Final Report on DOE grant DE-FG08-92ER14235
Paleoclimatic Drilling at Washoe Lake
November 1991 to March 1993
PI: Robert Karlin, University of Nevada, $47,598

A lacustrine sediment sequence in Washoe Lake in western Nevada was drilled in 1992 for paleoclimatic and paleohydrologic studies. In late June, 1991, the lake completely dried up for the first time since 1933-34 and only the second time in recorded history, offering a rare opportunity to obtain long continuous sections from a quasi-permanent lake in a climatically sensitive region. Washoe Lake located between Carson City and Reno NV, lies in the high Sierran semi-arid desert environment very near the present boundary between the Pinyon pine/mountain mahogany and the sagebrush ecotomes. At present, the lake is nominally ~31 km^2 in size and averages 3-4 m in depth. During the Pleistocene, the water depth was on the order of 13-17 m, and the lake occupied a much more extensive area as evidenced by strand lines occurring above the lake margins. Geologic studies of the basin sides suggest that lacustrine sediments have been deposited for at least the last 2.5 my.

Gravity, magnetic, and electrical surveying of Washoe Lake, NV were conducted to characterize the geometry and subsurface structure to better constrain depositional and tectonic controls on groundwater flow in the basin. The lake lies in an asymmetric fault-bounded half graben surrounded by the Carson and Virginia Ranges, the Truckee Meadows, and the Carson Basin. Gravity modeling of the basin suggests that the lake is underlain by sediment thicknesses of almost 600 m with maximum accumulations in the west. The magnetic data suggest that a relatively thin volcanic unit, probably Miocene in age, lies directly on Cenozoic basement at a depth of ~160 m beneath the eastern portion of the lake. The magnetic anomaly appears to be arcuate with its western edge offset by a NS-trending basement fault. Subtle east-west structures provide constraints on the relative ages of faulting. A major change in sedimentary facies from coarse alluvial sands in the west to fine-grained lacustrine sediments in the east coincides with a deep basement offset. The deepest portion of the present lake also lies to the east of the zone of thickest sediment accumulation. These relations suggest that both ancient and modern sedimentation patterns in the lake are tectonically controlled and exert a strong influence on groundwater flow.

Drilling operations in the dry lakebed were very successful. Two sites were drilled to 25 m, and undisturbed lake sections were obtained with better than 85% recovery. Two other sites yielded about 13 m of section until penetration was terminated because of fluidized sands. In addition, two 4-m trenches were sampled to obtain recent sedimentation history. The holes were geophysically logged to allow the cores to be reoriented. Magnetic susceptibility profiles of all sections were measured to characterize the stratigraphy. To date, sediment chemistry, textural analyses, and X-ray diffraction have been done on one drill site and one trench section.

Near the depositional center of the lake, the top 12-m of the sedimentary section consists of alternating intervals of lake sediments, peaty bog deposits, and soils. The lower part of the section contains predominantly lake sediments probably deposited within the last 60,000 years. The lake sediments are characterized by elevated $CaCO_3$ values, low susceptibilities, and relatively low abundances of terrigenous elements such as Al, K, and Na, which are usually associated with detrital aluminosilicates. Calcite and aragonite were authigenically precipitated as coatings and discrete, euhedral grains during alkaline lake stages. The soils show an inverse

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

relation with low $CaCO_3$ and high terrigenous elemental abundances. Peaty intervals show relatively high organic carbon, low $CaCO_3$, and intermediate Al_2O_3 concentrations.

Magnetic susceptibility profiles provide a sensitive, continuous record of lithology. Susceptibility maxima mainly reflect intermittent sand layers that were deposited in different environments. Textural variations have been used to map transport pathways and depositional environments. Sands occurring in different depth intervals are derived from turbidites and subaerial sheet flow deposits during the lake stages, discontinuous channelized fluvial sands during the peaty bog stages, and deflationary lag deposits in the arid soil stages.

The sediments suggest that climate has varied significantly during the Holocene. The top 3 m contains several silt/clay layers, some with buried clam zones, as well as peaty zones and soils that indicate the the lake has partially or completely dried up several times during the Holocene. Radiocarbon dating of three clam layers in the top meter and the presence of the Mazama ash gives sedimentation rates of 23 cm/ka from 0 to 2600 ^{14}C yrs BP and 11 cm/ka from 2600 to 6850 ^{14}C yrs BP. In the last 2600 years, climate has been relatively wet, and the lake has been fully developed, except for three brief desiccation episodes. Earlier in the Holocene, the climate was generally drier and more variable, causing deposition of soils and marshy peat horizons. Our results are consistent with a warm period from about 4000 to 6000 years ago that apparently dropped the level of Lake Tahoe 10 to 20 m and left submerged, upright trees in the lake (Rose, this volume). Further radiocarbon dating of lake, peat, and soil zones should allow us to determine the timing, frequency, and possibly duration of previous episodes of drought.

This project resulted in two published papers, three abstracts, and a hydrology MS thesis by R. Petersen.

Publications

Petersen, R. and Karlin, R. A hydrogeologic framework of Washoe Valley, Nevada from joint gravity and magnetic modeling and terrain conductivity data (1997). Proceedings of the Symposium on the application of geophysics to engineering and environmental problems, SAGEEP '97, Environmental and Engineering Society, 511-522.

Karlin, R., Trexler, J., Petersen, R. (1996) Initial results from paleoclimatic drilling and geophysical studies of Washoe Lake, Nevada, *USGS Circular 1119*, Water Resources Division 37-38.

Abstracts

Petersen, R. and R. Karlin, A hydrogeologic framework of Washoe Valley, Nevada fro joint gravity and magnetic modeling and terrain conductivity data, Environmental and Engineering Society SAGEEP '97 Meeting, Reno NV ,1997

R. Karlin, J. Trexler, and R.C. Petersen, Initial results from paleoclimatic drilling and geophysical studies of Washoe Lake, Nevada Paleoclimate Workshop, Reno, NV, May 16-18, 1993

Karlin, R., and R. Petersen, Hydrogeologic setting of Washoe valley, Nevada from gravity and magnetic modeling, GSA Cordilleran Meeting, Reno, NV, 1993