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THE AGE OF QUATERNARY SURFACES AT WAIHI BEACH

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Abstract

The Waihi Beach surfaces were originally mapped and correlated with European surfaces of similar altitude by Kear and Waterhouse (1961). Exposures along the edges of the surfaces indicate that they are covered with volcanic ashes, the younger of which are of known age. It is the sub-ash surface which should be used for height correlations, and it is the most seaward ash-covered part of the surface which is preferred as the reference point for altitude studies. The heights of the surfaces may not correlate with positions of sea-level at the ages indicated by the ash beds.

INTRODUCTION

Coastal surfaces between Waihi Beach and Bowentown on the Bay of Plenty coast have been mapped and surveyed by Kear and Waterhouse (1961). The surfaces they recognised extend across sediments which were "assumed to be the result of terrestrial aggradation as a consequence of the rise of sea level" (p. 436). These surfaces were correlated with those recognised by Brothers (1954) in the Kaipara area, northwest of Auckland, and tentatively with the European sequence of Tyrrhenian, Main Monastirian, Late Monastirian and Post-glacial levels.

The problems of long distance correlation of surfaces on a basis of altitude have been widely discussed. Not only are clear marker points of former sea levels often lacking, but there is increasing evidence of coastal instability in areas once thought to be stable. The series of former marine shorelines established in the Mediterranean by Depéret (summarised in 1918) suffers because the type localities are removed from one another and the North African coast is certainly unstable. The type localities of the Milazzian in Sicily and Monastirian in Tunisia are certainly disturbed (Gill, 1968; Biberson, 1970).

Re-examination of the sediments underlying the Waihi Beach surfaces has revealed that they are capped by volcanic ash beds which can be recognised from their field relationships. Some of the ash beds are also of known age and these provide a minimum age for the underlying surface. Using this evidence it is possible to show that correlation with the European sequence of sea levels is unreliable. Furthermore correlated heights have to be adjusted because the thickness of the ashbed column would have to be subtracted from any assumed height of a surface relative to sea level. The surface which should be mapped, therefore, is not the present-day land surface but the one underlying the ash beds. Such a procedure gives a slightly different height range for the surface.

WAIHI BEACH SURFACES

In their study Kear and Waterhouse (1961) described three surfaces with associated sediments and the remnants of a higher surface. Their descriptions are summarised in Table 1. The ash beds associated with the surfaces are also listed.

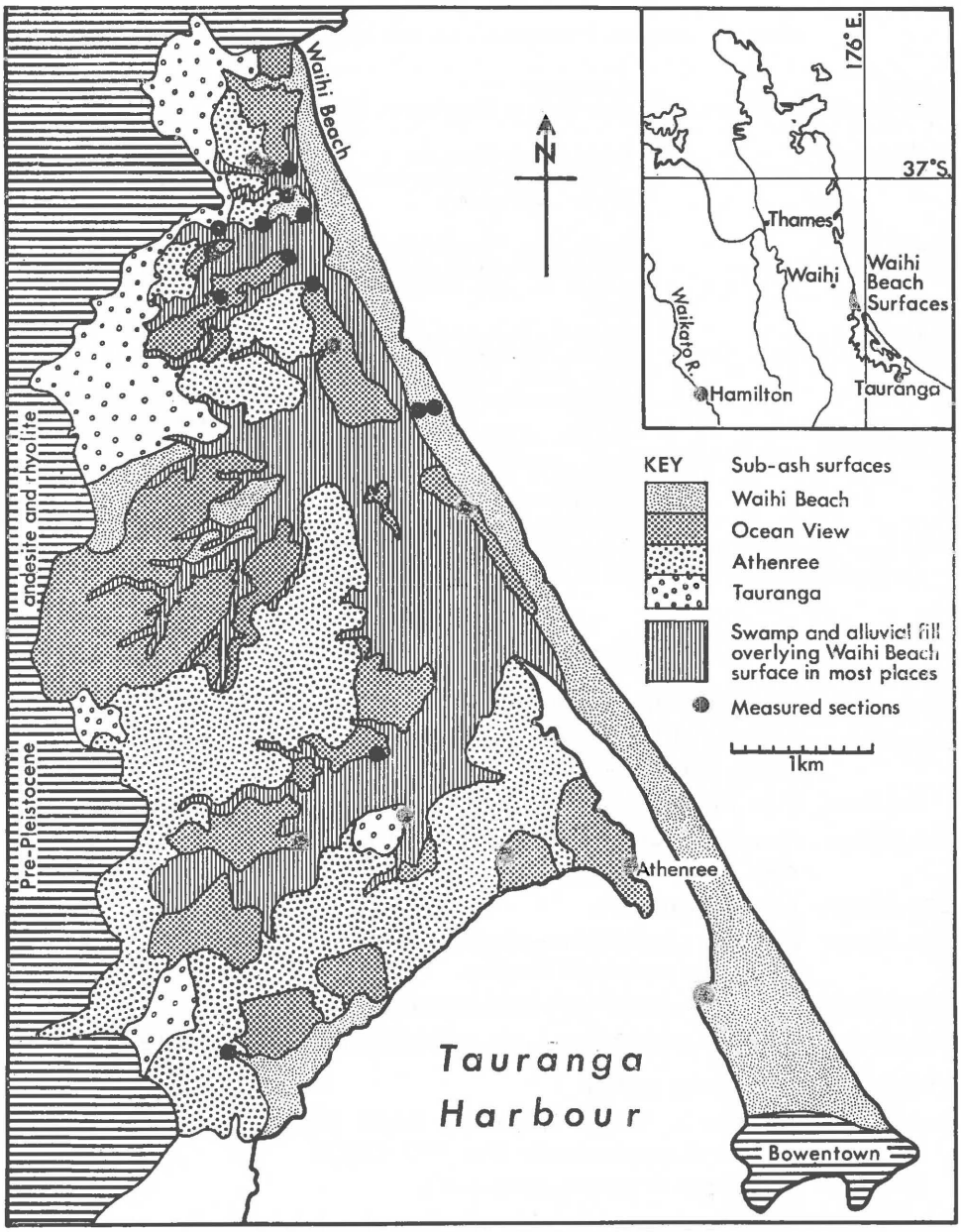

Figure 1. Distribution of the Waihi Beach sub-ash surfaces (based on Kear and Waterhouse, 1961) and the location of sections which were measured.

The surfaces dip gently towards the sea. They are dissected by streams which form a dendritic pattern. No field evidence was found to indicate whether they are of terrestrial or marine origin. Exposures in the walls of small valleys, road cuttings and auger holes make possible the mapping of the deposits on the surfaces. Sections were measured and described at a number of places which are indicated in Figure 1. For the sake of brevity these descriptions are not all included here but are represented by one section for each surface.

Table 1 Surfaces, Formations and Ash Beds at Waihi Beach.

Surface (after Kear & Waterhouse, 1961)	Formation (after Kear & Waterhouse, 1961)	Interpretation of ash beds
Waihi Beach 6 – 10 ft; 1.8 – 3.0m	Waihi Beach Formation: "alluvial and estuarine deposits, swamp, sand dunes."	Some dunes near or just inland of the present coast contain lapilli of Taupo Pumice.
Ocean View 15 – 20 ft; 4.6 – 6.1m	Ocean View Formation: "old reddish clayey sand dunes, gravels in clay matrix, white clays."	Late Pleistocene ash beds with Rotoehu Ash at the base.
Athenree ?60 – ?70 ft; ?18.3 – ?21.3m	Athenree Formation: reddish weathered clays overlying white sandy clays with volcanic and carbonaceous fragments*.	Late Pleistocene ash beds, overlying Hamilton and Kauroa Ash beds (Ward, 1967).
(Not named) ?110 – ?115 ft; ?33.5 – ?35.0m	"Locally derived clayey sands, with angular and rounded pebbles: pumiceous sediments. (Tauranga Formation)."	

* In their description Kear and Waterhouse include mention of "white sandy clays". These are thought to refer to bed H1 of the Hamilton Ash beds.

SECTION DESCRIPTIONS

Deposits on the highest (Tauranga) surface

Location: Junction of Fergus Road and Waihi Road at an altitude of approximately 46m, N53/412926.

0–160cm Late Pleistocene ash beds with Rotoehu Ash at the base.

160–210cm Hamilton Ash beds with nodules of halloysite and manganese at the base.

210–516cm Kauroa Ash beds.

516–746cm Red clay (probably weathered volcanic ash of haematite colour) with vermicular nodules at the base.

746–764cm Olive clay paleosol in weathered rhyolite.

764–814cm Rhyolite pebbles above a sharp boundary on purple weathered rhyolite.

Deposits on the Athenree surface

Location: Junction of Wilson Road and Waihi Beach Main Highway, at an altitude of approximately 18m, N53/422932.

0– 15cm A1 horizon of the present-day soil.

15– 89cm Late Pleistocene ash beds with Rotoehu Ash at the base.

89–255cm Hamilton Ash beds with nodules of halloysite and manganese at the base.

255–459cm Hamilton Ash beds with a pale yellow base of H1.

459–557cm Kauroa Ash beds with a yellow-brown base.

557–712cm Red ash (haematite red colour).

712–812cm on purple weathered rhyolite.

Deposits on the Ocean View surface

Location: Section alongside farm track, and auger hole, at Tirimoana Farm at an altitude of approximately 5.5m, N53/438911.

0– 20cm A1 horizon of present-day soil containing lapilli of Taupo Pumice.

20–145cm Late Pleistocene ash beds with Rotoehu Ash at the base.

145–167cm Dark brown sandy clay, uA1 horizon of paleosol.

167–207cm Olive greasy clayey sand, uB horizon of paleosol in weathered dune sand.

207–337cm Greasy sand of weathered dune.

337–455cm on wet dune and sand with water table at the base.

Deposits on the Waihi Beach surface

Much of this formation is composed of modern coastal dune sand. The dunes adjacent to the coast (N53/440912) have a poorly developed soil profile. The dunes 100m to 200m inland have a deeper A1 horizon which contains lapilli of Taupo Pumice.

BOWENTOWN SURFACES

Near Bowentown there are several exposures of volcanic ash forming a surface 2m to 3m above present high-tide level. A typical profile is:

Location: Low cliff overlooking estuary north of the Katikati entrance to Tauranga Harbour, N54/6, 457873.

0–100cm Late Pleistocene ash with Rotoehu Ash at the base.

100–265cm Weathered rhyolite.

on Purple banded rhyolite.

DISCUSSION

The sections indicate quite clearly that the Tauranga and Athenree Formations include Late Pleistocene, Hamilton and Kauroa Ash beds with underlying *in situ* weathered rock. The Ocean View Formation includes Late Pleistocene ash beds with Rotoehu Ash at the base, and the Waihi Beach Formation is composed of alluvial, estuarine and dune sand deposits. The older dunes were formed before the Taupo Pumice eruption, and the younger dunes were formed after the eruption.

Age of the Ash beds

The age of the Taupo Pumice is well established at 130 A.D. (Healy, Vucetich and Pullar, 1964). The Rotoehu Ash has an age of about 42,000yr B.P. (Vucetich and Pullar, 1969). [The Rotoiti Breccia with which it is correlated is dated at 41,700 ± 3,500yr B.P. (NZ 1126).] The ages of the Hamilton Ash beds and Kauroa beds are not known. Ward (1967) has argued that because of the position of Hamilton Ash beds on terrace sequences in the Glen Murray region of the lower Waikato Basin they must have been deposited between the formation of the

"Milazzian" terrace and before the construction of the "Tyrrhenian" terrace at a time when sea level was low. On this basis the Hamilton Ash beds are considered to be correlated with the Mindel Glaciation and would thus have an age of between 370,000 and 600,000yr B.P. (Zubakov, 1966). It has been shown above that such a method of dating is highly suspect, and certainly cannot be used to give dates to Waihi Beach surfaces without involving a circular argument. Kear, Schofield and Kermode (1964) have suggested an age of 75,000 to 125,000 years for the Hamilton Ash beds. The age of the Kauroa Ash beds is equally uncertain. All that can reliably be said is that the Hamilton and Kauroa Ash beds are older than 42,000yr B.P. and that judging by the degree of weathering and soil formation in them, they may be very much older.

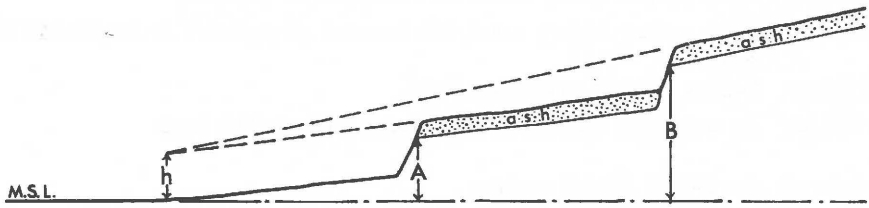

Figure 2. Two methods of determining the relative altitude of surfaces.

Surface Correlations

The ash beds on the Tauranga and Athenree sub-ash surfaces are about 8m thick and those on the Ocean View sub-ash surface are about 2m thick. These thicknesses must be subtracted from heights used for correlating surfaces.

The heights of surfaces used by Kear and Waterhouse were taken from a projection of the topographic surface to the present shoreline. Such a method may easily produce anomalous results, as is illustrated in Figure 2 where an extreme case is used. The height (h) of the surface depends upon the slope of the surface so it may be seen that a projected line from a steeply sloping upper surface may indicate that the upper and lower surfaces have the same height or even that the upper surface is lower than the bottom one. It is suggested that the most reliable method is to use the most seaward position of the sub-ash surface as the point from which to measure relative altitude (A & B in Figure 2). This contention is further supported by the knowledge that the coast is at present prograding and certainly was not in the same position in the past as it is now.

Ages of the surfaces.

Abandoned shorelines occurring at more-or-less similar altitudes have been described from many parts of the world (Fairbridge, 1961: Zeuner, 1958). Their existence is not reasonably in doubt but their origin and age is still debated. Two schools of thought are readily discerned. Fairbridge, Zeuner and many others contend that there has been a secular lowering of sea level during the Quaternary on the basis of evidence, from many of the world's coasts, of stepped sequences of elevated marine shorelines and terraces, decreasing in altitude with decreasing age. Fairbridge's (1961) eustatic curves assume a secular downtrend in sea level amounting to 135 m since the beginning of the Quaternary. The second school, as represented by Alt and Brooks (1965), postulates that during all but the earliest part of the Quaternary maximum interglacial stands of sea level were no higher than 9 to 12 m above present sea level and that all stands of sea level above 27 m

are definitely pre-Quaternary. This is supported by good evidence that the Antarctic and Greenland ice sheets did not diminish much more than their present volume during interglacial times, Denton *et al.* (1971). The widely reported surface at 8-9 m above present sea level possibly represents a terminal interglacial stand of sea level which occurred repeatedly during the Quaternary. Definite proof of either of these diametrically opposed hypotheses is not available at present and must await detailed dating and stratigraphic studies (Morrison, 1968).

An accurate date for the Hamilton and Kauroa Ash beds would allow a major contribution to be made towards settling the sea level controversy. At present several possible correlations of the Waihi Beach surfaces with sea level positions, derived from data from other parts of the world, are possible. One of these is shown is figure 3 (see Kear and Waterhouse, this issue for the second figure). If the Hamilton Ash beds are older than the ages suggested then other correlations are possible, and if the Waihi surfaces have been affected by tectonic movements then further complications will have to be considered. It is hoped that until these doubts are resolved the recommendation of the general assembly

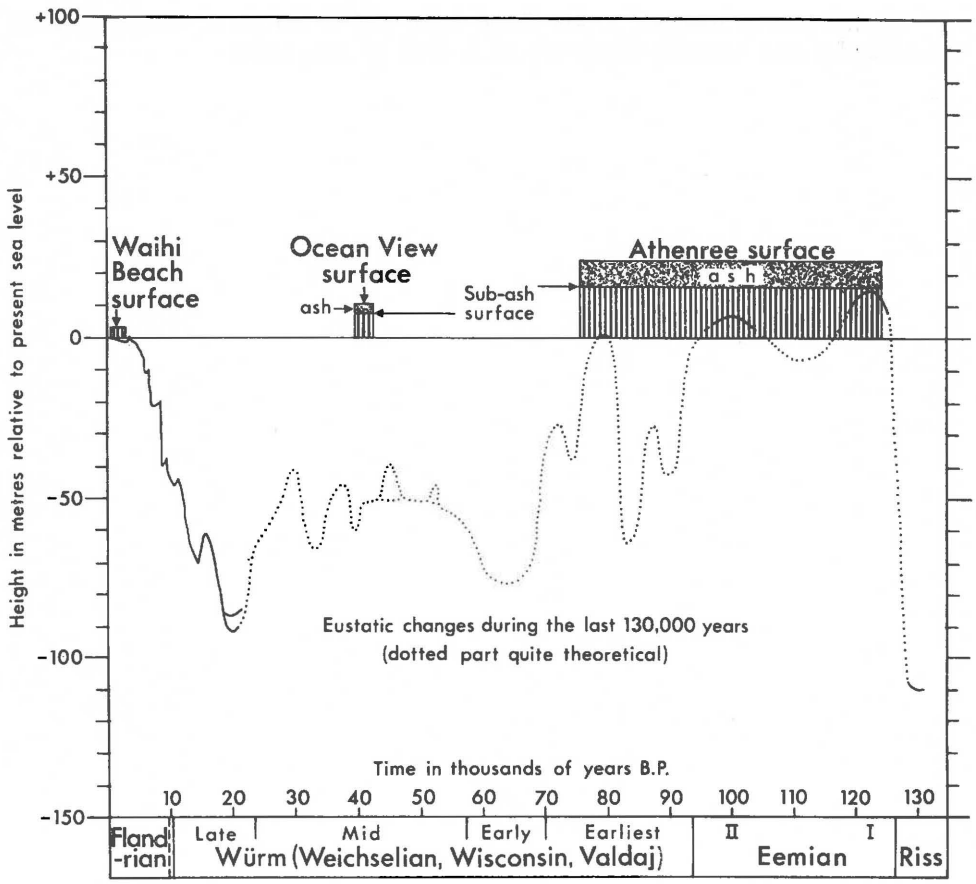

Figure 3. A sea level curve for the last 130,000 years (after Mörner, 1971) with the Waihi Beach surfaces shown at altitudes relative to present sea level. The age of the Waihi Beach surface and the youngest possible age of the Ocean View surface are known. The Athrenree surface is shown with the date proposed by Kear, Schofield and Kermode (1964).

of the Fifth International Congress on Quaternary Studies (INQUA) 1957 (Biberson, 1970, p.115) that the practice of applying Mediterranean terminology to marine transgressions in other parts of the world will be discontinued.

The Bowentown surfaces present a different problem. It has been contended by Schofield (1960) that there is evidence that during the last 4000 years sea level has been up to 2.1m above the present level. If this were so, and assuming the Tauranga coast is tectonically stable, it is difficult to imagine how the weakly consolidated ashes which form the Bowentown surface at heights of 2m to 3m above present sea level could have survived destruction by waves. Whilst this alone is not strong evidence against Schofield's contention it does appear to support Australian evidence against higher than present post-glacial sea levels (Thom, Hails and Martin, 1969). On the other hand the survival of the Bowentown surface may indicate that local earth movements have occurred along the coast.

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