Lake George and Its Geological History during the Last ~10,000 Years

Sheri Fritz, Department of Earth and Atmospheric Sciences, University of Nebraska – Lincoln

Our team of scientists from University of Nebraska – Lincoln, Duke University, Illinois State Museum, and Brown University continue to collaborate with Rick Bohn and Paul Nyren of Central Grasslands Research Extension Center - NDSU in a study of Lake George (also known as Salt Lake) near Streeter, North Dakota. Cores of lake sediment collected in February of 2009 are being analyzed for a variety of biological fossils and geochemical variables in order to reconstruct the history of the lake and surrounding region. We are interested in the long-term dynamics of climate and landscape, both to understand how the earth system works at time scales of decades to millennia and to provide a context for evaluating the magnitude of human impacts on the environment. Reconstructing the history of variation of lake-level and related variables will allow us to better understand long-term patterns of drought and its causes. Funding for this project is provided by the U.S. National Science Foundation.

Lake George is unusual among North Dakota's natural lakes because of its great depth (more than 150 feet deep) and its high salt content, presently about a third the salinity of seawater. The thrusting of ice by retreating glaciers at the end of the last ice age formed the lake more than 12,000 years ago. Because the lake is so deep, it has not dried up during major droughts of the past and has a continuous record of environmental change preserved in the layers of sediments. In contrast, many of the shallower regional lakes have dried at various times, and parts of the sediment record have been lost by erosion and deflation.

In August 2011, Paul Baker from Duke University and I conducted a seismic survey of the lake sediments, a technique that sends sound energy waves through the lake water and into the lake sediment. Different layers or types of material in the sediments differentially reflect the wave energy, and that reflected energy is measured to generate an image of the layers of sediment (see Figure 1). Seismic surveys can show the thickness of the sediment and its structure, as well as submerged features on the lake bottom, such as terraces that are indicative of former shorelines.

At Lake George, we found more than 30 m (~100 feet) of mud below the lake floor in deep water areas and saw evidence of small sub-surface deltas and terraces. Much of the basal layer of sediment was probably deposited during glacier retreat just after the lake was formed in massive flows of meltwater. This is overlain by material produced in the lake itself and material eroded into the lake from the surrounding watershed. Also apparent in the seismic

images is a dense hard layer that may reflect a period of substantial lake level-lowering caused by drought about 9000 years ago. In the coming months, we will be combining the images generated from the seismic survey with data from long cores of lake sediment retrieved from the lake bottom in 2009 to reconstruct the climate history of the region over the last ~10,000 years.

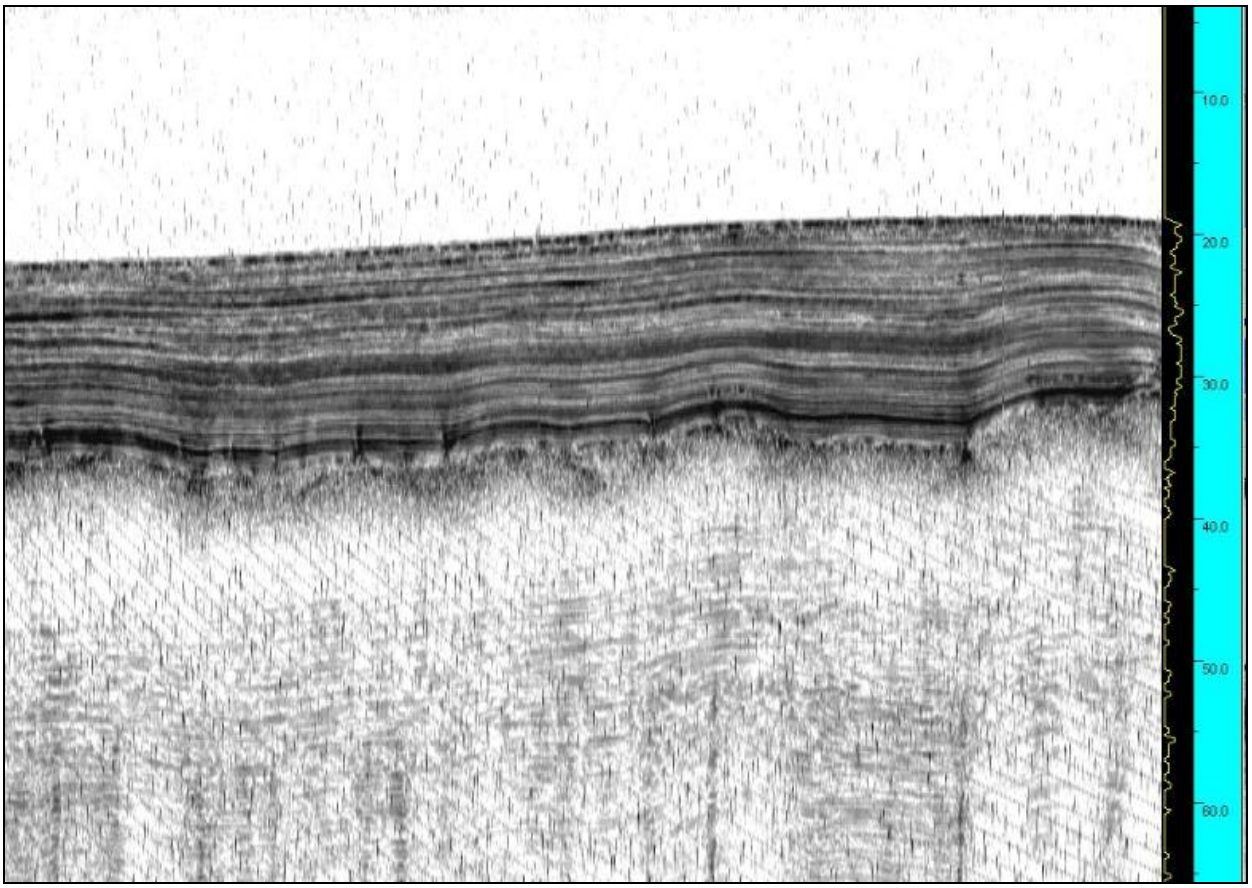

Figure 1. A seismic image of the sediments in 20 meters (66 feet) of water depth showing the layer-cake structure of the muds in moderately deep water. The layered sediment is about 10 meters (32 feet) thick.

At the time of the seismic survey, we also completed a temperature and chemical profile of the lake's waters. The lake was thermally stratified, with surface water temperatures of 23^{o} C (73^{o} F) and temperatures in the bottom waters of just above freezing. The unusually high salinity of Lake George likely occurs because the deep lake basin intersects deep saline sources of groundwater that do not feed the local shallower lakes. The salinity of inflowing groundwater is then modified by climate over time, as salts are concentrated by evaporation and diluted by precipitation.

We have sampled Lake George intermittently for more than 25 years. During the drought years of the late 1980s, the salinity of the lake's surface waters was more than 20 grams per liter (g L^{-1}), whereas the current salinity of the surface waters is 9 g L^{-1}, reflecting the wetter conditions of recent times. (The salinity of the oceans ranges from approximately 31 to 38 g L^{-1}, depending on location.) In Lake George, the dominant salt is sodium sulfate (Na_2SO_4), whereas the oceans are dominated by sodium chloride (NaCl).

The high salinity and the specific chemical composition of the lake water enable an unusual group of salt-loving microscopic algae (haptophytes) to grow in the lake. These algae contain temperature-sensitive lipids, and we are exploring the relationship of these lipids preserved in lake sediments to the long-term history of regional temperature.

CGREC Annual Report- December 2011

Panoramic photo by Rick Bohn