Disappearing and Flooding Prairie Lakes: Solving an Aquatic Whodunnit
Progress Report, December, 2008

Assessment of past changes in hydrological and limnological conditions within the northern Great Plains region of western Canada have been initiated at four lakes: Manito Lake (55°44'57"N; 109°42'30"W), Antelope Lake (50°16'20"N; 108°23'42"W), Waldsea Lake (52°16'25"N; 105°12'05"W), and Deadmoose Lake (52°18'23"N; 105°09'55"W).

Field and Laboratory Work

Field work began on this project in the spring of 2008 and continued through the summer months. Laboratory analyses of samples collected from the field efforts were begun immediately upon their arrival at University of Manitoba. A total of approximately six weeks of field work took place during the March-August period, during which each lake was visited and water and sediment samples were collected. On-site measured limnological data included lake level elevation, lake water temperature, pH, conductivity, and salinity. In addition, shoreline and strandline mapping was conducted in Manito and Antelope basins. A set of water samples was taken for subsequent analysis of oxygen and hydrogen isotope composition, major ions, and selected nutrients and trace elements. Water samples for stable isotope composition have been sent to Queen's Facility for Isotope Research. Samples for analysis of major ions and nutrients were stored at 4°C and sent to ALS Laboratory Group. Sub-samples of sediment were sent to Keck-CCAMS Group and Beta Analytic for radiometric age dating and to Queen's Facility for Isotope Research and Isotech Labs for stable carbon and oxygen isotope analyses. All other physical, mineralogical, petrographic, and geochemical analyses on the sediment collected are currently underway at University of Manitoba. In addition, historical data on water levels and groundwater hydrology have been collected. Analyses have begun on archival core material from three of the basins.

Preliminary findings, based on our field and laboratory data obtained to date, have been summarized in the following conference presentations and publications:

Ginn, F.M. and Last, W.M**.** 2008. Late Holocene Ikaite Pseudomorphs in a Saline Lake in the Northern Great Plains, Canada. Geological Society of America Abstracts with Programs. 40(6):399.

Last, W.M**.** and Ginn, F.M. 2008. A new location of modern lacustrine dolomite formation: Manito Lake, Saskatchewan, Canada. Geological Society of America Abstracts with Programs. 40(6):481.

Last, W. M. and Ginn, F. M., 2008. Modern and Late Holocene Dolomite in Lakes of the Northern Great Plains of Canada. Submitted, American Association of Petroleum Geologists Annual Meeting.

Ginn, F. M., Last, W. M., Fayek, M., and Halden, N. M. 2008 Occurrence and significance of a cold water carbonate pseudomorph in microbialites from a saline lake. Submitted Nature Geoscience.

Ginn, F. M., and Last, W. M., 2008. Carbonate microbialites and hardgrounds from Manito Lake, an alkaline, hypersaline lake in the northern Great Plains of Canada. Sedimentary Geology (in preparation).

Key preliminary results relative to this project include:

Manito Lake is alkaline (pH = 9.9) and presently saline, with about 40-50 ppt total dissolved solids (TDS). This salinity is dominated by Na^+, Mg^+, and SO_4^{2-} ions. Our detailed examination of the historical data shows, as expected, the salinity levels have increased concomitant with the dramatic decrease in lake level and volume over the past few decades. The current salinity is about 160% higher than that of the 1920's. Projections, using rates of water level decline over the past decade, indicate the lake will form four isolated basins by 2010.

Manito Lake microbialites offer an exceptional record of past water level, hydrology, and limnological conditions in the basin. Although the mineralogy of these laminated microbialites is exceedingly complex (comprising dolomite, aragonite, calcite, Mg-calcite, monohydrocalcite), this 2000 year long biomediated inorganic sediment records ~1500 years of cold, wet conditions with gradually increasing water levels, followed by 250 years of relatively stable lake levels prior to the most recent dramatic water level drops which began in the late 1920's.

Antelope Lake, also a relatively large, closed-basin saline lake located on the eastern margin of the Great Sand Hills area, has, similarly experienced a dramatic decrease in lake level over the past three decades. Since the mid-1970's levels have steadily decreased, with concomitant increase in salinity from less than 10 ppt to over 30 ppt. Currently the lake water is strongly supersaturated with respect to aragonite and protodolomite and slightly undersaturated with respect to gypsum. A preliminary ^{210}Pb chronology, combined with the historical hydrochemical and hydrologic information and detailed sediment composition, emphasize the complex interrelationships that exist between water level, salinity, endogenic mineral saturation and precipitation in even a relatively simple saline lake.

Work has just begun on Waldsea and Deadmoose lakes, two deep saline lakes that are experiencing anomalously high water levels similar to numerous other basins in central Saskatchewan. Preliminary examination of the most recent stratigraphic records in these closed basin lakes shows alternating laminae of finely crystalline aragonite, black, organic-rich muds and coarser layers of silt and sand. Crystal size and sorting, grain size and mineralogy are being examined in order to help reconstruct water level histories over the past several millennia.

In summary, the first nine months of work on this two year project has been very rewarding. The status of the project relative to the **specific objectives** listed in the proposal is as follows:

Specific Object 1: Retrieve sediment cores from the offshore basinal areas of Manito, Antelope, Waldsea, and Deadmoose lakes: **30% completed;** most of the offshore coring and sample acquisition will take place during the winter of 2009-2010.

Specific Objective 2: Acquire samples from carbonate microbialites, bioherms, and tufas from Manito Lake: **Completed**

Specific Objective 3: Establish a recent sediment chronology for the core and microbilite/tufa samples that allows differentiation of pre-settlement from post-settlement deposits: **Completed for the microbialites**

Specific Objective 4: Delineate and map any geomorphological and shoreline indicators of high water stands in each basin: **80% completed**

Specific Objective 5: Evaluate long-term (1500-2000 years) fluctuations in texture, petrography, bedding and sedimentary structures, mineralogy, organic content, and sediment and pore water geochemistry, and interpret these changes with respect to hydrologic and limnological fluctuations in the basins: **30% completed**

Specific Objective 6: Examine the periodicity of stratigraphic and geomorphic/shoreline changes and relate any changes to causal mechanisms, such as climatic variation or changes in drainage basin characteristics: **30% completed**

Specific Objective 7: Assess any recent, short-term (~100 years) changes in the sedimentary and geochemical parameters and attempt to relate these to changing land use characteristics and/or specific human events: **30% completed**

Specific Objective 8: Together with data and results from other paleolimnological investigations in the region, examine any regional pattern in the changes in these sediment histories, and relate these changes to either natural factors, such as climate, hydrology or geology, or to anthropogenic environmental modifications. **Will begin after core analyses are completed.**

Partner Involvement

Both partners will assume major rolls in the second part of the first year of the project and throughout the second year. Core materials that are archived with Natural Resources Canada will be subsampled during 2009. Sample and data collection from Waldsea and Deadmoose lakes will be carried out in 2009 in conjunction with Dr. Davies (Saskatchewan Watershed Authority).