

The following application was submitted to the MARGINS Office:

Name:

Kelvin Berryman

Category: Research Scientist

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Active Landscapes Section  
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Statement of interest:

I have received an invitation from the organising committee of the workshop requesting my attendance (Carter, 24 December). Along with Trustrum, Carter & Gomez, I was one of the initial proponents of the Waipaoa study site, and have been actively engaged in relevant research in that region for some 25 years (see resume statement).

I have submitted 3 abstracts, not necessarily wishing to present all, but indicating to the workshop conveners the range of existing research knowledge that exists on the topics of bedrock geology, tectonics, and Waipaoa catchment responses to climate and tectonics. I'm happy to present whatever background material the workshop organisers consider useful to set the scene.

Short resume:

Resume for Margins Waipaoa Focus Site Workshop - Kelvin Berryman

Present Position: Principal Scientist  
Present Employer: Institute of Geological & Nuclear Sciences Ltd  
Present Work Address: 69 Gracefield Road, Lower Hutt, New Zealand  
Academic qualifications: BSc, Victoria University of Wellington (VUW) (1974),  
BSc (Hons - 1st class) VUW (1977), geology  
PhD, VUW (1990), geology

Years as a practising researcher: 28

Honours/distinctions/membership of societies, institutions, committees:

&#61623; Member of NZ Geological Society,  
&#61623; Past Vice President of Neotectonics Commission of INQUA,  
&#61623; Member of the New Zealand National Society for Earthquake Engineering,  
&#61623; Management Committee of New Zealand National Society for Earthquake Engineering 1981-1986,  
&#61623; Otto Glogau award of the New Zealand National Society for Earthquake Engineering in 1993 & 2000,  
&#61623; Convenor of NZ Royal Society Committee for Quaternary Research 1981-87,  
&#61623; Member of the Loadings Code Committee of Standards New Zealand 1981-92,  
&#61623; Hochstetter Award of the Geological Society of New Zealand in 1995,  
&#61623; Member of Editorial Boards of Geology (1990-1992) & NZJGG (1997-2001),  
&#61623; NZ representative to IGCP projects 206 (1987-1992) & 274 (1988-1992)  
&#61623; Awarded NZ Science and Technology Bronze Medal by the Royal Society of New Zealand, 2000  
&#61623; Co-leader of International Lithosphere Program II-5 project, 2000-2002.

Present research/professional speciality:

1. Coastal neotectonics using former shorelines to determine vertical crustal deformation.
2. Earthquake geology, paleoseismicity and fault behaviour studies on active faults in New Zealand, and the Pacific region.
3. Late Cenozoic structural evolution of the Hikurangi margin.
4. Earthquake hazard studies from site specific to national scale.
5. Studies in Quaternary stratigraphy especially loess and tephra.
6. Earthquake geology studies of the Alpine Fault.
7. Investigation of rates and processes of landscape evolution and paleoclimate in New Zealand.

Number of Refereed Publications: 79 journal or book chapter manuscripts

Number of significant publications not included in the above: 65+ contract reports

List of major achievements pertinent to this application:

1. Major publications (since 1998)

Kelsey, H.M.; Hull, A.G.; Cashman, S.M.; Berryman, K.R.; Cashman, P.H.; Trexler, J.H.; Begg J.G. 1998. Paleoseismology of an active reverse fault in a forearc setting: the Poukawa fault zone, Hikurangi forearc, New Zealand. Geological Society of America Bulletin 110: 1123-1148.

Jackson, J.; Van Dissen, R.; Berryman, K.R. 1998. Tilting of active folds and faults in the Manawatu region, New Zealand: evidence from surface drainage patterns. NZ Journal of Geology and Geophysics 41: 377-386.

Stirling, M.; Wesnousky, S.; Berryman, K. 1998. A revised probabilistic hazard model of New Zealand. NZ Journal of Geology and Geophysics 41: 355-376.

Downes, G.L.; Dowrick, D.J.; Smith, E.G.C.; Berryman, K.R. 1999: The 1934 Pahiatua earthquake sequence: Analysis of observational and instrumental data. Bulletin of the New Zealand National Society for Earthquake Engineering 32(4): 221-245.

Berryman, K.; Marden, M.; Eden, D.; Mazengarb, C.; Ota, Y.; Moriya, I. 2000: Quaternary river terraces of the Waipaoa River, East Coast, New Zealand, and the tectonic and paleoclimatic significance. *New Zealand Journal of Geology & Geophysics* 43: 229-245.

Tudhope, A.W.; Buddemeier, R.W.; Chilcott, C.P.; Fautin, D.G.; Berryman, K.R.; Jebb, M.; Lipps, J.H.; Pearce, R.G.; Scoffin, T.P.; Shimmiel, G.B. 2000: Alternating seismic uplift and subsidence in the late Holocene at Madang, Papua New Guinea: Evidence from raised reefs. *Journal of Geophysical Research* 105 (B6): 13,797-13,807.

Eden, D.N.; Palmer, A.S.; Cronin, S.J.; Marden, M.; Berryman, K. 2001: Dating the culmination of river aggradation at the end of the last glaciation using distal tephra compositions, eastern North island, New Zealand. *Geomorphology* 38: 133-151.

Chagué-Goff, C.; Dawson, S.; Goff, J.R.; Zachariassen, J.; Berryman, K.R.; Garnett, D.L.; Waldron, H.M.; Mildenhall, D.C. 2001: A Mid Holocene (c. 6300 years BP) catastrophic saltwater inundation in Northern Hawke's Bay, New Zealand. *Sedimentary Geology* 150: 89-102.

Berryman, K.R.; Hull, A.G. (in press) Tectonic controls on late Quaternary shorelines in New Zealand: A review and prospects for future research. Chapter 2 In: Goff, J.; Nichol, S.; Rouse, H.L. (editors) *The New Zealand Coast: Te Tai O Aotearoa*. Brassell Publishing, Wellington.

Berryman, K.R.; Marden, M.; Palmer, A.S.; Wilson, K.; Mazengarb, c.; Litchfield, N. in prep. The post-glacial downcutting history in the Waihuka tributary of the Waipaoa River, Gisborne district, New Zealand, and implications for tectonics and landscape evolution.

## 2. Recent activities pertinent to this application

1. Along with colleagues in NIWA and Landcare Research we successfully advocated New Zealand as a world study site for the US National Science foundation initiative investigating sediment dispersal systems from source to sink in active continental margins.

2. I have developed a new initiative in GNS to investigate rates and processes involved in landscape evolution in New Zealand with particular studies on the West Coast of the South Island, and by way of contrast in the Canterbury valleys extending from the Southern Alps to the coast.

3. I have been involved in the Landcare Research led programme in the Waipaoa catchment and have been responsible for investigating the pre-historical record of tectonic and climatic influences on the fluvial terrace system.

4. I am managing and participating in GNS led research in active tectonics of the Hikurangi subduction margin, including supervision of post-doc (Nicola Litchfield) and PhD (Kate Wilson) research.

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## ABSTRACT

Title:

1. Tectonic and Geologic Setting of Waipaoa Catchment in the Hikurangi Subduction Margin, New Zealand
2. Tectonic and paleoclimate significance of Quaternary river terraces of the Waipaoa River, East Coast, North Island, New Zealand
3. The post-glacial downcutting history in the Waihuka tributary of Waipaoa River, Gisborne district, New Zealand, and implications for tectonics and landscape evolution.

Authors:

Kelvin Berryman (1), Michael Marden (2), Alan Palmer (3), Kate Wilson (3),  
Colin Mazengarb (1), Nicola Litchfield (1)

(1) Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand

(2) Landcare Research, Gisborne, New Zealand

(3) Massey University, Palmerston North, New Zealand

Abstract:

1. The Waipaoa catchment is situated within the active forearc margin of the Hikurangi subduction margin. There are marked contrasts in structural style along the length of the Hikurangi margin. In the northern sector, north of Gisborne, tectonic erosion of the subduction margin and widespread normal faulting. Southern sectors, south of Gisborne, are characterised by frontal accretion and a predominance of reverse faulting in outer parts of the margin, and strike-slip faults (accommodating the translational component of the oblique subduction) occur adjacent to the North Island axial ranges. The Waipaoa catchment probably lies in the northern sector as evidenced by widespread occurrences of late Miocene-Recent normal faulting, generally high uplift rates particularly around East Cape, and massive topographic collapse of parts of the submerged part of the margin. The subduction interface is located at a depth of c. 15 km beneath Gisborne and 30 km below the surface at the headwaters of the Waipaoa.

Widespread faults and folds deform Cretaceous-Pliocene bedrock in the catchment. The orientation and throw of these faults varies somewhat, although several of the major faults trend east-west or northwest-southeast, including the Otoko-Totangi, Rakauroa, Waerengaokuri and Arakihi Faults, which are downthrown toward the south or southwest. Late Quaternary fault scarps occur on several of the bedrock faults, but because of the low preservation potential of scarps in the landscape developed on soft Cenozoic bedrock, it is probable that the distribution of known active faults is only a subset of what may actually exist. It is likely that the Otoko-Totangi Fault is active because early-mid Quaternary fluvial and lacustrine deposits are tilted by c. 20° in close proximity to the fault. Two northeast-striking active faults occur near Lake Repongaere. One of them (Repongaere Fault) has a topographic scarp across hillslopes west of the Waipaoa flood plain, and displaces weathered Pliocene terrace gravel.

Late Quaternary vertical movements involving both uplift and subsidence have been described in coastal areas based on study of marine deposits. Most of the coastal areas in Raukumara Peninsula are recognised as undergoing uplift. The crest of the Raukumara Range is likely to be the area of greatest uplift, based on relief and a study of summit concordance. Part of the Poverty Bay flats is an area of net subsidence, as is an area to the east of Wairoa. Although some of this subsidence may be related to compaction of soft sediment, a component of tectonic subsidence is probable, in accordance with the westward tilting of the early-mid Quaternary Mangatuna Formation on the eastern hills adjacent to Gisborne City.

2. Remnants of four aggradational terraces in the lower 45 km of the main branch of the Waipaoa River have been correlated with cold/cool climate episodes of the

Otiran glaciation. The youngest of the aggradation levels - the Waipaoa-1 terrace - has the c. 14.7 ka Rerewhakaaitu Tephra as the oldest part of the covered sequence, indicating cessation of aggradation about 16 ka B.P. This terrace is broadly correlated with Ohakean-aged terraces in other parts of the North Island. The second-most-recent episode of aggradation - the Waipaoa-2 terrace - is slightly older than the c. 28 ka Mangaone Tephra, and is broadly correlated with the Rata terrace. The third-most-recent aggradation episode - the Waipaoa-3 terrace - is slightly older than the c. 55-57 ka Rotoehu Tephra (age estimate based on stratigraphic relationships in this study), indicating cessation of aggradation at c. 65 ka B.P., and correlative with the Porewa terrace. The fourth, and oldest aggradation episode we identify in the present landscape - the Waipaoa-4 terrace - has poor age constraints, but is probably related to the cool period of late Oxygen Isotope Stage 5 at c. 90 ka B.P. or the glacial period of Oxygen Isotope Stage 6 at c. 140 ka B.P.

Tectonic deformation in the middle reaches of the Waipaoa catchment is deduced from the elevation difference of pairs of aggradation terraces, and takes the form of broad regional uplift in the range of 0.5-1.1 mm/yr. Uplift is probably driven by subduction processes in the middle part of the catchment and by a combination of deep-seated subduction processes and local deformation associated with active faults and folds in the lower valley area. Downcutting rates of up to 7 mm/yr occur in upper reaches of the river. In the middle reaches of the valley where there are both uplift and downcutting data, we find that downcutting is about four times faster than tectonic uplift. Thus, climate fluctuations are interpreted to be the primary control on formation of fluvial terrace landscapes in the region.

3. In a 2.2 km long section of the Waihuka tributary of the Waipaoa River, in the Gisborne district of eastern North Island, New Zealand, a sequence of fluvial terraces and abandoned meanders up to 45 m above the modern river record post-glacial downcutting. Datable organic and tephra horizons in the terrace and meander infill stratigraphy, indicate that downcutting is dominated by a short-lived event in the early Holocene when as much as half of the downcutting was accomplished in only 10-15% of post-glacial time. The large downcutting event is interpreted to be a manifestation of knickpoint retreat in this catchment following the end of glacial-age aggradation in the Waipaoa catchment and a switch to post-glacial incision. The rate of knickpoint retreat up this tributary of the Waipaoa River is about 2 km/ka. This study leads us to suggest that each tributary of the Waipaoa has a different downcutting history depending on the confluence distance upstream in the Waipaoa, average gradient of the tributary and tributary catchment area. To determine the sediment flux in space and time for the post-glacial Waipaoa, similar studies to that presented here are required in all of the tributaries, as well as an understanding of the location and rate of landslide-generated sediment to the total flux. In the period before and after rapid downcutting in Waihuka catchment modest incision rates, mostly around 1 mm/yr average, may represent a regional tectonic uplift rate.

Wish to include graphics:

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