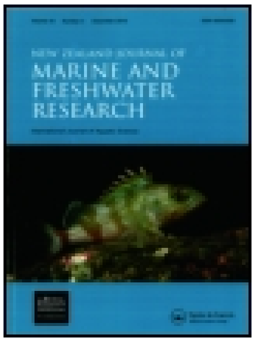

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Short communication

Radiocarbon age for estuarine shells from Lakelands, Lake Ellesmere (Te Waihora), New Zealand

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Abstract Shells of the estuarine species *Mactra ovata* from Lakelands, Lake Ellesmere, New Zealand give a ^{14}C Radiocarbon age of 670 ± 67 B.P. Their occurrence presents a problem as currently Lake Ellesmere is a brackish lake, separated from the Pacific Ocean by Kaitorete Barrier, a mixed sand and gravel barrier. According to previous research this barrier has enclosed a water body behind it in the position of Lake Ellesmere for up to 8000 years. Since the mid Holocene, at least three fluctuations between lacustrine and estuarine conditions are thought to have occurred. These fluctuations are believed to be associated with the avulsion of the Waimakariri River, to and from Lake Ellesmere. This study adds to the previous research by providing a timeframe within which one of these estuarine events occurred.

Keywords Lake Ellesmere; Kaitorete Barrier; Te Waihora

INTRODUCTION

Lake Ellesmere is the largest coastal lake in Canterbury and the fourth largest lake in New Zealand (Irwin 1975; Livingston et al. 1986). It is evident that in the past Lake Ellesmere was even larger (Hemmingsen 1997). It is now closed to the sea by Kaitorete Barrier. Located immediately south-west of Banks Peninsula in an interfan depression (Fig. 1), Lake Ellesmere is a large shallow brackish lake, nearly triangular in shape, surrounded on two sides by agricultural farmland from which it receives surface inflows, and on the seaward side by a mixed sand and gravel incorrectly named Kaitorete Spit. This barrier has formed over time by longshore coastal sediment transport, separating the barrier lake from the Pacific Ocean.

The present lake is artificially controlled, being opened to the sea by cutting a channel through the barrier at Taumutu, allowing both drainage and seawater influx. Wave action quickly closes the cut in a southerly storm. Lake Ellesmere currently covers an area which varies generally between 16.6 and 23.9 km^2 depending on the lake level (Hemmingsen 1997). The main inflows to Lake Ellesmere are from rivers and drains. Of these only the Selwyn River flows directly from the foothills of the Southern Alps. All other inflows rise within 19 km of the lake. In addition to the above sources, other inflows include groundwater percolation, seawater percolation, and artesian springs.

Early research by Speight found that Kaitorete "Spit" was a marine formed feature constructed by the littoral drift of sediment transported from the south toward Banks Peninsula (Speight 1910, 1928). He emphasised changes in the level of the land as a dominant process in changing shorelines in the area (Speight 1930). At the time of Speight's research there was no understanding of sea level change or eustatic behaviour thus the sequences he presents are correct, but inverted as the sea level moved, not the land.

Suggate (1968) attributed the formation of a spit to post-glacial sea level rise. He argued that there was some evidence that the sea probably extended over the area now occupied by Lake Ellesmere. Suggate also noted changes in lithology stating that the stratigraphy indicated a retreat of the sea as recorded by the presence of estuarine and lagoonal deposits.

Armon (1974a), in a study based principally on the Holocene development of Kaitorete Barrier,

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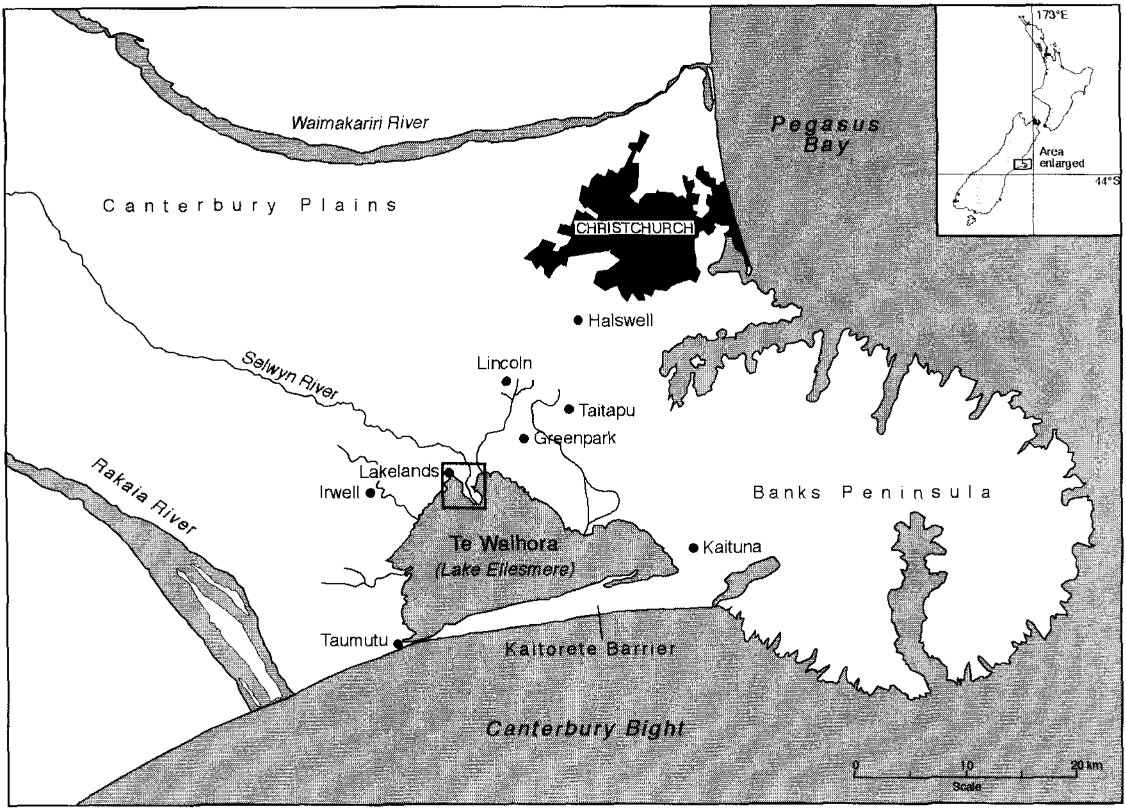

Fig. 1 Location map of the area and places mentioned in the text.

determined that it formed on a rising sea level and that beach ridges on the seaward side of the barrier have prograded following the joining of the Barrier to Banks Peninsula. Armon concluded that the spit developed 7000–6000 B.P. and before that the shoreline was open to the sea. Armon's study was based on general observations in the field and the work of Suggate. He gives no indication of when a paleo-lake might have dominated this area. However, Armon (1974b) does provide a ^{14}C date of 748 ± 41 B.P. for *Hyridella menziesi* (fresh water mussels) which would have been present at the time of a paleo-lake.

Kirk (1994) suggested that Lake Ellesmere has followed a sequence, in successive stages over the last 5000 years or so, of having once been a bay, then an estuary and finally a lake. He states that there is also the possibility of it again becoming a salt water estuary in the not too distant future owing to coastal erosion in the south. However, Kirk does not provide any dates as to when each stage might have occurred. His argument is instead based on inference from the work of both Suggate and Armon.

Soons et al. (1997) examined the Holocene evolution of Lake Ellesmere and Kaitorete Barrier. They suggested that a barrier/spit system has existed within the area for the last 8000 years. They state that there have been at least three fluctuations between lacustrine and estuarine conditions with the most recent of these occurring in the last 200–500 years. They argue that the spit may not have closed to become a barrier until as recently as 300 years ago. The changes are thought to have been associated with the avulsion of the Waimakariri River to and from the Lake Ellesmere basin. Soons et al. (1997) suggest that the most recent avulsion of the Waimakariri River occurred between 1000 years to 700 years B.P. with the lake finally closing off again by the building of a spit adjacent to Birdlings Valley around 550 years B.P.

Hemmingsen (1997) presents a similar sequence of fluctuations between lacustrine and estuarine conditions to that suggested by Soons et al. (1997). Hemmingsen (1997) has suggested that following the avulsion of the Waimakariri River into the Lake

Ellesmere basin estuarine conditions prevailed around 670 ± 67 years B.P.

The identification of an estuarine shell *Mactra ovata* (Gray 1843), from a site 1.2 km inland of the present landward shoreline of Lake Ellesmere adds further detail to the known history of the water body. Specifically, it adds support to the sequential notion put forward by Kirk (1994) that Lake Ellesmere may have followed an evolutionary sequence from a bay, to an estuary and then a lake.

The purpose of this study was to identify and date the shell and shell fragments found adjacent to the Selwyn River, as no previous records show the presence of shells so far inland.

METHOD

This research is drawn from a larger study of the paleo-shorelines and ridges around Lake Ellesmere (Hemmingsen 1997). Field observations were made in conjunction with the study of aerial photographs and topographic maps, historical maps, and previous publications to construct a geomorphological map.

Profiles were surveyed around the shoreline of Lake Ellesmere using a Sokkia Set 4B total station. Vertical accuracy was ±1.5 mm/km. All elevations are referenced to mean sea level correlated with the 1937 Lyttelton Datum.

A detailed investigation of landforms was carried out in the field using vertical sections dug by hand or with power auger, to examine the sediments, bedding, and stratigraphic relationships. It was during one of these investigations that shell fragments were found. Further investigation by excavation led to the careful recovery of both whole shells and shell fragments from the site. Preparation of shell material was undertaken by carefully washing with distilled water and air drying before shells were packed in plastic sample containers provided by the laboratory. Samples were sent to the Rafter Radiocarbon Laboratory, Lower Hutt for ^{14}C dating.

RESULTS

Shell samples were from within a layer 400 mm beneath the surface of a wave formed ridge. A profile along Selwyn Lake Road places the wave formed ridge from which the shells were removed, 1.2 km from the present lake shoreline, 5.36 m above mean sea level, and 0.4 m below the present ground level surface. Fig. 2 shows the location in plan-form and stratigraphy is presented in Fig. 3. The height of 5.36 m above mean sea level is comparable with the higher water levels of paleo Lake Ellesmere. Hindcasting has shown that water levels were c. 4.0 m above current lake levels (Hemmingsen 1997). Higher water levels would have resulted in an increase in wave action at the shore and would have been accompanied by a significant reworking of the lake ridges.

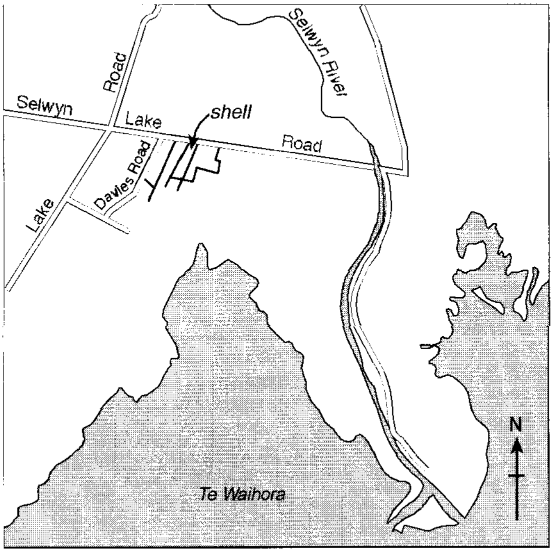

Fig. 2 Location of *Mactra ovata* shell, Lakelands, Lake Ellesmere, New Zealand.

The stratigraphy shows an upper zone containing a thickness of 300 mm of modern organics. In a "typical lawn", at a depth of 300 mm a thin layer of 20–40 mm of sand was found within which was a very thin layer (of <10 mm) of small pebbles. Below this layer for a depth of 100 mm was a layer of marine shells. Below the shell layer was a layer of marine sands to a depth of 580 mm from the surface. Beneath the sands a gradational layer of clays overlay a dark paleosol, which at a depth of 670 mm had some carbonised wood fragments. The wood fragments were 270 mm below the shell layer. The shells were *in situ* and there was no evidence to suggest that the shells had been burned nor the sand around the shell layer, thereby eliminating any possibility that the samples were from a midden. A grey clay with orange mottling at 800 mm from the surface was underlain by muds and silts on a very firm stony layer. From 1.0 to 1.5 m the stratigraphy consisted of a loose layer of clast supported, mixed sand and gravels.

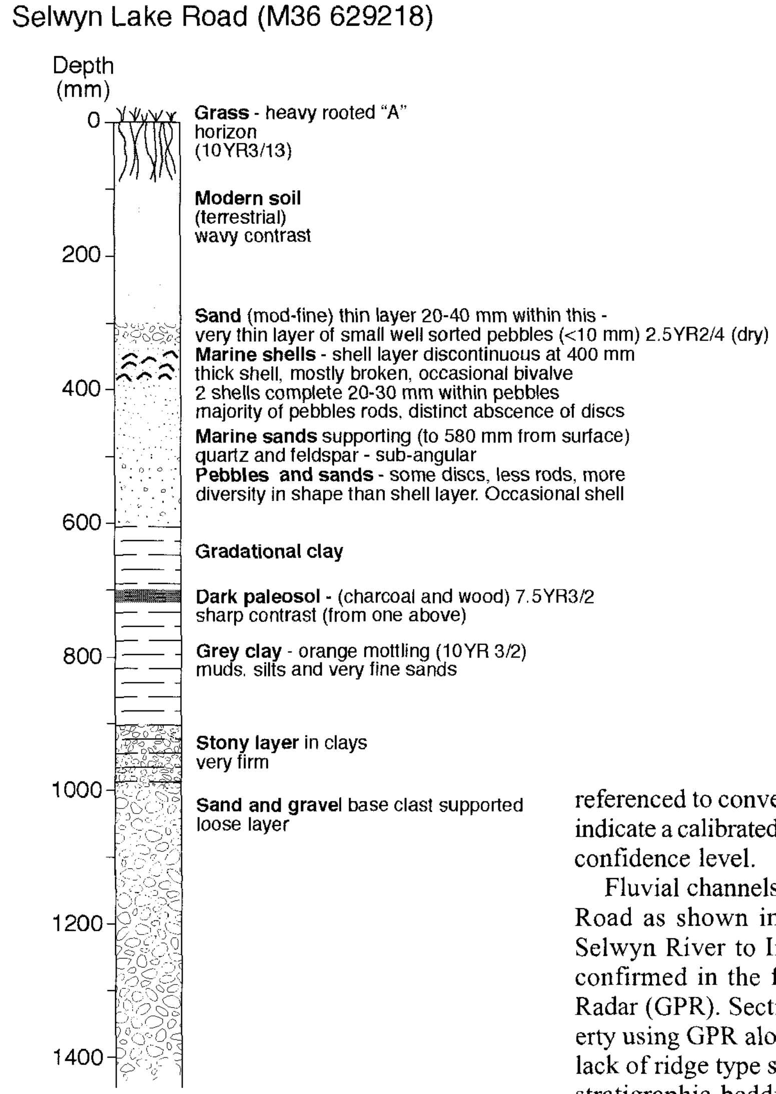

Fig. 3 Vertical stratigraphy of field site where *Mactra ovata* shell was found.

The shell samples were subsequently identified by Associate Professor Colin McLay (Zoology Department, University of Canterbury, New Zealand) as the estuarine species *Mactra ovata* (Gray, 1843). The shell layer was discontinuous with mostly broken shell and an occasional whole valve. Two shells were complete and up to 20–30 mm in width. Both whole shells and a sample of shell hash were sent to the laboratory for dating. Results confirmed an estuarine origin for the species and a radiocarbon age of 670 ± 67 B.P. (ref. NZA 7654). The ^{14}C date has been corrected for a δ^{13}C of –2%. These results are referenced to conventional radiocarbon ages, which indicate a calibrated age of 1480–1718 A.D. at a 95% confidence level.

Fluvial channels were noted along Selwyn Lake Road as shown in Profile "I" (Fig. 4) from the Selwyn River to Irwell. Fluvial forms were later confirmed in the field using Ground Penetrating Radar (GPR). Sections through the Walker's property using GPR along Selwyn Lake Road showed a lack of ridge type structure. Results found a lack of stratigraphic bedding taken to be consistent with fluvial activity (M. Holmes, Geology Department, University of Canterbury, New Zealand pers comm. 1997). The GPR was used at this site in an attempt to find the continuation of a series of what were termed Lakeside Ridges by Armon (1970). These Lakeside Ridges form part of a series of confused ridges that Armon (1970, 1974a) had previously identified as lake ridges. However, Armon was not able to explain the discontinuity of these ridges. Hemmingsen (1997), was able to confirm the position of these ridges and offered a possible explanation for their discontinuity, as the product of fluvial activity from the Selwyn River which previously

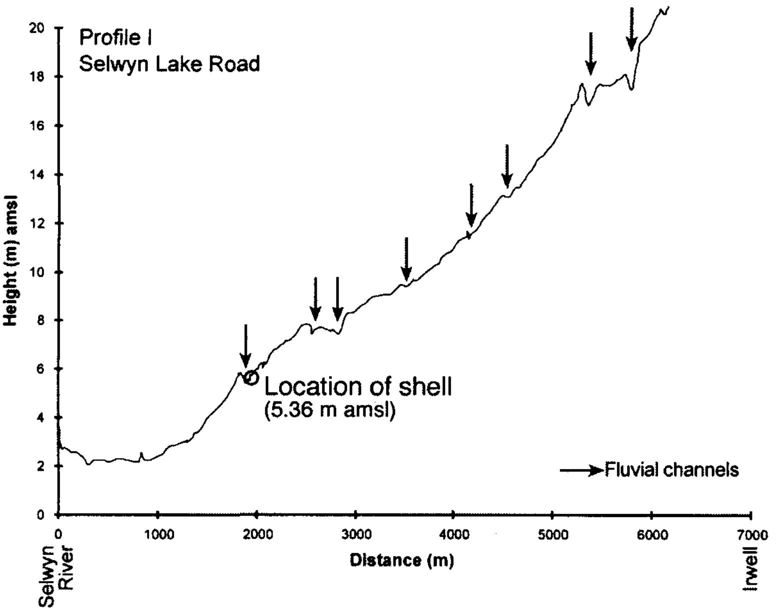

Fig. 4 Profile "I" along Selwyn Lake Road, from the Selwyn River to Irwell, Lake Ellesmere, New Zealand (from Hemmingsen 1997).

dominated this area. The Selwyn River is now channelised and the surrounding area protected by stopbanks.

DISCUSSION

These results are significant for two reasons: first, because there is no previous record of shells and shell fragments being found so far inland at Ellesmere (Speight 1930); and second, because the presence of estuarine shells indicates that the Lake Ellesmere area is likely to have been an estuarine environment as recently as 670 ± 67 years B.P.

Suggate (1958) was the first to identify estuarine conditions within the greater Ellesmere area. His study found that estuarine conditions were established as early as 9400 years ago. In later work Suggate showed that there were "major lithologic units" where the "basal beds are estuarine—silt or sandy silt with local peats, wood and estuarine shells..." (Suggate 1968 p. 294). Suggate concluded that stability of sea level in the area, in the past 5000 years, would have then been necessary before the spit that cuts off Lake Ellesmere from the Pacific Ocean could develop.

Kirk (1969) considers the present coast of the Canterbury Bight to be geologically recent. He notes that the old barrier beaches on Kaitorete Barrier standing 4–5 m above present sea level attest to a probable post-Pleistocene higher level of the sea. Armon (1974a) showed that Kaitorete Barrier is a major Holocene depositional complex, linking the spit to Banks Peninsula up to 6000 years ago. However, neither Kirk nor Armon were able to support their conclusions from dated samples.

Kirk (1994) argues that the interfan depression which is now occupied by Lake Ellesmere was a bay c. 7500–5000 years B.P. Kirk, like Suggate argued that once sea level became relatively stable, coastal features as we know them today began to develop very rapidly. Kirk states that c. 4000 B.P. the northward drift of sediments from the eroding southern coast would have resulted in the construction of a spit progressively growing in a north-easterly direction across the Bay. By c. 3000 B.P. the tip of this spit would have been close to Banks Peninsula, and the area now occupied by the lake would have been an estuary (Kirk 1994). Once the spit reached Banks Peninsula, a lake would have been impounded behind the shingle barrier. This barrier would have been breached on occasions when increased water levels built up to elevations high enough to facilitate over topping, enabling outflow to the sea across the beach ridges.

From the results presented in the present paper it would appear there has been another estuarine period at c. 670 B.P. This would indicate that a breach in the Barrier must have occurred. We know from the work of Armon (1974b) that freshwater conditions were also dominant around this time (750 years B.P.). Armon reported a date from fresh water mussel, *Hyridella menziesi* in a lake ridge at Taumutu adjacent to the south-western shore of Lake Ellesmere, having an age of 748 ± 41 years B.P. (N.Z. Fossil Number S93/500). It can be seen that Armon's date and the new date presented in this paper have overlapping error bars.

The work of Soons et al. (1997) supports the hypothesis of estuarine conditions occurring comparatively recently. They assert that such conditions have occurred some time between 1000 and 500 years B.P. The evidence presented here appears to confirm this.

CONCLUSION

The shell identification, date, and geomorphological evidence presented here adds to earlier work on changing late Holocene conditions at Lake Ellesmere. This lake has been a bay and an estuary in the past before eventually becoming a lake as stated by Kirk (1994). Soons et al. (1997) and Hemmingsen (1997) suggest that there have been at least three identifiable fluctuations between lacustrine and estuarine conditions. It would appear that the lake was at various times a freshwater lake and an estuarine environment around 750–670 B.P. Soons et al. (1997) have suggested a mechanism for breaching of the barrier that might lead to a period as an estuary. They refer to the possibility of avulsion of the Waimakariri River into the Lake Ellesmere basin at sometime between 1000 and 700 years B.P. Lake Ellesmere is likely once again to become an estuary in the future as predicted by Kirk (1994), but not because of avulsion of the Waimakariri River. Instead, breaching of Kaitorete Barrier is likely to occur because of ongoing coastal erosion from Taumutu southward, reducing the base of the mixed sand and gravel barrier.

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