GEOLOGICAL SOCIETY OF NEW ZEALAND
ANNUAL CONFERENCE
2ND-5TH DECEMBER, WHANGAREI
NORTHLAND 2002

FIELD TRIP GUIDES

Edited by
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(with thanks to Bruce Hayward, Ashwaq Sabaa and Jessica Hayward for editorial assistance)

Bibliographic Reference

Smith V. & Grenfell H.R. Editors (2002): Fieldtrip Guides, Geological Society of New Zealand Annual Conference "Northland 2002", Geological Society of NZ Miscellaneous Publication 112B, 116 pp.

Recommended referencing of field trip guides (an example):

Spörli K.B. & Hayward B.W. (2002): Geological overview of Northland. *Field trip guides, GSNZ Annual Conference "Northland 2002", Geological Society of NZ Miscellaneous Publication* 112B, p.3-10

2002

ISBN 0-908678-90-8

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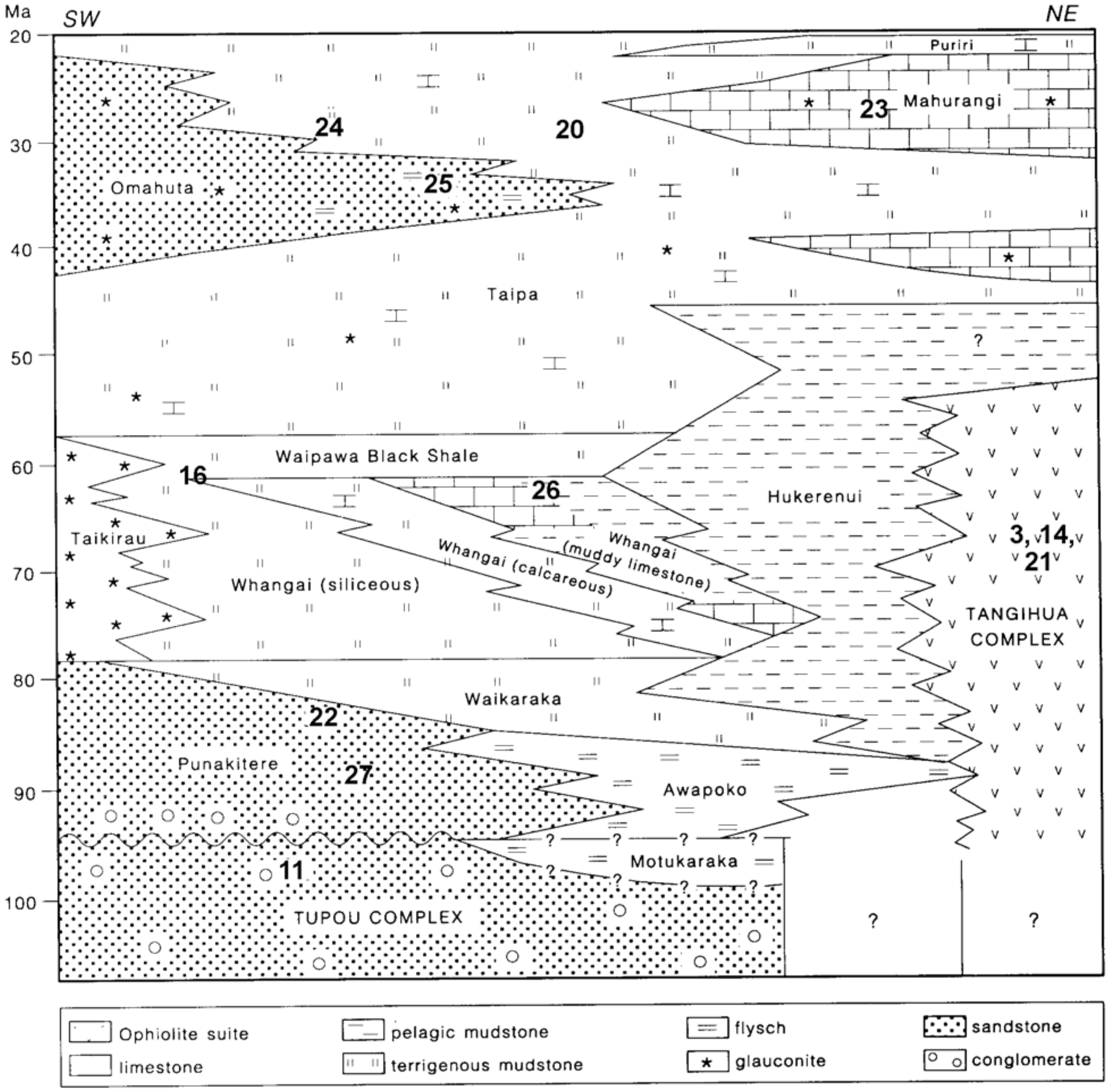

Fig. 7.1: Lithostratigraphic column of Northland Allochthon lithofacies and numbered stops where units will be seen (after Isaac et al. 1994).

Field Trip 7

A Taste of Northland Geology

Bruce Hayward and Ian Smith

Post conference fieldtrips leave from The Quarterdeck (formerly Valentines) carpark, 56 Otaika Road at 8AM on Friday 6th December.

DAY 1: Whangarei to Tauranga Bay (Fig. 7.1, 7.2)
Northland's young basalt volcanic fields; early Miocene Wairakau Volcano ring plain deposits.

0 km	8 AM Leave The Quarterdeck (formerly Valentines) carpark, Whangarei
2 km	Climb hill onto Mauna basalt flows (stone walls)
8 km	Pass 0.3 Ma Maunu scoria cone on right. View of 0.3 Ma Maungatapere scoria cone and 0.5 Ma Whatitiri shield volcano as we descend the hill (Fig. I6).
12 km	Photo **STOP 1**. Junction with Clendon Rd on left. Views of the three volcanoes.
22 km	8.45 AM **STOP 2**. 2 km down road on left to Wairua Falls which flows over the edge of a Whatitiri basalt flow.
22-26 km	Wairua River to Titoki. Flat-floored valleys part-filled with basalt flows from Whatitiri and Mirowhakitiki (Fig. I.6). Views in front to the west of conical Houto (Tangihua Volcanics with early Cretaceous fossils); and Tangihua massifs on skyline beyond (youngest thrust sheets of Northland Allochthon).
26 km	Cross Mangakahia River and into Northland Allochthon (mostly late Cretaceous-Paleocene sedimentary rocks here).
35-38 km	To Parakao. Follow Mangakahia River Valley with conical Houto on skyline on the left and Tangihua massifs to north and south with sedimentary blocks between.
53-58 km	Small gorges through Tangihua rocks.
55 km	Twin Bridges picnic area. No toilets. Rock exposures on opposite bank of river.
58 km	9.45 AM **STOP 3**. Tangihua rocks in small road quarry on right and small falls in river on left.
64 km	Awarua Valley with Tangihua massifs forming hills on both sides.

Kaikohe-Bay of Islands Basalt Volcanic Field (Fig. 7.3)
Basalt scoria cones and extensive basalt flows and shields have been erupted in this area over the last 10 million years. All the older (pre 2 Ma) cones have disappeared but eroded remnants of the flows now form upstanding plateaux, extending from Okaihau to Kerikeri and north to Whangaroa. We will be driving over these, early this afternoon. Deep, subtropical weathering of these has produced the rich volcanic soils that nurture Kerikeri's orchards and crops.

In the last half-million years, 12 small basalt volcanoes have erupted in the southern part of the field (Smith et al. 1993), forming a cluster of scoria cones around Kaikohe (Fig. 7.3). Te Puke volcano erupted in the hills behind Waitangi 100 000 years ago, forming three small cones and a spreading flow that now underlies Waitangi golf course and treaty grounds. The youngest volcano is Tauanui, 10 km south of Kaikohe, which 60 000 years ago produced a high scoria cone and a lava flow that flowed 19 km down the Taheke Valley towards the Hokianga Harbour (Stop 4). The field includes a small rhyolite dome (Putahi), overlooking Lake Omapere (Stop 7). The field should still be considered dormant, and not extinct.

72 km	Southern margins of young Kaikohe Basalt Field. View of 60 ka, 150 m high Tauanui scoria cone on right.
73 km	Basalt walls indicate that we have driven onto the Tauanui lava flow. Smaller less complete scoria mound with pa in front of Tauanui is Hangunui.
75 km	Turn left down Piccadilly Rd and drive along top of flow. Flat-topped Waipoua Plateau (Waipoua Basalt of Day 3) forms skyline to left.
77.5 km	10.30 AM **STOP 4**. 200 m before sharp corner, turn left into driveway and across to Piccadilly Rd quarry in Tauanui basalt flow.
92 km	11.15 AM Kaikohe. **STOP 5**. Toilet stop, behind shops.

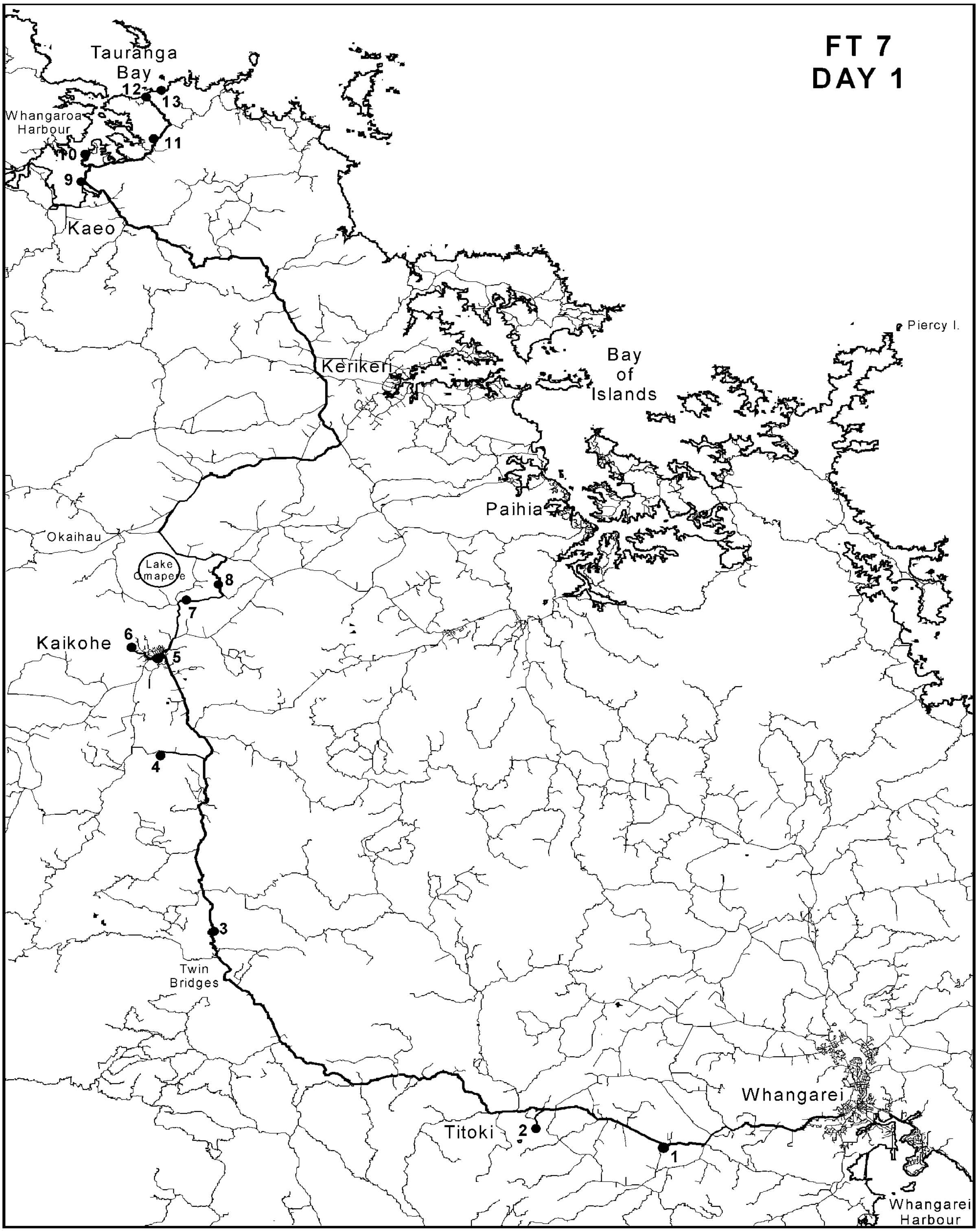

Fig. 7.2: Route map for day 1, Whangarei to Tauranga Bay.

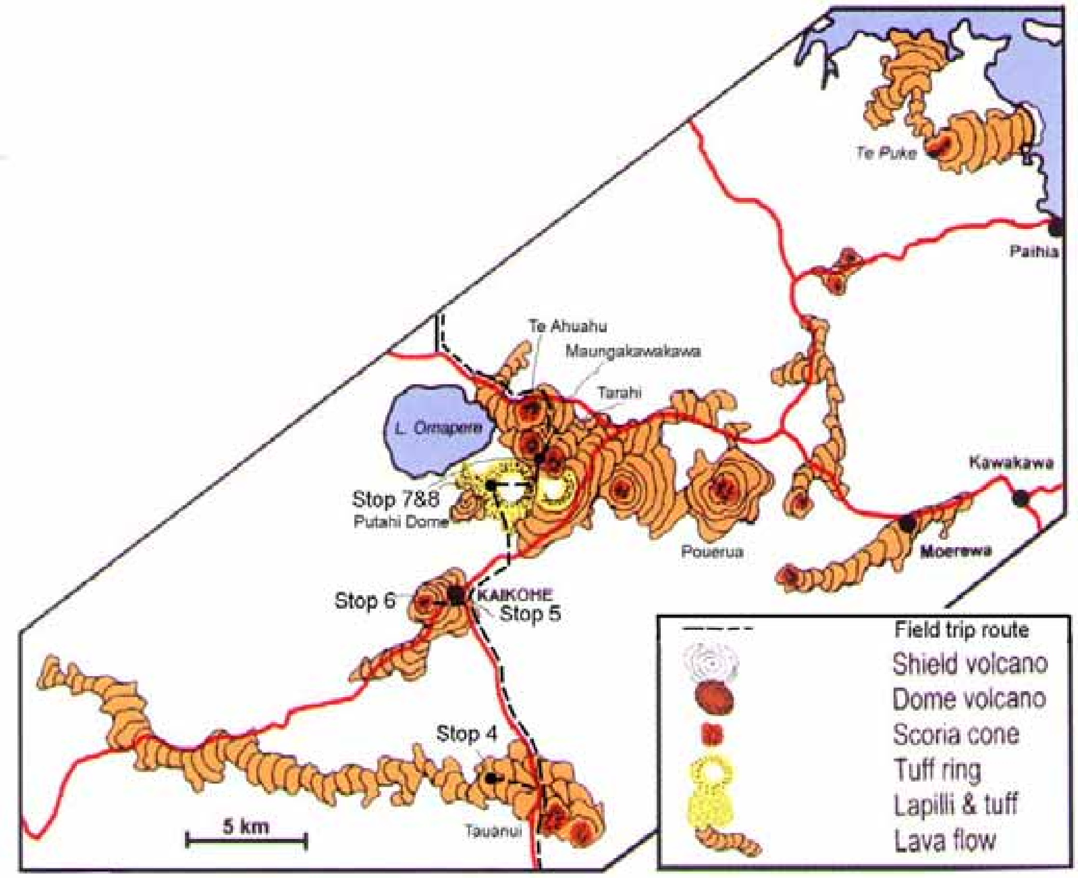

Fig. 7.3: Map of the young Kaikohe Basaltic Volcanic Field (younger than 1 Ma).(after Mulheim 1973)

93 km Follow signs to Hone Heke Memorial Reserve on top of Kaikohe Hill scoria cone on NW outskirts of town.
STOP 6. Early LUNCH. Views.
LEAVE 12.15 PM.

102 km Conical Putahi rhyolite dome on left side of road. Lake Omapere straight ahead.
Turn right onto Remuera Settlement Rd (opp. Lake Rd). View **STOP 7**. Drive through Te Pua Crater and flows and past Waimimiti scoria mounds (on right).

106 km Turn left onto Hariru Rd. High Tarahi scoria cone on right. Mangakawakawa and Te Ahuahu scoria cones along road on left. Pouerua in distance back to right. View **STOP 8.**

110 km Turn left onto HWY 1. Drive over flow from Te Ahuahu past perched Lake Omapere, 238 m asl.

Lake Omapere
A 7 m-long core and eight adjunct cores taken in the lake floor sediments provide a paleolimnological record extending back to the lake's formation, c. 80 ka (Newnham et al. in press). Two of the 14 tephra present (including Rotoehu Ash, c. 55 ka) provide chronological control and show that the lake (presently 2 m deep) has had a discontinuous history. The longest period of non-deposition (?no lake) was between 50 ka and 1 ka. The present lake was formed at about the time of Kaharoa Tephra fall (c.1300 AD) and settlement of the area by Polynesians.

117 km Turn right onto Wehirua Rd and follow signs towards Kerikeri. Driving over plateau of older, more weathered basalt flows all the way.

123-127 km Distant views of Bay of Islands and Piercy Island. Distant views of Kaikohe Volcanic Field to south and southwest.

128 km Water supply reservoir on left for Kerikeri horticulture.

153 km Just before Matauri Bay turnoff. Road cuts of white Whangai facies siltstone and Waipawa black shale (see Stop 16).

154 km Bluff on right is andesite laharic breccia of early Miocene Wairakau Volcanics.

162 km Kaeo Valley is cut into weathered greywacke blocks with mid Eocene (Ab) glauconitic sandstone (Ruatangata Sandstone) overlying.

Geology of Whangaroa area (Figs. 7.4, 7.5)

The geology of the Whangaroa area consists of a generally northwest-dipping sequence, comprising Waipapa Terrane basement greywacke unconformably overlain by autochthonous mid to late Eocene glauconitic sandstone(Ruatangata Sandstone; Te Kuiti Group), overlain by a series of Northland Allochthon thrust sheets, each separated from and their movement lubricated by sheared clay-rich multicoloured Paleogene mudstones.
From bottom up in this area, the thrust sheets comprise:

1. para-autochthonous Ruatangata Sandstone (Stop 9)

2. mid Cretaceous Tupou Complex (Stop 11), unconformably overlain by late Cretaceous Mangakahia Complex conglomerate and sandstone.

3. Cretaceous-Paleocene Tangihua Complex spilitic pillow lava flows, breccias and interbedded deep-water mudstone.

Following emplacement the Northland Allochthon thrust sheets and underlying autochthon of the Whangaroa area were tilted to the northwest (on the southeast limb of a large syncline that we will drive through tomorrow). Large portions of the resulting uplifted allochthonous rocks in the south were quickly removed (possibly by remobilised movement to the southwest) as the truncated tilted sequence was intruded and unconformably overlain by early Miocene Wairakau Volcanics. Attitudes within the volcaniclastic Wairakau Volcanic sequences and contours on their basal contact indicate that further post-eruption folding and faulting along NW-SE axes has occurred in this area (Fig. 7.6).

169 km 2 PM **STOP 9.** Intertidal cliff exposures on sharp corner of middle Eocene (Ab), glauconitic Ruatangata Sandstone (para-autochthonous sheet).

172 km 2.30-4.30 PM **STOP 10**. Whangaroa wharf. Boat trip on Kuri around Whangaroa Harbour to see early Miocene Wairakau Volcanics and underlying Tupou Complex rocks.

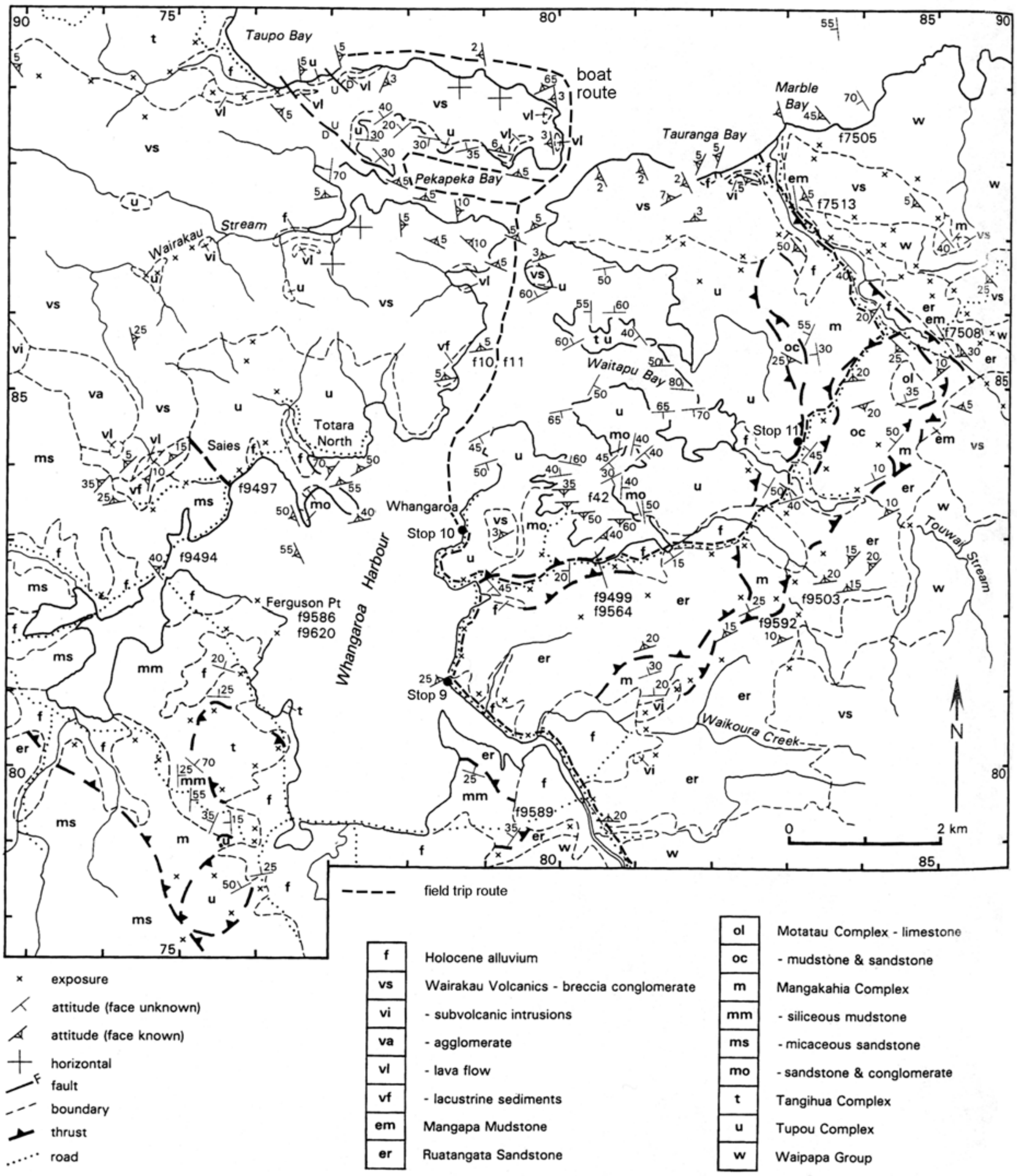

Fig. 7.4: Colour-your-own geological map of Whangaroa Harbour area (from Brook and Hayward 1989).

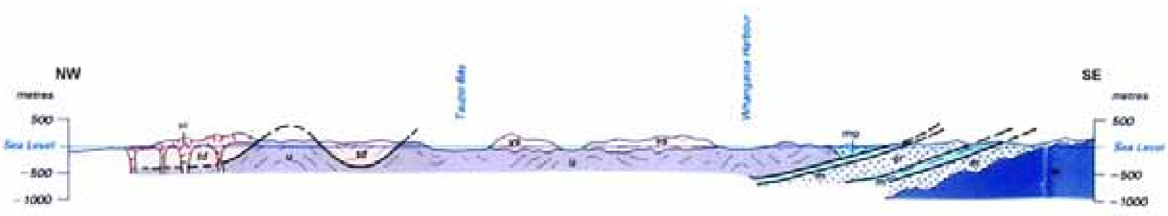

Fig. 7.5: Northwest-southeast cross-section through the upper level geology of the Whangaroa region (from Brook and Hayward 1989), showing Wairakau Volcanics (vs) intruding and unconformably overlying Northland Allochthon thrust sheets of Tangihua Volcanics (td), Tupou (u) and Mangakahia (mo) Complexes. In the south, Waipapa Terrane (w) is unconformably overlain by in-situ and a sheet of para-autochthonous Ruatangata Sandstone (er).

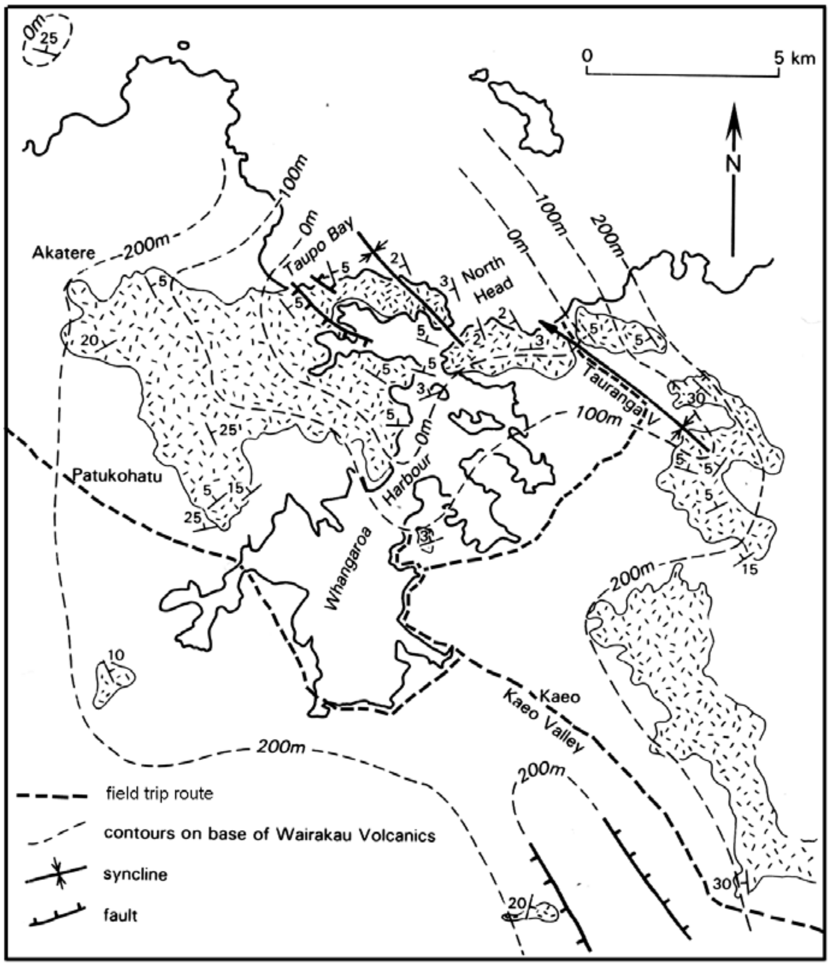

Fig. 7.6: Distribution and attitude of Wairakau Volcanics in the Whangaroa Harbour area. Contours on their unconformable basal contact on Northland Allochthon, Te Kuiti Group and Waipapa Terrane indicate the existence of a paleo-depression around the mouth of the harbour, as well as post-eruption folding and faulting (from Hayward 1991).

Early Miocene Whangaroa Volcanic Complex (Fig. 7.7)
Igneous and volcaniclastic rocks that outcrop in an 80 km long northwest-trending belt on the east coast of northern Northland (Fig. I.4) are inferred to be the eroded remnants of several large stratovolcanoes, each 1.5-3 km high and surrounded by a laharic ring plain. The belt can be divided into two halves (Fig. 7.7) - a northern more deeply eroded half comprising subvolcanic plutons and numerous dikes (Karikari Centre) and a southern area of laharic ring plain remnants and associated subvolcanic intrusions (Wairakau Centre).

Wairakau Volcanic Centre (Fig. 7.6, 7.7)
The Wairakau Volcanics around Whangaroa Harbour consist of weakly stratified, laharic, andesitic tuff breccia (Brook & Hayward 1989), inferred to be the remnants of the proximal portions of a subaerial ring plain (Hayward 1991). Steep-sided paleogullies are filled with laharic tuff breccia, fluvuially-reworked breccia, and fluvial coarse sandstone, with less common lacustrine rocks, and gully-confined andesite flows. Carbonaceous, tuffaceous mudstone and thin-bedded tuff accumulated in shallow lakes, when early lava flows or lahars dammed existing valleys.

Provenance of country rock clasts indicates laharic source areas in both the northwest (Tangihuas) and southeast (Ruatangata Sandstone). At least three major vent areas are inferred in the vicinity of the main concentrations of subvolcanic intrusions at Cone Rock, Patukohatu, and Upokorau valley (Fig. 7.7). The intrusions include andesitic dikes and irregular intrusive bodies, small rhyolitic and dacitic domes, and a large (probably vent-filling) body of massive tuff breccia (Hayward 1991). The intrusions, flows and primary volcanic breccia clasts are basaltic to rhyolitic in composition, though dominated by andesite and basaltic andesite (Smith et al. 1989).

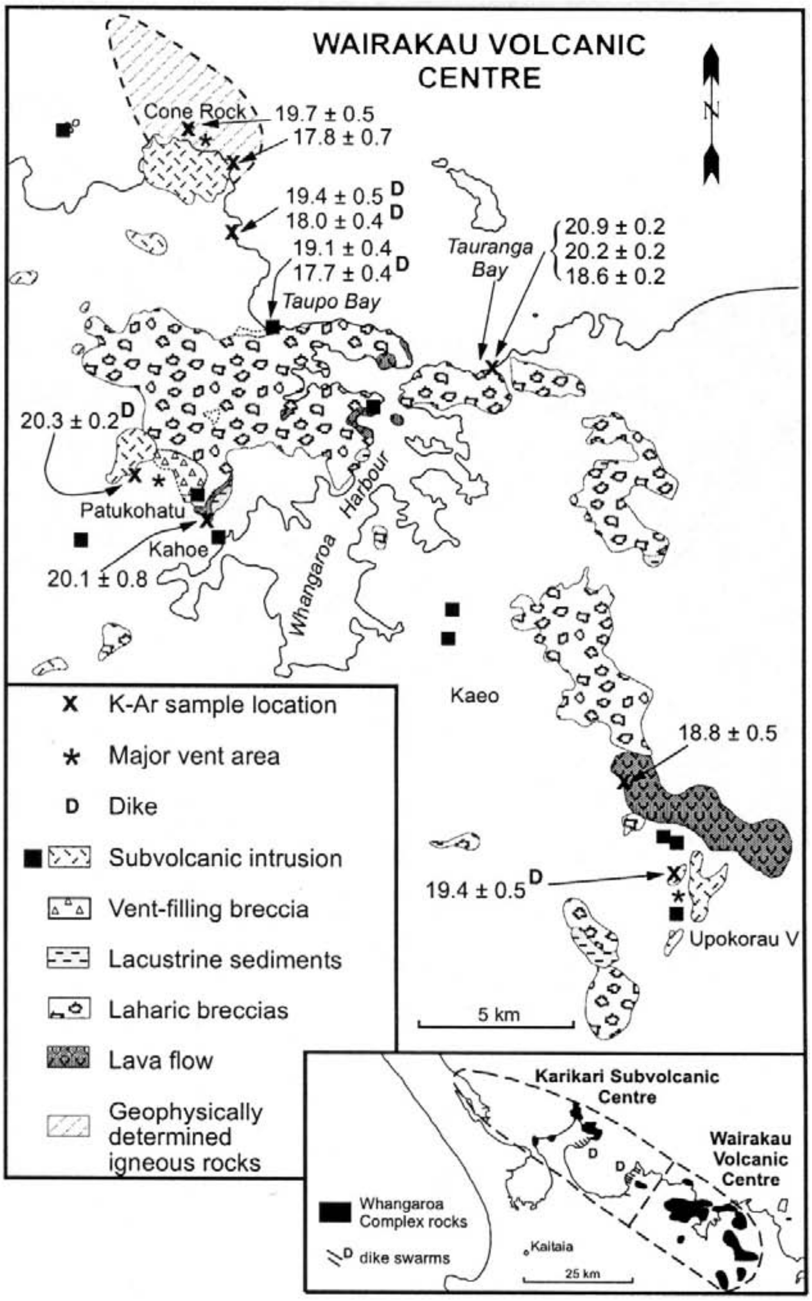

Fig. 7.7: Distribution of Wairakau Volcanic Centre outcrop around Whangaroa and stratigraphically acceptable K-Ar ages. Inset map of northern Northland showing inferred extent of the Whangaroa Volcanic Complex, with a subvolcanic northern half of unroofed intrusions and dikes around Cape Karikari and the slightly younger Wairakau Volcanics in the south (from Hayward et al. 2001).

Stipp & Thompson's (1971) age of 4.5 ± 0.1 Ma on an andesite breccia clast at Tauranga Bay led geologists for 15 years to believe that the Wairakau Volcanics were Pliocene in age. Only since the late 1980s have geologists refocused on the age of these rocks, and with 13 more ages (Robertson 1983; White 1985; Hayward et al. 2001) accepted that they are indeed early Miocene in age, having erupted and been emplaced within the period 20.5-17.5 Ma (late Otaian - early Altonian). Palynological dating of lacustrine sediments ponded within the base of the Wairakau Volcanics around Whangaroa gives an early Miocene, Otaian or Altonian age (Mildenhall 1991).

178 km **STOP 11**. Road outcrop on left on way up hill of early Cretaceous Tupou Complex with granitic pebbles.

183 km Tauranga Bay **STOP 12**. Staying overnight at Tauranga Bay Motel and Motor camp.
6.15-7.30 PM Optional field trip to **STOP 13** Marble Bay, van ride over the hill.
See notes for this locality in FT8.
8 PM BBQ dinner at motor camp.

DAY 2: Tauranga Bay to Opononi (Fig. 7.8)
Northland Allochthon thrust sheets. Tangihua Volcanics, Waipawa Black Shale, Paleocene and Oligocene deepwater limestones.

0 km 8 AM Leave Tauranga Bay
4 km Road cut of Oligocene Motatau calcareous mudstone and sandstone on left on way up hill.
9 km Just before Ota Rd junction. Road cuts of weathered, sheared late Cretaceous Whangai facies.
18-23 km Views of flat-topped Taratara to West – erosional remnant of early Miocene Wairakau laharic breccia.
23 km Totara North bridge over Kahoe River. Skyline to north and north-east is Wairakau Volcanics with neck, filled with monolithologic breccia at west end of bluffs (Fig. 7.7).
28 km Move up from Tupou thrust sheet into top thrust sheet of Tangihua Volcanics Complex.
30 km Bluffs of Wairakau laharic breccias on right.

44 km Turn right and drive through Manganui township. NO TIME TO STOP

48 km Rangikapiti Pa Rd. **STOP 14**. Walk down track to view Tangihua pillow lavas in high tide coastal rocks. The actual age of Tangihua Volcanics is again a matter of debate. Fossil ages all span the range early Createceous (Houto) to Paleocene, with the majority being Cretaceous (Hollis and Hanson 1991, Isaac et al. 1994). K-Ar dates obtained range between 102 and 6 Ma (Brothers and Delaloye 1982). The younger radiometric ages have generally been discounted as dating allochthon emplacement or to be a result of argon leakage (Isaac et al. 1994)
Leave 9.40 AM

51 km Coopers Beach. Fossil coconut fame. Sorry no time to stop and the coconuts are mostly found washed up at low tide, eroded out of subtidal exposures.

55 km **STOP 15**. Turn left just before Taipa estuary bridge. Disused Taipa Quarry. Blocks of garnet andesite quarried from early Miocene intrusion (19 Ma). Some could visit while other vans cross bridge to Taipa Bakery to pick up ordered lunches, to refuel vans or visit toilets, down road at right by Taipa Hotel at beach.
Leave 10 AM

63 km Blacks Quarry in Waipawa Black Shale, non-siliceous, petroliferous.

64 km 10.15 AM **STOP 16**. Price's Waipawa Black Shale Quarry on left. Good parking. In petroliferous siliceous facies with some associated cream Whangai facies. Leave 10.50 AM.

Waipawa Black Shale
This Paleocene lithofacies was described from the east coast of the North Island, where it reaches up to 50 m thick. It is rare in Northland and always occurs within displaced Northland Allochthon settings. Here at Ohia, a 3 km long series of low ridges alongside the highway are composed of a block of Waipawa Black Shale. It can be seen in three quarries. In two quarries (e.g. Black Quarry), it is a massive, highly carbonaceous mudstone which weathers dark grey to black. Locally there is abundant *Terebellina* and spherical pyrite concretions 1-3 cm in diameter. Yellow efflorescence of sulphate minerals is widespread, and the rock smells strongly of hydrocarbons. Black Quarry has been closed because of the petroliferous leachate that emanates from the rock. Stockpiles have been reported to autocombust. See more detailed description under FT 9 Stop 2.

Price's Quarry contains sheared blocks of Waipawa Black Shale with siliceous Whangai mudstone broken formation. This intercalation of the two facies has been interpreted as tectonic inclusion (Isaac et al. 1994) close to the basal thrust of the large overlying Tangihua thrust sheet. Sparse dinoflagellates indicate a Paleocene (Dt) age. This organic-rich unit is inferred to have accumulated in deep-water east of Northland. 67.5 km 11.00 AM **STOP 17** at signposted fossil forest (see notes for STOP 3 in FT9).
Leave at 11.15 AM

71 km **STOP 18**. Gum digger Holes Reserve. Leave at 11.30 PM.
Retrace route to Taipa Beach
82 km 11.40 AM LUNCH **STOP 19** on foreshore reserve by toilets and Taipa Hotel. Swim opportunity before lunch. Leave by 12.40 PM

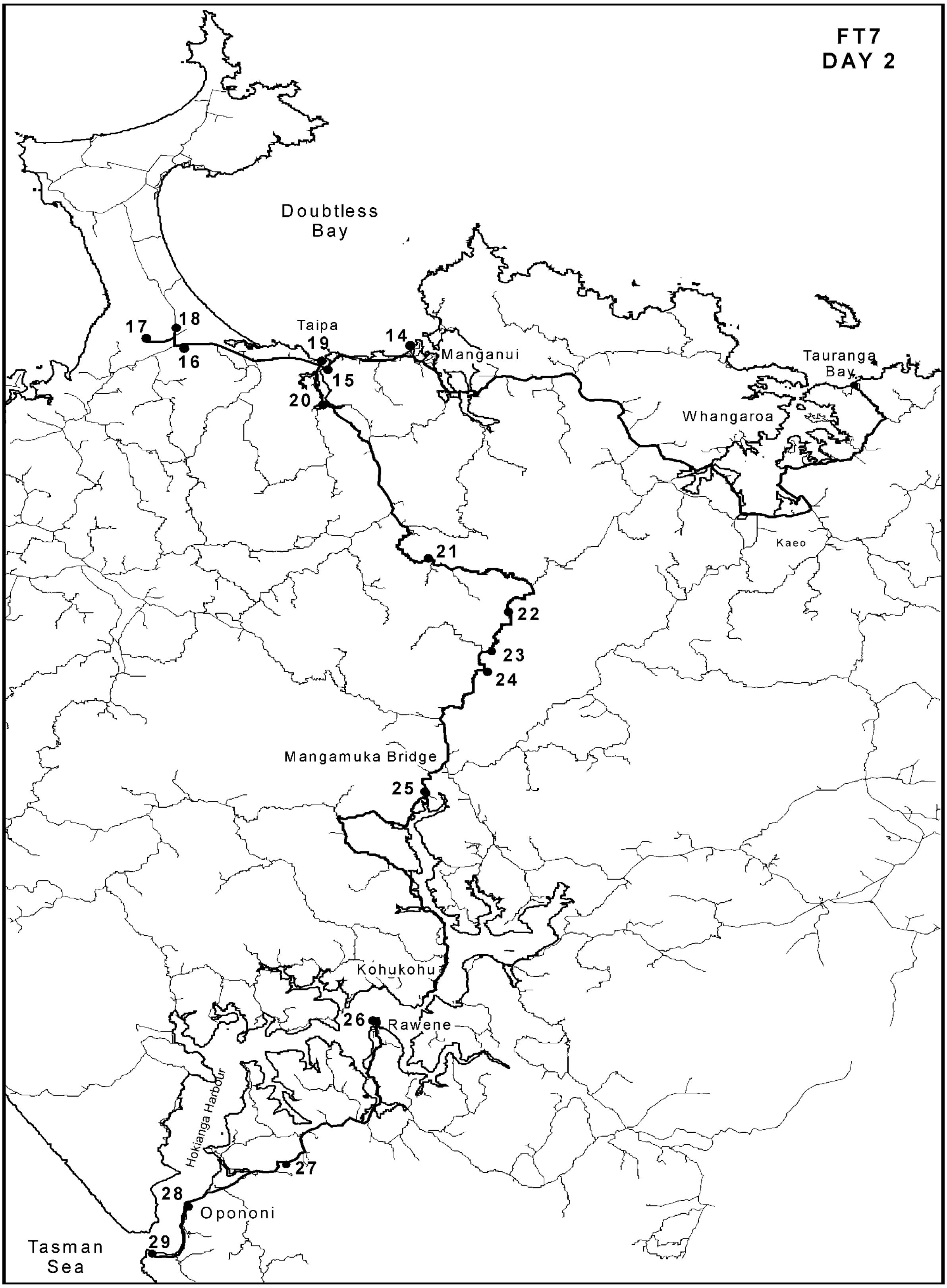

Fig. 7.8: Map of route for day 2, Tauranga Bay to Opononi.

Mangataniwha Range Syncline of Northland Allochthon thrust sheets

The first half of the afternoon will be spent travelling across the axis of a large syncline of folded Northland Allochthon thrust sheets (Fig. 7.9). The northwest-dipping sequence of sheets observed around Whangaroa were on the southeast limb of this syncline. The geology and structure of this area has been documented at 1:25 000 and 1:100 000 by Brook et al. (1988) and Brook and Hayward (1989). A sequence of six large thrust sheets (labelled i to vi; each 10-80 km across, 0.1-1.7 km thick, Sharp et al. 1989) was emplaced over the autochthonous Te Kuiti Group/Waipapa Terrane in the latest Oligocene.

The earliest sheets were mostly of late Eocene-Oligocene Motatau Complex rocks (sheet ii) and late Cretaceous-Paleocene Mangakahia Complex (sheets i, iii and iv). The later sheets were early Cretaceous Tupou (sheet v) and Cretaceous-Paleocene Tangihua (sheet vi) Complex rocks.

A process of offshore uplift and diverticulation (Ballance and Sporli 1979) is inferred (Fig. 7.10) with preferential delamination of the sequence along clay-rich Paleocene-early Eocene mudstones which helped lubricate sheet movement. Throughout most of Northland, the youngest thrust sheet is usually composed of oceanic basaltic Tangihua Complex rocks, but small rafts and blocks of Tangihua rocks occur in sheared melange zones throughout the allochthonous pile.

In this northern part of Northland, the pile of thrust sheets and the underlying Allochthon was further deformed by uplift, faulting and folding in the earliest Miocene, prior to eruption of the Wairakau Volcanics. The main feature formed during this phase of deformation is the large syncline with a southwest-northeast axis running along the Mangataniwha Range. The Range is composed of the youngest thrust sheet (vi) of more erosion resistant Tangihua Complex rocks. On both sides of the range this sheet is underlain by a Mangakahia Complex thrust sheet (iii) which is in sheared contact overlying a Motatau Complex sheet (ii). To the southeast, this sheet has been mapped with a decollement surface on late Eocene Te Kuiti Group mudstone (Mangapa Mudstone) overlying basement greywacke. On the northwest limb of the syncline, the earliest thrust sheet (ii, Motatau) forms most of the country between Taipa and Kaitaia (Fig. 7.9). The 1957 Kaiaka hydrocarbon exploration drill hole (Fig. 7.11), cored 600 m of this late Eocene Motatau Complex sheet before passing through 30 m of sheared multicoloured (?Paleocene) mudstone and bottoming (625 m) in green siliceous greywacke basement (Kear 1964, Hayward and Brook 1987), similar to that in Omahuta Range to the south.

In northern Northland, the Allochthon consists of these large mappable thrust sheets. Poorer exposure further south in central Northland only allows confident mapping of the more competent Tangihua blocks. In southern Northland and Auckland, around Whangarei, Kaipara, and Silverdale, the Allochthon is broken up into smaller, less discrete blocks or sheets, consistent with greater fracturing and deformation over a longer period (up to 4 million years) and greater displacement distance.

86 km — 12.50 PM Brief **STOP 20** at Paranui Rd turnoff. Walk along Oruru Rd to road cuts of Motatau Complex (thrust sheet ii) on right.
Oruru Rd runs along on valley alluvium along line of thrust contact between late Cretaceous Mangakahia Complex Whangai and Sandstone (sheet iii) on right and Tangihua Volcanics Complex (sheet vi) on left.

97 km — Tangihua Volcanics (sheet vi) in road cutting and small gorge.

101 km — 1.20 PM **STOP 21** Large new road cut on right, of sheared intra-Tangihua thin-bedded siltstones with thrust planes.

109 km — Break out of forest into farmland and pass down from Tangihua thrust sheet (vi) into late Cretaceous Mangakahia thrust sheet (iii).

113 km — 1.40 PM **STOP 22**. Cattle stop and gate at top of hill. Moderately fresh late Cretaceous Punakitere Sandstone (sheet iii) in weathered road cut. Intersheared with mudstone. Overlying Tangihua thrust sheet (vi) forms Mangataniwha Range running alongside road on right.

116 km — 2 PM Brief **STOP 23** at entrance to sheared muddy Mahurangi Limestone quarry (sheet ii).

119 km — 2.20 PM Brief **STOP 24.** Calcareous mudstone and sandstone road cuttings of Oligocene Motatau Complex (ii).

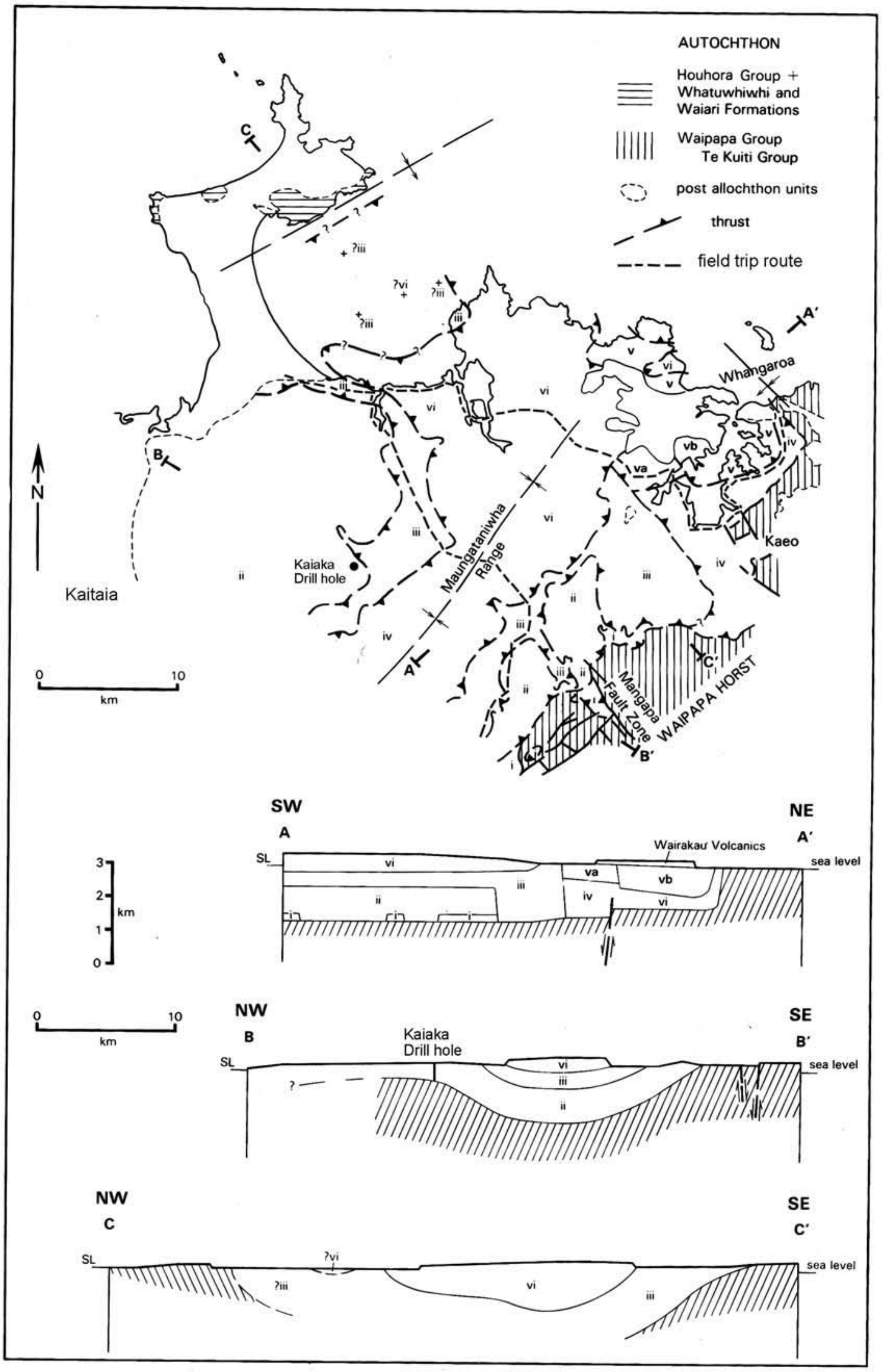

Fig. 7.9: Map of the Whangaroa-Kaitaia region of Northland showing the distribution of autochthonous Waipapa Terrane and Te Kuiti Group rocks in the southeast, overlain by a series of large Northland Allochthon thrust sheets (labelled nappes i to vi) emplaced in the latest Oligocene. Soon afterwards in the early Miocene, the region was uplifted, faulted and folded into a large syncline (B-B', C-C') along the SW-NE striking axis of the Mangataniwha Range. Schematic cross-sections below illustrates the inferred stacking of the thrust sheets as they were emplaced (A-A'). (from Brook and Hayward 1989).

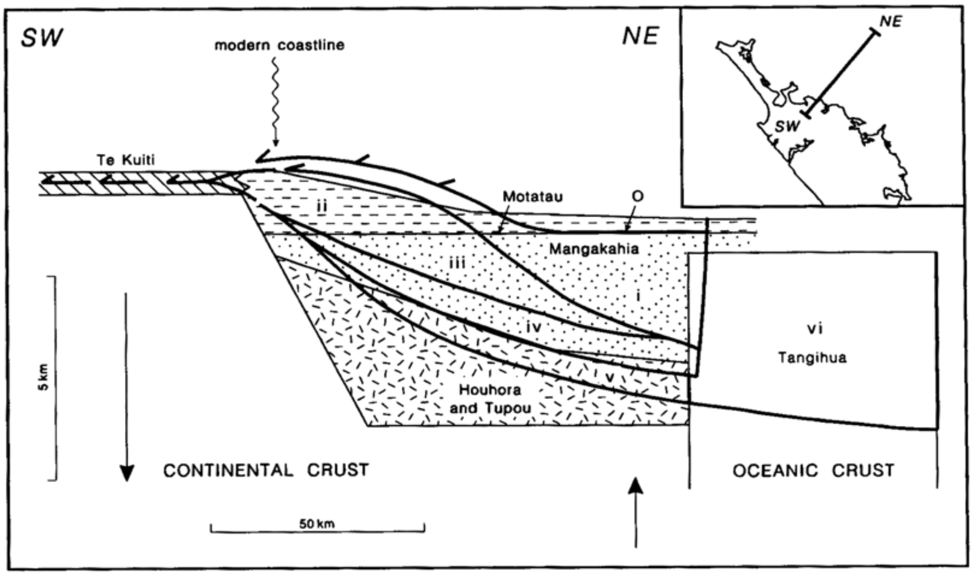

Fig. 7.10: Schematic cross-sectional reconstruction of the original stratigraphy of the Northland Allochthon rocks northeast of northern New Zealand. Bold lines show inferred size and origin of thrust sheets i to vi that successively slid off to the southwest onto a subsiding Northland as this area was uplifted (from Brook and Hayward 1989; Isaac et al. 1994).

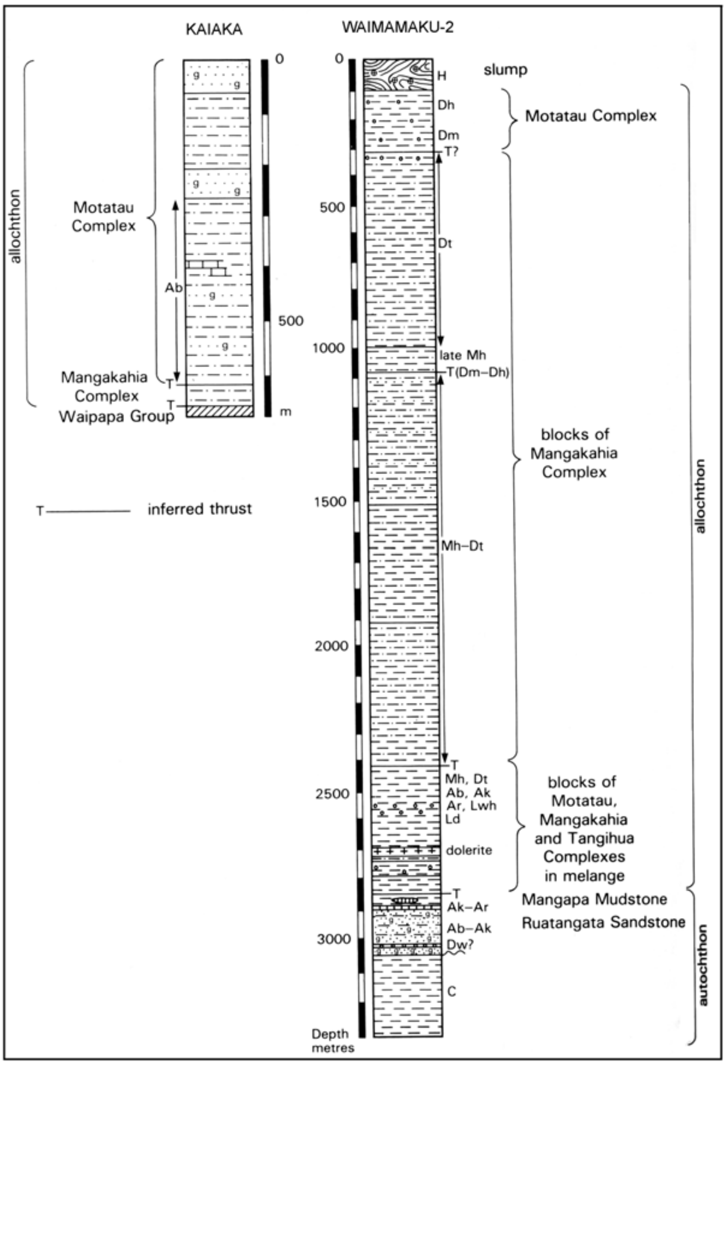

Fig. 7.11: Interpreted logs of the Kaiaka (east of Kaitaia, Fig. 7.9) and Waimamaku-2 (south Hokianga, Fig. 7.13) hydrocarbon exploration drill holes in Northland (from Kear 1964; Hornibrook et al. 1976; Brook and Hayward 1989).

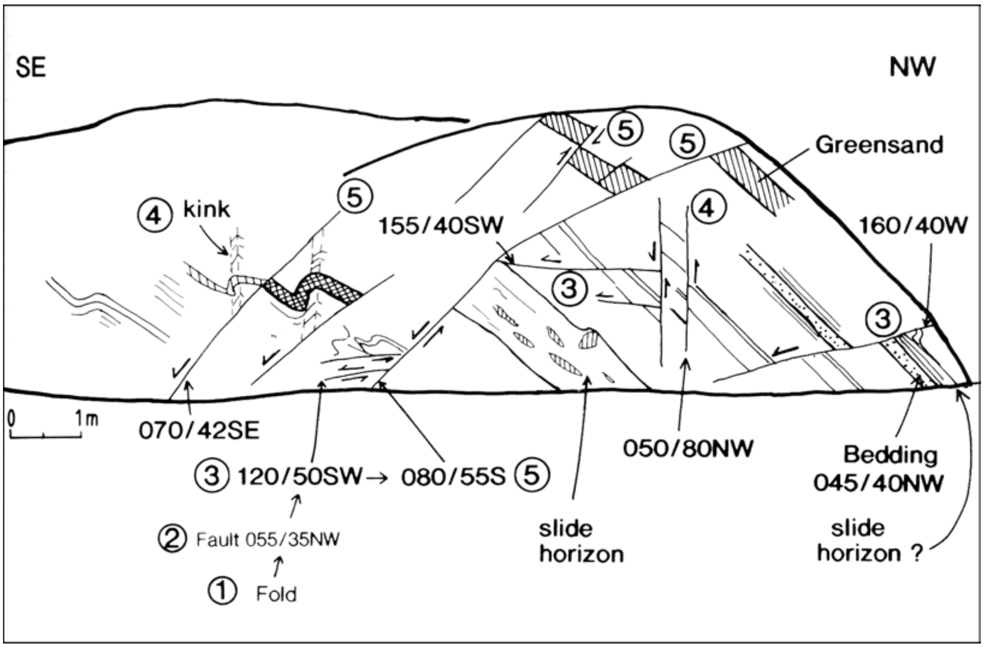

Fig. 7.12: Structure of roadside Oligocene exposure at south end of Mangataipa Reserve (Stop 25). Numbers in circles indicate sequence of deformations. Structures belonging to deformations 1 and 2 are too small to show (from Clarke et al. 1989).

Oligocene limestone near Mangamuka Bridge (Figs. 7.12, 9.11)

A 25 km^2 block of Oligocene Mahurangi Limestone (Motatau Complex, thrust sheet ii) west of Mangamuka Bridge is well exposed in road cuttings through Mangataipa Reserve. Detailed structural analysis (Clarke et al. 1989) records the following sequence of deformation: 1. local, soft-sediment, bedding-parallel sliding; 2. formation of south-verging chevron and kink folds, associated with southwards thrusting; 3. refolding by open N-S trending folds. "Faulting involves interchange of shortening and extension along both N-S and NW-SE directions. Towards the end of deformation, the generally contractional regime was replaced by extensional deformation, marking a change from southward thrusting of the Northland Allochthon to gravity sliding" (Clarke et al. 1989).

130 km 2.45 PM OPTIONAL STOP (2nd stopping place, not on corner) Sheared folded Mahurangi Limestone.

131 km 3 PM **STOP 25** (3rd stopping place on left, 100 m past sst/lmst interbeds – walk back) Faulted interbedded Oligocene glauconitic sandstone and limestone (Motatau Complex, Fig. 7.12) Leave NO LATER than 3.15 PM to catch ferry

138 km Turn left towards Kohukohu at junction. Road cutting of Whangai Siltstone on right just up hill. A programme of attempted eradication of an invasive bamboo is noticeable all along the roadside.

152 km Kohukohu township. No time to stop.

156 km The Narrows Car Ferry terminus. No toilets on ferry.

3.50 PM Catch FERRY (leaves on hour every hour)

4.20 PM Rawene. Toilet block to right off ferry.
STOP 26. Walk along foreshore looking at Paleocene (Dt) muddy limestone and muddy limestone section. Nannofossil studies have shown that all six Paleocene nannofossil zones are present in this deep oceanic section (Kadar 1988). (low tide 7 PM)
5 PM Leave Rawene.

164 km Turn right towards Opononi at HWY 12 junction. Drive mostly through Mh-Dt Mangakahia Complex rocks. Oue Quarry on right in late Oligocene Mahurangi Limestone.

174 km Optional **STOP 27**. Top of Kouto Hill. Cuttings, slips and concretions in late Cretaceous Punakitere Sandstone.

182 km 5.30 PM **STOP 28** Unpack at Opononi Tourist Hotel.

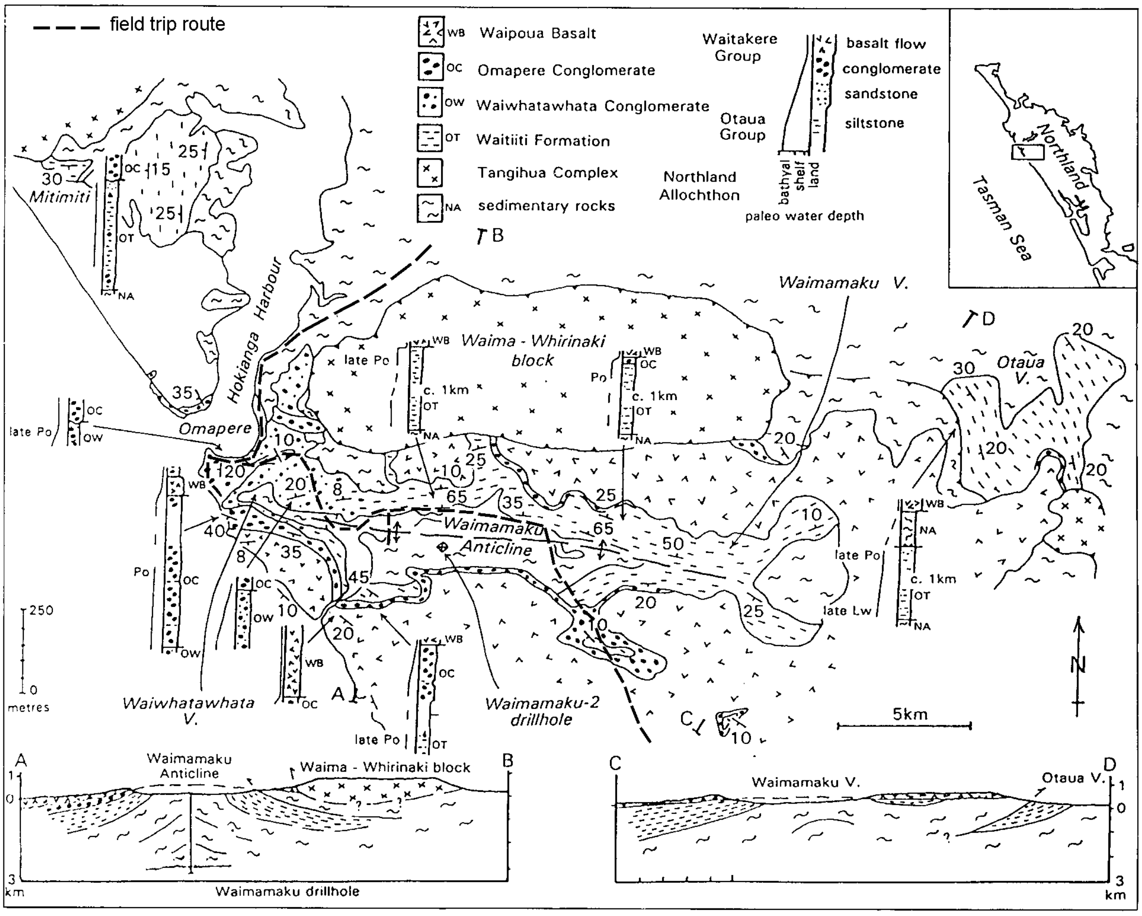

Fig. 7.13: Map and cross-sections of southwest Hokianga area showing distribution, structure, lithologic columns, age and paleodepth curves of early Miocene sedimentary rocks (Otaua Group) and their relationship to the underlying and overthrusting Northland Allochthon and the overlying Waipoua Basalt flows (from Hayward 1993).

Early Miocene geology of South Hokianga area (Fig. 7.13)

Early Miocene (late Lw-Po) sedimentary rocks (Otaua Group) accumulated in a 60 x 30 km depression on the upper surface of the still slightly mobile, Northland Allochthon (piggyback basin). They outcrop today on both sides of the lower Hokianga Harbour and are identified offshore to the northwest in seismic surveys (Isaac et al. 1994). The sediments that fill the basin were derived almost exclusively by erosion of the surrounding uplifted Northland Allochthon. Most of basin-filling sediment consists of up to 1 km of poorly bedded mudstone and fine sandstone (Waitiiti Formation) which foraminifera indicate accumulated in a marine environment shallowing from mid bathyal to shelf depths (Hayward 1993). Up to 200 m of sandy conglomerate (Waiwhatawhata Conglomerate) built a 5-10 km wide fan delta at upper bathyal-shelf depths in the Omapere area. It is characterised by a predominance of Northland Allochthon sedimentary clasts and a dearth of Tangihua or other igneous clasts.

North-south compression in the late Otaian produced the growing Waimamaku Anticline (Fig. 7.13) and thrust several slices of Allochthon over the Otaua Group sequence. A thrust block of Tangihua Volcanics (now the Waima-Whirinaki ranges) moved in from the north with its southern front pushed up to form high land, supplying an increasing volume of igneous clasts to the fan delta conglomerates (Omapere Conglomerate) which shallowed from shelf through to terrestrial (stops 29, 30). At the same time, the eastern parts of the basin and the growing anticline were pushed up above sea level and were gently eroding. A thin, irregular veneer of young Omapere Conglomerate was deposited unconformably over the eroded surface of the Waimamaku Anticline and its unroofed core of underlying Northland Allochthon lithologies (Fig. 7.11). The veneer was soon buried by the first extensive Waipoua Basalt lava flows that swept across the coastal plain from the south.

6.15 PM **Optional trip to Hokianga South Head** - Head west towards Omapere

185 km End of Signal Hill Rd. **STOP 29**. Loop walk for views over Omapere Conglomerate cliffs to North Hokianga sand dunes and Tasman Sea.

Take track down to beach to look at early Miocene Waitiiti Formation fossiliferous sandstone, beneath Omapere Conglomerate. Also visit historic Orbitolite bed (early Miocene, Po) at east end of beach. This bed was discovered by McKay in the 1880s and is the source of the largest foraminifera found in New Zealand, with one specimen 2.5 cm in diameter. (low tide 7 PM)

7.15 pm Climb back up track to carpark. Return to hotel via view point on top of Omapere Hill.

7.30 PM Arrive back at Hotel.

8 PM Buffet dinner in Opononi Hotel restaurant.

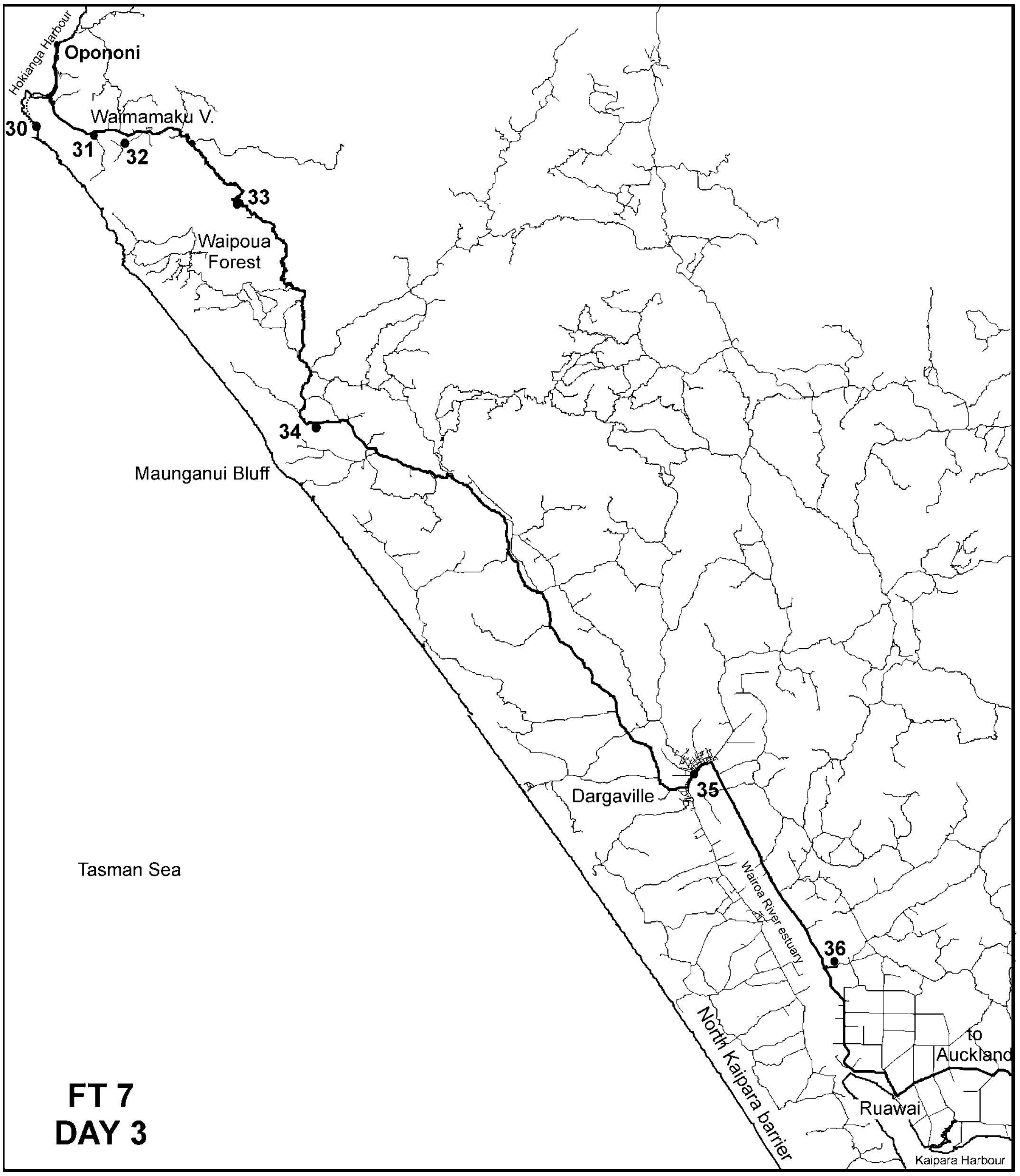

Fig. 7.14: Map of route for day 3, Opononi to Auckland.

DAY 3: Opononi to Auckland (Fig. 7.14)
Early Miocene Omapere Conglomerate, Waipoua Basalt and Tokatoka subvolcanic field.

0 km   8 AM Leave Opononi Resort Hotel
5 km   Turn left through farm gate and along farm road over terraces (Klaricich farm). Leave gates as found.

6.5 km   **STOP 30**. Waiwhatawhata Beach (low tide 7.30 AM)
Walk south along coastline examining early Miocene Omapere Conglomerate-Waipoua Basalt flows section. We need to keep a watch on the incoming tide and may have to return over the hill at the Waiwhatawhata Beach end of the section.

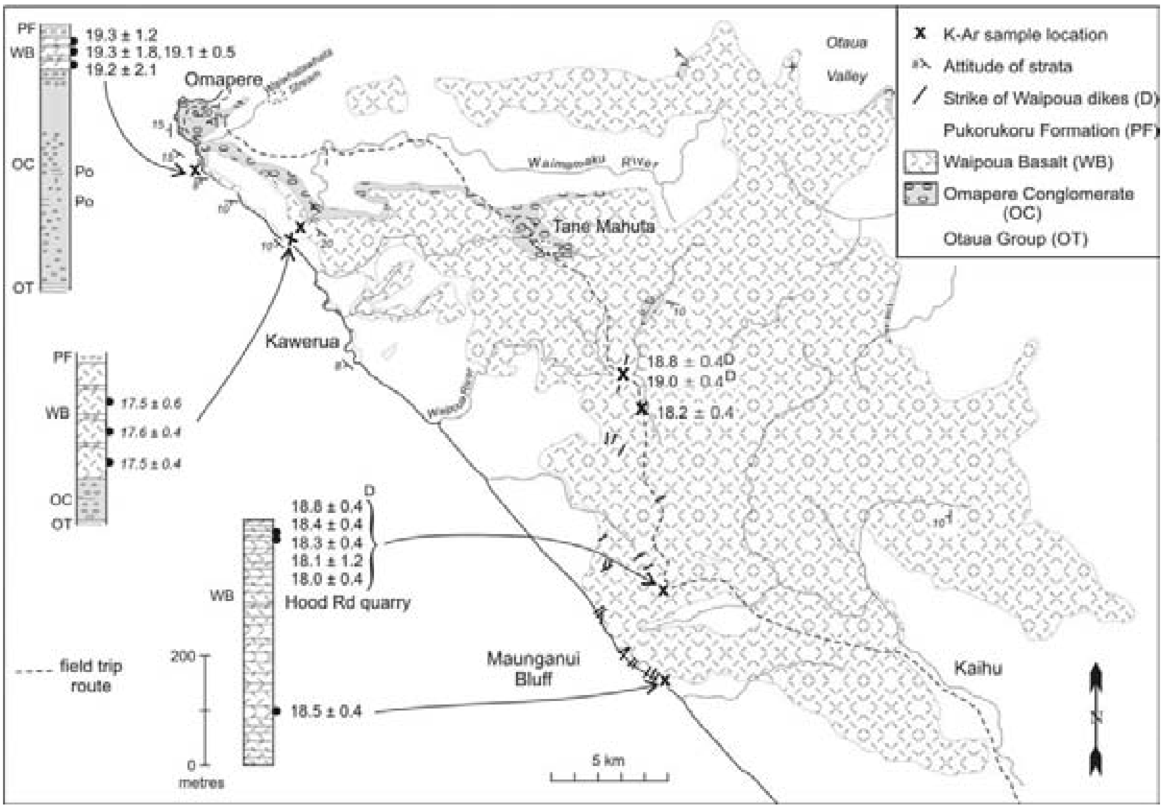

Fig. 7.15: Outcrop map, stratigraphic columns and stratigraphically accepted K-Ar dates of Waipoua Basalt geology (after Hayward 1975, Hayward et al. 2001).

Waipoua shield volcano
The Waipoua shield volcano is composed of extensive subaerial basalt lava flows and thin interbedded pyroclastic fall deposits (Hayward 1975; Wright 1980). These rocks outcrop over an area of c. 500 km^2 on land (Fig. 7.15) and comprise the eroded remnants of the northeastern third of the original 60 x 40 km shield volcano (Fig. I*), which has been mapped offshore by geophysical methods (Herzer 1995). Radiating dike swarms suggest that the shield was centred several kilometres offshore from Maunganui Bluff (Hayward 1975). The thickest outcropping sequence (c. 450 m) within the volcano forms Maunganui Bluff and surrounding hills (Stop 34).

Waipoua Basalt flows conformably and disconformably overlie early Miocene (late Po) Otaua Group and Omapere Conglomerate marine sedimentary rocks, in the Kaihu, Otaua, and Waimamaku valleys on the southern, eastern, and northern fringes of its outcrop (Hayward 1993). On the Waiwhatawhata coast, three Waipoua Basalt flows interfinger with the youngest, possibly terrestrial beds of Omapere Conglomerate and are overlain by terrestrial and freshwater sediments with preserved in-situ fossil forests (Pukorukoru Formation, Hayward 1973). A combination of K-Ar dates and the biostratigraphic control indicate that the Waipoua shield volcano was active between 19 and 18 Ma (Hayward et al. 2001). Both flows and dikes are glomeroporphyritic plagioclase-augite-olivine basalt (Wright 1980).

10.30 AM Leave beach

15 km — Waimamaku Beach turnoff. BRIEF **STOP 31**. View up Waimamaku Valley, axis of anticline. Tangihua Volcanics ranges (Waima-Whirinaki block) to left; flat-topped Waipoua Basalt in front, and dipping west on the right. Allochthon in the core of the anticline in the centre of the valley is overlain by early Miocene Otaua Group mudstone and sandstone, Omapere Conglomerate and Waipoua Basalt dipping away on both sides.

17 km — 11.20 AM Pokas Rd **STOP 32** at roadside and farm track (Harnetts Track) cutting through latest Oligocene (mLw) pebbly, cross-bedded, fossiliferous grit and sandstone (Harnett Formation, Evans 1994). Foraminiferal faunas are mid bathyal and oceanic (95-98% planktics). This exposure is a 100 x 50 m block surrounded on all sides by Northland Allochthon claystones. Although no contacts are exposed, the sequence is inferred to have accumulated in a deep-water channel on top or in front of the moving Allochthon and subsequently to have been incorporated into the top of it.

19 km — Pass Ambler Rd turnoff. Site of Waimamaku-2 drill hole (Fig. 7.11) on terrace at end of road on right. Sited on Waimamaku Anticline. This drill hole drilled 2.5 km of allochthonous late Cretaceous-early Eocene sedimentary rocks (2-3 thrust sheets) overlying a 450 m thick zone of mixed late Cretaceous-Oligocene lithologies and a Tangihua dolerite (originally interpreted as a sill). Beneath this basal Allochthon melange an inferred autochthonous, 200 m thick sequence of mid-late Eocene greensand and mudstone was encountered overlying early Cretaceous argillite (generally accepted to be uppermost Murihiku Terrane, Isaac et al. 1994).

22 km — Road climbs out of Waimamaku and Wekaweka Valleys from Allochthon through Otaua Group up into Waipoua Basalt (which underlies road for next 40 km, Figs. 7.13, 7.15).

31 km — NOON. LUNCH **STOP 33**. Short walk to Tane Mahuta in Waipoua Kauri forest. Toilet stop. Leave 12.40 PM.

51 km — Turn right onto Hood Rd.

53 km — 1.30 PM **STOP 34**. Hood Rd quarry. Short walk into quarry to look at several Waipoua Basalt flows and intervening baked pyroclastics all cut by intrusive dikes.
Leave 2.10 PM. Views.
Drive along with flat-topped Tutamoe Plateau cut in Waipoua Basalt on left and north end of North Kaipara sand dune barrier on right (all way to Dargaville).

65 km — Drop down off Waipoua Basalt at Kaihu and into underlying Allochthon all way to Dargaville.

95 km — 2.45 PM **STOP 35**. Dargaville toilet stop.

98 km — Just over bridge, quarry on left is in andesite at north margin of early Miocene Tokatoka Subvolcanic field.

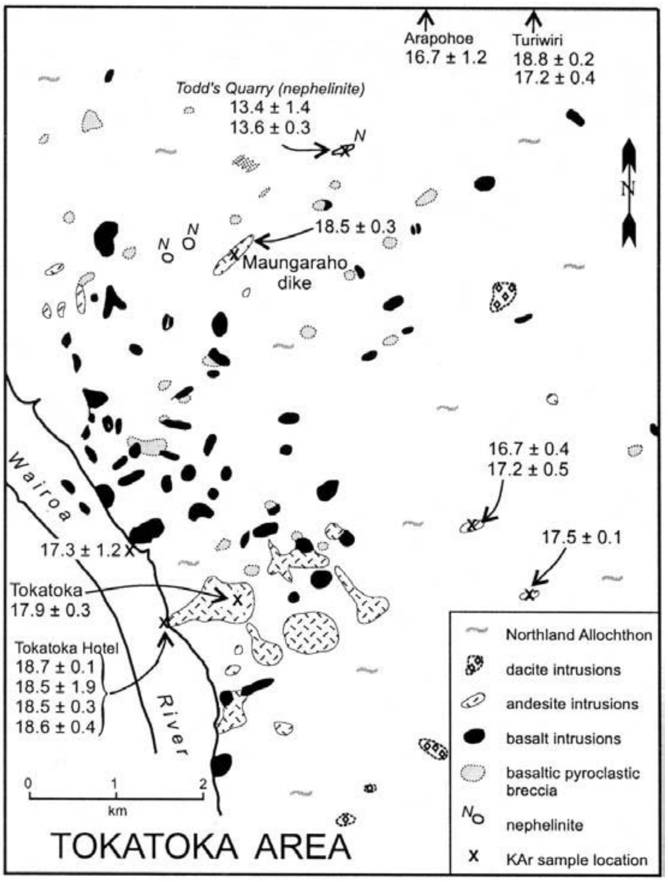

Fig. 7.16: Map of Tokatoka Subvolcanic field of intrusions, plugs and necks and K-Ar dates (after Black 1966, 1967; Hayward et al, 2001).

Tokatoka Subvolcanic Centre (Fig. 7.16)
In the Tokatoka area there are 140 small, basaltic, andesitic and dacitic plugs, dikes, sills, and pyroclastic breccia pipes (average size 20-200 m, max 1 km across) intruding Northland Allochthon country rock (Black 1966, 1967). Intrusion was along NNW and ENE trends, parallel to the main structural elements of Northland (Black 1967). These are probably the feeders and related erosion. The major cluster of basaltic to dacitic feeders is centred around Tokatoka (Stop 36). Tokatoka igneous rocks all intrude the Northland Allochthon, which here is largely Oligocene Mahurangi Limestone. K-Ar dates and biostratigraphic data indicate that the andesite and basalt of the Tokatoka centre were emplaced and presumably also erupted within the period 19-16.5 Ma (Hayward et al., 2001).

Middle Miocene nephelinite emplacement (Todd's Quarry) is believed to be unrelated to the earlier arc-type igneous rocks in the Tokatoka centre.

110 km View of Mangaraho dike protruding high as bare rock on left.
113 km Turn left at Tokatoka Hotel and up road.

114 km 3.15 PM **STOP 36**. Climb track to top of conical Tokatoka peak 10-15 mins walk. Spectacular views over Tokatoka Field intruding Allochthon (Mahurangi Limestone).
Leave 4 PM. Head home for Auckland.

Turn right at Wellsford and take HWY 16 via Helensville and Northwest motorway back to Auckland (to avoid probable Sunday afternoon traffic delays north of Warkworth and Orewa)
280 km Arrive Auckland University Geology Dept, c. 6.30 PM
295 km Arrive Auckland Airport, by 7.15 PM (in time to catch flights after 8 PM).