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Quaternary Sciences Center, Desert Research Institute Annual Report
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1.2.3.6 - CLIMATOLOGY:

STUDY 8.3.1.5.1.3 - CLIMATE IMPLICATIONS OF TERRESTRIAL PALEOCLIMATE

The objective of this study is to collect terrestrial climate indicators for paleoclimate synthesis. The paleobiotic and geomorphic records are being examined for the local and regional impact of past climates to assess Yucca Mountain's suitability as a high-level nuclear waste repository. In particular these data are being used to provide estimates of the timing, duration and extremes of past periods of moister climate for use in hydrological models of local and regional recharge that are being formulated by USGS and other hydrologists for the Yucca Mountain area. The project includes botanical, faunal, and geomorphic components that will be integrated to accomplish this goal. To this end personnel at the Quaternary Sciences Center of the Desert Research Institute in Reno, Nevada are conducting the following activities.

These data are being used to identify periods of much more mesic climate, and provide information that can be used to estimate the magnitudes and durations of rainfall shifts by reference to modern distribution, characteristics and ecophysiological response of analogous plant communities and/or indicator species. Our determinations of the amounts, and actual duration of the availability of excess water during these periods in combination with those derived from the geomorphological studies being conducted by DRI will be linked with the paleozoological indications of past climate to refine estimates of the duration and magnitudes of such excess water availability. Finally, ostracode and diatom analyses conducted by the USGS as part of the Lacustrine Studies of the Paleoclimate Phase of the Climate Program will provide reasonable indications of variations in climate that can be used to reconstruct past extremes in available precipitation that will serve as the best estimates of conditions that may be expected during the next 10,000 years at Yucca Mountain. Linked in this way, estimates of climate derived from the terrestrial environment can be compared with those derived from lacustrine environments to arrive at secure inputs for hydrological models of recharge.

ACTIVITY 8.3.1.5.1.3.1 ANALYSES OF PACKRAT MIDDENS

Paleonidological Studies:

1. Assembly of available woodrat midden data from the Intermountain West into a data base.

Progress: Assembly of available woodrat midden data from the Intermountain West into a data base has been one of the major focuses of this quarter's activities. This has included proofing of the data base, and adding the results of other analyses that we are conducting as they are completed. In addition, we have contacted previous investigators from the Great Basin and have received their co-operation in direct dating and stable isotope analysis of index plant species materials that were previously collected by them but never directly dated. This will greatly improve the robustness of the current data base. In addition, we are conducting preliminary analyses of vegetation data in this data to determine the protocols that we will use in its analysis.

DISCLAIMER

Synthesis: A comparison of the late Holocene valley floor pollen record from Lower Pahranagat Lake with Mehringer's late Pleistocene valley floor pollen record from Tule Springs in the Las Vegas Valley reveals that during the last 2000 years the highest proportion of pine and juniper to saltbush pollen values attained are only 1/50 of that which occurred during the more extreme portions of the late Pleistocene. Packrat midden data from southern Nevada indicate that this difference reflects the lowered elevational distribution of Limber Pine (Pinus flexilis) and a decline in the areal distribution of saltbushes which today characterize much of the valley bottoms around the Nevada Test Site.

Based upon the woodrat midden record Limber Pine elevational distribution was as much as 1,000 meters lower. Limber Pine needles are common in woodrat middens from:

- *the Nevada Test Site (2133 m in the Belted Range and 1525 m in the Ribbon Cliffs at 18 ka)*
- *the central Pahranagat Range (1600 m at 12 ka)*
- *the southern Pahranagat Range (1685 m at 18 ka, 16 ka and 12 ka)*
- *Stockade Wash on the south side of Rainier Mesa (1950 m at 12ka)*

This is in agreement with the evidence of Spaulding and Mehringer respectively that evidences Limber Pine occurrence between 1500 and 1300 m in the Sheep Range between 20 ka and 18 ka and down to 1900 m on Clark Mountain south of the Spring Range around 23 ka and again at 12 ka. Based upon modern analogue data this shift indicates that for the glacial maximum mean annual temperature (MAT) may have ranged from -41 to 0°C colder and mean annual precipitation may have been from 180 to 310 mm more than today (from 80 to 140 percent greater MAP).

These climate shifts were exceeded during the onset and demise of the glacial maximum as evidenced by the occurrence of White Fir (Abies concolor) needles in woodrat middens from:

- *the southern Pahranagat Range (1695 m at ~ 23 ka and 12 ka)*
- *Stockade Wash on the south side of Rainer Mesa (1950 m at 12 ka)*

This is in agreement with the evidence of Mehringer that evidences White Fir occurrence down to 1900 m on Clark Mountain south of the Spring Range ~ 23 ka and again at 12 ka. Based upon modern analogue data this shift indicates that for the glacial maximum mean annual temperature (MAT) may have ranged from -24 colder to 8°C warmer and mean annual precipitation may have been from 560 to 1660 mm more than today (from 250 to 750 percent greater MAP).

The elevational depression in White Fir distribution is also evidenced in the Tule Springs pollen record. In Unit D of the Las Vegas Formation ~ 22 ka fir pollen increases from nothing to about two percent of the record. Fir pollen values of almost six percent, indicating even greater abundance of White Fir on the landscape occur in Unit B of the Las Vegas Formation prior to 37 ka. Thus far, few well dated woodrat midden strata exist covering this earlier period to corroborate this even more extensive expansion of White Fir in response to wetter conditions.

ACTIVITY 8.3.1.5.1.3.2 ANALYSES OF POLLEN SAMPLES

Palynological Studies:

1. Process samples already collected that are pertinent to the goals of the project.

Progress: Samples previously collected from the Pahranagat Range of southern Nevada are continually being processed. Plant macrofossil materials from additional midden strata for radiocarbon dating to confirm the age and association of indicator species are being gathered to be ready to submit whenever the USGS subcontract with Beta Analytic is in place. Carbon-13

isotopic analyses on the cellulose of indicator species will be run on materials from these midden strata as they are dated. Insect remains from these woodrat midden samples continue to be analyzed by Dr. S. Elias, a subcontractee. In addition, another 98 pollen samples from the woodrat middens have been extracted for analysis. Currently ~ 40 pollen samples from a long-term midden record in northern Nevada have been analyzed and demonstrate surprising correspondence to lake core pollen records from the area. A Level 3: draft letter report to the USGS including pollen and woodrat midden data was submitted at the end of July.

2. Select, collect and process new midden localities that are pertinent to the goals of the project.
Progress: Despite monetary and current project deadline constraints we have decided to collect a series of middens in the elevational range between 2,000 and 5,000 feet elevation. This discussion was made because of the large gap in the woodrat midden data base that exists in this elevational range for the late Quaternary of southern Nevada. A tour of the Lower Pahranagat Lake area in mid May led to the discovery of additional woodrat midden localities with disjunct vegetation assemblages. In particular, we have found juniper containing woodrat middens at elevations lower than previously found in the White River Valley area. Additional higher elevation midden localities will provide additional documentation (ground truthing) of the expansion of various plant species in response to wetter climate during the late Holocene that have been recorded in the pollen record from Lower Pahranagat Lake. Preliminary collection and analysis of these middens have been completed and samples have been prepared for radiocarbon dating.

3. Extend the present 2,000 year long vegetation history record from Lower Pahranagat Lake, southern Nevada for the purpose of providing baseline data for the generation of transfer functions for interpretation of less complete Pleistocene paleoclimatic proxy records. Lower Pahranagat Lake also provides the eastern terminus of a network of sites that straddle the Nevada Test Site and Yucca Mountain. As such it will establish the regionality of any climate patterns that are revealed.

Progress: During the last quarter we have continued extraction and analysis of pollen samples removed from the cores from Lower Pahranagat Lake. Photography, sampling and description of the cores has now been completed with splits being forwarded to the USGS in Denver. This includes the final ten meters of ostracode and diatom samples which have been sent to Dr. R.. Forester at the USGS in Denver and are being processed and analyzed there We have continued the same sample resolution in the new cores of approximately a sample every 13 to 14 years. We estimate that we have sampled down to approximately 5,600 b.p. Comparisons of the results from ostracode samples from the first set of cores from Lower Pahranagat Lake submitted to Dr. R. Forester of the USGS with the pollen record indicate rapid shifts from periods of increased rainfall to severe drought and back again. Periods of more moister-loving terrestrial plant species correspond with ostracodes in the lake reflecting direct in put into the lake of surface runoff. On the other hand drier terrestrial conditions reflected by saltbush and other desert shrub increases correspond with ostracodes indicating a lake supported primarily by spring discharge. These data provide the high resolution, well-documented paleoclimatic data that will provide part of the analogue data for interpreting the less robust Pleistocene record of paleoclimate from southern Nevada. In addition, these data provide understandings regarding the nature of current variations in climate that might be expected in the immediate future. We have already identified a wet period centered about 1,400 years b.p.

that has high variability and major dry periods that have low variability. A major shift in the aquatic record that does not have a corresponding shift in the terrestrial record is being investigated by our geomorphologists as evidence of a lake-damming, fan building event. They have identified a major event centered about 1,400 years ago.

4. Assembly of available palynological data from the Intermountain West into a data base, including the augmentation of the data from some of the localities previously examined by us in order to accomplish the goals of the project. This includes the submission of radiocarbon dates and tephra analyses for the resolution of chronologies, and analyses of pollen samples taken at closer intervals to resolve the rates of climate change, their magnitude and the response of the vegetation community.

Progress: Assembly of available palynological data from the Intermountain West into a data base is ongoing.

5. Coring of selected southern Nevada localities for paleoenvironmental records.

Progress: Although all the requisite state-wide and local permits have been obtained from the BLM, and Fish and Wildlife Service have been obtained for the coring of selected southern Nevada localities for paleoenvironmental records, and although we have received provisional permission to core Indian Springs Playa and Three Lakes Playa, we are still awaiting security clearance from the Air Force to conduct our research on Nellis AFB. We hope to be coring the area between Lower and Upper Pahranagat lakes in winter of 1995/96. This will of course be constrained by how wet the playas are at the time that we receive permission.

Synthesis: Preliminary analysis of 128 pollen samples and seven radiocarbon dates from a 5-meter long, 10-cm diameter sediment core retrieved from Lower Pahranagat Lake (elevation - 975 m), Lincoln County, Nevada, gives us a rare, continuous, record of vegetation change at an interval of every 14 years over the last 2.0 ka. During this period increasing Pinus (pine) pollen values with respect to Juniperus (juniper) pollen values reflect the increasing dominance of piñon in southern Nevada woodlands during the last two millennia. Today Pinus pollen values indicate that piñon pine is more frequent in the southern Great Basin than at any time since the end of the first phase of the "Neoglacial" ~ 2.0 ka. During the same time frame, a general decrease in Poaceae (grass) pollen values with respect to Artemisia (sagebrush) pollen values reflect the general trend of increasing dominance of drier climate steppe and desert scrub species with respect to wetter climate grasses. Variations in these two species reflect not only the generally more xeric nature of climate during the last 1.0 ka in particular, but also periods of summer shifted rainfall ~ 1,800 to 1,600 years ago that encouraged both a period of more abundant grass and initiated piñon expansion. Expansion of piñon is mirrored in pollen records from the central Great Basin and of grasses in pollen records from the northern Great Basin.

The ratio of aquatic to littoral pollen types indicates generally deeper water conditions ~ 2.0 to 1.0 ka and more variable, but predominately more marshy, conditions during most of the last 1.0 ka. Investigation of ostracodes from the same record being conducted by Dr. R. Forester at the USGS corroborate the pollen record by evidencing shifts between open and closed hydrologic systems including lake, marsh and even stream habitats. Analysis of an additional 10 meters of core recovered in the summer of 1994 with a basal date of ~ 5.6 ka promises to provide the best record currently available of middle through late Holocene vegetation and climate history for southern

Nevada.

ACTIVITY 8.3.1.5.1.3.3 DETERMINATION OF VEGETATION CLIMATE RELATIONSHIPS

1. Assembly of a modern plant community pollen data base.
Progress: Assembly of modern plant community pollen data base is an on going effort being conducted at this time. Setting out passive pollen traps along elevational transects and near established weather stations so that modern weather data can be tied directly to the pollen record is ongoing. We have collections that now are centered in several mountain ranges of eastern and northern Nevada, as well as in the west central and southern Nevada areas.

2. Collection of modern vegetation and climate data pertinent to interpretation of woodrat midden data in an analogue/nonanalogue manner.
Progress: Collection of modern vegetation and climate data pertinent to interpretation of woodrat midden data for use in analogue/nonanalogue comparisons is on going. These localities correspond, in as much as is possible, with the pollen collection localities mentioned above.