HOLOCENE VEGETATION HISTORY FROM FOSSIL RODENT MIDDENS NEAR AREQUIPA, PERU

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The central Andes and adjacent Atacama Desert are vital to understanding the history of the South American summer monsoon (SASM), and hence the role of the tropics in global climate variability. Rodent (*Abrocoma, Lagidium, Phyllotis*) middens collected from 2350-2750 m elevation near Arequipa, Peru (16°S) provide an ~9600 yr vegetation history of the northern Atacama Desert, based on the identification of >50 plant species from plant macrofossils. Arequipa is located on the Pacific slope of the Andes and receives an annual average of 100 mm of precipitation. Most of the moisture that falls in the region originates from SASM storms spilling over the Andes between December and March (80.2% at 4495 m to 91.3% at 2150 m.).

Unlike the southwestern U.S., where a scarcity of mid-Holocene packrat middens has been attributed to persistent winter drought and reduced ecosystem productivity (*1*), rodent middens of mid-Holocene age are common in the Arequipa area. Midden ages show a bimodal clustering at 0-1000 cal yr B.P. and 2800-9560 cal yr B.P. (Fig. 2). Midden floras show considerable stability throughout the Holocene, with slightly more mesophytic assemblages in the mid-Holocene. Many species occur only during the periods where middens are clustered, from 0-1000 cal yrs. B.P. and 2800-9650 cal yrs B.P. At lower elevation sites, vegetation changes noticeably around 2800 cal yrs B.P. with the disappearance or increased rarity of several species—all of which persist at higher elevation sites. Vegetation at higher elevation sites appears more stable, but a lack of middens between 3240-770 cal yrs B.P. makes this impossible to assess. A notable occurrence at these sites, however, is the appearance of two species (*Stipa ichu* and *Opuntia ignescens*) characteristic of higher, wetter latitudes around 5000-4500 cal yr B.P.

Thus, the midden record does not reflect any effects of a mid-Holocene megadrought proposed from the extreme lowstand (100 m below modern levels >6000 to 3500 yr B. P.) of Lake Titicaca (*2*), only 200 km east of Arequipa. This is perhaps not surprising, given other evidence for wetter summers on the Pacific slope of the Andes during the middle Holocene (*3*) as well as the poor correlation in summer among modern weather stations in the central Andes-Atacama Desert. A regression of historical summer (December-March) precipitation (Global Historical Climatology Network; http://www.ncdc.noaa.gov/ol/climate/climateresources.html) from Arequipa and Puno (Lake Titicaca) shows little similarity ($r^2 = 0.17$, $p = 0.128$). Juliaca and Puno, located only 50 km apart on the shores of Lake Titicaca, exhibit no more correlation

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than do Arequipa and Puno ($r^2 = 0.18$, $p = 0.120$).

Precipitation variation in the central Andes has also been linked to long-term ENSO behavior (*4*). A comparison of precipitation data from Arequipa with historical ENSO events, however, shows only three of the five wettest years occurred during El Niño events and none of the driest years occurred during La Niña events. The marginal correspondence between ENSO and precipitation, in addition to the discordance between regional paleorecords, suggests that any links between long-term ENSO phonomena and central Andes or northern Atacama monsoonal precipitation remain premature. Continued investigation of paleoclimate records from the central Andes and Atacama Desert is necessary to fully understand regional climate variability and its large-scale forcing during the Holocene. Our success in extracting rich macrofloras from Peruvian rodent middens further promotes these deposits as one productive line of evidence for past vegetation and climates of arid South America.

Literature Cited

1) Spaulding, W. G., 1995. In: Steadman, D. W. and Mead, J. I. (Eds.). Late Quaternary Environment and Deep History: A Tribute to Paul S. Martin. 139-164. The Mammoth Site of Hot Springs, South Dakota, Inc., Hot Springs, South Dakota; Betancourt, J. L. et al., 1993. *USDA Forest Service General Technical Report* **RM-23,** 42-62; Webb, R. H. and Betancourt, J. L. (1990). In: Betancourt, J. L., Van Devender, T. R., and Martin, P. S. (Eds.). Packrat Middens: The Last 40,000 Years of Biotic Change. 59-84. University of Arizona Press, Tucson.

2) Cross, S. L et al., 2000. *The Holocene* **10,** 21-32; Rowe, H. D., Dunbar, R. B., Mucciarone, D. A., Seltzer, G. O., Baker, P. A., and Fritz, S. et al., (in press). *Climate Change*; Wirrmann, D. and De Oliveira Almeida, L. F., 1987. *Palaeogeography, Palaeoclimatology, Palaeoecology* **59,** 315-323.

3) Betancourt, J. L. et al., 2000. *Science* **289,** 1542-1546; Latorre et al., (submitted). *GSA Bulletin*; Placzek et al., (submitted). *Quaternary Research.*

4) Cane, M. A. et al., 2000. *Pages Newsletter* **8,** 3-7; Rodbell, D. T. et al., 1999. *Science* **283,** 516-519; Fontugne, M. et al., 1999. *Quaternary Research* **52,** 171-179; Keefer, D. K. et al., 1998. *Science* **284,** 1833-1835; Sandweiss, D. H. et al., 1996. Science 273, 1531-1533; Martin, L. et al., 1993. *Quaternary Research* **3,** 338-346.

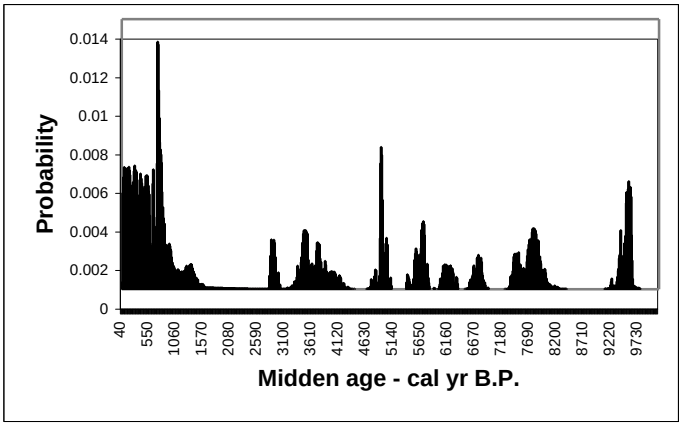

Figure1. Cumulative Probability of ^{14}C ages from rodent middens.