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LATE QUATERNARY TEPHRAS IN THE HAMILTON BASIN, NORTH ISLAND, NEW ZEALAND.

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ABSTRACT

This paper summarises the occurrence and distribution of late Quaternary tephras in the Hamilton (Middle Waikato) Basin and outlines a model to explain the pattern of soils formed from them. The collaborative work currently in progress on paleoecological aspects of the late Otiran-Aranuian history of the area is also reported.

BACKGROUND AND PREVIOUS WORK IN THE WAIKATO REGION

Isopach maps showing the distribution of late Quaternary tephras in New Zealand have been largely determined from field studies which are restricted to sites where the tephras are more than several centimetres thick: Pullar (1967), Vucetich & Pullar (1969), Pullar & Birrell (1973a), and Pullar et al. (1977). Tephra deposits in the Waikato generally thin northwestward away from the main source area in central North Island, well to the southeast (Fig. 1), and are difficult to differentiate in the field because of regional variations in original deposition, erosion, and mixing and weathering in the soil forming environment. Detailed examinations at reference sites (e.g., N.Z. Soil Bureau 1968a; Vucetich 1968; Pullar & Birrell 1973b; Jessen 1977; Hodder & Wilson 1976; Hodder 1978) have re-emphasised the composite rhyolitic and andesitic nature of these thin tephras and the soils formed from them. However, they have not been successful in identifying all of the constituent tephras. Only a few late Quaternary tephras have been mapped either close to, or to the northwest of Hamilton City (Fig. 1; see also Table 1).

In the Hamilton Basin, the late Quaternary cover bed deposits which overlie Hamilton Ash have been ascribed a loessic origin by McCraw (1967, 1975), Vucetich (1968), and Cowie & Milne (1973). Other workers have alternatively proposed that the deposits consist either of differently weathered forms of Hamilton Ash (Ward 1967), or of unnamed ash younger than Hamilton Ash (N.Z. Soil Bureau 1968a: 90). A combination of tephra and loess is also possible (Lowe 1981).

OCCURRENCE AND DISTRIBUTION OF TEPHRAS

The recent identification of numerous (>12) unweathered and unmixed thin, discrete airfall tephras in piston cores from shallow (<8m) peaty lakes near

TABLE 1 - Names, sources, approximate ages and thicknesses of known distal late Quaternary airfall tephras which have been deposited in the Hamilton City area. Unnamed tephras in addition to those listed also occur.

Tephra Formation or member	Source (volcanic centre)	Age (years B.P.)[1]	Approximate thickness (cm) (this study)		Previous references which report or predict the occurrence of the named tephra (? indicates uncertainty)
Ngauruhoe Tephra	Tongariro	Historical	<1		Nelson 1975; Nairn 1976
Taupo Pumice	Taupo	1800	1-2		Pullar 1967; Tonkin 1967; Pullar and Birrell 1973a; Pullar *et al.* 1977; Lowe *et al.* 1980
Whakaipo Tephra	Taupo	2700	1		
Tuhua Tephra	Mayor Island	6300	1		Lowe *et al.* 1980; Hogg and McCraw 1983
Mamaku Ash	Okataina	c.7000-8000	2-3		
Rotoma Ash	Okataina	c.7000-9000	2-3	20-25	Lowe *et al.* 1980
Opepe Tephra	Taupo	8800	2		Lowe *et al.* 1980
Andesitic Ash	Tongariro or Egmont	9000	1-2		Lowe *et al.* 1980
Mangamate Tephra	Tongariro	10000	3-4		Lowe *et al.* 1980
Waiohau Ash	Okataina	11300	2-3		Lowe *et al.* 1980
Okupata Tephra	Tongariro	12500	1		Lowe *et al.* 1980
Rotorua Ash	Okataina	13500	2 [<c.20][2]		Pullar and Birrell 1973a(?); Howorth *in* McGlone *et al.* 1978; Lowe *et al.* 1980
Rotoaira Lapilli	Tongariro	13800	<1		
Rerewhakaaitu Ash	Okataina	14700	2-3		Lowe *et al.* 1980
Okareka Ash	Okataina	c.19000	?5 [<c.20][2]		Pullar and Birrell 1973a(?); Pullar *et al.* 1973(?); Lowe 1981(?)
Kawakawa Tephra	Taupo	c.20000	?10-15 [c.10][2]	45-60	[3]Vucetich 1960(?); [3]Vucetich and Pullar 1969; [3]Pullar and Birrell 1973a; [3]Pain 1975; [3]Lowe 1981
Tahuna Tephra	Okataina	c.30100	?10-15 [c.20][2]		[4]Vucetich and Pullar 1969; [4]Pullar and Birrell 1973a; Lowe 1981
Rotoehu Ash	Okataina	c.42000	?20-30 [c.30-40][2]		Vucetich and Pullar 1969; Pullar and Birrell 1973a; Pullar *et al.* 1973; Lowe 1976.
Hamilton Ash	Unknown	>42000			Ward 1967; N.Z. Soil Bureau 1954, 1968b; Pain 1975; Lowe 1981

[1] Old (Libby) half-life basis

[2] Values according to previously published isopach thickness

[3] Reported as *Oruanui Ash*

[4] Reported as (undifferentiated) *Mangaoni Lapilli*

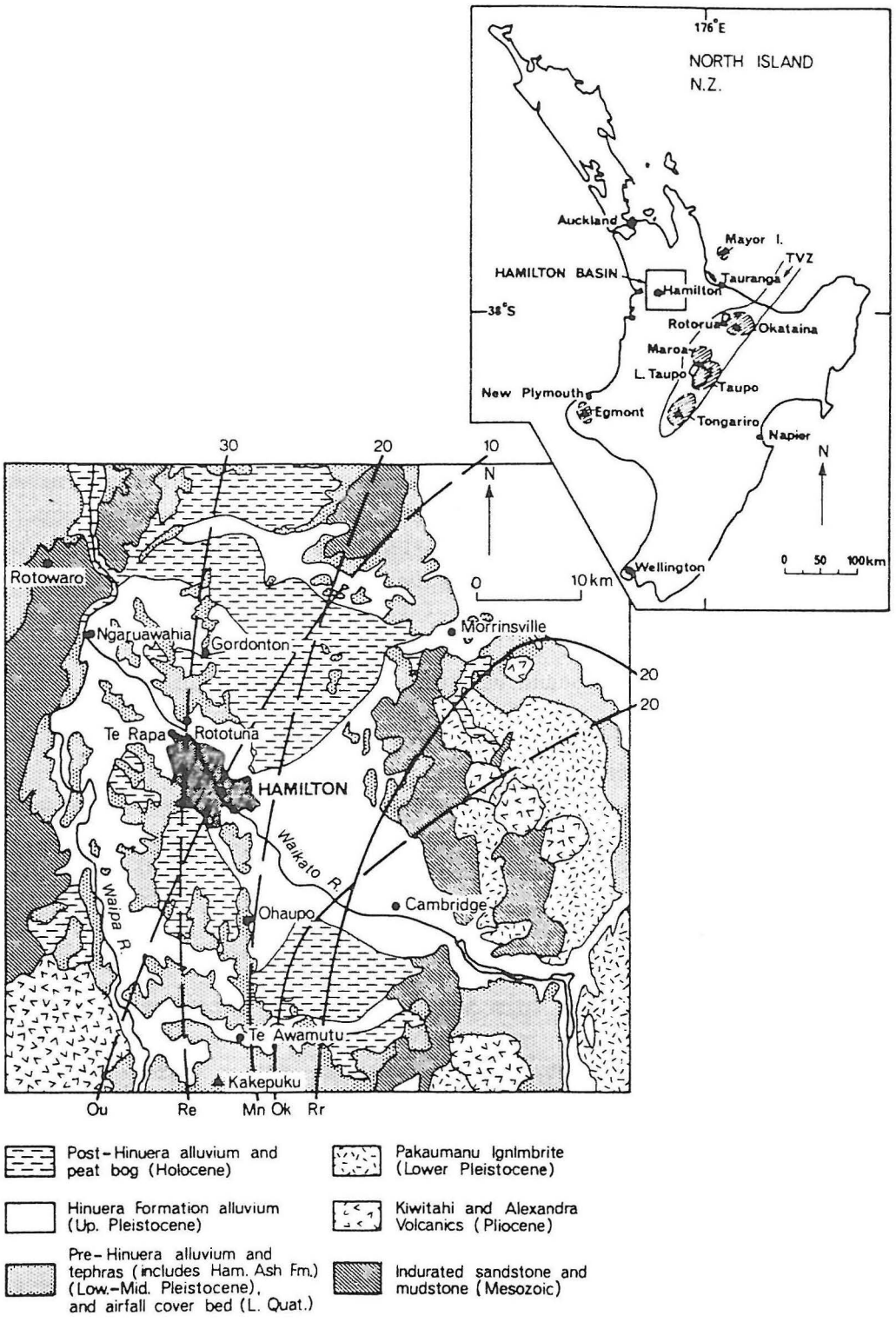

FIG. 1 - Simplified geological map of the Hamilton Basin (after Hume et al., 1975: 424), with distal-most tephra isopachs (cm) superimposed (from Pullar & Birrell, 1973a). Re = Rotoehu Ash; Mn = Mangaone Lapilli; Ok = Okareka Ash; Ou = Oruanui Ash; Rr = Rotorua Ash. Dashed line indicates isopach uncertain. Inset shows Hamilton Basin in relation to volcanic centres which were the most important sources of tephras, and Taupo Volcanic Zone (TVZ) (after McCraw, 1975; Mayor Island centre after Hogg, 1979). Note: "L.Quat." = Late Quaternary.

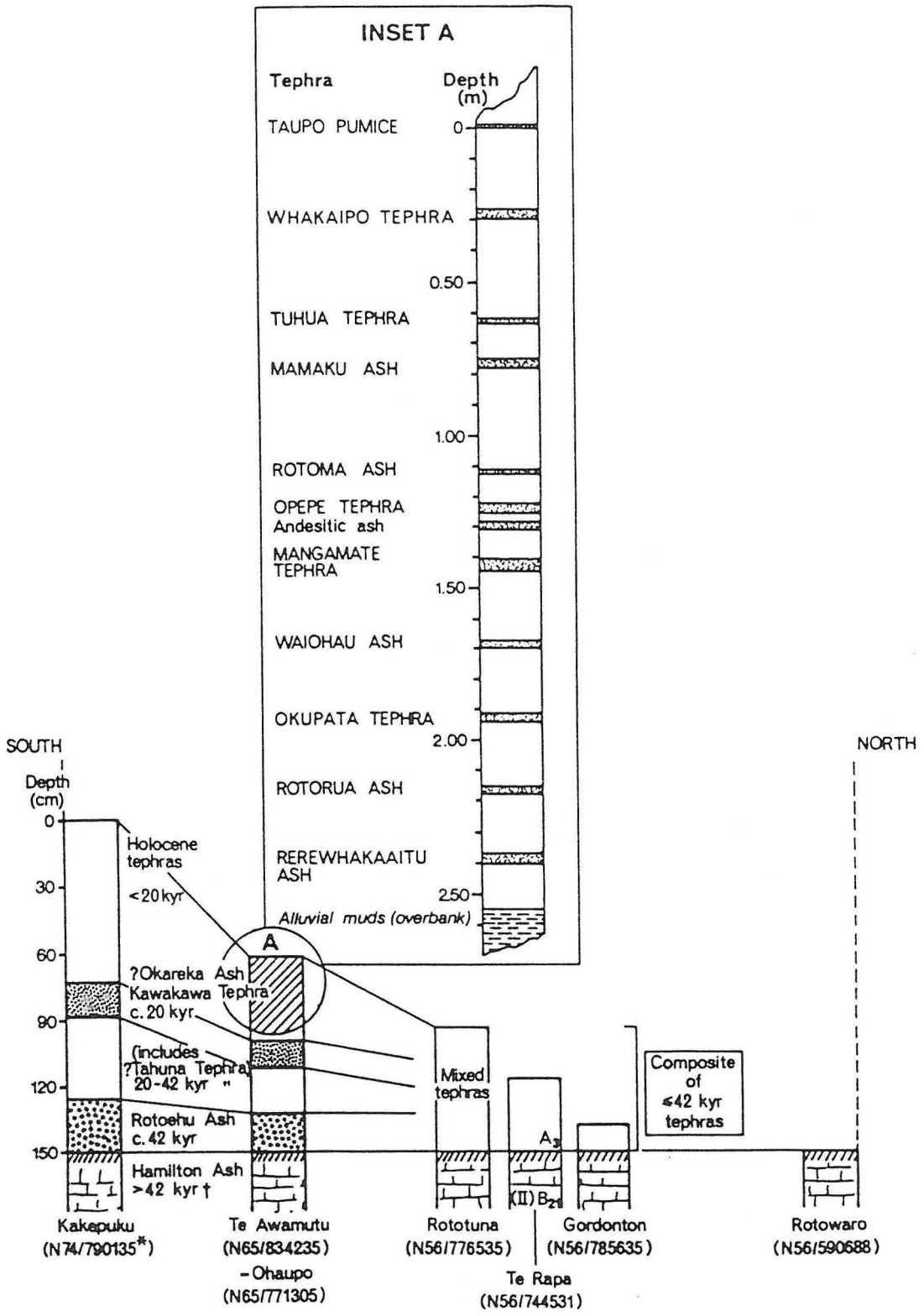

FIG. 2 - Correlation line apportioning relative thickness of late Quaternary deposits (soils) to proportionate thicknesses of Holocene and late Pleistocene tephras - illustrated at Te Awamutu-Ohaupo from Lake Maratoto core Inset A. In this transect, from south to north through Hamilton City, the changes in thickness of the late Quaternary deposits relate directly to the thinning of constituent tephras with increasing distance from source(s), and to erosion. Virtually all of the ≤ 42,000 years B.P. tephras have been removed from the Rotowaro site, but late Quaternary tephras are present further north near Auckland City. Site locations are indicated in Fig. 1.

INSET A Thin airfall tephras preserved in organic lake sediments in Lake Maratoto, a peaty lake about 8km south of Hamilton City. Rerewhakaaitu Ash at the base of the core has been radiocarbon dated at 14,700 years B.P. (Lowe et al., 1980). The inset indicates potential contributions of specific tephras as probable parent materials in the soil profile.

† kyr = 1,000 years B.P.

* Grid reference based on national thousand-yard grid of the 1:63360 topographical map series (NZMS 1).

Hamilton City has confirmed the presence and provided a stratigraphic record of late Pleistocene (post-Kawakawa Tephra) and Holocene tephras in the Waikato (Lowe et al. 1980). Field studies, plus detailed mineralogical, textural, and chemical analyses of samples from representative sections in the Waikato have added complementary stratigraphic and pedological data from which the occurrence and general distribution of late Quaternary (≤42,000 years B.P.) tephras has been determined (Lowe 1981).

Eruptive sources within Okataina and Taupo Volcanic Centres provided the bulk of the tephras, with much smaller contributions from Tongariro, Mount Egmont and Mayor Island sources. The source, age and approximate thickness of each named tephra identified near Hamilton is summarised in Table 1.

Late Quaternary deposits in this area are thus established as a composite of airfall tephras aged ≤42,000 years B.P., and are clearly not loess derived from Hinuera Formation alluvial deposits (Fig. 1).

Fig. 2 summarises the distribution of tephras in the Hamilton Basin, and the parent materials of the composite soils formed from them.

TEPHRA-SOIL PATTERN

Soil formation from the tephra deposits is a function of relative proportion of each tephra within the solum, and the soil climatic regime (Lowe 1979). With increasing distance from the tephra source areas, the age span of tephras in the solum increases (Fig. 2). The pattern of soils in the Waikato can be explained by a model of intermittent accumulation, with subsequent or concomitant mixing, of thinly bedded primary airfall late Quaternary tephras (Lowe & Gibbs 1981). North of Hamilton City, the thin increments of distal tephras have been more or less continuously modified by pedogenic mixing and weathering processes, producing silt-rich, compact and weakly structured deposits with characteristics commonly associated with loess.

COLLABORATIVE WORK

The tephrostratigraphy and radiocarbon dates determined from the lake cores also provide a geochronological framework for paleoclimatic, paleoecological and sedimentological investigations in the Waikato Basin. Paleolimnological studies (Green 1979) and palynological studies (McGlone et al. 1978) are currently in progress.

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DISCUSSION

1. Can you explain the so-called "loess balls" which occur in the firmer post-Kawakawa material? - R. Parfitt.

The so-called "loess balls" found in post-Kawakawa Tephra deposits also occur (often as "eggshells") in the paleosol on Tahuna Tephra and Rotoehu Ash which underlies Kawakawa Tephra in the eastern Waikato.

Kennedy (1980) suggests that the "balls" originate as an accretion of fine ash which accumulates in a snowball fashion while rolling along the ground. An alternative explanation is that the "balls" are accretionary lapilli, sometimes described as chalazoidites or volcanic "hailstones" (Vucetich & Pullar 1969), and essentially of primary origin. Self & Sparks (1978, 1979) outline two common circumstances for their formation:

(a) the explosive interaction of magma and water;

(b) the flushing out of fine ash from eruption clouds by rain, or by formation of clumps of ash by flocculation in a steam-rich eruption column (as was reported for the recent Mount St. Helens' eruptions).

In the Hamilton Basin, small (1-2cm) "birds eyes" are occasionally present in the late Quaternary cover bed deposits - these may be weathered accretionary lapilli or merely discontinuous fine-grained clasts remnant from the original tephra mantle.

2. In the slide of the core of the various tephras, could the "alluvium" at the base of the core be tephric loess that has fallen in the water? - N. Kennedy.

The 50cm-thick greenish-grey mud at the base of the Lake Maratoto core is thought to be an overbank flood deposit related to Hinuera-2 sedimentation (as described in Hume et al. 1975). The deposit contains ∿63% clay (<4 μm) and ∿36% silt (4-63 μm). Unpublished ^{14}C dates recently obtained from above and below the deposit are virtually identical, both being near 15,800 years B.P. This indicates a rapid depositional event, which argues against a relatively slow loess accumulation. Further, the dates place the deposit almost into the post-glacial period which is characteristicically devoid of loess (post c. 15,000 years: Kennedy 1980).

3. Do you recognise much in the way of tephric loess - Post-Kawakawa in the Hamilton area?

The late Quaternary cover bed deposits in the Hamilton area are considered to be predominantly primary airfall distal tephras (see Lowe 1981). The loess-like appearance of the composite deposit is explained by a model of incremental accumulation of fine-grained tephras with subsequent or concomitant pedogenic (biological) mixing. The deposits are currently

weathering in a wetting and drying environment. Weathering is intensified by the inclusion of the buried clay-rich Hamilton Ash beds in the solum (see also Lowe 1980).

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