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Paleoclimatic Variation in the Valley of Guatemala during Precolumbian Times

Research Year: 2000
Culture: Maya
Chronology: Pre-Classic
Location: Valley of Guatemala
Site: Lake Amatitlán

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The investigators who are responsible for this project are deeply indepted to the Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI) for the funds that made the investigations possible.

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Background of the Project

At present very little is known regarding the paleoclimate of highland Guatemala. The information that we have is based largely on a number of paleoclimate investigations that have been carried out in recent years in the lowland regions of Mesoamerica. These data were obtained by sediment coring in lakes Petén Itzá, Quexil, Salpeten and Petenxil (Brenner, 1994; Curtis *et al.*, 1998; Islebe *et al.*, 1996; Leyden *et al.*, 1993) in the Department of Petén, with similar investigations in the Yucatán peninsula, including Lake Cobá and Cenotes San José Chulchacá, Sayaucil, and Chichancanab (Curtis *et al.*, 1996; Leyden *et al.*, 1996; 1998) Additional studies have been carried out in the Candelaria watershed (Gunn and Folan, 1995; Gunn, Folan and Robichaux, 1995). Lake sediments are particularly useful for determining ancient climate patterns because they often contain pollen which provide clues to the nature of the ancient vegetation in the area, phytoliths as indicators the presence of maize agriculture, and microfossils (ostracods and gastropods) which are sensitive to temperature and humidity changes.

The chronology for the lowland paleoclimate sequences that began at the termination of the Pleistocene glacial period is based on radiocarbon dating with climatic inferences established largely on the basis of pollen and isotope geochemistry ($\delta\ _{18}O$) of carbonate shells. These data can be used to infer past changes in the relation between evaporation and precipitation (E/P). By this means, the following pattern of alternating cool/dry and warm/wet periods in the Precolumbian Guatemala lowlands and Yucatán was determined (Leyden *et al.*, 1996):

3850 B.C. – 1800 B.C.	Moist conditions
1800 B.C. – 1 A.D.	Long term drying trend
1 A.D. – 900 A.D.	Oscillation to wetter and more seasonal
900 A.D. – Historical	Resumption of drying trend

It remains to be determined whether the Guatemala highlands reflect a similar pattern or what differences may exist in comparison with the lowlands. It has been noted that the most severe dry period in northern Yucatán occurred around 900 – 1000 A.D., a time contemporary with the collapse of Maya civilization (Hodell *et al.*, 1995; Curtis *et al.*, 1996). It seems very probable that climatic stress was one of the factors that complicated the deteriorating situation at the end of the Classic period. It may be that wet and dry periods among geographically distant sites coincided, suggesting that climatic events were widespread and may have played a critical role in cultural developments. However, it is not known to what degree climatic events in the lowlands were comparable to with those in the Guatemala highlands, nor whether changes in weather patterns in both regions were simultaneous with one another. Without adequate climatic reconstructions from highland sites, the effects of climatic change in the region cannot be inferred.

It was in view of the above consideration that we initiated our study of the paleoclimate of the Valley of Guatemala. The valley is situated at an altitude of 1500 m above sea level and is the location of a major Precolumbian site, Kaminaljuyú, where considerable archaeological investigations have been carried out in recent years. It was hoped that we might obtain a record of temporal climatic patterns in this area over the past 3000-4000 years, with a special focus on the period 1000 B.C. to 1000 A.D., the time that Kaminaljuyú was flourishing.

The Objectives of the Paleoclimate Project

There were two basic reasons for our interest in investigating the paleoclimate of the Valley of Guatemala. One of these was based on the fact that archaeological excavations at Kaminaljuyú during the 1980s and 1990s (Popenoe de Hatch, 1997; 1999; Barrientos, 1998) had revealed the presence of two irrigation canals which supported a system of hydraulic agriculture that began around 600 B.C. or earlier (Figure 1). The canals drained from a post-Pleistocene lake, termed Lake Miraflores that dried up around 200 A.D., at which time the canals fell into disuse. The lake apparently had formed in a fault-caused depression which collected water from rainfall and local springs. The objective of the Paleoclimate Project was to determine to what degree the desiccation of the lake was due to climatic change, or to human over-exploitation of the water, or both factors.

A second objective of the Project was to determine to what degree the paleoclimate of highland Guatemala correlates with the patterns from the Mesoamerican lowlands (México, Yucatán and the Caribbean), information which had been previously obtained and analyzed by Drs. Brenner and Curtis (see, for example, Brenner, 1994; Curtis *et al.*, 1996; 1998). The methodology requires obtaining cores from lake sediments and, based on the presence of microfossils and pollen associated with radiocarbon dating, changes in climatic patterns can be observed. Lake Amatitlán just southwest of the valley of Guatemala was chosen as the best place to obtain cores. Although the lake had been investigated for climatic inferences by E. Deevey and M. Tzukada (1967), it was considered that additional cores could supplement the information and provide a more comprehensive sequence of dates.

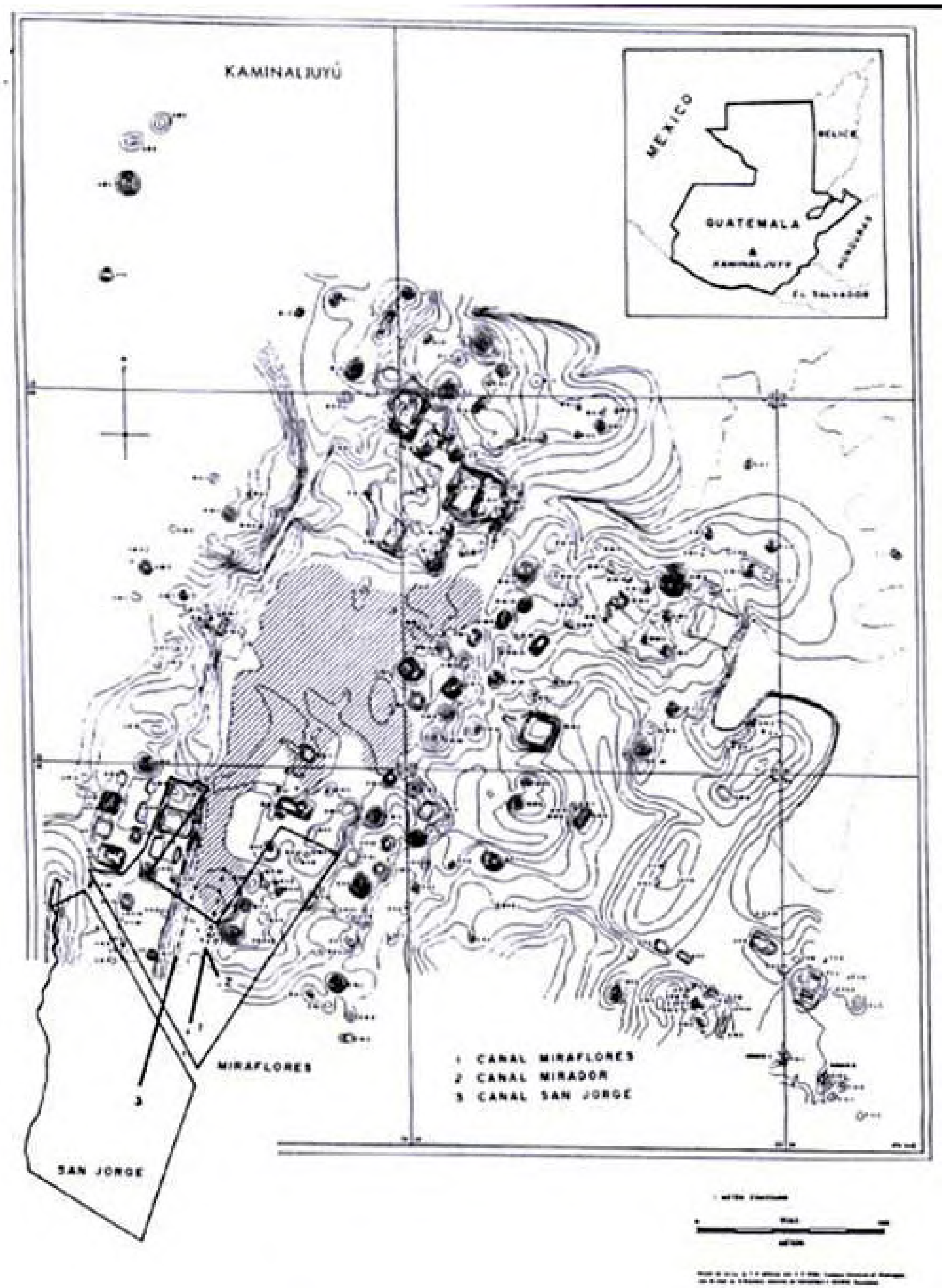


Figure 1: Map of Kaminaljuyú showing its location in highland Guatemala and its association with the ancient Lake Miraflores (hachured area). The sections investigated by the San Jorge and Miraflores archaeological projects are indicated at the lower left, where the San Jorge, Miraflores, and Mirador irrigation canals were encountered. (Michels 1979, adapted by A. Roman).

The investigations of the paleoclimate of the Valley of Guatemala were carried out during the month of March, 2000. Drs. Mark Brenner and Jason Curtis arrived from the University of Florida, Gainesville, on March 5. The two investigators with the project in Guatemala were Dr. Marion Popenoe de Hatch and Licenciado Erick Ponciano.

Samples recovered from the bed of the extinct Lake Miraflores (6-11 March, 2000)

In preparation for soliciting funds from FAMSI, we had opened a test pit in the dry bed of the ancient Lake Miraflores. In September of 1999, Dr. Brenner had removed samples of the sediments down to a depth of 200 cm (for profile of the test pit, see Figure 2). His subsequent analysis of the samples revealed the presence of diatoms of the genus Pinnularia and a few of the genus Aulacoseira, beginning at a depth of 145 cm, indicating the ancient presence of standing water. Upon receiving the funding we hired two workers in March, 2000, to re-open the pit. This time it was taken down to 315 cm where the sedimentary deposits became extremely hard and difficult to excavate. Dr. Brenner employed the same methodology as that of the previous September, extracting by trowel a sample of soil at 5 cm intervals from the side wall of the pit (Figure 3). The samples were extracted from the west profile, beginning at 50 cm below surface and continuing down to 315 cm. Sub-samples from 170 to 315 cm in the profile were transferred to labeled Whirl-pak bags to be transported to the U.S. by Brenner and Curtis (samples above these levels had already been removed and taken for analysis in September, 1999).

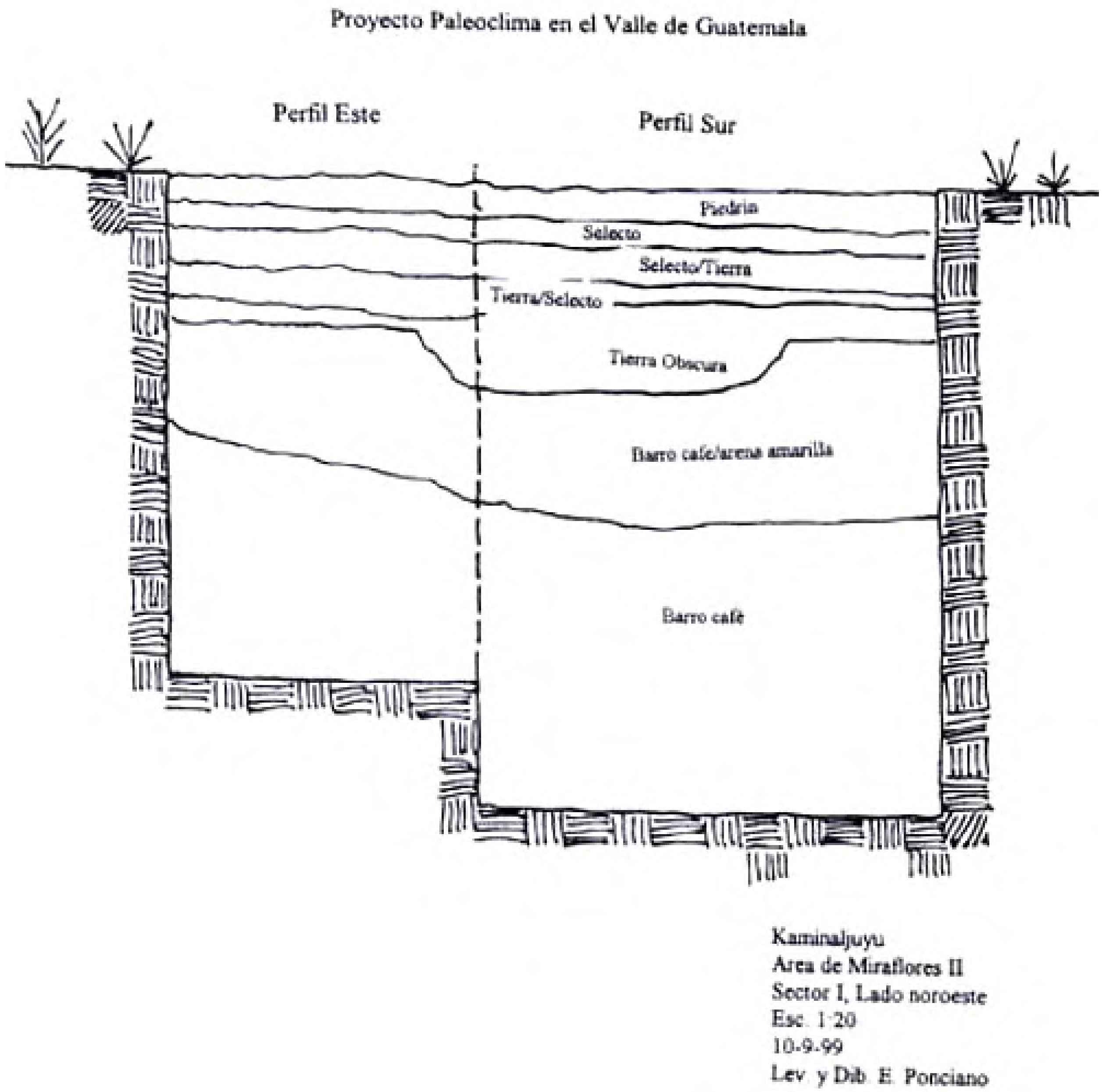


Figure 2: Profile of the test pit excavated to a depth of 200 cm in the area of Kaminaljuyú Miraflores during September, 1999. Layers 1-3 pertained to recent activity; layers 4-5 contained a few Preclassic sherds; layer 6 consisted of clay mixed with disintegrated pumice particles; layer 7 was composed of dark brown clay which became increasingly more compact in the lower levels.

Figure 3: Photographs of excavation in the bed of extinct Lake Miraflores.

Figure 3a: Test pit being initiated, showing the encroachment of the buildings of Guatemala City into this area.

Figure 3b: Dr. Brenner starting the sampling in the test pit at Kaminaljuyú, 1999 season.

Figure 3c: Student from Universidad del Valle assisting in the sampling, 2000 season.

Figure 3d: Close-up view of sampled test pit.

Sufficient soil was removed to provide stratigraphic samples for Ingeniero Franklin Matzdorf to carry out an analysis of physical properties in the Civil Engineering Laboratory at the Universidad del Valle de Guatemala. Based on his analysis, the contents of the pit fall into three major strata: 50 – 100 cm; 100 – 210 cm; 210 – 315 cm. Stratum 1 corresponds roughly to layers 1 to 6 in Figure 2, Stratum 2 to level 7, the third stratum to the excavation carried out in March 2000. He reports that Strata 2 and 3 show extreme impermeability which would be characteristic of lake bottom sediments. The details of the physical characteristics will have relevance when view in light of the pollen and microfossil analysis.

Core samples removed from Lake Amatitlán (13-15 March, 2000)

Personnel: Dr. Mark Brenner, Dr. Jason Curtis, Lic. Erick Ponciano, Dr. Guillermo Mata, Ing. Federico Gularte Hernández (AMSA), Ing. Juan Fernando Valladares Morales

(AMSA), Carlos M. Vega (AMSA), Jaime Adolfo Estrada (AMSA), Arturo Olivares (AMSA). (The initials AMSA indicate that these people work for the management of Lake Amatitlán (Autoridad para el Manejo Sustentable de la cuenca y del lago Amatitlán).)

Figure 4a: Investigations in Lake Amatitlán. View of the lake.

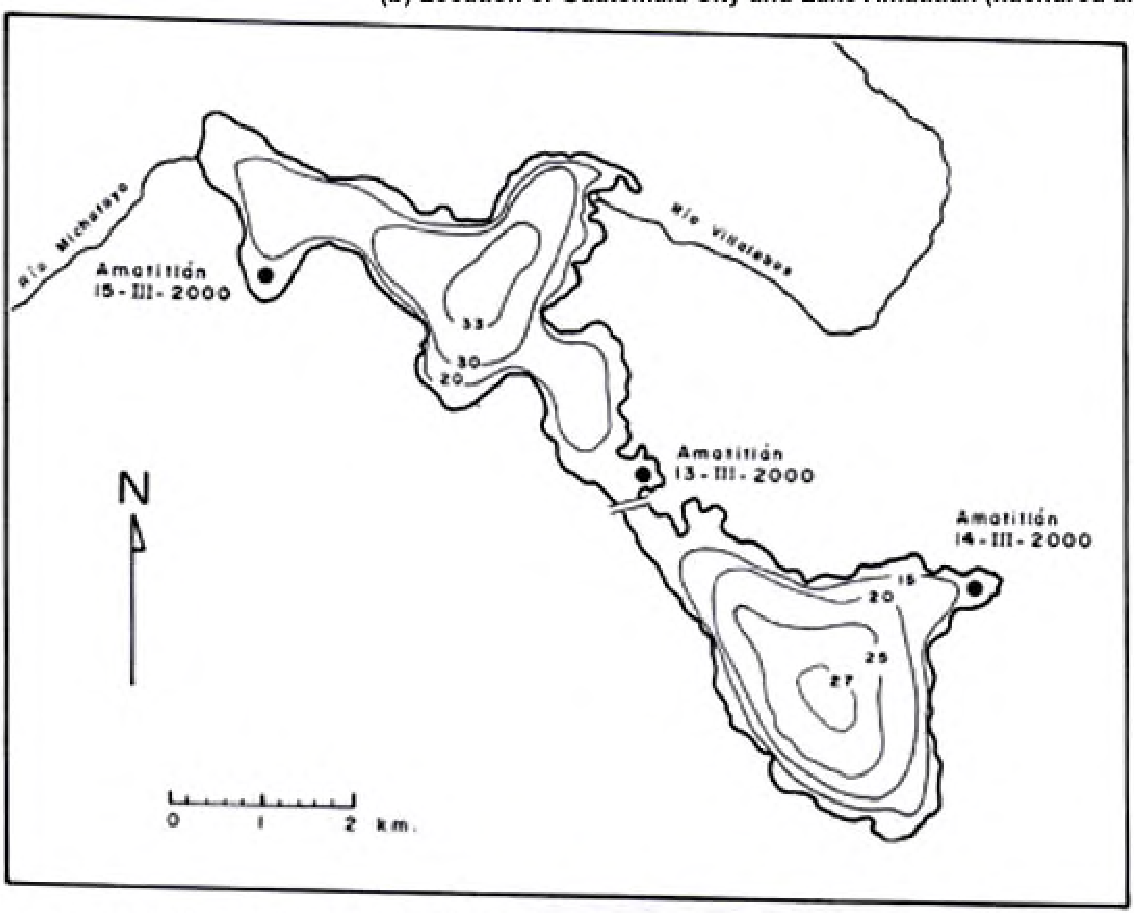
Figure 4b: Core barrel used by Brenner & Curtis to remove samples from Lake Amatitlán.

The main equipment used for lake coring was brought from the U.S. by Drs. Brenner and Curtis; appropriate tubing, rope and other necessary materials were purchased in Guatemala (Figure 4). A boat was loaned by the Friends of Amatitlán through the help of Dr. Guillermo Mata, who also provided information and a map showing the depths at closely spaced intervals around the lake. Three stations were selected as appropriate for coring (for details see Appendix. For locations of the stations, see Figure 5).

Drs. Brenner and Curtis began the sampling on March 13, continuing over the next two days. Sediment/water interface cores were extruded and sampled at 4 cm intervals into a tray attached to the top of the core barrel. The sediment was transferred to labeled Whirl-pak bags, then placed in Zip-lock bags and stored in a Rubbermaid container. A description of the coring follows (also see Appendix).

a) Location of the valley of Guatemala and Lake Amatitlán.

(b) Location of Guatemala City and Lake Amatitlán (hachured area).



(c) Plan view of Lake Amatitlán, copied from a portion of the Instituto Geográfico Nacional de Guatemala (1:50,000) map of the area. The plan shows approximate contours of the lake and location of stations used for vertical coring sections.

Figure 5: Map of Guatemala and Lake Amatitlán.

Station 1 (site 13-III-2000 on Figure 5) was established in the bay just to the north of the railroad crossing that separates the lake into two basins. Water depth at this site was 13.0 m;. GPS coordinates were N 14°27°23.3" and W 90°33°57.8". Seven drives were completed, ultimately reaching a depth of 475 cm below the sediment/water interface.

Station 2 (site 14-III-2000 on Figure 5) was in the bay in the southeastern area of the lake (southern basin). Water depth was 11.05 m; GPS measurements were N 14°26°45.5" and W 90°31°53.7". A total of eight drives were accomplished, obtaining samples down to a depth of 544 cm.

Station 3 (site 14-III on Figure 5) was in the northwest area of the lake (northern basin). Water depth was about 13.6 m; GPS measurements were N 14°28°27.1" and W 90°36°17.5". At this station nine drives were made, obtaining samples down to a depth of 701 cm.

All core material was subsequently transferred to the University of Florida Department of Fisheries and Aquatic Sciences where it was stored in a cooler kept at 4°C.

AMS C14 Dates

In December we received the AMS radiocarbon dates from the Amatitlán cores, for which we are deeply indebted to the Center for Accelerator Mass Spectrometry at the Lawrence Livermore National Laboratory.

Location	Depth	C14 Date	Approx. Cal. Year
AM-13-III-00	419-421 cm	660 ± 60	1290 A.D.
AM-14-III-00	541-543 cm	1650 ± 50	300 A.D.
AM-15-III-00	240 cm	710 ± 50	1240 A.D.
	340 cm	2910 ± 130	960 B.C. (anomaly)
	440 cm	1530 ± 190	420 A.D.
	540 cm	2010 ± 100	60 A.D.
	610 cm	2340 ± 110	390 B.C.
	690 cm	2570 ± 40	620 B.C.

The dates are in general quite young, ranging from around 600 B.C. to sometime between 1200 and 1300 A.D. The AM-15-III-00 date is apparently an anomaly, probably a reflection of the high sedimentation rates in the lake area. Although the dates will provide little information regarding post-Pleistocene climate changes, they will be highly relevant for correlating any climatic variation which may have affected the Kaminaljuyú irrigation system which existed between 600 B.C. and 200 A.D.

Magnetic Susceptibility Analysis

At the end of June, 2000, Dr. Brenner took the cores to the laboratory at Florida State University, Tallahassee, to run them through the Multi-Sensor Core Logger to determine the magnetic susceptibility profiles. This analysis should help reveal the sediment stratigraphy of the cores to correlate with the AMS carbon-14 dating.

Further funding is being sought for the analysis. The pollen content of the cores is currently being investigated by Dr. Barbara Leyden of the University of South Florida. Dr. Jason Curtis will analyze the samples for isotope ratios on microfossil (gastropods and ostracod) shells, the most critical indicators in tracing climatic change. His work will include an analysis of the geochemistry of the sediments, including evidence of vulcanism. We expect to have these results within the next few months so that, when correlated with the radiocarbon and magnetic susceptibility data, final conclusions can be drawn up and published.

Appendix

The following is a detailed report provided by Dr. Brenner regarding the sampling at Lake Amatitlán.

Station 1 13 March 2000

A. 13-III-2000-MWI. First attempt at mud-water interface (MWI) core failed, as we did not have any water on top of the interface. This try was made starting the drive 20 cm down from the top of rod #8 (i.e. 13.24 m below water surface). The retry, starting 40 cm down from the top of rod #8 yielded a good MWI core about 75 cm long.

B. 13-III-2000-1. Nominal drive was 50-150 cm depth in the sediment, or about 25 cm overlap with the MWI core. We tried four attempts before getting a satisfactory, complete drive.

C. 13-III-2000-2. Good, full drive (150-250 cm), though there was some bending of the rods on the way down. Will require casing pipe for further coring.

D. Set 15 m of 3" PVC casing pipe. We repeated drive 2 and discarded the collected sediment. This was done to clean the hole to a depth of 250 cm below the sediment surface.

E. 13-III-2000-3. Drive 3 went smoothly and we retrieved sediment from 250-350 cm.

F. 13-III-2000-4. Drive 4 was an incomplete drive because the sediments were dense and resistant. We retrieved 67 cm of material, or 350-417 cm below the sediment/water interface.

G. 13-III-2000-5. Drive 5 was an incomplete drive because the sediments were dense and resistant. We retrieved 58 cm of material, or 417-475 cm below the sediment/water interface. End coring.

Station 2 14 March 2000

A. 14-III-2000-MWI. Retrieved an 80-cm MWI core with about 15 cm of water over the sediment surface. For drive 1, we marked up 65 cm on the rod from the start of the MWI drive. This accounts for 15 cm of water and 50 cm of sediment. We expect about 30 cm of overlap between drive 1 and the MWI core.

B. 14-III-2000-1. Nominal drive was 50-150 cm depth in the sediment, but the piston did not lock and we had to push several times to complete the drive. Will set casing and redrill to 150 cm to clean out the hole.

C. Cleaned out mud in the casing pipe to a depth 150 cm below the sediment interface.

D. 14-III-2000-2. Good, full drive (150-250 cm). A few cm of bottom deposits were hanging from the end of the core tube on retrieval, probably due to gas expansion. Material was cut and placed in a labeled bag. There appear to be snails at some depths in this section.

E. 14-III-2000-3. Good, full drive (250-350 cm). Took a lunch break.

F. 14-III-2000-4. Only retrieved 75 cm (350-425 cm), and piston did not trigger properly.

G. 14-III-2000-5. Retrieved 54 cm of mud (425-479 cm).

H. 14-III-2000-6. Retrieved 65 cm (479-544 cm) and the sample appeared to terminate on an ash layer. We evidently hit a gas pocket because the casing had some serious bubbling going on for several minutes.

Station 3 15 March 2000

A. 15-III-2000-MWI. Retrieved an 85 cm MWI core with about 12 cm of water over the sediment surface. We began the drive at the joint between rods #8 and #9, i.e. 13.44 m below the water surface. For drive 1, we marked up 60 cm on rod #9 from the start of the MWI drive. This accounts for 12 cm of water and ~50 cm of sediment. We expect about 35 cm of overlap between drive 1 and the MWI core.

B. 15-III-2000-1. Nominal drive was 50-150 cm depth in the sediment. Came up full with a few cm hanging from the bottom end of the core tube. This was cut and placed in a labeled bag.

C. 15-III-2000-2. Drive was attempted without casing. Piston did not release on first attempt. We reset piston and cored a second time without casing, retrieving a full drive (150-250 cm).

D. Set 5 sections (15 m) of 3" PVC casing, with casing down about 1.5 m in mud. Cleaned out mud in the casing pipe to a depth 250 cm below the sediment interface.

E. 15-III-2000-3. Good, full drive (250-350 cm).

F. 15-III-2000-4. Complete drive (350-450 cm), but we needed to hammer through some hard material. Once we hammered through the hard section (5-10 cm thick), we pushed the rest of the drive. The second boat then pulled up to us and the turbulence moved us off station. The second boat reset one anchor and we were able to position ourselves at the casing pipe again.

G. 15-III-2000-5. We pushed and then hammered the last ~30 cm of the drive. The nominal drive was 450-550 cm, but the section length was about 96 cm.

H. 15-III-2000-6. Retrieved 70 cm of mud (550-620 cm), which required hammering.

I. 15-III-2000-7. Retrieved 81 cm of mud (620-701 cm), which required hammering. There are several sand layers evident in the core.

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