U-Th geochronological constraints on paleolake levels and climate change recorded in carbonate sedimentation at Laguna Lejía, Nothern Chile. S. K. Byram[1], I. Ukstins Peate[1], M. K. Reagan[1], N. A. Cabrol[2&3], E. A. Grin[2&3], [1]Department of Geoscience, University of Iowa, 121 Trowbridge Hall, Iowa City, IA 52242; [2]NASA Ames Research Center, CA; [3]SETI Carl Sagan Center, CA.

Abstract: Laguna Lejía is a saline lake located in the Altiplano of the northern Chilean Atacama desert at 4365 m. elevation. The Altiplano is currently one of the driest places on Earth, but paleolake deposits in the Altiplano record wide variations in moisture levels since the last glacial period [1]. The extreme climate combined with the high UV flux in the area provide an analogue to early environmental conditions on Mars, and allow for the study of rapid climate change as well as the study of organisms that survive and adapt in such extreme environments.

This study examines 11 samples collected from the current and past lake margins of Laguna Lejía. Petrographic analysis of thin sections reveals that the samples represent both biotic and abiotic carbonate material, and well as gypsum, trace volcanic material and clay sediment. Non-skeletal carbonate tubes occur commonly throughout paleoterrace outcrops south of the laguna. These tubes appear to be the result of carbonate precipitation around aquatic plant stems. Some samples show layers of fine, regular laminae that may represent abiotic carbonate precipitation, interspersed with layers of rough, irregular laminae that may indicate algae growth or other biologically mediated carbonate precipitation. Stromatolites and algal-laminated sediments, which have similar morphologies, are common in shallow marginal waters of saline lakes [2] like Laguna Lejía. This lamination is seen in sample 028 [Fig. 1], collected from a paleoterrace on the flow

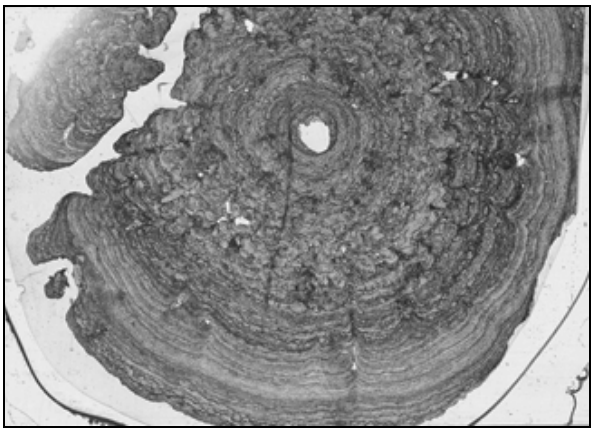

Figure 1. Sample 028 in plane-polarized light, showing alternation between smooth and rough laminae. Width of field of view 3.5 cm.

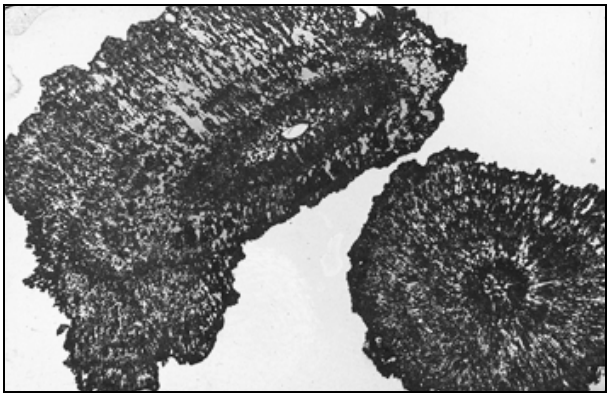

Figure 2. Sample 009 in plane-polarized light showing radially distributed elongate carbonate crystals with void space and dark clay material. Width of field of view 3.5 cm.

front of a volcanic lava that stretches towards the laguna from Chiliques Volcano. The sample has a spherical void at the center that is 2.7 mm in diameter with irregular carbonate precipitation on the inside of the tube and four distinct phases of concentric carbonate precipitation on the outside, classified as S_0, S_1, S_2, and S_3. S_0 is 1.2 mm thick and contains laminae of light colored carbonate precipitation 100-120 μm thick. S_1 is 9.5 mm thick and has irregular, bulbous laminae 120-270 μm thick which represent a period of high biological activity. The outer laminae of S_1 are darker in color due to more clay or organic material. S_2 is 3.8 mm thick and has much thinner (50-130 um), smoother laminae of carbonate that represent periods of little or no biologic activity. S_3 is 1.1 mm thick and also has thin laminae 50-170 μm across, but they are more irregular than S_2, indicating a second phase of increased biological activity.

Previous studies indicate that the maximum water level of Laguna Lejía was up to 25 meters higher than the current level and that the maximum occurred between 13,500 and 11,300 yr B.P. [3]. Studies of similar lakes in northwestern Argentina show that ^{210}Pb and U-Th series dating may give significantly different age dates than ^{14}C dating if there is a large reservoir effect from the addition of ^{14}C-free CO_2 to the hydraulic system due to volcanic and geothermal degassing [1]. Laguna Lejía is located close to active volcanoes Chiliques and Lascar and pre-glacially active volcano Aguas

Calientes [4], and therefore may be subject to similar ^{14}C-free CO_2 additions to the lake system.

U-Th series age dating was performed on sample 009 to constrain the age and extent of the maximum paleolake level and to avoid complications of carbon dating due to a possible reservoir effect. Sample 009 represents the highest elevation from which samples were collected. It was taken from a paleoterrace deposit located at 4386 m on the NE flank of the volcanic flow. It contains light and dark layers of carbonate precipitates which are less distinct and less regular than layers seen in sample 028. Thin sections reveal oval shaped tubes at the center of the samples [Fig. 2]. One tube is 1.7 mm x 0.7 mm, another is 620 μm x 200 μm. The tubes are surrounded by radially distributed elongate carbonate crystals with abundant void spaces. Preliminary U-Th analysis suggests that sample 009 was precipitated 3,757 yr B.P. with a minimum possible age of 3,476 yr B.P. and a maximum possible age of 4,038 yr B.P. The analysis shows that the lake level has dropped at least 20 m in roughly 4,000 years indicating decreased precipitation, increased temperatures, or a combination of both. This rapid change in climate provides insight into changes that have occurred on Mars, such as the drying at the Noachian/Hesperian transition. Further studies of Earth analogues will allow better identification of geo-signatures to help identify the potential presence of life on Mars and will provide critical information on the ability of organisms to adapt to extreme environments during episodes of rapid climate change.

References:

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