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Zealandia in Space and Time

Victoria University of Wellington
25th-27th November 2015

Field Trip Guides

ZEALANDIA IN SPACE AND TIME

GEOSCIENCES 2015

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25th-27th November Wellington

Field Guides

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FIELD TRIP 2

Wellington Rocks: An introduction to Wellington geology and landscape

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This fieldtrip guide provides an introduction to Wellington's geology and landscape. It is an abbreviated version of a Victoria University 100-level Geography and Earth Science fieldtrip. This version is aimed at teachers and outreach specialists to highlight some of topics we introduce to first year students. We will visit several sites in the Wellington area to examine the bedrock, faulting, landscape evolution and coastal processes. The guide gives an outline of our planned itinerary and comments on the features we will see. Locations are shown an aerial photo of the Wellington region (Figure 1).

ITINERARY

9.00 - 9.20am	Drive along old Wellington shoreline to Te Papa.
9.20 – 9.45am	**Stop 1:** Te Papa seismic base isolators
9.45 – 10.00am	Drive to Mt Victoria Lookout
10.00– 10.30am	**Stop 2:** Mt Victoria Lookout (regional landscape overview)
10.30 – 11.15am	Follow the Wellington Fault along SH1/2 to Upper Hutt
11.15 – 12.30pm	**Stop 3:** Walk along the Wellington fault scarp at Harcourt Park
	– Wellington Fault and offset river terraces
12.30-1.15pm	Lunch
1.15 – 2.15pm	Drive to QEII park via Haywards Hill and Paekakariki Hill
2.15 – 2.45pm	**Stop 4:** QEII park to discuss coastal processes
2.45 - 3.10pm	Drive to Plimmerton
3.10 - 3.30pm	**Stop 5.** Shore platform at Plimmerton (Torlesse bedrock)
3.30 – 4.00pm	Return to Victoria University

Figure 1. Oblique aerial photograph of Wellington region with fieldtrip stops shown. Photo by D.L. Homer modified (from Begg and Mazengarb, 1996).

Figure 2 shows a model of the tectonic setting of the Wellington region showing the subducting Pacific Plate beneath the Australian Plate and the location of the main fault lines and seismic activity. The tectonic setting and location of faults has a major influence on the shape of the Wellington landscape, giving the dominant northeast-southwest alignment of hills and valleys. The geology is dominated by Triassic age sandstone and argillite of the Torlesse Complex with localised areas of younger sedimentary rocks overlying.

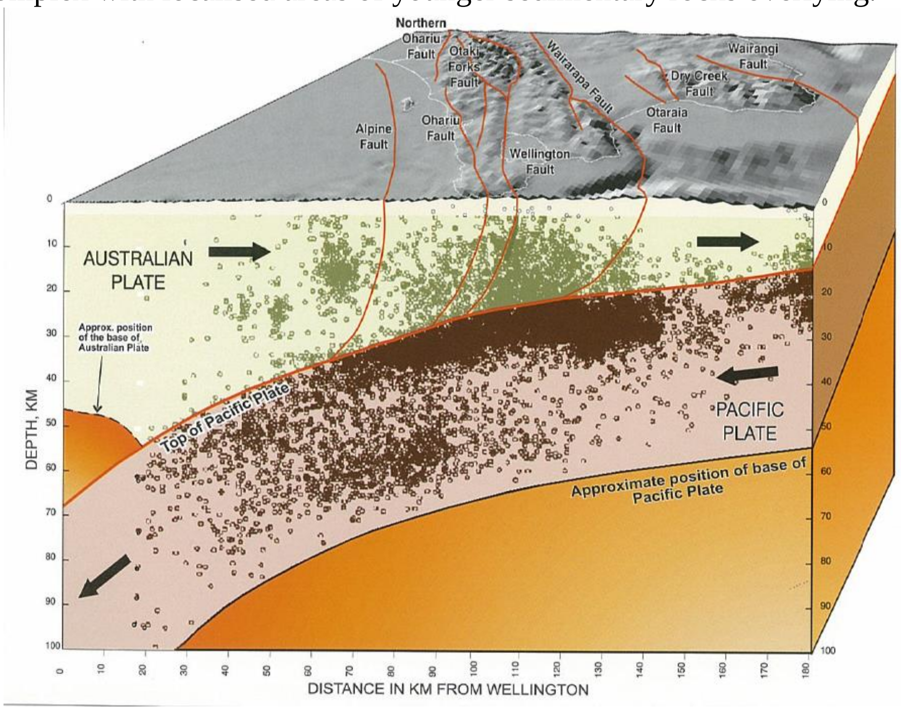

Figure 2. Cross section though the Wellington showing the relationship between the Pacific and Australian plates and location of main earthquake generating faults. Black arrows indicate relative plate motion and small circles indicate microseismic activity between 1987 and 1993 (from Begg and Johnston, 2000).

From Victoria University, we will drive along Lambton Quay in Wellingtons CBD, following the old shoreline prior to the regional uplift associated with the 1855 Wairarapa earthquake and subsequent land reclamation (Figure 3). The railway yards, wharf, Westpac Stadium, Frank Kitts Park, the events centre, Te Papa and Waitangi Park are sited on reclaimed land. Also, prior to 1855, plans were drawn up for construction of a shipping channel to the 'basin lagoon'. After the uplift, the plan was abandoned and the proposed channel turned in Kent and Cambridge terraces and the basin converted into the Basin Reserve cricket ground (Figure 4).

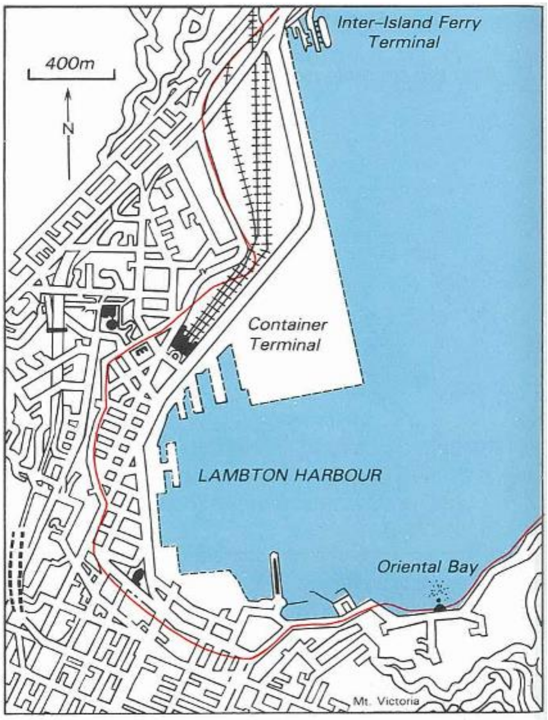

Figure 3. Position of the pre 1855 shoreline (red line). It follows the edges of the old terraces in the Thorndon Quay and Bowen Street areas and then curves across Te Aro flat, roughly following today's Wakefield Street (from Stevens, 1991).

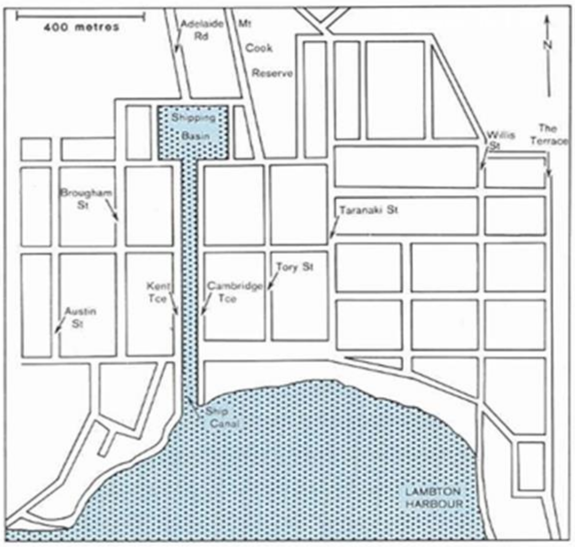

Figure 4. Map of the proposed channel to the shipping basin prior to 1855. After the uplift, the project was not feasible so the basin was turned in a cricket ground and the channel became the broad two roads of Kent and Cambridge terraces (from Stevens, 1991).

STOP 1: Te Papa Tongarewa 9.20 – 9.45am

Due to the close proximity to several large faults, Wellington City has a significant seismic hazard. At Te Papa, we can view the efforts taken to mitigate earthquake hazards on reclaimed land. The ground was compacted prior to construction and the building is perched on 157 'base isolators' (Figure 5). The isolators are made of laminated rubber and steel blocks with lead cores inside. They were designed by Dr. William Robinson and allow the building to move independently of the ground by up to 0.5m in any direction. The lead core is designed to soften under stress and absorb much of the energy, greatly reducing the amount of shaking and damage the building will experience during an earthquake. This base isolator technology is now used in buildings around the world.

Figure 5. The rubber and lead 'base isolators' underneath Te Papa and many other buildings in Wellington. These act to 'isolate' the building from the ground to mitigate the shaking during and earthquake.

STOP 2: Mt. Victoria lookout 10.00– 10.30am

This location offers a 360º panoramic view of Wellington, allowing us to observe many of the features that make up the Wellington landscape and how they have changed over time.

View West & North (Figure 6):

- Reclaimed land of Wellington CBD, includes buildings such as Westpac Stadium, wharf, Railway Station, NZRU headquarters, Events Centre, Frank Kitts Park and Te Papa.
- Wellington Fault, motorway and railway. The motorway and railway lines are built on the platform uplifted ~1.5m as a result of the 1855AD earthquake on the Wairarapa Fault.
- The tops of all the hills are at about the same elevation. This is called the Wellington "K surface". It is the remnants of an old eroded flat landscape (peneplain) that has been uplifted, exposed and dissected by streams into the modern landscape.
- The Petone shoreline and entrance of the Hutt River into the harbour. The Hutt Valley comprises thick gravels, peat lenses, and thin layers of marine mud that have accumulated in the Wellington Fault angle depression. This has formed an excellent aquifer system.
- Matiu-Somes Island. It has three levels, representing interglacial wave cut platforms that have been uplifted through time.

Figure 6. View from Mt Victoria looking north-west over Wellington City, Wellington Fault and the Hutt Valley.

View East & South (Figure 7):

- Eastern Hills and Rimutaka Range. The Wairarapa Fault is located on the eastern side of the Rimutaka Range – the Wairarapa Fault ruptured during the 1855AD earthquake.
- Baring Head. The steps or benches represent interglacial wave-cut platforms that have been uplifted tectonically.
- Entrance to Wellington Harbour, between Pencarrow Head and Miramar Peninsula. Just offshore is Barrett's Reef – site of the Wahine Disaster, 1967.
- The Rongotai isthmus. Prior to the 1460AD uplift on the Wellington Fault, Miramar Peninsula existed as an island but has gradually been connected to the mainland by uplift and accumulation of gravel and sand (tombolo). The Hutt River probably drained through this area during the Last Glacial Maximum - 20,000 years ago.
- Wellington's South Coast, shows wave cut shore platforms that were uplifted during the 1855AD earthquake.

Figure 7. View from Mt Victoria looking south west over Miramar Peninsula, airport and Wellington Harbour entrance. The Rimutaka Range forms the skyline in the background.

We will now follow the Wellington Fault along the Wellington-Hutt motorway to Harcourt Park in Upper Hutt. The Wellington-Hutt Valley section of the fault forms a distinctive trace oriented northeast-southwest, with uplift of the Torlesse bedrock forming the hills along western edge of Wellington Harbour and the Hutt Valley. Regional uplift on the Wairarapa Fault in 1855 raised a wave cut bench along the side of Wellington Harbour, adjacent to the Wellington Fault, providing a convenient platform for construction of the Wellington-Hutt road and railway (Figure 8).

The western side of the Hutt Valley is characterised by a ~ 300 m thick sediment wedge that has accumulated in a fault angle depression adjacent to the Wellington Fault. Tectonic subsidence and repeated changes in sea level have resulted in deposition of alternating layers of permeable river gravel and impermeable marine mudstone forming an excellent aquifer system (Figure 9). The aquifer is recharged by water infiltration in the Taita-Avalon area and about 25% of water consumed in Wellington and Hutt Valley is extracted from the aquifer. Some water re-emerges as springs in Wellington Harbour near Matiu-Somes Island (Begg and Johnston, 2000).

Figure 8. Aerial view of Wellington Fault scarp looking north. The western hills have been uplifted on the upthrown side of the fault and the Hutt Valley has formed by accumulation of sediment in a fault angle depression on the on the downthrown side.

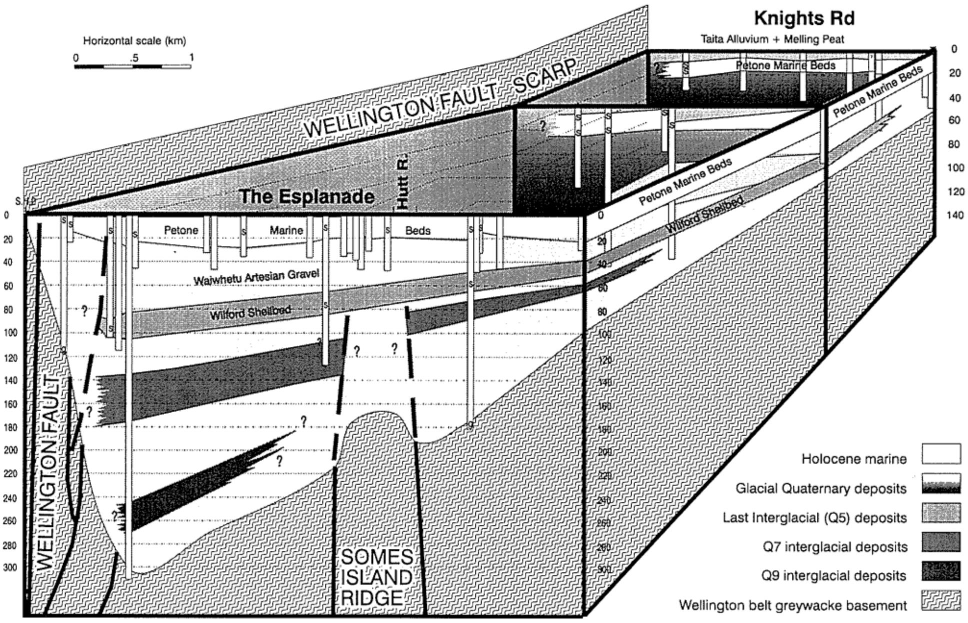

Figure 9. Cross section along the Petone shoreline showing thick accumulation of sediment in the fault angle depression forming the Hutt Aquifer (Begg and Johnston, 2000).

STOP 3a: California Drive 11.15 – 12.30pm

At California Drive, we walk through Totara Park, following the trace (scarp) of the Wellington Fault – i.e. where the fault meets the ground surface. The uplifted western block is clearly visible relative to the down-thrown eastern block. As we walk, note that houses are built in close proximity to the trace of the Wellington Fault. This location offers a clear example to students of how the fault rupture is expressed at the ground surface.

Where the fault trace crosses the Hutt River, we should be able to observe the Wellington Fault exposed in the northern bank (Figure 10). Basement rocks (upstream or west) have been uplifted relative to the younger alluvial gravels on the down-thrown side of the fault (downstream or east). The fault is marked by the change of rock types and ground up rock that is referred to as fault gouge.

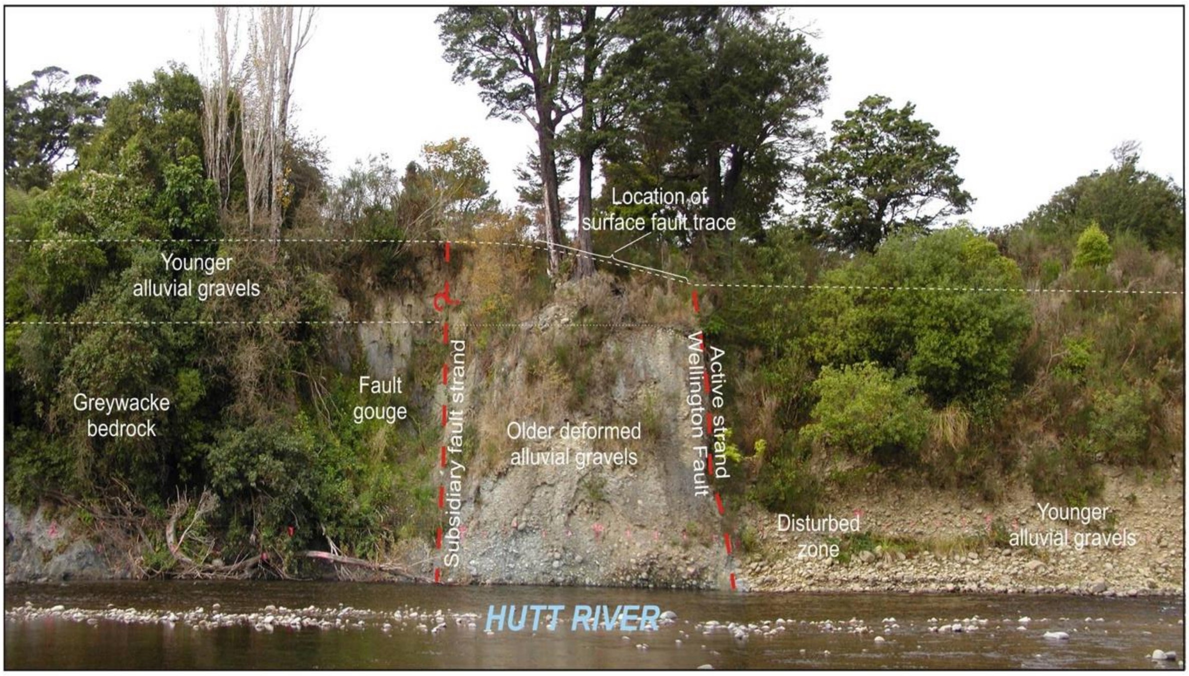

Figure. 10. View of the Wellington Fault in cross-section exposed in the river bank, showing older Greywacke bedrock (left of photo) that has been uplifted against much young alluvial gravels (right of photo) (Figure from Begg et al., 2008).

For the 100 level student fieldtrip, we also carry out a detailed hydrology exercise at this site using hand-held stream flow meters to measure the flow volume and then compare the results with data from one of the Greater Wellington Regional Councils river monitoring stations nearby.

STOP 3b: Harcourt Park

On the northern side of the Hutt River in Harcourt Park we can observe the trace of the Wellington Fault where it has offset a series of old river terraces formed by the Hutt River. These offset river terraces are shown in Figures 11 and 12.

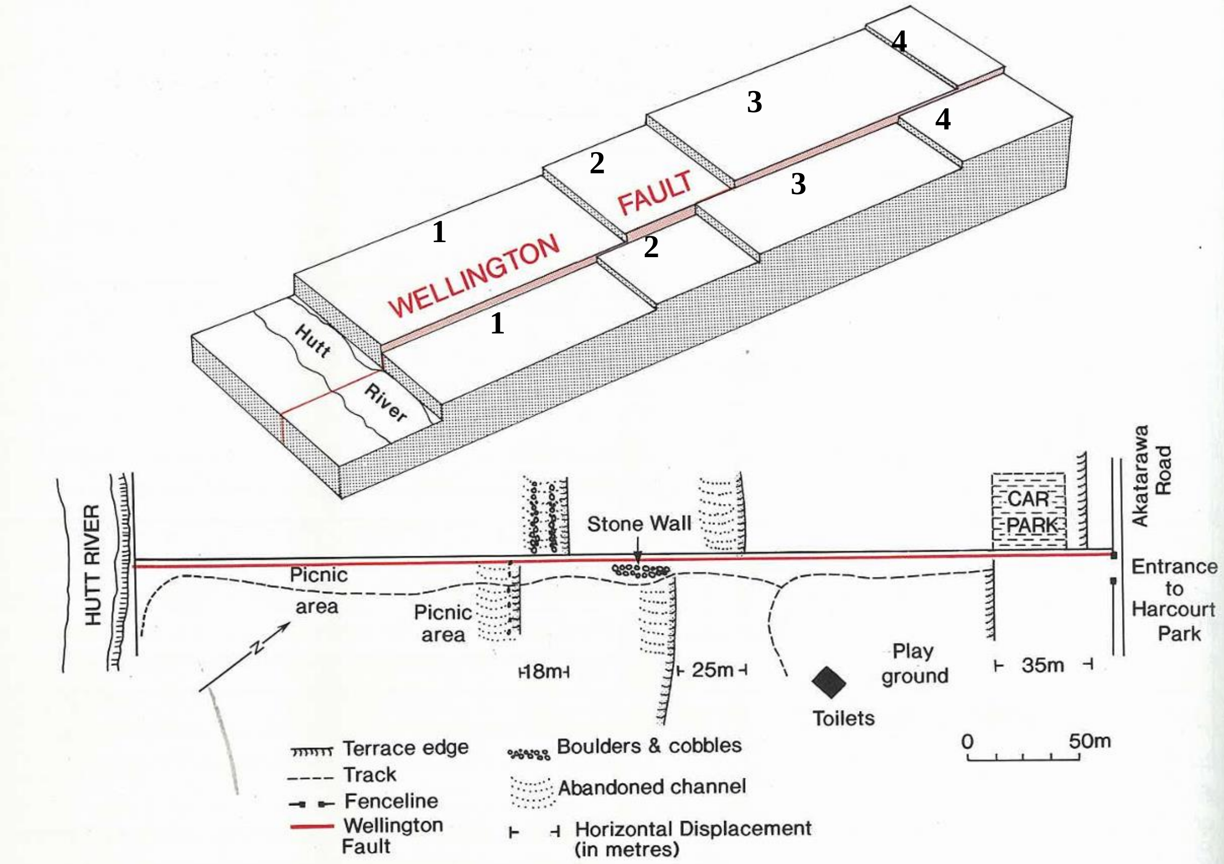

Figure 11. Harcourt Park, showing cultural features and approximate positions of the offset terrace treads and risers (from Stevens, 1991).

We can use the base or the top of each terrace riser on each side of the fault as linear markers to measure the cumulative offset on the fault (see detailed map in Figure 12). This makes an excellent hands-on group activity for students followed by a series of questions related to the relative sense of movement on the fault and calculating individual and cumulative earthquake event offsets.

The recurrence interval on the Wellington Fault is about 500-770 years (Berryman, 1990, Van Dissen et al., 1991, Begg and Johnston, 2000) with the most recent surface ruptures identified at around 335-485 years BP and 670-830 years BP (Begg and Johnston, 2000). The fault displays dextral horizontal movement ranging between 4-6 m movement and a smaller vertical movement (1-2 m). Overall, the fault has produced up to 1km of vertical offset and 10-12km horizontal offset (Begg and Johnston, 2000).

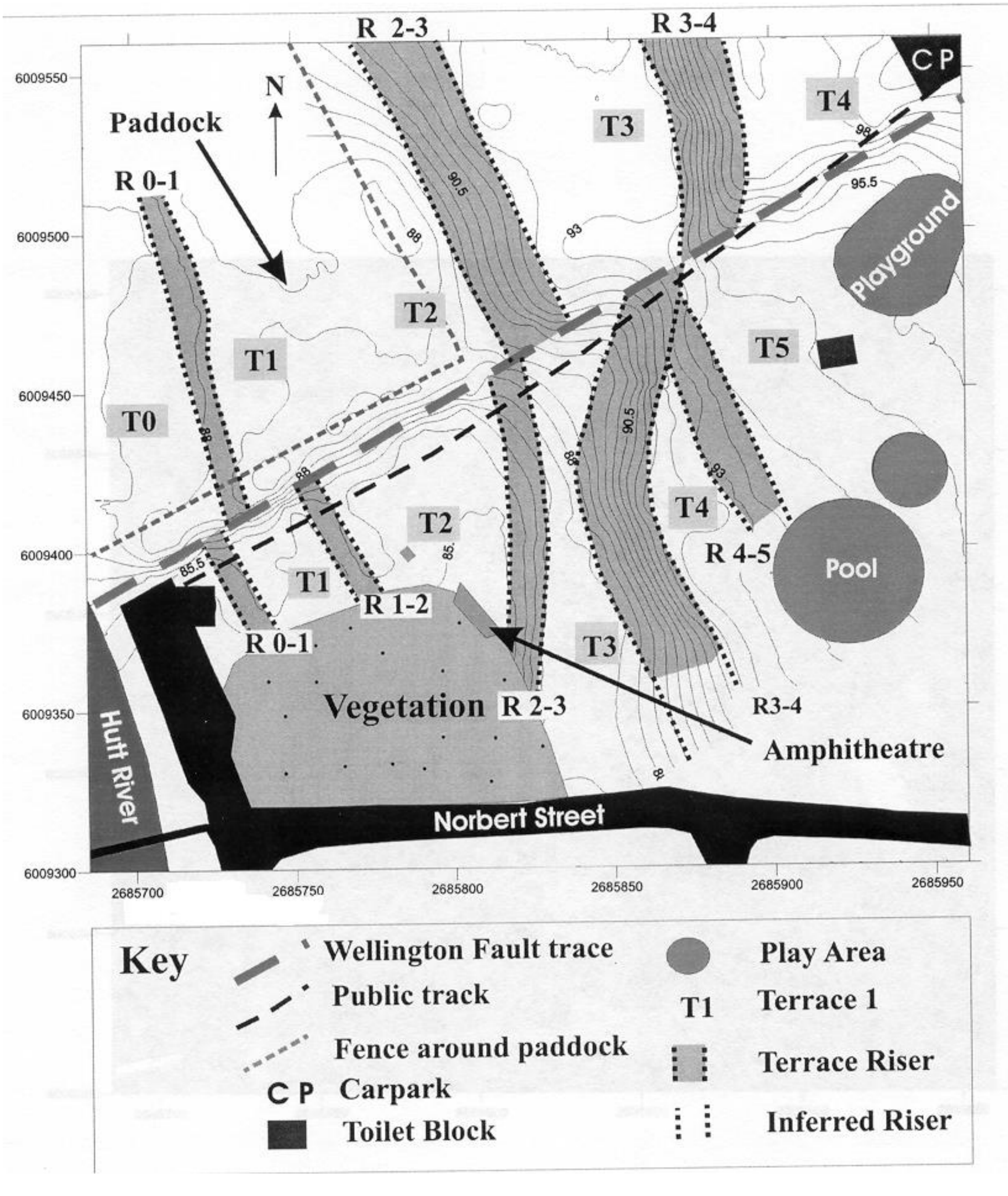

Figure 12. Detailed map of the terrace treads and risers. Contour interval is 0.5m (from Robbins, 2003)

*Note: the **River Terraces** are flat areas in the park, and were formed by the river, **NOT** the Wellington Fault. River Terraces are labelled **T0**, **T1**, **T2**, **T3**, **T4**, & **T5**, with **T5** being the oldest terrace preserved at Harcourt Park. In between each River Terrace, there is a change in slope, which represents the **Terrace Risers**. These Terrace Risers are labelled **R0-1**, **R1-2**, **R2-3**, **R3-4**, & **R4-5**, denoting the rise between adjacent terraces.*

LUNCH- 12.30 -1.15pm.

There are public toilets available in the park near the playground and at the sports grounds opposite the park.

We will now drive to the Kapiti Coast via Haywards Hill and Paekakariki Hill. The view from Paekakariki Hill is a good place to pause for an overview of the main landscape features (Figure 13).

The Kapiti coast is a low-lying coastal plain comprising several belts of sand dunes and inter-dune swampy areas. It has built out (accreted) over the last approximately 6000-6500 years from an old shoreline and sea cliff along the base of the greywacke bedrock ranges. The rate of sedimentation and accretion has varied along the coast forming a distinctive cuspate foreland with the apex or 'nose' extending from the old shoreline opposite Kapiti Island. The area provides a good place to introduce students to the complex processes operating on a dynamic coast.

Features to note from Paekakariki Hill:

- Torlesse 'greywacke' ranges in the east. The steep cliff represents the shoreline approximately 6000-6500 years ago.
- Cuspate foreland (bulge in the coastline at Paraparaumu) due to variable rate of coastal accretion related to the wave shadowing effect of Kapiti Island.
- Coastal plain comprising dune sediments between the old sea cliff and the modern coast that has formed (accreted) during the last 6000 years.

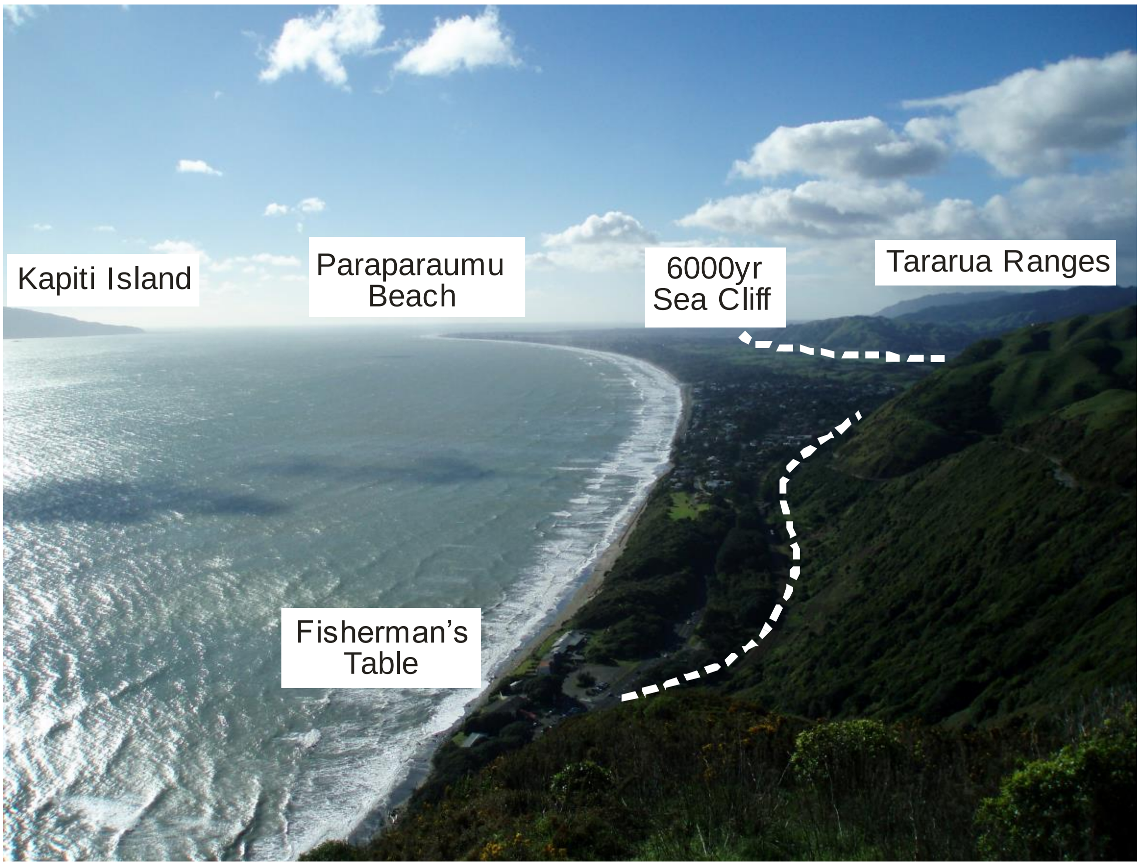

Figure 13. View looking north from Paekakariki summit showing Torlesse 'greywacke' ranges in the east, cuspate foreland, coastal plain and Kapiti Island to the west.

STOP 4: Queen Elizabeth Park, Kapiti Coast 2.15 – 2.45pm

Figure 14 shows a map of the Kapiti cuspate foreland. Sediment supply is predominately sourced from rivers to the north and transported along the coast via long shore drift. The northern limb of the cuspate foreland has a positive sediment budget and is actively accreting at up to 0.6m per year, culminating in a coastal plain about 4km wide at Paraparaumu Beach. This part of the coast is directly opposite Kapiti Island which shelters Paraparaumu Beach from waves. On the southern limb, the coastal plain narrows toward Paekakariki. It has a negative sediment budget and is actively eroding (Gibb, 1978).

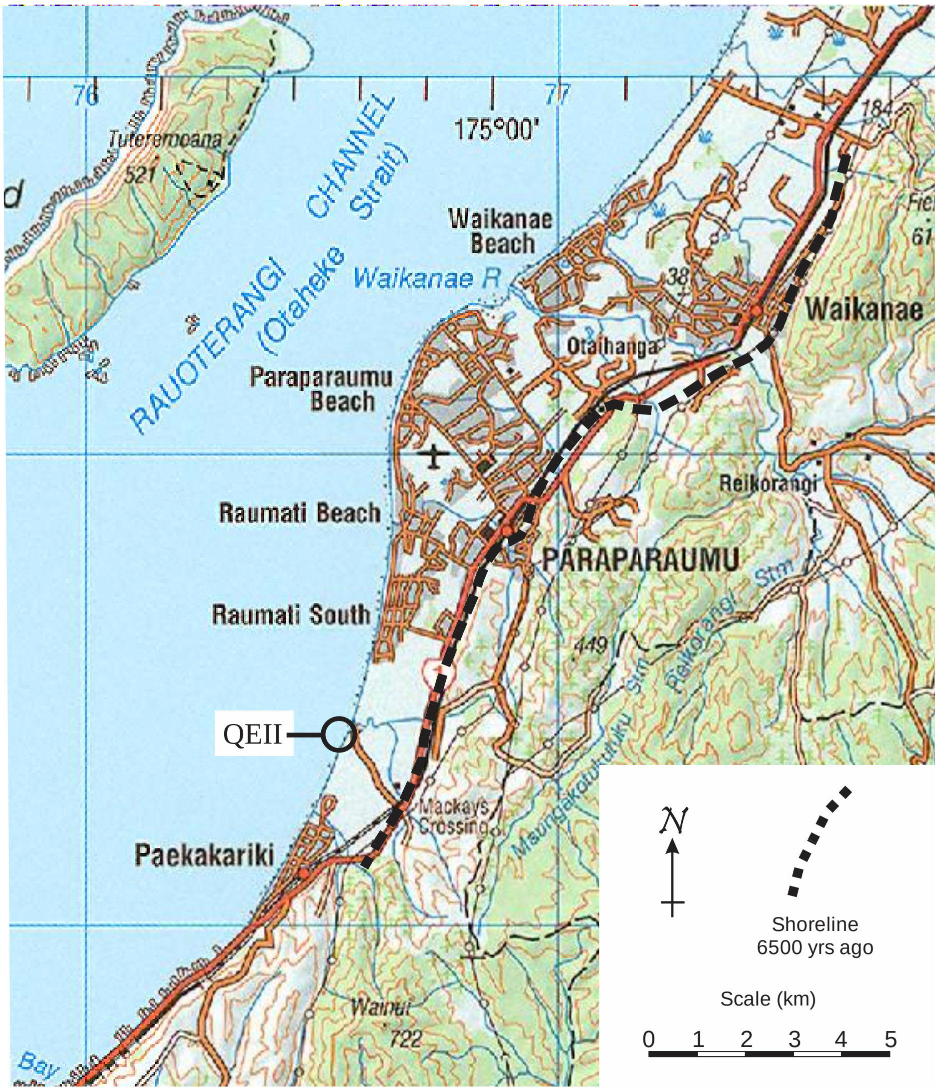

Figure 14. Map of the Kapiti coast showing the position of the shoreline 6000-6500 years ago and location of Queen Elizabeth Park.

At Queen Elizabeth II Park, the coastal plain is less than 2km wide. As we leave the main highway and the 6500-year-old shoreline and head out to the modern beach at we can see the belts of sand dunes separated by flat grass and swampy areas. The beach at this site is significantly narrower than at Paraparaumu and the dunes are actively eroding. During stormy weather, waves wash up to the foot of the dunes (Figure 15).

Figure 15. Storm wave washing up to the foot of actively eroding dunes at Queen Elizabeth Park.

The erosion of the dunes frequently produces fresh outcrops where the internal structure of the dunes can be examined. Notable features include layers of Taupo Volcanic Zone sourced pumice that has been transported south and washed into the dunes and lenses of charcoal with shells interpreted as middens (Figure 16).

Figure 16. Shell layers with charcoal exposed in an actively eroding dune, QEII Beach front.

The dramatic change from accretion in the north to erosion is the south is largely related to changes in longshore sediment transport as the cuspate foreland has grown (Gibb, 1978). However, students are encouraged to discuss the many other factors that influence the copmplex dynamics of coastal areas such as long term tectonic movement, vegetation changes, large storm events, tsunami and also consider the likely impacts of future sea level rise projections.

STOP 5: Plimmerton Beach 3.10 - 3.30pm

At Plimmerton, we can examine good exposures of the bedrock that underlies the Wellington region (Figure 17). Most of the Wellington bedrock is Triassic (~220 to 200 million years old) sandstone and argillite collectively known as 'greywacke' of the Torlesse Complex (Begg and Johnston, 2000). The layers are sandstone (lighter colour) and mudstone/argillite (darker colour) and were originally deposited on the sea floor from submarine turbidity flows on the continental slope off the coast of Gondwanaland. As the flows slowed down, the larger grains were deposited first (sandstone), followed by the finer grains (argillite), giving a 'fining-up' deposit. These flows were repeated many times resulting in the repetitive sandstone/argillite package of rocks.

Other minor components of the Torlesse include: basalt, chert, coloured argillite, diamictite and limestone. In the Wellington area, the rocks contain fossil radiolarians, foraminifera, conodonts, rare molluscs and vertebrates. The Torlesse rocks have experienced low-grade metamorphism and been extensively tectonically deformed. The deformation is present as folding and faulting with common veins and joints visible in outcrop. The originally horizontal or sub horizontal sedimentary layers are often exposed as near vertical layers.

Figure 17. Layers of sandstone and argillite tilted on end give the rocks a "striped" look at Plimmerton Beach. Lighter coloured layers are sandstone, darker coloured layers are argillite. Layers are approximately 20-30 cm wide.

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