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UNIVERSITY OF WAIKATO RADIOCARBON DATES I

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The radiocarbon dating laboratory at Waikato was established in 1975, primarily as a research tool in the fields of geomorphology, volcanology, tephrostratigraphy, coastal studies, and paleolimnology, to cope with the increasing supply of late Quaternary lake sediment, wood, peat, and shell samples submitted by University staff and postgraduate students undertaking research in the North Island of New Zealand. The method employed is scintillation counting of benzene using the procedures and vacuum systems designed by H A Polach for the Australian National University (ANU) Radiocarbon Dating Research Laboratory (Hogg, 1982). This date list reports on samples submitted by University of Waikato researchers and assayed in the Waikato laboratory mainly between 1979 and 1985. Other dates on material submitted by individuals working in other organizations in New Zealand, and overseas, are to be reported later.

When necessary, combustible samples are boiled in both dilute NaOH and dilute H_3PO_4 to remove humic acid contaminants and inorganic carbon. Carbonate samples are leached in dilute HCl, dried, crushed, and analyzed by XRD methods to determine the relative proportions of calcite and aragonite. Benzene is synthesized using the three well-established chemical steps: oxidation of sample carbon to carbon dioxide, conversion to acetylene, and catalytic trimerization to benzene (eg, Noakes, Kim & Stipp, 1965; Polach & Stipp, 1967; Polach, Gower & Fraser, 1972; Tamers, 1975). Carbon dioxide is generated by combustion in a silica combustion tube, and purified using a purification train including $AgNO_3$, hot CuO (600 °C), KI in I_2, $Hg(NO_3)_2$, and chromic acid. The CO_2 is desiccated by a series of ethanol slush traps (at −80 °C) and a silica gel column and the CO_2 condensed by liquid N_2 traps. The CO_2 is converted to C_2H_2 using a stainless steel reaction vessel based on the design of Polach, Gower & Fraser (1972). Acetylene is trimerized to benzene using Noakes' catalyst, sealed in silica catalyst columns and cleaned between samples by flushing with air at 500 °C. Undersized samples are diluted with dead CO_2 prior to C_2H_2 generation to standardize benzene synthesis reactions. The dead CO_2 is obtained from coal for combustible samples, or from ancient limestone for carbonates.

Synthesized benzene samples are transfered into 5ml, low-K glass vials (constructed after the design of Polach, 1969), into which 75mg of scintillator (t-butyl PBD) has been weighed. The vials are then sealed with teflon stoppers and the benzene weight (ca 4.5g) accurately determined. Machined aluminium caps (black anodized) are then slid over the teflon stoppers and butted against the glass vials to reduce cross-talk between the counter photomultiplier tubes. Sample activities are determined in either an LKB 1211 scintillation counter, factory modified by Wallac ("Kangaroo

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Package") for low level ^{14}C determinations, or a Packard Tri-Carb, similarly modified for low level counting. Eight samples and two reference standards (sealed ANU sucrose and AR benzene) are interspersed in a chain and automatically cycled over a period of 14 days with a counting interval of 20 minutes, with each sample being counted for a minimum of 1980 minutes. Background levels vary between counters and vials and range from 0.72 cpm/gC to 0.96 cpm/gC. Modern activities (A_{on}) also vary, ranging from 8.11 cpm/gC to 9.80 cpm/gC. The laboratory working standard is ANU sucrose, with the normalized oxalic activity calculated using the conversion factor determined from an international cross-calibration exercise conducted by H A Polach of ANU ($D^{14}C$ = 508.1 ± 2.0‰ Currie & Polach, 1980).

Radiocarbon dates presented are *conventional radiocarbon ages* as defined by Stuiver & Polach (1977) with ages expressed in years BP ± 1 standard deviation. The counting error includes the statistical uncertainties of the sample, background, and reference standards and, in addition, errors in estimating the $\delta^{13}C$ (in the few samples where this was not measured), and in the ANU sucrose/oxalic acid conversion factor. ^{13}C determinations for each sample were performed on a Micromass 602C mass spectrometer. Interlaboratory comparisons are reported in Table 1. Sample descriptions and interpretations are based upon information received from the submitters.

ACKNOWLEDGMENTS

We wish to thank H A Polach and his staff at the ANU Radiocarbon Research Laboratory, Canberra, for their valued assistance in the construc-

TABLE 1
Interlaboratory check samples

Wk-1. Benzene cross-check #24 — **19,925 ± 300**; *Est* $\delta^{13}C = -25‰$

ANU-1310. 19,600 ± 300

Wk-526. Lab cross-check (NPL-64) — **9450 ± 100**; $\delta^{13}C = -31.7‰$

ANU-03. 9410 ± 100, 9800 ± 220

Wk-742. Lab cross-check (ACT VII) — $\frac{A_{sn}}{A_{on}}$ = **1.2444 ± 0.0056‰**; $\delta^{13}C = -23.2‰$

Reported A_{sn}/A_{on} values from participating labs (M Stuiver, pers commun, 1986):

Quaternary Isotope Laboratory (M Stuiver): 1.2460 ± 0.0022‰
Participating Lab A: 1.2506 ± 0.0019‰
Participating Lab B: 1.2538 ± 0.0040‰

tion and operation of our laboratory. We are particularly grateful to H A Polach for helping to design the original vacuum systems, for providing the ANU sucrose standard, and for organizing a fellowship to help in the training of one of the authors (AGH). We thank the University Grants Committee of New Zealand for contributing to the cost of the scintillation counters. J E Noakes of the University of Georgia willingly provided the catalyst and M Stuiver the international calibration standard ACT VII. For technical assistance in the laboratory between 1975 and 1985, we thank E Raynor, P Chevis, A Brennan, A Limmer, J Smeaton, M Lawrence, and V Lockwood. Mass spectrometric determinations were carried out by A Thomas and W Schick. Finally, special thanks are due A T Wilson who founded the laboratory, and J D McCraw and K M Mackay who encouraged its development.

GEOLOGIC SAMPLES

New Zealand

Most dates reported here relate to the deposition of distal airfall tephras in lakes and peats in central and northern North Island, New Zealand (Sec 1). The tephras were erupted from rhyolitic and andesitic sources in the Taupo Volcanic Zone or from Mt Egmont or Mayor Island (Fig 1). They are useful as datable stratigraphic marker beds for a wide variety of purposes (eg, Pullar, 1973; Self & Sparks, 1981; Howorth *et al,* 1981; Pillans *et al,* 1982; McGlone, Howorth & Pullar, 1984; Harper, Howorth & McLeod, 1986), and as a "window" into volcanic processes, volcanic history, and the composition and evolution of magmas (eg, Walker, 1980, 1981a, b; Hodder, 1981, 1983; Froggatt, 1982; Wilson *et al,* 1984; Blake, Smith & Wilson, 1986). The preservation of tephra deposits in suitable organic sediments potentially allows their stratigraphic and chronologic relationships to be determined more accurately and possibly in much greater detail than might be obtained from subaerial exposures, particularly at distal localities where relatively thin tephras can be difficult to trace with certainty because of postdepositonal mixing and weathering processes (eg, Hodder & Wilson, 1976; Howorth, Froggatt & Robertson, 1980; Lowe *et al*, 1980; Hogg & McCraw, 1983; Lowe, 1986a). Lakes and peat bogs of late Quaternary age in North Island, particularly in the Waikato region (Fig 1), have proved ideal sites for preserving multiple tephra layers, including fine-grained deposits only a few millimeters thick (Lowe, Hogg & Hendy, 1981; Green & Lowe, 1985; Lowe, 1986a; Pl 1). Ongoing paleoenvironmental studies of the Waikato lakes have utilized the time-stratigraphic framework provided by the tephras, and include Green (1979), Boubée (ms), Green *et al* (1984), McGlone, Nelson & Todd (1984), Lowe (1985, 1986b), McCabe (ms), Kellett (ms), and Green & Lowe (1985).

The dates in Section 1 were determined on lake sediment (dy or gyttja) and peat from cores obtained with a modified Livingstone piston corer (Rowley & Dahl, 1956; Green, 1979) and with a modified D-section Russian/Jowsey peat corer (Jowsey, 1966), except where noted. The samples are grouped into series named after the lake or peat bog cored (Fig 1), and

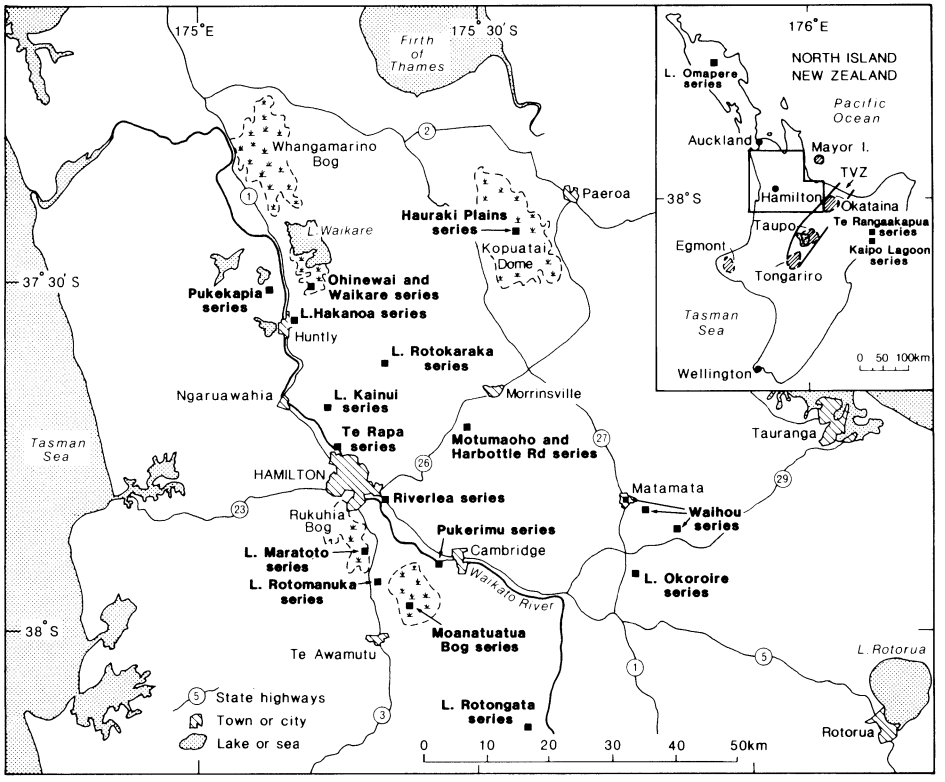

Fig 1. Locations of sample series in the Waikato region, New Zealand. Inset shows locations of other series and the main tephra-producing volcanoes (hatched) active in the late Quaternary period. TVZ = Taupo Volcanic Zone (after Cole & Nairn, 1975). *Note:* Mt Egmont is also known as Mt Taranaki.

arranged stratigraphically with samples closest to the surface listed first. Most samples came from five lakes; stratigraphic columns showing the sampling positions with respect to identified tephras are given in Figure 2. Most samples consist of slices of sediment (usually 1-2cm thick in the lake cores, 2-5cm or occasionally thicker in the peats) from above or below a tephra layer. Such slices of sediment, deliberately kept as thin as possible, represent an accumulation interval and, hence, may reduce date accuracy (with respect to the age of deposition of the tephras). This possible reduction in accuracy is offset by the tight stratigraphic control that the continuous cores provide, and by the availability of dates for many of the tephras in other environments (see below), thus acting as independent monitors of error (*cf* Mathewes & Westgate, 1980). To provide sufficient material for dating, slices of lake sediment from two or more suitable cores (taken within the same lake) were commonly combined into a composite sample (Green & Lowe, 1985). In some samples with very low carbon content, the slices from above and below the tephra have been combined as a "straddle" sample, providing an average age for the tephra. Where tephras are closely

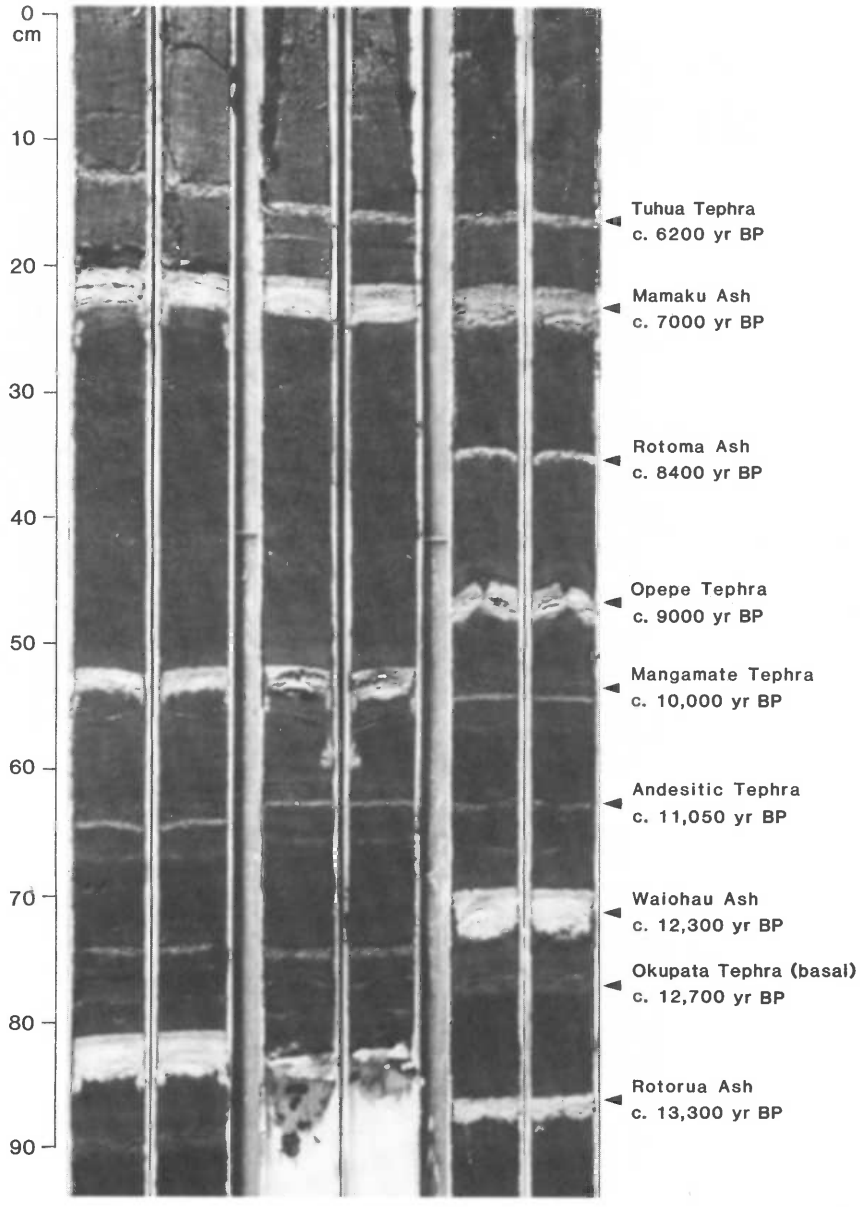

Plate 1. Three longitudinally sliced cores from Lake Rotomanuka, near Hamilton, showing ash-grade tephra layers preserved within dark, fine-grained organic lake sediment. The tephras are derived from five volcanic centers located 110 to 180km from Lake Rotomanuka (Fig 1). Photograph: RR Julian and W Forbes.

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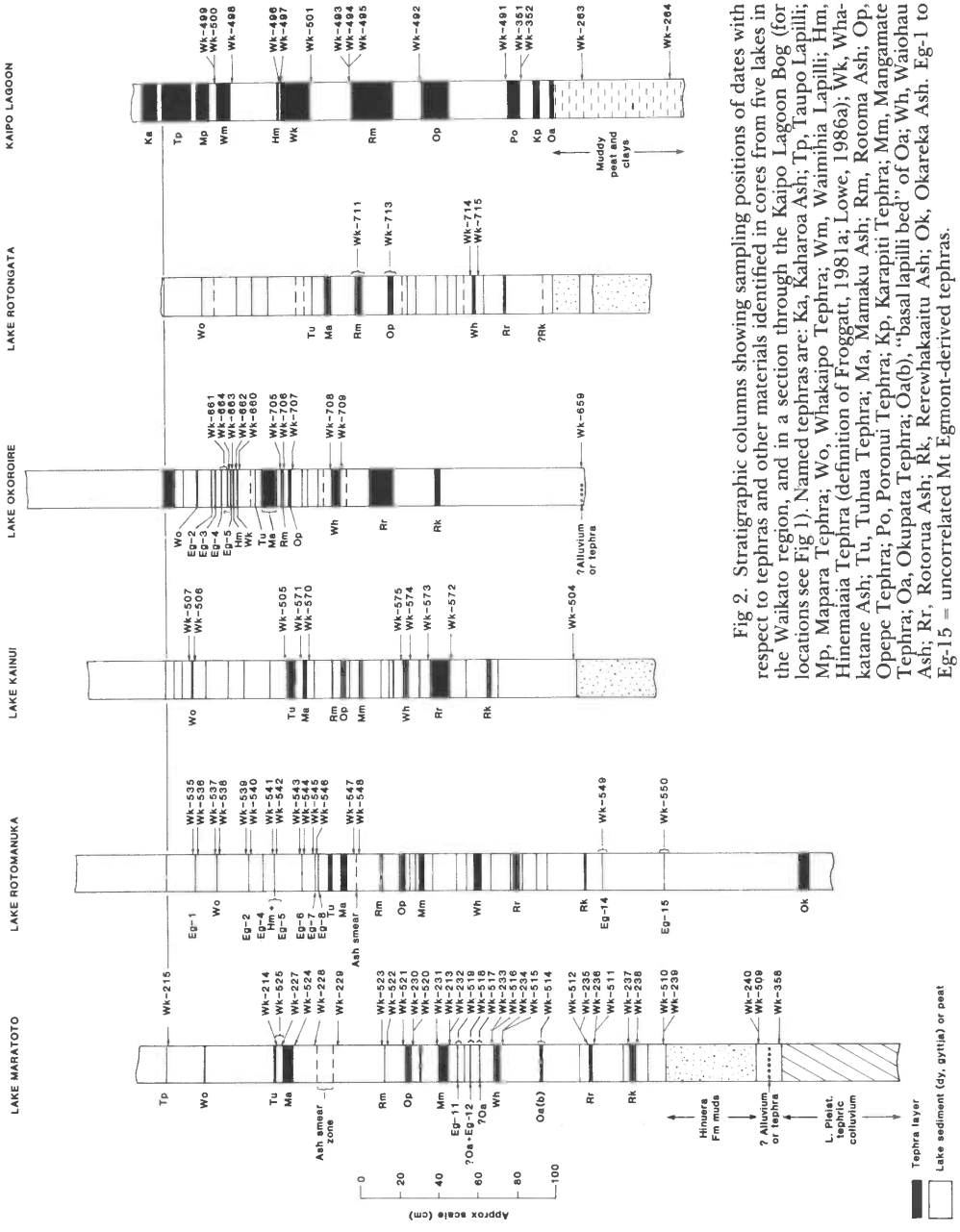

Fig 2. Stratigraphic columns showing sampling positions of dates with respect to tephras and other materials identified in cores from five lakes in the Waikato region, and in a section through the Kaipo Lagoon Bog (for locations see Fig 1). Named tephras are: Ka, Kaharoa Ash; Tp, Taupo Lapilli; Mp, Mapara Tephra; Wo, Whakaipo Tephra; Wm, Waimihia Lapilli; Hm, Hinemaiaia Tephra (definition of Froggatt, 1981a; Lowe, 1986a); Wk, Whakatane Ash; Tu, Tuhua Tephra; Ma, Mamaku Ash; Rm, Rotoma Ash; Op, Opepe Tephra; Po, Poronui Tephra; Kp, Karapiti Tephra; Mm, Mangamate Tephra; Oa, Okupata Tephra; Oa(b), "basal lapilli bed" of Oa; Wh, Waiohau Ash; Rr, Rotorua Ash; Rk, Rerewhakaaitu Ash; Ok, Okareka Ash. Eg-1 to Eg-15 = uncorrelated Mt Egmont-derived tephras.

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spaced in the cores, the entire layer of sediment between two adjacent tephras (*ie*, "bridging" the tephras) was occasionally sampled. The date thus obtained applies equally to both tephras, giving a maximum age for one, and a minimum for the other (eg, Lowe, 1986a).

Except for Lakes Purimu and Maungaratiti (Wk-426, -842), none of the lakes sampled have calcareous rocks in their catchments; hence, the "hard-water effect" frequently encountered in such environments in Europe, Scandinavia, North America, and elsewhere (eg, Ogden, 1967; Olsson, 1979; Mathewes & Westgate, 1980) does not arise.

Most of the tephras have been correlated with named eruptive units elsewhere using diagnostic mineralogic and chemical criteria, together with stratigraphic and age relationships (Lowe *et al*, 1980; Green & Lowe, 1985; Lowe & Hogg, 1986; Lowe, 1986a, c, and work in progress). Although most of the rhyolitic tephras (from Taupo, Okataina, and Mayor Island sources, Fig 1) were dated previously (Healy, 1964; Vucetich & Pullar,

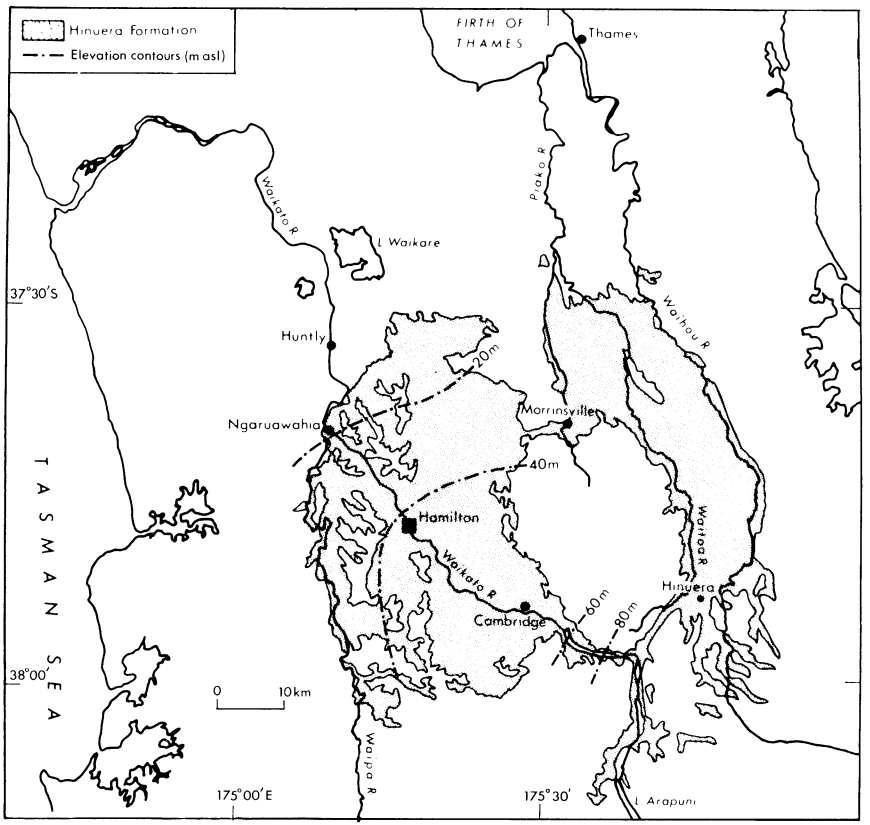

Fig 3. The distribution of the Hinuera Formation in the Hamilton Basin (left) and the Hauraki Basin. Contours show the alluvial fan form. From Selby (1982), based on Hume, Sherwood & Nelson (1975).

1964, 1969, 1973; Grant-Taylor & Rafter, 1966; Pullar & Heine, 1971; Topping & Kohn, 1973; McCraw, 1975; Nairn, 1980; Froggatt, 1981a, b; Hogg & McCraw, 1983), many have only one or two dates. The andesitic tephras (from Tongariro and Egmont sources, Fig 1) have a rather complex stratigraphy with relatively few available dates (Topping, 1973; Neall, 1972, 1979; Neall & Geddes, 1981; Neall & Alloway, 1986). In the lake cores, many of the tephras derived from the Mt Egmont volcano have not yet been positively correlated with named eruptives, so they are informally designated as "Eg-1", "Eg-2", etc, in the date list (Fig 2).

The dates listed in Section 2 were obtained on carbonaceous matter associated with the Hinuera Formation, an extensive low-angle fan of volcanogenic alluvium that was deposited in several phases in the Waikato and Hauraki basins before and during the last stade (isotope stage 2) of the last glaciation (Fig 3; Schofield, 1965; Hume, Sherwood & Nelson, 1975; McGlone, Nelson & Hume, 1978; Cuthbertson, ms; Selby, 1982; Green & Lowe, 1985). The aggradation of the Hinuera Formation resulted in the formation of most of the lakes noted above (McCraw, 1967; Lowe & Green, 1987). Therefore, some of the dates obtained for material from the lower parts of cores from these lakes provide information on the age of Hinuera Formation sedimentation. These dates could be grouped in Section 2, but have been retained in Section 1 because of their stratigraphic relationship to the overlying dates associated with the tephras.

In Section 3, the samples comprise materials associated with peat bog growth or local sedimentation that postdates the deposition of the Hinuera Formation, *ie*, < ca 15,000 BP. Samples in both Sections 2 and 3 are grouped into series according to geographic location, and, where appropriate, arranged stratigraphically with uppermost samples shown first.

Map location grid references refer to the national 1000m grid of the New Zealand 1:50,000 topographic map series, NZMS 260 (1st ed).

1. Dates Associated with Deposition of Airfall Tephras in Lakes and Peat Bogs

Lake Maratoto series

Organic lake sediment (humic copropel, dy-gyttja) coll by piston corer from Lake Maratoto, 10km S of Hamilton (37° 53′ S, 175° 18′ E) (S15/130663). Coll and subm by D J Lowe and J D Green, School Sci, Univ Waikato. Coll in 4 sampling sets in 1979 (Mo/A), 1980 (Mo/C), 1981 (Mo/D), and 1982 (Mo/E).

Wk-215. Mo/A5 **1730 ± 60**
Est $\delta^{13}C = -28‰$

Comment: diluted, 82% sample. (DJL): date is max for Taupo Pumice Fm (Taupo Lapilli Member).

Wk-214. Mo/A4 **6210 ± 70**
$\delta^{13}C = -28.4‰$

Comment (DJL): date is max for Tuhua Tephra Fm.

5800 ± 70

Wk-525. Mo/E1 $\delta^{13}C = -28.8‰$

Comment (DJL): sample bridges two tephra layers; date is max for Tuhua Tephra Fm and min for Mamaku Ash Fm. Date is younger than expected for eruption of Mamaku Ash. This may be due to overthick sample (given a very slow sedimentation rate) or possibly to sample contamination in core.

6830 ± 90

Wk-227. Mo/C12 $\delta^{13}C = -27.0‰$

Comment: diluted, 57% sample. (DJL): date is min for Mamaku Ash Fm.

7920 ± 80

Wk-524. Mo/E2 $\delta^{13}C = -29.8‰$

Comment (DJL): date is max for Mamaku Ash Fm and may overestimate eruption age. See comment for Wk-228.

8170 ± 90

Wk-228. Mo/C11 $\delta^{13}C = -29.7‰$

Comment: diluted, 72% sample. (DJL): date is max for Mamaku Ash Fm. Date considered perhaps ca 1000 yr too old, with regard to eruption of Mamaku Ash, as mineralogic evidence shows sample contaminated by underlying Rotoma Ash Fm (Green & Lowe, 1985).

7650 ± 160

Wk-229. Mo/C14 $\delta^{13}C = -30.0‰$

Comment: diluted, 34% sample. (DJL): date is min for Opepe Tephra Fm and younger than expected for eruption of Opepe Tephra (by ca 1000 to 1500 yr?), possibly due to compression of sediment in core between Mamaku and Opepe tephras.

8350 ± 100

Wk-523. Mo/E3 $\delta^{13}C = -30.7‰$

Comment: diluted, 72% sample. (DJL): date is min for Rotoma Ash Fm; differs from previous ones on eruption of this tephra, ca 7000 to 7300 BP (Pullar & Heine, 1971; Pullar, Birrell & Heine, 1973), but is closer to date of (NZ1945) 8860 ± 120 BP given by Nairn (1980). Dates 8000 to 9000 BP considered more reliable, but specific eruption age remains uncertain.

8370 ± 90

Wk-522. Mo/E4 $\delta^{13}C = -31.3‰$

Comment: diluted, 78% sample. (DJL): date is max for Rotoma Ash Fm. See comment for Wk-523.

8670 ± 110

Wk-521. Mo/E5 $\delta^{13}C = -31.2‰$

Comment: diluted, 62% sample. (DJL): date is min for Opepe Tephra Fm.

9370 ± 210

Wk-230. Mo/C13 $\delta^{13}C = -31.6‰$

Comment: diluted, 33% sample. (DJL): date is max for Opepe Tephra Fm.

8930 ± 100

Wk-520. Mo/E6 $\delta^{13}C = -31.1‰$

Comment: diluted, 72% sample. (DJL): date is max for Opepe Tephra Fm.

9700 ± 140

Wk-231. Mo/C10 $\delta^{13}C = -30.9‰$

Comment: diluted, 52% sample. (DJL): date is min for Mangamate Tephra Fm (?Te Rato Lapilli Member).

10,120 ± 100

Wk-213. Mo/A3 *Est* $\delta^{13}C = -27‰$

Comment: diluted, 82% sample. (DJL): date is max for Mangamate Tephra Fm (?Te Rato Lapilli Member).

10,000 ± 120

Wk-232. Mo/C9 $\delta^{13}C = -31.9‰$

Comment: diluted, 76% sample. (DJL): date is max for Mangamate Tephra Fm (?Te Rato Lapilli Member).

10,100 ± 100

Wk-519. Mo/E7 $\delta^{13}C = -31.9‰$

Comment: diluted, 86% sample. (DJL): sample straddles tephra layer; date is average for uncorrelated tephra from Egmont, Eg-11.

11,050 ± 130

Wk-518. Mo/E8 $\delta^{13}C = -32.1‰$

Comment: diluted, 68% sample. (DJL): sample straddles two (?) intermixed andesitic tephras visible as a single "speckled" layer; date is average for tephras tentatively identified as unnamed member of Okupata Tephra Fm (from Tongariro) and uncorrelated tephra from Egmont, Eg-12. Volcanoes apparently erupted approx contemporaneously.

11,700 ± 180

Wk-517. Mo/E9 $\delta^{13}C = -34.6‰$

Comment: diluted, 47% sample. (DJL): sample straddles tephra layer; date is average for unnamed Member of (?) Okupata Tephra Fm.

12,200 ± 230

Wk-233. Mo/C8 $\delta^{13}C = -35.0‰$

Comment: diluted, 42% sample. (DJL): date is min for Waiohau Ash Fm. Date is older than previous dates obtained on charcoal from this tephra between ca 11,100 to 11,800 BP (generally accepted age is ca 11,300 BP,

Pullar & Heine, 1971; Pullar & Birrell, 1973). Sample conceivably contaminated by redeposited older organic material (eg, Olsson & Florin, 1980; Björck & Håkansson, 1982), but Green & Lowe (1985) and Lowe & Hogg (1986) suggest instead that charcoal dates may underestimate real age of Waiohau eruption by several hundred years at least, *ie*, Waiohau Ash age probably closer to ca 12,000 BP than 11,000 BP. See dates in other series below.

Wk-516. Mo/E10 **12,300 ± 190**
$\delta^{13}C = -31.6‰$

Comment: diluted, 47% sample. (DJL): date is min for Waiohau Ash Fm. See comment for Wk-233.

Wk-234. Mo/C7 **12,500 ± 190**
$\delta^{13}C = -35.6‰$

Comment: diluted, 47% sample. (DJL): date is max for Waiohau Ash Fm. See comment for Wk-233.

Wk-515. Mo/E11 **12,450 ± 200**
$\delta^{13}C = -32.4‰$

Comment: diluted, 44% sample. (DJL): date is max for Waiohau Ash Fm. See comment for Wk-233.

Wk-514. Mo/E12 **12,700 ± 200**
$\delta^{13}C = -33.4‰$

Comment: diluted, 46% sample. (DJL): sample straddles tephra layer; provides average age of "basal lapilli" bed (?) of Okupata Tephra Fm (as denoted by Topping, 1973).

Wk-512. Mo/E14 **12,800 ± 150**
$\delta^{13}C = -33.2‰$

Comment: diluted, 68% sample. (DJL): date is min for Rotorua Ash Fm. Thick sample slice may reduce reliability. See comment for Wk-511.

Wk-235. Mo/C6 **12,900 ± 310**
$\delta^{13}C = -32.5‰$

Comment: diluted, 26% sample. (DJL): date is min for Rotorua Ash Fm.

Wk-236. Mo/C5 **12,600 ± 230**
$\delta^{13}C = -35.6‰$

Comment: diluted, 33% sample. (DJL): date is max for Rotorua Ash Fm. Date is younger than expected. See comment for Wk-511.

Wk-511. Mo/E15 **13,450 ± 120**
$\delta^{13}C = -31.9‰$

Comment (DJL): date is max for Rotorua Ash Fm. Agrees closely with near-source date on this tephra of (NZ1615) 13,450 ± 250 BP (Nairn,

1980). Taking other dates on Rotorua Ash, and those on adjacent tephras (Waiohau, Rerewhakaaitu) into account, age of eruption thought to be near ca 13,300 BP.

Wk-237. Mo/C4 **14,700 ± 220**
$\delta^{13}C = -31.6‰$

Comment: diluted, 55% sample. (DJL): date is min for Rerewhakaaitu Ash Fm.

Wk-238. Mo/C3 **14,700 ± 180**
$\delta^{13}C = -30.5‰$

Comment: diluted, 78% sample. (DJL): date is max for Rerewhakaaitu Ash Fm.

Wk-510. Mo/E16 **15,850 ± 130**
$\delta^{13}C = -28.5‰$

Comment (DJL): dates fm of present-day Lake Maratoto and cessation of final episode of deposition of Hinuera Fm at this site.

Wk-239. Mo/C2 **16,300 ± 250**
$\delta^{13}C = -29.7‰$

Comment: diluted, 52% sample. (DJL): dates fm of present-day Lake Maratoto and cessation of final episode Hinuera Fm deposition at this site.

Wk-240. Mo/C1 **16,900 ± 470**
Est $\delta^{13}C = -30‰$

Comment: diluted, 28% sample. (DJL): dates beginning of final episode of Hinuera Fm deposition at this site, which resulted in fm of present-day Lake Maratoto. Sample is gyttja deposited in relatively short-lived "proto-Lake Maratoto" formed by penultimate episode of Hinuera Fm sedimentation. This gyttja contains indistinct band of grayish sandy mud with pumice lapilli that is most likely reworked volcanogenic alluvium. However, lapilli might represent uncorrelated airfall tephra. If so, its stratigraphic position below Rerewhakaaitu Ash suggests (?) Okareka Ash Fm (Fig 2; Vucetich & Pullar, 1969); thus, age obtained (also Wk-509, -358) would be min. Elsewhere, Okareka Ash is undated but thought to be ca 17,000 BP (Nairn, ms).

Wk-509. Mo/E17 **16,200 $^{+360}_{-340}$**
$\delta^{13}C = -25.9‰$

Comment: diluted, 35% sample. (DJL): dates beginning of final episode of Hinuera Fm deposition at this site that resulted in fm of present-day Lake Maratoto. Sample is gyttja deposited in relatively short-lived "proto-Lake Maratoto" formed by penultimate episode of Hinuera Fm sedimentation. See comment for Wk-240.

Wk-358. Mo/D1 **17,050 ± 200**
$\delta^{13}C = -29.9‰$

Comment: diluted, 78% sample. (DJL): dates fm of "proto-Lake Maratoto" by penultimate episode of deposition of Hinuera Fm alluvium in this area. See comment for Wk-240.

General Comment (DJL): Wk-213, -214, -215 are first dates obtained on airfall tephras in Hamilton Basin. Ages generally accord with stratigraphy (increase down core), and dates on tephras closely match those on same tephras elsewhere, except as noted (Lowe *et al*, 1980; Hogg & McCraw, 1983; Green & Lowe, 1985). Dates on Okupata Tephra and uncorrelated Egmont tephras (Wk-517, Wk-518, Wk-519) are consistent with sparse dates on related eruptive sequences nearer source (Topping, 1973; Neall & Alloway, 1986). Deposition of Hinuera Fm at Lake Maratoto ca 16,000 to 17,000 BP agrees with ages in McGlone, Nelson & Hume (1978) and McGlone, Nelson & Todd (1984). Dates also give rates of sedimentation during lake's developmental history (average ca 0.1 to 0.2mm/yr; Green & Lowe, 1985)—similar average rates are evident for most other Hinuera-dammed lakes (see below).

Lake Rotomanuka series

Organic lake sediment (dy, gyttja, or dy-gyttja) coll by piston corer (Pl 1) from Lake Rotomanuka, 15km S of Hamilton (37° 55′ S, 175° 19′ E) (S15/136615). Coll 1983 by D J Lowe, J D Green, and C H Hendy; subm by D J Lowe and J D Green.

Wk-535. Rot/D-1 **2560 ± 80**
$\delta^{13}C = -29.9‰$

Comment: diluted, 57% sample. (DJL): date is min for uncorrelated tephra from Egmont, Eg-1.

Wk-536. Rot/D-2 **2350 ± 80**
$\delta^{13}C = -29.5‰$

Comment: diluted, 58% sample. (DJL): date is max for uncorrelated tephra from Egmont, Eg-1.

Wk-537. Rot/D-3 **2560 ± 60**
$\delta^{13}C = -29.5‰$

Comment: diluted, 77% sample. (DJL): date is min for Whakaipo Tephra Fm. Date (and Wk-538) supports identification of this tephra as Whakaipo (based upon chem analysis of glass, Lowe, 1986a) rather than older Waimihia Fm reported by Lowe *et al* (1980).

Wk-538. Rot/D-4 **2860 ± 60**
$\delta^{13}C = -29.9‰$

Comment: diluted, 88% sample. (DJL): date is max for Whakaipo Tephra Fm and agrees closely with near source dates on this tephra (Vucetich & Pullar, 1973).

3610 ± 60

Wk-539. Rot/D-5 $\delta^{13}C = -28.8‰$

Comment (DJL): date is min for uncorrelated tephra from Egmont, Eg-2.

3750 ± 70

Wk-540. Rot/D-6 *Est* $\delta^{13}C = -29.9‰$

Comment (DJL): date is max for uncorrelated tephra from Egmont, Eg-2. Also sets upper age limit for indistinct tephra, Eg-4, which sporadically occurs below Eg-2 in some cores from lake.

4490 ± 70

Wk-541. Rot/D-7 $\delta^{13}C = -29.4‰$

Comment (DJL): sample overlies layer of two(?) apparently admixed tephras; date is min for Hinemaiaia Tephra (definition of Froggatt, 1981a; Lowe, 1986a), and for uncorrelated tephra from Egmont, Eg-5. Date also gives lower age limit to overlying Eg-4 tephra. Supports dates on Hinemaiaia Tephra reviewed in Lowe (1986a).

4470 ± 70

Wk-542. Rot/D-8 $\delta^{13}C = -29.6‰$

Comment (DJL): sample underlies layer of two(?) apparently admixed tephras; date is max for Hinemaiaia Tephra (definition of Froggatt, 1981a; Lowe, 1986a), and uncorrelated tephra from Egmont, Eg-5. Supports dates on Hinemaiaia Tephra reviewed in Lowe (1986a).

5280 ± 80

Wk-543. Rot/D-9 $\delta^{13}C = -30.2‰$

Comment: diluted, 77% sample. (DJL): date is min for uncorrelated tephra from Egmont, Eg-6.

5210 ± 90

Wk-544. Rot/D-10 $\delta^{13}C = -29.9‰$

Comment: diluted, 72% sample. (DJL): date is max for uncorrelated tephra from Egmont, Eg-6.

5850 ± 80

Wk-545. Rot/D-11 $\delta^{13}C = -30.3‰$

Comment: diluted, 84% sample. (DJL): date is min for uncorrelated tephra from Egmont, Eg-7.

5850 ± 80

Wk-546. Rot/D-12 $\delta^{13}C = -29.5‰$

Comment: diluted, 75% sample. (DJL): sample bridges two tephra layers; date is max for uncorrelated tephra from Egmont, Eg-7 (overlies sample) and min for uncorrelated Egmont tephra, Eg-8 (underlies sample).

Wk-547. Rot/D-13 **7980 ± 150**
$\delta^{13}C = -31.1‰$

Comment: diluted, 36% sample. (DJL): sample occurs about midway between Mamaku Ash and Rotoma Ash and overlies (*cf* Wk-548 which underlies) indistinct, discontinuous layer of tephra-like material. Indistinct layer was originally thought to represent separate eruptive event but is now considered to be reworked from adjacent Mamaku and/or Rotoma tephras (either naturally or in coring procedure). Date gives approx age limits for Mamaku Ash Fm (max) and Rotoma Ash Fm (min)–*cf* Wk-228.

Wk-548. Rot/D-14 **8030 ± 200**
$\delta^{13}C = -30.8‰$

Comment: diluted, 29% sample. (DJL): date gives approx age limits for Mamaku Ash Fm (max) and Rotoma Ash Fm (min). See comment for Wk-547.

Wk-549. Rot/D-15 **14,750 ± 130**
$\delta^{13}C = -22.7‰$

Comment (DJL): sample straddles tephra layer; date is average for uncorrelated Egmont tephra, Eg-14, occurring 7cm below Rerewhakaaitu Ash Fm in core.

Wk-550. Rot/D-16 **14,650 ± 240**
$\delta^{13}C = -24.7‰$

Comment: diluted, 47% sample. (DJL): date is max for uncorrelated Egmont tephra, Eg-15, that occurs ca 30cm below Rerewhakaaitu Ash in core. Date younger than expected, being similar to reliable dates on Rerewhakaaitu Ash (14,700 BP, see Lake Maratoto series); possibly due to contamination of sample by younger carbon in coring procedure or to relatively high sedimentation rate in lake in this early postglacial period (*cf* Green & Lowe, 1985).

General Comment (DJL): dates on distal Egmont-derived tephras in this series contribute greatly to relatively few dates available nearer source and may help to establish distribution patterns and correlations of eruptives from Egmont volcano.

Lake Kainui series

Organic lake sediment coll by piston corer from Lake Kainui (also known as Lake D), 15km NW of Hamilton (37° 41′ S, 175° 14′ E) (S14/072892). Coll 1982 by D J Lowe, J D Green, and C H Hendy and subm by D J Lowe, Earth Sci, Univ Waikato.

Wk-507. Lake D-12 **2010 ± 80**
Est $\delta^{13}C = -28‰$

Comment: diluted, 49% sample. (DJL): date is min for Whakaipo Tephra Fm, younger than expected. See comment for Wk-538.

3030 ± 70

Wk-506. Lake D-11 $\delta^{13}C = -28.0‰$

Comment: diluted, 53% sample. (DJL): date is max for Whakaipo Tephra Fm.

5800 ± 90

Wk-505. Lake D-10 $\delta^{13}C = -28.8‰$

Comment: diluted, 56% sample. (DJL): date is min for Tuhua Tephra Fm.

7140 ± 110

Wk-571. Lake D-5 $\delta^{13}C = -29.2‰$

Comment: diluted, 47% sample. (DJL): date is min for Mamaku Ash Fm.

7200 ± 120

Wk-570. Lake D-4 $\delta^{13}C = -29.1‰$

Comment: diluted, 40% sample. (DJL): date is max for Mamaku Ash Fm.

11,800 ± 230

Wk-575. Lake D-9 $\delta^{13}C = -31.6‰$

Comment: diluted, 33% sample. (DJL): date is min for Waiohau Ash Fm. See comment for Wk-233.

11,700 ± 270

Wk-574. Lake D-8 $\delta^{13}C = -32.3‰$

Comment: diluted, 29% sample. (DJL): date is max for Waiohau Ash Fm. See comment for Wk-233.

12,350 ± 210

Wk-573. Lake D-7 $\delta^{13}C = -32.1‰$

Comment: diluted, 42% sample. (DJL): date is min for Rotorua Ash Fm, younger than expected (by ca 1000 yr?); may be due to disturbed top and base of tephra (has *in situ* gas pockets, tephra-infilled cracks in gyttja). See comment for Wk-511.

12,650 ± 230

Wk-572. Lake D-6 $\delta^{13}C = -31.1‰$

Comment: diluted, 37% sample. (DJL): date is max for Rotorua Ash Fm, younger than expected. See comment for Wk-573.

15,150 $^{+680}_{-630}$

Wk-504. Lake D-1 $\delta^{13}C = -26.3‰$

Comment: diluted, 15% sample. (DJL): dates fm of Lake Kainui and cessation of deposition of Hinuera Fm sediments at this site. Age consistent

with previous determinations elsewhere (McGlone, Nelson & Hume, 1978; Green & Lowe, 1985).

General Comment (DJL): ages generally accord well with previous determinations except those noted as younger than expected.

Lake Okoroire series

Organic lake sediment coll by piston corer from Lake Okoroire, 5km N of Tirau (37° 55′ S, 175° 48′ E) (T15/555611). Coll 1984 by D J Lowe, C H Hendy and M Ouellet and subm by D J Lowe. *Note:* minimal sample material was available for this series. Samples Wk-661 to -664 each bridge two closely spaced tephras, thus applying equally to both tephras (Fig 2).

Wk-661. Ok-6 **3950 ± 90**
$\delta^{13}C = -30.6‰$

Comment: diluted, 42% sample. (DJL): date is max for uncorrelated tephra from Egmont, Eg-4, and min for uncorrelated tephra of uncertain source.

Wk-664. Ok-5 **3810 ± 140**
$\delta^{13}C = -30.6‰$

Comment: diluted, 20% sample. (DJL): date is max for uncorrelated tephra of uncertain source and min for uncorrelated tephra from Egmont, Eg-5.

Wk-663. Ok-4 **3510 ± 150**
$\delta^{13}C = -30.2‰$

Comment: diluted, 21% sample. (DJL): date is max for uncorrelated tephra from Egmont, Eg-5, and min for Hinemaiaia Tephra Fm (definition of Froggatt, 1981a; Lowe, 1986a). Date younger than expected as it is inconsistent with succession of dates on overlying and underlying sediments (Wk-660, -661, -664) and, hence, may be unreliable (contaminated by younger carbon?).

Wk-662. Ok-3 **4260 ± 140**
$\delta^{13}C = -31.7‰$

Comment: diluted, 23% sample. (DJL): date is max for Hinemaiaia Tephra Fm (definition of Froggatt, 1981a; Lowe, 1986a) and min for Whakatane Ash Fm.

Wk-660. Ok-2 **4850 ± 80**
$\delta^{13}C = -32.1‰$

Comment: diluted, 55% sample. (DJL): date is max for Whakatane Ash Fm (Lowe, 1986a).

Wk-705. Ok-7 **7520 ± 130**
$\delta^{13}C = -31.5‰$

Comment: diluted, 44% sample. (DJL): date is min for Rotoma Ash Fm; gives max limit for Mamaku Ash Fm as sample is within a few cm of base of

Mamaku Ash Fm (Fig 2). Younger than expected for Rotoma Ash (probably ca 8000 to 9000 BP), but expected for Mamaku Ash range (see comment for Wk-523). Sedimentation rate in lake was probably very low at this time, so sample slice, although only 2cm thick, may span ca 1000 yr.

Wk-706. Ok-8 **7920 ± 130**
$\delta^{13}C = -31.5‰$

Comment: diluted, 44% sample. (DJL): date is max for Rotoma Ash Fm; gives min age for Opepe Tephra Fm, as sample is within a few cm of top of Opepe Tephra Fm (Fig 2). See comment for Wk-705.

Wk-707. Ok-9 **8700 ± 130**
$\delta^{13}C = -32.4‰$

Comment: diluted, 49% sample. (DJL): date is max for Opepe Tephra Fm.

Wk-708. Ok-10 **10,220 ± 160**
$\delta^{13}C = -27.0‰$

Comment: diluted, 47% sample. (DJL): date is min for Waiohau Ash Fm; younger than expected for this tephra, dated between ca 11,000 and 12,500 BP elsewhere. See comment for Wk-233.

Wk-709. Ok-11 **11,570 ± 130**
$\delta^{13}C = -27.3‰$

Comment: diluted, 68% sample. (DJL): date is max for Waiohau Ash Fm. See comment for Wk-233.

Wk-659. Ok-1 **15,850 ± 320**
$\delta^{13}C = -20.0‰$

Comment: diluted, 32% sample. (DJL): date is min for fm of Lake Okoroire (base of lake sediments not seen) and gives upper limit to deposition of Hinuera Fm sediments in this area (see comment for Waihou series). Sparse white pumice grains at base of sample may represent uncorrelated tephra layer. If so, may be Okareka Ash Fm, based solely upon stratigraphic position relative to Rerewhakaaitu Ash Fm in core (Fig 2; Vucetich & Pullar, 1969), and thus could give upper age limit for this possible tephra. See comment for Wk-240.

General Comment (DJL): dates, except Wk-663, accord with stratigraphy. In dating tephra eruptions, degree of resolution that can be achieved through dating associated lake sediment is limited when sample material is restricted and sedimentation rates are slow (*ie,* ca 0.1 mm/yr or less).

Lake Rotongata series

Organic lake sediment coll by piston corer from Lake Rotongata, Arapuni Dist (38° 08′ S, 175° 36′ E) (T16/380376). Coll 1985 by D J Lowe, C H Hendy, and M Ouellet and subm by D J Lowe.

Wk-711. Rn-1/2 **8000 ± 170**
$\delta^{13}C = -32.5‰$

Comment: diluted, 34% sample. (DJL): sample straddles tephra layer; date is average for Rotoma Ash Fm. See comment for Wk-523.

Wk-713. Rn-3/4 **8990 ± 220**
$\delta^{13}C = -33.0‰$

Comment: diluted, 28% sample. (DJL): sample straddles tephra layer; date is average for Opepe Tephra Fm.

Wk-714. Rn-5 **11,840 ± 340**
$\delta^{13}C = -24.1‰$

Comment: diluted, 22% sample. (DJL): date is min for Waiohau Ash Fm. See comment for Wk-233.

Wk-715. Rn-6 **11,990 ± 230**
$\delta^{13}C = -25.8‰$

Comment: diluted, 35% sample. (DJL): date is max for Waiohau Ash Fm.

Lake Omapere series

Organic lake sediment or wood fragments coll by piston corer from five sites in Lake Omapere, near Kaikohe, North Auckland (35° 21′ S, 173° 47′ E) as part of joint New Zealand-Japan project in paleolimnology organized by S Horie, chairman of Special Working Group of Societas Internationalis Limnologiae (Lowe, 1984). Coll 1984 by D J Lowe, J D Green, J A T Boubée, S Bergin, and S Horie and subm by D J Lowe and J D Green.

Wk-625. Om-4 **1190 ± 90**
$\delta^{13}C = -27.4‰$

Lake sediment at loc P5/827494. *Comment:* diluted, 33% sample. (DJL): dates soft brown gyttja overlying greenish gray clay layer ca 20cm below surface of sediments in Lake Omapere. Gray clay seems to represent increased erosion in catchment, possibly forming present-day lake by blockage of drainage (Lowe & Green, 1987). Such erosion is likely to reflect deforestation, either by natural causes or possibly in response to Polynesian cultural activities (*cf* McGlone, 1983) as date obtained is around time of earliest known settlement of Polynesians in New Zealand (Davidson, 1981). See also general comment for Lake Hakanoa series, below.

Wk-604. Om/E1-30B **5410 ± 150**
Est $\delta^{13}C = -25‰$

Lake sediment at loc P5/827494. *Comment:* diluted, 24% sample. (DJL): sample overlies diffuse tephra layer (lab no. 7) tentatively identified as Mamaku Ash Fm; date is min. If tephra is Mamaku, age is younger than expected (see Wk-227) but could easily be explained by excessively thick sample slice (5cm). See Wk-626.

8030 ± 330

Wk-626. Om/E1-40 $\delta^{13}C = -25.4‰$

Lake sediment at loc P5/827494. *Comment:* diluted, 14% sample. (DJL): sample underlies diffuse tephra layer (lab no. 7) tentatively identified as Mamaku Ash Fm. Date is max, age is consistent with range for this tephra in Waikato lakes (see series above), and supports identification as Mamaku Ash.

>35,000

Wk-590. Om-2 $\delta^{13}C = -25.5‰$

Lake sediment at loc P5/827494. *Comment:* diluted, 15% sample. (DJL): sample underlies airfall tephra 10cm thick (lab nos. 1, 2) provisionally identified as Rotoehu Ash (member of Rotoiti Breccia Fm, Nairn, 1972). Date agrees with previous dates of ca 42,000 BP (Pullar & Heine, 1971) and est age of ca 50,000 BP (McGlone, Howorth & Pullar, 1984).

>35,000

Wk-589. Om-3 *Est* $\delta^{13}C = -25‰$

Lake sediment at approx loc P5/821505. *Comment:* diluted, 26% sample. (DJL): sample at ca 1m depth in core. Dates thin, slightly gritty layer within grayish, muddy gyttja.

>35,000

Wk-588. Om/D1-225 $\delta^{13}C = -28.6‰$

Lake sediment at loc P5/821505. *Comment:* diluted, 25% sample. (DJL): sample straddles thin, intermittently occurring tephra (?) layer (lab no. 6) at ca 2.2m depth that marks change in sediments from grayish mud above to brownish gyttja below.

>30,000

Wk-587. Om/C2-247 $\delta^{13}C = -24.5‰$

Lake sediment at loc P5/827494. *Comment:* diluted, 24% sample. (DJL): sample straddles uncorrelated white rhyolitic ash layer (lab no. 3) at ca 2.5m depth in core; date is average for tephra.

>35,000

Wk-586. Om-1 $\delta^{13}C = -24.3‰$

Lake sediment at loc P5/821505. *Comment:* diluted, 46% sample. (DJL): sample straddles uncorrelated white rhyolitic ash layer (lab no. 4) at ca 4m depth in core; date is average for tephra.

>35,000

Wk-585. Om/C2-400 $\delta^{13}C = -21.7‰$

Basal lake sediment at loc P5/827494. *Comment:* diluted, 44% sample. (DJL): dates fm of initial "proto-Lake Omapere." As initial lake basin was thought to be formed by lava flow blocking drainage (Bell & Clarke, 1909; Cotton, 1958), sample should date eruption of lava (from Te Ahuahu, Maungakawakawa, or other volcano).

Wk-584. Om/C2-417 **>30,000**
$\delta^{13}C = -22.5‰$

Small fragments of conifer wood (either *Podocarpus totara/hallii* or *Dacrydium cupressinum* or *Libocedrus;* R Patel, pers commun, 1984) and assoc carbonaceous material in paleosol-like muds underlying basal lake sediments at loc P5/827494. *Comment:* diluted, 53% sample. (DJL): date is max age for inundation of pre-lake surface by proto-Lake Omapere at this site.

Wk-581. Om/E1-470 **>35,000**
$\delta^{13}C = -26.3‰$

Wood fragments in peat underlying basal lake sediments at loc P5/821501. *Comment* (DJL): date is max for inundation by proto-Lake Omapere at this site, and age of sub-lake peat bog.

Wk-583. Om/A2-160 **>35,000**
$\delta^{13}C = -26.2‰$

Wood (*Agathis australis*?) underlying basal lake sediments at loc P5/840502. *Comment* (DJL): date is max for inundation of pre-lake surface by proto-Lake Omapere at this site.

General Comment (DJL): changes in nature of lake sediment, range of ages obtained, and sparse tephras preserved, suggest that lake has existed only intermittently in Omapere basin with gaps in depositional record. Modern lake was possibly formed only ca 1000 BP. Dates on Mamaku (?) Ash, Rotoehu Ash, and the older tephras (probably all derived from Taupo Volcanic Zone) are first obtained on rhyolitic tephras in Northland other than late Holocene Kaharoa Ash and Taupo Pumice deposits (Pullar, Kohn & Cox, 1977; Stewart, Neall & Syers, 1984).

Kaipo Lagoon series

Peat containing abundant coarse roots coll from two sites at outlet of Kaipo Stream, draining Kaipo Lagoon, Urewera National Park (38° 41′ S, 177° 11′ E) (W18/740720). Kaipo Lagoon is 73ha ombrogenous shrub bog at 1100m alt surrounded by mature silver beech (*Nothofagus menziesii*) and red beech (*N fusca*) (Lowe & Hogg, 1986). Coll and subm 1982 by N B Rogers, D J Lowe, and A G Hogg, School Sci, Univ Waikato. Samples are from site 1 unless noted. Some samples were split into coarse (handpicked roots) and fine (fine peat residual after root extraction) fractions, each being dated separately.

Wk-499. K-I1 **2910 ± 60**
$\delta^{13}C = -25.7‰$

Coarse root fraction of K-I (for residual fine peat fraction, see Wk-500). *Comment:* diluted, 91% sample. (DJL): date is min for Waimihia Lapilli Member of Waimihia Fm.

3040 ± 50

Wk-500. K-I2 $\delta^{13}C = -26.4‰$

Residual fine peat fraction of K-I (for coarse root fraction, see Wk-499). *Comment* (DJL): date is min for Waimihia Lapilli Member of Waimihia Fm. Similarity of date to Wk-499 indicates that material is probably autochthonous.

3250 ± 70

Wk-498. K-H $\delta^{13}C = -26.4‰$

Bulk peat. *Comment:* diluted, 71% sample. (DJL): date is max for Waimihia Lapilli Member of Waimihia Fm.

4490 ± 60

Wk-496. K-G $\delta^{13}C = -26.9‰$

Bulk peat. *Comment* (DJL): sample bridges two tephras; date is max for Hinemaiaia Tephra Fm (definition of Froggatt, 1981a; Lowe, 1986a) and min for Whakatane Ash Fm.

4530 ± 60

Wk-497. K-Gg $\delta^{13}C = -26.4‰$

Bulk peat from site 2, 10m S of site 1. *Comment* (DJL): date is max for Hinemaiaia Tephra Fm (definition of Froggatt, 1981a; Lowe 1986a) and min for Whakatane Ash Fm.

4860 ± 70

Wk-501. K-J $\delta^{13}C = -26.4‰$

Bulk peat from site 2, 10m S of site 1. *Comment:* diluted, 73% sample. (DJL): date is max for Whakatane Ash Fm.

5440 ± 170

Wk-493. K-F1 $\delta^{13}C = -25.8‰$

Coarse root fraction of K-F (for residual fine peat fraction, see Wk-494). *Comment:* diluted, 23% sample. (DJL): date is min for Rotoma Ash Fm; significantly younger than Wk-494, suggesting natural contamination of peat overlying tephra. Thus, date is unreliable for eruption of Rotoma Ash.

7380 ± 80

Wk-494. K-F2 $\delta^{13}C = -26.8‰$

Residual fine peat fraction of K-F (for coarse root fraction, see Wk-493). *Comment* (DJL): date is min for Rotoma Ash Fm; nearer previous dates on this tephra but still appears anomalously young. See comment for Wk-523.

7560 ± 100

Wk-495. K-Ff $\delta^{13}C = -26.2‰$

Bulk peat from site 2, 10m S of site 1. *Comment:* diluted, 57% sample. (DJL): date is min for Rotoma Ash Fm; may be anomalously young for eruption of this tephra. See comment for Wk-523.

8710 ± 80

Wk-492. K-E $\delta^{13}C = -26.7‰$

Bulk peat. *Comment* (DJL): date is min for Opepe Tephra Fm.

9560 ± 80

Wk-491. K-C $\delta^{13}C = -27.0‰$

Bulk peat. *Comment* (DJL): date is min for Poronui Tephra Fm. First date for this tephra (with Wk-351, -352).

10,160 ± 130

Wk-351. K-B1 $\delta^{13}C = -29.4‰$

Coarse root fraction of K-B (for residual fine peat fraction, see Wk-352). *Comment:* diluted, 61% sample. (DJL): date is max for Poronui Tephra Fm (see comment for Wk-491). Also gives close estimate of min age of Karapiti Tephra Fm (ca 10,100 BP), which is only a few cm below sample (see Figs 2 and 4). Date agrees with Wk-352; hence, likely to be reliable.

9960 ± 90

Wk-352. K-B2 $\delta^{13}C = -28.5‰$

Residual fine peat fraction of K-B (for coarse root fraction, see Wk-351). *Comment* (DJL): date is max for Poronui Tephra Fm (see comment for Wk-491) and est of min age of underlying Karapiti Tephra Fm (see comment for Wk-351).

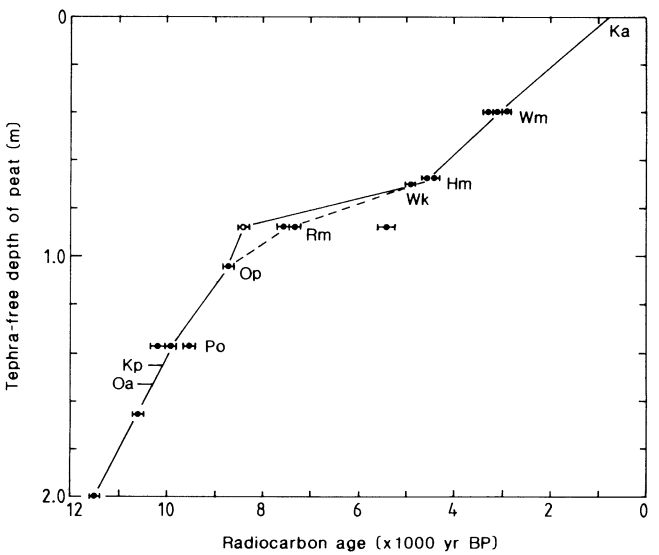

Fig 4. Peat accumulation rate curve for the Kaipo Lagoon Bog based on dates in the Kaipo Lagoon series (closed circles). Tephra abbreviations are given in Figure 2. The dates on Rotoma Ash (Rm) are considered anomalously young; hence, the preferred sedimentation rate curve (solid line) is drawn through the dates obtained on this tephra in the Lake Maratoto series (open circle, Wk-522, -523). After Lowe & Hogg (1986).

10,600 ± 90

Wk-263. K-A $\delta^{13}C = -29.6‰$

Bulk peat. *Comment* (DJL): date is max for lowermost tephra, probably member of Okupata Tephra Fm, at 2.3m depth in section.

11,500 ± 80

Wk-264. K-K $\delta^{13}C = -29.1‰$

Bulk peat. *Comment* (DJL): sample at 2.7m depth in section; date is max for inception of peat growth in Kaipo Lagoon.

General Comment (DJL): apart from three dates assoc with deposition of Rotoma Ash (Wk-493 to -495), which are considered anomalously young, dates on other tephras generally accord with previous determinations (Lowe & Hogg, 1986). Difference between Wk-493 (coarse root fraction) and -494 (residual fine peat) suggests that where contamination is suspected in bogs, fine peat fractions may produce more reliable dates than roots or bulk samples. Plot of peat accumulation rates (Fig 4) for Kaipo Lagoon bog shows slow rates overall (average 0.19mm/yr). However, average rate between ca 11,500 and ca 8700 BP was 0.37mm/yr but from ca 8700 BP to bog surface (ca 700 BP) was much slower 0.13mm/yr. Lowe & Hogg (1986) suggest that this pattern may relate to climatic change, but that variations in local conditions could also have been important influences.

Moanatuatua Bog series

Samples of peat and wood fragments coll by Russian/Jowsey peat sampler from Moanatuatua Peat Bog at Muir Rd near Ohaupo in Hamilton Basin (37° 57′ S, 175° 22′ E) (S15/180581). Coll 1982 by D J Lowe, R S P Lane, and A G Hogg and subm by D J Lowe and A G Hogg. Moanatuatua Bog is oligotrophic, high moor, restiad bog with mesotrophic margins, up to ca 12m thick, and covers ca 85km^2 (Davoren, 1978).

5850 ± 70

Wk-562. Muir-137 & 139 $\delta^{13}C = -27.7‰$

Comment (DJL): sample between two tephra layers; date is min for uncorrelated tephra (Mamaku Ash Fm?) at ca 6.2m depth and approx max for uncorrelated tephra at ca 6.0m depth.

10,650 ± 140

Wk-561. Muir-150 & 151 $\delta^{13}C = -28.0‰$

Comment (DJL): sample bridges two tephra layers; date is max for uncorrelated tephra at ca 9.3m depth, min for uncorrelated tephra at ca 9.4m depth. Base of bog at ca 10.8m.

12,800 ± 110

Wk-531. Muir-168 & 170 $\delta^{13}C = -27.4‰$

Comment (DJL): sample straddles tephra layer tentatively identified as Waiohau Ash Fm at ca 10.7m depth; date is average (see comment for Wk-233). Base of bog at ca 10.9m.

12,950 ± 110

Wk-530. Muir-48 $\delta^{13}C = -28.0‰$

Comment (DJL): sample overlies tephra, probably Rotorua Ash Fm, at ca 10.9m depth; date is min. Base of bog at ca 11.0m.

13,300 ± 110

Wk-529. Muir-50 $\delta^{13}C = -28.6‰$

Comment (DJL): sample comprises muddy peat and underlies tephra, probably Rotorua Ash Fm, at ca 10.9m; date is max. Also dates start of peat growth at this site (base of bog at ca 11.0m). See also Wk-116 (Waikato Swamp series).

General Comment (DJL): first dates on tephras in bogs in Hamilton Basin. Dates also indicate that average rate of peat growth of Moanatuatua bog at this site has been ca 1mm/yr (growth rate may not have been uniform, however).

Hauraki Plains series

Peat cored from Kopuatai Peat Dome of Hauraki Plains Swamp, Hauraki Plains (37° 25′ S, 175° 34′ E) at three sites. Coll 1977–1980 by A G Hogg, D J Lowe, and L Gaylor and subm by A G Hogg. Kopuatai Dome is largest raised (domed) bog in natural condition left in New Zealand (Irving, Skinner & Thompson, 1984). Hauraki Plains Swamp is oligotrophic, high moor restiad bog covering ca 240km^2 and is up to ca 12m thick (Davoren, 1978).

6280 ± 70

Wk-106. HP2 $\delta^{13}C = -27.6‰$

Coll 1977 from 6.0 to 6.3m below surface of bog at T13/377162. *Comment:* diluted, 84% sample. (AGH): date is max for Tuhua Tephra Fm.

6070 ± 80

Wk-241. HP3 $\delta^{13}C = -28.0‰$

Coll 1980 from 5.9m below surface of bog at T13/373190. *Comment:* diluted, 79% sample. (AGH): date is min for Tuhua Tephra Fm.

6440 ± 80

Wk-242. HP4 $\delta^{13}C = -28.2‰$

Coll 1980 from 6.0m below surface of bog at T13/373190. *Comment:* diluted, 87% sample. (AGH): date is max for Tuhua Tephra Fm.

6060 ± 80

Wk-244. HP5 $\delta^{13}C = -27.3‰$

Coll 1980 from 5.9m below surface of bog at T13/366188. *Comment* (AGH): date is min for Tuhua Tephra Fm.

6710 ± 80

Wk-243. HP6 $\delta^{13}C = -27.9‰$

Coll 1980 from 6.0m below surface of bog at T13/366188. *Comment* (AGH): date is max for Tuhua Tephra Fm; probably overestimates age of eruption because of excessive sample size.

9360 ± 100

Wk-102. HP1 $\delta^{13}C = -27.6‰$

Coll 1977 from base of Hauraki bog (9.7 to 10.0m depth) at T13/377162. *Comment* (AGH): marks initial formation of bog at this site.

General Comment (DJL): dates agree with that for Tuhua Tephra at Lake Maratoto (Lowe *et al,* 1980; Hogg & McCraw, 1983). Dates indicate average growth rate for bog has been ca 1mm/yr.

Te Rangaakapua series

Peat coll from pit dug into subalpine bog containing tephra beds at Te Rangaakapua, Urewera National Park (38° 31′ S, 177° 12′ E) (W17/765894). Coll 1984 by W B Shaw and subm by W B Shaw and D J Lowe, School Sci, Univ Waikato. Each sample ca 4cm thick and separated from overlying and underlying tephra layers by ca 2 to 3cm of peat, *ie,* not immediately adjacent to either tephra.

3660 ± 70

Wk-610. TR1 $\delta^{13}C = -25.4‰$

Comment: diluted 72% sample. (DJL): date is max limit for overlying Waimihia Lapilli Member of Waimihia Fm, and min limit for underlying Whakatane Ash Fm.

5510 ± 70

Wk-611. TR2 $\delta^{13}C = -26.0‰$

Comment: diluted, 80% sample. (DJL): date is max limit for overlying Whakatane Ash Fm and min for underlying Rotoma Ash Fm.

General Comment (DJL): dates are broadly consistent with previous results for these tephras (Lowe & Hogg, 1986; Lowe, 1986a), given position of samples with respect to tephras.

8560 ± 80

Wk-612. Mata-2/132-138 $\delta^{13}C = -25.5‰$

Peat cored with motorized Giddings auger from shallow peat bog at end of Pohlen Rd, Matamata (37° 47′ S, 175° 47′ E) (T14/562762). Coll 1984 by D J Lowe and M McLeod, and subm by D J Lowe. *Comment* (DJL): date is min for Mamaku Ash Fm (?) (possibly reworked); dates inception of peat growth at this site.

1920 ± 110

Wk-425. Rotokare-1 $\delta^{13}C = -31.6‰$

Grayish lake sediment cored from Lake Rotokare, near Eltham, Taranaki (39° 27′ S, 174° 24′ E) (V17/219904). Coll 1980 by C H Hendy and subm by D J Lowe and C H Hendy. *Comment:* diluted, 26% sample. (DJL): date is min for andesitic tephra at ca 1.3m depth (tentatively correlated with Mangatawai Tephra (?) of Topping, 1973 or Kaupokonui tephra (?) of Neall & Geddes, 1981); estimates rate of sedimentation in lake (ca 1.5mm/yr); date is min for fm of lake (base of lake sediments not seen).

2. Dates Associated with Deposition of Alluvium of Hinuera Formation

Motumaoho series

Logs and peat from exposure on Hamilton to Morrinsville Rd (SH 26), 100m S of junction with Harbottle Rd (37° 42′ S, 175° 29′ E). Coll 1975 and subm by H S Gibbs, Earth Sci Dept, Univ Waikato. Samples occur either within or overlying Hinuera Fm sediments at three sites (A, C, F). Peat 1 layer, 300 to 330cm below surface; peat 2 layer, 50cm below peat 1 layer, *ie,* 380cm below surface. See also Harbottle Rd series.

Wk-65. A/2 **16,630 ± 670**
Est $\delta^{13}C = -25‰$

Peat in Hinuera sediments, upper 8cm of peat 1 layer, at site A, S14/276860. *Comment:* diluted, 69% sample.

Wk-66. A/3 **16,600 ± 750**
Est $\delta^{13}C = -25‰$

Peat in Hinuera sediments, 8 to 15cm of peat 1 layer, at site A, S14/276860. *Comment:* diluted, 72% sample.

Wk-67. A/4 **15,400 ± 1200**
Est $\delta^{13}C = -25‰$

Peat in Hinuera sediments, 20 to 30cm of peat 1 layer, at site A, S14/276860. *Comment:* diluted, 39% sample.

Wk-70. C/2 **16,710 ± 480**
Est $\delta^{13}C = -25‰$

Peat in Hinuera sediments, peat 1 layer, at site C, S14/275860, 50m W of site A.

Wk-74. Site F/1 **17,050 ± 540**
Est $\delta^{13}C = -25‰$

Log in peat layer 2 at site F, S14/276861, 70m NNW of site A.

General Comment (HSG): dates are in broad agreement with each other and are approx for last period of deposition of Hinuera-2 sediments by ancestral Waikato R in Morrinsville Gap.

Te Rapa series

Peat from Eastern Sanitary Interceptor, Te Rapa, Hamilton (37° 44′ S, 175° 15′ E) (S14/081826). Coll 1975 by C S Nelson and D Cope and subm by C S Nelson, Earth Sci Dept, Univ Waikato.

Wk-37. CSN-1 **39,900 $^{+3300}_{-2400}$**
Est $\delta^{13}C = -25‰$

Bore 2, 30m below Waikato R level on W bank.

Wk-38. CSN-2 **>40,000**
Est $\delta^{13}C = -25‰$

Bore 6, 30m below Waikato R level of W bank, 10m from bore 2.

General Comment (CSN): first dates for Hinuera-1 alluvial deposits of Hinuera Fm in Hamilton Basin. Wk-37 also yielded preliminary U/Th age of <65,000 BP (C H Hendy *in* McGlone, Nelson & Hume, 1978).

Riverlea series

Carbonaceous mud and sand with occasional poorly preserved woody fragments from three carbonaceous strata within fluvial pumiceous silts, sands, and gravelly sands of Hinuera Fm at site opposite Riverlea Wreckers near Hamilton on Hamilton to Cambridge hwy (37° 49′ S, 175° 20′ E) (S14/162744). Coll 1981 and subm by C S Nelson.

Wk-393. W3 **18,250 ± 180**
Est $\delta^{13}C = -25‰$

Carbonaceous mud, 0.25m thick, 3.5 to 3.75m below Hinuera surface. *Comment* (CSN): dates closing period of active aggradation of Hinuera sedimentation in Hamilton Basin.

Wk-392. W2 **20,200 ± 210**
Est $\delta^{13}C = -25‰$

Carbonaceous pumice sands, 0.5m thick, 10.75 to 11.25m below Hinuera surface. *Comment* (CSN): dates active aggradation phase of Hinuera sedimentation in Hamilton Basin.

Wk-391. W1 **21,300 ± 240**
Est $\delta^{13}C = -25‰$

Woody, carbonaceous sands, ca 0.7m thick, ca 14.5 to 15m below Hinuera surface. *Comment* (CSN): dates active aggradation phase of Hinuera sediments in Hamilton Basin.

General Comment (DJL): dates accord with stratigraphy and generally agree with previous determinations on Hinuera-2 sedimentation in Hamilton Basin (McGlone, Nelson & Hume, 1978).

Waihou series

Peat occurring as lenses within pumiceous silts, sands, and gravels of Hinuera Fm, exposed either within rd cuttings and quarries or obtained from drill cores. Sampled at four sites near Matamata in Waihou R valley. Coll 1979 by A S Cuthbertson and subm by C S Nelson.

Wk-216. C3 **19,400 ± 200**
$\delta^{13}C = -28.2‰$

Peat ca 2.5m below ground surface from quarry near Matamata on Matamata to Tauranga hwy (37° 49′ S, 175° 45′ E) (T14/572716). *Comment* (ASC): upper age of Hinuera sedimentation in central S Hauraki Lowlands.

Wk-217. C2 **18,400 ± 200**
$\delta^{13}C = -26.8‰$

Peat within layer 6.2 to 7.0m below ground surface from rd cutting near Omahine Stream Bridge on Matamata to Tauranga hwy (37° 51′ S,

175′ 52′ E) (T15/628677). *Comment* (ASC): upper age of Hinuera sedimentation in central S Hauraki Lowlands.

Wk-218. Bore 37 **23,900 ± 400** $\delta^{13}C = -25.9‰$

Peat lens, 0.8m thick, 28.1m below land surface, obtained from drill core in center of Matamata Township (37° 48′ S, 175° 46′ E) (T14/542732). *Comment* (ASC): lower age of Hinuera sedimentation in central S Hauraki Lowlands.

Wk-274. S36 **>40,000** $\delta^{13}C = -27.6‰$

Peat lens, 2m thick, ca 20m below land surface, from section exposed along Waiomou Stream on Matamata to Tauranga hwy (37° 51′ S, 175° 53′ E) (T15/621680). *Comment* (ASC): date may represent boundary between Hinuera-1 and Hinuera-2 depositional periods.

General Comment (DJL): dates indicate period when ancestral Waikato R entered Hauraki (Matamata) basin (Cuthbertson, ms).

Lake Rotokaraka series

Lake sediment overlying or within sandy muds to muddy sands of Hinuera Fm obtained with piston corer from Lake Rotokaraka, Whitikahu, Hamilton Basin (37° 37′ S, 175° 20′ E) (S14/166965). Coll 1983 by D J Lowe, C H Hendy, and L J Gaylor and subm by D J Lowe.

Wk-567. A/4-2.2 **13,800 ± 370** $\delta^{13}C = -26.6‰$

Comment: diluted, 24% sample. (DJL): sample 20cm thick at base of lake sediment. Dates fm of modern Lake Rotokaraka and last depositional event of Hinuera Fm at this site. Also estimates age for uncorrelated andesitic (?) tephra ca 15cm above base of lake sediment column. Date is younger than expected as Rerewhakaaitu Ash, ca 14,700 BP, occurs in lake sediment 1.5m above sample.

Wk-568. A/4-2.8 **15,900 ± 630** $\delta^{13}C = -25.5‰$

Comment: diluted, 18% sample. (DJL): dates proto-Lake Rotokaraka that existed between last and 2nd to last depositional episodes of Hinuera Fm deposition at this site.

Wk-569. A/4-3.7 **16,600 ± 260** $\delta^{13}C = -25.7‰$

Comment: diluted, 52% sample. (DJL): dates proto-Lake Rotokaraka that existed between 2nd to last and 3rd to last depositional episodes of Hinuera Fm at this site.

General Comment (DJL): establishes chronology for succession of Hinuera-2 depositional episodes at this site (see Lake Maratoto series and Green & Lowe, 1985).

17,500 ± 540

Wk-59. *Est $\delta^{13}C = -25‰$*

Sample from peat layer, 3 to 10cm thick, 5m below top of Hinuera Fm at Hamilton Refuse site, Rototuna, Hamilton (37° 44′ S, 175° 16′ E) (S14/102830). Coll 1974 by T M Hume and C S Nelson and subm by C S Nelson. *Comment* (CSN): near upper age on Hinuera Fm alluvial deposits (Hinuera-2) within Hamilton Basin at this site.

17,790 ± 290

Wk-169. *$\delta^{13}C = -31.2‰$*

Peat in layer approx in middle of Hinuera Fm silts and sands, total thickness 7.3 to 11.5m, forming highest of series of degradational terraces, at site 3km SE of Karapiro Hall, Karapiro (37° 56′ S, 175° 35′ E) (T15/370593). Coll 1978 and subm by H S Gibbs, Earth Sci Dept, Univ Waikato. *Comment* (HSG): dates time ancestral Waikato R broke through Karapiro Gorge.

15,700 ± 200

Wk-566. LA/1-2.6 *$\delta^{13}C = -23.9‰$*

Lake sediment, ca 5.5 to 5.7m below sediment surface, cored from Leeson's Pond, Tauhei to Motumaoho Rd, Hamilton Basin (37° 39′ S, 175° 28′ E) (S14/287929). Coll 1983 by D J Lowe and L Gaylor and subm by D J Lowe. *Comment:* diluted, 61% sample. (DJL): base of lake sediment not seen. Date is min for fm of Leeson's Pond and estimate of last deposition of Hinuera Fm sediments in this part of Hamilton Basin. Sedimentation rate for period between Wk-566 and Rerewhakaaitu Ash, ca 14,700 BP, at 4.5m depth is relatively fast (0.7mm/yr) compared with later rates (see General Comment for Lake Maratoto series).

17,600 ± 190

Wk-614. Rototuna-1 *$\delta^{13}C = -26.5‰$*

Peat with twigs underlying lake sediment, ca 6.6 to 6.8m below sediment surface, cored in drained "Rototuna lake," Lake Tunawhakapeka with motorized Giddings auger near Rototuna, Hamilton (37° 43′ S, 175° 17′ E) (S14/116853). Coll 1984 by D J Lowe and L Gaylor and subm by D J Lowe. *Comment:* diluted, 88% sample. (DJL): sample overlies gritty mud, Hinuera Fm. Dates fm of Lake Tunawhakapeka and is min age for deposition of Hinuera Fm at this site.

Waikare series

Carbonaceous mud and sand from drill cores at two sites (nos. 5, 13) in Ohinewai Peatland near Lake Waikare (37° 30′ S, 175° 12′ E). Coll 1979–1980 by A J Todd and subm by C S Nelson, Earth Sci Dept, Univ Waikato.

17,800 ± 200

Wk-280. P43 *$\delta^{13}C = -28.3‰$*

Sample from 10.9m depth at site 13 (S13/035109) in lacustrine mud. *Comments* (AJT): dates late Pleistocene mud underlying modern surface

peats and unconformably overlying Pleistocene fluvial gravelly sands. (DJL): mud unit found in proto-Lake Waikare formed by deposition of Hinuera Fm sediments (McGlone, Nelson & Todd, 1984).

Wk-226. P42 **>40,000** $\delta^{13}C = -29.8‰$

Sample from 25.7m depth at site 5 (S13/039097) in coarse volcaniclastic sands, alluvium, in either Karapiro or Puketoka Fm that antedate Hinuera Fm sediments. *Comments* (AJT): dates Quaternary fluvial sequence in Lower Waikato Basin. (DJL): date is max for Hinuera Fm deposition at this site (McGlone, Nelson & Todd, 1984). See also Ohinewai Peatlands series.

Pukerimu series

Peat and peaty mud in section through terrace at ca 40m asl, ca 10m above Waikato R, Pukerimu Lane, off Cambridge to Ohaupo Rd, Pukerimu dist (37° 54′ S, 175° 26′ E) (S15/241642). Higher terrace, at ca 60m asl, forms main Hinuera Surface. Coll 1985 by D J Lowe and M Lowe and subm by D J Lowe.

Wk-726. Pukerimu-4 **22,900 ± 350** $\delta^{13}C = -25.7‰$

Carbonaceous mud, gyttja-like, at top of layer, ca 0.6m thick, ca 2.2m below terrace surface. Layer underlies gravelly sand, Hinuera Fm, and overlies sticky blue clay, overbank flood deposit (?), Hinuera Fm. *Comment:* diluted, 82% sample. (DJL): date is max for latest episode of Hinuera-2 sedimentation, overlying deposits, in Hamilton Basin.

Wk-725. Pukerimu-3 **22,700 ± 290** $\delta^{13}C = -27.0‰$

Carbonaceous mud, gyttja-like, at base of layer, ca 0.6m thick, ca 2.8m below terrace surface (see Wk-726). *Comment* (DJL): date supports Wk-726.

Wk-724. Pukerimu-2 **>40,000** *Est* $\delta^{13}C = -25‰$

Peaty pumiceous mud layer, ca 0.2m thick, at ca 3.8m depth below terrace surface. Overlain by sticky blue clay, underlain by cross-bedded pumiceous sands and gravelly muds of Hinuera Fm. *Comment:* diluted, 25% sample. (DJL): date indicates that underlying sediments represent Hinuera-1, or earlier, deposits through which Waikato R has re-entrenched.

Wk-723. Pukerimu-1 **>40,000** *Est* $\delta^{13}C = -25‰$

Peat with small wood fragments at base of peat layer, ca 1m thick, ca 7.5m below terrace surface, at rd level. Peat layer underlies sands and muds of Hinuera Fm and overlies bluish ignimbrite, gleyed Puketoka Fm (?). *Comment* (DJL): date suggests that overlying sediments up to Wk-725, -726 represent Hinuera-1 deposits, in agreement with Wk-724.

General Comment (DJL): dates agree with stratigraphy. Wk-723 and -724 add to two previous dates on Hinuera-1 sediments in Hamilton Basin (see Te Rapa series). Wk-725 and -726 indicate that overlying sediments in this terrace, and higher terrace at 60m asl, represent Hinuera-2 sedimentation (McGlone, Nelson & Hume, 1978). Thus, section apparently shows contact between Hinuera-1 and Hinuera-2 sediments, first such subaerial exposure known in Hamilton Basin.

3. *Dates Associated with Peat Bog Growth or Local Sedimentation that Postdates Deposition of Hinuera Fm, ie, <ca 15,000 BP*

Lake Hakanoa series

Wood or organic lake sediment coll by piston corer from Lake Hakanoa, Huntly (37° 33′ S, 175° 10′ E) (S13/018033). Coll 1982 (Hak-1) and 1984 (HK 1-3) and subm by B McCabe, D J Lowe, and C H Hendy. Hk 1-3 samples, coll by BMcC, date silt band within organic sediment column and Hak-1, coll by DJL, BMcC & CHH, is derived from base of column.

Wk-608. HK-3 **750 ± 50**
$\delta^{13}C = -29.0‰$

Lake sediment overlying silt layer. *Comment:* diluted, 75% sample.

Wk-607. HK-2 **1020 ± 50**
$\delta^{13}C = -31.0‰$

Lake sediment from within silt layer. *Comment:* diluted, 82% sample.

Wk-606. HK-1 **1240 ± 60**
$\delta^{13}C = -32.3‰$

Lake sediment underlying silt layer. *Comment:* diluted, 55% sample.

General Comments (BMcC): dates deposition of silt band that accompanied deforestation in catchment surrounding Lake Hakanoa and change in $\delta^{13}C$ of lake sediment. (DJL): postulated deforestation may relate to natural events or to Polynesian cultural influence (*cf* McGlone, 1983). Polynesians inhabited many sites adjacent to such lakes in Waikato district in last millenium (Pick, 1968; Shawcross, 1968; Bellwood, 1978; Lowe *et al,* 1984).

Wk-424. Hak-1 **2040 ± 50**
$\delta^{13}C = -26.9‰$

Wood (kauri?) within gritty muds overlain by ca 1m of Taupo Pumice Alluvium and ca 0.9m of lake sediments. *Comment* (DJL): date is approx for deposition of Taupo Pumice Alluvium; dates fm of Lake Hakanoa (Lowe & Green, 1987). Average sedimentation rate in lake, ca 2mm/yr, is ca 10 times faster than average rate in Hinuera-dammed lakes (see General Comment for Lake Maratoto series).

Pukekapia series

Peat from drained swamp E of Pukekapia Rd near Lake Rotongaro, Huntly Dist (37° 30′ S, 175° 8′ E) (S13/982089). Coll 1974 and subm by H S Gibbs. Peat is ca 2.4m thick and overlies silty base.

3760 ± 110

Wk-61. S4 *Est* $\delta^{13}C = -25‰$

Sample from 2.07 to 2.17m below peat surface.

4040 ± 120

Wk-60. S2 *Est* $\delta^{13}C = -25‰$

Sample from 2.27 to 2.34m below peat surface.

General Comment (HSG): date is approx for commencement of peat fm at this site (see also Ohinewai Peatlands series and McGlone, Nelson & Todd, 1984).

Ohinewai Peatlands series

Peat from drill cores at two sites (nos. 5, 9) in Ohinewai Peatland, near Ohinewai (37° 30′ S, 175° 12′ E). Coll 1981 by A J Todd and subm by C S Nelson. Ohinewai Peatlands are near Lake Waikare, cover 15km^2, and are mesotrophic with some oligotrophic characteristics (Davoren, 1978). Peat has average thickness of 6 to 9m, max 11.5m, and overlies lacustrine mud deposited in proto-Lake Waikare (McGlone, Nelson & Todd, 1984).

2310 ± 60

Wk-356. P87 $\delta^{13}C = -29.3‰$

Sample from 0.4m depth at site 9 (S13/044100). *Comment* (AJT): date is min for surface peat fm in Lower Waikato Basin.

3290 ± 60

Wk-359. P88 $\delta^{13}C = -27.9‰$

Sample from 3.4m depth at site 9 (S13/044100). *Comment* (AJT): improves age definition of surface peat in Lower Waikato Basin.

5820 ± 60

Wk-281. P86 $\delta^{13}C = -27.7‰$

Sample from 6.5m depth at site 9 (S13/044100). Base of peat at 6.9m. *Comment* (AJT): dates base of surface peat of Lower Waikato Basin.

4950 ± 70

Wk-224. P40 $\delta^{13}C = -28.3‰$

Sample from 1.2m depth at site 5 (S13/039097). *Comment* (AJT): provides peat accumulation rate in Ohinewai bog, Lower Waikato Basin.

7100 ± 80

Wk-225. P41 $\delta^{13}C = -29.1‰$

Sample from 4.1m depth at site 5 (S13/039097). *Comment* (AJT): provides peat accumulation rate in Ohinewai bog, Lower Waikato Basin.

General Comment (DJL): dates provide chronology for palynologic study by McGlone, Nelson & Todd (1984). See also Waikare series.

Harbottle Road series

Tree stumps in silty sands overlying peat layers on Hinuera Fm sediments in exposure on Hamilton to Morrinsville Rd, SH 26, at two sites, B, F

(37° 42′ S, 175° 27′ E) (see Motumaoho series for additional stratigraphic details). Coll 1975 and subm by H S Gibbs.

6410 ± 290

Wk-68. B/1 *Est* $\delta^{13}C = -25‰$

Tree stump in silty sand 170cm below terrain surface and 130cm above peat layer 1, at site B (S14/276860), 8m W of site A. *Comment:* diluted, 49% sample.

7000 ± 170

Wk-73. E/1 *Est* $\delta^{13}C = -25‰$

Tree stump in silty sand at 300cm depth and lying above peat layer 1, at site E (S14/276861), 70m N of site A.

General Comment (HSG): dates are much younger than dates on underlying peat and wood assoc with Hinuera Fm sediments (see Motumaoho series); this suggests that silty sands are locally reworked deposits rather than from ancestral Waikato R.

Waikato Swamps series

Basal peat or wood cored with Hiller corer from Rukuhia and Moanatuatua Peat Swamps, near Hamilton (Fig 1). Wk-114 to -116 coll 1977 by A T Wilson and K Thompson and subm by A T Wilson, Chemistry Dept, Univ Waikato; other samples coll 1982–1983 as noted. Rukuhia bog, like Moanatuatua (see Moanatuatua series) is ombrogenous oligotrophic high moor bog with mesotrophic fringes, up to 12m thick, and covers ca 64km^2 (Davoren, 1978).

10,250 ± 90

Wk-114. *Est* $\delta^{13}C = -25‰$

Peat from base of Rukuhia bog, 8.3m depth (37° 54′ S, 175° 18′ E) (S15/076694).

10,750 ± 90

Wk-115. $\delta^{13}C = -28.4‰$

Peat from base of Rukuhia bog, 9m depth (37° 54′S, 175° 18′ E) (S15/119691).

11,800 ± 120

Wk-116. Moana #1 $\delta^{13}C = -28.6‰$

Peat from base of Moanatuatua bog, 10m depth (37° 57′ S, 175° 22′ E) (S15/187608). See also Wk-529, Moanatuatua bog series.

General Comment (ATW): dates are max for peat fm at these sites.

10,600 ± 90

Wk-553. GC1-1(RJ) $\delta^{13}C = -28.5‰$

Basal peat cored by Russian/Jowsey corer from 7.5m below surface of Rukuhia peat bog 400m W of Lake Maratoto, near Hamilton (37° 54′ S,

175° 18′ E) (S15/123660). Coll 1983 by D J Lowe and L Gaylor and subm by D J Lowe. *Comment* (DJL): dates start of peat growth at this site.

12,550 ± 110

Wk-508. GC3-2 $\delta^{13}C = -25.9‰$

Rimu root wood (*Dacrydium cupressinum;* L Donaldson, pers commun, 1983) embedded in upper part of late Pleistocene colluvium underlying peat in arm of Rukuhia bog at N end of Lake Maratoto, near Hamilton (37° 54′ S, 175° 19′ E) (S15/663130). Wood at ca 6m below peat surface, ca 0.8m below base of peat, 5.2m depth, and sampled with motorized Giddings auger. Coll 1983 by D J Lowe, J D Green, and L Gaylor and subm by D J Lowe. *Comment* (DJL): gives approx age when growth of Rukuhia peat overwhelmed rimu tree, *in situ*?, at this site (Lowe, 1985).

15,200 ± 130

Wk-534. RJ1-4 $\delta^{13}C = -27.7‰$

Basal woody peat overlying Hinuera Fm sediments cored by Russian/Jowsey corer from 7.2m below surface of Rukuhia peat bog on SW shoreline of Lake Maratoto, near Hamilton (37° 54′ S, 175° 19′ E) (S15/126657). Coll 1983 by D J Lowe, J D Green, M A Chapman, and T G Northcote and subm by D J Lowe. *Comment* (DJL): dates initial development of marginal peat around Lake Maratoto shoreline soon after fm of lake basin by deposition of Hinuera Fm (see Lake Maratoto series). Such growth may indicate that effective rainfall increased at this time (Green & Lowe, 1985).

General Comment (DJL): most of dates indicate that major parts of Rukuhia and Moanatuatua bogs developed after ca 10,000 to 12,000 BP, possibly in response to climatic change with marked increase in net precipitation. Somewhat earlier date of ca 15,000 BP (Wk-534) is interpreted as initial localized peat growth near Lake Maratoto that later spread outwards and contributed to development of main body of Rukuhia bog (Green & Lowe, 1985; see also McGlone, Nelson & Hume, 1978). Dates indicate that main body of Rukuhia bog has had average growth rate ca 1.2 to 1.4mm/yr.

(98.6 ± 1.3)% modern

Wk-426. Purimu-2/1 $D^{14}C = -13.7 \pm 13.1‰$ $\delta^{13}C = -28.0‰$

Peaty lake sediment 0.9m below lake sediment surface cored from Lake Purimu, near Waipukurau, Hawkes Bay (40° 08′ S, 176° 29′ E) (Q14/464718). Coll 1980 by C H Hendy and subm by D J Lowe and C H Hendy. *Comment:* diluted, 19% sample. (DJL): catchment contains calcareous rocks hence "hard-water effect" may apply. Gives est rates of sedimentation in Lake Purimu and min age of lake fm; base of lake sediments not seen.

2620 ± 90

Wk-842. Maungarataiti-1 $\delta^{13}C = -27.6‰$

Woody lake sediment ca 2.9m below lake sediment surface cored from Lake Maungarataiti, near Hunterville, ca 50km E of Wanganui (39° 54′ S, 175° 31′ E) (S15/282431). Coll 1986 by C H Hendy and subm by D J Lowe and C H Hendy. *Comment:* diluted, 47% sample. (DJL): region contains cal-

careous sediments hence "hard-water effect" may apply. Gives est rates of sedimentation in Lake Maungaratatiti and min age of lake fm; base of lake sediments not seen but presence of wood suggests that it might be close (Lowe & Green, 1987).

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