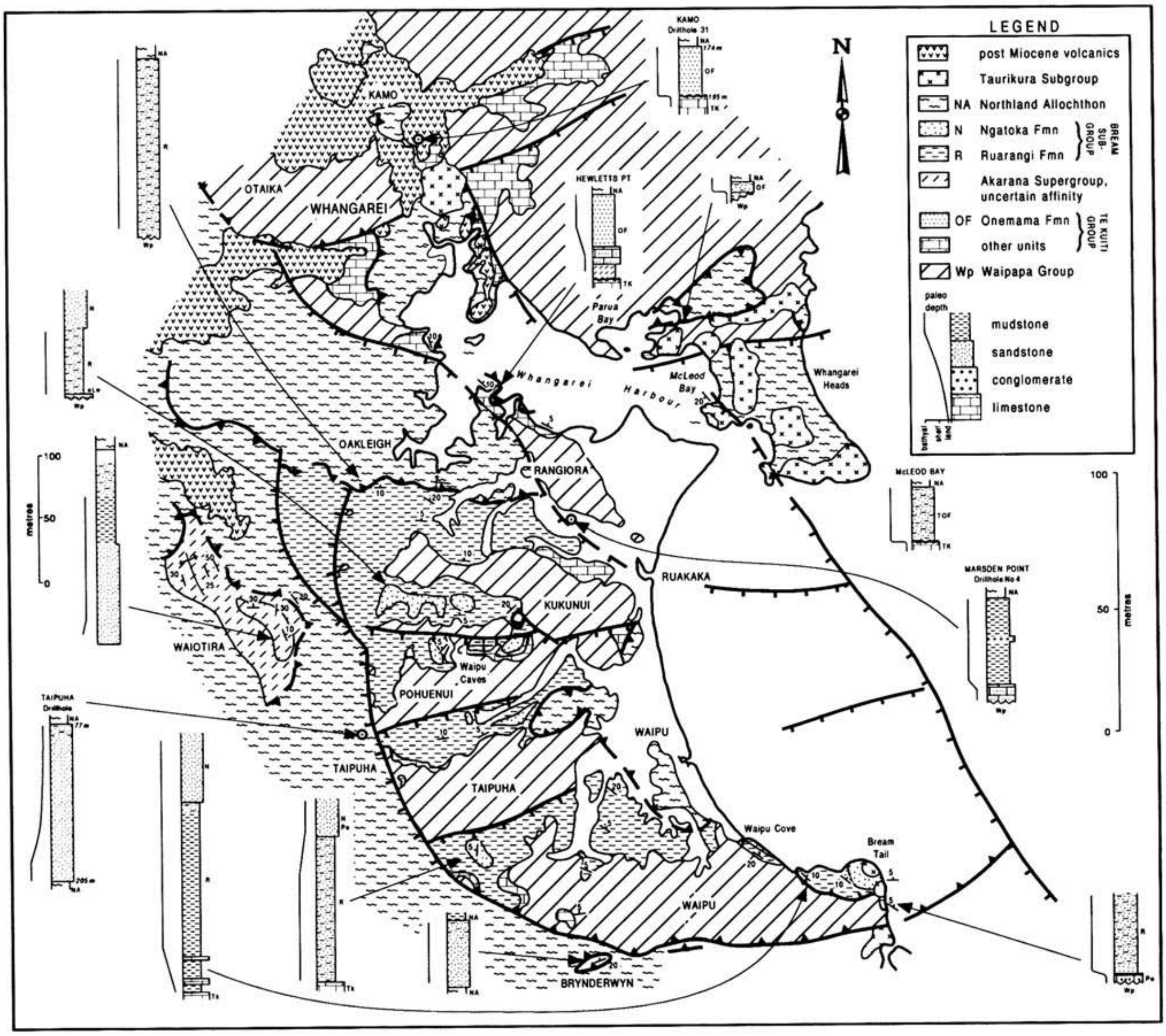

Fig. 1.2: Map of Whangarei-Waipu area of eastern Northland, showing distribution, lithologic columns, and paleodepth curves of early Miocene (late Waitakian-Otaian) Waitemata Group (Bream Subgroup) rocks, and their relationship to the underlying Te Kuiti Group and Waipapa Terrane basement and sheared contact with the base of the overlying Northland Allochthon (from Isaac et al. 1994).

The block is cut into five north-dipping segments by four west-east faults, each downthrown to the south. The mid Tertiary sequence overlying the irregular Waipapa Group greywacke surface is similar in each segment. When complete, it consists of thin basal Kamo Coal Measures (near Ruakaka) and glauconitic Ruatangata Sandstone (both late Eocene) overlain by crystalline, bioclastic Whangarei Limestone (Oligocene). These Te Kuiti Group units are conformably overlain by a deepening sequence of early Miocene Waitemata Group laminated mudstone and thick-bedded sandstone (Ruarangi and Ngatoka Formations). In several places these Waitemata sequences are obliquely truncated by sheared Northland Allochthon lithologies of Cretaceous and Paleogene age.

Our main stop for the day will be to examine part of the sequence in the northernmost Rangiora segment of the Waipu Block on the southwest shore of the Whangarei Harbour.

161 km **STOP 2: ONEMAMA** (3 hrs from University of Auckland)

Turn right onto Oaks Rd (200 m past turnoff to Portland)

Drive to end of road, up hill, take private road down to left and down drive towards railway line and park in front of David Kay's house.

Take lunch, we will be away from vehicles for 2-3 hrs.

15 min walk along railway line (watch out for trains!) and onto foreshore – slightly muddy.

Vans will leave from here at *c.* 2.15 pm

Mid-Tertiary stratigraphy (Fig. 1.3)
The most complete, composite mid Tertiary sequence on the south shore of Whangarei Harbour in the Rangiora segment consists of Waipapa greywacke overlain by c.20 m of glauconitic sandstone (Ruatangata Sandstone, Ar) passing up into c.10 m of Whangarei Limestone (Lwh-Ld). This is overlain by up to 30 m of an unusual flaggy, calcareous, glauconitic sandstone (upper Te Kuiti Group, Onemama Formation, latest Oligocene, early Lw, Isaac et al. 1994). Onemama Formation is conformably overlain by c.20 m of cm- to dm-bedded, calcareous-poor, terrigenous sandstone and siltstone of the Waitemata Group (late Lw-Po, deep bathyal). This is overalin unconformably by a sheared mixture of Northland Allochthon lithologies in several places.

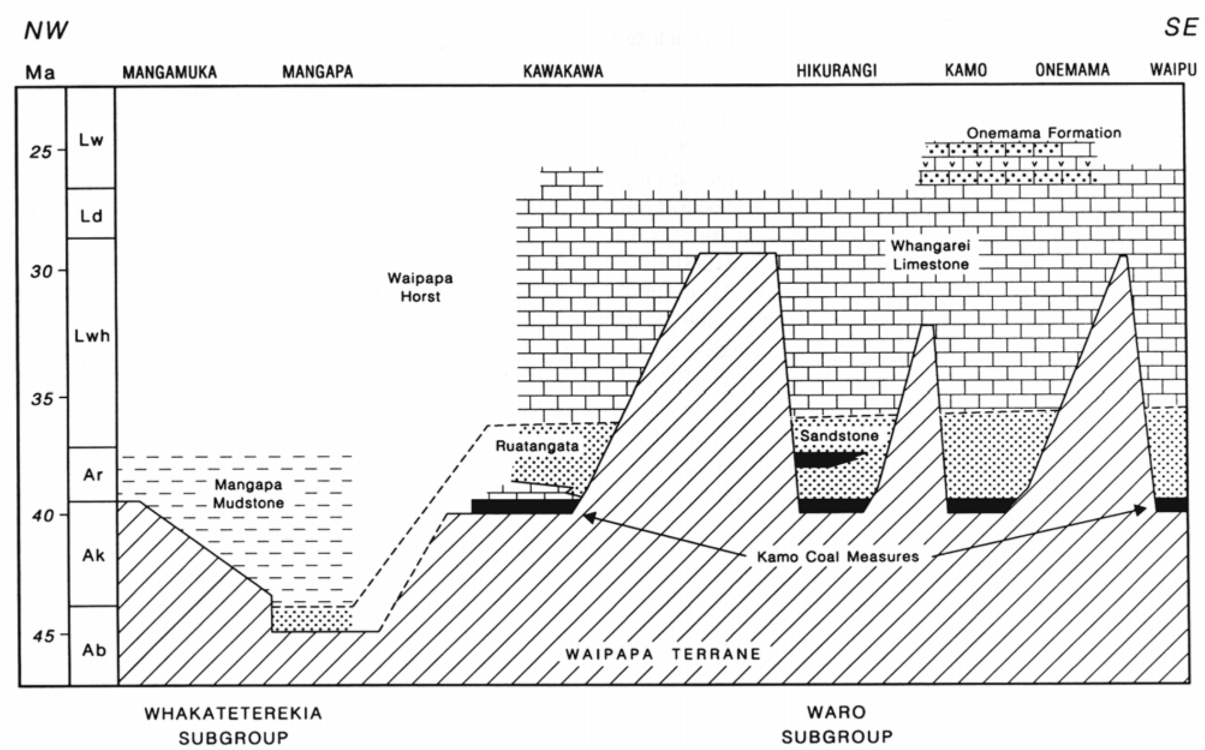

Fig. 1.3: Schematic NW-SE cross-section illustrating the distribution of Te Kuiti Group lithofacies in eastern Northland (from Isaac et al. 1994).

Onemama foreshore
The Onemama foreshore (Q07/310007) contains the best exposed sections through the Onemama Formation, recording the onset of Northland Allochthon emplacement into a deepening marine sequence. Fossil foraminifera (Q07/f8, f109) indicate outer shelf paleodepths (c. 100-200 m). Rare macrofossils have been found in this unit (in Paradise Quarry on the nearby hillside) including an exceptionally well-preserved outer shelf-bathyal lantern fish (Hayward and Stephenson 1991).

Lower parts of Onemama Formation seen in the foreshore contain sheared-in slivers or thin thrust slices of Northland Allochthon mudstones and beds of allochthon-derived, mudstone pebble conglomerate. Characteristically Onemama Formation consists of flaggy, mid grey, well sorted, medium- to fine-grained, glauconitic sandstone to sandy limestone on a 1-3 cm scale, with rare planar cross-sets to 30 cm high.

Tuff horizon
At least one, and possibly two units (up to 5 m thick) of hard, cemented, pale grey to yellow, limonite-stained siltstone (Paradise Member) are conformable within the sequence. This is now 60% mordenite, originally probably dacitic tuff (Sameshima 1978) and provides some of the earliest evidence of the onset of subduction-related calc-alkaline volcanism in the early Miocene of Northland.

In the Onemama foreshore the tuff unit is structurally complex. The southernmost exposure (a prominent reef) is sub-isoclinally folded by a NW-SE trending, NE-verging fold. This fold direction is also evident in the northernmost exposure. However the tuff units in between are affected by an open (west verging?) syncline/anticline pair trending at right angle to this. The cause for these folds is not yet clear. However, the north-verging folds are similar in geometry to the infolding of the Northland Allochthon into greywacke basement, seen across the harbour at Ocean Beach and Parua Bay (mid-conference field trip FT4). Note that there is also a prominent north-verging kink fold in the very competent (structurally-resistant) Onemama formation in an abandoned quarry a few hundred metres south of the tuff exposures in the foreshore and 10 m stratigraphically below a similar (?same) tuff bed in the top of the quarry.

Paradise Tuff member is of similar age to the other oldest tuff beds in onland Northland which occur within the top of latest Oligocene (early Waitakian, 25-23 Ma) argillaceous limestone (Wainui Siltstone, Waterhouse 1966), which appears to have been incorporated into the top of the Northland Allochthon as it was emplaced into southern Northland (Hayward et al. 1989). These beds include both white rhyolitic and darker basaltic tuff, which provide evidence of some of the earliest arc-type volcanism probably of the offshore western volcanic complexes.

Tapu Pt
Return along railway line and look at old quarry exposure over fence to N on Tapu Pt (Q07/306017; also David Kay property), where sheared red, green and grey mudstone (Northland Allochthon) overlies Onemama Formation tuff and calcareous sandstone that abuts a greywacke high. Variations in attitude of the bedding again indicate a north-verging fold.

165 km **STOP 3**: **PORTLAND QUARRY** (Q07/293985) (*c.* 2.30 pm)
Toilets in office building. Hard hats and boots must be worn in quarry (not in toilets silly).
Sunglasses recommended for glare (especially if sunny).

THESE ROCKS ARE EXTREMELY FRACTURED AND LOOSE: TAKE EXTREME CARE NEAR THE QUARRY FACES. NO HAMMERING IN-SITU ROCK ON THE QUARRY FACES. Preferably restrict yourself to examining the quarried loose rocks on the side of the carriage way.

Mahurangi Limestone
Portland Quarry is located on a large block of Oligocene, fine-grained Mahurangi Limestone, which is one of the most dominant units in the Northland Allochthon. Fossil foraminifera and nannofossils indicate a late Oligocene age (late Whaingaroan-Duntroonian) and a deep bathyal paleodepth in an oceanic setting. It accumulated as pelagic foram nanno ooze on the floor of the Pacific Ocean.

Mahurangi Limestone is typically moderately to well-cemented, sheared and tectonically-deformed, argillaceous micritic limestone, blue-grey when fresh, but rapidly weathering to a distinctive, light creamy-white colour. Exposure are often massive and thoroughly homogenised by bioturbation, although bedding or lamination can occasionally be discerned. Lenses and intercalations of thin, graded calcareous sandstone, glauconitic sandstone and rippled fine sandstone are locally conspicuous (Isaac et al., 1994).

Mahurangi Limestone is typically composed of planktic foraminifera (up to 50%) set in a nannofossil-rich micritic matrix, with minor radiolaria and sponge spicules, and fine silt-sized quartz, clays and other terrigenous matter. Macrofossils are extremely rare (e.g. deep-water bivalve *Parvamussium*), but trace fossils are reasonably abundant. The most common ichnotaxa are *Zoophycos* and *Phycodes/Planolites*. At Portland Quarry a wide variety of large and small *Zoophycos* can be found. Several large *'Paramoudra'* concretions, developed around simple, non-branching burrows have been seen here.

Portland cement
Carbonate content of Mahurangi Limestone ranges between 55 and 80%. It is a widely used resource throughout Northland for roads and for pasture improvement, but here at Portland it is quarried for the manufacture of cement (600 000 tonnes p.a.). Portland Quarry was opened in 1913, with earlier operations starting in 1901 on Limestone Island in the middle of the harbour. The carbonate content of the cement

feedstock has to be raised to an appropriate level by the addition of c.150 000 tonnes p.a. of crystalline Whangarei Limestone (90-95% carbonate) from Wilsonville Quarry, Hikurangi (FT3-FT5). Rock from the two quarries is crushed here at the Portland Quarry and carried down to the plant below by conveyor belt. In the plant, the rock is mixed, crushed to a fine powder and fed into a kiln where it is heated to 1450°C where they become semi-molten leading to the formation of clinker nodules. These are cooled and the clinker is then ground down in a rotating mill to a fine powder, called cement. 4% by weight of imported gypsum is added to the clinker in the mill, and acts as a setting time control, allowing time for concrete to be worked. From Portland, the cement is distributed in bags, or in bulk road or sea tankers around New Zealand and to the Pacific.

Quarry exposures of two thrust slices
We will stop at a cut which exposes a cross-section through the NE –SW trending structure of the rocks. The prominent thick, north-dipping dark seam bisecting the outcrop consists of dark grey, frittery mudstone at the bottom overlain by glauconitic sandstone (greensand). This seam is enclosed within ordinary Mahurangi Limestone. The Mahurangi Limestone to the north of the seam contains some prominent 20-30 cm thick greensand horizons.

Nannofossils studies (Kadar 1988) have indicated that the grey mudstone is of late Eocene (Ak) age and therefore the oldest unit in the quarry. Mahurangi Limestone is the youngest. The lower contact of the dark grey mudstone is therefore a thrust, repeating the sequence in the form of two thrust slices. This is supported by top-to-the-south shear sense indicators that can be seen at the top of the lower Mahurangi Limestone in the northern exposure. These are mostly E-W trending as south-verging folds in the lower limestone are probably due to the same regime.

The Mahurangi Limestone has reacted to deformation by acquiring a spaced pressure solution cleavage (see KBS sample and loose samples along the carriage way). NE-SW to E-W trending, south-verging folds and associated cleavages in Mahurangi Limestone are one of the most constant structures in the Northland Allochthon (e.g. Pahi, FT2, Spörli and Kadar, 1989).Vertical faults in the southern face are associated with clearly visible stepped calcite fibre striations, indicating dip-slip movement.

Leave Portland Quarry *c.* 4.15 pm

WEST WHANGAREI VOLCANIC FIELD LOOP (45 mins)

For a decsription of the Whangarei basaltic volcanic field see the introductory chapter (Fig. I.6)

Drive back to Hwy 1 and across intersection towards Maungatapere.
Upfaulted greywacke block on right. Maunu scoria cone in front.

Climb up onto basalt flows as road approaches Maungatapere.

175 km In Maungatapere take turnoff towards Kaikohe and Titoki on right.

176.5 km **STOP 4: VOLCANO VIEWS** (Junction with Clendon Drive on left)
Views of Maunu and (Maungatapere scoria cones and Whatatiri Shield volcano.

K-Ar determined ages (Smith et al. 1993):
Maunu, 0.32 ± 0.09 my.
Maungatapere, 0.29 ± 0.05 my.
Whatatiri, 0.5-0.6 ± 0.1 my.

Return to Maungatapere and turn left taking road direct into Whangarei, past Maunu scoria cones and down flow dropping off into autochthon near hospital.

190 km Whangarei motel precinct, *c.* 5 pm.

6.45 pm Ice-breaker party in Cafler Suite, Forum North (free food and drinks).