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Contents

GEOLOGICAL OVERVIEW OF NORTHLAND

Bernhard B. Spörli and Bruce W. Hayward

Northland is surrounded offshore (from W to E) by the Norfolk Rise, Norfolk Basin, Three Kings Rise, and the South Fiji Basin. The continental extensional "ribbon" of the Norfolk Rise links it to New Caledonia, with which it shares quite a few geological traits. The northeastern shelf area occupied by large expanses of allochthonous material (Herzer et al 2002) and containing a ?sliver/metamorphic core complex? of enigmatic Tertary biotite schist (Mortimer et al. 2002) is very wide and still not well known. It and the bounding (dextral?)Vening Meinesz Fracture zone played an especially important role in the Cenozoic development of Northland

In considering the geological history of the Northland region the following events are important:

1. Accretion of basement "greywacke terranes" (Waipapa terrane, Torlesse terrane) onto the Gondwanaland margin (Paleozoic - Mesozoic)
2. Cretaceous rifting during the separation of New Zealand from Gondwanaland (100- 80 million years)
3. Possible further rifting in the early Tertiary (Challenger Rift)
4. Emplacement of the Northland Allochthon as an effect of renewed subduction under Northland
5. Establishment of a NW – trending calcalkaline volcanic arc, and the intravolcanic Waitemata Basin over the subduction zone (early Miocene)
6. Migration or jump of the arc and subduction zone, via the Coromandel arc,into its present location (Taupo Volcanic Zone) and into a NE trend to leave Northland in a behind–arc tectonic position during establishment of the present day Alpine fault regime (middle Miocene to present)

Basement is only exposed in uplifted blocks along the east coast and in some inland exposures. There it almost entirely consists of what was until recently called the **Waipapa terrane** (Spörli 1978). However, Black (1994) suggested a new subdivision into units relating to the tectono-stratigraphic terranes of the South Island. A westernmost unit (Omahuta – Puketi area) is correlated with the Caples terrane. A middle terrane (Bay of Islands – northern Waipapa area) is compared with the Rakaia sub-terrane of the Torlesse terrane, whereas the easternmost (Helena Bay-Hunua unit) is linked with the Pahau subterrane of the Torlesse. Basic structure of these units is one of intense thrust slicing in an accretionary prism affected by terrane collision (Aita and Spörli 1992).

A different "basement", the **Mount Camel terrane**, is exposed at the northern end of Northland. It is younger than any "Waipapa terrane" and has experienced a different tectonic history (Toy et al. 2002), which is more similar to that of the Northland Allochthon (see below). A concealed boundary (?fault?) between it and the Waipapa terrane in the south trends WSW from Whangaroa Harbour to Ahipara (Fig I.1). What underlies the Mount Camel Terrane is one of the big unsolved problems of Northland.

In the main part of Northland the "Waipapa" basement extends westward, but is covered by up to 2km of younger deposits, including the Northland Allochthon (see description further on). The western boundary of the Waipapa basement is formed by the Permian/Triassic **Dun Mountain /Maitai terrane** which can be traced in the subsurface from Auckland to Ahipara as the **Magnetic Junction Anomaly** (JMA, Fig. I.1). By definition any concealed basement rocks to the west of the JMA must belong to the highly fossiliferous **Murihiku terrane** which rises to the surface at Port Waikato as the Kawhia synclinorium, and together with the Dun Mountain Belt can be traced all the way to the South Island.

Waipapa terrane rocks are unconformably overlain by **Te Kuiti Group**, ranging from coal measures to glauconitic sandstones and limestones (Whangarei and Onemama Lst). The unconformity documents Cretaceous uplift (rebound) of the Waipapa accretionary prism after metamorphism ranging up to pumpellyite–actinolite facies and the onlapping sediments document an upward deepening (Isaac et al 1994).

The >50 000 km^3 deep-water **Northland Allochthon** is the most widespread tectonic unit in Northland. It consists of Cretaceous to Oligocene sedimentary rocks tectonically overlain by the Cretaceous/Early Tertiary Tangihua ocean floor volcanics (Fig. I.2, I.3), interpreted as having been formed in a supra-subduction tectonic environment (Malpas et al. 1992).

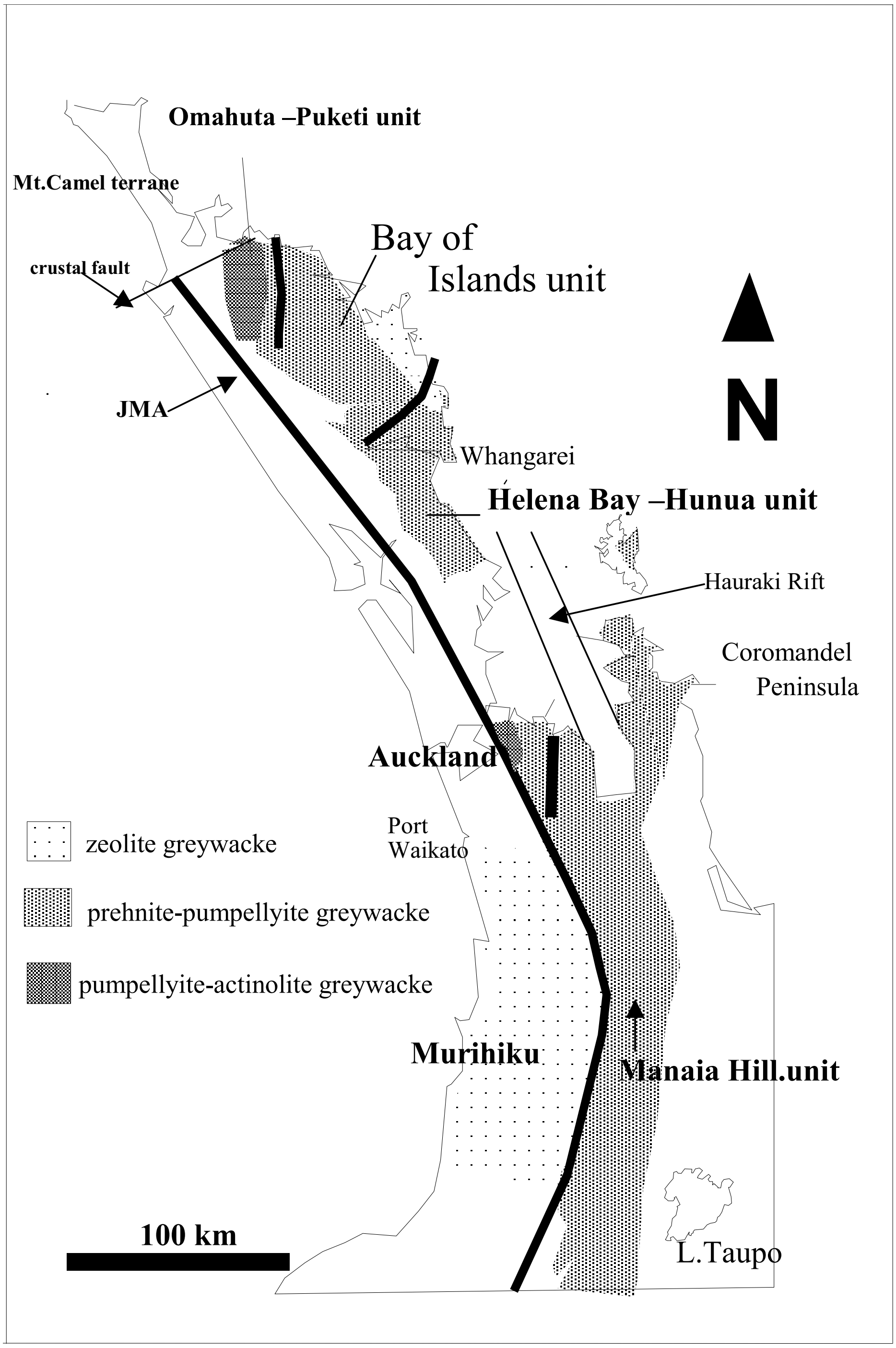

Fig. I.1: Map of the northern half of the North Island, showing the distribution of major tectonic units and of basement metamorphism. Thick lines (except “JMA”) are boundaries of terranes or their subunits (names are in bold script). Manaia unit is not mentioned in text. Modified after Woldemichael and Black (2002).

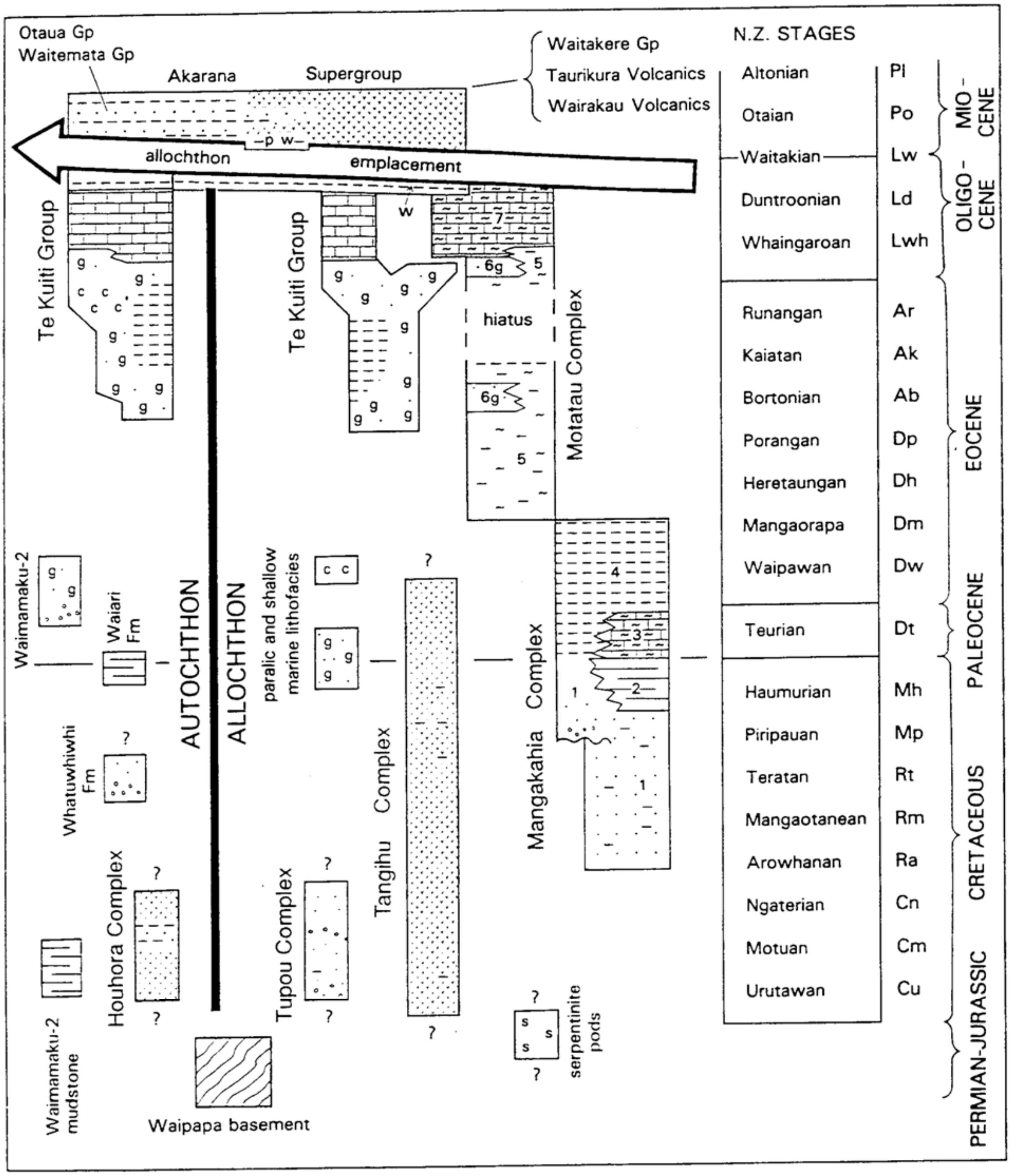

Fig. I.2: Lithostratigraphic summary of the main Permian-early Miocene autochthonous and allochthonous rocks of Northland. Mangakahia lithofacies are: 1. clastic flysch (Punakitere Sandstone); 2. siliceous mudstone (Whangai facies, Ngataturi Siltstone); 3. muddy limestone; 4. non-calcareous mudstone. Motatau lithofacies are: 5. calcareous mudstone; 6. sandstone; 7. fine-grained limestone. G = glauconitic (from Hayward et al. 1989).

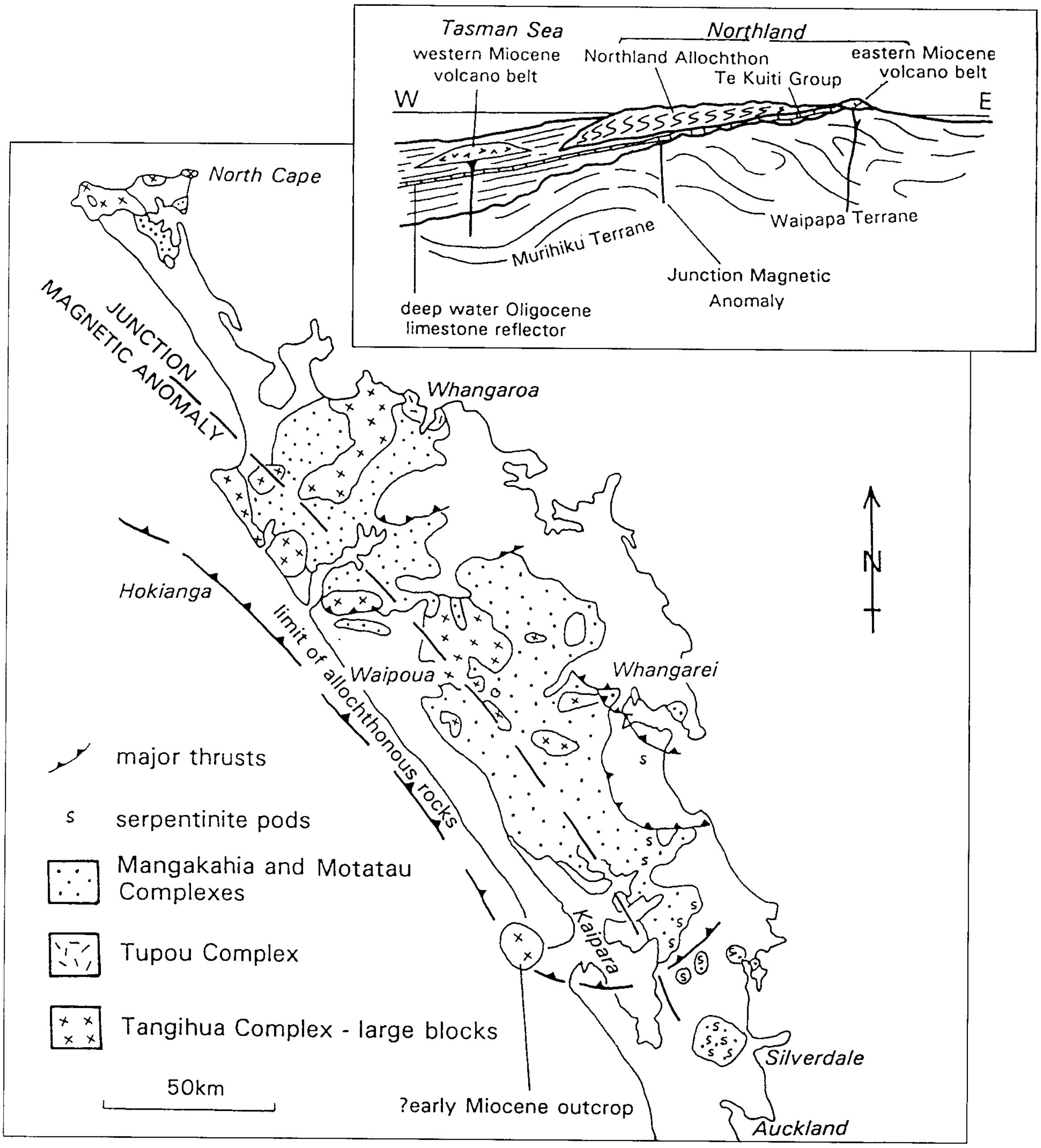

Fig. I.3: Distribution of major lithological units within the Northland Allochthon outcrop (from Hayward et al. 1989)

Autochthonous sedimentary rocks record rapid latest Oligocene (Ld-eLw) subsidence starting in northern Northland and migrating southwards through to Auckland over the suceeding 2 to 3 million (earliest Miocene, Po) years. Subsidence was followed by emplacement of the Allochthon from the north-east. After the main phase of nappe-like emplacement in the north, the Allochthon was uplifted, folded and subjected to further mobilisation, thrusting and terrestrial erosion. During this later phase, early Miocene marine sediments (**Akarana Supergroup**) accumulated in depressions on the surface of the slowly moving Allochthon at Parengarenga and Hokianga, and over its margins to the west and south. South of the southern toe of the Allochthon near Wellsford, subsidence formed the **Waitemata Basin** which began to fill with turbidites derived from erosion of the uplifted Allochthon. During infilling of the Waitemata Basin, the toe of the Allochthon was remobilised southwards into the basin (Hayward 1993). The Auckland region and Waitemata Basin were everted at the end of the early Miocene (Pl). The only marine Tertiary strata overlying Akarana Supergroup rocks on land are calcarenites of the mid Miocene Waikuku Limestone near North Cape, which indicate a brief period of shallow water conditions in the Far North.

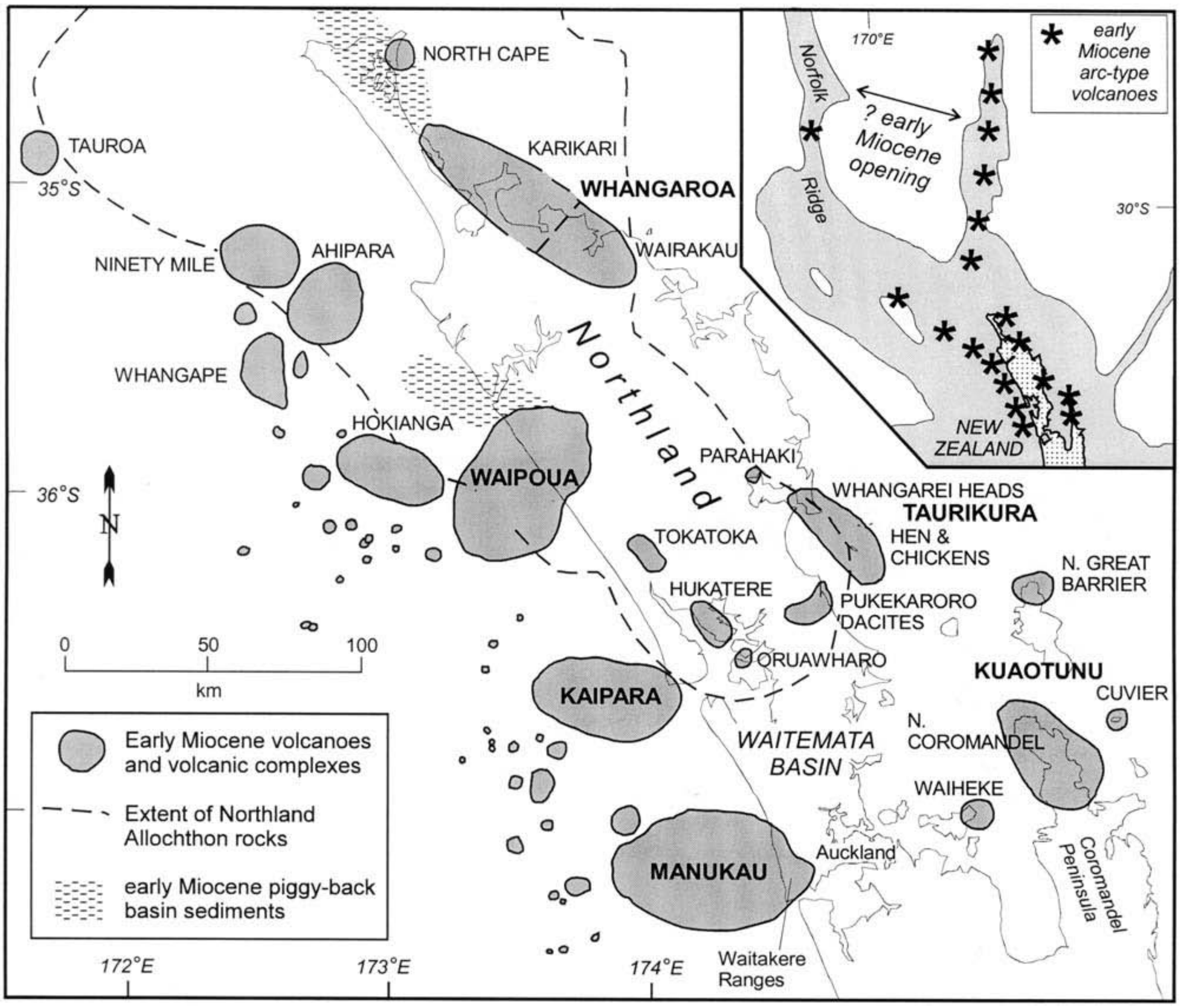

Fig. I.4: Distribution of early Miocene arc-type volcanic centres in northern New Zealand (after Hayward 1993, Herzer 1995). Location of main early Miocene marine sedimentary basins on top of and to the south of the Northland Allochthon is also shown.

Subduction must have begun in the late Eocene and Oligocene with the first evidence (tuffs) of the outbreak of calc-alkaline volcanism documented in latest Oligocene para-allochthonous and autochthonous rocks. Arc-type volcanoes erupted throughout the early Miocene along two belts on either side of Northland (Fig. I.4) with terrestrial stratovolcanoes erupted through and over the Northland Allochthon at Whangarei Heads and Whangaroa and a large basalt shield volcano at Waipoua. All subduction-related volcanism in Northland and Auckland had ceased by the end of the early Miocene (c. 15 myrs ago). Since then, Northland and Auckland have been uplifted, tilted to the west and considerably eroded with most of the sediment accumulating off the west coast.

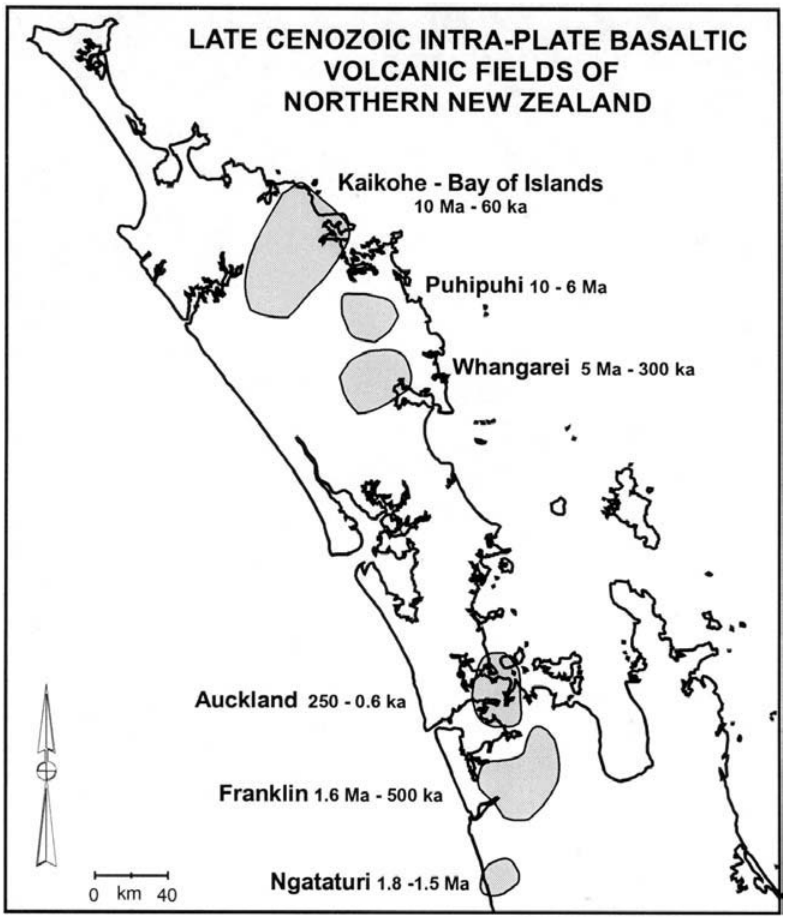

Fig. I.5: Miocene-Recent intra-plate basaltic volcanic fields of northern New Zealand.

By the late Miocene, a profound change in the tectonic framework of Northland was beginning to make itself felt, as the subduction regime in the region died and was transferring towards its present location in the Taupo Volcanic Zone. **Behind–arc volcanism** probably associated with lithospheric extension led to formation of the Kaikohe–Bay of Island , Puhipuhi–Whangarei, Auckland and South Auckland fields (Fig. I.5). The Whangarei Volcanic field is a good example of these very localised groups of volcanoes (see below).

The present distribution of tectonic units has been greatly influenced by **block-faulting**. This is best expressed in the basement strips along the east coast (Whangaroa to Whangarei) and in the Waipu Blocks. While the basement blocks may have originated during the Cretaceous-Tertiary rifting of New Zealand (2 above) as is the case further south, there is no direct evidence for this in Northland. Faults in the Waipu block were certainly available as tectonic features in the Miocene as is indicated by the ENE- WSW alignment of Parahaki Volcanics through Mangawhai Heads and Bald Rock (e.g. Thompson 1961). Post-basal Akarana Supergroup faulting and folding is evident around Whangarei (see FT4).

Extension is also evident from the active Hauraki Rift (Hochstein and Ballance 1993 and Fig I.1) which almost reaches Whangarei.

WHANGAREI'S PLIOCENE AND PLEISTOCENE VOLCANOES (Fig. I.6)

The first period of basalt eruptions occurred 2 to 4 million years ago with several volcanoes active around Kamo and also southeast of Parahaki. Scoria cones produced during this period have mostly eroded away, but the more resistant lava flows still underlie parts of the city and surrounding area. Basalt, erupted from a centre on the southeast slopes of Parahaki, flowed southwards down a valley. Subsequent erosion has removed the surrounding softer rocks of the valley sides and the flow is now left upstanding as a hard cap over Onerahi Peninsula, part of which is used for Whangarei's airport.

The second period of basalt eruptions was 300 000 to 500 000 years ago and these volcanic landforms are far less eroded. Three scoria cones were formed northeast of Whangarei and are still clearly visible near the road to Tutukaka. Stone walls snaking across the paddocks indicate the extent of their associated lava flows.

Four more, somewhat larger scoria cones were formed by fire-fountaining eruptions just west of Kamo. Bush-capped **Hurupaki** forms the prominent 350 m high cone on the skyline. One flow from these centres advanced southwards almost as far as central Whangarei. The three cones east of Kamo and the four to the west are all aligned and the magma feeding them probably ascended along a fault line.

South and west of the city, three more large scoria cones were produced about 300 000 years ago. These form the prominent landmarks of **Maunu**, **Maungatapere** and **Maungakaramea**, all of which stand 150 to 200 m above the surrounding landscape. The upper, forested slopes of Maungatapere are now enjoyed by many day trippers as the only one of Whangarei's ten scoria cones with reserve status.

Furthest west is the perfect little shield volcano of **Whatitiri**, with its gentle slopes rising to a 350 m high peak. It was built up by a succession of overlapping lava flows about 500 000 years ago. The most fluid lava flowed out to the north and west and 10 km down the Wairua Valley to Titoki. Wairua Falls are formed by the modern river cascading over the edge of the hard basalt flow. Not far away is **Titoki natural bridge** where stream water has eroded its way along fractures through a basalt flow to form a spectacular hole through a narrow ridge.

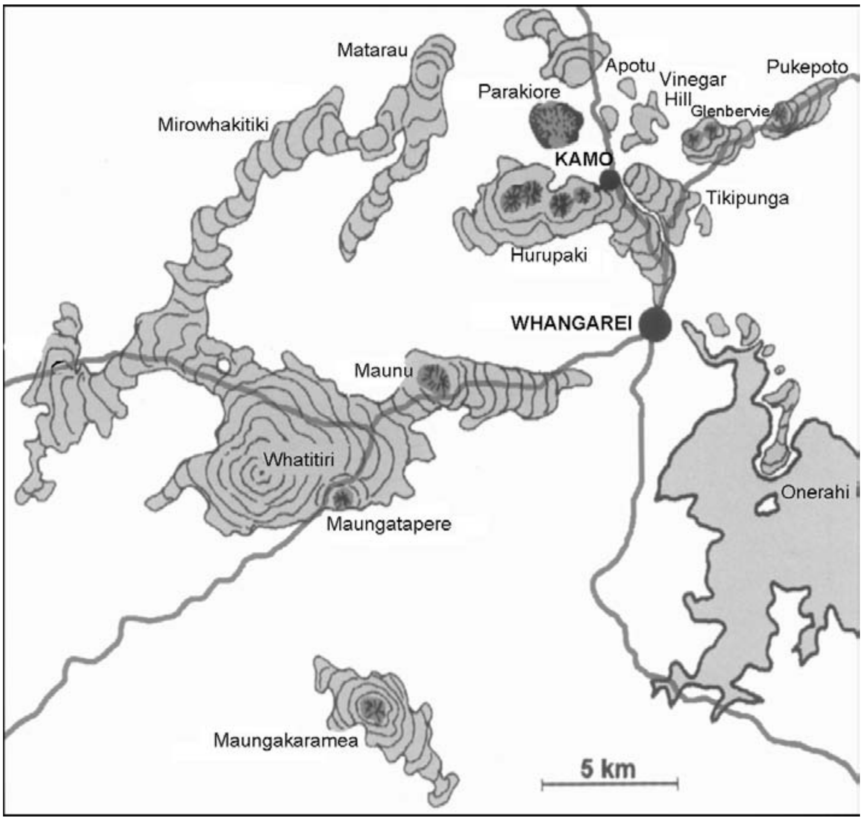

Fig. I.6: Map of the late Pliocene and Quaternary Whangarei basalt volcanic field, showing location of scoria cones and lava flows.

K-Ar AGES OF WHANGAREI'S PLIOCENE AND PLEISTOCENE VOLCANOES (Fig. I.6)

Two groups of basalt volcanoes (from Smith et al. 1993) -

a) Eroded, no centres visible, Pliocene:

1. Onerahi flow remnants, possibly erupted from vent on south side of Parahaki. 4 ± 2 my.
2. Apotu flow remnants, centre eroded away. 4.2 ± 1.1 my.
3. Vinegar Hill and Tikipunga flow (Whangarei Falls). No centre visible now. 2.4 ± 0.3 my.
4. Matarau remnants. 2.3 ± 0.2 my.
5. Mirowhakitiki remnants. 1.06 ± 0.08 my.

b) Slightly eroded, 10 scoria cones, 1 shield volcano, extensive flows, 300 000 to 500 000 years old.

6. Whatitiri shield volcano and Titoki flows (Wairua Falls). 0.5-0.6 ± 0.1 my.
7. Whangarei city flow, two possible vents identified. 0.30 ± 0.13 my.
8. Pukepoto, breached scoria cone and flows, 0.30 ± 0.06 my.
9. Glenbervie, two scoria cones and flows. 0.30 ± 0.12 my.
10. Hurupaki, part of a cluster of four scoria cones with flows, 0.31 ± 0.15 my.
11. Maunu, scoria cone. 0.32 ± 0.09 my.
12. Maungatapere, scoria cone. 0.29 ± 0.05 my.
13. Maungakaramea, scoria cone. 0.30 ± 0.06 my.

c) Two Pleistocene dacite domes.

14. Parakiore. 0.45 my.
15. Hikurangi. 1.23 my.

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