

PALAEO-CLIMATE RESEARCH

Drilling Lake Tutira for evidence of climate change



The erosion-scarred hills surrounding Lake Tutira after Cyclone Bola 1988. (Photo: Landcare Research)

The Lake Tutira drilling group

Thanks to a multi-organisation collaborative project, Lake Tutira in Hawkes Bay is starting to give up some exciting information about climate conditions during its 7400-year history.

In this rapidly warming world, realistic assessment of how climate will change relies upon dependable records of past climate. Unfortunately, such records tend to be short. Meteorological data for New Zealand covers, at best, the last 150 years. This is far too brief a period to use for prediction, bearing in mind that climate is affected by long-term influences with time scales of decades to millennia, as well as the familiar short-term fluctuations such as the seasons and El Niño. As a result, emphasis is placed on substitute or *proxy* records of climate, in particular those captured by ice cores, tree rings and marine sediments. Each of these proxies has strengths and weaknesses. Marine sediments, for example, can take us back millions of years, but they usually lack the detail to identify annual or even decadal episodes. In contrast, tree rings represent annual effects, but the total history from trees is one to two millennia long.

Lake Tutira

Another source of detailed proxy information is the sediment contained in lakes. These deposits are Nature’s encyclopedias, containing a wealth of information including long-term climate patterns, major storms, volcanic eruptions and human influences, especially the effects of bush clearance following the colonisation of New Zealand.

Sediment deposited in Lake Tutira, 40 km north of Napier, represents a key source of information about ancient New Zealand. The small, beautiful lake was formed by a giant landslide about 7400 years ago. As the lake filled, multi-coloured layers of mud accumulated to a total thickness of around 26 m in the lake centre. In the 1990s the Landcare Research members of the Tutira drilling group used short sediment cores to highlight, for the

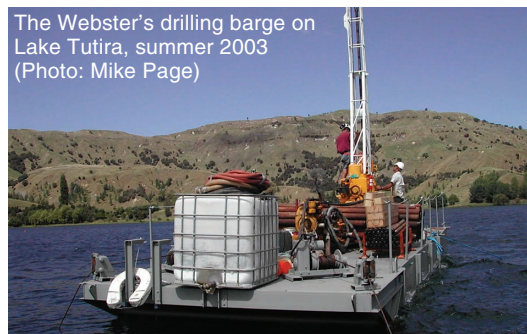
first time, the potential of these sediments to act as a window into the past. Within the cores are light-grey layers of sand and mud, which represent detritus washed in during major storms. Between storms, normal lake deposits are evident as layers of dark-brown organic-rich mud. The short cores spanned 2200 years of environmental change; the proof that the grey layers were indeed storm deposits came from a near-perfect match of the youngest layers with the rainfall measurements made at nearby Tutira sheep station, immortalised by celebrated author and naturalist H. Guthrie-Smith in his book *Tutira*.

Drilling to the lake bottom

The exciting results from that earlier study encouraged us to core the full thickness of lake deposits. Our intentions were to

- improve the quality of the core record to detect, for example, annual cycles in the normal lake deposits;
- extend the history of climate change back 7400 years to reveal how New Zealand responded to global climate signals such as the possible onset of strong El Niño–La Niña conditions about 4000 years ago;
- identify any trends in the occurrence of storms;
- evaluate long-term rainfall patterns and the reasons why;
- compare our data with a nearby marine record of past changes in the ocean to learn how the ocean affects the climate onshore;

Teachers’ resource for NCEA AS: Science 2.2, 2.5, 3.5; Geography 2.1. See www.niwa.co.nz/edu/resources



The Webster’s drilling barge on Lake Tutira, summer 2003 (Photo: Mike Page)

The Lake Tutira drilling group: Lionel Carter, Lisa Northcote (NIWA); Mike Page, Hannah Brackley (Landcare Research); Noel Trustrum (GNS); Basil Gomez (Indiana State University); Alan Palmer (Massey University).

- create a database that provides quality information for improving computer models of climate change.

In March 2003 a barge anchored in the centre of Lake Tutira. Onboard, a drill-coring system, operated by Webster’s Drilling Company, began the first trial core. As cores were retrieved, they were ferried to the onshore science group who commenced core logging – a process that involved description, sampling, photography, and measurement of magnetic and compositional properties. Three suites of cores each penetrated the full 26 m of lake sediment, but only the third was complete, having no gaps or disturbances caused by the drilling operations. Thus we obtained a continuous record of environmental change from the present back to 7400 years ago.

One feature familiar to lake swimmers is the oozy mud on the bottom. This material is about 30 cm thick, and is a corer’s nightmare. The mud slops around in the core tube, mixing layers into an indecipherable soup. This problem was resolved by using an “icebox corer” – a wedge-shaped box filled with dry ice. It is gently lowered into the soft bottom where the dry ice freezes the surrounding sediment. This solidified mass is returned to the surface with the original layering intact.



The excitement of a freshly opened core exhibiting its layered history of climatic events. (Photo: Lionel Carter)

It’s all in the timing

History is about timing and to learn how environments behaved in the past we need a reliable calendar. Fortunately, Lake Tutira is downwind of Mount Taranaki and the Taupo Volcanic Zone, the latter being one of the most active volcanic regions on Earth. Ash from major eruptions has been carried by the prevailing westerly winds to deposit in the lake as distinctive layers. Like a forensic expert

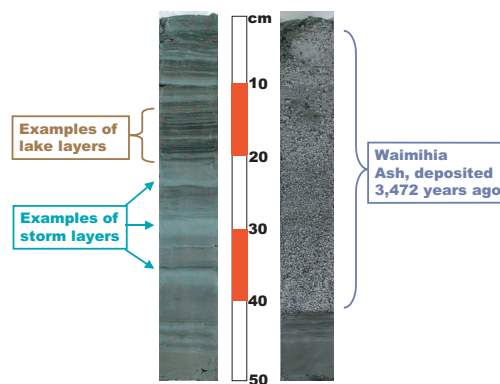
uses DNA, we use the chemical composition of the volcanic ash to identify the source of the eruption. And since times of geologically recent eruptions are generally well known, the resultant ash layer becomes a time-marker. A case in point is the 40-cm-thick layer of ash recovered from 11 m below the present lake bottom. This ash came from the Waimihia eruption of 3472 years ago, the time of the Egyptian pharaohs. To date, 12 ash time-markers have been recognised in the core, with several others awaiting identification.

We have also used radiocarbon dating on fragments of wood, in particular, large chunks at the base of the core. These chunks are from trees that inhabited the valley before the giant landslide formed Lake Tutira. Thus, their age of around 7400 years pinpoints the lake’s birth.

Finally, there is a potential annual record preserved in the layers of brown lake mud. In detail, a layer displays a gradual colour change from light to dark brown. This variation may represent an annual cycle of lake deposition, with the light brown mud forming during winter and the dark brown mud depositing in summer when production of algae and other organic matter is high. This hypothesis has yet to be tested, but if it is correct, we will be able to refine the age of the sediments by simply counting annual layers between the volcanic-ash time-markers.

“And here is the weather for 4500 BC”

Until we complete the analysis of the cores, it’s premature to produce a weather forecast (more accurately a *hindcast*) for any specific period in the past. Nevertheless, preliminary work has detected periods of frequent storms as shown by concentrations of the light-grey mud layers. Such periods may span 400 years or more and involve 40 plus storms. For instance, about 2000 years ago, 118 storms swept through Hawke Bay over a 181-year period – an average of 1 major storm per 18 months. In these climatically uncertain times, the new lake record will allow us to identify trends in storminess and rainfall to improve planning for the years ahead. ■



Storm, lake and ash layers all combine to give a past climate record of high accuracy.

Further reading

Guthrie-Smith, H. (1999). Tutira: the story of a New Zealand sheep station. University of Washington Press. 536 p.
 Page, M.J.; Trustrum, N.A.; DeRose, R.C. (1994). A high-resolution record of storm-induced erosion from lake sediments, New Zealand. *Journal of Paleolimnology* 11: 333-348.