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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 10,000 years. By looking at the physical and geochemical proxies from the TL05 Tulare Lake Core at a 1 cm interval we will be able to construct a record that will attain decadal scale resolution and it will lead to improved forecasting for Sierran discharge over the next several decades after this record is compared to improving coeval records of sea-surface temperatures of the Pacific Ocean.

Prior to diversion of streamflow 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: the 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 associate with trenches taken from close to the 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 this summer internship, there were a number of other interns working on the same project as myself and tasks related to the project were divided among the interns and other research assistants. For this project, interns were asked to assist in attaining geochemical (eg., inorganic carbon content, carbon/nitrogen ratios) and physical analysis (grain-size) on the Tulare Lake sediments. For a majority of the internship my main task was to do the physical analysis portion on the lake sediment by acquiring grain size data (median grain sizes and sand percentages), and prepare my data graphically for later correlational analysis. The data I collected will be used as one of the proxies to determine past lake-levels for Tulare Lake.
As it pertains to potential career pathways, my time working under the USDA research internship in the Department of Geology, California State University, Bakersfield was very influential stepping stone in pursuing my goal to get involved with geological research. The internship helped me prepare for a potential career as a geologist for the USDA. This regionally important research project has solidified my desires to continue doing geological research. As for research topics, I have become very interested in continuing my work with lacustrine depositional environments since Tulare Lake was the focal geologic setting of our team's research. Being involved in this research has given me personal satisfaction knowing that my contribution will help with the future decision making on water-shed management in areas connected to the Southern Sierrian run-offs.

**Project Approach**

During the internship I acquired physical grain-size measurements via laser particle size analysis using the Malvern Mastersizer 2000 laser particle analyzer. Before grain size analysis via the laser particle analyzer, the samples underwent pre-analysis preparation. 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. A standard sample consisted of 1.0 gram 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 then added to the vial of sediment and was left to sit for at least 24 hours before any further preparation. After 24 hours of soaking in the deionized water the sample was ready for further preparation. 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 because the Mastersizer is only designed to a measure grain less than 2mm. Any organic matter found during preparation was taken out of the sample, and stored for future analysis and 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 are noticeable, the sample was then ready for analysis. Each sample then underwent four 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 analysis was the Stir Analysis (Procedure A), where the contents of the remaining sediment were vigorously stirred and pipetted into the Mastersizer bath until the desired obscuration was met. This sediment was then analyzed by the Mastersizer.
The Stir Analysis was also intended to capture both coarse and fine sediment in the output. The remaining content was then left undisturbed to prepare for the next procedure. The third analysis was the Cloud Analysis (Procedure B). For this analysis, the sediment solution was left undisturbed while pipetting only the cloudy solution into the Mastersizer bath until the desired obscuration was met. The sample then underwent analysis. The Cloud Analysis was meant only to focus, capture, and observe the differences in the finer sediment in the resulting output of the Mastersizer. The fourth and final analysis is called the Settle Grains Analysis (Procedure C). While the Mastersizer was finishing up the third 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 of the particular sample. For example, if the sample had more coarse sands and hardly any clays, the Mastersizer had less particles to obscure the laser. However, the Mastersizer was still able to output reliable results. The Settle Grains Analysis was intended to focus, capture and observe differences for the coarser sediment in the resulting output. After the four analysis 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 summer I was able to analyze over 250 samples of sediment from the Tulare Lake core. With the analysis of over 250 samples our grain size results spanned as far at 18,000 yr cal BP. However, we have not yet acquired results for a complete continuous record because of gaps in the lake core. 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 and Figure 2. This overall result suggests quiet water deposition throughout. Superimposed on this trend, there were intervals where the coarser fraction, though, minor, was nevertheless present and in the medium sand range (~3,000, ~7,300, ~11,300,~17,800-18,400 cal yr BP). 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.

![Figure 1: Median Grain Size vs. Age for Procedures A,B,C, and D taken from TL05-4A Tulare Lake core.](image-url)
Figure 2: Sand Percentages vs. Age for Procedures A, B, C, and D taken from TL05-4A Tulare Lake core.

Conclusions

The current research enabled us to construct a high-resolution lake-level history of Tulare Lake. However, due to the gaps in the record 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. U-channels taken from the trenches of the original study from Negrini et. al. (2006) and a complete 1.5 m section from a core (TL05-4B) taken adjacent to our core will be the next set of sediments analyzed in hopes that they will help fill in the missing gaps in the record. Combining all the results from the physical and geochemical proxies that have been gathered and still need to be gathered we will be able to better reconstruct past lake-levels and, in turn, Sierran discharge in the future. In particular, our 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 has taught me much 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 environment which 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.

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