NEW ZEALAND
FRIENDS OF THE QUATERNARY FIELDTRIP
Hawke's Bay 1st – 3rd July, 2005

**Nicola Litchfield [1], Kyle Bland [2], Bruce Hayward [3], Mike Page [4],
and Robert Langridge [1]**

[1] GNS, Gracefield Research Centre, PO Box 30368, Lower Hutt
(n.litchfield@gns.cri.nz)
[2] Department of Earth Sciences, University of Waikato, Private Bag 3105, Hamilton
(Kyle@waikato.ac.nz)
[3] Geomarine Research, 49 Swainston Rd, St Johns, Auckland
(b.hayward@geomarine.org.nz)
[4] Landcare Research NZ Ltd, Private Bag 11052, Palmerston North
(PageM@landcareresearch.co.nz)

DAY 1 Saturday 2nd July
SH2 north

STOP 1a. Poraiti Lane, Lagoon Farm, off Tamatea Rd. c. 6 km V21/408829
Bruce Hayward, Geomarine Research, Auckland

View site where cores were taken near SW margin of Ahuriri Lagoon to provide
Holocene history of vertical elevation relative to high tide level to identify major
earthquake-related displacements (Hayward et al., submitted). Across the stop bank from
the end of Poraiti Lane is site of peat excavations reported on by Hull (1986). Inferred
paleogeographic history of the Poraiti Lane embayment is shown in Figure 1.

Foraminiferal and diatom assemblages and sediment thicknesses in eleven cores (3-7.5 m
deep) from the former bed of brackish-marine Ahuriri Inlet (Figure 2), provide a record of
8.5 m of subsidence followed by 1.5 m of uplift in the last 7200 cal years. The following
major, earthquake-related displacements are inferred: c. 7000 cal yrs BP (>-0.6 m
displacement); c. 4200 cal yrs BP (c. - 1.5 m); c. 3000 cal yrs BP (-1.4 to -1.8 m); c. 1600
cal yrs BP (c. -1.7 m); c. 600 cal yrs BP (c. -1 m); 1931AD Napier Earthquake (+1.5 m).
Further smaller events involving regional subsidence or earthquake-shake compaction are
indicated during the 7000-3000 yrs BP interval, but cannot be identified precisely. The
four, large (?subduction interface) subsidence events in the last 4200 years have had a
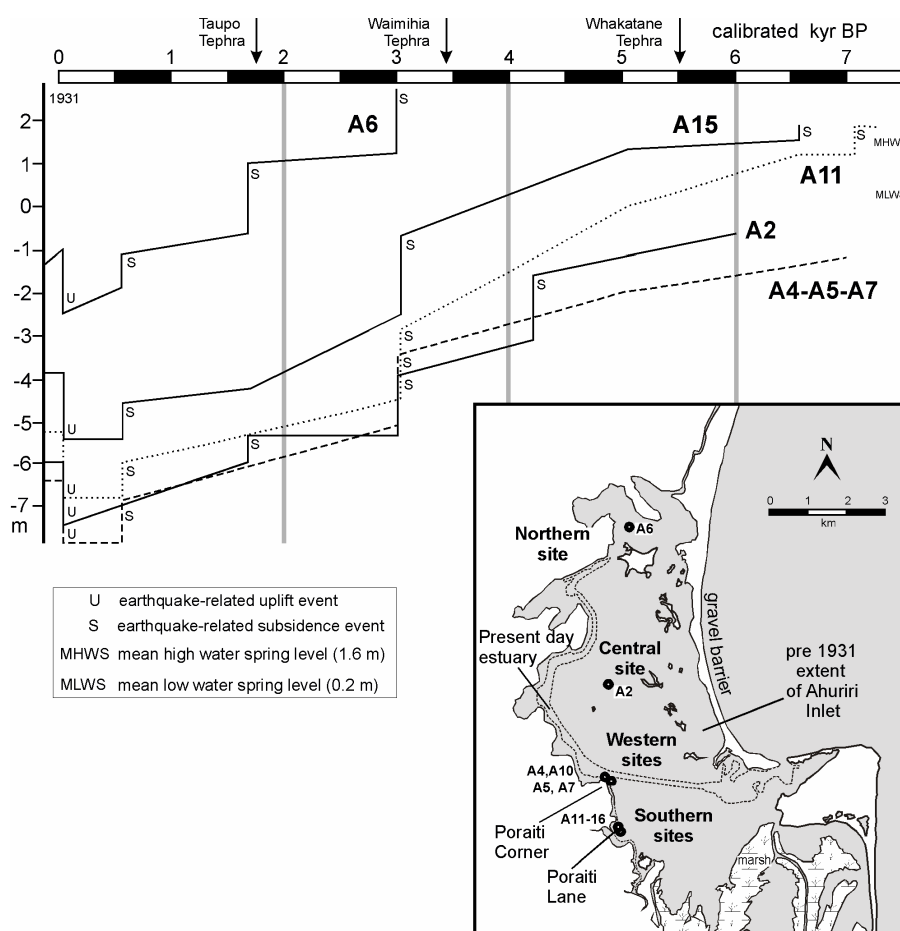return time of 1000-1400 years.

Figure 1. Holocene land elevation history curves for five Ahuriri core sites, based on the indicated
elevational record from foraminifera and diatoms, corrected for slight eustatic sea-level change, and
adjusted for basement depth and lithology-influenced compaction. Accuracy limits on ages assigned to
sudden elevational changes have been deleted for simplicity.

Figure 2. Generalised Holocene lithostratigraphy of five SW Ahuriri Inlet cores plus that recorded in a nearby excavation by Hull (1986). Radiocarbon and tephra ages are shown (in cal yrs BP). Inferred Holocene paleogeographic history of this embayment is shown in six maps at the bottom.

STOP 1b. North side of **Ahuriri Estuary mouth** bridge, SH2. c. 13 km V21/440842
Bruce Hayward, Geomarine Research, Auckland

Park in carpark off road. 3 min walk to see high tidal exposure of in-situ bed of subtidal *Ruditapes largillierti* that lived in the current-swept entrance to the Ahuriri Lagoon prior to its 2 m uplift in 1931 earthquake. (High tide 3 PM)

References:
Hayward, B. W., H. R. Grenfell, A. T. Sabaa, R. Carter, U. Cochran, J. H. Lipps, P. A. R. Shane, and M. S. Morley, submitted. Micropaleontological evidence of large earthquakes in the past 7200 years in southern Hawke's Bay, New Zealand., *Quaternary Science Reviews.*

Hull, A.G., 1986. Pre-A.D. 1931 tectonic subsidence of Ahuriri Lagoon, Napier, Hawkes Bay, New Zealand. *New Zealand Journal of Geology and Geophysics* 29, 75-82.

STOP 2. Devils Elbow, latest Pliocene-early Pleistocene geological overview.
43 km. V20/447080-V20/458070.
Kyle Bland, University of Waikato, Hamilton

This section is on a busy highway with tight, narrow corners. Please take care!
Access is from SH2 (Napier-Wairoa Road) traveling north from Napier to the series of road cuttings leading downhill to the Devils Elbow double culvert. Park in a gravel pit/car park on the eastern side of the road.

The "Devils Elbow section" provides a valuable and very well-exposed window into some of the youngest stratigraphic units in the study area (Figure 3). The section displays a series of alternating siltstone-sandstone/limestone packages, or sequences, assigned to obliquity-controlled 41 ky oscillations in sea-level. The lowest stratigraphic unit comprises the **Darkys Spur Formation**, which is in turn overlain by the **Mairau Mudstone**, **Tangoio Formation**, **Te Ngaru Mudstone**, **Waipatiki Formation**, **Devils Elbow Mudstone** and **Kaiwaka Formation**. The Plio-Pleistocene boundary lies within the Waipatiki Formation (Beu and Edwards 1984) and the top Olduvai paloemagnetic transition (1.78 Ma) within the overlying Devils Elbow Mudstone.

Mudstone intervals are inferred to represent periods of sea-level highstand (Highstand Systems Tracts, HSTs). Sandstone facies are assigned to the regressive systems tract (RST) and limestone beds are inferred to represent either regressive or transgressive systems tracts. The assignment of limestones into either RSTs or TSTs is dependant upon the composition, sedimentary structures and most importantly the nature of surfaces bounding the unit. These issues can be discussed at the stop.

The river below the Devils Elbow section (Waikoau-Aropaoanui River) contains a number of tephra beds underlying the stratigraphy exposed in the Devils Elbow section. One of these units (Figure 3) has been correlated to tephras in ODP 1124, and assigned an age of approximately 2.14 Ma (B. Alloway, T. Naish and K. Bland unpublished data). This has important implications for the timing of sequence development in this area.
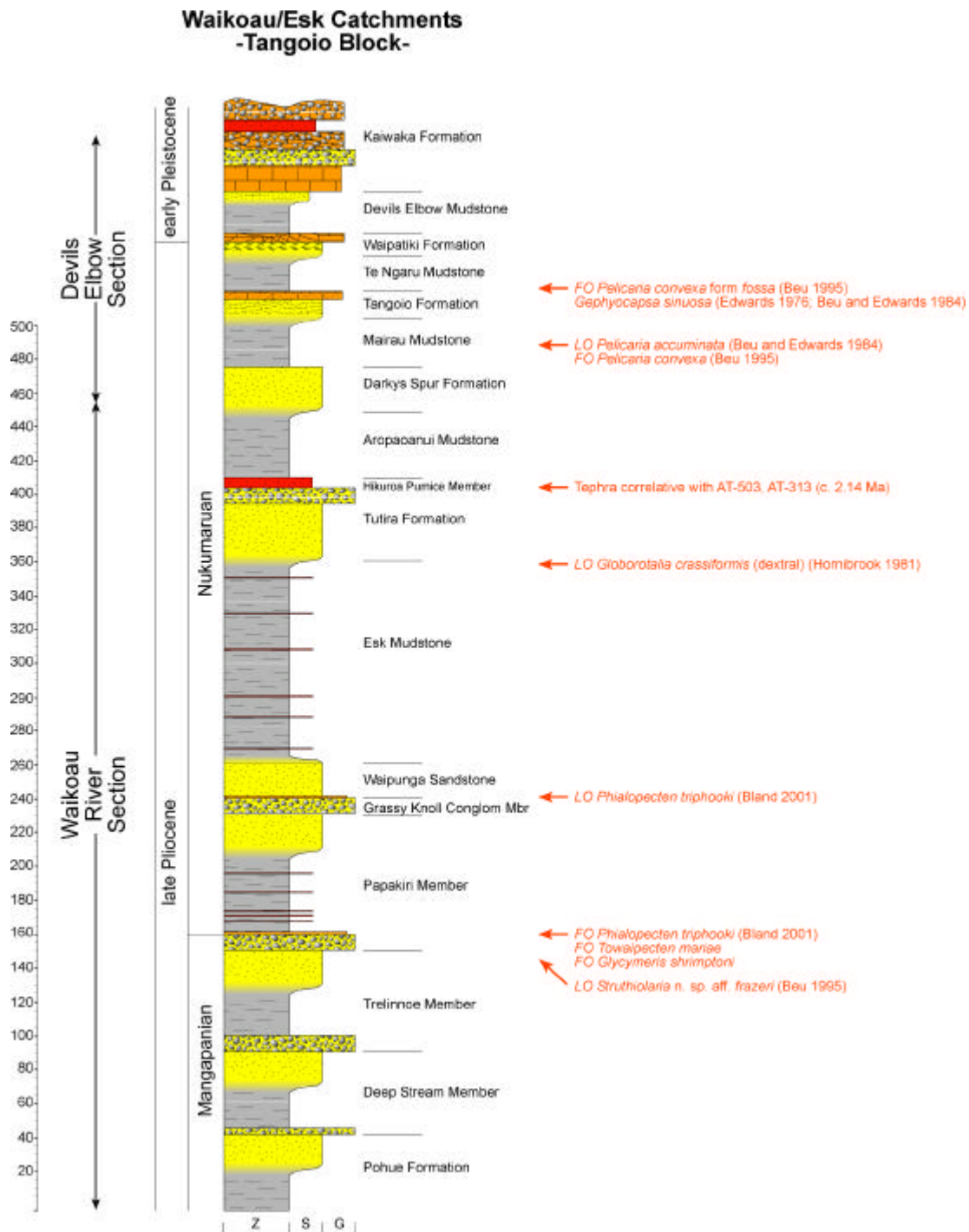
Figure 3. Composite stratigraphic column of the late Pliocene sedimentary succession cropping out in the Waikoau/Esk catchments and the Tangoio Block. Colu mn is adapted from Haywick *et al.* (1991), Bland (2001), Graafhuis (2001) and Bland (in prep.).

References:

Beu, A.G., 1995, Pliocene limestones and their scallops. Lithostratigraphy, pectinid biostratigraphy and paleogeography of eastern North Island la te Neogene limestone: *Institute of Geological and Nuclear Sciences monograph 10.* 243 p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences limited.

Beu, A.G.; and Edwards, A.R., 1984, New Zealand Pleistocene and late Pliocene glacio-eustatic cycles: *Palaeogeography, Palaeoclimatology, Palaeoecology, v. 46*, p. 119-142.

Bland, K.J., 2001, Analysis of the Pliocene forearc basin succession, Esk River catchment, Hawke's Bay. Unpublished MSc. thesis, The University of Waikato.

Bland, K.J., in prep: Analysis of the late Miocene-early Pleistocene Hawke's Bay Basin. PhD thesis, The University of Waikato.

Graafhuis, R.B., 2001, Stratigraphy and sedimentology of Pliocene strata in the forearc basin (Waikoau and Waikari river catchments), northern Hawke's Bay. Unpublished MSc. thesis, The University of Waikato.

Haywick, D.W., Lowe, D.A., Beu, A.G., Henderson, R.A., and Carter, R.M., 1991: Pliocene-Pleistocene (Nukumaruan) lithostratigraphy of the Tangoio block, and origin of sedimentary cyclicity, central Hawke's Bay, New Zealand: *New Zealand Journal of Geology and Geophysics, v. 34*, p. 213-225.

STOP 3. Lake Tutira, A high resolution lake sediment record of late Holocene storm history, vegetation change and landscape response. c. 50 km. V20/460117.
Mike Page, Landcare Research, Palmerston North

Lake Tutira is one of a number of landslide-dammed lakes on the east coast of the North Island It is highly sensitive to environmental changes, both natural and human-induced, in the surrounding landslide-prone 32 km^2 catchment. The steep, dissected hills, underlain by soft siltstones and sandstones, have been mantled by a number of tephras that proved valuable time lines of landscape change. These catchment characteristics, and the morphometry and thermal stratification on the lake, are conducive to the formation and preservation of laminated sediments, including the erosion products of individual storms.

Our studies at Tutira began with the construction of a sediment budget for a major storm – Cyclone Bola. This storm, with a rainfall of 753 mm in 4 days, occurred in March 1988, and is the largest on record. Sediment was generated at a rate of 48720 t / km^2, 90% of which was derived from landslides. Fifty-six percent of this sediment then entered the lake (Page *et al.* 1994a). Analysis of the lake sediments show that high magnitude events produced disproportionately large amounts of sediment in comparison with low magnitude events, with Cyclone Bola and the next largest storms on record responsible for more than half the storm-generated sediment since European arrival. Correlation of storm-generated sediment layers with storm history has identified the threshold for the generation of sediment, and the relationship between sediment thickness and storm rainfall. However, the relationship is not straight forward and is affected by changes in the threshold for land sliding or "event resistance", where the magnitude and/or frequency of earlier storms reduces the available sediment (Page *et al.* 1994b)

Human impacts in the catchment began only 500 years ago with Polynesian arrival, and consisted of repeated burning of the indigenous forest and replacement by fern and scrub (Wilmshurst 1997). European conversion to pasture began in the late 1870's. This recent but dramatic human impact is also recorded in the lake sediments. While the sedimentation rate increased by ~60% under fern/scrub, following conversion to pasture the sedimentation rate increased by an order of magnitude (Page and Trustrum 1997).

These high erosion and sedimentation rates have led to concerns about the sustainability of pastoral farming on these landscapes.

The lake sediments also contain a high resolution record of climate variability and landscape response for much of the Holocene that is free of human impacts. A 6500 year history of the magnitude and frequency of paleostorms is preserved in the sediment. To date, the chronology of storms for the last c.2250 years has been established from a c.6m core (Eden and Page 1998). In the pre-European record there are 340 storms layers, with an average storm return interval of ~6 years. However, the frequency of these storm varies. Clusters of sediment layers identify six major periods of increased erosion, five of which are related to increased storm frequency. During these periods the average return interval of storms is 1-3 years, whereas in the less stormy periods intervals are 7-13 years. The dates of the storm periods are 2175-2155, 2090-1855, 1455-1435, 1085-935, and 375-355 cal. Yr B.P. Most of these periods correspond to warm climate intervals previously identified from New Zealand and other Southern Hemisphere paleoclimatic evidence. A majority of the storms recorded in the European derived sediment are associated with La Niña phases of ENSO.

Landcare Research in collaboration with NIWA have recently recovered a 27m core that will allow us to investigate the relationship between the magnitude and frequency of storms and ENSO for the full 6500 year period, and to correlate this record with other proxy records of paleoclimate to identify long-term climate variability for this region of New Zealand.

References:
Eden, D.N., and Page, M.J. 1998: Palaeoclimatic implications of a storm erosion record from late Holocene lake sediments, North Island, New Zealand. *Palaeogeography, Palaeoclimatology,Palaeoecology, 139:* 37-58.
Page, M.J., Trustrum, N.A., and Dymond, J.R. 1994a: Sediment budget to assess the geomorphic effect of a cyclonic storm, New Zealand. *Geomorphology, 9:* 169-188.
Page, M.J., Trustrum, N.A. and De Rose, R.C. 1994b: A high-resolution record of storm-induced erosion from lake sediments, New Zealand. *Journal of Paleolimnology, 11:* 333-348.
Page, M.J., and Trustrum, N.A. 1997: A late Holocene lake sediment record of the erosion response to land use change in a steepland catchment, New Zealand. *Zeitschrift für Geomorphologie N.F., 41 (3):* 369-392.
Wilmshurst, J.M. 1997: The impact of human settlement on vegetation and soil stability in Hawke's Bay, New Zealand. *NZ Journal of Botany 35:* 97-111.
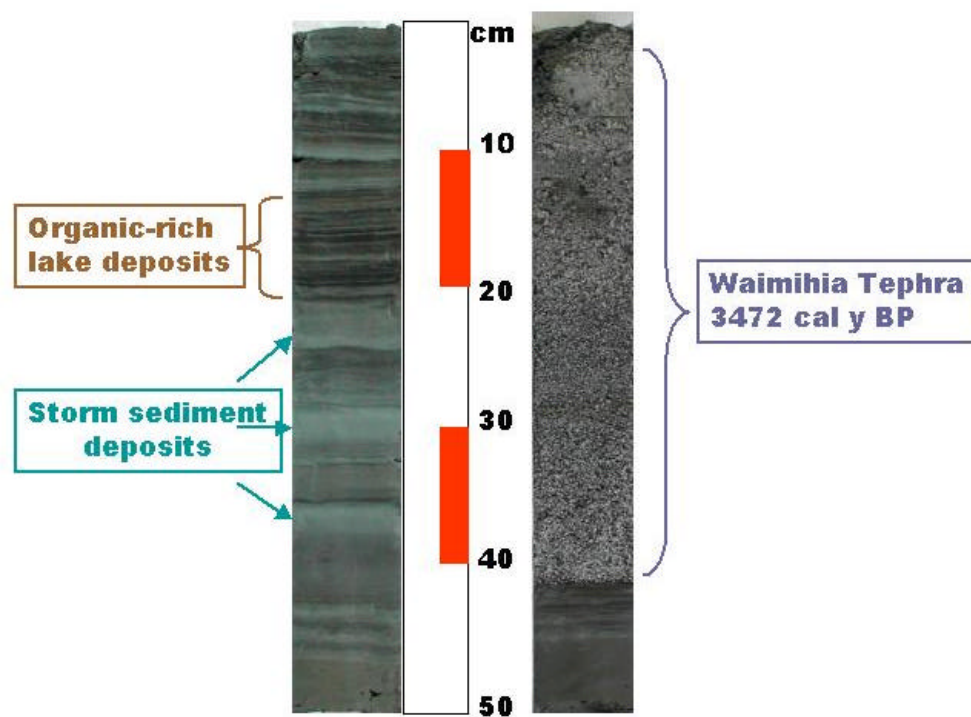
Figure 4. Sections of core LT24 showing (left) storm sediment deposits, and (right) Waimahia Tephra at a depth of 1191 cm.
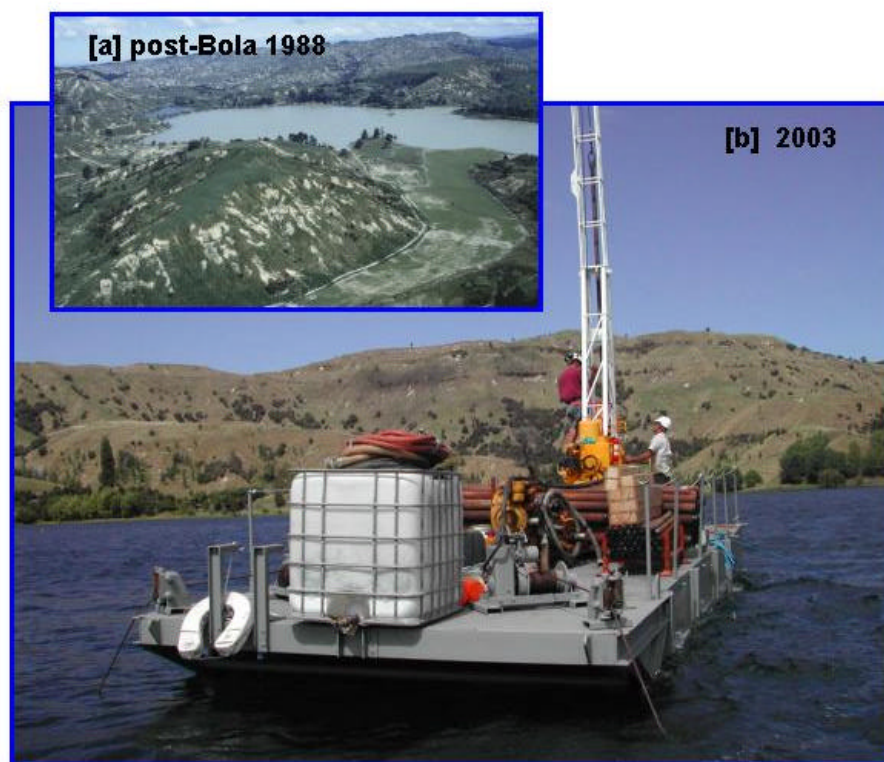

Figure 5. Drilling barge on Lake Tutira, summer 2003, and Lake Tutira following Cyclone Bola 1988 (inset).

STOP 4. Mohaka River mouth: overview of fluvial terraces c. 106 km W19/730264
Nicola Litchfield, GNS, Lower Hutt

The Mohaka River is one of the largest rivers in the eastern North Island (length = 171 km, catchment area = 2434 km^2. The river drains from the Kaimanawa and Kaweka ranges and is locally deflected northeast along the Mohaka Fault in the middle reaches. Fluvial terraces are preserved along much of the river length, with the oldest terraces (= c.140 ka) preserved only along the lower 20 km (Figure 6; Litchfield 2003; Litchfield & Berryman in press).

One of the most prominent fluvial terraces is the Last Glacial Maximum (LGM) aggradation terrace (the Ohakean terrace equivalent). The predominantly gravel terrace deposits are locally very thick (=30 m) and in places contain silt lenses within which the c. 26.5 cal. ka Kawakawa Tephra is preserved. A longitudinal profile records post-glacial incision of up to 200 m (Figure 7). Assuming incision started at approximately the Last Termination (18 ka), incision rates are =11 mm/yr, which are some of the highest in the eastern North Island (Litchfield & Berryman, submitted).

At the river mouth, the Ohakean terrace is at c. 80 m altitude, which is anomalously high relative to other eastern North Island rivers, and considering that during the LGM the river was grading to the sea level lowstand position, c. 120 m below present. Two possible explanations for this are: (1) locally very high uplift rates, and (2) locally high coastal erosion rates, which cause a relative drop in baselevel (sea level). The latter is presently being investigated on historic and geologic timescales by comparing historical aerial photographs and by reconstruction of the longitudinal profile of the 1.8 ka Taupo Alluvium terrace (which graded to approximately present day sea level).

Figure 6. Fluvial terraces at the Mohaka River mouth. T1-T4 are aggradation terraces corresponding to the Ohakean, Ratan, Porewan, and Greatford or Marton terraces in the Rangitikei Valley in the central North Island. TpA = Taupo Alluvium terrace.
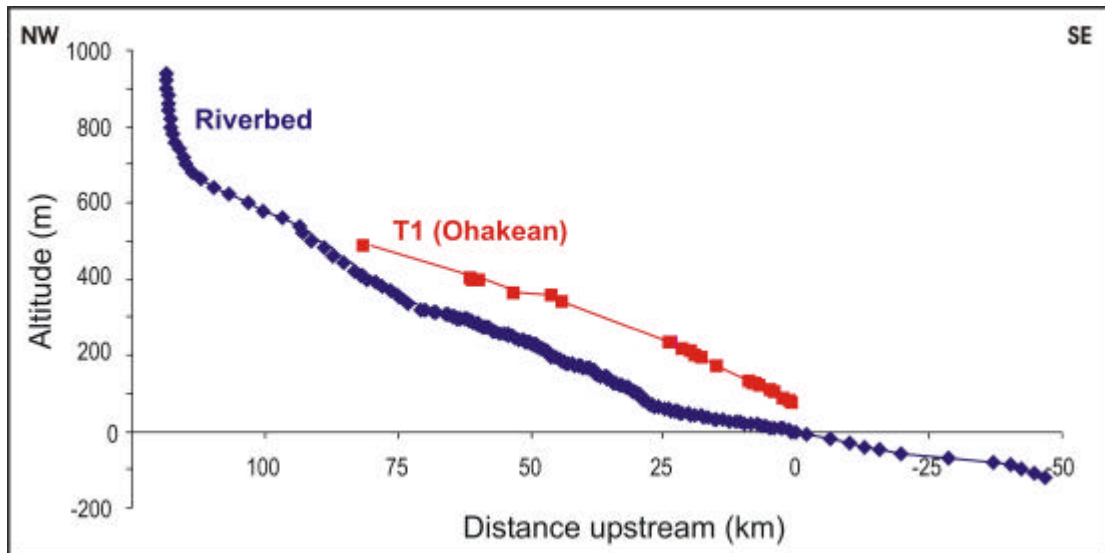
Figure 7. Longitudinal profile of the T1 terrace along the Mohaka River. S. Read and A. Hull (unpubl. data).

References:

Litchfield, N. 2003. Maps, stratigraphic logs and age control data for river terraces in the eastern North Island. *Institute of Geological & Nuclear Sciences Science Report* 2003/31.

Litchfield, N. J., and K. R. Berryman Submitted. Relations between post-glacial fluvial incision rates and uplift rates in the North Island, New Zealand. *Journal of Geophysical Research*

DAY 2 *Sunday 3ʳᵈ July*
Puketitiri Road west

STOP 1. Patoka Fault. Recent paleoseismic investigations in the North Island Dextral Fault Belt. c. 49 km. V20/200997.
Robert Langridge.

The Patoka Fault forms an important active fault in the western branch of the NIDFB. The fault splays off the Mohaka Fault to the SW of us and can be traced for a distance of c. 30 km to Te Pohue. Kyle has mapped a structure which probably links the Patoka Fault to the Rangiora Fault to the NE.

A short walk from the Halliday's farmhouse on Raumati Station will take us down to the fault scarp and the site where we excavated two trenches in 2003 as part of Sarah's Honours thesis at Victoria (Halliday 2003). Don't dally at the trucks too long.
We will show you the geomorphology of the trench site, including a sag pond, an offset stream and spurs where we trenched (Figure 8). We will present logs of the two trenches, e.g. Figure 9, discuss the Holocene stratigraphy, including tephras, fault slip rate and paleoearthquake sequence. We will also ponder the significance of this fault within the NIDFB.

A 13 ± 3 metre dextral deflection on the stream has been used in conjunction with the oldest date from Trench 1 (Figure 9) to produce a maximum dextral slip rate of 1.9-3.2 mm/yr. The two trenches at the site show evidence for multiple Holocene earthquakes. The current surface rupture history consists of: a most recent event which is post-Taupo in age and probably close to a 2-sigma calibrated age of 659-531 yr BP (1291-1419 AD); a penultimate event that is pre-Taupo/post-Waimihia in age, but probably close in age to the latter (3500-3600 cal yr BP) and an antepenultimate event of age 4500-5300 cal. cal. BP. The recurrence range for these three events (possibly missing a fourth) is 1920-2385 yr. Therefore, having a similar slip rate to the Mohaka Fault in this region, the Patoka Fault is a significant fault in the NIDFB.
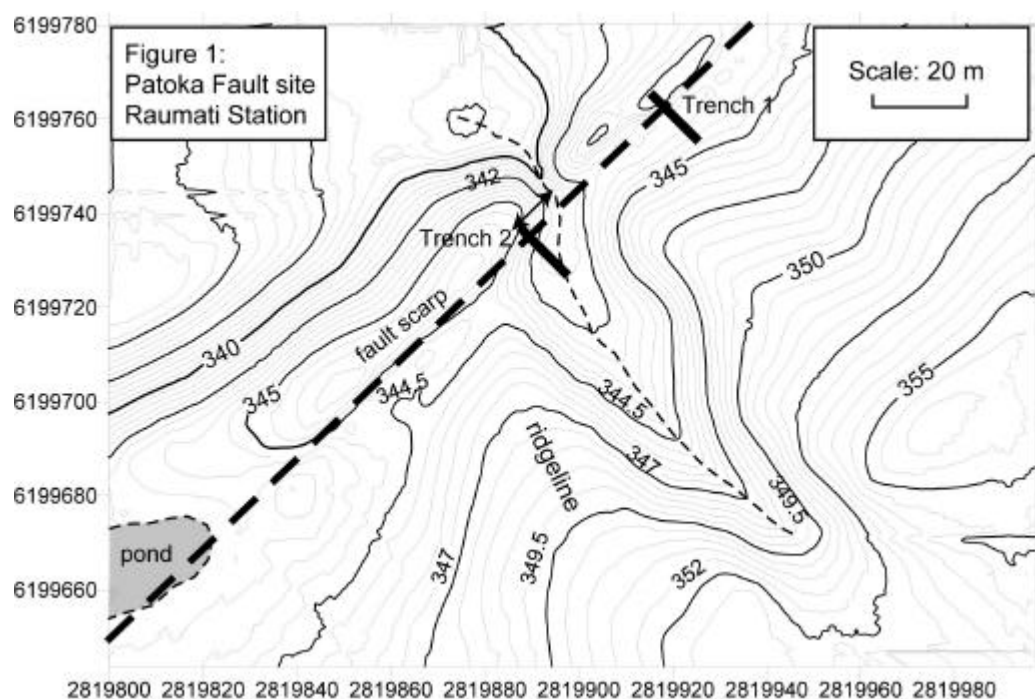

Figure 8. Micro-topographic map of the Patoka Fault scarp and trench sites (contour interval = 0.5 m).
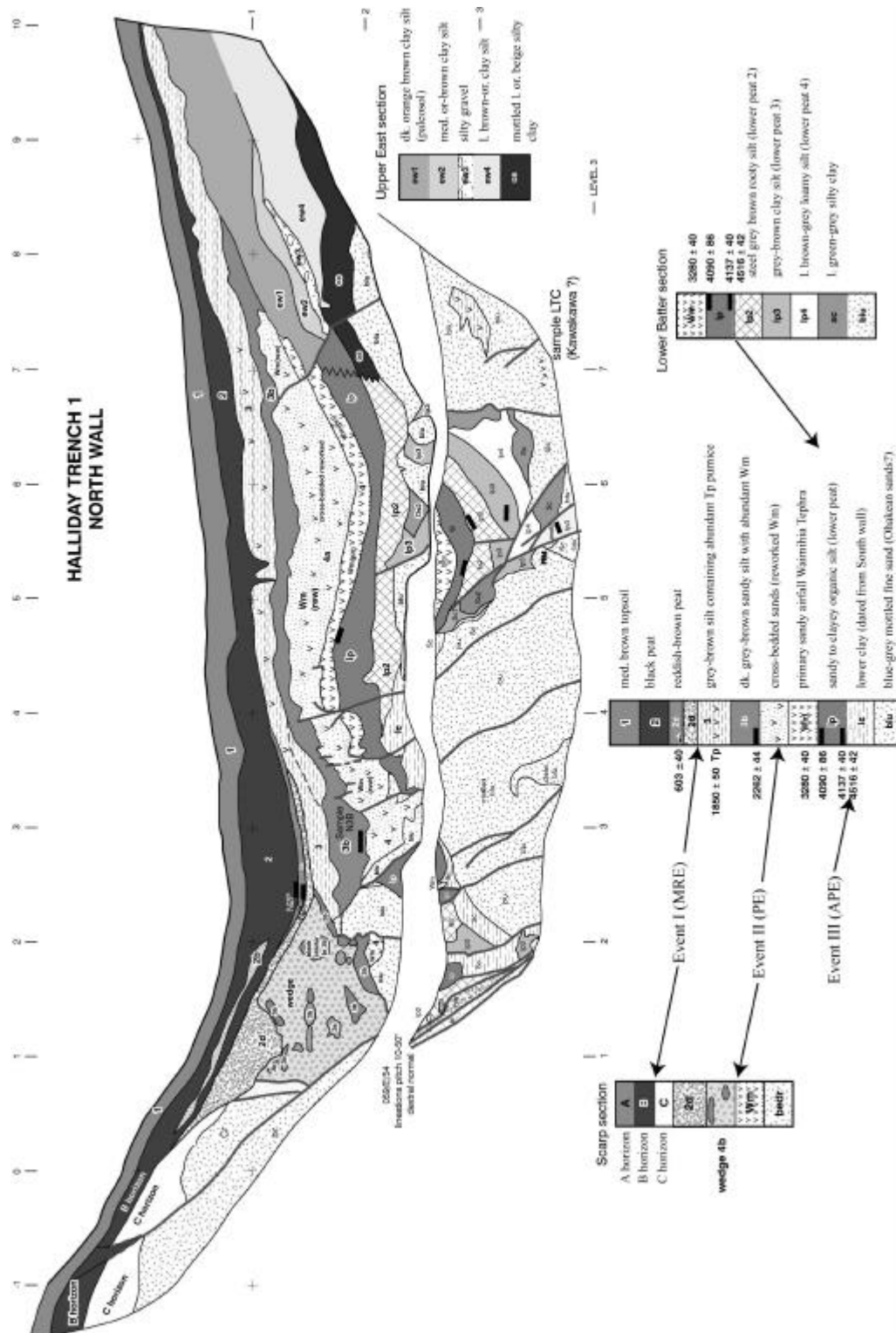
Figure 9. Trench log for the north wall of Halliday trench 1. Scale is in metres.

Reference:
Halliday, S 2003. The Tectonic Geomorphology and Paleoseismology of the Patoka Fault, North Island Dextral Fault Belt, New Zealand. B.Sc. (Hons.) thesis, School of Earth Sciences, Victoria University of Wellington, Wellington, New Zealand.

STOP 2. Ruahine Fault Zone and Puketitiri area geological overview. c. 65 km.
U20/090076
Kyle Bland

The Puketitiri area straddles the North Island Shear Belt and lies between the Ruahine and Mohaka Faults, with the Kaweka and Patoka Faults nearby. The region is underlain by Mesozoic basement greywacke and flysch-type facies. The oldest Cenozoic beds in the area are assigned to the **Pakaututu Formation,** a 10-85 m-thick late Opoitian (early Pliocene) interval comprising greywacke conglomerate, concretionary sandstone and a distinctive, coarse-grained shelly limestone (**Hukanui Limestone Member**). This is in turn overlain by the **Puketitiri Formation,** a 120 m-thick interval of siltstone, fine-sandstone with minor coarse-grained conglomerate and shellbeds. Limited age data assign a Waipipian age to this unit. The Puketitiri Formation is unconformably overlain by a 50 m-thick interval of limestone assigned to the **Te Waka Formation** which in this area displays spectacular giant-scale cross-stratification. The Te Waka Formation forms the summit of Hukanui, the Te Waka and Maniaroa Ranges. The Maniaroa Range, and to a lesser degree the Te Waka Range, are products of vertical displacement on the Mohaka Fault which bounds the Puketitiri area.

A well-defined modern trace of the Ruahine Fault Zone is clearly exposed at this locality, though this trace may not represent the Ruahine Fault itself. We can discuss this at the stop. The fault is a dextral strike-slip structure with a significant vertical component. While modern uplift is to the northwest, offset on the Hukanui Limestone Member several kilometres north of this stop demonstrates significant southeast-side-up displacement since the Opoitian. Displacement of the limestone member across the Ruahine Fault strongly suggests that horizontal displacement is less than 10 km since the Opoitian.
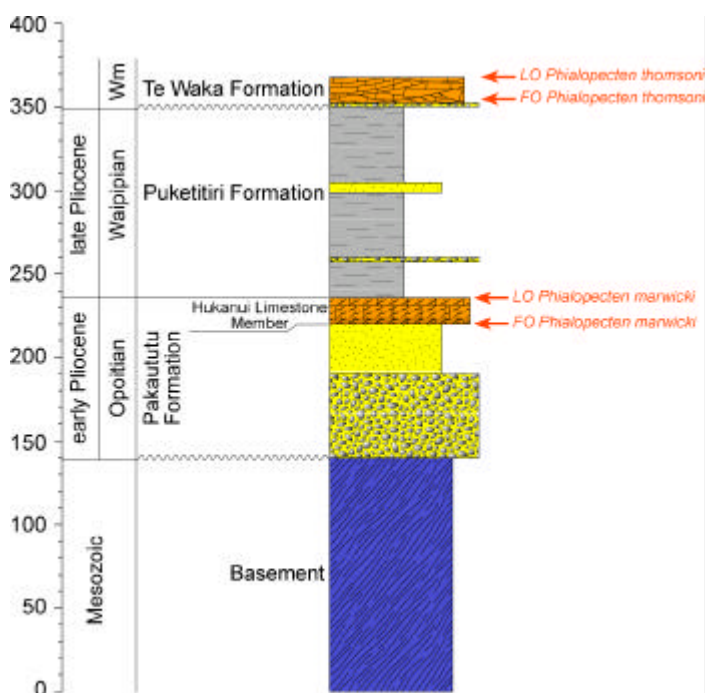

Figure 10. Schematic stratigraphic column for the Puketitiri area. The Pakaututu and Puketitiri Formations do not crop out east of the Mohaka Fault. Only the Pakaututu Formation is present west of the Ruahine Fault.

Rob Langridge will discuss a trench site excavated across the Ruahine Fault just below Baldy Quarry on the Davis Farm. This trench was studied as part of Jude Hanson's PhD thesis on the Wellington – Mohaka and Ruahine Faults (Hanson, 1998). Rob will enlist the help of Brent Alloway to discuss the tephrostratigraphy of central Hawke's Bay, as recognised from a number of trenches across NIDFB faults.

Reference:

Hanson, J.A. 1998: The neotectonics of the Wellington and Ruahine Faults between the Manawatu Gorge and Puketitri, North Island, New Zealand. PhD thesis, Massey University, Palmerston North.

STOP 3. Hot Springs Road, Puketitiri: Early Pliocene Pakaututu Formation, modern Ruahine Fault trace and constraints on displacement history
c. 82 km. V20/116115
Kyle Bland

The oldest Cenozoic rocks in this area are contained in the Pakaututu Formation (Bland *et al.* 2003), a stratigraphic unit whose outcrop pattern has implications for constraining displacement on the North Island Shear Belt in this area. East of the Ruahine Fault the formation comprises a thick basal greywacke conglomerate that overlies basement. This conglomerate thins rapidly away from the Ruahine Fault and may indicate syn-depositional fault movement. The conglomerate is in turn overlain by sandstone and the Hukanui Limestone Member (Figure 11). West of the Ruahine Fault the Hukanui Limestone Member directly overlies basement.

The Hukanui Limestone Member comprises a well-cemented, densely fossiliferous coarse-grained unit 10-15 m thick with a very distinctive macrofauna. The macrofauna is conspicuously dominated by valves of *Tucetona laticostata*, a bivalve common on coarse-grained, high-energy substrates around the modern New Zealand coast. The limestone also contains the scallop *Phialopecten marwicki*, which suggests a late Opoitian (Early Pliocene) age.

The Ruahine Fault trace continues along the foot of the range west of the road. The nature of the trace changes as we continue northeast, with the prominent uphill-facing spurs at Baldy Quarry absent here. In many places through this area dextrally offset streams are prominent across the fault (Figure 12). A splinter fault off the Ruahine Fault runs just below the road, and vertically offsets Hukanui Limestone Member by approximately 80m.

At this stop we can begin to place some constraints on the broad-scale displacement history of the Ruahine Fault. This will be complimented by the following stop.
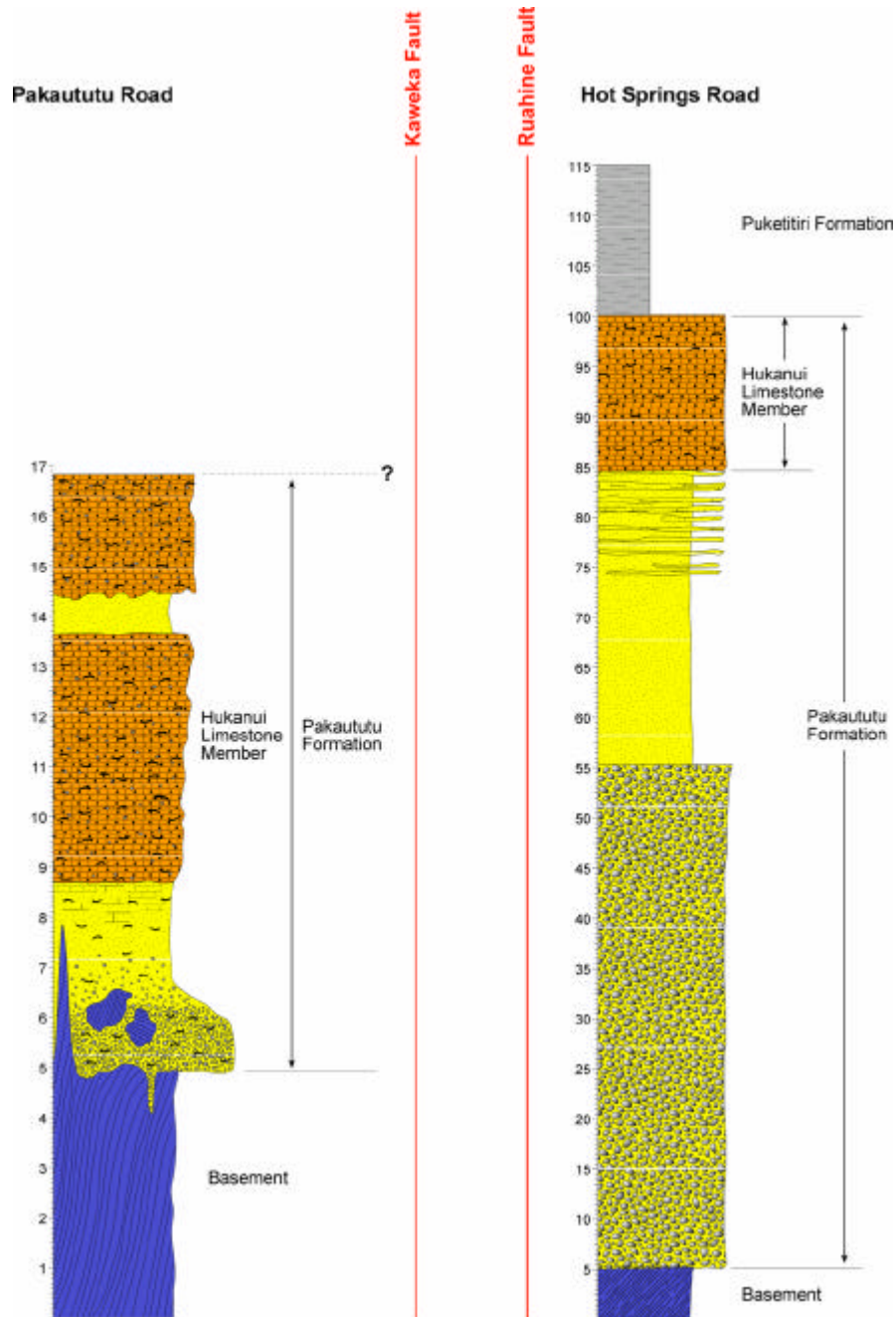
Figure 11. Stratigraphic columns of the Pakaututu and Hot Spring Road areas. Note the different scales (in metres) in the two sections. Note also the thick greywacke conglomerate bed that forms the lower part of the Pakaututu Formation in the Hot Springs Road area.

Figure 12. Ruahine Fault trace (arrowed) exposed west of Hot Springs Road as viewed from Hukanui Station above the road. Note how the character of the trace here is different to that at Baldy Quarry, only 7 km to the southwest. Streams visible crossing the fault commonly display dextral offset. Modern uplift is to the west (top) side of the fault.

Stop 4. Mohaka River, Pakaututu Road: Early Pliocene to Recent geological overview, Pliocene to recent displacement history on Ruahine and Kaweka Faults
c. 91 km V20/125180-134159
Kyle Bland

The stratigraphy in this area comprises flysch-type basement, unconformably overlain by Early Pliocene Hukanui Limestone Member (Pakaututu Formation), and thick gravels assumed to be of Castlecliffian to Recent age. Thick deposits of Taupo Pumice Alluvium are exposed in this valley where the Mohaka and Ripia Rivers emerge from narrow basement gorges. These deposits form prominent terraces along the margins of the river valleys up to 70 m high.

Both the Ruahine and Kaweka Faults have traces through this area. Hukanui Limestone Member is upthrown 120 m to the west by the Kaweka Fault (Bland *et al.* 2003). The member is upthrown a minimum of 200 m to the east by the Ruahine Fault, although recent vertical offset is to the west. From geological mapping in this area total strike-slip displacement on the Ruahine Fault since the Early Pliocene appears to be <10 km.

Reference:

Bland, K.J.; Nelson, C.S.; Kamp, P.J.J. 2003: Latest Miocene-Early Pliocene onlap limestone beds in the western forearc basin, Hawke's Bay. *In:* Mortimer, N.; Lee, D. *eds.* Programme and abstracts, Geological Society of New Zealand Annual Conference 2003, Dunedin. Geological Society of New Zealand Misc. Pub. 116A. p.21