EARTHQUAKES AND UPLIFT HISTORY OF MIRAMAR PENINSULA, WELLINGTON

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ABSTRACT

Twelve radiocarbon dates have been obtained from the Miramar area using EQC funding. Six other radiocarbon dates were obtained using funding from other sources. Our detailed field observations together with the radiocarbon dates, provide evidence for at least 4 uplift events in the last 7000 years. These events probably relate to activity on the Wairarapa Fault, as was the case in the 1855 earthquake. The effects of activity on the Wellington, Evans Bay and Seatoun Faults, are not clear at this stage, but they may cause subsidence rather than uplift at Miramar. Further radiocarbon dating and field sampling are required to refine our conclusions.

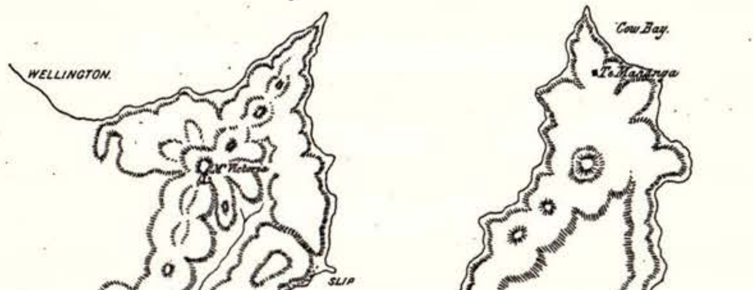

Figure 1: Sketch map of Miramar Peninsula from Crawford (1873)

INTRODUCTION

Background

This report contains a summary of research results obtained from geological investigations on Miramar Peninsula, partly funded by the Earthquake and War Damage Commission (EQC Research Grant 91/78). Funding was also provided by the Lotteries Board, Victoria University and the Department of Scientific & Industrial Research. The study forms the major part of an MSc thesis being undertaken by Mr Phil Huber, supervised by Dr Brad Pillans. The thesis is due for completion in September 1992, and copies will be lodged in the library of Victoria University.

Our major objectives in this research are firstly to locate and date old shorelines on the Miramar Peninsula, and secondly to use these as a basis for determining the uplift history resulting from large earthquakes such as occurred in 1855.

Miramar Peninsula

Miramar Peninsula is situated on the west side of the entrance to Wellington Harbour, 3 to 6 kilometres southeast of the city centre. The peninsula is separated from Wellington city by the Rongotai Isthmus, a low lying area occupied by the suburbs of Lyall Bay, Kilbirnie and Rongotai, including Wellington airport. The peninsula is 1.5 to 3 km wide, 7 km long and reaches a maximum height of 163 m (Mt Crawford). The northern and eastern parts of the peninsula are dominated by hills of greywacke rock. The central and southwestern parts (Miramar Valley) are relatively flat lying, and are underlain by unconsolidated sediments up to 60 m thick.

PREVIOUS WORK

Maori oral history, reported by Best (1923), records that when the Maori first visited the Wellington area, Miramar Peninsula was an island and a waterway extended across part of the Rongotai Isthmus. Maori oral history indicates that a violent earthquake occurred in the 15th century, resulting in uplift and blocking of the waterway (Best 1923). In 1773, Captain Cook recorded that Miramar was indeed a peninsula. In 1855, the Wellington region was dramatically affected by a large earthquake which caused uplift of about 2 metres (Stevens 1973), further elevating the Rongotai Isthmus.

The earliest geological observations in the area were those of Crawford (1873;1885), who noted the presence of three old gravel beach ridges (shorelines) in Miramar Valley, as well as abandoned sea caves and the borings of marine <u>Pholadae</u> up to about 15 feet above sea level. Crawford also reported the presence of marine shells in sediments beneath the valley floor, and the presence of pumice and moa bones in some areas. The sketch map (Fig. 1) of Crawford (1873) shows the location of two lakes: Miramar Lagoon on the northeast side of Rongotai isthmus and Burnham Water (also known as Para Lagoon or Lake Te Rotokura) within Miramar Valley around the area of the present day Miramar shops. Lake Te

Rotokura was drained by Crawford by way of a tunnel through the ridge to Evans Bay.

A series of drillhole investigations were undertaken on the Rongotai Isthmus during the 1920s and 1930s, and further drilling occurred in the 1950s associated with expansion plans for Wellington airport. Drillhole logs for some of these are shown in Grant-Taylor et al (1974) and Begg et al (1992). Two further series of drillholes, as well as seismic investigations, were undertaken at the southern end of Evans Bay in the 1970s (Lewis & Carter 1976; Lewis & Mildenhall 1985). These latter studies defined the position of the north-south trending Evans Bay Fault, and showed that the fault had been active during recent time. Previously, Adkin (1956) had described the Seatoun Fault on the eastern side of the peninsula, and inferred recent activity on the basis of a relatively fresh surface scarp at one locality. Both faults are apparently downthrown to the east.

The most significant previous work of relevance to the present study is that of Stevens (1973,1974), who described detailed evidence of uplifted shorelines in the Wellington region, including the Miramar Peninsula. Stevens documented the uplift associated with the 1855 earthquake, and he also recognised the three older shorelines in Miramar Valley (Fig. 2) that Crawford (1873) had noted previously. The three older shorelines were shown to be at heights of about 6, 4 and 3 metres above present mean sea level (Fig. 2), the lowest of which Stevens attributed to uplift in the 15th century earthquake of Maori oral history (sometimes known as the 1460 or Hao-whenua earthquake). Stevens concluded that uplift on Miramar Peninsula was about 2 metres in the 1855 earthquake, and perhaps 1-2 metres in the 1460 event.

NEW DATA

Methods

A summary geological map based on our work is shown in Figure 3. The map was compiled using field observations (including hand augering and mechanical drilling) as well as examination of old maps and aerial photographs. The overlay shows the location of drillholes and samples collected for radiocarbon dating. Eighteen new radiocarbon dates have been obtained, twelve of which were funded by EQC (Table 1). All radiocarbon dates were determined by the Radiocarbon Dating Laboratory at Waikato University. Unless otherwise stated all radiocarbon ages reported here are "conventional radiocarbon ages", calculated using the Libby half life, and expressed in years BP (where BP refers to years before 1950 AD).

Heights of marine sediments and other marine features were determined by surveying to benchmarks or man-hole covers. Unless otherwise stated, all heights are relative to present mean sea level (MSL).

The 1855 earthquake

We have identified shoreline features associated with uplift during the 1855 earthquake at several locations around the Miramar Peninsula and Rongotai Isthmus. Uplifted shore platforms are extensive, but their irregular surface and lack of surface deposits make interpretation of uplift somewhat difficult. Also, many previously well defined gravel beach ridges have been subsequently destroyed by urban development (see photographs in Stevens 1973,1974).

Our most precise estimates of uplift in the 1855 event come from areas to the north and south of Shelly Bay on the northwest coast of the peninsula. To the north, a shore platform is 1.54 m above MSL. To the south, an exposed shore platform is 1.09-1.62 m above MSL, with a mean height of 1.37 m. At one site, to the south of Shelly Bay, a shore platform at 1.5 m above MSL is overlain by well rounded beach pebbles and is exposed beneath road fill in the eroding beach cliff. The modern shore platform at these sites occurs within the intertidal zone, at a height of 0.85 m below MSL, so that uplift of 2-2.5 m is indicated. At Kau Bay, on the northeast side of the peninsula, a possible 1855 gravel beach ridge occurs 2.06 m above the modern beach ridge, in good agreement with the results from Shelly Bay.

Remnants of 1855 shoreline deposits are still visible on the south coast at Palmer Head and Hue-te-taka Peninsula. However, this area is more exposed to storm waves, and resultant shoreline deposits are less certain to use as height datums. Our observations in these areas are generally in accord with those of Stevens (1973), with uplift estimates in the range 1.2-2.6 m depending on which shoreline datums are used. Stevens (1973) also reported the height of the 1855 beach at Lyall Bay to be 1.8 m above MSL, but we could not verify the height because the beach has now been completely destroyed.

1855 AD to 1000 years BP

Small remnants of shore platforms and associated beach deposits, which are higher than the 1855 shoreline, occur at three localities around the coast of the peninsula. North of Shelly Bay, a shore platform overlain by rounded beach cobbles is at 2.80 m above MSL. A Maori shell midden overlying the beach cobbles yielded a radiocarbon age of 660±45 years BP (Wk-1923). At Hue-te-taka Peninsula a boulder beach about 3 m above MSL contains shells dated at 960±50 years BP (Wk-2431). At Palmer Head, Stevens (1973) described a boulder beach at 3.8 m above MSL, which is a probable correlative of the one at Hue-te-taka Peninsula.

1000 to 2000 years BP

Shells from gravel beach ridges at Seatoun and Lyall Bay yield ages of 1260±60 years BP (Wk-2430) and 1240±50 years BP (Wk-2325) respectively. Shells from a shelly sand at 3.4 m above MSL near Rongotai College gave an age of 1740±60 years BP. This latter site is interesting because the shells are all identified as Austrovenus stuchburyi (New Zealand cockle), a species typical of quiet, shallow water sites in bay-heads and estuaries. We therefore infer that the Rongotai Isthmus provided shelter to the south, and was probably largely emergent at the time.

A prominent gravel beach ridge, evident on old photographs, extends south from Broadway through the western side of Miramar golf course. This ridge may correspond, in part, to the ridge recognised by Stevens (1973) and Crawford (1873) in this vicinity. Although undated at this stage, we suggest its age is in the interval 1000-2000 years BP. We will refer to this ridge as the golf club beach ridge.

2000 to 4000 years BP

Shells from a shelly sand at 1.9 m above MSL in Miro St, Strathmore, gave an age of 3370±60 years BP. These shells, inland of the golf club beach ridge, provide a maximum age for the golf club ridge. In Strathmore Ave, Strathmore, a piece of wood at 4.1 m above MSL gave an age of 3280±60 years BP; the age is a minimum age for beach pebbles and sand immediately below the wood.

4000 to 6000 years BP

Several radiocarbon ages fall within this time range (Wk-2297, 2298, 2323, 2324, 2326, 2373 and 2427). Five of these come from marine and beach deposits in the central area of Miramar Valley and the other two are from Rongotai Isthmus. The two shell samples from Rongotai were from an auger hole in Yule St, and yielded ages of 4910±60 years BP (Wk-2323) at 4.0 m above MSL and 4780±60 years BP (Wk-2324) at 6.0 m above MSL. These two samples were from shelly, pebbly beach sands near the crest of an extensive gravel ridge, probably the boulder bank referred to briefly by Travers (1869), that extends across the isthmus to the area of Rongotai College (Fig. 3). We will refer to this ridge as the Rongotai beach ridge.

6000 to 7000 years BP

Shells dated at 6910±70 years BP (Wk-1921), at a height of 3.3 m below MSL in a drillhole near the tennis courts at Miramar Park, indicate marine deposition almost to the head of Miramar Valley at this time. Both Stevens (1973) and Crawford (1873) reported a gravel beach ridge to the north of this site, but this appears to have been destroyed by urban development.

Shells from sandy marine mud were dated at 6630±70 years BP (Wk-2374) at a height of 13.5 m below MSL in a drillhole at the Polo Ground (see also Begg et al 1992). These sediments were probably deposited offshore from a beach, in water depths of more than 10 metres. A radiocarbon age of >50,000 years BP (Wk-2076) was obtained on peat at a height of 30.4 m below MSL at the Polo Ground, but this date is not relevant to this report, except to confirm the presence of very old deposits at depth.

INTERPRETATION

In order to interpret the uplift history of Miramar Peninsula, we must know the history of sea level over the past several thousand years. Sea level history in the New Zealand region has been established by Gibb (1986), using dated shoreline deposits in generally stable tectonic areas of New Zealand (eg. Otago, Canterbury and Auckland areas). Essentially, sea level rose rapidly from a height of about 30 metres below present MSL at 10,000 years BP to approximately its present level between 6000 and 7000 years BP; since that time sea level has stabilised within 1 metre of the present level.

We conclude that as sea level rose between 10,000 and 6,000 years ago, the sea gradually inundated Miramar Valley, much of the Rongotai Isthmus, and the lower parts of Seatoun. Dates of 6910 and 6630 years BP from Miramar Valley support this interpretation. The highest marine deposits in the area are 6 to 10 metres above present MSL (Stevens 1973; Ota et al 1981; this work), and are almost certainly 6000 to 7000 years BP in age. These heights and ages suggest mean uplift rates of some 1 to 1.5 m/1000 years since that time. Uplift was presumably accomplished as a series of uplifts associated with large earthquakes.

Rapid sediment infilling of Miramar Valley occurred from 7000 to 4500 years BP. Several dated sites in the central part of the valley indicate that the shoreline was probably in the vicinity of Hobart Street by 4500 years BP, almost half way to the present shoreline from the northernmost shoreline in the head of the valley.

It is important at this stage to distinguish shoreline movement resulting from progradation (natural sedimentation and building out of the shoreline), and that resulting from earthquake-induced uplift. The former will be characterised by dominantly horizontal movements in the shoreline, whereas the latter will be characterised by both horizontal and vertical movements. In Miramar Valley, there is little difference in height between shoreline deposits dated at 4920 and 3370 years BP, and we conclude that there was no net uplift in this period. However, there is a height difference of up to several metres between these and the highest shoreline deposits (6000 to 7000 years BP). In the drillhole at the Polo Ground, there is a marked change in sediment character at about 9 m below present MSL (Begg et al 1992), indicating a sudden shallowing in water depth, perhaps caused by uplift. Radiocarbon dates show that the decrease in water depth occurred between 6630 and 5130 years BP.

On Rongotai Isthmus, shells dated at 1240 and 1740 years BP are some 3 metres lower in elevation than shells dated at 4780 years BP, consistent with uplift in the period 4780 to 1740 years BP. The evidence from Miramar Valley (see above), further constrains this uplift to the period 3370 to 1740 years BP. By 1740 years BP, we suggest that a significant part of the western Rongotai Isthmus was emergent. If a channel persisted until Maori times, we suggest it was only a few hundred metres wide, on the northwestern margin of the present Wellington airport, along the line of the Evans Bay Fault (Fig. 3).

Two other uplift events are represented at Hue-te-taka Peninsula - the 1855 event, and a boulder beach dated at 960 years BP. The radiocarbon age of 960 years BP is equivalent to a calendar age in the interval 1300-1450 AD (Stuiver et al 1986), in good agreement with previous age estimates of the Hao-whenua earthquake in the interval 1380-1580 AD (Moore 1987).

SUMMARY AND CONCLUSIONS

Our research so far indicates at least 4 major uplift events have affected Miramar Peninsula and Rongotai Isthmus in the last 7000 years. Each of these uplift events, as in 1855, was presumably associated with a large earthquake. The similarity in ages of these uplift events to those identified at Cape Turakirae by Moore (1987), suggests that major uplift at Miramar may be controlled by movement on the Wairarapa Fault.

The roles of the Wellington, Evans Bay and Seatoun Faults in the uplift history of the Miramar area are unclear at this stage, but could result in subsidence rather than uplift. There is some evidence (Lewis & Mildenhall 1985) to suggest that the long term tendency in eastern Evans Bay is for subsidence to dominate over uplift, and certainly the Miramar Peninsula lies within a generally low lying topographic area. This matter requires further investigation.

FUTURE WORK

Once we have undertaken further radiocarbon dating and field investigations, we would like to provide EQC with an updated report of our research. This would most conveniently be done at the time of completion of the MSc thesis by Huber (September 1992).

So far we have obtained 12 radiocarbon dates with EQC funding, at a total cost of $4800 (invoice to be forwarded shortly). The drilling programme which we carried out in conjunction with DSIR, resulted in a a saving of the $2000 originally budgeted for drilling costs. We seek permission of EQC to use this money to obtain 5 more radiocarbon dates, to further improve our age control on uplift events at Miramar.

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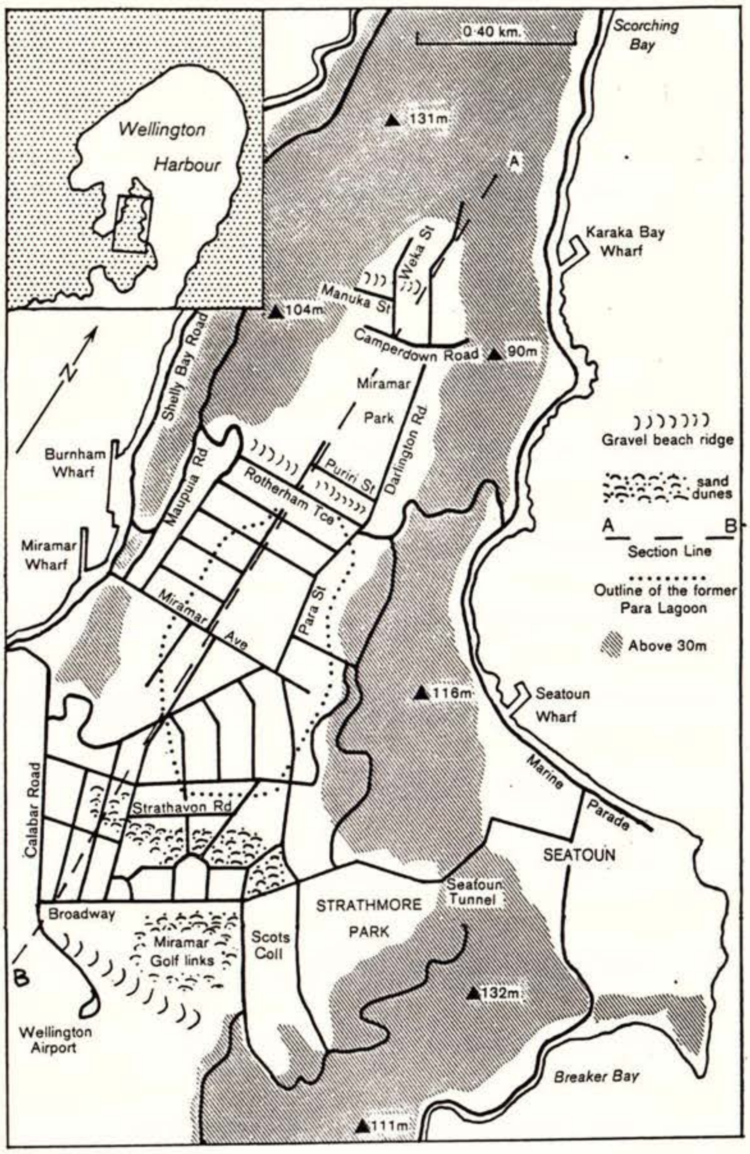
TABLE 1: Radiocarbon dates obtained from Miramar Peninsula area

Lab No.	Material	Height (m)	Age (yrs BP)	Comments
Wk-1921	Shell hash	-3.3	6910±70	From drillhole (marine)
Wk-1922	Charcoal	+3.3	modern	Maori midden
Wk-1923	Shells	+4.1	660±45	Maori midden
Wk-2076	Peat	-30.4	>50000	From drillhole (swamp)
Wk-2297	Shell hash	+2.7	5460±50	Beach sediment
Wk-2298	Shell hash	+2.1	4920±50	Beach sediment
Wk-2323	Shells	+4.0	4910±60	Beach sediment
Wk-2324	Shells	+6.0	4780±60	Beach sediment
Wk-2325	Shells	+3.2	1240±50	Beach sediment
Wk-2326	Shell hash	+3.1	4880±60	Beach sediment
Wk-2373	Shells	-3.5	5130±60	Shallow marine
Wk-2374	Shells	-13.5	6630±70	Offshore marine
Wk-2427	Shell hash	+1.4	4670±100	Shallow marine
Wk-2428	Shell hash	+1.9	3370±60	Beach sediment
Wk-2429	Shells	+3.4	1740±60	Beach sediment
Wk-2430	Shell hash	+2.0	1260±60	Beach sediment
Wk-2431	Shell hash	+3.0	960±50	Boulder beach
Wk-2432	Wood	+4.1	3280±60	Wood on beach sediment

Notes: Wk-1921 to 1923 funded by DSIR; Wk-2076, 2297, 2298 funded by Lotteries Board; others funded by EQC.

FIGURE 2: Map of Miramar Valley and cross section showing positions and heights of beach ridges recognised by Stevens (1973).



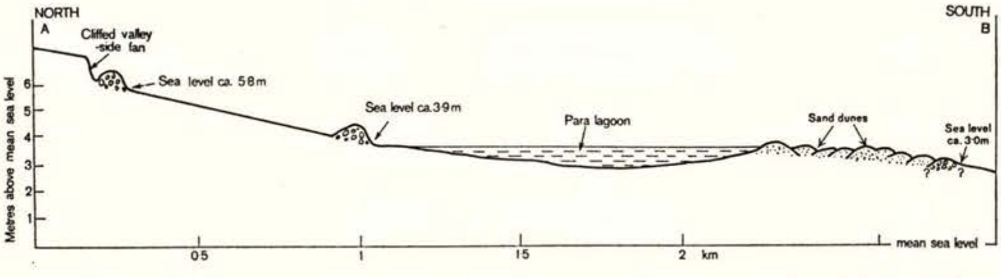
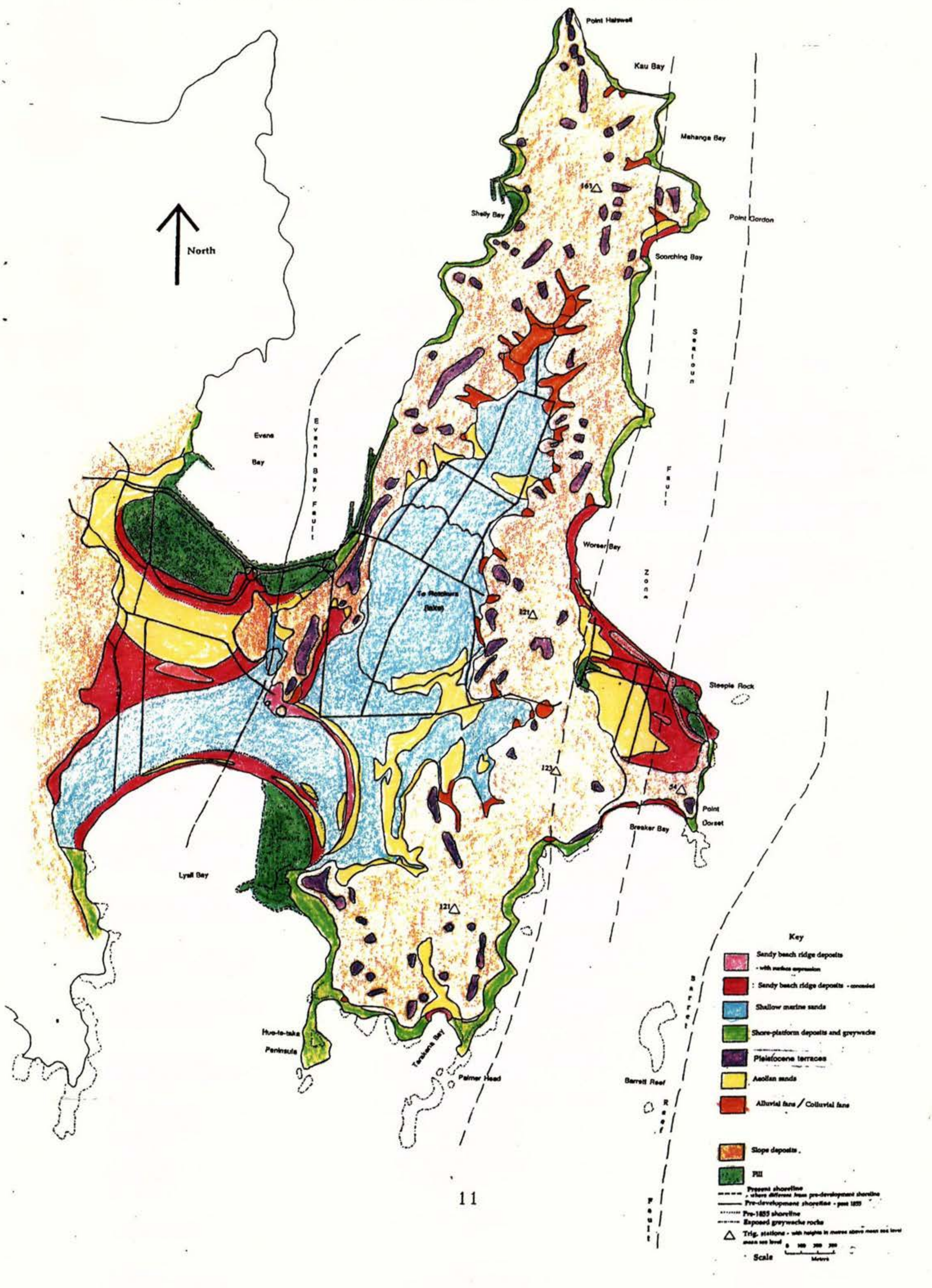
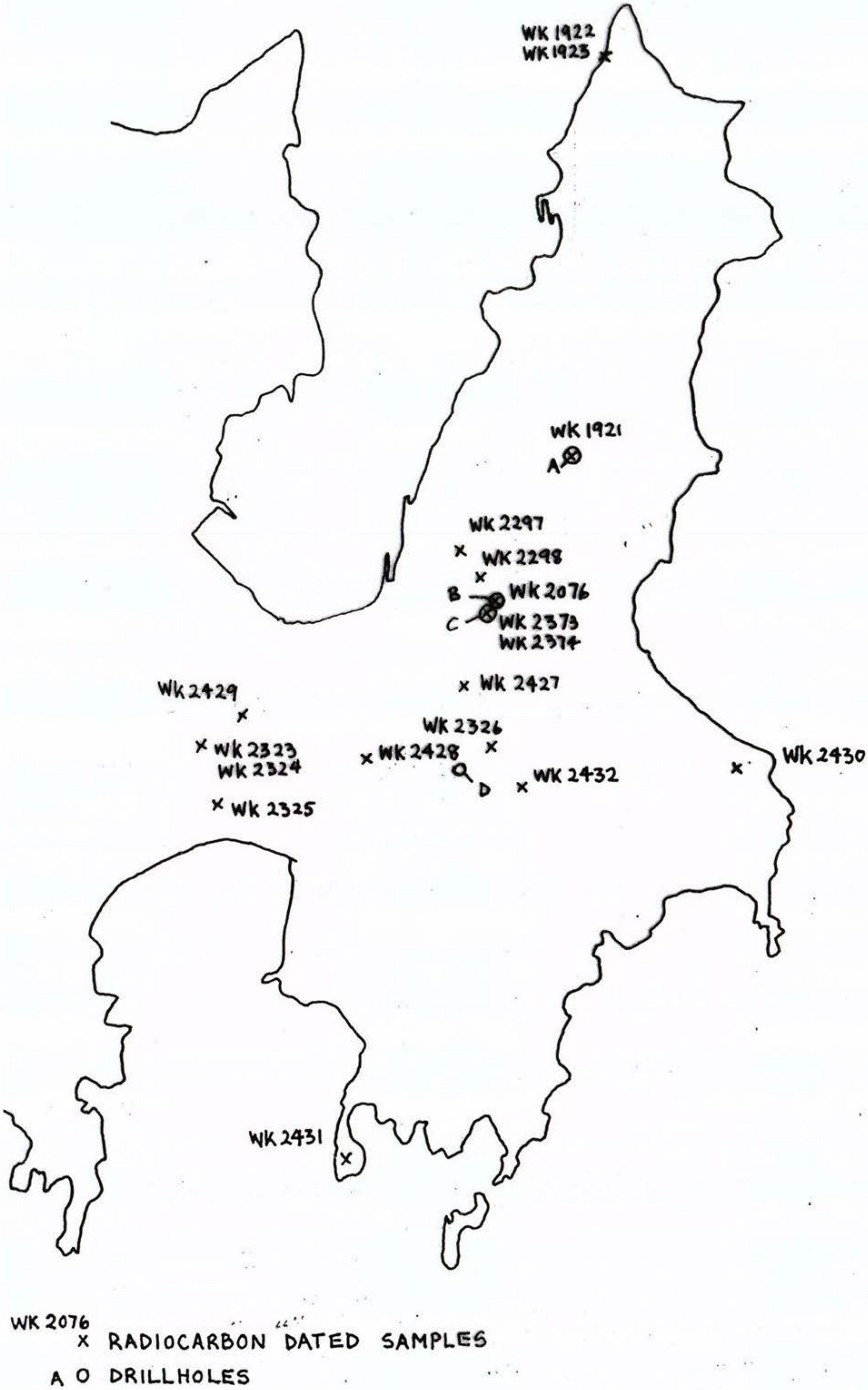


FIG. 8—Profile of the central valley of Miramar Peninsula, showing the distribution of beach ridges and related features. Levels obtained by Wellington City Council have been used in the preparation of the figure.

FIGURE 3: Surficial geology map of Miramar Peninsula.





WK 1922
WK 1923
WK 1921
A
WK 2297
WK 2298
B
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C
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FIGURE 3: Surficial geology map of Miramar Peninsula.