Lake George (Salt Lake) Continues to Reveal New Insights on Past Climates and Rare Algal Species

Jaime L. Toney, Geological Sciences, Brown University, RI

Similar to using fossil dinosaurs bones to piece together information about the environment during the Jurassic era, much smaller, molecular fossils in the sediments of Lake George, Streeter, ND have led to the discovery of new information regarding environmental and climate changes over the past 10,000 years.

Molecular fossils known as long-chain alkenones are organic lipids that are only produced by algal species belonging to the division Haptophyta. By sequencing ribosomal DNA from Lake George sediments, we have recently discovered that Lake George is home to two living species of haptophytes. One of these species, *Chrysotila lamellosa* (Figure 1), has been reported from lakes and marginal marine environments; whereas, a new species has been identified that is unique to Lake George and is genetically similar to haptophytes that are found only in Ace Lake, Antarctica. We have now been able to grow both of these algal species under culture conditions and confirm the temperature dependency of the alkenones

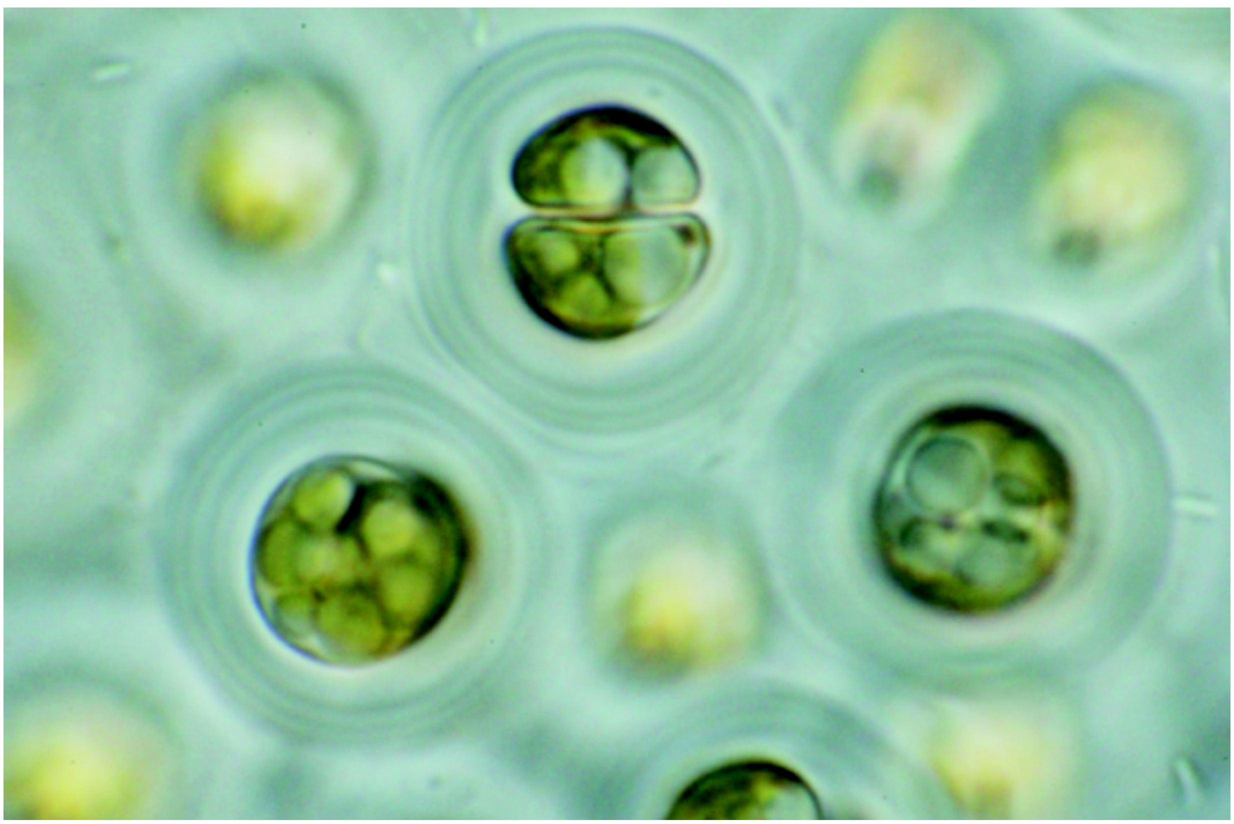

Figure 1. Haptophyte algae, *Chrysotila lamellosa*, from Lake George cultures. (Isolated by Bob Andersen, Professor Emeritus – Michigan Technical University).

that they produce. This is the first time that anyone has been able to culture this new elusive, lacustrine haptophyte species and get it to produce alkenones in the lab.

Analysis of modern samples collected by Paul Nyren and Rick Bohn from the Central Grasslands Research Extension Center has allowed us to gain information about the ecology of these unique algae. This knowledge allows us to interpret the molecular fossil record in a 13-meter long sediment core from Lake George. The record shows that the long-term trend in spring temperature is controlled by the precession of the Earth's orbit around the sun, which created shorter and cooler springs from about 10,000 to 5,000 years ago. These cool spring temperatures show similarities to changes in the North Atlantic Deep Water formation and the effects of the waning of the Laurentide ice sheet. After about 5,000 years ago, the shorter-term, centennial-scale changes in spring temperature match both sea surface temperature and hydrologic changes in the tropical Pacific Ocean. These results imply that at 5,000 years ago a major change occurred in climate boundary conditions, before which the Laurentide Ice Sheet and the North Atlantic region forced regional spring temperature, after which there has been a much stronger connection to the tropical Pacific Ocean.

Another molecular fossil that contains a wealth of information is the hydrogen-isotope composition of leaf waxes that are deposited in lake sediments. Comparing the leaf wax molecular fossils with the instrumental record from Jamestown, ND, we are able to detect the amount of growing season rainfall in the Northern Great Plains. We have now reconstructed the rainfall proxy at high-resolution over the past 10,000 years, and this new proxy from Lake George, ND and Kettle Lake, Williams County, ND (Figure 2) leads to three important conclusions: (1) seasonal variations in rainfall are crucial for deciphering the balance between precipitation and evaporation and show that not all summer rainfall deficits lead to severe drought conditions (for example, a rainfall deficit can be buffered by moisture in the subsurface aquifer), and persistent droughts can occur without an accompanying summer rainfall deficit (for example, if they are forced by evaporation due to high temperatures); (2) The spatial pattern of severe rainfall deficits in the Northern Great Plains corresponds with increased freshening of the source region, the Gulf of Mexico, with rainfall constrained to a more southerly position; (3) rainfall in the Northern Great Plains appears to be linked to the entire climate system through a chain of events. Drought periods in the Northern Great Plains coincide with changes in the El Niño/Southern Oscillation region of the tropical Pacific Ocean that cause increased hurricane formation in the North Atlantic via atmospheric connections. Increased hurricane formation leads to freshening of the Gulf of Mexico, which reduces ocean circulation and leads to cool conditions in Greenland. During all of the major drought periods over the past 10,000 years, we see evidence for this chain of events. While we better understand these global connections, another major conclusion of this work is that droughts with the severity and persistence of the 1930s Dust Bowl Drought were not as frequent as suggested by previous studies and are, in fact, relatively rare events.

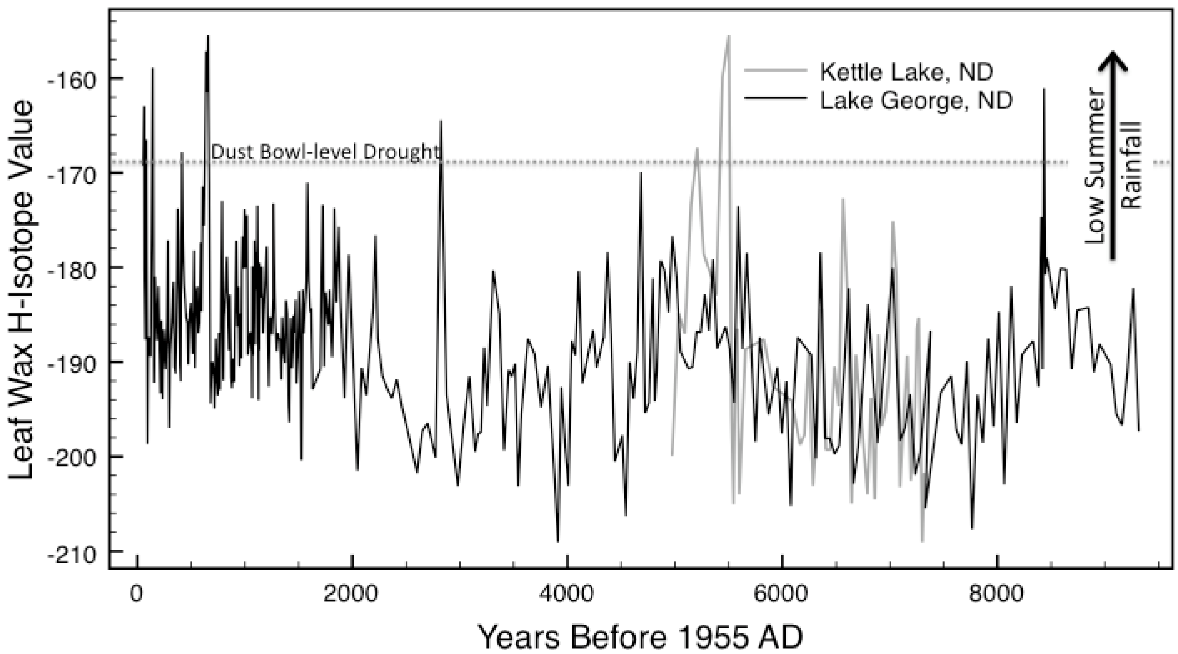

Figure 2. Summer Rainfall Reconstruction from Lake George (black) and Kettle Lake (gray).