A 106 KYR PALEOCLIMATE RECORD FROM THE SALAR DE ATACAMA, CHILE: EVIDENCE FOR WET LATE GLACIAL CLIMATES

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Three subsurface cores (40m, 100m, and 200m) from the Salar de Atacama, Chile, ($23^0$30' S, $68^0$25' W) comprised of evaporites and minor interbedded siliciclastics, contain a 106 kyr paleoclimate record of hydrologic balances and temperatures based on closed basin paleoenvironments, 11 uranium-series dates, and fluid inclusion homogenization temperatures in halite. Comparison of the positions, thicknesses, and ages of equivalent stratigraphic horizons in each core indicates: (1) basin-center evaporite facies (saline lake halites and subaerial efflorescent halite crusts) are laterally continuous deposits and the stratigraphic record is virtually the same in each subsurface core, even across a major fault. (2) despite long periods of subaerial exposure, the stratigraphic record is temporally complete on the millennium time scale. (3) major aggradation occurs in subaerial environments via growth of efflorescent halite crusts from evaporation of groundwater brines. (4) the use of single long cores from the centers of arid closed-basins for interpreting regional paleoclimates is valid because all three cores have essentially the same paleoclimate records.

Dating of cores was done using the ^{230}Th/^{234}U disequilibrium method. Uranium is incorporated into evaporitic and detrital siliciclastic sediments during deposition in lacustrine environments. The age of a stratigraphic horizon is calculated by measuring the disequilibrium between ^{230}Th and ^{234}U and between ^{234}U and ^{238}U in evaporitic and associated detrital clastic sediments. Five horizons were dated in core 2002 and six horizons in core 2005. Ages were extrapolated to undated horizons by assuming a constant sedimentation rate between dated horizons. Stratigraphic horizons with large errors in dating lacked a uranium-rich clay component.

Saline lake deposits in the Salar de Atacama cores indicate that climate in the Central Andes was significantly wetter in the past, with the largest, freshest lake at the end of the last glacial. The wettest period of the 106 kyr record is recorded in a 5-m-thick perennial saline lake sequence, 27-16.5 ka in age, which is spatially complete across the basin center. These lake deposits contain primary chevron and cumulate halite crystals, carbonate/gypsum laminites, and fecal pellets. Laminites from the perennial lake sequence (24-19.8 ka extrapolated ages) were likely deposited during relatively low-salinity lake stages, when lake waters were undersaturated with halite but saturated with respect to carbonate and gypsum. Fecal pellets in this deposit indicates the existence of saline tolerant fauna.

Wetter conditions than the modern, represented by ephemeral saline lakes and expanded mudflats, also existed in the Salar de Atacama from 76-61 ka, 53-27 ka, 11-10 ka and at 5 ka.

Measurements of homogenization temperatures from fluid inclusions in halite are direct measurements of the temperatures of the brine from which the halite crystal precipitated. Fluid inclusion homogenization temperatures (Th) in primary subaqueous halite from each core (5243 total measurements) were used to interpret the temperatures of ancient surface brines and paleoclimates. These halites are 67-5 ka in age and have Th values within the range of average

summer-time air temperatures in the Salar de Atacama during the 1990's, 6°C to 32°C between October and March. Mean Th values for all stratigraphic intervals are within +/- 4°C of the mean modern summer-time air temperature (19°C), which suggests that warm season air temperatures have not varied significantly at the Salar de Atacama since 67 ka. The results of this study suggest that changes in relative aridity at Salar de Atacama over at least the past 67 ka were caused by significant increases in precipitation and relatively small temperature changes.

Dry, desiccated conditions, similar to the modern, dominated the Salar de Atacama from 106-76 ka, 61-53 ka, 16.5-11 ka, 10-5 ka, and <5 ka to the present. These hyperarid conditions are represented by subaerial efflorescent halite crusts, formed by evaporation of saline groundwater and precipitation of efflorescent halite crusts, which aggraded at sedimentation rates up to 2.4 m/kyr.