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feet and caused flooding up the reaches and arms of the lake, thus linking up swamps and lagoons and overwhelming kaihikatea and swamp kauri forests. These trees died and rotted off at the water level but the stumps were preserved by the acid in the water. These stumps were first observed by the writer in 1925. The trees grew on the swamp and the lower undulating slopes but all were cut off level. This was unusual for kaihikatea; when a bushman fells kaihikatea, he chops above the "flare" or thickened buttress so peculiar to the variety, and to the eye the tops of the stumps are irregular in height. The last of these stumps were removed only eight years ago. It is quite possible that the blocked up waters of Ngaroto lake would have partly covered the Bank's Road pa mound as well as Steighs mound.

After the Maori War of 1863 almost two million acres were confiscated by the Government. This, of course, contained the Rukuhia swamp. When the area was surveyed for settlement, the settlers whose farms bordered the lake banded together to clear the blocked up Manga-o-toma stream. This clearing of the stream has been an annual task and the lake water level has fallen possibly eight feet since the war of 1863.

When time and opportunity permits, our group will visit and record the pa and villages on the many other swamps - namely the Moana-toa-toa and Piako.

REPORT ON THE NATURAL FOUNDATIONS OF THE NGAROTO SITE

R. Garry Law, B.E.

In Easter 1967 an investigation was undertaken to ascertain the relationship between the artificial mound and the natural lake sediments and swamp build up at the Ngaroto site, N65/18.

In historic times the lake has surrounded the mound, but it has since been lowered by the excavation of a channel deepening the outlet. There is evidence for a still higher level in the form of a scarp at the foot of the surrounding hills. It is apparent from the height of the scarp above the present lake that this level must pre-date the site. There is also some evidence for a raising of the lake level artificially, by damming the outlet during the period of archaeological occupation (D. Pick, personal

communication), while the excavated sections reveal a peat layer as the "natural" on the site.

Three hand auger bores were sunk, as shown on the plan and section, in order to investigate these deposits.

DESCRIPTION:

Bore 1. Clay, organic, rooty, brown; over clay, organic, rooty, varying from light grey to grey, to blue grey vertically; over sand, fine, silty, rusty; over silt, white pumiceous; over clay, organic, grey rooty, with occasional gravel, pumiceous and one very gravelly lens; over clay, slightly organic, slightly silty, slightly sandy, changing from brown to grey brown; over clay, light grey.

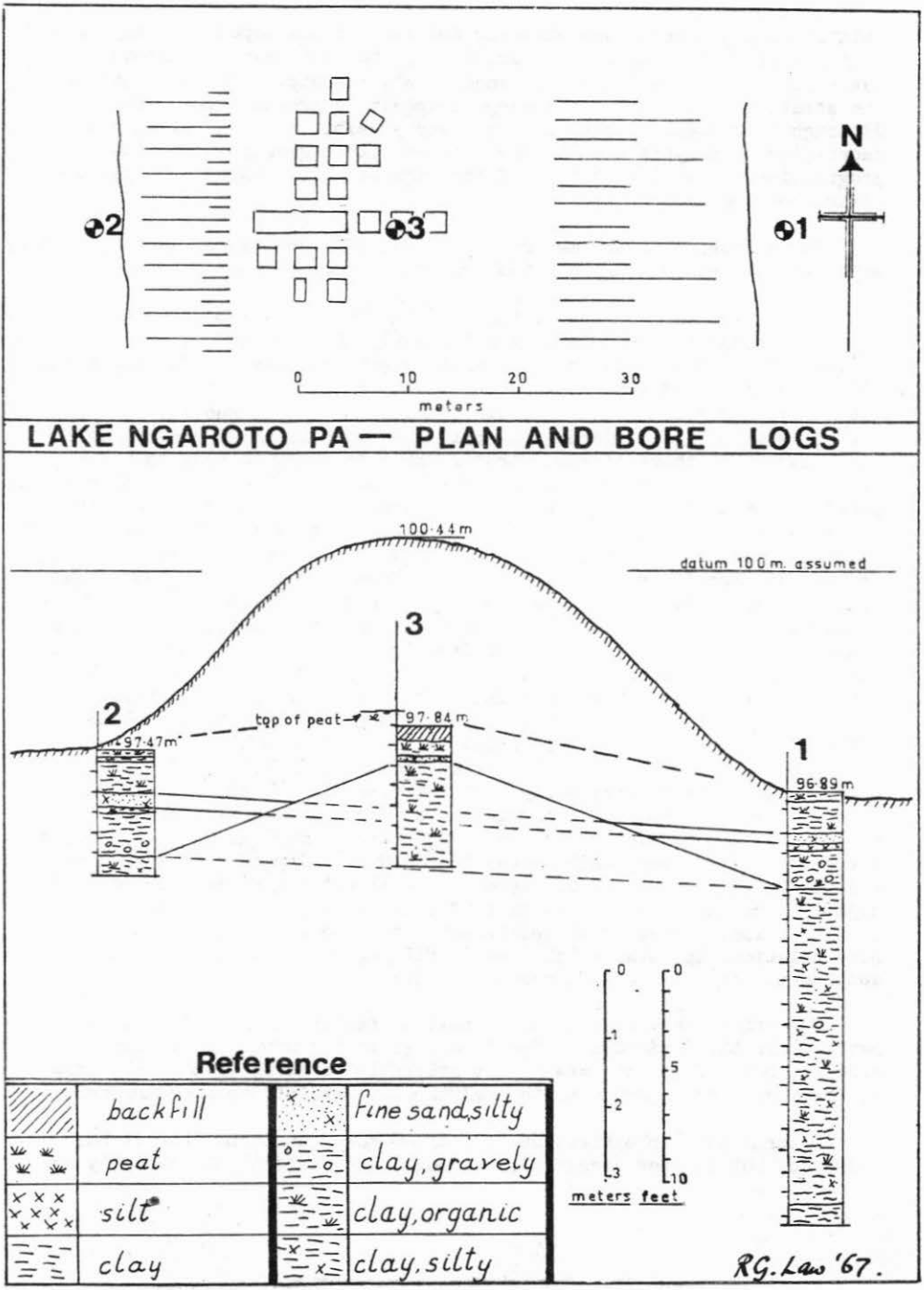
Bore 2. Clay, organic, black; over clay, yellow; over clay, organic brown; over fine sand, silty, rusty; over clay, organic, grey brown, with ferruginous streaks; over clay, light grey (pumiceous?), with ferruginous streaks, becoming darker with depth, gravelly, pumiceous, more so with depth; over clay, slightly silty, slightly organic, grey.

Bore 3. Drilled from the bottom of a partially backfilled square. Fill, black shelly; over peat, slightly clayey, yellow brown; over fine sand, silty, organic, black; over clay, slightly organic, grey brown.

STRATIGRAPHIC RELATIONSHIP:

There is a close agreement between Bores 1 and 2, the strata having a slight dip towards the centre of the lake. These have undoubtedly resulted from lake bottom deposition. The underlying, slightly organic clay can be seen to have a natural rise under the site. Furthermore, the yellow brown peat overlying this in Bore 3 does not appear in Bores 1 and 2. As its removal from the sides of the site for use as fill seems unlikely, it would appear that it was accumulating at the surface of the lake on a natural rise at the time of the initial filling for the mound. Palaeobotonical study of this stratum should reveal, not only the type of swamp vegetation, but by inference from habitat, relative water level (Butzer, 1965: 186). The silty sand layers in all three Bores may be one layer; however, this apparently requires a rise in lake level shortly before its deposition, as neither of the two strata underlying the silty sand, correlating in Bores 1 and 2, appear in Bore 3.

Of the strata on either side of the mound only those at Bore 2 show any evidence of human activity. This is the thin, imported yellow clay layer immediately under the surface. It is within a few metres of the foot of the mound. If the site were palisaded, debris left by the import of fill would tend to be concentrated round the entrances. The disposal of waste would be similarly limited, so that proof of a


2
3
1
N
0
10
20
30
meters
LAKE NGAROTO PA — PLAN AND BORE LOGS
100·44m
datum 100m. assumed
97·47m
top of peat
97·84m
96·89m
Reference
backfill
peat
silt
clay
fine sand, silty
clay, gravely
clay, organic
clay, silty
meters
feet
RG. Law '67.

relationship between mound build-up and lake bottom deposition may only be found at these places. Alternatively, the site may have grown laterally over the evidence for such a relationship. On this section the strata encountered at the margins appear to pre-date the site. Although this might seem to rule out any possibility of a pollen and macro-floral analysis tied to the cultural stratigraphy, a supposed progressive, lateral expansion of the site may have sealed off suitable pollen-bearing material.

The pumiceous layers may relate directly to geological events, or they may have been secondarily derived from previously formed deposits.

The broken line on the section represents the lake bottom at the time of first occupation, but it does not clearly show the natural rise inferred above. This anomaly may be explained by soil settlement, for the cultural strata in the mound show small scale block faulting with fault scarps in the floors and sections. They also show a vertical sinuosity. These are suggestive of a differential soil settlement within a general soil settlement, and there is some stratigraphic evidence to show that the sinuosity and "faulting" developed during the occupation (F. W. Shawcross, personal communication). The mound layers, being thin and generally well compacted by being lived on, would not settle much within themselves. The completed mound at Bore 3 would exert an effective vertical stress of around 4000 Kgm./sq.M. on the natural. Theoretically, using Westergaards formula, this load increment would only be reduced to 2000 Kgm./sq.M. at 36 metres depth. Thus, deep-seated compressible material could be the cause of settlement. This may be stratigraphically demonstrable if the natural rise does not occur under the whole site. It should also be noted that for deep-seated settlement the margins will also settle. The strata down to the slightly organic clay in Bores 1 and 2 were generally soft, i.e., technically with a shear strength of less than 2 psi. The slightly organic clay in Bore 1 varied from firm to soft. The peat in Bore 3 was doubtless originally very compressible, so that settlement of all of these is likely. Drainage operations, by causing a change from buoyant to bulk density of previously submerged material may have caused extra soil settlement, while excavation and shifting of soil may allow a slight recovery, but it would seem that soil settlement in the order of 0.5M. is not unlikely. A quantitative investigation of the soil mechanics would reveal soil settlement rates and total soil settlement. Some relationship between lake level, filling on the site, and soil settlement may very well be shown to exist.

The other possible form of foundation failure on the site, which may explain the formation of fault scarps, is the creation of slip circles, but sufficient data is not available to stratigraphically show if these have been formed or to analytically predict their occurrence.

Clearly this investigation has raised more questions than it has answered, but further archaeological work may establish the validity or

otherwise of some of the points above, while others should yield further investigations of this kind, and the results may help to explain both problems of archaeological excavation and interpretation, and also factors which controlled the form of the prehistoric settlement.

ACKNOWLEDGMENTS:

I should like to thank my employers, Tonkin and Taylor, consulting and foundation engineers of Auckland, for the use of the auger.

REFERENCE:

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NORTH CAPE NOTES

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Although Cape Reinga and the Lighthouse have been readily accessible for many years and are visited by thousands of people, the North Cape area which is over twenty miles East of the Lighthouse is still rather difficult to reach. This region has some flat country but it is mostly hilly and is bordered by rocky cliffs or magnificent sand beaches. It provides a great variety of interest for geologist, botanist and archaeologist, as well as for the holiday camper. There is ample evidence of the former Maori population.

In January 1960, with three companions, I visited the area the hard way. The schoolmaster at Te Hapua ferried us across Parengarenga Harbour, and then with everything on our backs we crossed to the sea coast and walked through this small, roadless, uninhabited corner of New Zealand. Since then a quarry for serpentine has been opened at Kerr Point and a good clay road enables the rock to be placed on barges not far from the entrance to Parengarenga Harbour. The quarry is closed during winter