Determination of Tulare Lake, CA Late Pleistocene and Holocene Lake Level History
Through Total Inorganic Carbon Analysis

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Executive Summary:

The objective of the CSUB NSF CREST Project in cooperation with CSU San Bernardino’s Water Resources Institute is to reconstruct the Holocene discharge of Sierran rivers into the San Joaquin Valley with a lake-level history of Tulare Lake. In principal, this can be done by mapping and dating shoreline deposits (e.g., Atwater et al., 1986; Negrini et al., 2006), but the discontinuous nature of such deposits requires infilling with relative lake-level indicators (aka “proxies”) from continuously deposited deeper lake sediments. Here we use the Tulare Lake Core, TL05-4A, to obtain total inorganic carbon (TIC), which is an indicator of relative lake level because a shallow lake bed is likely to form and deposit evaporate minerals which contain inorganic carbon. Other CREST-related studies are measuring carbon-nitrogen ratio and grain size data from the same core to act as proxies for the historic relative lake level. The results we obtained discerned three especially shallow periods in the lake’s history in the last 18,000 years that are consistent with previous results.
Project Objectives:

For this project, total inorganic carbon levels will be measured from core taken from the now dry Tulare Lake in order to determine total inorganic carbon levels deposited in this lake throughout time. Total inorganic carbon is a good indicator of periods of relatively low lake levels, because the low water levels allow evaporite minerals to form and deposit (Cohen, 2003); these evaporates are the sources of the measured TIC. This information will aid in the USDA’s pursuit in predicting resources for the next 50 years in coincidence with predicted climate change. Personally, this project is aiding me in my pursuit to a career with the USDA as a geologist. These skills in lab and analytical techniques will be a great asset to have once I am done with my education. My original goal for this project was to acquire additional knowledge in research methods and presentation on top of the knowledge I am gathering in class. The internship has been great and I have met the goals I set out to accomplish. A few of the tasks I was required to do included prepping core samples for analysis and conducting the geochemical analysis of said samples by operating the UIC, Inc. carbon coulometer and its acidifier module. I presented my final findings at the annual Water Resources and Policy Initiatives in Sacramento.

Project Approach:

Because there was a need to obtain a higher resolution analysis of the lake-level history, we took ~100 mg samples from the core at a spacing of every one centimeter. They were then dried in an oven for roughly two days to ensure that the samples were completely free of any water, crushed down to a fine powder, and finally placed in a desiccator to keep them dry without heating them. Each sample was then analyzed for TIC% levels using a CM-135 Carbon Coulometer. The acid used in the coulometer was perchloric acid in 2N (normal) concentrations.
and in 10 mL quantities per sample test. To ensure consistent and proper results, standards were run of a known TIC% every ten samples. The standard chosen was calcium carbonate (CaCO₃) which has a known TIC% of 12.

**Project Outcomes:**

The measured TIC levels found that three fluctuations occurred in part of the lake’s history covered by our samples. As illustrated in figure 1, these fluctuations were around 10200-9200, 8380-7300, and 3000-2700 calibrated years before present. These areas are indicative of high TIC, and tell us that during that time period, lake levels were relatively low. The instances of relatively wet climates, shown by the low amounts of TIC, are supported by a study of two southern California lakes (figure 1) done by Kirby et al (2012). The PE-III lake level event is also reflected in figure 3 by the high water conditions indicated by the grain-size and C/N proxies prior to 3,000 cal yr B.P. Further correlation of Lower Bear Lake and Tulare Lake and the wetter-than-usual events are shown in figure 3.

Because Tulare Lake and the southern California lakes are the same distance from the Pacific Ocean, this correlation of water level fluctuation could indicate that the events of a wet/dry climates are regional instead of local in nature (Negrini et al., 2006; Kirby et al., 2012). To support the idea that the increase in general water levels are brought on by these pluvial events, grain size analysis was used and found to increase during these PE events (figure 2)(Cohen 2003; Kirby et al., 2012).
Figure 1. Total inorganic carbon levels and calibrated age. Lower levels here represent a higher percentage of TIC, which is indicative of low lake levels. Pluvial events as documented by Kirby et al are shown in dark grey. Age was determined through $^{14}$C dating on organic matter in samples by Dr. Sinan Akciz of UC Irvine and converted to calibrated ages using Calib 6.0 at http://calib.qub.ac.uk/calib/.

Figure 2. Carbon/nitrogen ratios around 3000 calibrated years BP. Pluvial events introduce a lot more water and transport larger materials and grain sizes, as indicated by the increase in C/N ratios and grain size (Cohen 2003; Kirby et al., 2012).
Figure 3. Pluvial events (PE) from different California lakes. Lower Bear Lake charts molar carbon/nitrogen ratios. PE-V, PE-IV, and PE-III are related to this study. (Kirby et al 2012).
Conclusions:

What we’ve found was that over the course of the core’s studied history, there were instances of high total inorganic carbon levels and instances of nonexistent total inorganic carbon levels. These fluctuations correlate well with past studies from Tulare Lake and from other southern California lakes. What we can infer from this is that during these times of high TIC levels, lake levels were very low, while the opposite is true for times of extremely low TIC. This study is just a small piece in a much larger picture. Future works will include a more complete core, multiple cores taken from different locations in the lake bed, analysis of u-channels taken from trenches, and correlation of total inorganic carbon, carbon/nitrogen, pollen counting, and organic carbon levels into one graph. These additional analyses will test our initial results and also fill in gaps in our record. All of this can one day lead to a better method of water resource prediction for the upcoming half century.

This internship has given me many opportunities to develop skills that I otherwise would not have obtained through normal coursework. For instance, during the time I have been here researching, I have had to maintain high levels of organization when dealing with hundreds of core samples while ensuring none were mixed up. Presenting my data at the Water Resources and Policies Initiative conference in Sacramento enhanced my public speaking and presentation skills, which will be crucial for jobs with the USDA. I deeply appreciate this opportunity and hope to renew my fellowship with the WRI/USDA.
Appendix:


