CSUB San Joaquin Valley Paleoriver Discharge Record: Grain-Size Proxy

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Executive Summary

California State University, Bakersfield is in the process of acquiring a record of Sierran River discharge into the southern San Joaquin Valley that will cover the past 18,000 years. By analyzing physical and geochemical proxies from the Tulare Lake TL05 Core at 1 cm intervals we may be able to construct a record that will attain decadal-scale resolution and will lead to improved forecasting for Sierran discharge over the next

several decades after this record is compared to continually advancing coeval records of sea-surface temperatures of the Pacific Ocean.

Prior to diversion of stream flow for the purpose of irrigation, Tulare Lake was the largest fresh water lake west of the Great Lakes (Preston, 1981). At that time, its lake level was linearly related to the discharge of four Sierran streams: Kern, Tule, Kaweah, and Kings Rivers (Atwater et al., 1986). This relationship is the basis for reconstructing the discharge of these rivers through time by locating and dating the past surface elevations of Tulare Lake. This research is building off the prior research conducted in Negrini et. al. (2006) article "The Rambla highstand shoreline and the Holocene lake-level history of Tulare Lake, California, USA" which displayed a low resolution record of lake-level history based on sediment descriptions and sample analysis associated with trenches taken close to the Tulare Lake highstand shoreline. The grain size and sand percentage data acquired in this research along with other geochemical and geophysical proxies will be crucial in better reconstructing past lake levels for Tulare Lake.

Project Objectives

For the 2012-2013 internship period, the CSU Bakersfield USDA interns, including myself, were asked to continue data collection for the research we were conducting on the Tulare Lake cores the previous year. During the previous year, interns were asked to assist in acquiring geochemical (e.g., inorganic carbon content and carbon/nitrogen ratios) and geophysical (grain-size) data on the Tulare lake sediments in the TL05-4A core, of which the geophysical data being the primary focus for my research. This year, I

continued to collect grain-size distribution (e.g., median grain size and sand percentage) on the Tulare Lake sediments. My main objective was to fill in the missing gaps that resulted in the previous year's research by sampling from a different core (TL05-4B), which correlates with the previous core analyzed (TL05-4A). Some re-sampling of the TL05-4A core was required. The data collected during this research internship gave a more continuous record of lake history and it will be used as one of the proxies to determine past lake-levels for Tulare Lake.

As for potential career pathways, my experience during the USDA internship in the Geology Department of California State University, Bakersfield has been very influential and positive in all regards. This internship has also helped me prepare for a potential career for the USDA as a geologist. Being a second year intern, working under this project definitely sparked my interests in continuing to work with environmentally and regionally important research projects. As for the immediate future, I plan on continuing my work with either Tulare Lake or another lacustrine environment. My involvement in this research is personally satisfying because I know that my contribution will assist in the future decision-making in regards to the water-shed management in the San Joaquin Valley, especially those areas than are greatly dependent on the Southern Sierran stream run-offs.

Project Approach

During the internship, I acquired physical grain-size measurements, via laser particle size analysis, using the Malvern Mastersizer 2000. Samples underwent pre-analysis preparation before grain size analysis. Samples analyzed from the Tulare Lake

core were taken at 1 cm intervals in order to acquire a decadal scale resolution for changes in grain size and sand percentage. Standard samples consisted of 1.0 g of sediment from each 1 cm interval of the Tulare Lake core, each of which were transferred into a 50 mL plastic vial. For each sample, 10 mL of deionized water was added to the vial of sediment and left to sit for at least 24 hours before any further preparation. After soaking, the sample was then completely sieved through a 1 mm sieve into a 400 mL beaker in order to take out extremely large grains, organic material, etc., which could possibly damage the grain-size analyzer due to the Mastersizer's in ability to measure grains greater than 2mm. Any organic matter found during preparation was taken out of the sample, and stored for possible carbon dating. Shortly afterward, 5 mL of hexametaphosphate was then added to the beaker of sediment and deionized water solution in order to help break down the clay-rich sediment clumps into individual grains. The new solution was then stirred vigorously and then placed into a sonicator bath for 5 minutes to aid in further breakup of the sediment. A small sample of the solution was pipetted into a tray to observe for flocculated clays under a microscope. If the sample was free of sediment clumps and individual grains were noticeable, the sample was then ready for analysis. Each sample then underwent two types of analysis through the grain size analyzer. The first analysis was the *Splitter* Analysis (Procedure S). Using a sample splitter, the entire contents of a sample were split into portions of ½, ¼, 1/8, 1/16, and 1/32 if necessary. Portions would be added into the Mastersizer bath until the desired laser obscuration was met, which was about 18-20% for most samples. This analysis was intended to capture and observe the

differences between samples for both coarse and fine sediment in the resulting output. This portion of the sediment was then analyzed and the remaining portion was recombined for the next analysis. The second and final analysis was called the *Settled Grains* Analysis (Procedure C). While the Mastersizer was finishing up the *Splitter* Analysis, the remaining cloud solution was pipetted into a separate beaker for disposal in order to leave just the remaining settled grain sediment for this analysis. The desired obscuration was sometimes low in this final step due to the composition (size) of the particular sample. For example, if the sample had more coarse sand and hardly any clays, the Mastersizer had less particles to obscure the laser. However, the Mastersizer was still able to output reliable results. The *Settled Grains* Analysis was intended to focus, capture, and observe differences for the coarser sediment in the resulting output. After the two analyses were complete, data was then extracted from the Mastersizer 2000 program and used as a physical proxy for determining past lake-levels. In general, coarser sand indicated shallower lake levels while finer clay and silt particles were indicative to a deeper lake environment. Alternatively, coarse particles within and overall fine-grained matrix could indicate deep lakes fed by flood deposits (e.g., Kirby, 2012). In conjunction with the other proxies, lake size can be properly reconstructed.

Project Outcomes

Over the course of the internship, I was able to analyze and reanalyze a 100+ samples of sediment from the Tulare Lake core for the purpose of filling in the missing data. With the analysis of these Tulare Lake samples. our grain size results spanned as far at ~18,000 yr cal BP. We were able to construct a relatively continuous lake history

record using the newly acquired data. The results to-date show that throughout the record, the mean grain-size was uniformly in the extremely fine clay to silt sized range presented in Figure 1 (Appendix pg.9). This overall result suggests quiet water deposition throughout. In particular, we see a steady increase of clay sized particles from ~18,000 cal yr B.P. to ~14,000 cal yr B.P., which suggests that Historic Tulare lake was experiencing a steady period of growth. Superimposed on this trend, there were intervals where the coarser grain fraction was present and in the medium sand range (~2,000, ~2200-2400, ~5900, ~6400-6500, ~8700, ~10,000-10,200, ~18,000-18,800 cal yr B.P.) . These intervals suggest a deep water lake fed by occasional coarse-grained flood deposits which interspersed with the deep water silts and clays. Our findings were consistent with the results from Negrini et. al. (2006) on the Tulare Lake sediments and with Kirby, et al. (2012) on lake sediments from farther south in California.

Conclusions

The current research and data collection of the TL05-4B core and some re-sampling of the TL05-4A core has enabled us to fill in major gaps in the data and construct a high-resolution lake-level history of Tulare Lake. However, due to the complexity of determining lake levels via sediment analysis more samples and further research must be done on the Tulare lake sediments to acquire a better model for the lake level of Tulare Lake. The next set of sediments that need to be analyzed are taken also from Tulare Lake. However, the sediments that need to be sampled and examined should give us results that date back further into the Pleistocene (past 18,000 cal yr BP). Looking further back in to the Pleistocene will allow us to look at the behavior of Historic

Tulare Lake during more extreme climate changes. Further research on Tulare Lake also needs to be done on the most recent part of the Holocene (~2,000 cal yr B.P.-present). After we acquire more geophysical and geochemical data on Tulare Lake, in addition to the current data gathered, we will be able to better reconstruct past lake-levels and ultimately Sierran discharge. The interpretation of flood deposits contributing to deep lakes will be tested by complimentary studies designed to detect C/N ratios in the same sediments (Chauhan et. al., 2012).

This research experience continues to teach me more about myself and has improved my ability to effectively work on research individually and with a group. Conducting this lake research has also helped improve my critical thinking skills and increased my general knowledge of lacustrine depositional environments. These newly acquired skills will help me when I continue research at the Masters and/or Ph.D. level. The experience I gained will undoubtedly help in continuing my goal to make a career in research and I look forward to exploring a possible career as a research geologist for the USDA.

Appendix

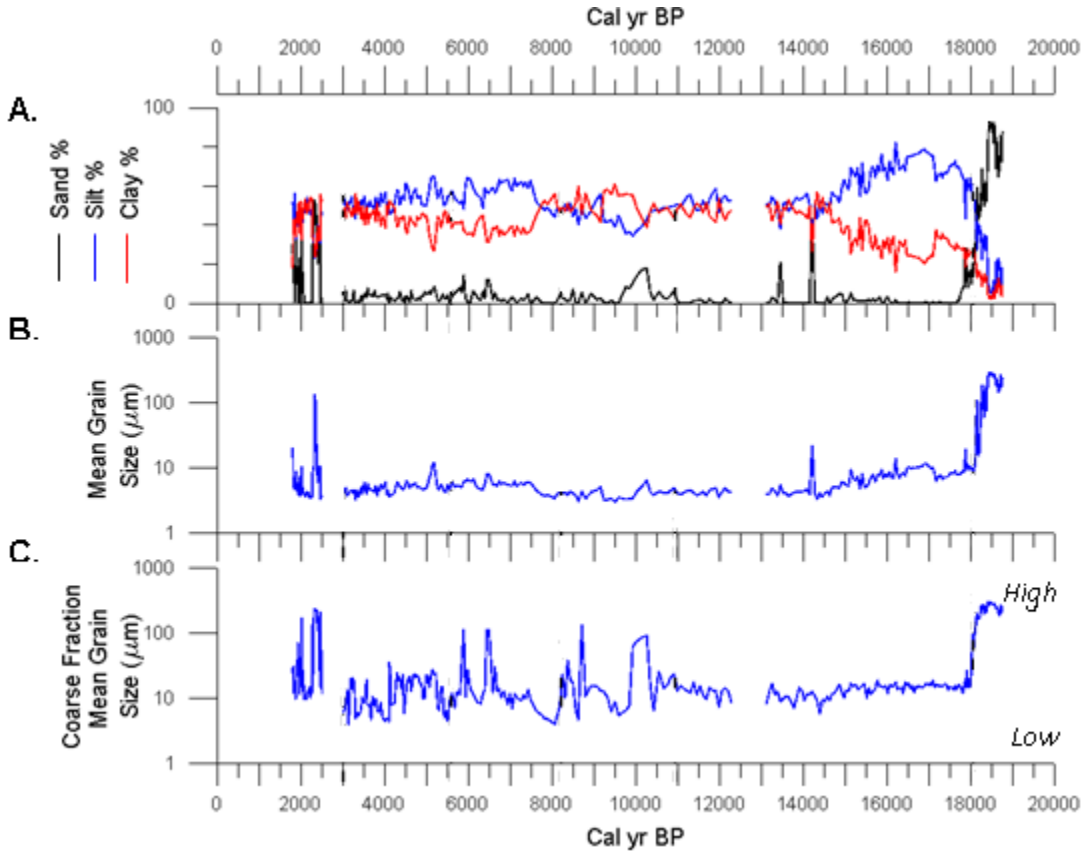

Figure 1. Grain Size Data taken from the Tulare Lake cores TL05-4A and TL05-4B. A) Sand, silt, and clay content. B) Splitter Analysis (microns), C) Settled Grain analysis (microns). (From Blunt, 2013).

References

Atwater, B.F., D.P. Adam, J.P. Bradbury, R.M. Forester, R.K. Mark, W.L. Lettis, G.R. Fisher, K.W. Gobalet, S.W. Robinson. 1986. Fan Dam for Tulare Lake, California and implications for the Wisconsin glacial history of the Sierra Nevada. Geological Society of America Bulletin, 97, 97-109.

Blunt, A.B. 2013. Latest Pleistocene through Holocene lake levels from the TL05-4 cores, Tulare, CA. Bakersfield, CA: California State University.

Chauhan, J., Chehal, R., Shugart, J., Shurbaji, H. 2012. Forecasting San Joaquin Water Supply Using Tulare Lake-Level History: Laying the Groundwork, poster presentation at REVS-UP Conference, CSU Bakersfield.

Kirby, M.E., S.R. Zimmerman, W.P. Patterson, J.J. Rivera. 2012. A 9170-Year Record of Centennial-to-Multi Centennial Scale Pluvial Events From Coastal Southwest North America: A Role for Atmospheric Rivers, Quaternary Science Reviews.

Negrini, R., Wigand, P., Draucker, S., Gobalet, K., Gardner, J., Sutton, M., Yohe, R. 2006. "The Rambla highstand shoreline and the Holocene lake-level history of Tulare Lake, California, USA."*Quaternary Science Reviews* 25, no. 13-14: 1599-1618 p.

Preston, W.L., 1981. Vanishing Landscapes: Land and Life in the Tulare Lake Basin. University of California Press, Berkeley, CA.