FIELD TRIP 2

Beach Geology and Geomorphology at Turakirae Head, Wellington

Mauri McSaveney[1]
David Kennedy[2]

[1]GNS Science, Lower Hutt
[2]Victoria University of Wellington

Looking across the uplifted 1855 beach ridge at Turakirae Head to the Last Interglacial Terraces at the end of the Wainuiomata Valley.

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Trip Summary

This field trip to Turakirae Head will investigate the modern and uplifted gravel beaches that have fascinated geologists since people first explored the region's coast. The uplifted beaches which we will walk along have provided some of the key evidence for uplift of the region's fault systems, particularly the Wairarapa Fault, and continue to be a source of scientific debate. The key element in the landscape is the link between beach development, its rate and source, and the magnitude of uplift that eventually preserves the sequences. The trip will first traverse the modern gravel beach between the Wainuiomata and Orongotongo Streams from where we will walk along the beach uplifted in 1855, to the tip of Turakirae Head.

The coastal section is a gazetted "Site of special scientific interest" preserving a flight of Holocene marine beach ridges reputed to be New Zealand's best, which lie below the larger, uplifted, coastal plains of the Last Interglacial period. The trip is about the view (particularly of South Island), the wildlife (lizards, seals, birds, shell fish - Alan Beu (McSaveney et al. 2006) has recorded 97 species of molluscs here), and the beach ridges (5 and often 6 - the lowest one can be ephemeral), and there also is some hard-rock geology to see.

Hard-Rock Geology

The walk from the Orongorongo River mouth to Turakirae Head crosses the boundary between Rakaia and Esk Head terranes in the Mesozoic "greywackes". Late Norian (or perhaps early Rhaetian) radiolaria have been extracted from phosphatic concretions found in outcrops beside the bridge crossing Orongorongo River. Much of the coastal outcrop is "broken" formation, and there are limestones and volcanics. Exposure along the surf line generally is excellent.

Coastal Geomorphology

Gravel beaches are predominantly subaerial features that differ from sandy beaches in the way they respond to increased wave height. A sandy beach tends to flatten its profile during high wave energy events by transferring sand from the beach face onto the subtidal portion of the beach profile. For gravel beaches, there is often a weak link between the subaerial part of the beach profile and the offshore sedimentology. Effectively the capacity of the profile to respond to a storm is limited by the volume of sediment on the beachface. During storms the profile is reworked landward producing a distinct berm on the beach (Fig. 1). As wave energy decreases the high portions of the profile become inactive and a series of berm features are developed in a seaward direction. On coasts with abundant gravel supply these berms may record storm events at decadal to centennial scales.

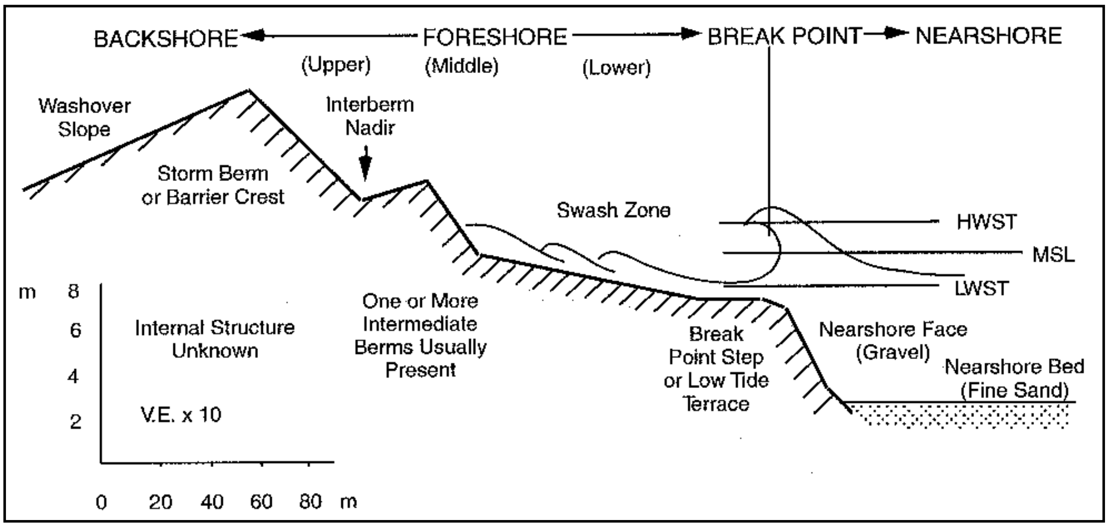

Figure 1: Schematic profile of a typical gravel beach (from Kirk 1980)

As these beaches are primarily suberial features uplift of enough magnitude preserves them. This is what has happened at Turakirae Head, with the steeper beachface and more gentle overwash slope still observable on the gravel ridges. For the sequence of beaches observed on the Head to be developed, after each uplift event has occurred sediment supply must be high enough for the beach system to re-establish. At the site, longshore drift from the Wainuiomata and Orongotongo Streams is a possibility, as is *in situ* erosion of the rocky substrate, though after investigating local geology Hinton and McSaveny, 2007) suggested the alluvial fans which dissect the relict Holocene sea cliff are the most likely source. This is supported by the observable littoral drift directions along the modern beach, we will walk along, which indicates a westerly movement of material towards Wellington Harbour, driven by energetic wave process that reach almost 19m in height in Cook Strait.

For reasons that are clouded in history, there was some confusion as to which of the lower beach ridges was the one raised above the fetch of storm waves on 23 January 1855. Part of the confusion stems from the use of the term "1855 beach" - there are two 1855 storm beaches. In common usage, the "1855 beach" generally is intended to be the beach that died in 1855, and not the beach that was born in 1855. Through a failure to appreciate the severity of the Wellington climate, however, the label was attached to the younger one, because it was at the height that the "1855" one was expected to be at (*ca* 2 m asl).

BR1 - The modern, post-23-January-1855 beach

For this trip, the modern storm beach is best recognised as the lowest of the large gravel ridges (BR1 on Fig. 2), about 3 m above the highest fetch of waves on a fine day. Look for abundant modern artefacts in the flotsam immediately landward of its ridge crest. Near the Orongorongo River mouth there sometimes are two crests, with a minor crest about 2 m lower than the main one.

BR2 - the pre-23-January-1855 beach

Next above BR1 in the sequence (2 Fig. 2) is the pre-January 1855 storm beach. The diagnostic evidence confirming this inference will be seen out near Turakirae Head where among the abandoned 1855 surge pools there are abundant remains of the former sub-littoral, intertidal and supratidal flora and fauna (97 species of molluscs, 4 species of barnacles, and representatives of 5 other phyla, Alan Beu, ops cit.), some still in life position (barnacles, worm tubes and calcareous algae), and others clearly where they have dropped from life position beneath large boulders (paua, limpets, snails). Look for snails still with opercula inside. Most fossils preserve life colour, with but little degradation. Radiocarbon dates of shells taken from where they had dropped from life position in 1855 provide a new estimate of the geographic offset δR of 3±14 radiocarbon years for New Zealand, open-ocean shells.

BR3 - the pre-pre-1855 beach

The time when BR3 ceased growing (and by inference was raised by an earthquake) is dated at about 330 BC (NZA 4746, 2603±86 BP and NZA 4747, 2566±78 BP). Micromoluscs were handpicked from among a mat of worm tubes found beneath some of the larger boulders in the abandoned surge pools in front of beach ridge 3 for the AMS ^{14}C dating. The rest of the fauna is long since leached by the acid surface water.

BR4 & 5 - the pre-pre-330BC beaches

The age of uplift of BR5, and initiation of BR4, is recorded by driftwood and peat accumulated behind BR5. Three dates from driftwood overlying BR5 gravel are from *ca*. 4660 - 4970 BC (5946±54 yr BP). They indicate when BR4 first became active, and hence when BR5 ceased to grow. The time when the surface of BR5 became stable also has been dated using *in situ* cosmogenic ^{10}Be: the ridge stabilised about 6.7±0.6 ka BP. Uplift of BR4 is dated only by slip-predictable uplift at ca. 2760 – 3400 BC (5030±190 yr BP).

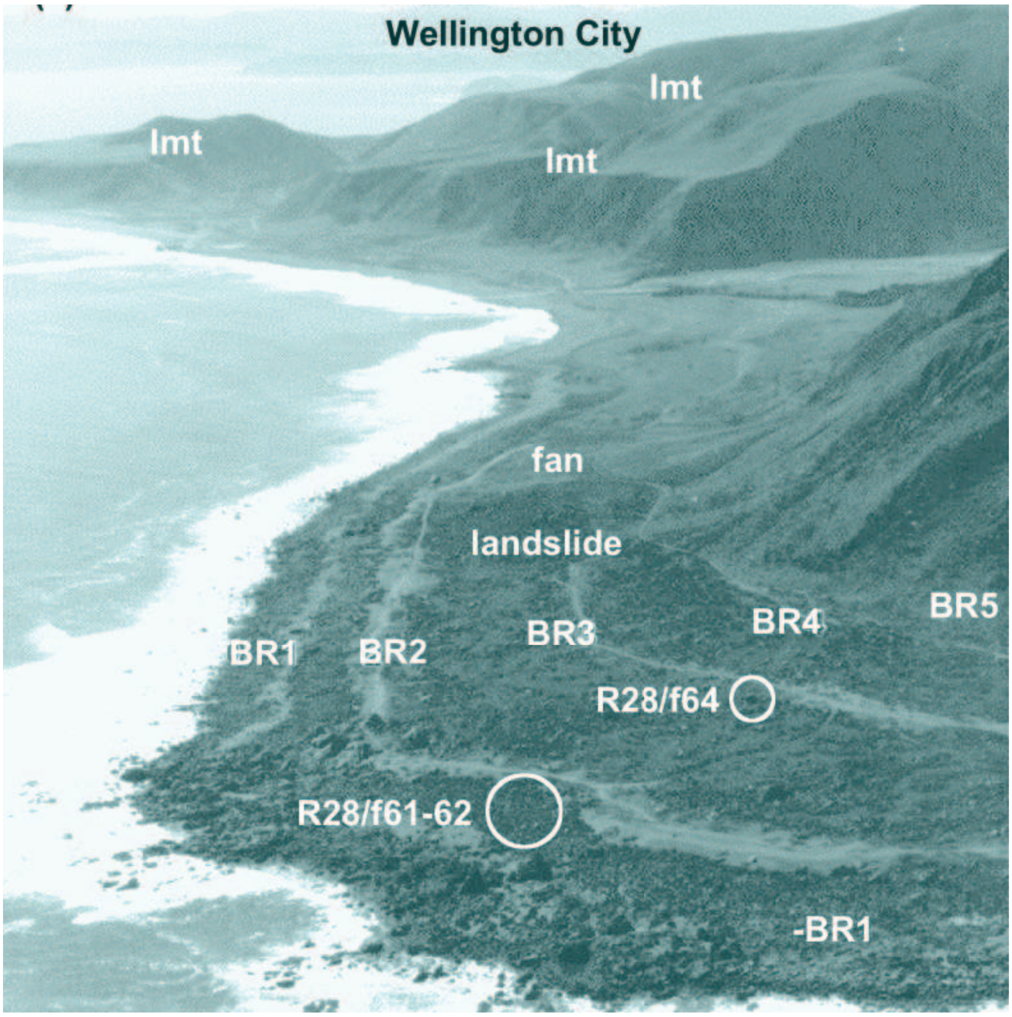

Figure 2. Aerial view of Turakirae Head: gravel beach ridges ring a broad coastal platform. The grey gravel strip immediately above high-tide level is the current storm beach (BR1). The first prominent ridge above it (BR2) was raised during the 1855 Wairarapa earthquake. A higher beach (BR3) was raised during an earthquake dated at *ca.* 200-382 BC. BR 4 was raised about 2760-3400 BC. A yet higher beach (BR5) not clearly discernible in photographs, was raised *ca.* 4660-4970 BC. Sites of new radiocarbon dates are circled and labelled with the site fossil record numbers. Modern storm beach ridge is absent at -BR1 because there is no local supply of gravel to form it. Sites marked fan and landslide are alluvial fan and landslide deposits truncated by BR2 that were local sources of gravel to form the large BR2 beach ridge at Turakirae Head. View to north-west towards Wellington City, with raised interglacial marine terraces (lmt) in background. Photography by Lloyd Homer.

Older beaches

BR5 is not the oldest nor highest former shoreline in the area. It is however the oldest and highest recognised on the Holocene marine-cut platform. Two higher marine platforms can be seen west of Orongorongo River (Fig. 3). These are inferred to date from the preceding two Interglacials. Each probably has multiple beach deposits much like those on the Holocene platform, but thick cover beds obscure them.

Uplift and tilting

The four Holocene storm-beach ridges above the modern one are tilted relative to sea level, with tilt being progressive with increasing age and uplift (Fig. 4). The tilt on the last-Interglacial platform is quite obvious (Fig. 2). Maximum coastal uplift in the 1855 earthquake was about 4 km Northeast of Turakirae Head; and is measured at 6.4 m, not 2.7 m as previously thought. BR3 had maximum coastal uplift of 9.1 m, at the same locality. The maximum uplift defines where the crest of the Rimutuka anticline (Wellman 1967) reaches the coast. Remnants of the last-Interglacial platform survive here at an elevation of almost 400 m.

Although we've (McSaveney et al. 2006) reduced the number of raised beaches by one, and increased the average recurrence interval of beach-raising events by 20%, we've not greatly changed the estimate of the average rate of uplift (4m per 1000 yr), because the height and age of the highest beach (BR5) are still as they were first interpreted by the late Prof. Harold Wellman.

What happened to the beach first raised by the Haowhenua earthquake (*c.* 1460 AD)?

BR2 formerly was thought to date from the Haowhenua earthquake of Maori oral tradition. We now know that ^{14}C dates of about 450 yr BP are to be expected from material from beaches of 1855 AD. There is no beach at Turakirae Head that was raised at the time of the Haowhenua event. All of the episodes of beach uplift are accounted for at other times.

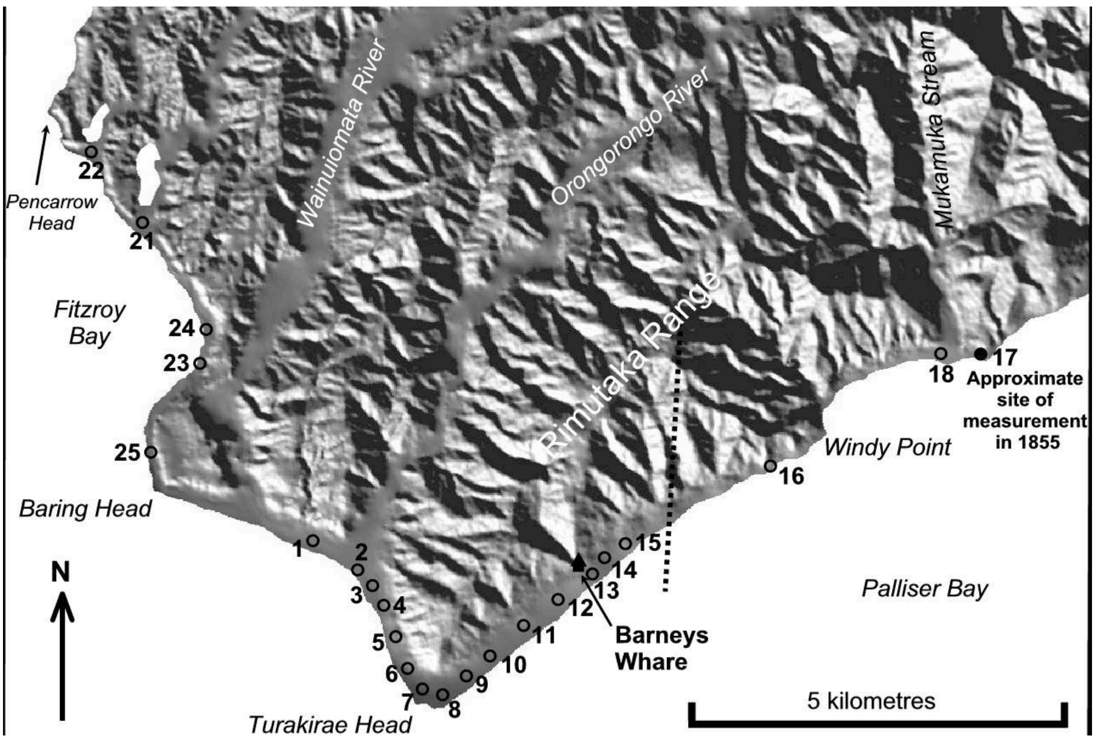

Figure 3. Map of the southern Wellington coast in the vicinity of Turakirae Head, showing approximate locations of measured beach profiles, including measurement made by Edward Roberts in 1855.

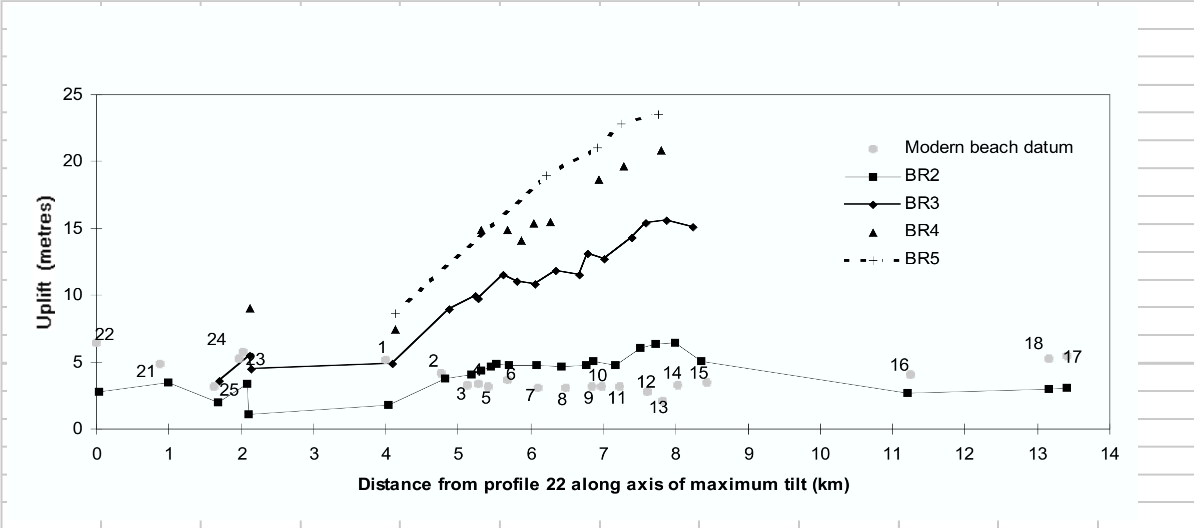

Figure 4. Elevation of beach ridges relative to the height of the modern storm beach ridge (BR1) perpendicular to the axis of maximum tilt of BR3 as determined above. Elevation of the modern storm beach (BR1) also is plotted. See Fig 3 for profile locations.

Uplift at Turakirae and rupture of the Wairarapa Fault: a continuing controversy?

In 1855, there was observation of uplift in the vicinity of Turakirae Head (at Mukamuka Rocks), and the Wairarapa Fault was found to be ruptured further to the North, following a very large magnitude earthquake. It is logical to infer that the uplift, rupture and earthquake were connected, and that previous uplift events at Turakirae also involved very large earthquakes and rupture on the Wairarapa Fault. Hence, there is an expectation that the dated uplift events at Turakirae should correspond closely with dated ruptures of the Wairarapa fault, within the uncertainties inherent in current dating. Recent dating by Little et al. (in press; and guide to field trip #5, this volume) based on trench stratigraphy has found that additional rupture events have occurred on the Wairarapa Fault that are not preserved in the beaches sequences.

Several reasons could be put forward to explain this ascertain, and will (hopefully!) prove interesting discussion points on the field trip. These include (1) uplift may not be high enough to completely remove a ridge from the surf zone during storms, (2) the time between uplift events may not be long enough to establish a beach or (3) not all events cause uplift at Turakirae Head.

Whichever the explanation, it is clear that our understanding of uplift along our local faults is incomplete and further research is needed to fully assess the hazard they pose to the region.

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