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CLIMATE-CONTROLLED TEPHRA REDEPOSITION ON POUAKAI RING PLAIN, TARANAKI, NEW ZEALAND

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ABSTRACT

Redeposited tephra deposits have been identified over 250 km² of Pouakai ring plain in Taranaki, and are here termed the **Katikara Formation.** The deposits are discontinuous and consist of massive, blocky, sandy loam material, containing weak cross-stratification. They form mounds and sinuous ridges or dunes up to 10 m thick, which have modified the pre-existing relief, mostly between 150 and 300 m altitude. Below 150 m altitude, and between the larger deposits above 150 m altitude, the formation averages <3 m-thick and, where present, is conformable with the underlying tephras. Both air-fall and air-flow tephras are interbedded within cross-stratified redeposited tephra deposits indicative of an aeolian origin.

The Katikara Formation is interbedded near its base with the Saunders Ash, radiocarbon dated (NZ942) at 16 100 ± 220 yr B.P. At most localities the Okato Tephra, dated (NZ1143) at 12 550 ± 150 yr B.P., overlies the formation. Within the Saunders Ash, charcoal at 300 m altitude has been identified as *Dracophyllum* sp.; this is consistent with a lowered tree line during the last stadial. Above 150 m altitude, widespread erosion breaks are often preserved beneath the base of Katikara Formation deposits, and beneath the Saunders Ash where the former is absent. The formation is thought to represent the result of widespread erosion of older tephras on the upper slopes of Pouakai volcano, corresponding in age to the earlier and later Kumara-3 glacier advances in Westland and to the deposition of the Mokai Sands in the Central North Island.

It is suggested that the Lepperton surface in western Taranaki simply represents an equivalent of the Maitahi surface which was severely eroded and modified during the last glacial. Last stadial Katikara Formation deposits are apparently absent on Egmont ring plain, probably because most of the present Egmont cone has been constructed in post-glacial time.

INTRODUCTION

Whilst mapping lahar deposits and tephras in western Taranaki (NZMS 1, Sheets N108, N109, N118, and N128), widespread redeposited tephra deposits were found over an area of 250 km² on Pouakai ring plain (Fig. 1). A new formation is proposed for these redeposited tephras and is here named the **Katikara Formation.** It is named after Katikara Stream which originates in the Pouakai Range at 1 377 m altitude and flows north-westwards to the coastline between Okato and Oakura.

DEFINITION

The formation is defined to encompass all the redeposited tephras on Pouakai ring plain deposited between the Oakura Tephra and the Koru Tephra. Two reference or subsidiary sections are designated in addition to the type locality to show the variable nature of the formational lithology.

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The type section is named on Saunders Road between the junctions of Wiremu (prior to 1970 called Okahu) Road and Carrington Road, at N118/510698*. The section is a 5-m-high and 35-m-long exposure through the formation, on a sharp corner to the south side of the road (Fig. 2). Here there is exposed:

1·5 m Oakura Tephra and Okato Tephra
3·0 m Katikara Formation, containing a layer of 20–30-mm-thick "cream-cakes" (for terminology see Neall 1972, p. 516) about 1 m above Saunders Ash
0·1 m Saunders Ash with charcoal and rare boulders up to 0·4 m across within deposit
0·3 m Katikara Formation to base of section.

The formation is composed of yellowish brown (10YR 5/6)† massive, firm, coarse ash with faint cross-stratification. The material contains fine rhizomorph channels throughout with weak vertical joints.

The Saunders Ash has slightly wavy and gradational upper and lower contacts within the Katikara Formation, in contrast to sharp contacts where it is preserved outside the area of the Katikara Formation.

The Katikara Formation wedges out on both sides of the hill. At the eastern extremity of the wedge there is a large andesite boulder, within the Saunders Ash (see Fig. 2).

The following reference sections are designated in conjunction with the type section.

(1) **Section on Carrington Road,** on south side of type locality for Saunders Ash and Carrington Tephras (N108/534704, 1962 ed.; see Section 3 of Appendix *in* Neall 1972). The formation here is wedged between the Okato Tephra and the Saunders Ash. It is absent from the crest of the section, but to the south is in excess of 3 m thick, with the base unexposed. Weak but distinctive cross-stratification is visible within the deposit.

(2) **Section on State Highway 3 (Junction Road),** approximately 300 m south of the New Plymouth Crematorium and alongside Mangamahoe Nurseries. Here the formation is exposed in 6-m-high sections on both sides of the road (N109/693837, 1965 ed.). Well developed cross-laminations are visible (Fig. 3) where black bands rich in mafics (mainly magnetite and augite) alternate with strong brown (7·5YR 5/6) ash beds. The mafic minerals adhere only loosely and easily fret from vertical faces by weathering. Thus, together with the colour contrast, the mafic layers tend to accentuate the laminations. Coarse bands with fragments up to 10 mm across, average about 2·5 mm thick, whilst finer alternations may be only 3 mm thick. The laminations dip, up to a maximum angle of 24°, to the north-west.

The base of the formation is always sharp but the upper contact is often difficult to distinguish because of the similar structure and colour to the overlying Okato Tephra.

DISTRIBUTION

The Katikara Formation is restricted to ring plain surfaces graded to the Pouakai Range. It is well exposed in road cuttings along Carrington Road, and between the 200 m and 400 m contours on Upper Pitone and Dover Roads. However, the formation appears absent in the vicinity of Pukeiti.

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*Grid reference based on the national thousand-yard grid of the 1:63 360 topographical map series (NZMS 1), Sheet N118 Egmont (1965 ed.).

†Colours described are of the Munsell Colour notation.

On the north and north-east sides of the Pouakai Range the formation is more widespread and thicker. It extends from the upper slopes of the Pouakai Range almost to the present coastline at Omata, and extends towards the coast along all the major river systems, especially the Oakura River and Tapuae Stream. The formation does not extend north of New Plymouth, and it has not been located south of Waiwakaiho and Stony Rivers.

GEOMORPHOLOGY

The formation is associated with two principal ring plain surfaces on the lower slopes of the Pouakai Range. Below the 150 m contour, the formation is associated with a gently seaward-dipping, thickly tephra-mantled surface (termed "Maitahi lahars" by Hay 1967). This surface possesses extensive planar interfluves separated by characteristic box-shaped gullies which form an intricate dendritic drainage system. On the interfluves are thin accumulations (<3 m thick) of the formation with little modification of the pre-depositional surface. Here, the base of the formation is sharp but conformable with the underlying tephras.

The other ring plain surface (termed "Lepperton lahars" by Hay 1967) generally occurs above the 150 m contour and consists of a more dissected topography with rolling hills, steep slopes, V-shaped gullies, and few planar interfluves (Fig. 4). On this surface the Katikara Formation is often greater than 3 m thick and has modified the pre-existing landscape, frequently forming new ridges ("dunes") or circular mounds (Fig. 5A). The ridges tend to be slightly sinuous rather than straight and occur in a radial orientation to the Pouakai Range, i.e., they parallel the major drainage systems (Fig. 1). Some hills have been buried by the deposits and new ridge crests are displaced to one side of them (Fig. 5B). At many localities above 150 m altitude, where the formation is discontinuous, a widespread erosion break is seen which defines its base (Fig. 6). Few "dunes" occur above 300 m altitude.

THICKNESS AND VOLUME

The largest mounds observed within the formation occur along Kent Road where they reach 10 m thick. Many mounds can easily be mistaken for lahar mounds until their composition is examined. Towards New Plymouth, 10-m-high ridges of similar material are well exposed between Mangorei and Plymouth Roads, where they range from 500 to 1000 m long and average about 100 m wide (Fig. 7). In many areas the ridges as viewed on aerial photographs may be mistaken for remnants of a former widespread surface. Because of the variable thickness of the formation it is difficult to accurately estimate its volume. Assuming a 1 m average thickness the formation totals about 0·25 km^3.

LITHOLOGY

Initial investigations suggested the formation was an air-fall eruptive because of its similar appearance to most Taranaki tephras, but detailed studies now indicate the material is redeposited. The general lithology is similar to massive blocky andesitic tephra of sandy loam texture, but, on close inspection, weak cross-stratification is discernible. At a few localities lenses of stones and wood occur at the base of the deposit and may measure up to 50 mm across. In the vicinity of Carrington Road between Frankley and Saunders Road junctions, two thin grey ash "creamcake" layers of primary air-fall origin are preserved near the top of the formation.

The formation generally rests sharply upon the Saunders Ash (Neall 1972), where it is present, but in the region between Oxford and Saunders Roads the andesitic Saunders Ash is interbedded with the lower part of the formation. Here the upper and lower contacts of the Ash are not sharp but rather gradational, although they remain distinctive due to colour differences. This indicates the base of the formation is time-transgressive.

At the second reference section (Fig. 3), the well-developed cross-laminations within the formation clearly differ from the weak cross-stratification evident elsewhere. Although grain sizes are not necessarily very different between the upper and lower parts of each lamination, the base is always marked by the heavier mafic grains. The mafic grains are principally augite and magnetite, with minor hornblende and hypersthene, indicating an andesitic source. None of the heavy mineral grains are rounded or worn in any way, indicating they have not been transported over a very great distance. A sample from this locality was dry sieved and has a sorting coefficient ($\sigma\Phi$ of Inman 1952) of 0·6, (i.e., well sorted), compared to a value of 1·6 obtained from weakly cross-stratified deposits elsewhere.

The formation is composed entirely of andesitic sand, silt and clay sized particles. Clay fractions separated from the Katikara Formation and analysed by X-ray diffraction and differential thermal analysis techniques show that although the dominant clay is allophane, there is some halloysite present. Tephrostratigraphy studies in this region of Taranaki indicate that halloysite does not occur in tephras less than about 70 000 years old, and all tephras younger than this are richly allophanic. This suggests that the Katikara Formation is derived from older halloysite-bearing tephras as well as younger allophanic tephras.

AGE

The formation is always overlain by the Oakura Tephra, dated (NZ1144) at 6970 ± 76 yr B.P., and except for rare sections it is overlain by the Okato Tephra, dated (NZ1143) at 12 550 ± 150 yr B.P. This indicates that the bulk of the formation is older than 12 550 years, but near Oxford–Carrington Road junction in particular, it may be as young as 7000 years old. Isopachs drawn from thicknesses measured between the top of the Oakura Tephra and the base of the Okato Tephra (Neall 1972, fig. 9) show up to 30% discrepancy with isopachs of the individual tephras combined. This difference is attributed to small indistinguishable pockets of the Katikara Formation which appear to occur between the Okato and Oakura Tephras.

In sections along southern Carrington Road, the Saunders Ash is preserved at or within and near the base of the Katikara Formation. Beyond the distribution of the Saunders Ash the formation rests upon the Carrington Tephras, and in the vicinity of Barrett, Frankley, and northern Carrington

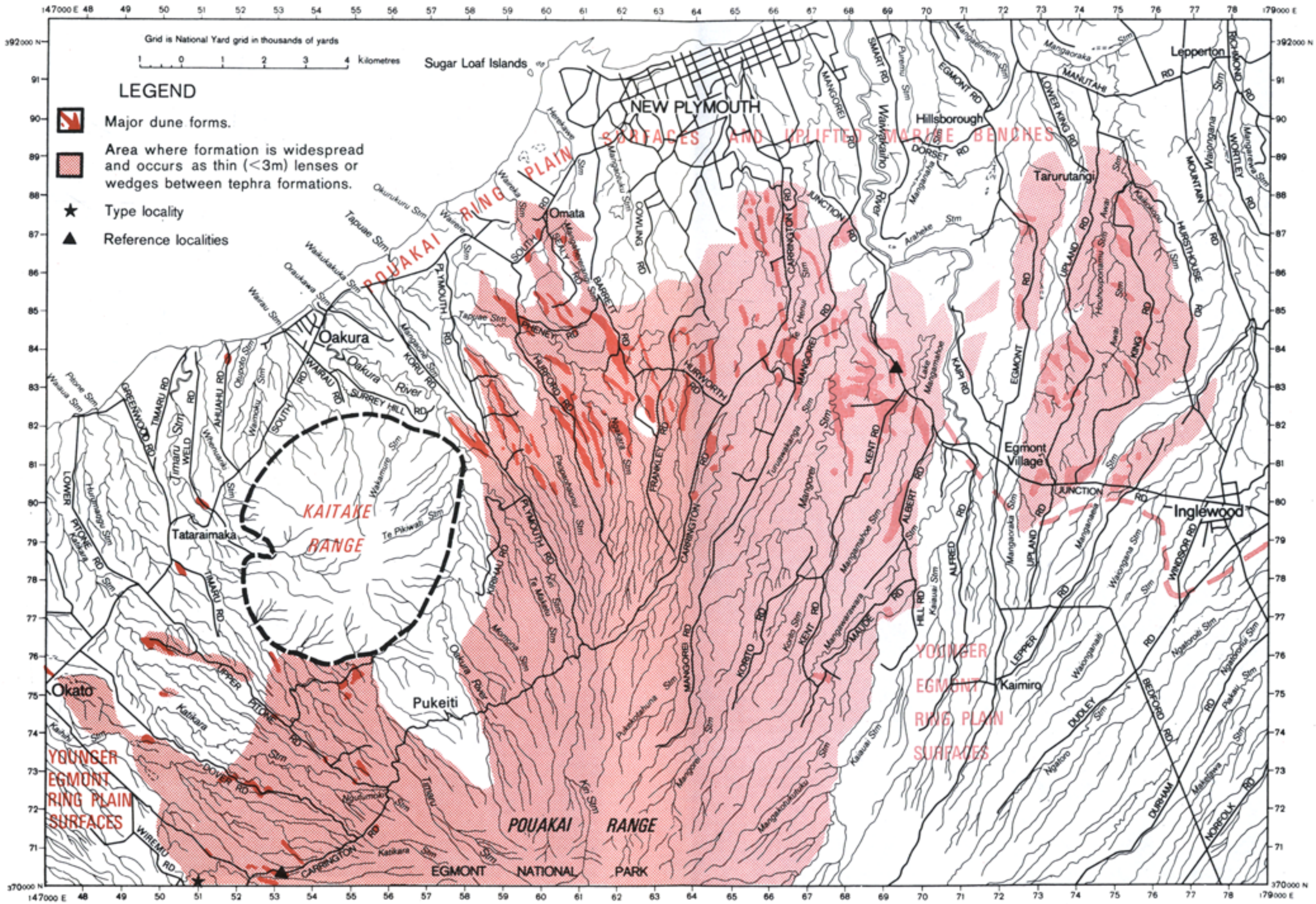

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FIG. 1—Distribution of major dune forms and discontinuous <3 m thick deposits of the Katikara Formation, to the north of Mt Egmont, Taranaki. Note: few observations have been made in the Kaitake Range.

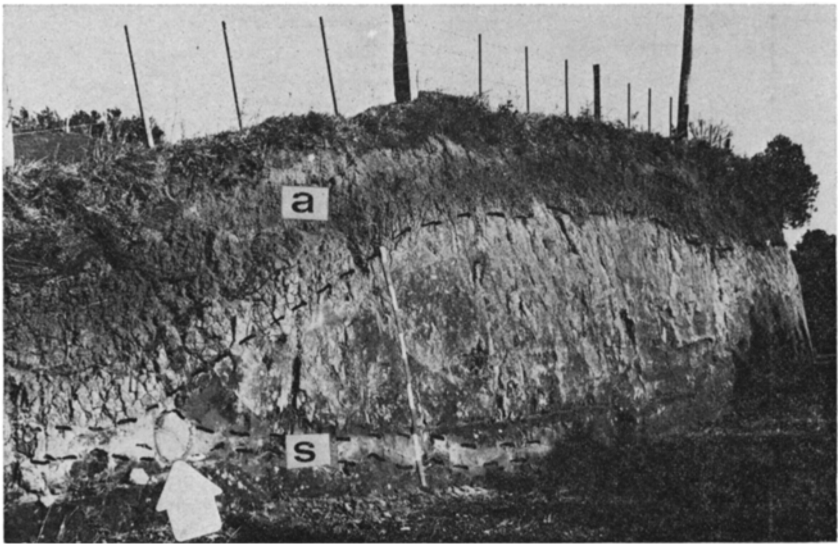

FIG. 2—Type locality of Katikara Formation on Saunders Road at N118/510698. Exposure shows Katikara Formation overlain by (a) Oakura and Okato Tephras, and containing (s) Saunders Ash near its base. Arrow indicates andesite boulder 0·6 m across within Saunders Ash. Tape is 2·5 m long.

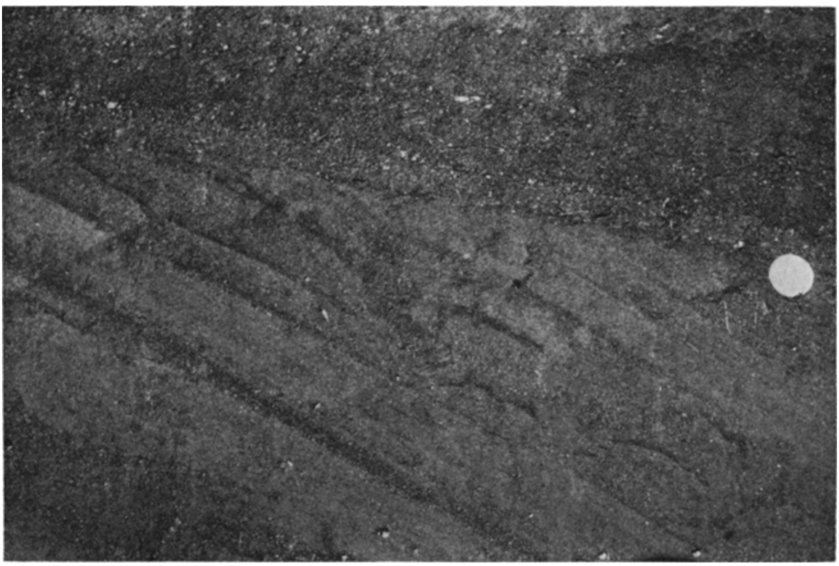

FIG. 3—Cross-laminations within Katikara Formation on State Highway 3 at N109/693837. Layers rich in magnetite and augite crystals alternate with brown ashy layers rich in allophane. Coin is 32 mm diameter.

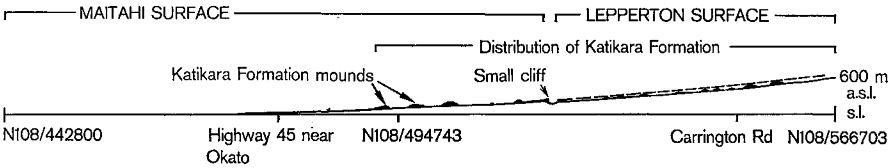

FIG. 4—Cross-section of Maitahi and Lepperton surfaces in the Okato district. Note the small eastward-facing cliff that separates the two surfaces, and the distribution of the Katikara Formation that covers most of the Lepperton Surface and generally covers the upper parts of the Maitahi Surface.

Roads rests directly on a highly weathered volcanic breccia which forms the Tapuae–Manganui Ridge (Gibson & Morgan 1927). This indicates the Saunders Ash was erupted about the same time as deposition of the formation commenced, in places on an eroded surface. Because the Saunders Ash, which is dated (NZ942) at 16 100 ± 220 yr B.P., is preserved near the base of the formation, the formation is probably less than 20 000 yr B.P. The bulk of the formation was deposited between the Okato Tephra and Saunders Ash, i.e., between 12 550 and 16 000 yr B.P., which corresponds to the earlier and later Kumara-3 advances (Suggate & Moar 1970).

ORIGIN

Four likely origins (or combinations of them) for the formation can be considered.

(1) The general occurrence of the formation in both valleys and on ridges, displaced radially to the Pouakai Range, makes a fluvial origin for the entire formation unlikely. This origin invokes a widespread and very large flood which is likely to have admixed coarser materials, and produced more prominent bedding at other localities within the formation. It could also then be expected to occur on the Egmont ring plain. It is probable that parts of the formation containing coarser particles were deposited by water, but because the bulk of the formation elsewhere contains only weak cross-stratification and is of medium to fine grain size, it is unlikely that all of it originated by this process.

(2) The restriction of the deposits to the Pouakai ring plain does suggest that its origin is due in part to the presence of the volcanco, either primarily as a volcanic environment or due to its orographical effect. The widespread recognition of base surge deposits (Moore 1967; Fisher & Waters 1969; Sparks & Walker 1973) produced during volcanic eruptions and nuclear atmospheric tests deserves consideration as a possible origin. If a base surge originated from Egmont, features produced by this event should be found on the Egmont ring plain landscape, instead of being confined to the Pouakai Range. Because the Pouakai Range is likely to have been extinct for 250 000 years it is not considered a likely source area for last stadial age base surge deposits. In addition, the bulk of base surge dunes reported

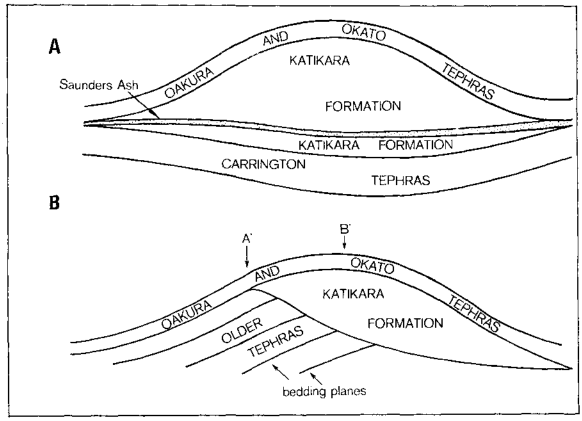

FIG. 5—(A) Diagrammatic cross-section of exposure at type locality of Katikara Formation (N118/510698) on Saunders Road. (B) Diagrammatic cross-section of exposure on Dover Road, at N108/535724. Note displacement of hill crest from position A' to position B'.

by Moore, tend to be concentric to the source area (see Moore 1967, figs 11, 12), and not radial as in the case of the Katikara Formation. Thus this origin is considered unlikely.

(3) Slightly sinuous dunes, very similar to the formation, were produced by nuées ardentes which descended the Walibou River during the 1902 eruption of La Soufriére on St Vincent (see Anderson 1903, plate IX). However, the Pouakai Range is unlikely to have been active at this time and, for similar reasons discussed above (2), such a mechanism should have produced similar features on the Egmont ring plain if such nuées ardentes were derived from Mt Egmont.

The charcoal-bearing Saunders Ash is considered to be a flow deposit which probably originated as a nuée ardente (Neall 1972) that descended the Stony River catchment from Egmont summit. A nuée ardente origin would explain the large andesite boulders preserved within the Saunders Ash at the type locality of the Katikara Formation. The gradational boundaries of this ash within the Katikara Formation together with the formation's weak cross-stratification could be interpreted as indicative of a continuous event which involved a hot mode of emplacement. However, if the entire formation was deposited by a nuée ardente then charcoal should not be restricted to the Saunders Ash. Wood fragments are rarely found near the base of the formation but charcoal is absent. In addition, the presence of grey "creamcakes" within the deposit indicates incorporation of undisturbed air-fall tephras, which are difficult to preserve in the centre of a single nuée ardente deposit. This origin is, therefore, considered untenable.

(4) During the mapping of the Katikara Formation, the possibility that the deposits were of aeolian origin was initially considered unlikely, because simple dunes were considered most likely to have formed near the coast where sand dunes now form under the influence of mainly westerly winds. The bulk of the formation, on the other hand, tends to have accumulated on the seaward sides of hills at higher altitudes, which suggests an origin from the high flanks of the volcano. The presence of an erosion

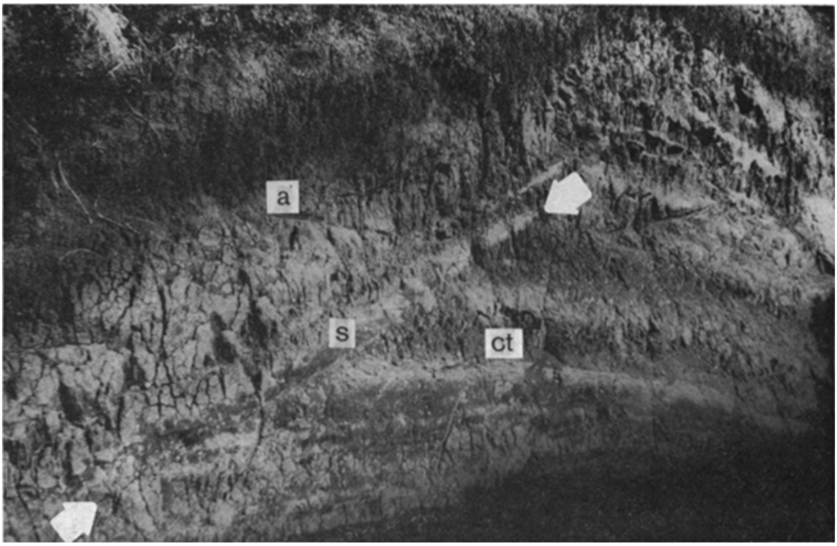

FIG. 6—Exposure on Carrington Road at N108/524704. Arrows point to erosion break preserved beneath (s) Saunders Ash, where the Katikara Formation is absent or very thin. (a) indicates Oakura and Okato Tephras. Carrington Tephras (ct) are preserved beneath the erosion break.

break stratigraphically beneath the formation at widespread localities above 300 m altitude indicates that erosion was widespread prior to the deposition of the formation (Fig. 7). The incorporation of the Saunders Ash and the grey "creamcakes" within the air-fall formation seems to preclude the other three origins, but is consistent with an aeolian origin. This together with the weak cross-stratification in the deposits suggests that the mounds and dunes accumulated by deflationary processes, and that as they were deposited they incorporated any tephras erupted at the time. Although some of the particles could be considered too large to be carried by aeolian processes, their low bulk density has probably aided in their transportation.

DISCUSSION

During the last stadial it is apparent that widespread erosion occurred along all stream channels draining Pouakai Range above the 200 m contour. It is to be expected that during this time there would have been a lowering of the bush line in Taranaki, and Willett (1950) concluded that the permanent snow line dropped to 1290 m, i.e., below the present summit heights of the principal Pouakai Range peaks. It is not clear whether the Pouakai Range was unvegetated at this time, but charcoal samples from the Saunders Ash dated (NZ942) at 16 100 ± 220 yr B.P. have been identified (by B. P. J. Molloy, Botany Division, Lincoln) as *Dracophyllum* sp. (Neall 1972),

FIG. 7—Oblique aerial photograph looking north-westwards towards New Plymouth. Low sinuous ridges are largely composed of Katikara Formation deposits, ranging from 500 to 1000 m long and up to 100 m wide.

suggesting that the dominant vegetation was a subalpine scrub. Thus the great thickness of tephras which mantled the Pouakai Range at this time would have become susceptible to erosion by deflation, once the vegetation cover became sparse or was removed during a period of cooler climate.

The lack of any similar deposits on Egmont ring plain is notable and two possible explanations are suggested. First, there is a possibility that Egmont was not as high as Pouakai during the last stadial. Evidence from tephrochronological studies suggest that much of the Egmont cone has been constructed during the last 16 000 years (Neall 1974) and, therefore, there may not have been a source area for tephras to be deposited further south. Second, there is a limited cover of tephras above the 1200 m contour on Egmont, due principally to the relative youthfulness of the surfaces and to the altitude and angle of slope. Thus during the last stadial there may have been insufficient fine material at high enough altitude on Egmont, to be influenced by aeolian processes, i.e., most material was coarse sandy debris. Recent radiocarbon dating of lahars derived from Mt Egmont indicate much of Egmont cone is post-glacial in age, which supports the first alternative.

The presence of halloysite in the formation indicates that older tephras were admixed with younger eruptives and this could occur if old and young tephras were eroded and redeposited by predominantly aeolian processes. In places the deposits were re-sorted by fluvial action probably related to water action on exposed dune surfaces. It is concluded that the formation represents tephras re-sorted by deflationary processes and deposited on the flanks of the thickly tephra-mantled Pouakai volcano during the last stadial, when the bush line was lowered. The formation can be considered a Taranaki correlative of the Mokai Sands found in the Central North Island (Vucetich & Pullar 1969).

The boundary between the Maitahi and Lepperton surfaces (Hay 1967) is generally distinct, and is often marked by a small cliff which faces inwards towards the Pouakai Range (see Fig. 4). It nearly always extends seawards down major river channels. Occasionally it is obscured by dunes and mounds of the Katikara Formation burying the cliff. It is suggested that the Lepperton surface in western Taranaki simply represents the equivalent of the Maitahi surface which was severely eroded and modified on the higher flanks and in major river systems of Pouakai volcano, during the last glacial.

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REFERENCES

ANDERSON, T. 1903: Recent volcanic eruptions in the West Indies. *Geographical Journal 21 (March)*: 265–81.

FISHER, R. V.; WATERS, A. C. 1969: Bed forms in base-surge deposits: Lunar implications. *Science 165*: 1349–52.

GIBSON, W.; MORGAN, P. G. 1927: The geology of the Egmont Subdivision. *N.Z. Geological Survey Bulletin 29*. 99 p.

INMAN, D. L. 1952: Measures for describing the size distribution of sediments. *Journal of Sedimentary Petrology 22 (3)*: 125–45.

HAY, R. F. 1967: Sheet 7 Taranaki. "Geological Map of New Zealand 1:250 000". N.Z. Department of Scientific and Industrial Research, Wellington.

MOORE, J. G. 1967: Base surge in recent volcanic eruptions. *Bulletin Volcanologique 30*: 337–63.

NEALL, V. E. 1972: Tephrochronology and tephrostratigraphy of western Taranaki (N108–109), New Zealand. *N.Z. Journal of Geology and Geophysics 15 (4)*: 507–57.

——— 1974: "The Volcanic History of Taranaki". 14 p. Egmont National Park Board. New Plymouth.

SPARKS, R. S. J.; WALKER, G. P. L. 1973: The Ground Surge Deposit: a Third Type of Pyroclastic Rock. *Nature (London) 241*: 62–64.

SUGGATE, R. P.; MOAR, N. T. 1970: Revision of the chronology of the Late Otira Glacial. *N.Z. Journal of Geology and Geophysics 13 (3)*: 742–6.

VUCETICH, C. G.; PULLAR, W. A. 1969: Stratigraphy and chronology of late Pleistocene volcanic ash beds in Central North Island, New Zealand. *N.Z. Journal of Geology and Geophysics 12 (4)*: 784–837.

WILLETT, R. W. 1950: The New Zealand Pleistocene snow line, climatic conditions, and suggested biological effects. *N.Z. Journal of Science and Technology 32 (B)*: 18–48.