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HAMILTON

FIELD EXCURSIONS GUIDE BOOK

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QUATERNARY STRATIGRAPHY, LANDSCAPE AND SOILS OF THE HAMILTON BASIN

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The Hamilton Basin is a roughly oval shaped depression 80 km north to south and 40 km wide centred about Hamilton City (Fig. 1). The basin is surrounded by ranges up to 300 m high developed mainly in Mesozoic basement strata. The physiographic basin is essentially a fault bounded basement depression of Late Tertiary and Pleistocene age. Throughout the Quaternary this basin has been a receptacle of terrestrial sedimentation; the materials have derived mainly from extrabasin sources and principally the Central Volcanic Region to the southeast. In addition, materials have been derived from erosion of the bounding ranges, and Coromandel Peninsula. The last major depositional episode involved flood deposits of the Taupo Pumice. The present landscape has evolved through several episodes of deposition and incision.

During the excursion it is intended to show the participants exposures of the major Quaternary units of basin infilling, and some aspects of the landscape and the soil pattern, within the environs of Hamilton City.

The standard geological reference covering the geology of Hamilton Basin is New Zealand Geological Survey Bulletin 88 (Kear & Schofield, 1978). The surface features and soil pattern of the basin are succinctly covered by McCraw (1967) and Bruce (1979).

Basin Structure

Mesozoic basement forms much of the skyline of the Hamilton Basin although it is semicontinuous in the south and east, and partly overshadowed by the late Pliocene-early Pleistocene basaltic volcano of Mount Pirongia in the southwest. The basement is clearly downfaulted 200-300 m on the western margin of the basin (shown by displaced Lower Tertiary strata) by *en echelon* north and northeast trending normal faults. Elsewhere unequivocal evidence of faulting of the basin margin is not apparent because of the absence of

Tertiary outliers, but faulting is suspected. The partially exhumed largely flat lying Cretaceous peneplain is visible from Hamilton City on the western skyline, north of Pirongia.

The mainly subsurface Waipa Fault which occurs within but near the western boundary of the basin is an important structural feature of Rangitata and Kaikoura age. It represents the juxtaposition of the western, shallow marine, volcaniclastic, fossiliferous and structurally simple facies of the Murihiku terrane, with the eastern deeper marine, unfossiliferous, structurally complex and low grade metamorphic strata of the Waipapa terrane. Suturing accompanied by substantial uplift of the Waipapa terrane is believed to have occurred during a later phase of the Rangitata Orogeny.

The exact position of the Waipa Fault is unclear due to the cover of Pleistocene deposits; its inferred subsurface trace trends through the western flanks of Pirongia, the township of Whatawhata (16 km west of Hamilton), and then trends northeast parallel to but east of the Hakarimata Range (Kear and Schofield, 1978).

Much Late Tertiary vertical displacement on the Waipa Fault about the latitude of Hamilton is inferred from the difference in elevation of basement across the basin. Gravity and drillhole data from the central part of the basin (Kear and Schofield, 1978) suggests that the Waipapa terrane occurs at variable depth and in places up to c.2000 m below the surface; this is in addition to the 300 m of displacement evident in the present topography. Intrabasin faulting other than on the Waipa Fault is also suspected from the occurrence of an inlier of basement on the Waikato River between Cambridge and Hamilton (N65/882373). Normal faults with 1 to 2 m of throw and trending N or NE are sometimes observed to displace Pleistocene strata.

Pleistocene Stratigraphy

Within the basin is a system of low ridges and isolated hillocks. In the south (Te Awamutu) and west (Whatawhata) the hills and ridges are semi-

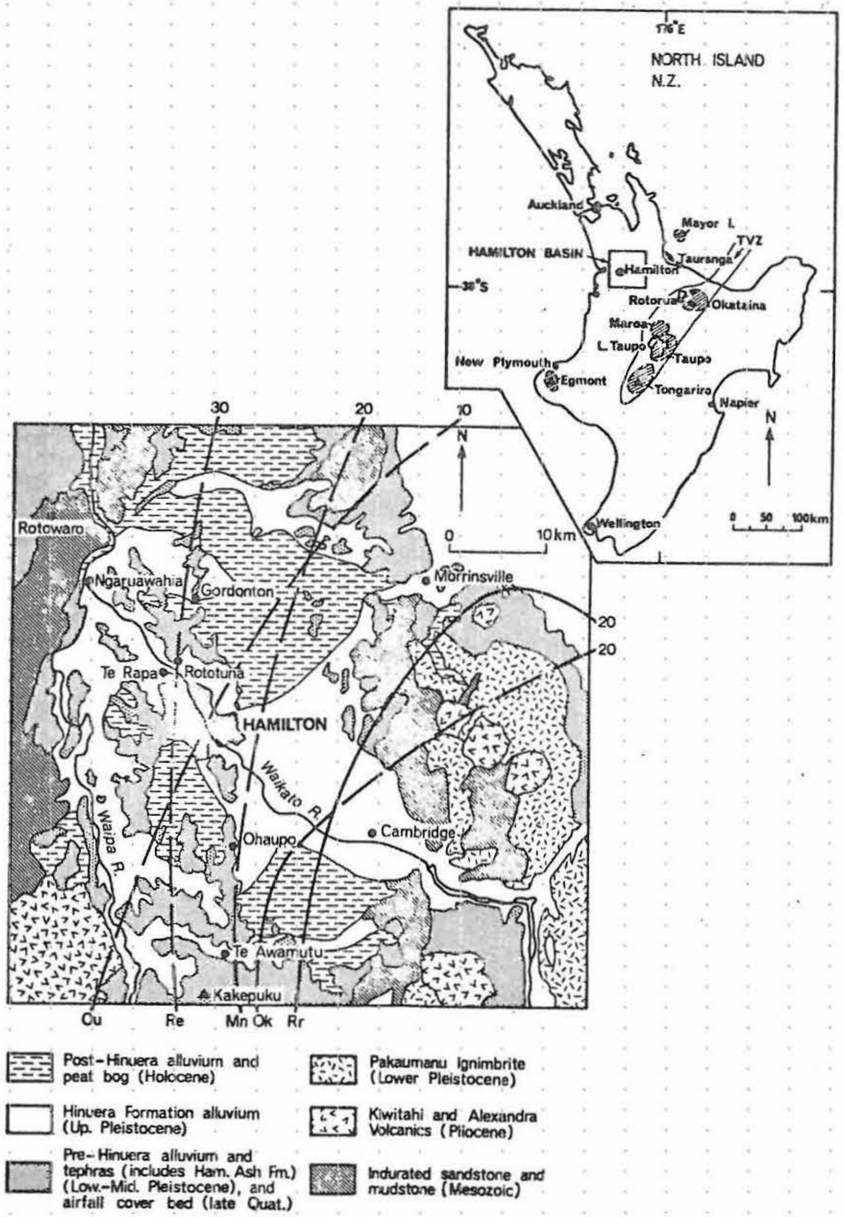

Fig. 1. Simplified geological map of the Hamilton Basin with distal-most tephra isopachs (in cm) superimposed (after Hume *et al.* 1975, p.424; Pullar and Birrell 1973). Re = Rotoehu Ash; Mn = Mangaoni Lapilli; Ok = Okareka Ash; Ou = Oruanui Ash; Rr = Rotorua Ash. Dashed line indicates isopach uncertain.
The inset shows the Hamilton Basin in relation to volcanic centres which were the most important sources of tephras, and Taupo volcanic zone (TVZ) (after McCraw 1975).

continuous and 30 to 60 m above the valley floors; to the north and east the hills are more widely spaced and protrude through an extensive alluvial plain (Fig. 1). The bulk of these Pleistocene deposits are included in the Tauranga Group as defined in Kear and Schofield (1978).

The hills comprise a spatially and temporally complex stratigraphy of interdigitating tephras, distal ignimbrites and volcaniclastic sediments that developed in an actively eroding and depositing landscape. A simplified stratigraphy of the hills outlined by Kear and Schofield (1978) and Ward (1967) is as follows:

	Hamilton Ash Formation
	Kauroa Ash Formation
Walton Sub-group	Karapiro Formation
	Puketoka Formation

Some modification of this stratigraphy is outlined in the route notes below.

Between the hills and overtopping them towards the northeast is the extensive Upper Pleistocene Hinuera Formation (Piako Sub-group) of unconsolidated alluvium. This volcaniclastic sediment was introduced to the basin from the southeast via the Maungatautiri Gorge which now forms the apex of a large, very low angle fan deposit. Sedimentation occurred in essentially two phases: Hinuera-1 sedimentation (between c.65,000 and 25,000 y B.P.) and Hinuera-2 sedimentation (between c.20,000 and 17,000 y B.P.) (Hume *et al.* 1975; McGlone *et al.* 1978). Between 25,000 and 20,000 y B.P. an ancestral Waikato River debouched via the Hinuera valley at Paerere into the Hauraki rift valley (Cuthbertson, 1981). The areal extent of the Hinuera Formation in the Hamilton Basin was controlled by the pattern of hills and major shifts in the course of the braided river system of the ancestral Waikato River during fan building (McCraw, 1967; Hume *et al.* 1975). The uppermost depositional surface of the fan (Hinuera-2), named the Hinuera Surface (Hume *et al.* 1975), is characterised by numerous lakes, extensive peat bogs, low levees

and shallow paleochannels, the origin of which are discussed by McCraw (1967) and McGlone *et al.* (1978).

Taupo Pumice Alluvium (Piako Sub-group) is a subaqueous terrace-forming deposit, within or near the Waikato River channel comprising reworked Taupo Pumice material erupted c.1800 y B.P. (186 A.D.).

Excursion stops and route:

We depart from Bryant Hall and travel through Hamilton East the bulk of which is built upon the Hinuera Surface. Good views of the Hinuera Surface incised by the present channel of the Waikato River can be gained from Cobham Drive. As we drive across Cobham Bridge a low terrace of Taupo Pumice Alluvium is evident on both sides of the river.

STOP 1 - Davies Quarry, Peacockes Road (N65/810438) to examine in section characteristics of Taupo Pumice Alluvium (Melville Pumice Member) and Hinuera Formation. The Melville Pumice Member is variable in grain size (cobble - fine sand) and sorting characteristics, is commonly bedded - either horizontally or crossbedded (forset dips up to 30°), and contains fragments of charcoal. Note the degree of soil formation (Waikato soil, a yellow-brown pumice soil or Typic Vitrandept/Entic Vitrudand) in 1800 years.

Hinuera Formation: Sediments are mainly gravelly sands, sandy gravels and silts; peat beds are developed locally. Gravel size material is dominated by fragments of rhyolite, pumice and ignimbrite; sand and silt fractions by volcanic quartz, oligoclase/andesine plagioclase, pumice and glass shards. Heavy minerals are hypersthene, magnetite, hornblende, augite, epidote and biotite. Sedimentary structures are dominated by thick cosets of cross-stratified gravelly sands and sandy gravels. From composition, texture and sedimentary structures seven lithofacies related to flow regime have been erected for the Hinuera Formation (Hume *et al.* 1975; Table 1) which correspond to deposits formed in a variety of subenvironments in a braided river system of the ancestral Waikato River. The two phases of aggradation of the Hinuera Formation were initiated by volcanism in the Central Volcanic Region, and sustained by increased rates of erosion under a cold, seasonally wet and possibly drought-prone climate.

Travel past the hospital and around Hamilton (Rotoroa) Lake (N65/776460). From Innes Common (playing fields) note that the lake is dammed by peat of the Rukuhia Bog at the mouth of a horseshoe-shaped valley. The lake is shallow (< 6 m) and an important recreation spot. Note Waikato Hospital on the hill.

Many small, typically peaty, post-glacial lakes occur on the Hinuera Surface and their origin can usually be attributed to damming of a valley by a levee of Hinuera alluvium. Subsequently the lakes may be drained by down cutting through the dam (e.g. 'Waipa lake'), or the lakes become filled with peat (e.g. Whatawhata Road Peat bog). The lakes and peats provide ideal sites for tephra and palaeoecological studies (see Stop 5 and Fig. 2).

Continue via Killarney Road to Whatawhata (Raglan) Road.

<u>STOP 2</u> - just outside city limit on Whatawhata Road (N65/728463) to examine cutting of Hamilton Ash Formation over Kauroa Ash Formation.

<u>Hamilton Ash Formation</u>

The Hamilton Ash Formation in the basin comprises strongly weathered, clay-rich, airfall tephra beds of rhyolitic and andesitic character in which paleosols are common (Ward, 1967: Pain, 1975). The formation has been subdivided into eight members (H1 to H8) which may appear to contain the product of a single eruption and the soil developed on it, but it is possible that each bed is a composite of tephras. Variations in colour and consistence are the principal features that distinguish the separate beds; colours range from red through yellowish brown and brown to white, but reddish yellow, strong brown and very pale brown predominate. Individual beds may have a friable,

firm or hard consistence. The clay mineralogy is variable between members and largely determines the consistence and structure; H2 and H5 are dominated by allophane and correspondingly friable, H4, H6 and H7 are dominated by halloysite and are firm and blocky.

The name Ohinewai Ash Member (redefined as Ohinewai Tephra by Vucetich *et al.* 1978) has been given to the basal member of Hamilton Ash Formation (Ward, 1967). It occurs in two dissimilar forms said to be variants of the same tephra by Ward, but are considered to be separate tephras by Tonkin (1970) and Pain (1975). The Te Uku Variant, named H2 by Ward, is strongly weathered and the original structure of the parent Ohinewai Ash is almost completely destroyed. It is strong brown to yellowish red with prominant fragile root pseudomorphs and large halloysite/gibbsite nodules near the base. The Huntly Variant (H1) (at this site) is characteristically pinkish grey, firm, blocky, grading up into brownish grey silt loam. Corroded quartz and plagioclase, and rare weathered hornblende and augite in a clay matrix stained with manganese occur in the basal part. Everywhere the lower boundary is sharp and forms a prominant marker bed.

The Ohinewai Ash Member has age estimates from c.400,000 y B.P. or older (Ward, 1972; McCraw, 1975) to c.150,000 y B.P. (Vucetich *et al.* 1978). A new date of 200,000 (+120,000, - 45,000) y B.P. has recently been obtained by the Uranium-Thorium disequilibria method (Hendy *et al.*, in press).

Where the Hamilton Ash materials are exposed at the surface, well-developed and strongly-structured soils occur (e.g. Naike soil, a brown granular loam or Typic Haplohumult to Humic Hapludult).

<u>STOP 3</u> - We travel 200 m along the road to the next major cutting where Puketoka Karapiro, and Kauroa Ash Formations are exposed (N65/725463).

<u>Puketoka Formation</u>

Kear and Schofield (1978) identified two distinct types of material in the Puketoka Formation: well sorted and commonly bedded pumice deposits of lacustrine and fluviatile origin; and unsorted, massive, pumiceous deposits of a distal ignimbrite. The ignimbrite facies is exposed at and above road level in this cutting, and is offset by a steeply dipping normal fault. Note how the pumice blocks and lapilli become distended and their long axes change orientation as the fault plane is approached. The association of pumice lapilli coarsening upwards to blocks in a fine grained matrix indicates a pyroclastic flow origin.

Mapping further south by Blank (1965), and work in progress by staff and post-graduate students of Earth Sciences at University of Waikato, indicates that this flow deposit is most probably the distal equivalent of the 0.75 My B.P. (Kohn, 1973) Ongatiti Ignimbrite. This pyroclastic flow entered the basin from the south and southeast and is believed to underlie most of the hills in the basin. The unwelded ignimbrite facies in places was readily reworked to give the associated, predominantly light coloured, almost pure pumiceous fluviatile and lacustrine sediments.

The welded facies of the Ongatiti Ignimbrite has the greatest distribution of the Central Volcanic Region ignimbrites (Blank, 1965); it might reasonably be expected to also have the most extensive apron of unwelded distal facies. On the basis of age we believe that distal ignimbrite deposits previously mapped in central western North Island(i.e. Oparau Tephra (Pain, 1975); Pehiakura Ash - Kaawa Section and Awhitu Peninsula (Barter, 1976)), Hamilton Basin (Puketoka Fm.), Hawke's Bay (Kidnappers Tephra Formation (Kamp, in press (a) and (b)), Wanganui Basin (Rewa Pumice (Seward, 1976)), and Hauraki rift valley as far north as Torehape, are correlatives of the Ongatiti Ignimbrite (in prep.). The distribution of this deposit has a diameter centred about Taupo of at least 360 km.

Kauroa Ash Formation

The name Kauroa Ash Formation was proposed by Ward (1967) for 17 mainly rhyolitic ash beds near Raglan (N64/437420) separated from the overlying

Hamilton Ash Formation by a well-defined erosional unconformity. The Kauroa Ash Formation (or "K-beds") is generally strongly weathered with numerous and distinct paleosols. Recent detailed compositional examinations have been made by Salter (1979) and Kirkman (1980). Within the Hamilton Basin the uppermost bed is marked by a very prominant fossil soil, dark reddish brown (chocolate) with a strongly developed blocky or prismatic structure; this was evident at the last site. Here the 'K-beds' are confusing because they have suffered post burial alteration and thus are unrepresentative. However, this site serves to show that some members underlie the Karapiro sediments. We know from elsewhere in the basin that some members also overlie Karapiro Formation, and still others underlie the Puketoka/Ongatiti Ignimbrite. Thus the Kauroa Ash Formation within the basin interfingers with the Puketoka and Karapiro Formations, while outside the basin, such as at the type locality near Raglan, only tephras are preserved. We suspect that some members of the 'K-beds' derive from volcanic centres on Coromandel Peninsula.

Karapiro Formation

Alluvium consisting of weathered and cross-bedded volcanic grits and pumiceous and rhyolitic gravelly sands, unconformably over Puketoka Formation and members of the 'K-beds', is exposed in this cutting. Elsewhere the Karapiro sediments are strongly weathered displaying multicolours including oranges, pinks and reds. Apart from their degree of weathering, Karapiro sediments are not unlike Hinuera sediments; they are probably deposited in similar environments (braided river) and originated from erosion of older ignimbrites (Ahuroa ?) and volcanics. The fact that the Karapiro Formation does not occur at the same elevation as some exposures of Puketoka Formation (Kear and Schofield, 1978) suggests that the former was deposited within a rolling landscape cut in Puketoka Formation, thus analagous to the flooding of Hinuera sediments around and over Hamilton Hills 65 - 17,000 y B.P.

STOP 3 - (N65/723462) We walk 50 m further west to another cutting, this time exposed in the golf club car park (please take care with any vehicles parked there).

Here, the lacustrine facies of the Puketoka Formation is well exposed in a cutting that has been case-hardened by the migration and precipitation of silica. A shallow lake is envisaged as the depositional environment, mainly because of the horizontal stratification.

We now travel via Newcastle Road, Ellicott Road, Forest Lake Road, Victoria Street, Fairfield Bridge to River Road and Sylvester Road corner. We travel through the northern suburbs of Hamilton City which has a population of 98,000 people. City expansion to the east and west is constrained by peat bogs; to the south by zoning regulations (class 1 land); and all present/future expansion is planned to go north on both sides of the river.

STOP 4 - (N56/755533) to examine a section exposing (at the base) the ignimbrite facies of the Puketoka Formation, highly weathered Karapiro Formation, thin (remnant) members of the Hamilton Ash Formation and overlying Late Quaternary tephras. An appreciation of the thickness of the ignimbrite can be gained from its exposure at this elevation, and in the adjacent banks of the Waikato River.

Travel via Rototuna School Road to a site exposed near the Rototuna refuse tip.

STOP 5 - (N56/776535) to briefly examine an exposure of late Quaternary tephras unconformably overlying Hamilton Ash beds. Detailed mineralogical examinations at this site indicate that the buff-coloured, silt-rich cover bed materials are a composite accumulation of thin airfall tephras over the last c.42,000 years which have been pedogenically mixed. Examinations at other sites, together with the identification of numerous thin, post-glacial and Holocene tephras well preserved in organic lake sediments (Lowe *et al.* 1980), have provided a stratigraphic record of late Quaternary (<42,000 y B.P.) tephras and their distribution in the Hamilton Basin (Lowe, in press; summarised in Fig. 2).

The thickness of the late Quaternary tephra column with respect to the buried Hamilton Ash paleosol, the soil moisture regime and its fluctuations, and the organic cycle control the site weathering conditions, and hence strongly influence the soil morphological and mineralogical characteristics; in turn these determine and explain the soil pattern and classification.

The soil formed in the late Quaternary tephra materials (Kainui soil) is usually classed as a composite yellow-brown earth over brown granular loam, the latter representing the buried Hamilton Ash paleosol; in U.S. Taxonomy terms it qualifies as an Andic Dystrochrept.

Travel via Thomas Road, then Hamilton-Tauhei Road (Tramway Road) to "Pumpkin Pit" (if time permits).

STOP 6 - (N56/796526) to briefly examine ridge and swale topography and soils associated with Hinuera Formation deposits. At this site pumice silts (lithofacies D in Table 1) in the swale (depression) occur in erosional contact with massive to horizontally stratified sandy gravels (lithofacies C1) forming a low amplitude ridge. Both lithologies are underlain by cross-stratified gravelly sands (lithofacies A1) (Hume *et al.* 1975).

The pumice silts are poorly drained and support the pale, gleyed Te Kowhai soil (a gleyed Yellow-brown pumice soil, or Mollic Haplaquept [Ochraqualf if argillic horizon present]). The sandy gravels, admixed with a mantle of airfall tephras, support the freely drained, yellowish brown, friable Horotiu soil (a yellow-brown loam, or Typic Vitrandept/Entic Vitrudand).

Return to University via Ruakura Agricultural Research Centre and N.Z. Meat Research Laboratories. The Hamilton office of Soil Bureau is situated on this campus, and Geological Survey (Huntly) are due to move here also.

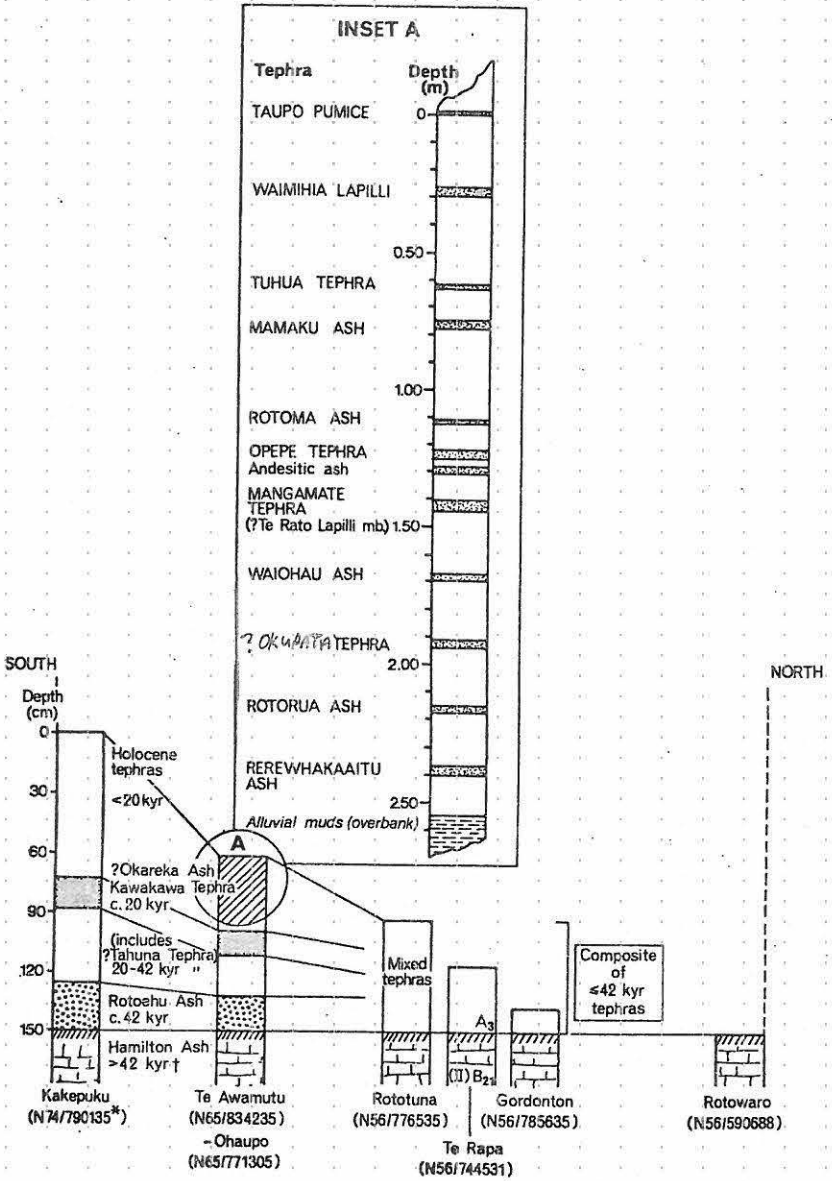

Fig. 2. Diagram summarising the occurrence and approximate thickness of late Quaternary (≤42,000 years B.P.) tephras in the Hamilton Basin. Site locations of this transect from south to north through Hamilton City are indicated in Fig. 1.
INSET A shows thin airfall tephras preserved in organic lake sediments in Lake Maratoto, a peaty lake about 8 km south of Hamilton City. Rerewhakaaitu Ash at the base of the core has been dated at 14,700 years B.P. (Lowe *et al.* 1980). The inset indicates potential contribution of specific tephras to the adjacent subaerial deposits (soils). After Lowe (in press).

* Grid reference based on national thousand-yard grid of the 1:63,360 topographical map series (NZMS 1).
† kyr = 1000 years B.P.

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Table 1: Sedimentological characteristics and environmental interpretation of lithofacies of the Hinuera Formation (*from* Hume *et al.* 1975, p.456).

Lithofacies	Occurrence	Dominant Composition	Dominant Texture	Sedimentary Structures	Flow Regime	Bed Forms	Depositional Environment	Stratigraphic Position
A1	Extremely common	Quartz-feldspar-rhyolitic rock fragments-pumice	Gravelly sand	Rho cross-stratification	Upper part of lower to lower part of upper	Dunes on longitudinal bars or longitudinal bar migration	Active braided channel	Channel
A2	Rare		Gravelly sand	Epsilon cross-stratification	Upper or lower			
B	Fairly common	Quartz-feldspar-pumice	Sand	Nu cross-stratification	Lower part of lower	Ripples on transverse bars		
C1	Uncommon	Quartz-feldspar-rhyolitic rock fragments	Sandy gravel	Type 1 horizontal stratification or massive	Upper	Plane-bed on longitudinal bars		
C2	Rare	Quartz-feldspar-pumice	Gravelly sand	Type 2a horizontal stratification	Transitional			
D	Moderately common	Glass shards-pumice	Silt	Type 2b horizontal stratification or massive	Suspension deposits	-	Abandoned braided channel	Overbank
E	Uncommon	Carbonaceous material-glass shards-pumice	Silt	Type 2b horizontal stratification	*In situ* and suspension deposits	-	Floodbasin	