Geoarchaeology of the Salinas de Chao Paleo-embayment Chao, Peru

Summer 2011 Field Season Report

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Project Summary

The Chao paleo-embayment is located just south of the Chao River mouth. A relict escarpment with a log-spiral beach plan-view marks the paleo-embayment. The elevated surface surrounding the escarpment is littered with archaeological sites. Today the paleo-embayment is a flat Salinas environment devoid of life. It is hard to imagine that this harsh desert environment with temperatures reaching into the 80 degrees Fahrenheit range even during austral winter once supported a large Preceramic population. In order to understand changes in the archaeological record an accurate environmental record is essential. By dating changes in sea level in the paleo-embayment the 2011 field expedition aimed to create such a chronology. My strategy was to find datable organics at the furthest point of inundation along the paleo-embayment by digging trenches at the interface between the escarpment and the paleo-embayment. In doing so the project aimed to better understand past environmental conditions in this area as well as how the timing of changes in this environment coincided with changes in human occupation of the area.

The National Geographic Society, the Churchill Fund, and a generous donation by Marshall Cloyd funded the project, which took place July 17th through July 20th 2011. I conducted a survey of the escarpment and directed the excavation of several test pits along the apex of the paleoembayment's escarpment, where datable organics were recovered. Samples of both the organics and soil were shipped back to the University of Maine under a USDA soil permit (permission provided by Dr. Ann Dieffenbacher-Krall) and are currently stored in the Paleoecology Research Laboratory at the University of

Maine. In the coming months the soil samples will be sorted for ecological indicators such as diatoms and the organic material will be sent off for radiocarbon dating.

Logistical Information

National Geographic funding was provided through a grant obtained by Dr. Daniel H. Sandweiss for his GPR fieldwork at the Los Morteros mound site in the Chao paleo-embayment. This grant was graciously extended to include this project with the remaining funds. The Churchill Fund also provided me with funding.

Francisco Burga C. of the San Simon Agroindustrial Company provided the permit to use the access road into the study area. I rented a truck for the duration of the project from R & R Cargueros S.A.G in Trujillo, Peru. The crew consisted of three volunteers Caitlin Smith Lackett, Henry Annesley, and Oswaldo Chozo Capuñay. I ran this project as part of my pursuit of a Masters Degree in Climate and Quaternary Studies from the Climate Change Institute at the University of Maine. The project began July 17th Caitlin Smith Lackett and I did a reconnaissance of the escarpment's southern extension from the inland apex to the modern shoreline (Figure 1). The following day Oswaldo Chozo Capuñay joined in as the crew began excavating several test pits along the edge of an alluvial fan deposit that bisects the paleo-shoreline escarpment. On July 19th Henry Annesley joined the project and the crew began excavating an outcrop of unconsolidated debris flow deposits exposed on one section of the shoreline. Later this day Caitlin Smith Lackett and I conducted another field survey of the northern extension of the escarpment. On July 20th we dug a transect of test pits from the escarpment out into the dried embayment. July 21st we extended this transect sketched, sampled, and backfilled.

Setting

The Chao Valley is located in northern Peru between 78.56^{o} - 78.30^{o} north latitude and 8.30^{o} -8.48^{o} west longitude. The Chao River is the driest drainage in the Peruvian Andes; it begins at the foot of the Ururupa mountain range where the rivers Chorobal, Cerro Blanca and Huamansana join. Located in the coastal subtropical zone, the Chao Valley is arid with an average temperature of 78^{o} F and scarce annual rainfall (7mm minimum and 44 mm maximum) (Uceda, 1988). The soil in this region is rocky and low in nutrients, and the watertable is salinized with borate salts. All of these factors contribute to the lack of wildlife and sparse plant species (Tillandsia sp., cactus, zapote, and salt grass in the Salinas zones) (Alva, 1986).

The paleo-embayment is located 8 km southeast of the Chao river mouth and is surrounded by coastal mountains, Cerro Jaime to the northeast and Cerros de Coscomba to the southeast. The Salinas are located on a flat plain that stretches from the modern shoreline 3 km inland to an escarpment. This escarpment, which has a log-spiral beach form, likely represents the location of the interface between the paleo-beach face and the terrestrial zone. The escarpment is between 5 and 20 m above the flat Salinas plain and is eroded away in several locations by alluvial ravines. Additional features on the Salinas include several large dune fields growing southward draping the mountains to the north. Previous work done in the area used shell and plant remains on the Salinas plain to date the gradual regression of the shoreline seaward from 5000 to 3000 years before present (Perrier et al., 1994). However, this research did not date the interface between the paleo-embayment and the escarpment and thus did not date the furthest point of inundation, which my research aims to do.

The Chao Valley contains some 190 archaeological sites; of these 21 are Preceramic sites located on the surface of the raised escarpment surrounding the paleoembayment (Cardenas, 1977; Cardenas, 1999). Remains of gourds, mollusks, cotton, fish, and whale indicate that during the Preceramic the Chao paleo-embayment supported a thriving society with a mixed maritime and terrestrial economy. Considering the dry and desolate conditions of the area today, it is clear that severe changes have occurred on this landscape since its previous occupation.

Research Design

This study tests the postulate that the local environment surrounding the Chao paleo-embayment which supported Preceramic populations has changed drastically due to sea-level change, intensified weather patterns with the onset of El Niño, increased aridity, and water table salinization. The research is concerned primarily with comprehending the temporal and spatial dimensions of the interaction between humans and their environments using the interdisciplinary research program of Historical Ecology (Balee, 2006). While this project focuses on the environmental record recovered during the Summer 2011 field season, due to permit restrictions, funding, and time constraints. I do not however, plan to exclude the element of human agency in environmental change. I will use previous research conducted in the area, which has focused primarily on the archaeological component, to corroborate the findings of this study. Below I review the previous research done in the area on the human component.

In 1976, a large archaeological project excavated 7 sites surrounding the Chao paleo-embayment. Of these was Los Morteros (site 7), a large elliptical landform, is a sand draped temple-like structure. Los Morteros was first believed to be a natural dune formed by bedrock catchment and overlain with anthropogenic midden deposits (Cárdenas Martin, 1995) this was later disproved using GPR (ground-penetrating radar) to reveal the temple-like substructure (Sandweiss et al., 2010). Los Morteros' western side overlays a paleo-shoreline; this geomorphic relationship has been cited as evidence for its construction subsequent to the Holocene transgressive maximum (Wells and Noller, 1999). The initial date of construction at Los Morteros is unknown, but radiocarbon dates from near surface organic matter place its abandonment between 5,462- 3,623 cal yr BP (Sandweiss, 1983; Cárdenas Martin, 1995; Cárdenas Martin & Vivar Anaya, 2002). While Los Morteros maybe one of the earliest sites in the paleoembayment, the site Salinas de Chao (site 10) may well represent the last Preceramic occupational period. This site was excavated as a part of the 1976 archaeological project by Walter Alva and has an occupation date of 4100-3000 cal yrs B.P (Alva, 1987). Other sites of interest excavated at this time are Piedras Negras A & B which are located along the main arroyo draining into the paleo-embayment from the northeast. Piedras Negras A (site 137) is located closest to the embayment and dates to 5211- 4765 cal yrs. B.P. while Piedras Negras B (site 138) is located further up the channel and dates to 5431- 3370 yrs. B.P.. Salinas de Chao is located where the channel meets the foot of Cerro Jaime. The relationship between the location of these sites and the channel may be the result of a diminishing spring source coming from the base of the mountain; as the spring began to dry up and retract, settlements followed the spring. All of the sites thus far mentioned support the idea that this area has become increasingly arid since its last preceramic occupation nearly 3000 years ago.

While sea-level stabilization in this area is estimated between 7,000-5,000 cal yr BP (Wells, 1996; Perrier et al., 1994), the paleo-shoreline around the sites has never been directly dated. Knowing when the paleo-shoreline was active, how the environment evolved over time in response, and the processes that caused its eventual retreat is imperative for future research concerned with environmental change in the archaeological record of the area.

Methods

In order to determine when sea level changed in the Chao paleo-embayment this research project will directly date the paleo-shoreline associated with the site using radiocarbon samples obtained from the sedimentary sequence at the paleo-shoreline's edge. The shoreline was surveyed to locate the best location for uncovering shallow beach sequences. Several test pits were dug in the proximity of the alluvial fan under the theory that thick consolidated alluvial deposits would aid in maintaining a secure profile on one side of the pit even if the beach sediments were unstable on the other side. Unfortunately, finding the contact of the edge of the fan and the beach face proved difficult and we had to take a new approach. While the vast majority of the shoreline is draped in aeolian sand one section of the escarpment is not, and an outcrop of the underlying material below the surface where archaeological sites rest is exposed. Starting here, a large pit was dug down to semi-consolidated bedrock. Then a series of trenches was extended seaward into the paleoembayment. Each trench was mapped, photographed, GPS coordinates were taken and soil was sampled down the profile with each change in the natural stratigraphy.

Findings

A walking survey covered the southern extent of the escarpment (see Figure 1). Sinuous drainages from El Nino periods of anomalous rainfall, expanding dune fields, cobblestone beach ridges, and rock outcrops all bisect the paleo-shoreline escarpment (see Figure 2). Within the paleoembayment is a flat pampa or Salinas. Here the water table is very close to the surface and driftwood is prevalent (Figure 3). In addition to drift wood anomalous clusters of wood, charcoal, shell, and salt are present (Figure 4). A large shell scatter of a single species is located on the southeastern margin of the escarpment (see Figure 5). Along the northern bend of the escarpment, a large dune field covers the surface where archaeological sites are common (Figure 6). Toward the southern seaward side of the escarpment approximately 1.2 km from the modern shoreline, two gravel beach ridges jut out of the escarpment. Atop one ridge is a black archaeological midden covered in charcoal, dead trees in living position, and ceramic fragments (see Figure 7). Also in this part of the paleo-embayment is a large shell midden lacking ceramics and architecture measuring roughly 20 m in diameter. We walked over and recorded these sites along with the other 19 archaeological sites surrounding the embayment.

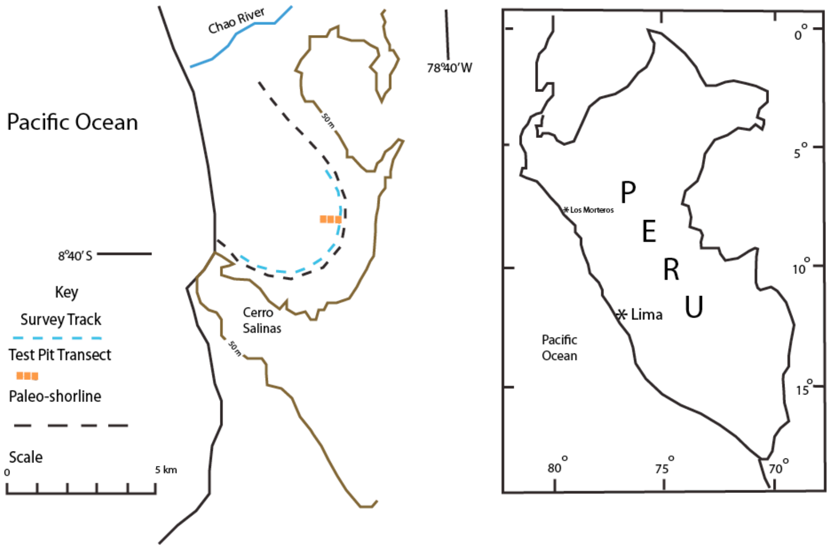

Figure 1: Map of Field Area

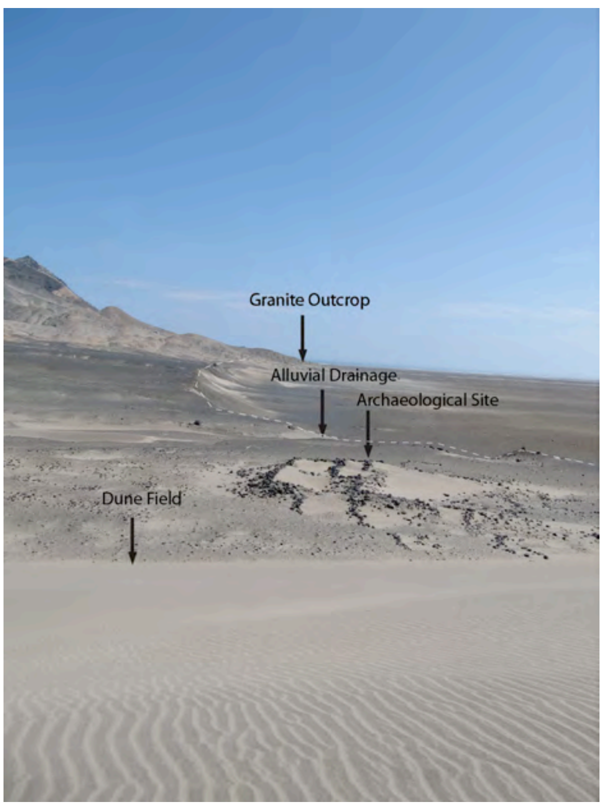

Figure 2: Picture of paleo-shoreline escarpment's southern extent facing west (escarpment outlined in white dotted line). The various features highlighted are common along the shoreline.

Figure 3: Flat Salinas showing water on surface and abundance of drift wood.

Figure 4: Wood, salt, shell, and charcoal clusters.

Figure 5: Shell Scatter on surface of paleoembayment with inset of shells close up with scale equal to 10 cm.

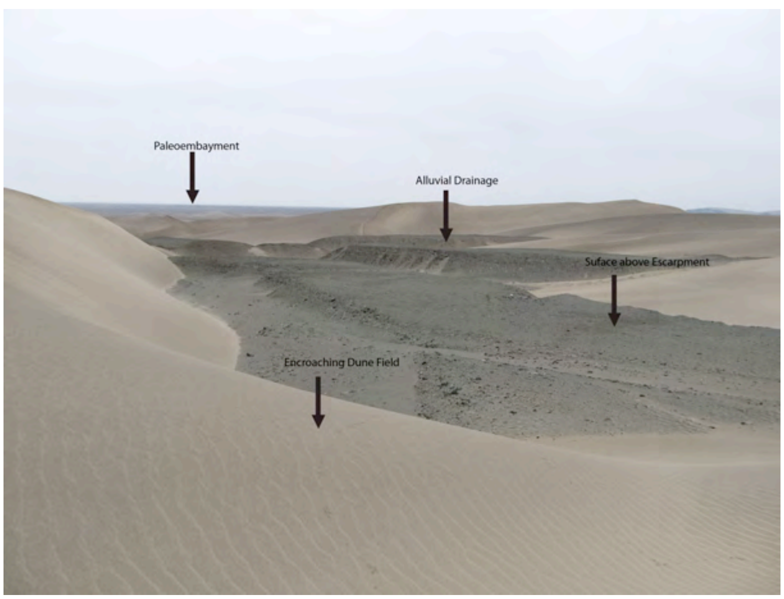

Figure 6: Shoreline within dune field along the northern bend of escarpment facing west.

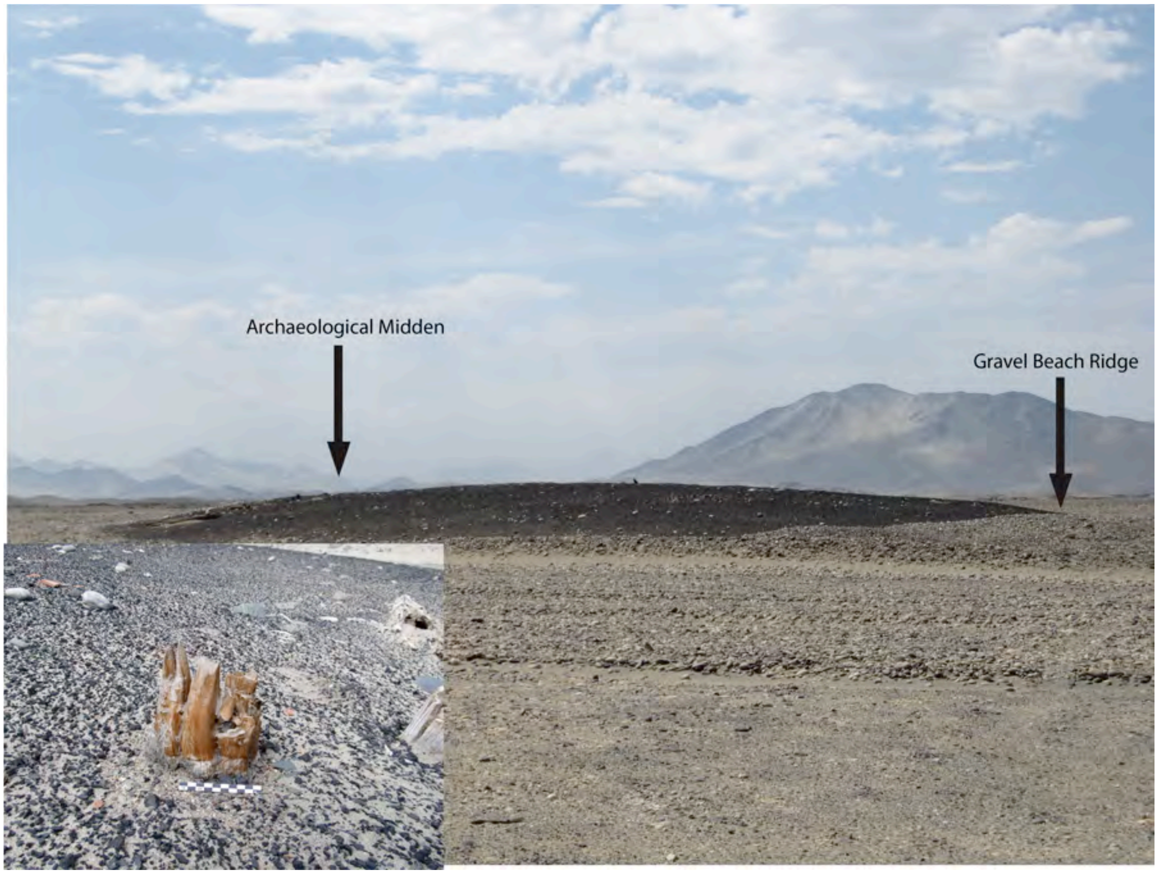

Figure 7: Archaeological midden located on gravel beach ridge inside paleoembayment. Inset shows tree in living position on midden surrounded by charcoal and ceramic fragments.

The field crew dug two series of test pits in order to obtain datable remains. The first transect of test pits was done near an alluvial fan, because a debris flow could provide a sturdy profile wall on one side of the test pits. Unfortunately, the alluvial fan outwash through the drainage is intermixed with layers of aeolian sand, making the profile very unstable and hard to dig. Further undermining this approach was the issue of finding the extent of the outwash and its contact with the paleo-beach face, at which the crew was unsuccessful. No beach-like strata were found in the first transect and thus we took a new approach. The second transect of test pits was placed at an exposed outcrop in the escarpment where no alluvial fan outwash deposits were visible at the surface. Figure 8 shows the location of these transects.

Figure 8: Shows the two transect test pit locations and the archaeological site Los Morteros.

The following is a summary of test pits grouped by transect. Test pits 25-29 are part of transect one and pits 41-47 are part of transect two. Pits are listed by transect and in order of their distance from the escarpment. The term alluvium is used here to mean intermixed angular poorly sorted clasts with sand.

Transect One

Test Pit 25: Sand and angular poorly sorted clasts (20 cm- 1mm). The strata were homogenous and the concentration of clasts made excavation exhausting, therefore work was halted at a depth of 60 cm.

Test Pit 26: Interbedded alluvium and aeolian sand. The strata begin with an aeolian sand layer followed by a thin layer of grey sand mixed with small clasts ~2 mm in size. These layers are underlain by another layer of aeolian sand, then a thin lamination 5 mm thick of clasts < 1 mm in size, and a third layer of aeolian sand. Next in the sequence is a thick layer of alluvium (20 cm), another layer of aeolian sand, and an even thicker layer of alluvium with clasts ranging from 15 cm to 1mm in size. Finally, a layer of aeolian sand was found at a depth of 140 cm at which point the pit began to collapse.

Test Pit 27: Interbedded alluvium and aeolian sand. Much like pit 25, this pit contained mostly large angular clasts. The pit was capped by a layer of aeolian sand, followed by a 7 cm level of clasts ranging in size between 2 cm- 15 cm, a thin layer of sand 3 cm thick with small pebbles in it about 1-4 mm in size, another layer of alluvium about 12 cm thick follows this again with clasts of 2-15 cm in size, and again another thin layer of sand 2 cm thick with pebbles 1-4 mm in size. This is underlain by a layer of alluvium 31 cm thick with clasts between 2-15 cm and the final layer is aeolian sand reaching a depth of 100 cm.

Test Pit 28: The first 50 cm consist of fine quartz sand with red iron oxide staining, a porous texture, and mineral nodules. From 50-70 cm the red staining is less apparent and the sand is mixed with silt however the mineral nodules continue. From 70 to 100 cm the sand contains mica flakes and lacks the red staining entirely.

Test Pit 29: Capped by aeolian sand, a 40 cm layer of graded alluvium begins with angular clasts 10-4 cm in size for the first 10 cm followed by a gradual shrinking of clast size for the next 30 cm. Where the bottom of this layer is mostly clasts 2-4 mm in size. Next is a small layer of sand with interspersed small clasts 1-2 mm in size and a layer of grey sand with mineral nodules, quartz sand with mineral nodules and finally a quartz sand with black laminations (biotite) and clay nodes at a depth of 100 cm.

Transect Two

Test Pit 41: An exposed outcrop of debris flow 2.3 meters high. Homogenous sand extended 1.7 m below the outcrop. The bottom 25 cm that contain interspersed purple, green, and white mineral staining. We did not excavate to the bottom of this deposit.

Test Pit 45: This pit was capped by light olive brown sand mixed with small clasts 4-1 mm in size. Next was layer of dark grey sand with small pebbles <1 mm in size. The next layer was a grayish brown sand with waved bedding and crushed shell. The deepest sand layer contained fish vertebrae and charcoal. The total depth of the pit was 125 cm.

Test Pit 42: Interbedded aeolian sand and alluvium with crushed and whole shell intermixed. Semi-consolidated salt concretions were unearthed on the floor of the test pit, which halted excavation at a depth of 85 cm.

Test Pit 44: This pit was capped by aeolian sand, followed by a thin layer of 5 cm of salt minerals intermixed with clasts 1-2 mm in size, a 8 cm layer of interbedded grey and black sand laminations, a 5 cm layer with red and brown mud laminations, a thick (25 cm) layer of salt concretions, and a well sorted grayish brown sand with red organic staining in semi-circle shapes. The total depth of the pit was 73 cm.

Test Pit 47: Capped by aeolian sand, followed by a level of sandy clay, a layer of grayish sand, a layer of salt concretions, a layer of mottled brown and grey sand with plant remains, and finally sterile grey sand. The total depth reached was 110 cm.

Test Pit 43: The surface is aeolian with a thin clay lens just 3 cm from the surface. The layers continue with a layer of salt concretions, a clay wedge, a layer of interlaminated sand and clay, a layer of homogenous grey sand, a layer of rhythmites with oxidized and unoxidized clay bands, a layer of grey sand with semi-circular ferrous staining. Dark red organic material was recovered in the rhythmites layer. The total depth reached was 73 cm.

Test Pit 46: The pit is capped by a thin layer of aeolian sand followed by flaser bedding of dark grayish brown sandy clay and grayish sand containing sparse salt laminations. Large clasts (~25 cm in size) were found in the last layer. The total depth reached was 58 cm.

Figure 9: Test Pit 43 A) thin clay lens B) salt concretions C) interlaminated sand and clay D) rhythmites of oxidized and unoxidized clays E) dark red organic remains F) semi-circular iron-oxide staining G) Clay wedge

Discussion- Interpretation

The fieldwork conducted over the Summer of 2011 satisfied my main objective of finding datable material at the paleo-shoreline escarpment; these samples will be sent off for radiocarbon dating in the coming months.

The walking survey found that outwash channels eroded the escarpment but not the dune field; therefore, these channels were already present when the sand dunes expanded across the paleoembayment (see Figure 6). Given this relationship it is not unreasonable to infer that these channels were active while the escarpment was an active shoreline. The abundance of archaeological sites located along the escarpment gives weight to the possibility that other archaeological sites maybe present above the escarpment underneath these dunes. Future fieldwork using GPR could confirm or refute this hypothesis. The dunes they may have stabilized the shoreline and protected any sites underneath them from the erosion that has impacted the rest of the area.

I believe, the raised clusters of wood, shell, salt and, charcoal within the embayment are archaeological structures based on the fact that they are elevated and circular in plan view (see Figure 4). However, another interpretation might be that they are natural groupings of plant communities that were exploited by human populations who deposited their refuse on them. In the same vicinity as the clusters previously mentioned are large quantities of driftwood (Figure 3). The transportation of driftwood into this treeless valley implies that even after the sea regressed to its current position storm surge still deposited debris into the dried paleo-embayment. This overwash process way well be a major component in the geomorphic evolution of the paleo-embayment.

The archaeological site distribution around the escarpment is highly variable. Not only are there both Preceramic and Formative period sites, but the location of the sites varies between being located directly on the escarpment, within the embayment on beach ridges, and in the foothills away form the shore toward the alluvial fans. By looking at site location by time period (Preceramic versus Formative) it may be possible to infer environmental conditions during these roughly divided time periods. I will use publications on sites excavated in this area as well as observations made during the 2011 field season to assess this idea.

The excavation of pits along the escarpment uncovered several sedimentary sequences that may be helpful in interpreting the paleoenvironment of the area. The interbedding of aeolian sand and alluvium in test pits 25-27 & 29 is interpreted to represent alternating periods of El Niño and normal conditions. The alluvium is deposited during El Niño rainfall events and the aeolian sand accumulates in the periods of time between events when the climate is relatively arid. The salt concretions found in the test pit are inferred to represent locations of surface exposure for extended periods of time leading to evaporation or water and the formation of salt deposits. By tracing the vertical change in the location of these deposits in relation to the dates received on the organic material, it may be possible to correlate the change in sea level to periods of exposure as evidenced by these salt deposits.

The test pit 41-47 transect contains several geologic features indicative of the hydrological transportation of sediment. These include thinly laminated sediments of sand and clay that were present in test pits 42, 43, 44, and 46. The alteration between sand and mud is due to changes in wave energy in coastal environments, mud is deposited during times of low wave energy and sand is deposited during periods of higher wave energy (Reineck and Singh, 1980). The transect sediments are uniform horizontal laminations and thus can be interpreted as being indicative of three coastal environments. The first possibility is that they represent a wide tidal flat environment. The second is a choked-lagoon in which the tidal effect is small (and such sedimentary structures are dwarfed in scale) due to the narrow opening to the sea. Finally, the sinuous channels could have at one time had more consistent freshwater flow and these features may be from a freshwater coastal lagoon formed by the inflow of water into the paleo-embayment after the sea regressed oceanward. At this time all interpretations are possible. In order to distinguish between these possibilities, diatoms will be extracted from the clay sediments. There are many different species of diatoms and each species prefers specific living conditions, for example brackish versus fresh water. Since choked-lagoons are hypersaline due to restricted water flow, the salinity of an open tidal flat would be close to that of the ocean, and a river fed lagoon would have freshwater, diatom analysis should help determine which of these paleo-environments is more likely.

The clay wedge found in test pit 43 (see G in Figure 9) had a dip of 15 degrees west. This layer contrasts sharply with the other strata, which were more or less horizontal to the ground level (which had a slope of 3 degrees). This layer in addition to the driftwood found in the embayment could be evidence of washover fans from storm events.

The red staining found in sand layers within test pits 28, 43, 44, and 47 are semi-circular in shape and are trace fossils. Trace fossils can be used as environmental indicators. These biogenic structures resemble escape structures of the Skolithos ichnofacies that are indicative of the sandy shore zone where changes in water level cause organisms that dwell at specific depth in the substrate to change their depth as the water level fluctuates (Frey and Pemberton, 1984). The red staining is likely due to the later staining of these structures by stale groundwater. Further research must be done to find a comparable sample and confirm this assertion.

The previously described evidence d supports the hypothesis that the local environment surrounding the Chao paleo-embayment that supported Preceramic populations has changed drastically since that occupation. The presence of tidal structures in the sediments near the shore in addition to the shells and fish vertebrae are supportive of a shift in sea level from the escarpment to the modern shoreline. The expanding dune fields as well as the dune covering the site Los Morteros are evidence of increased aridity. Several authors (Sandweiss et al., 1996; Wells and Noller, 1999) have proposed the intensification of weather patterns with the onset of El Nino around 5800 cal yrs B.P.. While this onset most likely had an effect on the peoples of the Chao paleo-embayment and may have caused the formation of the drainage channels around the escarpment, no direct correlation between these lines of evidence can be made at this time.

This research project will continue down the previously mentioned avenues using those samples collected during the 2011 field season, in order to comprehend the temporal and spatial dimensions of the interaction between humans and their environment during the occupation of the Chao paleo-embayment.

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