Paleoclimatic Drilling at Washoe Lake
November 1991 to March 1993
PI: Robert Karl~ 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 Sieman 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 -km2 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 stand 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 deposition 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 sedimental 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 CaCO3 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...
PROGRESS REPORT
by Peter Winkler, University of Nevada, Reno. DOE Contract DE-FG08-90ER14160

When we earlier [Win-89a] suggested a new recombination mechanism (Resonant Radiative Recombination [RRR]) which, based on very general physical arguments, should happen in dense plasmas and promises to provide useful information for the local temperature and density diagnostics of plasmas we assumed the existence of screening resonances. For model potentials the existence of screening resonances has been demonstrated beyond reasonable doubt in a number of calculations. The key question, how well those potentials describe the dominant effects of a real plasma remains open. The relation of theoretical predictions to experimentally measurable effects is an important issue at the present stage of our research. In particular, RRR is expected to account for enhanced recombination rates of low energetic electrons with their ions, since the first stage is the resonant capture of a slow electron by an atom or ion. The mechanism that traps an electron is a combination of complicated many-body interactions of the ions and electrons. For clarity we start here, however, with a discussion in terms of local potential traps the shapes of which are determined predominantly and in an average way by two factors: the degree of screening present at the ionic site and the degree of short-range order in the immediate neighborhood of this ion.

We have since established a working computer code for the calculation of ion-ion and ion-electron pair distribution functions. The programming and testing of the needed computer codes turned out to be rather straightforward. The difficulty was to make the iterative scheme converge properly. The procedure solves simultaneously for bound and scattering solutions of the Schrödinger equation for the plasma electrons and the hypernetted chain equation for the ions until self-consistency has occurred.

The electron wave function of a shape resonance has characteristics of both continuum states and bound states. It is more localized than a continuum state but less so than a bound state. For the particular case of s-partial waves (considered here because of the low energy of the electrons) the wave function extends well beyond the several nearest neighbors of the central ion. Hence, it will have to adjust to properties of the environment. As a consequence of this, our studies, which so far considered only spherical averages of the screened electron-ion potential, have recently been extended to include screened electron-electron interactions. To our knowledge this has never been done for nonuniform systems, although a recent theory has been formulated by Amusia [Amu-92] which we intend to utilize. We have previous experience in a closely related context by incorporating model-interactions in the computation of two-electron matrix elements which were used in photodoubleionization computations [Win-77]. Then the model-interactions served the purpose of approximating core polarization effects. The modification of the relevant codes will still be major job, in particular, the modification of Froese-Fischer's 1972 code. Our present version of this particular code has screening included only in the one-electron parts. This is probably the most urgent task for further progress.

The use of shape resonances as probes for a molecular environment is not new. For many years, Dill and Dehmer have successfully pursued related ideas in their studies of molecular fields [Deh-79]. However, the present project is distinct from theirs in several aspects. First, we start out from a very different environment. Second, over the last two years or so we have developed novel computational techniques to calculate resonance wave functions specifically applicable to potentials without repulsive barriers (in most cases it requires a combination of several approaches to locate resonances [Win-92]). Third, the inclusion of resonances that are not bound by potential barriers makes it feasible to probe a larger region of the neighborhood because the corresponding wave functions are spatially more extended and, in fact, do resemble Rydberg states.
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
Further studies of ours have shown that screening resonances are not restricted to dense plasma environments but are likely to occur also in dilute, cold plasmas such as the ion-electron plasma of an electron cooler and in molecular and crystal fields. It has been hypothesized that the ion beam may undergo a phase change into a Wigner crystal with huge lattice distances. There is plenty of experimental evidence of such ordered ionic structures and phase changes in trap experiments ([Wue-59], [Bol-84], [Bre-87], [Win-79], [Jav-80], [Ste-86], [Blu-88] and [Sol-90]) but only sparse experimental evidence so far from ion storage rings ([Par-80], [Dem-80], [Sch-89] and [Mue-90&91]).

In the interior of the electron cooler the process of condensation of "matter" of a strange kind under rather unusual but experimentally well accessible and controllable conditions. With the electron and ion beams merged with zero relative speed one expects ion losses due to recombination processes. Mechanisms of recombination that have been studied in the past include RR (a direct process that dominates at low electron energies), DR a resonant process that involves the participation of a second electron and requires a minimum amount of kinetic energy of the impinging electron) and recombination in three-body collisions (where the energy of the incident electron is absorbed by a second free electron close by - a density dependent process). The RR and DR processes are sometimes enhanced by laser light. Recently the investigation of two other mechanisms for recombination in such plasmas has begun: The release of kinetic energy of the electron via phonon excitation and the RRR mentioned above.

There is indirect evidence from plasma experiments that the predicted shape resonances do indeed exist. At least we take the fact that oscillator strengths do not change much when an energy level is pushed into the continuum by pressure ionization [Dya-81] as confirmation of their existence. The study of plots of the hydrogen energy levels versus screening strength started us to ask: Do bound states appear as resonances when pushed into the continuum simply by increasing the screening beyond a critical value? Is there a richly structured continuum right above threshold? What are the consequences for recombination rates?

Research Publications and DOE Reports.


Presentations.
13 - "Metastability and Divergent Wave Functions", invitation to give an address at the Joint APS and AAPT Spring Meeting in Washington DC, April 1993.

Note: This Progress Report for the period from 1990 to 1993 was previously incorporated in the application for renewal. That document contains the explicit reference list.