Final Report: New Mexico NSF EPSCoR Infrastructure Seed Grant Program

Proposal Title: Late Pleistocene to Holocene Paleoclimate of the Las Vegas National Wildlife Refuge and Adjacent Great Plains, northern New Mexico: A Multidisciplinary Science Educational Endeavor

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ABSTRACT
We present the preliminary results from an integrated, paleoclimatic study of sediment cores collected from the Las Vegas National Wildlife Refuge (LVNWR) and surrounding region that bear on the late Pleistocene to Holocene paleoclimatic variations in northeastern NM. We collected sedimentologic, midge fossil, and rock magnetic data from sediment cores to characterize the materials, identify stratigraphic changes, document shifting lake levels, assess temperature changes, and infer paleoclimate conditions. Data from McAllister and Wallace Lake are encouraging and reveal depth dependent changes in fossil assemblages, grain size, and rock magnetic properties that we interpret to reflect climatic driven variations impacting the depositional system. We recognize three different types of chironomid subfamilies (Chironomini, Tanypodinae, and Orthocladiinae). Based on the fossil results, the water has been warm in the most recent years. Grain size distribution from the lower to upper core levels reveal that the amount of fine sand-sized sediment (0.125 mm diameter) increases while the amount of medium (1.25) to coarse (0.50) sand-sized sediment decreases implying that there may have been a reduction in stream energy and hence precipitation over the time period represented by the core. Bulk low-field magnetic susceptibility decreases by an order of magnitude from the surface to the base of the measured core suggesting a change in detrital magnetic influx into the lacustrian system. Curie point estimates indicate that the dominant magnetic mineral in all samples is cubic, low-Ti titanomagnetite phase. We postulate that concurrent with alpine glacial activity during the Pleistocene, the LVNMWR and the transitional Great Plains region to the northeast was an expansive single lake or interconnected lake system, analogous to the Pleistocene lakes of the Estancia Basin (Lake Estancia) and the Tularosa Basin (Lake Otero) of central and southern NM. Following the end of glacial activity, these lacustrian systems shrank to their current condition of minor low-volume isolated lakes and numerous playas and pluvial bodies. We hypothesize that sediment from the LVNMWR and surrounding playas contain an invaluable and untapped record of late Pleistocene to Holocene climatic change.

INTRODUCTION
The Las Vegas National Wildlife Refuge is home to a variety of marshes, wetlands, ponds, and especially lakes. While the available habitats alone make it interesting, what is more fascinating is that these hydrologic features are present in an area located between three very differing regions. The refuge sits on the edge of the Great Plains that extend to the east, with the Rocky Mountains lining the landscape to the west, and the Chihuahuan desert occupying the area to the

south. The surrounding environments show no obvious evidence to the origin of this lake system. Satellite imaging of the region reveals that there are a number of intermixed active lakes and potentially playa lakes scattered in a southwest to northwest trend. These are predicted to be remnants of a former extensive lake or lake system that may have been present during the late Pleistocene to early Holocene time periods. This study is collecting sediment core samples from the remnant lake bottoms. The samples are being analyzed to determine the mineral composition, the depositional system involved, the climate alteration of the area during deposition, the source of the deposits, the relative age of the deposits, and the magnetic susceptibility and fluctuation of the samples. From these data we aim to determine the past climate of the surrounding area and how it has changed from the time period studied until present.

DATA COLLECTION METHODS

Sediment core samples were taken using a Livingstone-type drive rod piston corer. These samples were taken from Wallace Lake, one of the many small lakes located on the Las Vegas National Wildlife Refuge. This lake was muddy beneath the surface but dry on most of the surface at the time of collection. Multiple cores were retrieved in a variety of locations around the center of the depression. Each core was examined in the field, and all observations were recorded, including GPS coordinates, color, and length. These samples were then returned to the lab to be divided into 4 equally sized cores and stored in the cold room until further analysis was done. Each quarter was designated for sediment analysis, magnetic analysis, biological analysis, or as a back-up sample.

RESULTS

Rock Magnetism

Rock magnetic experiments were conducted to identify variations in type and concentration of magnetic phases present within the lacustrian sediments. Experiments include Curie point estimates, Lowrie-Fuller test, susceptibility studies, IRM acquisition, and low-temperature studies. Preliminary results indicate a change in the bulk concentration of magnetic phases (susceptibility) present with depth, a change in magnetic grain size, and that (titano) magnetite is the dominant magnetic mineral phase.

Midge Fossils

In a very general sense the midge larvae (chironomid) taxa that belong to the families: Diamesinae, Orthocladiinae, and Tanypodinae are considered cold water species and taxa that belong to the family and tribes of chironominae, tanytarsini, and chironomini respectively, are considered warm water species. Proportions of fossilized head capsules taken and identified from 2.2cm thick increments had representatives from all the families and tribes mentioned above. Warm water families dominated in the core archive. There are no specific trends in increasing or decreasing temperature.At this level (family and subfamily) of taxonomic identification of midge fossilized head capsules, we discern no cooling or warming patterns from the data. However, fossilized head capsules are still being identified to the species level which is more sensitive to climate change. Core subsections 2.2-4.4cm, 6.6-8.8cm, 19.8-22cm in which no fossilized head capsules were found may indicate that Wallace Lake was dry during those depositional intervals.

Sedimentology

The sediments were further analyzed for grain size and grain type. On the cut faces, observations were recorded about the samples average grain size, color, length, reaction to acid, and overall descriptions. The cores contained major quartz, gypsum, and calcium carbonate. The core was divided into 4.4 cm sections. Each subsection underwent wet sieving in order to determine the particle size distributions. Two cores from Wallace Lake show unimodal grain size variation indicating that the sediment is very well sorted. The negative skewness illustrates that the majority of sediment measured less than 0.625 mm in diameter (medium-sized silt or finer). The very fine grain size suggests that the sediments were deposited in a low energy, quiet water environment typical of a lacustrine depositional setting. No stratigraphic variation was observed in the grain size distribution, sorting, and skewness. This suggests that paleotopography, paleoslope, and paleoclimate were unchanging during the depositional history recorded by the Wallace Lake cores. Note that the core was not analyzed for clay mineralogy, which is a better proxy for climate conditions than grain size.

CONCLUSION

The magnetic characteristics of the core sample shows a change in the bulk susceptibility with depth, a change in magnetic grain size, and a dominance of magnetite in the magnetic mineral phase. We tentatively interpret these data to indicate that the depositional basin received systematic changes in detrital input into the system. This may reflect a change in sediment source or an evolving fluvial system that impacted the lacustrian environment. Both cold water and warm water midge larvae taxa occur throughout the Wallace Lake cores. Warm water families dominate in the depositional time recorded by the cores. We discern no cooling or warming patterns from the data. Core subsections 2.2-4.4cm, 6.6-8.8cm, 19.8-22cm in which no fossilized head capsules were found may indicate that Wallace Lake was dry during those depositional intervals. The Wallace Lake cores are composed predominantly of fine (≤medium-sized silt). Grain size did not vary during the core record. No stratigraphic variation was observed in the grain size distribution, sorting, and skewness. This suggests that paleotopography, paleoslope, and paleoclimate were unchanging during the depositional history recorded by the Wallace Lake cores.

EQUIPMENT PURCHASED

- Research Grade Compound Microscope Meiji MT4300H Series with an INFINITY1-5 digital camera and adapter ($5,000)
- Livingstone Piston and Griffith Corer ($4094):
- Four Garmin GPS CSx60 ($900)
- Sample boxes 300 @ $135/100 boxes ($405):
- Liquid Helium and Nitrogen ($1000)
- Miscellaneous PVC Pipes, tape, and plastic ($500):
- Other expendable laboratory chemicals and supplies such as microscope slides and mounting medium for midge analyses ($500); thin sections (20 @ $25/section) ($500)
- Replacement Sample Handlers for the JR6 and MFK-1 ($714):
- ^{14}C radiometric age determinations of sediment core samples (4 dates @ $375).

PUBLICATIONS

Cedillo, D.N., *A.R. Brister, *C.A. LoPresti, *M. Maldonado, *R.M. Pitrucha, *C. West, E. Martinez, J. Lindline, M.S. Petronis, 2011, Preliminary Results from a Late Pleistocene to Holocene Paleoclimate Study of the Lake Sediment Cores, Northern New Mexico, GP51B-1170, presented at 2011 Fall Meeting, AGU, San Francisco, CA

Brister, A., Cedillo, D., Petronis, M.S., Lindline, J., Martinez, E., 2012, Preliminary Results from a Late Pleistocene to Holocene Paleoclimate Revealed from Study of the Lake Sediment Cores, west of Las Vegas, Northern New Mexico, New Mexico Geological Society Spring 2012 meeting, Socorro, NM

Juarez, R., C. West, B. Gonzales, E.A. Martinez, 2012, Paleolimnological Study of Sediment Cores: Using Chironomid Head Capsules to Determine Past Climate Events. Poster presentation at the 9th Annual Research Day, New Mexico Highlands University, April, 2012

NAMES, DEGREES, AND DEMOGRAPHIC INFORMATION FOR ANY STUDENTS SUPPORTED BY THIS AWARD

- Cedillo, D.N., Hispanic American, Environmental Geology B.S. May 2012
- A.R. Brister, White American, Environmental Geology B.S. December 2012
- C.A. LoPresti, Hispanic American, Environmental Geology B.S. candidate
- M. Maldonado, Hispanic American, Environmental Geology B.S. candidate
- R.M. Pitrucha, White American, Environmental Geology B.S. December 2012
- C. West, White American, Environmental Geology B.S. candidate
- W. Jaremko Wright, White American, Forestry B.S. May 2011
- A.R. Juarez, Hispanic American, Forestry B.S. candidate
- T.E. Bogert, White American, Environmental Geology B.S. candidate
- B. Gonzalez, Hispanic American, Forestry B.S. candidate