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Paleomagnetic secular variation and environmental magnetism of Holocene-age sediments from Tulare Lake, CA

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ABSTRACT

The lake-level record from Tulare Lake, CA has been shown to provide valuable constraints on late Pleistocene and Holocene runoff from the Sierra Nevada mountain range into the San Joaquin Valley of California, one of the world's most prolific agricultural centers. This project uses the magnetic properties of the Tulare Lake sediments in order to date the sediments and to constrain the relative lake level at the time of deposition. Shallowing lake conditions were identified leading up to a prominent unconformity; magnetic mineralogy and grain size indicators, primarily decreasing ARM/IRM and S-Ratio values suggest coarser grain sizes and more oxidizing conditions. Approximately half of the samples possessed well-behaved paleomagnetic directions suitable for paleomagnetic secular variation dating. The results indicate that the sediments below the unconformity were deposited approximately 7600–8500 cal yr BP, and the sediments above the unconformity were deposited approximately 2500–800 cal yr BP. The ages of the corresponding sediments are consistent with the time intervals during which previous studies indicate that lake level was above the elevation of this site, before and after a mid Holocene regression.

Introduction

Tulare Lake is located in the southern San Joaquin Valley, in Kings County, California (Fig. 1). Its central coordinates are 36.00 °N, 119.72 °W and it covers approximately 1600 square kilometers. Currently dry due to agriculture diversion, Tulare Lake was the largest fresh water lake west of the Great Lakes with respect to area, with depths reaching up to 12 m (Preston, 1981). The Kings, Kaweah, Tule, and Kern Rivers feed the Tulare Lake basin from the Sierra Nevada and discharge from these rivers controls Tulare Lake levels as shown by hydrologic balance models (Atwater et al., 1986). Therefore, Tulare Lake level is controlled by climate-driven changes in the Sierran precipitation and runoff. This hypothesis is further supported by the consistency of this lake-level history over the past 10,000 yr (Negrini et al., 2006; Blunt and Negrini, 2016) with other paleo-lake records from south-central California (Bacon et al., 2006; Kirby et al., 2012).

The purpose of this project was to test previous lake-level records obtained from exposures and core from the western edge of the lake by studying the magnetic properties of the Tulare Lake sediments from the south-east side of this large lake basin. The paleomagnetic secular variation (PSV) method (e.g., Bradley, 1999) was used to date these new exposures in order to test their ages above and below an unconformity that represents a middle Holocene lowstand of the lake, inferred from previous work. In addition, magnetic properties of sediments were investigated to determine the composition, concentration, and grain-size of magnetic minerals, which are used as proxies for lake conditions, flood events and regional climate change (Evans and Heller, 2003).

Previous work

Building upon earlier works by Davis (1999), Atwater et al. (1986) and Negrini et al. (2006) used stratigraphy and radiocarbon dating primarily from trench exposures on the west side of the lake basin (Fig. 1) to constrain several major lake-level fluctuations in Tulare Lake throughout the Holocene. Blunt (2013) and Blunt and Negrini (2016) elaborated on this by constraining the lake level in the north-western part of Tulare Lake using geochemical and

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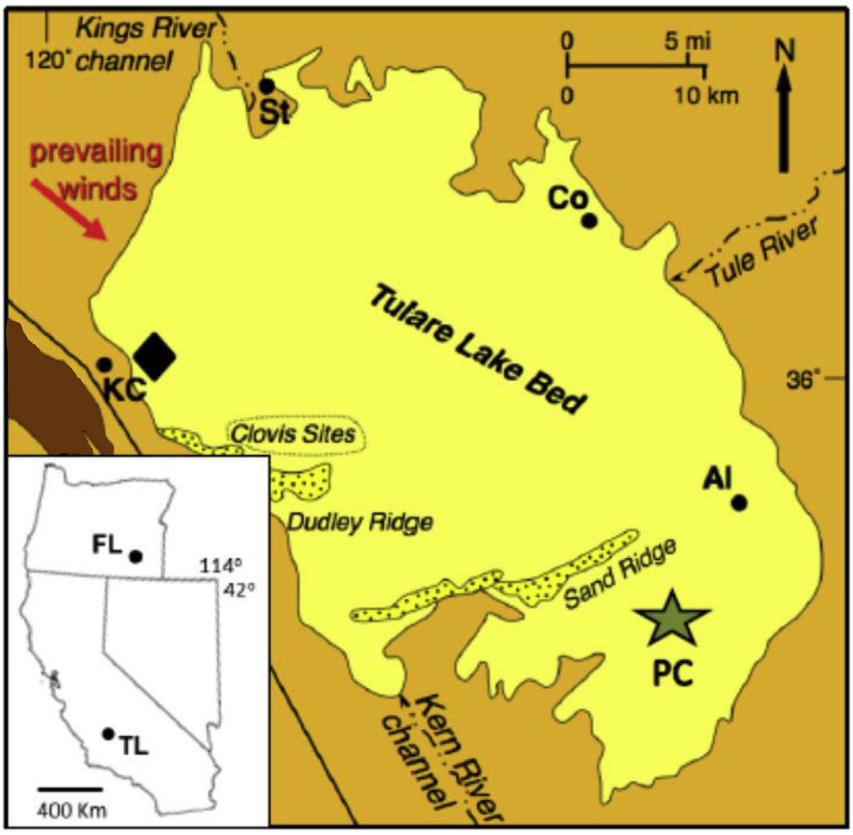

Figure 1. Location of Tulare Lake and simplified geologic map modified from Page (1986) and Negrini et al. (2006). The largest extent of the lake is shown in yellow. The Poso Canal Site is located in the southeast part of the lake, and is marked by a star. The work from Blunt (2013) and Blunt and Negrini (2016) was conducted on core sediments from the northwest part of the lake; the coring site is shown as a diamond on the map. The location of the site corresponding to the Fish Lake, OR paleomagnetic secular variation record (Verosub et al., 1986) is shown in the inset. KC, Co, and Al represent the towns of Kettleman City, Corcoran, and Alpaugh respectively.

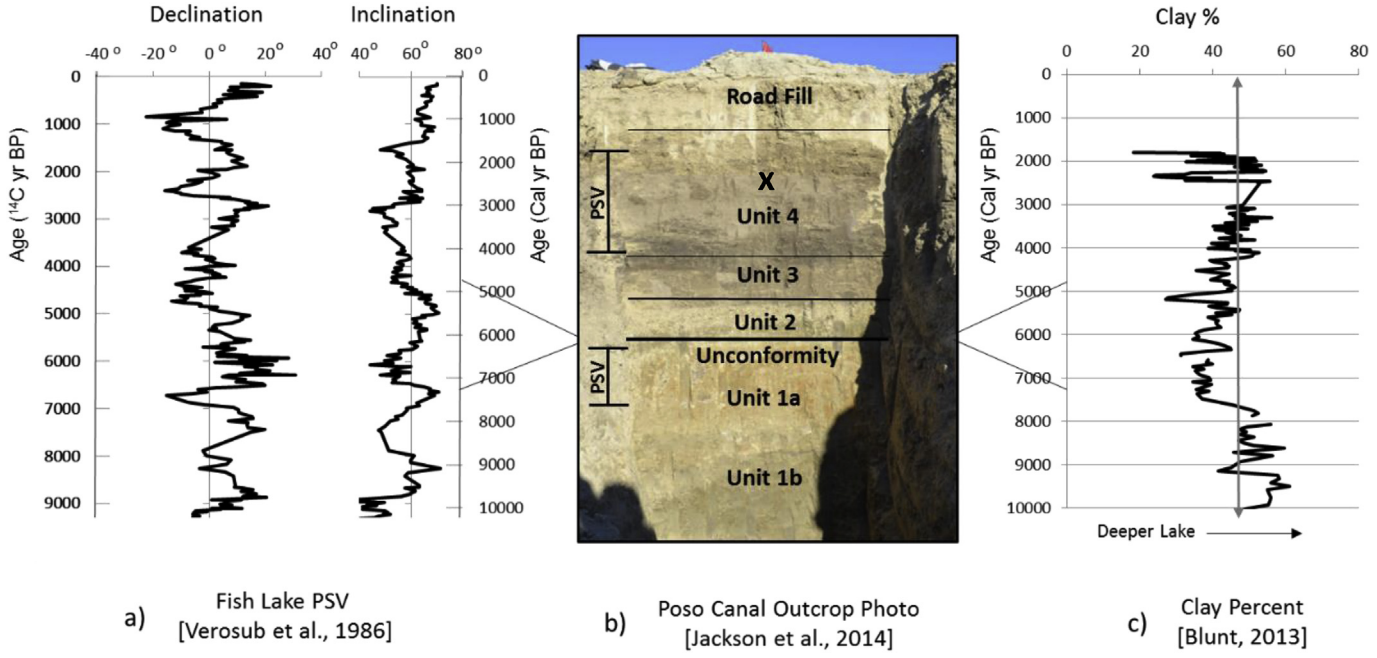

Figure 2. Previous work used for age control. The Poso Canal outcrop photo is shown, along with the stratigraphic units and radiocarbon dating from Jackson et al. (2014). Unit 1a consists of well sorted olive clays, and Unit 1b is heavily oxidized and coarsens upwards from clay to very fine grain sand. A prominent unconformity separates Unit 1 from Unit 2, a coarse-grained, poorly sorted, fossiliferous sand. Unit 3 is a dark olive clay, and Unit 4 is a clay with dark and light gray laminations. A radiocarbon date obtained from charcoal, which gave an approximate age of 790 ^{14}C yr BP, was obtained from the spot marked with an 'x' on the outcrop. The PSV record from Fish Lake (Verosub et al., 1986) is also shown. The age predicted for the oldest sediments above the unconformity and the youngest sediments below the unconformity are indicated, as well as the depths at which PSV dating was successful for this study. The PSV ages from the present study correspond to the ages of highest lake levels shown by the clay percent proxy in Blunt (2013) and Blunt and Negrini (2016). The 45% clay line plotted in the Figure is shown to indicate the depth above which there was predicted to be deposition at the Poso Canal site, as well as the corresponding time intervals.