REPORT TO THE EARTHQUAKE COMMISSION
ON FINDINGS FROM A STUDY OF:

THE STRATIGRAPHY AND DIATOM CONTENT OF SEDIMENTS FROM LAKE KOHANGAPIRIPIRI

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Ursula Cochran *

Dr Michael Hannah *

Dr James Goff *

Dr Alan Hull ^

* Research School of Earth Sciences, Victoria University of Wellington

^ Institute of Geological and Nuclear Sciences, Lower Hutt

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TECHNICAL ABSTRACT

Lake Kohangapiripiri is situated in a tectonically active area, almost half way between Turakirae Head and Wellington Harbour. At both these sites well documented uplift records exist. This study of the sediment and diatom flora of Lake Kohangapiripiri shows that the lake has been unexpectedly stable.

Sediment beneath the lake is brownish black and >88% mud. Grain size and organic carbon content are uniform throughout the core sequence. The diatom flora shows that there has been a fresh-brackish water lake at this site, with a barrier between it and the sea, for the last 7000 years.

Raised beach ridges at Turakirae Head are evidence that at least four large uplift events have occurred in this region in the last 7200 years. Raised beach ridges have also been documented at Rongotai and Petone. There is no evidence from the lake sediment or diatom assemblage of any of these events.

It appears from this study that the lake environment is highly stable (in the time scale studied) and is relatively insensitive to earthquake events. It may also be that uplift that has occurred at the lake, has been balanced or totally overriden by subsidence caused by downward tilting to the west.

LAYPERSON'S ABSTRACT

Lake Kohangapiripiri is a small coastal lake with a barrier between it and the sea. The study of the sediment beneath Lake Kohangapiripiri and the microscopic algae within the sediment, has shown that the lake is at least 7000 years old. The lake is situated in an area where large earthquakes are known to have occurred in the past. However the uniformity of the sediment indicates that the lake has not been greatly affected by earthquake events.

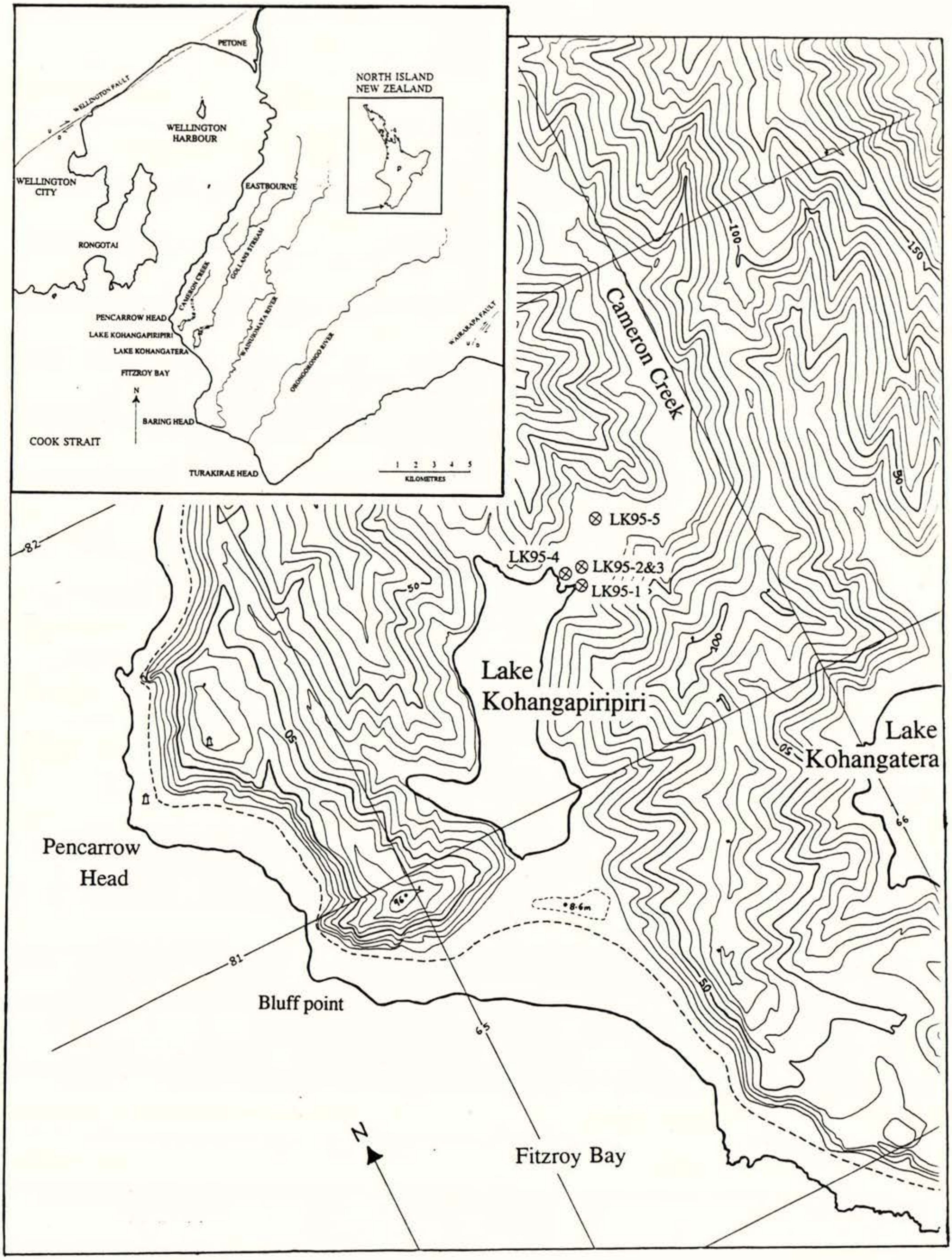

Figure 1 Location of the study area

INTRODUCTION

This project aimed to determine a tectonic uplift history of the Pencarrow Head area by studying the stratigraphy and fossil content of the sediments of Lake Kohangapiripiri.

Lake Kohangapiripiri is one of two small coastal lakes on Wellington's southern coast to the east of Pencarrow Head (Figure 1). The lake occupies the seaward end of Cameron Creek and is contained behind a gravel barrier. The hills around the lake become truncated into steep bluffs at the lake edge and are thought to be wave-cut cliffs.

Five cores were taken from the north eastern end of the lake in a large wetland area. The longest core extended down to 9 metres depth and did not reach basement rock. From these cores the sediment was described, grain size analysis carried out, and a detailed study of the diatom content of the sediment was completed.

SEDIMENT CHARACTERISTICS

The sediment beneath the lake is a brownish-black, silty mud. The sediment is highly uniform throughout the whole core sequence, with only minor changes in grainsize and organic carbon content. Visual changes in the cores include banding of darker mud (due to an increased concentration of organic carbon), the occurrence of small pieces of wood and organic matter, and the presence of vivianite.

The sediment shows no obvious evidence of uplift events or any indication that the environment was once open to the sea.

Core No. / Depth (mm)	Reference Number	$\delta^{13}C$ (‰)	Radiocarbon Age (yrs BP)	Calibrated Age (yrs BP)	Accumulation Rates (mm/yr)
					0.42 to 0.48
LK95-4 / 1420	NZA 5598	-27.2	3049 +/- 140 BP	3353 to 2982	↕
					1.67 to 1.81
LK95-5 / 3440	NZA 5599	-25.4	3974 +/- 150 BP	4559 to 4096	↕
					1.42 to 1.44
LK95-5 / 4720	NZA 5600	-26	4612 +/- 148 BP	5458 to 4984	↕
					1.18 to 1.63
LK95-5 / 5430	NZA 5601	-26.6	5000 +/- 146 BP	5893 to 5585	↕
					3.82 to 3.96
LK95-5 / 7770	NZA 5602	-22.9	5587 +/- 166 BP	6505 to 6176	↕
					2.10 to 2.36
LK95-5 / 9170	NZA 5603	-26.8	6138 +/- 174 BP	7172 to 6769	

Table 1 Radiocarbon age results for Lake Kohangapiripiri

RADIOCARBON DATING

Six wood and reed samples were submitted for radiocarbon dating to provide chronological control for the record (Table 1). The base of the 9 metre core is about 7000 calibrated years BP. Sediment accumulation rates were fairly consistent between 7000 and 3000 years BP at about 1.5 - 2 mm/yr, except for an increase to 4 mm/yr at one stage. A much slower rate of about 0.45 mm/yr has persisted in the last 3000 years.

DIATOM ASSEMBLAGE

Diatoms were identified and counted from 65 samples down 9 metres of core. In total 95 species were identified in the sediment. Diatoms live in a wide range of environments such as in marine conditions, brackish water, rivers, lakes and wet soil. Different species of diatoms live in water of a certain salinity. The salinity preferences of the different diatom species found in the lake sediment were obtained from various references in order to determine whether the lake had once been an inlet of the sea and whether there had been any marine incursions since this time.

Figure 2 shows that the diatom assemblage has been predominantly fresh-brackish for the last 7000 years BP. Marine diatoms were present mainly between 7000 and 5800 years BP and almost all of these were found as fragments. Brackish and brackish-fresh water species exist in small percentages throughout most of the core sequence. Fresh water diatoms increase from 0% to 20% in the last 1000 years.

The results indicate that a barrier was in place between the lake and the sea 7000 years ago because the water in the lake was dominantly fresh-brackish

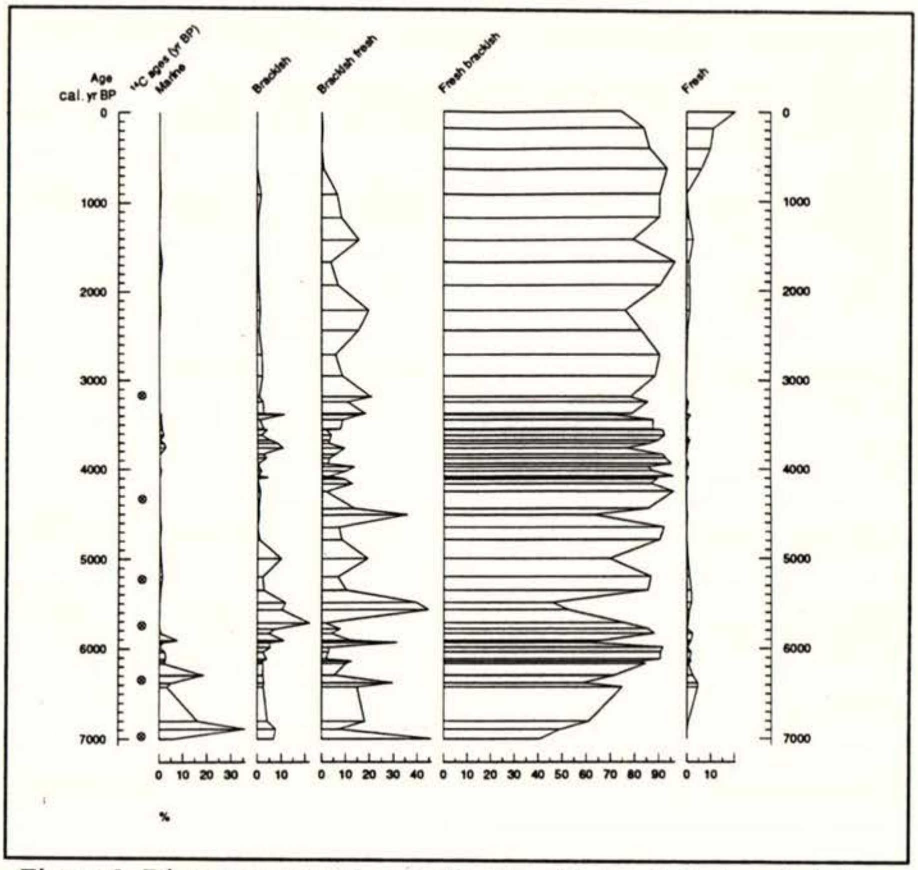

Figure 2 Diatoms grouped according to salinity plotted against time

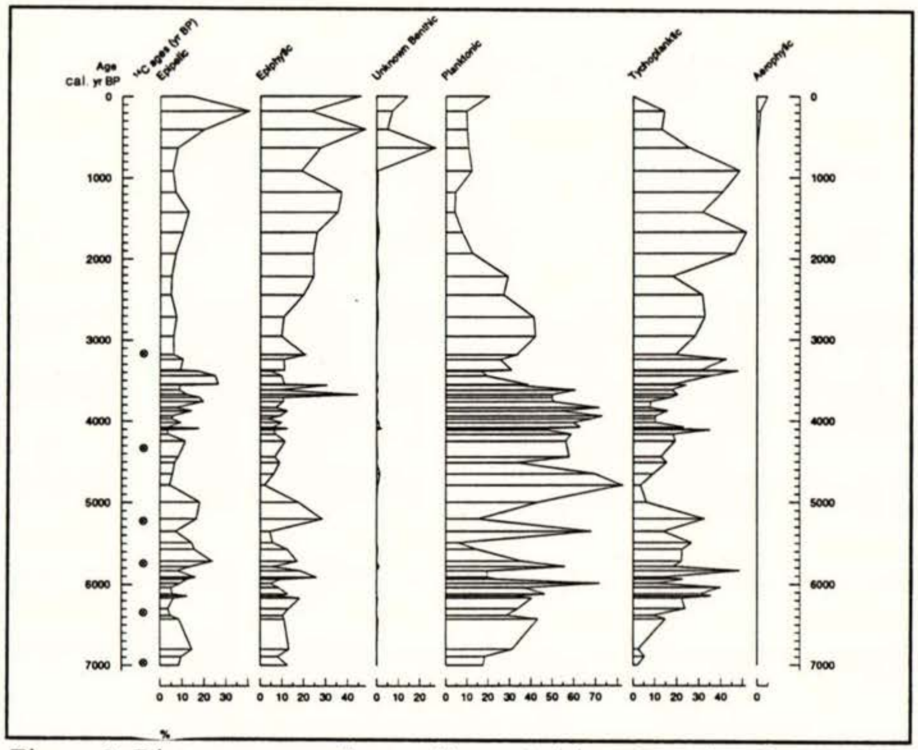

Figure 3 Diatoms grouped according to habitat plotted against time

at the time, and no whole marine diatoms were getting into the lake, nor many brackish diatoms. It is suggested that the lake and barrier were lower and closer to sea level and because of this, waves could wash over the barrier during storm events carrying marine diatoms (that got broken up on the beach face) into the lake. It is likely that marine fragments declined as the barrier grew wider and higher due to sediment accumulation and / or tectonic uplift.

At about 5800 years BP, it is possible that an uplift event was responsible for raising the barrier out of reach of storm waves. Other changes in the diatom assemblage that can be explained by an uplift event occur at this time but they are not evidence of an event in themselves.

The habitats of different diatom species were also studied (Figure 3). An indication of relative water depth of the lake is able to be inferred from this diagram. It is suggested that the lake was relatively deep between 5100 and 3500 years BP. The lake has been relatively shallow from about 2100 years BP. A slow infilling of the lake has occurred in the last 1000 years with wetlands forming around the lake edge.

The diatom assemblage of the lake sediments is also unexpectedly uniform, showing no definite uplift events and indicating that a fresh to brackish water lake has existed at this site for the last 7000 years.

UPLIFT HISTORY

The only definite evidence of uplift at the lake is the raised beach on the gravel barrier in front of it. This beach ridge is 8.5 metres above sea level

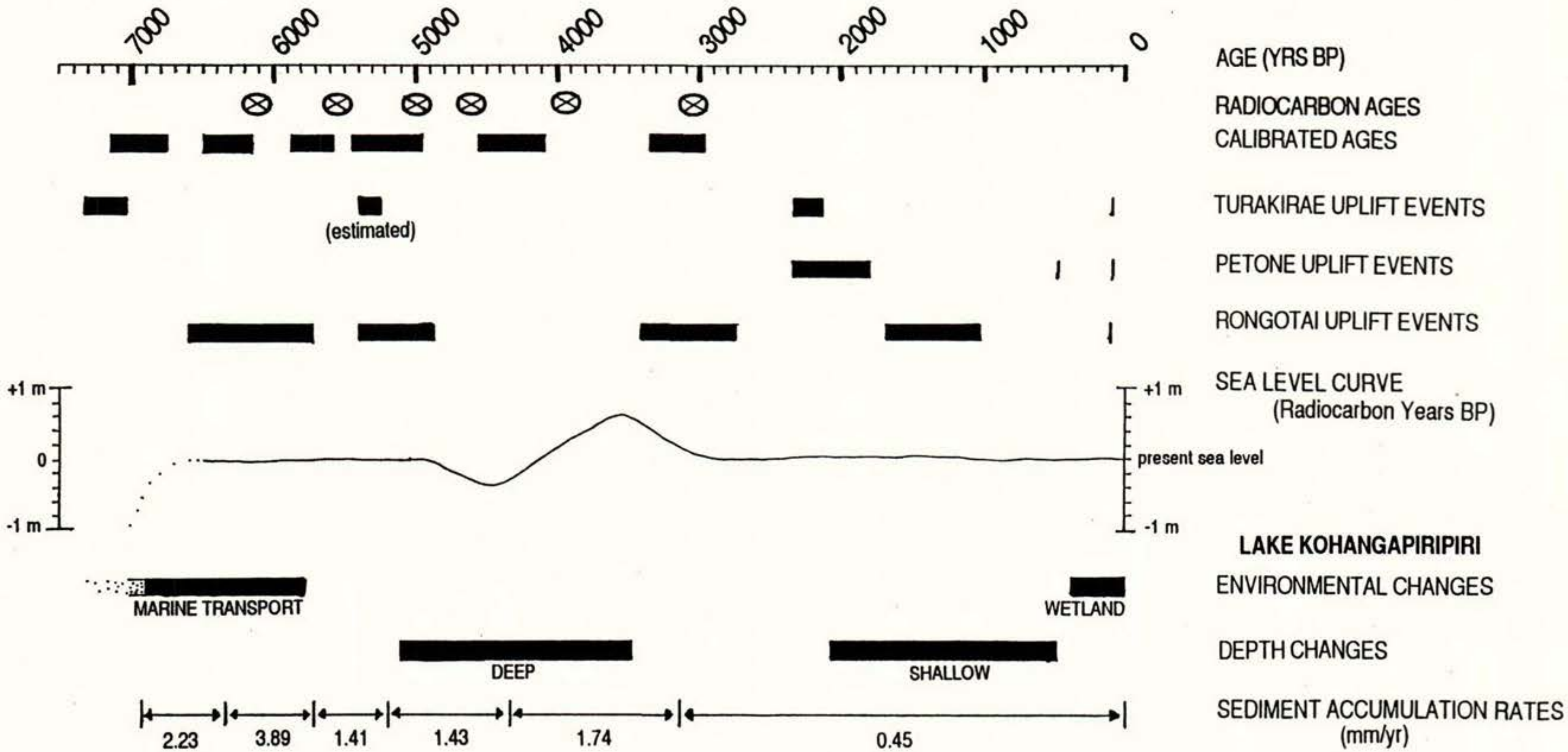

Figure 4 Diagram showing uplift events at Turakirae Head *(after McSaveney and Hull, 1995)*, Petone *(after Stirling, 1992)*, and Rongotai *(after Huber, 1992)* compared to changes at Lake Kohangapiripiri. Minor sea level changes are shown in radiocarbon years *(after Gibb, 1986)*.

NB: Initial deepening of lake coincides with transgression when not calibrated.

and is thought to be that raised in the 1855 earthquake. Any beaches uplifted by previous events have not been clearly preserved in the vicinity.

The removal of the lake from marine influence and the shallowing and shrinking of the lake are likely to be due in part to tectonic uplift. However the sediment and diatom assemblage show no definite events. Figure 4 shows the uplift events that have been recorded at Turakirae Head, Petone and Rongotai. These are compared to the sea level curve (which has been relatively stable over the last 6500 years) and to the main changes at Lake Kohangapiripiri.

The end of marine transport of diatoms into Lake Kohangapiripiri, coincides with one of the Rongotai events and may coincide with the Turakirae Head event that has not been directly dated (Beach Ridge 4). Earthquake events also occur at Turakirae Head and Petone at about the same time as the lake begins to shallow.

An uplift history was unable to be developed because of the lack of evidence for distinct earthquake events. The wave-cut cliffs are assumed to have formed when the valley was open to the sea. If the cutting of these cliffs could be dated an uplift rate for the area could be calculated. However there remain several possible stillstand periods in which the cliffs could have been cut, giving uplift rate estimates of 0 mm/yr to 3 mm/yr or higher.

At present there is approximately 6.8m of fresh-brackish lake sediment below sea level. This implies that if no uplift has occurred at the lake site, then at some stage (after 7000 years BP) the lake bottom must have been

6.8m or deeper below sea level. This would require a very large, well-cemented barrier below sea level in order to keep sea water out of the lake. If uplift has occurred in this area then an even larger barrier is necessary. It is difficult to envisage how a barrier of such a size and depth below sea level could form, let alone be maintained for some time. Alternatively, the thickness of sediment could be explained by subsidence. Perhaps, although uplift does occur at this site during some events (for example the 1855 Wairarapa earthquake), subsidence is the dominant movement at the lake over the period studied.

It is concluded from this study that the lake environment is relatively insensitive to earthquake events. Changes in the grainsize and organic carbon content of the sediment are small, and changes in the diatom assemblage may be due to uplift events in some cases but are not distinct enough to define an event in themselves. Large earthquake events are recorded at sites to the east and west of Lake Kohangapiripiri as uplifted beaches. The sediment record of the lake shows no such events.

FUTURE RESEARCH

The stability of the lake is interesting in itself. Future research should involve coring to basement in the centre of the lake in order to sample pre-7000 year old sediment and recent sediment, and possibly coring the neighbouring Lake Kohangatera. The sediment is ideal for carrying out a palynological study, which has the potential to provide not only a complete history of the lake, but a detailed, continuous record of Holocene vegetation and climate.

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