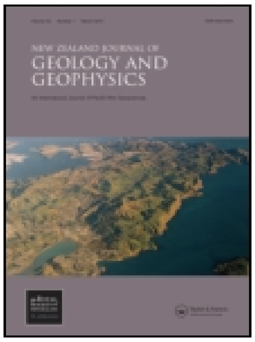

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Pre-A.D. 1931 tectonic subsidence of Ahuriri Lagoon, Napier, Hawke's Bay, New Zealand

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Abstract Excavations for drainage of Ahuriri Lagoon near Poraiti has exposed a sequence, up to 8 m thick, of peat containing remains of two separate human skeletons, overlying primary airfall Waimihia Lapilli, and overlain by estuarine sediments. Stratigraphy together with radiocarbon dating of peat, wood, human bone, and shell samples is interpreted to indicate tectonic subsidence of 8 m in the last 3500 years at the pre-A.D. 1931 western margin of Ahuriri Lagoon. Most of this subsidence occurred between 3500 years B.P. and 1750 years B.P. at an average rate of 4.6 m/1000 years and was probably matched by the similar rate of peat accumulation. A hiatus in peat growth between c. 1800 years B.P. and c. 500 years B.P. was possibly the result of tectonic uplift.

Maori human bones were buried in the upper 0.5 m of the peat 480–550 years B.P. and their burial was followed immediately by inundation by Ahuriri Lagoon as a result of either further tectonic subsidence or the breaching of a barrier at the western margin of the lagoon. The entire sequence was uplifted 1 m during the A.D. 1931 M7.8 Hawke's Bay earthquake.

If all tectonic movement was co-seismic, as in A.D. 1931, then the four or five earthquake events deduced from the geologic record at Poraiti are a minimum.

Keywords Late Quaternary tectonics; Holocene; C-14; A.D. 1931 Hawke's Bay earthquake; Waimihia Lapilli; Ahuriri Lagoon; Napier Syncline; Kidnappers Anticline

INTRODUCTION

The 3 February A.D. 1931 Hawke's Bay earthquake (magnitude 7.8) was accompanied by up to 1.5 m of uplift near Napier, Hawke's Bay (Fig. 1) (Henderson 1933). The most dramatic effect of this uplift was the emergence above sea level of approximately 1300 ha of Ahuriri Lagoon, into which the Tutaekuri and Esk Rivers then flowed (Marshall 1933). The entire western margin of the lagoon was uplifted 1 m, and the Westshore gravel bar forming the eastern lagoon margin rose 1.5 m. A further 1700 ha of lagoon has since been artificially drained (Grimmett & Struthers 1939; Cottrell 1955) and reclamation is still continuing.

In July 1982, drainage by B. W. Lindeman (landowner) of several hectares 1500 m south of Poraiti (Fig. 1), exposed beneath uplifted lagoon sediments an extensive peat layer in which at two localities were buried human bones. The thick peat had not previously been known to underlie this part of the western margin of Ahuriri Lagoon (Fig. 2). The presence of peat containing human bones and overlain by estuarine sediments suggested that the lagoon may have extended westward during the relatively short time (c. 1000 years) of human occupation of this part of New Zealand. The discovery of a range of different organic materials with clear stratigraphic relationships and all within the range of radiocarbon dating provided an opportunity for the late Holocene geological history of part of a historically active, tectonic area to be studied. Only a small part of the former lagoon bottom remains unmodified.

STRATIGRAPHY

Stratigraphy (Fig. 3) was determined from machine-dug pits, up to 8 m deep, and a 1 m deep hand-dug pit excavated in an unmodified area. An inferred schematic cross-section of the peat-filled valley along the western margin of former Ahuriri Lagoon is given in Fig. 4. The human bone samples had earlier been excavated by Mr B. W. Lindeman, who estimated their depths below the ground surface.

A thin soil has developed since A.D. 1931 in the upper 0.2 m of the shelly silty sand after natural and artificial drainage. Shell species with both

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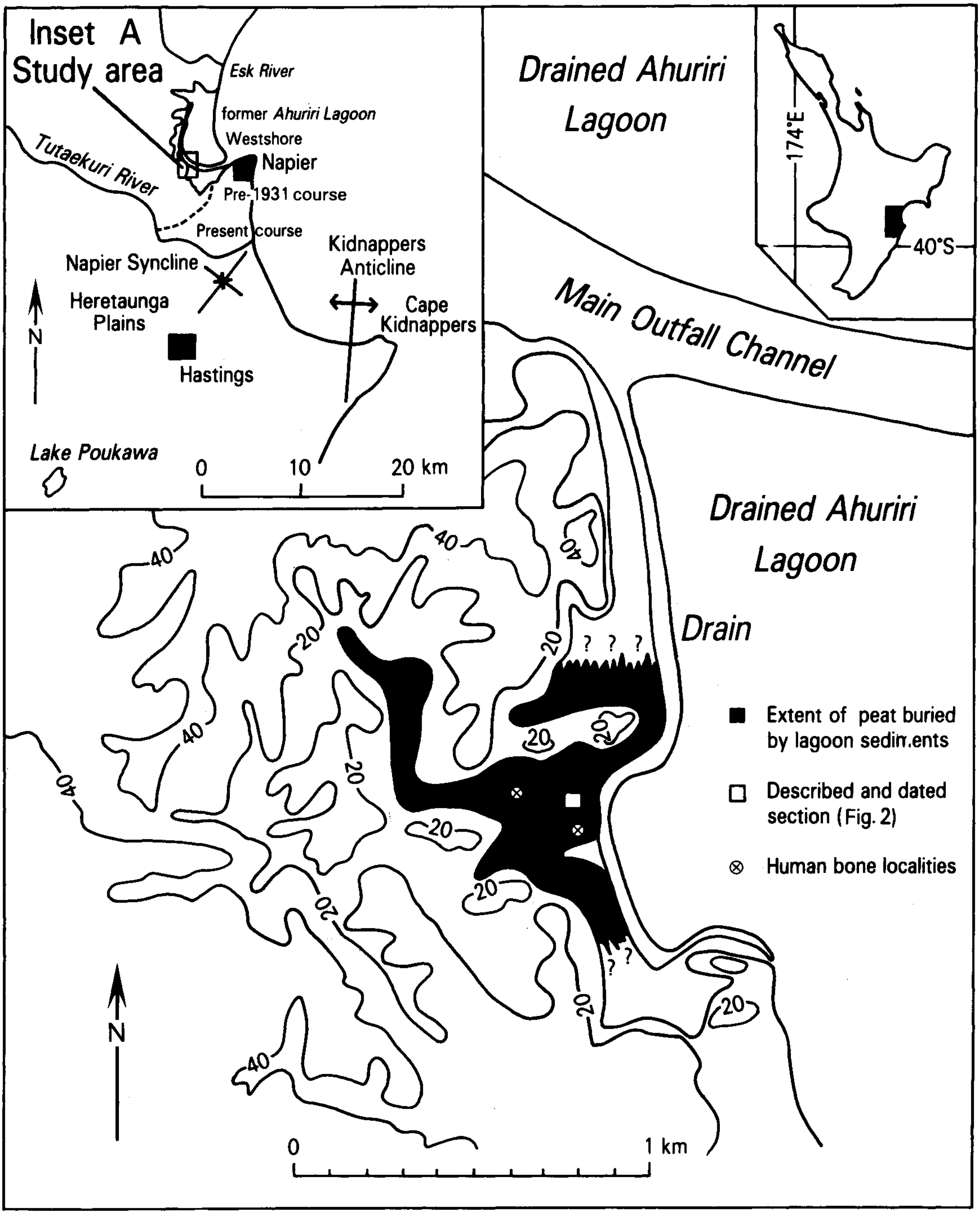

Fig. 1 Positions of dated samples and described section at Poraiti near Napier. Map shows present topography at part of the western margin of the former Ahuriri Lagoon and is enlarged from NZMS 270 sheet V21B, 1:25 000. Contour interval is 20 m. The "Main Outfall Channel" corresponds to the main lagoon channel before A.D. 1931 and the "Drain" trending NNW marks the eastern limit of land drained naturally by the A.D. 1931 uplift. Pumping is still necessary to maintain free-draining conditions on all drained land, which, near the centre of the former lagoon, is 1 m below present mean sea level. Question marks indicate that peat is not known to continue beyond that area, although peat is known immediately west of Poraiti. Inset A shows localities in Central Hawke's Bay and major structural features discussed in text.

Fig. 2 View west over drained Ahuriri Lagoon to peat-filled valley occupied by Ahuriri Lagoon prior to the A.D. 1931 earthquake and currently under reclamation. Arrows indicate location of human bones, square indicates locality sampled for dating. Westward deviation in drain (foreground) is the same as that shown on Fig. 1. Note the considerable ground surface modification that has followed uplift and drainage. (Photo by D. L. Homer, NZGS Ref. No. A13442b).

articulated and broken valves are dominated by *Austrovenus stuchburyi* and indicate an intertidal, estuarine environment (A. Beu written comm. 1982).

Peat, with twigs and leaves of *Dacrycarpus dacrydioides* (R. Patel written comm. 1982) underlie the estuarine deposits. The contact is sharp, but some peaty material is mixed with shells in the lower 0.1 m of the overlying marine silt. In its natural state, the peat is waterlogged and generally free of inorganic sediment. The peat is fibrous and woody with logs of *Podocarpus totara, Dacrydium cupressinum* and *Dacrycarpus dacrydioides*, up to 1 m in diameter, throughout the total thickness of the peat layer. Several tree stumps are in their growth and standing position, many being surrounded by well-preserved twigs and leaves.

A lens of poorly sorted pebbly-silty sand is exposed 1–2 m below the top of the peat at several localities close to the margins of the former valley (Fig. 4). Some of the constituent clasts within the lens of sediment are creamy-yellow, rounded pumice lapilli up to 10 mm in diameter. Pumice is correlated with the Taupo Pumice eruption c. 1800 years B.P. (Healy et al. 1964; Froggatt 1981) on the basis of clast size, vesicularity, and known distribution.

A tephra at the base of the peat shows no bedding, but grain size decreases from a fine lapilli at the base to medium ash at the top of the 0.3 m

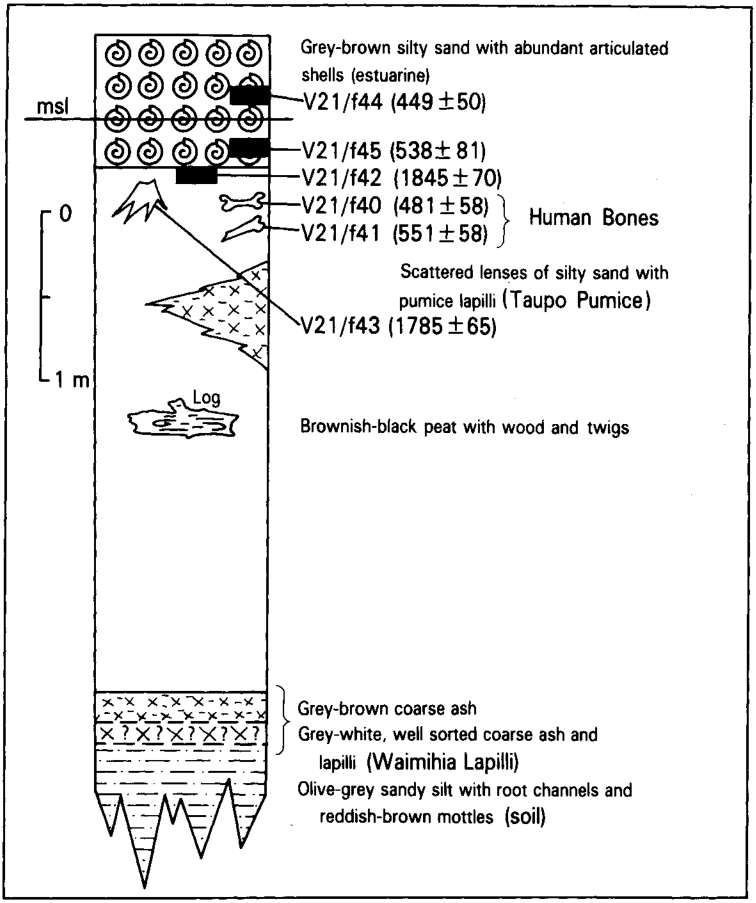

Fig. 3 Composite stratigraphy drawn mainly from section described at locality shown in Fig. 1. Radiocarbon sample localities and ages (new half-life) and New Zealand Fossil Record numbers are shown. Lower part of section drawn from a machine-dug pit excavated beneath an earlier hand-dug pit. Depth and position of dated bones are from information supplied by landowner.

thick layer. Pumice lapilli are typically vesicular with up to 10% obsidian which increases to 15% in the upper, finer part. Ferromagnesian mineralogy is dominated by hypersthene, with augite and biotite as minor constituents. Field character, grain-size distribution, ferromagnesian mineralogy, and known distribution indicate that this ash is Waimihia Lapilli dated at c. 3500 years B.P. (Healy et al. 1964; Froggatt & Howorth 1980).

Waimihia Lapilli rests conformably on a pale olive, orange-mottled sandy silt at least 1 m thick. The presence of root channels and soil colour mottles, and the absence of shells, indicate a terrestrial origin for this silt. The sharp contact both above and below Waimihia Lapilli, the angular nature of the pumice grains, and the lack of any detrital contaminants within the tephra indicate that Waimihia Lapilli is a primary airfall deposit at this locality.

The peat is up to 8 m thick in the centre of the former valley and thins to less than 0.5 m at the edges (Fig. 4). Similarly, the depth to Waimihia Lapilli, which everywhere underlies the peat, also varies, indicating that this tephra mantled the valley which was subsequently filled with the peat. Marine sediments are relatively uniform in thickness over the entire area, but show a slight thinning away from the centre of the former Ahuriri Lagoon.

DISCUSSION

Radiocarbon dates of shell, wood, and peat (Table 1) are consistent with the stratigraphy shown in Fig. 2. However the youngest bone sample (481 ± 58 years B.P., NZ5608B) is younger than the oldest shell sample (538 ± 81 years B.P., NZ5613B) which stratigraphically overlies it and suggests that the bones may have been buried after the deposition of the estuarine sediment. There is overlap in the 1 standard deviation counting errors for both these dates and the samples must be considered to be of similar age. There is good agreement between dates

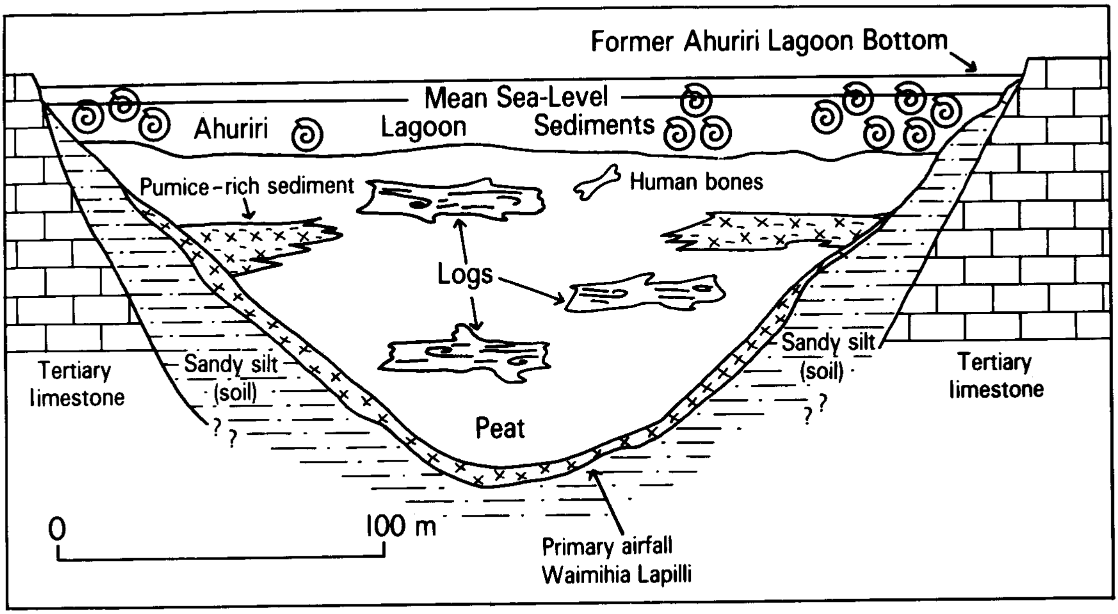

Fig. 4 Schematic section of peat-filled valley at the western margin of former Ahuriri Lagoon. 10× vertical exaggeration.

Table 1 Radiocarbon dating results for samples at Poraiti.

N.Z. Fossil Record sample number	Depth below ground surface (m)	(1) Sample type	$\delta^{13}C$‰	(2) N.Z. number	(3) Age (years B.P.)
V21/f44	0.3	Shells mostly articulated	+ 0.3	NZ5612A	436 ± 48
		Austrovenus stuchburyi		NZ5612B	449 ± 50
		(0.2% calcite)			
V21/f45	0.6	As for V21/f44	+ 0.2	NZ5613A	523 ± 79
		(0.3% calcite)		NZ5613B	538 ± 81
V21/f43	0.8	Wood from small tree	−27.2	NZ5611A	1735 ± 65
		in standing position		NZ5611B	1785 ± 65
		Dacrycarpus dacrydioides		NZ5611C	1720 ± 70
V21/f42	0.8	Peat and twigs	−27.0	NZ5610A	1790 ± 65
		surrounding V21/f43		NZ5610B	1845 ± 70
				NZ5610C	1775 ± 70
V21/f40	1.0 − 1.5	Human femur	−16.4	NZ5608A	467 ± 56
				NZ5608B	481 ± 58
				NZ5608C	503 ± 58
V21/f41	1.2 − 1.5	Human ribs	−16.5	NZ5609A	536 ± 56
				NZ5609B	551 ± 58
				NZ5609C	560 ± 63

(1) Shells identified by Dr A. G. Beu, New Zealand Geological Survey.
Wood identified by Dr R. Patel, Botany Division, Department of Scientific and Industrial Research.
(2) A ages calculated with old T½ (5568 years).
B ages calculated with new T½ (5730 ± 40 years).
C ages corrected for secular variations in atmospheric ^{14}C.
(3) All ages expressed as years before A.D. 1950.
All shell ages calculated with respect to New Zealand shell standard ($\Delta^{14}C$ − 41‰) (Rafter et al. 1972).
All bone ages calculated with respect to New Zealand bone standard ($\Delta^{14}C$ + 4.8‰) (Rafter et al. 1972).
All ages normalised to $\delta^{13}C$ fractionation of −25‰ (PDB).

from both wood and peat, indicating that both are preserved in their growth position.

Prior to deposition of Waimihia Lapilli (3500 years B.P.) an eastward-draining stream valley had been cut, partially filled with fluvial silt, and a soil developed on it. Waimihia Lapilli rests on this soil indicating that the area was above sea level 3500 years ago, but how much above or whether the valley contained a stream is not known.

After deposition of Waimihia Lapilli the local drainage deteriorated and peat growth began. Peat accumulation was very rapid but ceased sometime after c. 1750 years B.P. as indicated by dates of a small tree and the surrounding peat (V21/f43, 42). Up to 8 m of woody peat accumulated in the 1750 year period after Waimihia Lapilli deposition. If peat growth commenced immediately after Waimihia Lapilli was deposited then it accumulated at a rate of 4.6 mm/year. Rapid peat accumulation rates of 4–6 mm/year have been observed in a *Typha* peat near Rotorua (Campbell & Kennedy 1981). The woody peat at Ahuriri Lagoon would have been able to grow rapidly because of the inclusion of *in situ* noncompactable logs and at least one lens of sediment.

A period of local erosion and deposition resulting in the deposition of pumice-rich sediment occurred near the landward margin of the peaty embayment toward the end of the rapid peat accumulation period. This was probably a result of the erosion of up to 0.1 m of airfall pumice deposited on the surrounding hillsides following the Taupo Pumice eruption c. 1800 years ago.

Peat accumulation slowed or ceased after 1750 years B.P, but the date of cessation is not known as an unknown amount of peat may have been eroded from the top of the sequence. It is certain, however, that by 500 years B.P. when two human bodies were buried, the area was still a swamp and not part of Ahuriri Lagoon. It is also possible that the period between c. 1800 years B.P. and c. 500 years B.P., represents a hiatus in peat growth brought about by the completion of infilling of the old stream valley. There is no evidence of erosion of the peat by marine or fluvial processes.

The human bones, from their age, are of Maori origin and were probably buried by immersion in the swamp in the manner similar to that described by Best (1905). Burial must have taken place immediately prior to inundation by Ahuriri Lagoon c. 500 years B.P., as judged by the undisturbed nature of the estuarine sediments overlying the peat and the similarity of age between shell and bone samples. Estuarine conditions persisted until A.D. 1931 when the area was uplifted and once again became a low-lying swamp as a result of the Hawke's Bay earthquake.

TECTONIC IMPLICATIONS

The presence of primary airfall Waimihia Lapilli overlying alluvial silt up to 8 m below present mean sea level indicates that a period of rapid relative sea level rise occurred during the last 3500 years. If Waimihia Lapilli was deposited at or near sea level, an average relative sea level rise of 2.3 m/1000 years over the last 3500 years is indicated. Much of this relative rise must have taken place between 3500 years B.P. and 1750 years B.P. when rapid peat accumulation was taking place.

Sea-level curves for the New Zealand region during the last 4000 years (Schofield 1960; Gibb 1986) indicate eustatic sea-level fluctuations for this time period of no more than 1 m from the present mean sea level. It is therefore concluded that much of the relative sea-level rise was brought about by land subsidence at a rate of 4.6 m/1000 years. The valley which has been filled by the peat is small and unlikely to contain a significant thickness of compactable sediment (Fig. 4). Subsidence is therefore likely to be the result of tectonic downwarping.

The relative sea-level rise c. 500 years ago may have been brought about either by tectonic downwarping on the Napier Syncline (Fig. 1) or as the result of the breaching of a temporary barrier at the mouth of the peat-filled valley, perhaps during large storms. The valley must, at this stage, have been below sea level to permit the deposition of up to 1 m of estuarine sediment. If this estuarine sediment was deposited as the result of a single downwarping event, then the amount of downdrop was about 1 m. Only detailed studies of all valleys on the former western margin of Ahuriri Lagoon can determine whether the c. 500 years B.P. depositional event was of tectonic or climatic origin.

The A.D. 1931 co-seismic uplift of Ahuriri Lagoon is a reversal of the late Holocene trend of subsidence. Assuming that all relative sea-level changes during the last 3500 years at Poraiti are the result of tectonic movement, these movements were, in chronological order:

(1) c. 1750–3500 years B.P.: rapid downdrop of 8 m (1 or more events).

(2) c. 500–c. 1750 years B.P.: stability or slight uplift.

(3) c.500 years B.P.: downdrop c. 1 m (inundation by estuarine sediments).

(4) 19 years B.P.: uplift 1 m (A.D. 1931 Hawke's Bay earthquake).

The disastrous Hawke's Bay earthquake of A.D. 1931, which had a marked effect on the development of Napier and its environs, thus appears to be an abnormal uplift event which, without the historic record, would be difficult to determine from a sequence of downwarping events, unless the hiatus in peat growth between 1785 and 538 years B.P. is also a result of uplift(s) similar to that in A.D. 1931. The stratigraphic record tends to only preserve the net effect of ground-level changes resulting from large earthquakes. The total number of earthquake events prior to A.D. 1931 that have affected the western margin of Ahuriri Lagoon cannot be determined. Net subsidence is clearly demonstrated by the stratigraphy.

Studies of uplifted Holocene benches at Cape Kidnappers (Fig. 1) indicate rapid uplift of up to 5 m in the last c. 2300 years B.P. (Hull 1985). Cape Kidnappers lies on the eastern flank of the north-south-striking Kidnappers Anticline, that has deformed late Quaternary marine and terrestrial sediments (Lewis 1971), and adjoins the active Napier Syncline underlying the Heretaunga Plains further west (Kingma 1971). If these two structures form an anticline-syncline pair, then uplift and growth of the Kidnappers Anticline might be associated with downwarping and growth of the Napier Syncline. Such a relationship might explain the rapid peat growth as a response to downwarping on the Napier Syncline between 3500 and 1750 years B.P. Similarly, the lack of evidence for uplift since 2300 years B.P. at Cape Kidnappers matched by little known subsidence on the Napier Syncline may also explain the hiatus in peat growth at Poraiti after 1750 years B.P. No uplift or downdrop occurred at the Kidnappers Anticline in A.D. 1931 (Marshall 1933), but minor downwarping did occur in the eastern part of the Heretaunga Plains.

At Lake Poukawa, southeast of Hastings (Fig. 1), studies of fault-displaced tephra layers preserved in peat (Froggatt & Howorth 1980) indicate continued tectonic activity throughout the Holocene. The tectonic event which is best dated, and apparently the largest (0.4 m vertical displacement), occurred shortly after the deposition of Waimihia Lapilli. It is possible that this event may also have affected the western margin of Ahuriri Lagoon and resulted in some of the subsidence preserved there as surface deformation in A.D. 1931 affected both Ahuriri and Poukawa.

At any one site, such as Poraiti, the tectonic history is likely to result from continued deformation of the structure developing there (Napier Syncline) and the regional effects of other developing structures (Kidnappers Anticline, Poukawa Basin) if these are extensive enough. The four or five events recorded at Poraiti are therefore likely to represent a minimum number of major earthquakes to have affected the site. A detailed subsurface investigation of the whole of the former Ahuriri Lagoon could provide valuable evidence on the depositional and tectonic history related to major earthquakes in Central Hawke's Bay.

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REFERENCES

Best, E. 1905: Maori eschatology: the whare potae and its lore. *Transactions of the New Zealand Institute 38*: 148–239.

Campbell, E. O.; Kennedy, N. M. 1981: Nature of the peat bordering Rotorua airport, North Island, New Zealand. *New Zealand journal of botany 19*: 243–244.

Cottrell, M. 1955: Reclamation by earthquake. *Australian geographer, walkabout 21(11)*: 29–30.

Froggatt, P. C. 1981: Stratigraphy and nature of Taupo Pumice Formation. *New Zealand journal of geology and geophysics 24*: 231–248.

Froggatt, P. C.; Howorth, R. 1980: Uniformity of vertical faulting for the last 7000 years at Lake Poukawa, Hawke's Bay, New Zealand. *New Zealand journal of geology and geophysics 23*: 493–497.

Gibb, J. G. 1986: A New Zealand eustatic sea level curve and its application to vertical tectonic movements. *In:* Reilly, W. I. *ed.* Recent crustal movements of the Pacific region. *Royal Society of New Zealand bulletin 24.*

Grimmett, R. E.; Struthers, W. 1939: Napier Harbour reclaimed lands. *Department of Scientific and Industrial Research bulletin 70*: 44–51.

Healy, J.; Vucetich, C. G.; Pullar, W. A. 1964: Stratigraphy and chronology of late Quaternary volcanic ash in Taupo, Rotorua and Gisborne Districts. *New Zealand Geological Survey bulletin 73.*

Henderson, J. 1933: Geological aspects of the Hawke's Bay earthquakes. *New Zealand journal of science and technology 16*: 38–75.

Hull, A. G. 1985: Late Quaternary geology of the Cape Kidnappers area, Hawke's Bay, New Zealand. Unpublished M.Sc. thesis, lodged in the Library, Victoria University of Wellington.

Kingma, J. T. 1971: Geology of the Te Aute Subdivision. *New Zealand Geological Survey bulletin 70.*

Lewis, K. B. 1971: Growth rate of folds using tilted wave-planed surfaces: coast and continental shelf, Hawke's Bay, New Zealand. Pp. 225–231 *in:* Collins, B. W.; Fraser, R. *ed.* Recent crustal movements. *Royal Society of New Zealand bulletin 9.*

Marshall, P. 1933: Effects of earthquake on coast line near Napier. *New Zealand journal of science and technology 16*: 79–92.

Rafter, T. A.; Jansen, H. S.; Locherbie, L.; Trotter, M. M. 1972: New Zealand radiocarbon reference standards. *Proceedings of 8th International Conference on Radiocarbon Dating, Wellington, New Zealand*: 625–675.

Schofield, J. C. 1960: Sea-level fluctuations during the last 4,000 years as recorded by a chenier plain, Firth of Thames, New Zealand. *New Zealand journal of geology and geophysics 3*: 467–485.