Reprinted from: New Zealand Science Monthly 3: 8-9 (1992).

The Lore of Lakes

Mud on lake bottoms has much to tell.

By John D. Green and David J. Lowe

Studies of lakes and their many layers of silt and sediment can tell us a great deal, from centuries-old deforestation practices to the climate changes over thousands of years. The study of the history of lake ecosystems is a fast developing field known as palaeolimnology.

In the northern hemisphere, palaeolimnological studies have been used to identify general patterns of the development of lakes in many regions, and human impacts on them. These include the impacts of Roman road construction on Italian lakes, the effects of palaeolithic forest clearing and farming activities on lakes in England and the eutrophication of many lakes in Europe and North America.

New Zealand palaeolimnology has given us a greater understanding of the geological and climatological processes which have formed our landscape, as well as the effects of both Maori and European settlement on it.

This understanding is based on analysis of the sediments which accumulate over time on lake bottoms. These sediments are derived both from within the lake and from its catchment, and can hold organic compounds (lipids, pigments), or bits and pieces of plants and animals preserved in the bottom muds as microfossils.

From the surrounding catchment come various inorganic minerals eroded from rock and soil materials and deposited as sand, silt, or clay particles, chemicals leached from the soil, and organic matter from both soil and vegetation, such as humus, leaf remains and pollen. The sediments accumulate gradually and lock away information on the catchment and the lake.

The task of the palaeolimnologist is to read this record – to open the door to the past. However, to "open the door" is not an easy task, nor is the view through it when opened always clear.

Drilling into the Past

How is palaeolimnology done? Cores through the lake sediments are taken by a variety of methods. Most commonly used is a piston corer which is rammed into lake bed and which collects the sediment without it being deformed or compressed.

However, this method is not suitable for the most recently deposited sediments which are often rather sloppy and are disturbed by coring. For these, palaeolimnologists have begun to use freeze coring, in which a tube containing dry ice or liquid nitrogen is used to freeze sediments and haul them to the surface intact. This method enables very precise studies of changes in recent lake history, sometimes on a yearly or even monthly time scale.

Once obtained, the sediments are analysed by a variety of methods, involving specialists such as geoscientists, physicists, chemists, biochemists, palynologists, algologists, and various sorts of zoologists. Palaeolimnology is a perfect example of a modern multidisciplinary science.

For palaeolimnological studies to be of most use, it is necessary to determine the age of the sediments throughout the core. There are various ways of doing this. Radiocarbon dating is widely used and covers the past 50,000 years or so. Lead-210 dating is useful for dating more recent sediments deposited in the past 100-200 years, and caesium-137, originating from atmospheric testing of atomic bombs, has been used on sediments deposited over the past few decades.

A technique that has been particularly valuable in New Zealand and other volcanic countries is tephrochronology, where volcanic ash or tephra layers are used as a dating tool. The eruptions of North Island volcanoes have deposited many such tephra layers in our lakes. In some lakes, there have been up to 40 such deposits over the last 18,000 years. These provide a very detailed chronological framework for tying together lake and catchment histories in New Zealand, unsurpassed anywhere.

Another important analytical tool has been that provided by a small group of palynologists, who study fossil pollen. Pollen analysis provides essential information on past vegetation around a lake and in the surrounding region and is important for climate reconstruction.

Learning from Lakes

The earliest palaeolimnological study in New Zealand was carried out in 1955 in Canterbury's Pyramid Valley and since then many lake sediments have been analysed for their microfossils, pollen, plant material and geophysical changes.

The New Zealand Oceanographic Institute has studied the patterns, mechanisms and rates of sedimentation in many of the larger glacial lakes such as Wakatipu, Tekapo, Ohau, and Te Anau. The lakes have been found to be giant sediment traps for material eroded from the Southern Alps. As yet, however, there is little information on the chemical and biological history of these lakes, which are difficult to core, primarily because of their great depths and thick sediments.

In the North Island, a major focus of palaeolimnological interest has been Lake Poukawa, a small peaty lake in Hawke's Bay, near Napier. Scientists from Victoria University have found that local deforestation caused by Polynesian and European settlement had marked affects on the lake's algal communities. They were also able to demonstrate that the abundance of various microscopic diatoms increased following the deposition of tephra layers in the lake, because of the latter's fertilizing effect.

Further north, in the small landslide lake of Tutira, freeze-coring studies have been used to show changes in erosion rates in relation to land use in the catchment area.

The lakes in the central volcanic region have also attracted attention. In Lake Rotorua, diatoms and pigment stratigraphy for the period since the 1886 Tarawera eruption have been studied. Sediment nutrient levels have also been investigated in an attempt to determine if these showed any changes in association with eutrophication of the lake. A detailed history of lake level changes in Lake Rotorua over the past 140,000 years has been worked out using evidence provided by ancient shorelines dated by tephrochronology.

At Waikato University, palaeolimnological studies initially focused on a number of the small peaty riverine lakes in the Waikato region that have turned out to be palaeolimnological gold mines. This is because many of them are as old as 18,000 years, a period spanning the major climatic changes between the end of the last glaciation and the warmer climates of the last 10,000 years, and because the sediments contain many tephra layers that enable changes from lake to lake to be matched in time.

Dozens of cores have been taken from 14 lakes, and a very detailed study of the origins and development of one of them, Lake Maratoto, has been made. Studies of pollen records have enabled changes in the vegetation and climate across the region to be reconstructed. These, together with various chemical and microfossil studies, have allowed a synthesis of both catchment and lake level changes in relationship to climate change.

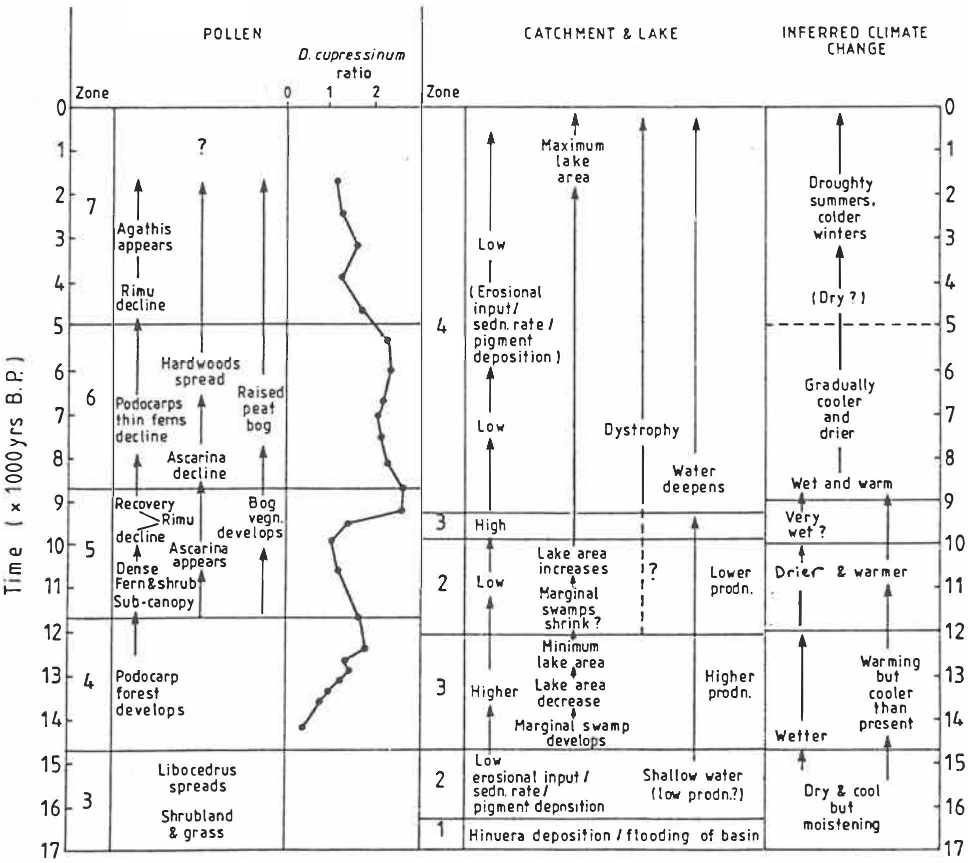
In addition to studies dealing with relatively long time spans, freeze-coring techniques are to be used for detailed studies of the impact that Polynesian and European colonisation has had on lake ecosystems in the northern North Island. Previous work has indicated that Polynesian settlers had a dramatic effect on the vegetation in the Waikato region from about 800 years ago.

International teams have worked on lake studies in New Zealand and abroad. A joint New Zealand-Japan project is under way at Lake Omapere near Kaikohe, and is providing tantalising glimpses of past environments in the area extending back perhaps 100,000 years. The lake has appeared and disappeared a number of times during this period and has probably always been rather shallow and weedy as it is today.

Palaeolimnology is an exciting and rapidly growing discipline and studies on New Zealand lakes have the potential to make a real contribution to its development. Palaeolimnologists now have their own journal and regular specialist international conferences.

The 6th International Conference on Palaeolimnology, in Canberra next April, has a proposed New Zealand field trip. It is hoped that this, the first such conference to be held in the southern hemisphere, will help to stimulate further the development of palaeolimnology in this country.

John D. Green and David J. Lowe are members of the School of Science and Technology at Waikato University.



This represents a summary of the palaeoenvironmental changes which happened in and around Lake Maratoto, near Hamilton, from when it first formed around 17,000 years ago to the present day.
Shrubland and grass covered the area when the basin was first flooded. As the climate got wetter, swampland developed and water-loving vegetation is recorded.
Increases in the fossil pollen ratio of *D. cupressinum*, better known as rimu, indicate a wetter climate more suitable for the growth of that tree species.
As the climate dried out, the pollen ratio dropped, indicating a decline in rimu and kauri pollen is detected.
Erosion and sedimentation rates tell palaeolimnologists about how the lake itself changed over time.
Other studies of the microfossil populations in the lake's sediments also provide information about lake levels.
Combining all this information gives researchers a reasonably accurate picture of climate and vegetation changes over thousands of years.