Recent History of Brooklands Lagoon, Canterbury, NZ shown in Foraminifera Record

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Abstract
Foraminifera can be used to determine qualities of paleo-environments. The goal of this study was to quantify tectonic subsidence at Brooklands Lagoon, Canterbury, NZ by using the foraminifera record. A 3m core was taken from the lagoon and sampled for sediment size and foraminifera. The types of foraminifera found at the lagoon do not indicate tidal exposure, however they do have implications for salinity. The mouth of the Wamakariri River was previously near the site of the core. The conclusion is that the decrease in marine foraminifera over time is a result of the closing of this river mouth. This information can be applied to other studies to help interpret causes for changes in salinity seen in the foraminifer record.

Inroduction

Brooklands Lagoon has a tumultuous history. It lies on the eastern coast of Canterbury, New Zealand, 15km northeast of Christchurch city center (Fig.1). It is fed by the Waimakariri River which has a record of devastating floods. For decades, engineers attempted, unsuccessfully, to tame the Waimakariri River. Including trying to divert the river mouth north of Brooklands Lagoon. It wasn't until 1940 that the Waimakariri River chose its current path, abandoning Brooklands Lagoon and empting into the sea 2km north of the previous river mouth (Logan 2008). The lagoon has had two main sediment sources since 1940; the Waimakariri delivers mostly silt and the coast provides wind blown and washed in sands (Hicks and Duncan, 1993). The amount of sand in the lagoon decreased between 1977 and 2005, as the sand spit became more stable (Bolton-Ritche, 2007). Recognizable subsidence occurred at Brooklands due to the 2010, magnitude 7.1 earthquake centered roughly 45km from Brooklands Lagoon and the 2011, magnitude 6.3 earthquake centered roughly 25km away (GeoNet)

Benthic foraminifera live in the upper centimeters of underwater sediment and are sensitive to changes in conditions; therefore the types of species present have a strong indication for environment. Much research has been done to correlate species of benthic foraminifera with given environmental conditions (Hardy, 1999). Due to foraminifera's sensitivity to tidal exposure, the foraminifera record can be used to signify and even quantify subsidence due to past seismic activity. Studies have used the foraminifera record to quantify paleosubsidence – some sucesfully (Guilbault J.P. et al,1996; Hayward B.W. 2010), others not (Hawkes A.D. et al, 2009). Due to the subsidence at Brooklands Lagoon, evidence of changes in tidal exposure was expected in the foraminifera record. Alas, types of foraminifera found in this study live in large quantities at a wide range of tidal exposures, so the data is inconclusive with regards to subsidence. The data instead tells a story of decreasing salinity.

Methods
The sampling locations and methods of this study were modeled after a 2005 Environment Canterbury Technical Report of Brooklands Lagoon, the most recent survey of the area (Bolton-Ritche, 2007). The mentioned survey consisted of 7 transects, a core sample and a vegetation review. This study focuses on the core sample. A 3m core was extracted on the southwestern side of the lagoon (Fig. 1). A sand volcano made up the surface layer of the core location.

The samples were wrapped in plastic and brought back to the laboratory to be examined. After the details of the core were noted, it was visually divided into rough sections and two samples were taken from each, one for sediment review and one for foraminifera review. The foraminifera samples were floated and sorted and counted manually through microscopic observation. Sediment was run through a Micrometritics Saturn DigiSizerII, as well as visually inspected.

Hardy (1999) was used as a reference for foraminifera identification. The percentages of each species of foraminifera in each sample were put into an excel table. Species that occurred in less than three samples were grouped into *Other Brackish* and *Other Marine* categories and the data was graphed with a straight-line scatter. Figure 2 from Hardy (1999) was used to interpret the foraminifer results.

Based on sediment size, the core can be divided into 6 units.

Unit 1: 0-15cm

Fine clean sand from sand volcano, crab boreholes.

Unit 2: 15-30cm

Muddy medium silt. Crab boreholes at upper contact.

Unit 3: 30-96cm

Gradational transitions between muddy medium silt and muddy fine sand. Sandier areas contain gastropod shells and peat.

Unit 4: 96-138cm

Alternating layers of muddy medium silt with muddy fine sand, sharp contacts. Some peat. Bore holes at 120cm.

Unit 5: 138-170

Fine sand with some mud mixed, gastropod shells in sandier areas.

Unit 6: 170-300cm

Bioturbated muds and sand with general fining downward. Sandier portion from 198-202cm, does not follow general fining trend. Occasional gastropod shell fragments throughout.

The most abundant species found in the core are *Miliammina fusca* and *Ammonia parkinsoniana*. *M. fusca, a brackish water species,* dominates the upper portion of the core. Between 100-150cm the principal species transitions from *M. fusca* to *A. parkinsoniana, a salt-water species* (Fig. 3). This transition is associated with a period of alternating muds and sands. Before the transition, changes in sediment size are gradational; during the transition there are sharp changes in sediment size (Fig. 3). Other marine foraminifera appear with *A. parkinsoniana* in the lower half of the core. Omitting the top 15cm that was transported by a sand volcano, marine foraminifera are absent in the upper half of the core.

Interpretation/Discussion

The foraminifera record shows the transition of the lagoon from a more marine environment to a fresher, more brackish, environment (Fig. 2). This change is associated with a sudden increase in the percentage of sand, which gradually grades back to mud in the upper portions. The sharp increase in sand at the base of unit 5 (Fig. 3) indicates a sudden event that produced a relatively high-energy environment and a new sandy sediment source. The sharp return to mud at the base of unit 4 (Fig. 3) marks the end of the high-energy period; however the continued sharp alternation between sand and mud reveals the sand source is still available. Unit 3 (Fig. 3) shows the return to the low-energy environment that existed in unit 6 with the one crucial difference in species of foraminifera.

The closing of the old Waimakariri River mouth explains the changes seen in the core. A 1940 flood moved the Waimakariri River mouth to the north (Logan 2008), leaving an unhindered ocean current to flush sand and salt water into the lagoon. Unit 4 (Fig. 3) represents the period after the old river mouth was abandoned, but before it was closed. The point in the core where *Ammonia Parkinsoniana* no longer occurs is when the sand bar filled in the old river mouth, blocking salt water from accessing the lagoon. Wind blown sands were more prevalent for a period (unit 3) before the new section of sand bar was secured by vegetation. The closing of the river mouth is illustrated in Figure 4.

Conclusion

The original goal to quantify subsidence at Brooklands Lagoon was not met. Taking a deeper core or observing a larger number samples could have helped identify subsidence; however, considering the infrequent occurrence and low diversity of foraminifera it is improbable that subsidence could be quantified using this method. It is more likely that the suggested changes would simply provide a more detailed account of the river mouth closure that was shown in this study.

The river mouth closure has been documented through description and aerial photographs. The foraminifera record backs-up what is already known about the history of this area. It is interesting to have the opportunity to confirm the stories against each other- this is not always possible with geologic research. Because the events at Brooklands are known, the core can give some insight into how this particular event appears in the foraminifera record. This can provide insight into how foraminifera track older events with little or no other documentation.

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Figures

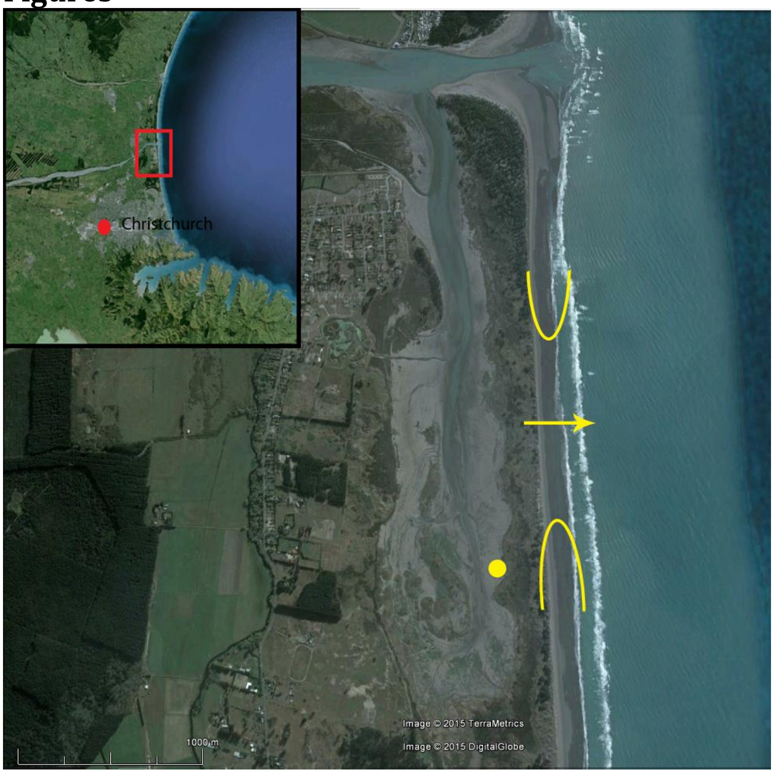


Figure 1. Satellite photo of Brooklands Lagoon (Google Earth 2015). Pre-1940 Waimakariri river mouth shown with yellow lines: location based on 1856 Map (Hills, 2002). Site of core sample marked with yellow dot.

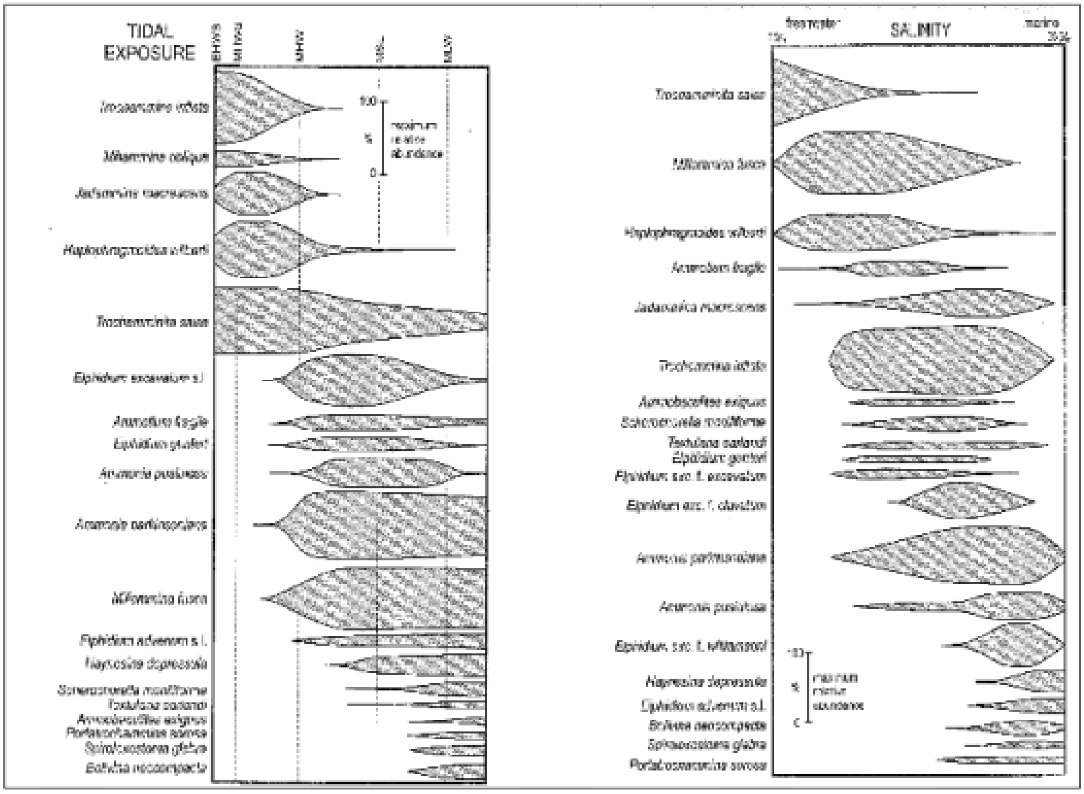
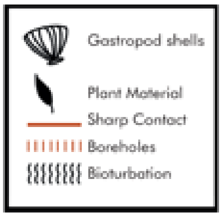


Figure 2. Tidal exposure and salinity application of foraminifera from Hardy (1999)



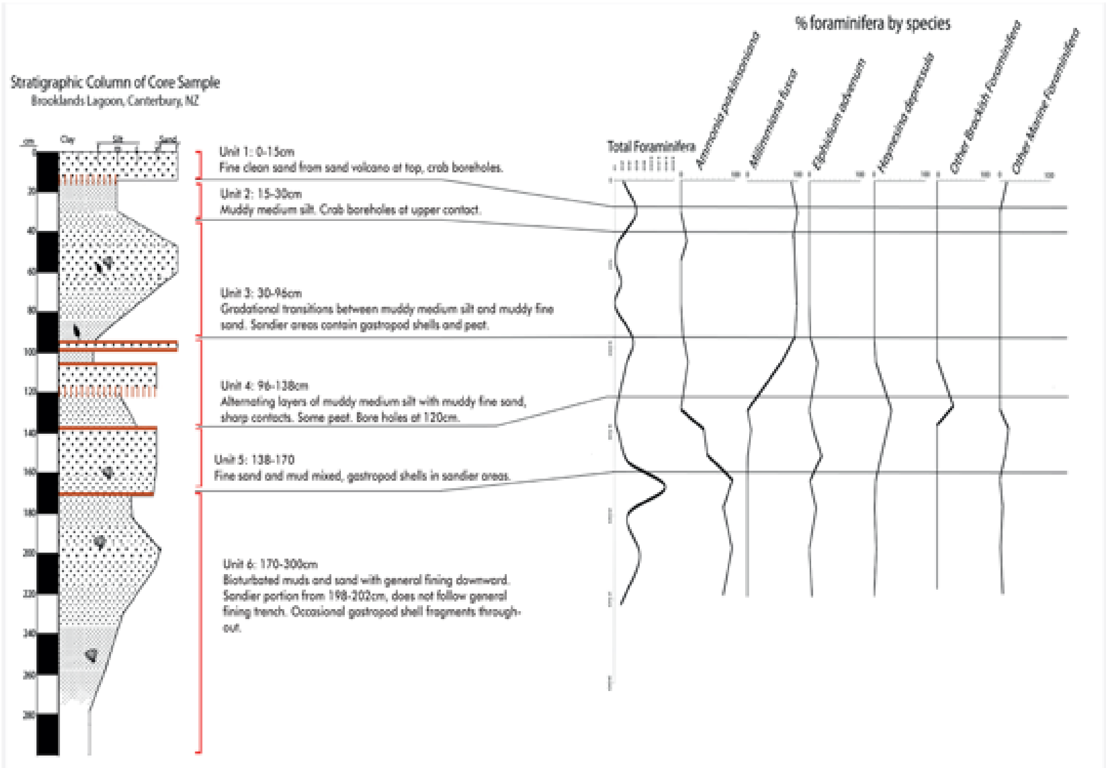


Figure 3. Stratigraphic column of core aligned with foraminifera record

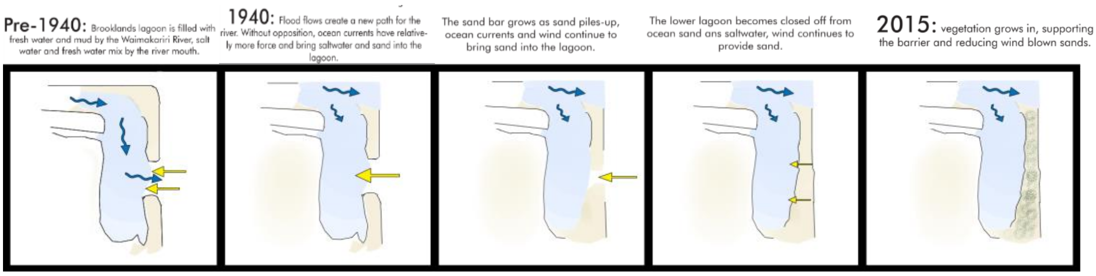


Figure 4. Animation of interpreted and known history of Brooklands Lagoon