LATE HOLOCENE HYDROLOGIC AND CLIMATIC VARIABILITY IN THE WALKER LAKE BASIN, NEVADA AND CALIFORNIA

By

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ABSTRACT

Oxygen and carbon isotopic measurements of the total inorganic carbon (TIC) fraction of sediments from Walker Lake (Nevada, USA) were completed at a decadal-scale resolution spanning the last ~3000 years. On the basis of radiocarbon dating of the total organic fraction of cored sediments, the late Holocene isotope record recorded a relatively dry climate in Period LH-1 (1000 BC to AD 800), a relatively wet climate punctuated by a few severe droughts in Period LH-2 (AD 800 to 1900), and an anthropogenical perturbation era (LH-h: 1900-2000). Relatively high accumulation rates in Period LH-2 (AD 800 to 1900) provided detailed information on climatic and hydrologic variability in this region. Coupled with the tree-ring-based Sacramento River flow record, the radiocarbon-based age model was refined for the interval of AD 800 through 1900. A high-resolution (3.5 year per sample) TIC $\delta^{18}O$ record spanning the last 1200 years was generated to reflect fluctuations in winter snowfall of the Sierra Nevada. This TIC $\delta^{18}O$ record shows at least two prolonged droughts that occurred during the Medieval Warm Epoch, which are chronologically well consistent with previous findings (STINE, 1994). Time series analyses on the TIC $\delta^{18}O$ and the Sacramento River flow records reveal that interdecadal and centennial modes of climate variability persisted over the last millennium. PDO-like interdecadal oscillations that centered in the periods of 50-90 yr were almost in phase with thermal fluctuations in ocean climate of the California Current, suggesting that indedacadal climate oscillations in the Sierra Nevada were intimately linked with the Pacific dynamics. The underlying centennial to multicentennial variability corresponding to the Medieval Warm Epoch and the Little Ice Age comprise the major share of total variance. In addition, the TIC $\delta^{18}O$ record of Walker Lake is visually well correlated with the polar ice-core-based cosmogenic nuclide production and the Rice Lake Mg/Ca records. This suggests that some centennial oscillations in winter precipitation of the Sierra Nevada were associated with solar activity over the last millennium.

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PREFACE

People of the Anasazi culture appeared in Nevada as early as 300BC and began raising crops and developed irrigation between ~AD 700 and 1100 (ENCYCLOPEDIA, 1999). The Anasazi culture expanded widely after AD 900, reached maximum extent about AD 1100, and shrank drastically around AD 1300 (SMITH, 2002). The history of the Anasazi is a mystery as we do not know why the Anasazi population shrank suddenly in ~AD 1300. One of the possible causes is attributed to the severe drought that occurred from AD 1276 to 1299 (SMITH, 2002). Paleoclimatic records (like tree-rings and dated tree stumps) suggest that the climate was relatively dry in the period from AD 900 to 1400, compared to the subsequent five centuries in this area. These results seem to implicate that the Anasazi people developed and boomed during the relatively dry intervals of the last millennium. This is contradictory to the conventional wisdom. However, the oxygen isotopic signal extracted from Walker Lake carbonate sediments forces me to tell a different story about the climate during the last millennium.

This research has been focused on reconstructing hydrologic and climatic variability using Walker Lake sedimentary deposits. On June 19, 2000, I participated in the core acquisition team that was supervised by Dr. L. Benson of the U.S. Geological Survey. Two piston cores and one box core were collected as part of a USGS project and were kindly provided to me by Dr. L. Benson. I splitted and sliced the cores and prepared samples to extract geochemical and isotopic signals preserved in down-core carbonate sediments. The carbon and oxygen isotopic analyses were performed in the Stable Isotope Laboratory at the University at Albany with the assistance of S. Howe and the coulometric analyses were conducted in Dr. D. Rodbell's laboratory at the Union College. Dr. J. McGeehin (USGS) kindly performed the radiocarbon dating analyses.

This dissertation research takes advantage of previous work by Dr. L. Benson (USGS) and his co-workers. They have generated and complied important background data pertinent to the oxygen and carbon isotopic composition in the Walker River and Walker Lake surface water systems. These data serve as an important information source to decipher the isotopic signals extracted from down-core sediments. In chapter 2 and 3, I use this important background data to examine the distribution of oxygen and carbon isotopes and their responses to changes in hydrologic conditions and to establish a linkage between lake level and down-core carbonate $\delta^{18}O$ composition. The isotopic results from the piston cores are reported in Chapter 4. In the last chapter, i.e., Chapter 5, I attempt to detect the climatic variability or modes through spectral analyses on the oxygen isotopic signal of the Walker River during the last ~1000 years.

It is hoped that the results and methods presented in this dissertation will refine our understanding in the history of the climate and its variability over the last ~3000 years in this climatically critical region.