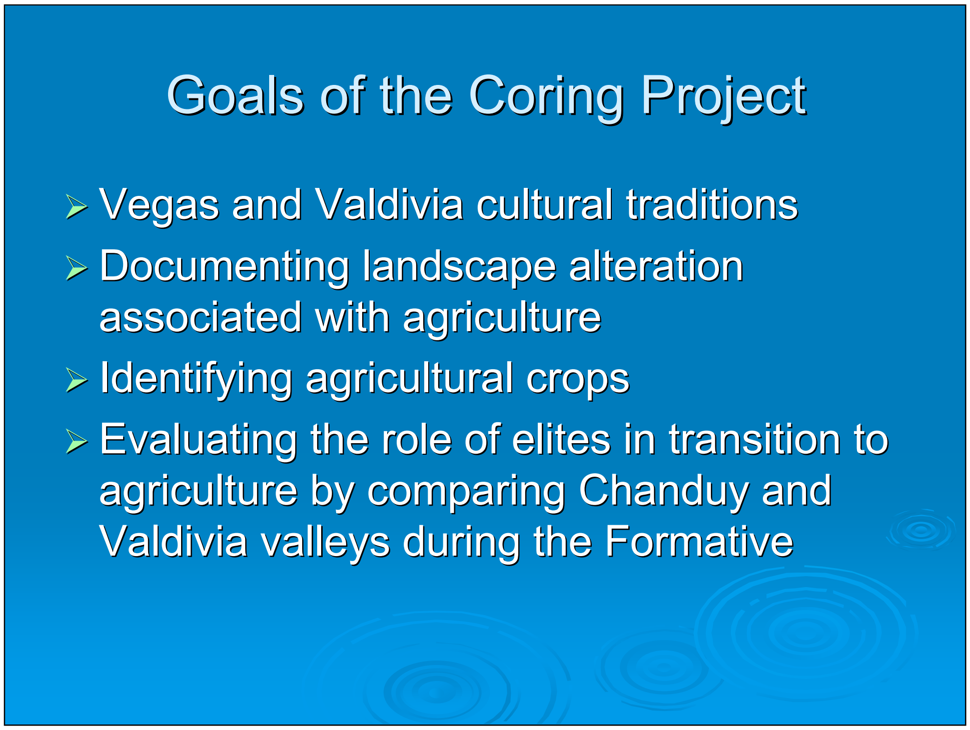
Environmental Coring in SW Guayas Province, Ecuador: Dating of Sequences and Preliminary Results

Deborah M. Pearsall
Neil A. Duncan
University of Missouri



Today I'm going to present some of the results from on-going paleoenvironmental research in southwest coastal Ecuador. Our focus today will be on three sequences recovered by vibracoring that date to the early-mid Holocene. These cover the time periods of the preceramic Vegas and the early Formative Valdivia occupations of southwest coastal Ecuador. Prior archaeological research has demonstrated that squash was locally domesticated, and that maize was introduced, during this time-frame.

The objectives of this NSF-funded project were two: to document vegetation and landscape alterations associated with the onset of agriculture, as a measure of the intensity of agricultural production; and to identify the suites of crops grown in different parts of the region. With these data, we hoped to not only trace the temporal trajectory of agricultural development, but to compare two valleys, Chanduy and Valdivia, which differ in archaeological evidence for social and political complexity.

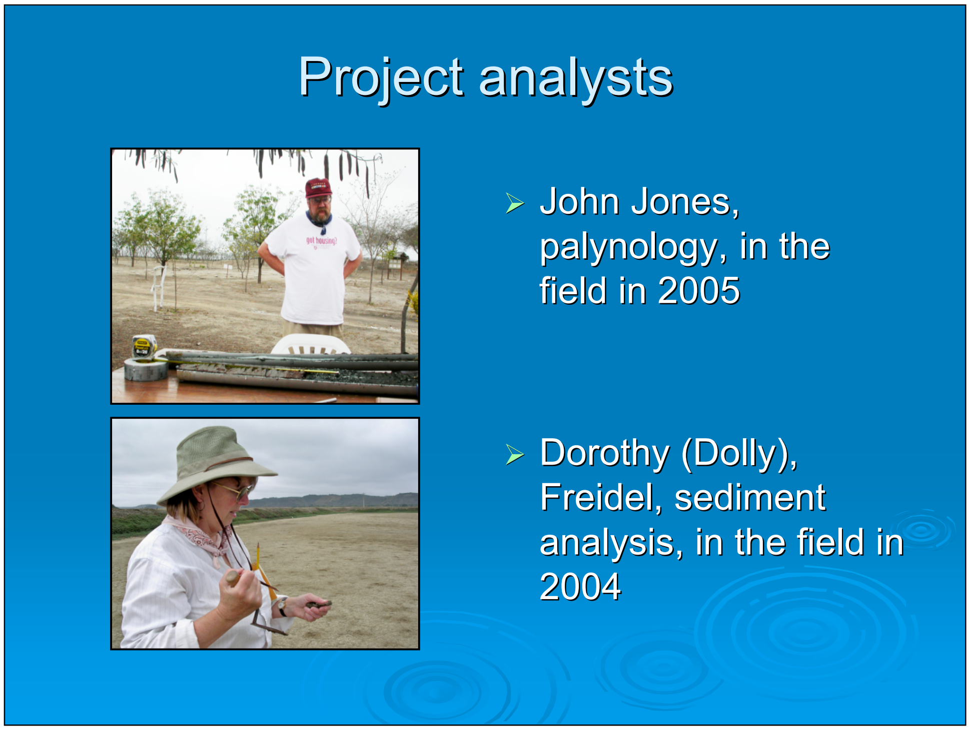
This image of southwest coastal Ecuador shows the locations of the three core sequences I'll discuss today: the Chanduy valley (CH), Punto Carneiro (PC), and the Valdivia river valley (VA).

These localities were selected for coring because of the known occurrence of preceramic and/or Early Formative sites in the drainages of the rivers. The Chanduy estuary is the outflow of the Rio Verde and Zapotal rivers. The early Formative Real Alto site, occupied beginning 4400 cal BC, is located on the lower reaches of the Rio Verde. The Rio Grande, which enters the Pacific at Punto Carneiro, drains an area in which sites of the 8000 cal BC Las Vegas occupation are found. In the Valdivia valley are located both the Early Formative Valdivia type site, at the mouth, and Loma Alta, 15 Km inland.

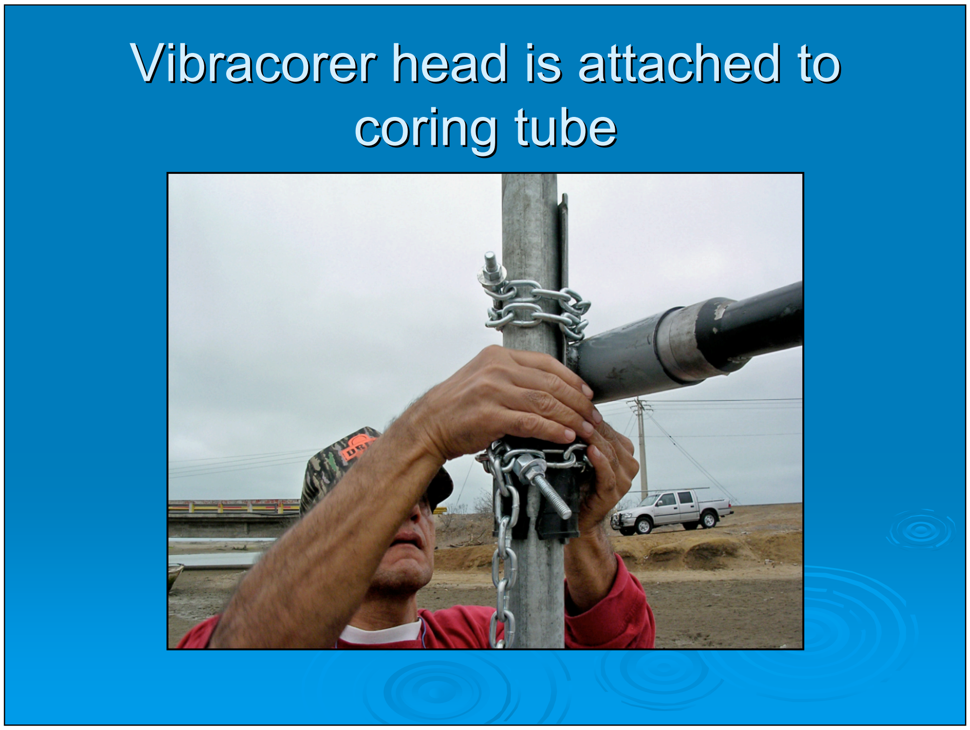
Mangrove swamps of coastal Ecuador

- Remnant mangrove in Estero Chanduy
- Saline and fresh water flow required
- Road cuts and salt, shrimp ponds destroy mangroves

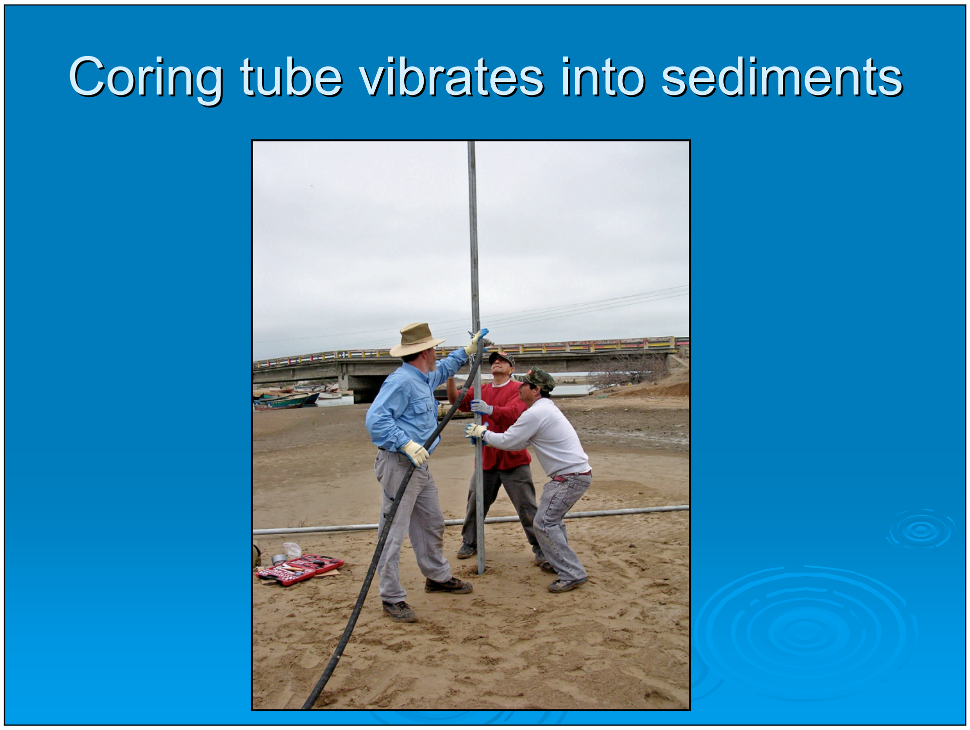
The research design of the project was to extract sediment cores from the land-ward side of former mangrove swamps that fringed the coast. There are no lakes along the Ecuadorian coast, so swamps provide an alternative sedimenting environment to capture a record of past vegetation—pollen become deposited through wind action; phytoliths are carried in by water. Today one has to look closely to see the mangrove (note the skinny red mangrove in the foreground), but in the recent past a thick belt of mangrove swamp ringed the Chanduy and other estuaries and captured sediments. Disruption of fresh water flow by road cuts and salt and shrimp ponds has lead to most mangroves being destroyed.



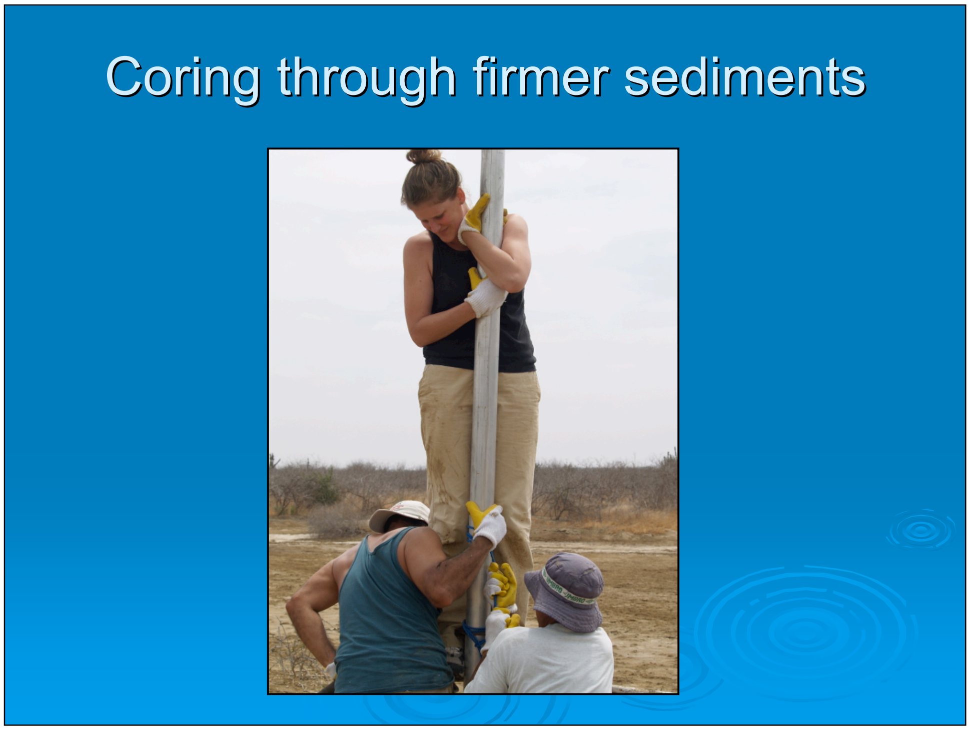
In addition to myself and MU graduate student Neil Duncan, who directed coring for the 2005 and 2006 field seasons and is analyzing phytoliths from cores, Dr. Dolly Freidel is characterizing the core sediments and selected the coring localities in each valley, and Dr. John Jones is conducting the palynological research for the project. Logistical support for the project was provided by Cesar Veintimilla, director of the Real Alto museum.



The next series of slides show the process of extracting sediment cores by vibracoring. Basically, vibrations created by a cement settling machine are passed to a coring tube, and cause the tube to sink into the wet sediments. Here you see Cesar Veintimilla attaching the vibrator head to the core tube.



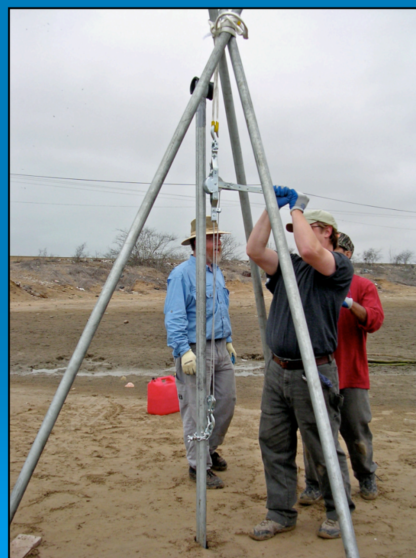
The machine is running, and the vibrations are starting to drop the tube. It goes easily through silty-clayey sediments and peat, less easily through sandy sediments.



When you hit a sandier level, sometimes a bit of added weight—in this case MU graduate student Meghann O'Brien during the 2006 field season--helps the tube penetrate. When it won't sink further, the drive is over.

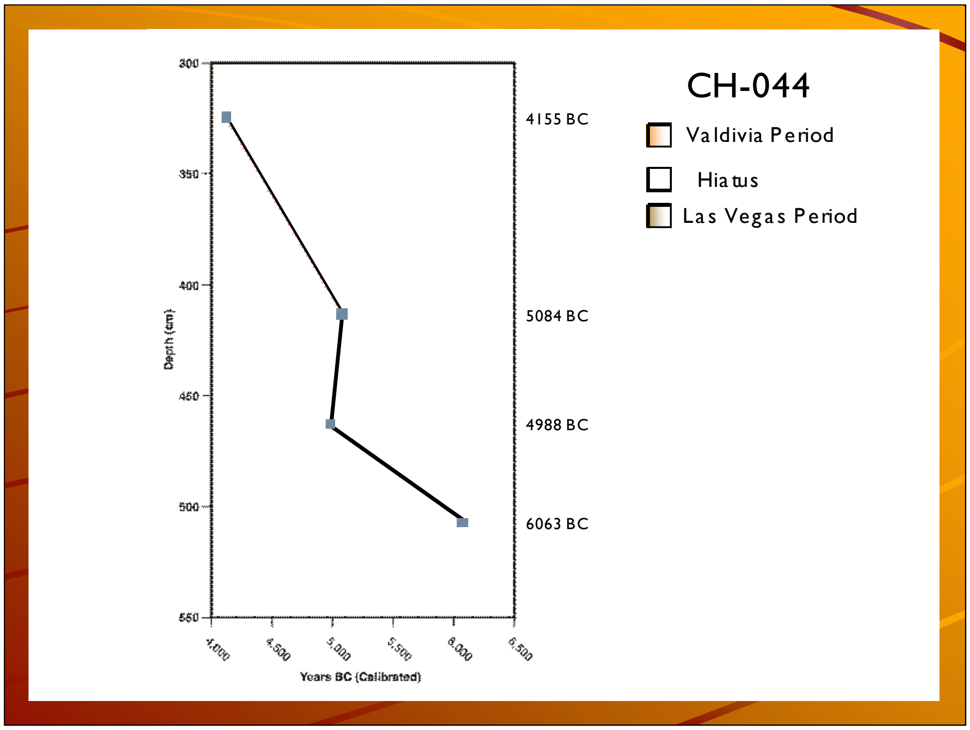
To extract a tube it is first filled with water, then the tube is capped and sealed with duct tape, as Neil is seen doing in this shot. This ensures that when the tube is pulled out of the ground, the sediments stay inside.

Extracting the coring tube



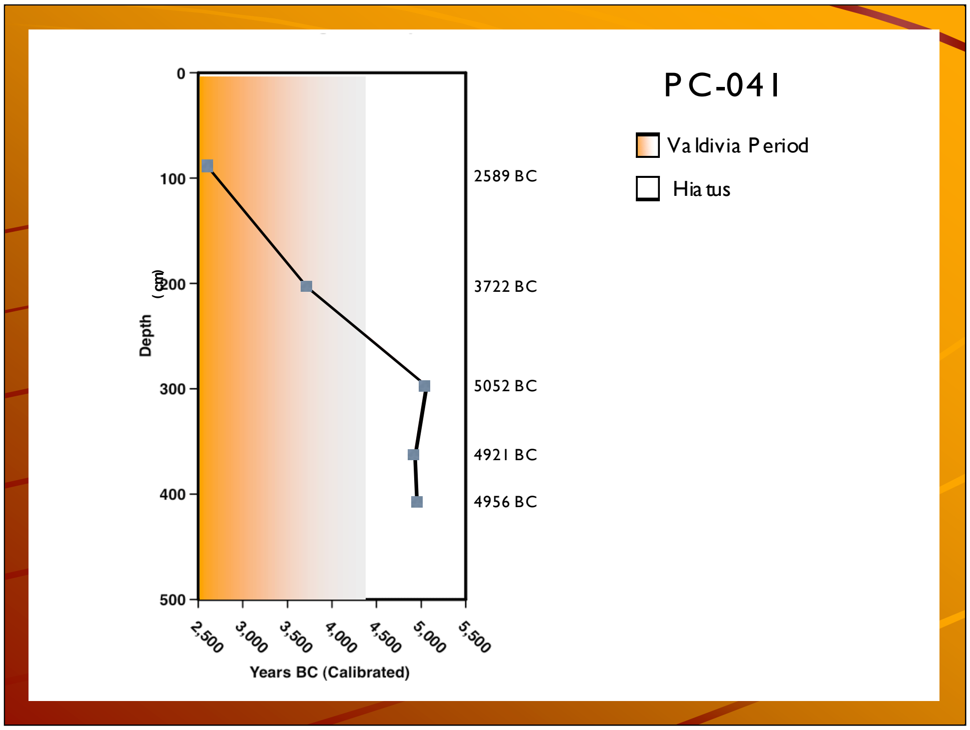
A 4 or 5 m tube filled with sediment is heavy and a challenge to pull out of the ground. Here we use a tripod and come-a-long, or hand winch, to raise the core. Once the core is removed, an empty tube is inserted into the hole and the drive continues, until no further depth can be attained. Typically our cores ended in coarse sands 450-550 cm below surface.

Coring tubes are split lengthwise, giving a clear view of the continuous sediments. Note the change from sandy to silty-clay sediments in this core segment. The cores were sampled in the field for C14 dates, pollen, phytoliths, and bulk sediment analysis.

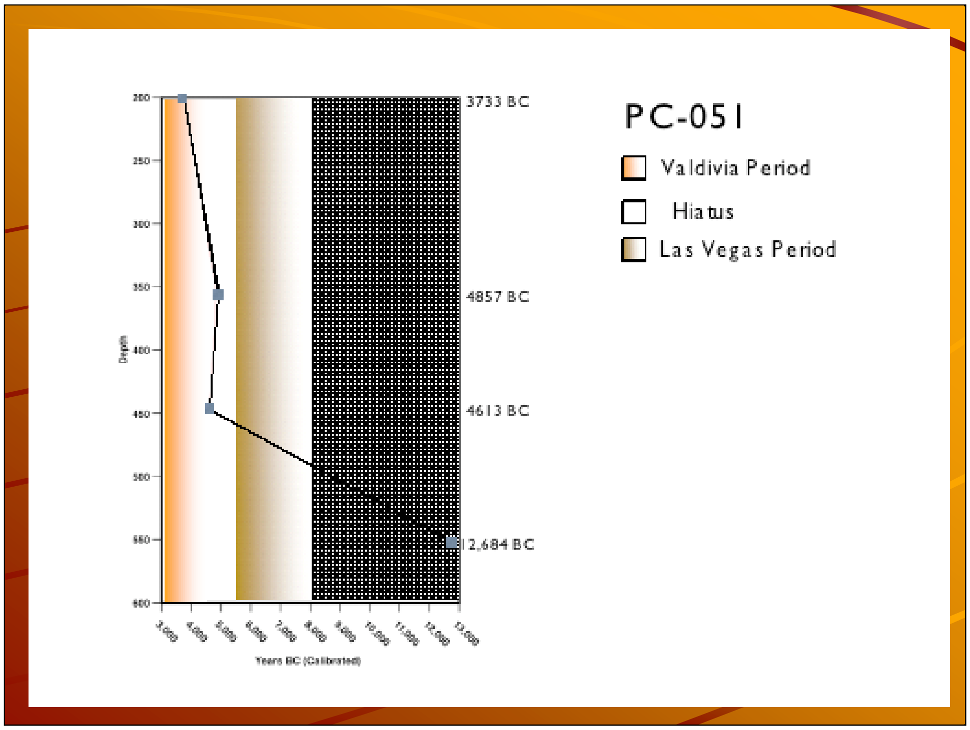


The next series of slides show the age/depth relationships for the cores recovered from Chanduy, Punto Carneiro, and Valdivia. Depth in cm below surface is shown on the left, age on the bottom (calibrated BC). The squares indicate the C14 dates. For convenience of this discussion, the cultural periods of the region, preceramic Las Vegas and Early Formative Valdivia, are overlain on the cores. There is a hiatus of some 1200 years between these phases.

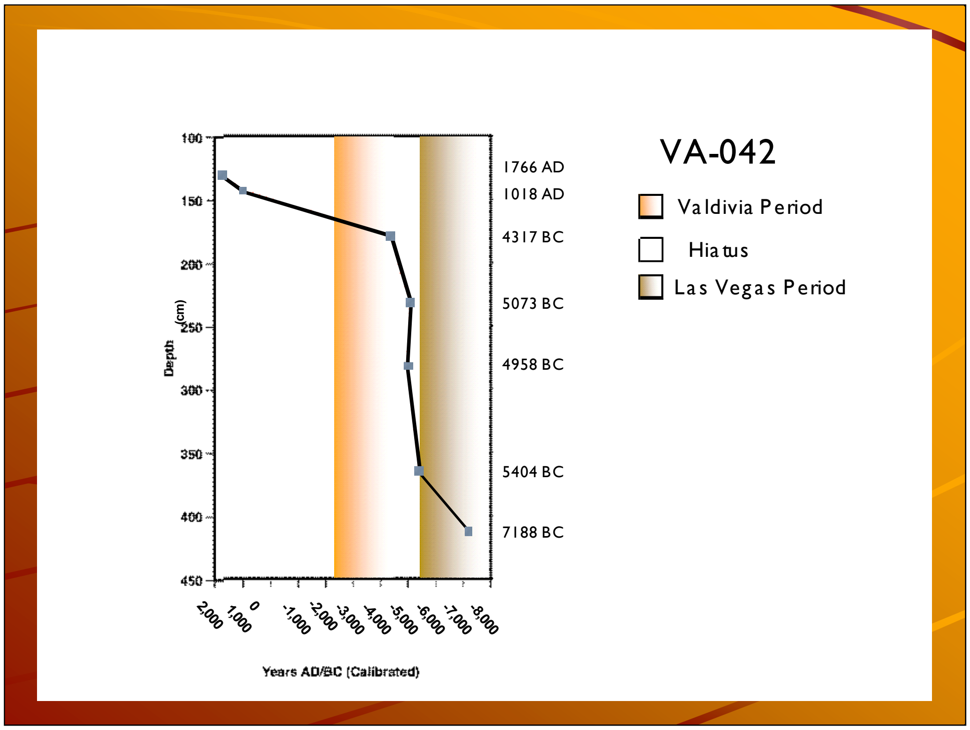
This is the best Chanduy core, located down-stream of the Real Alto site. Notice the change in sedimentation rate (nearly vertical line) in the middle of the sequence, during the hiatus.



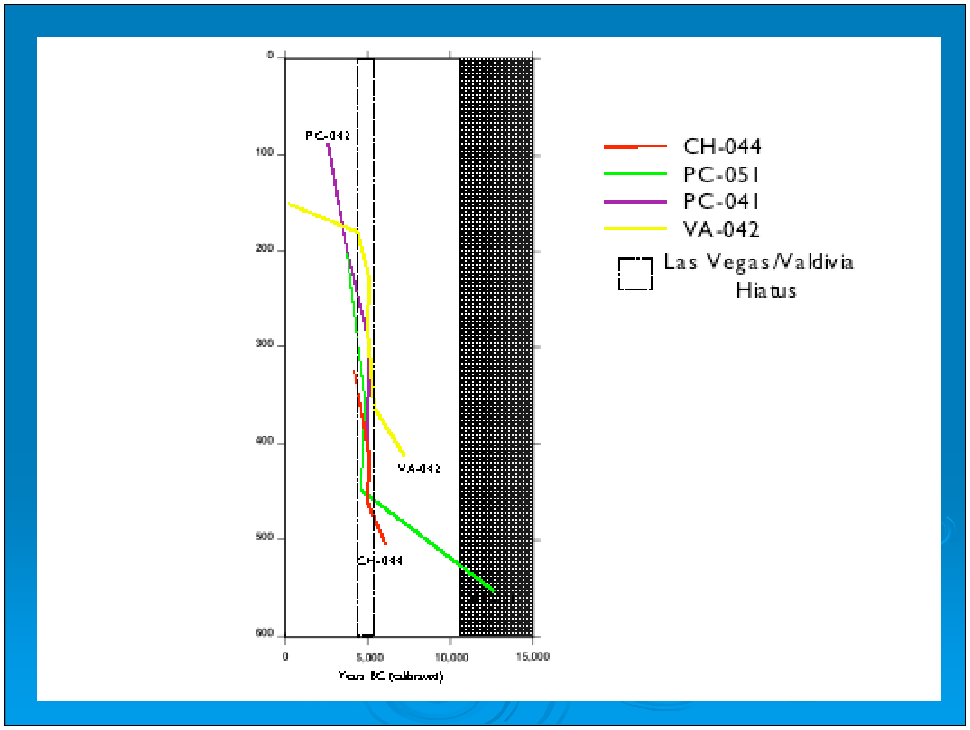
Here is the 2004 core from Punto Carneiro. Again, note the change in sedimentation rate during the hiatus between Valdivia and Vegas.



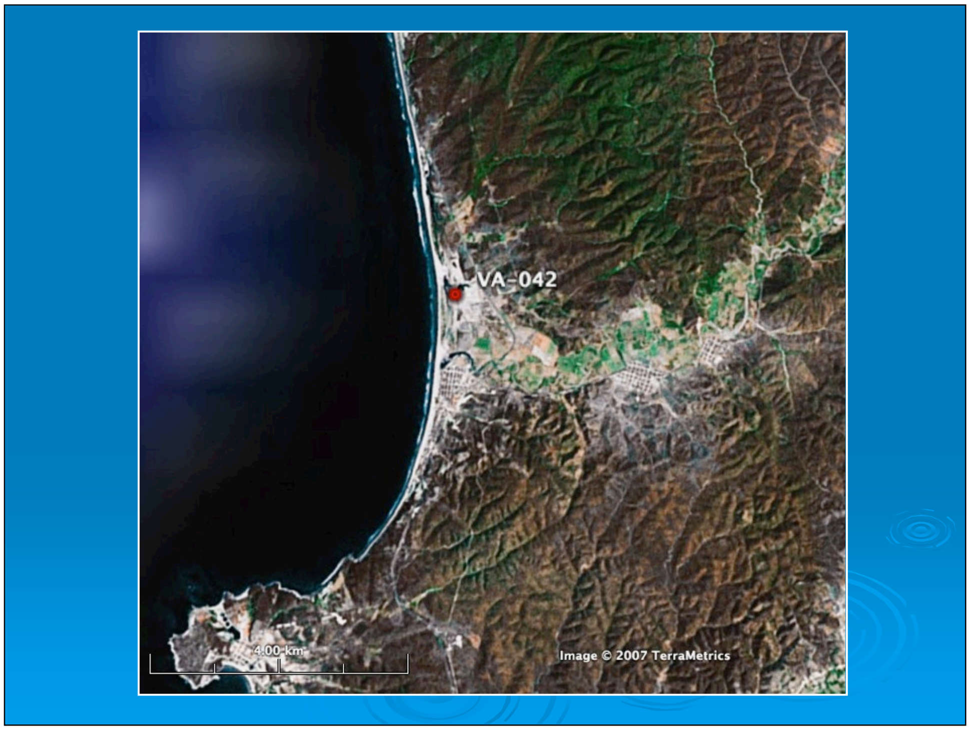
We returned to Punto Carneiro in 2005 to attempt to penetrate sediments contemporary with Las Vegas. We were more than successful, coring to 12,000 BC.



Finally, here is the Valdivia valley core. This is our best dated sequence, and the one for which we have preliminary pollen, phytolith, and sediment data. I will return to this sequence and present some of those results in a moment.



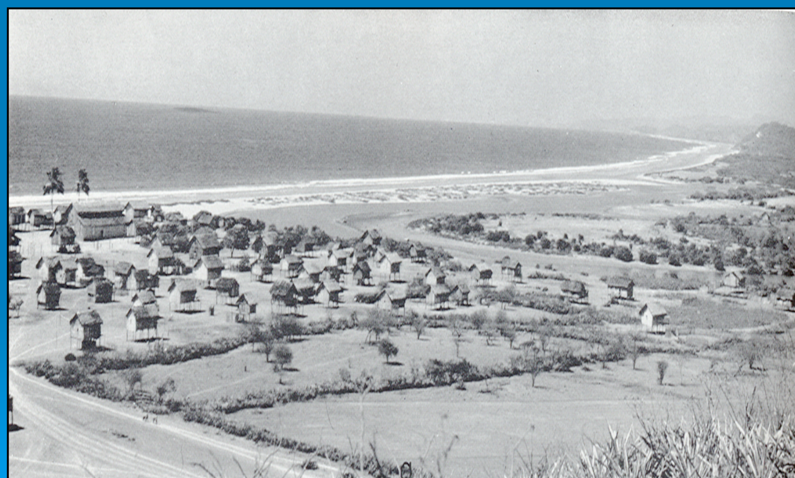
The age/depth relationships for the cores recovered from Chanduy, Punto Carneiro, and Valdivia show a consistent pattern of rapid sedimentation centered on 5000 cal. BC, and lasting a few hundred years. The synchrony of this event suggests that it is climatically controlled, rather than a result of human-induced environmental changes.



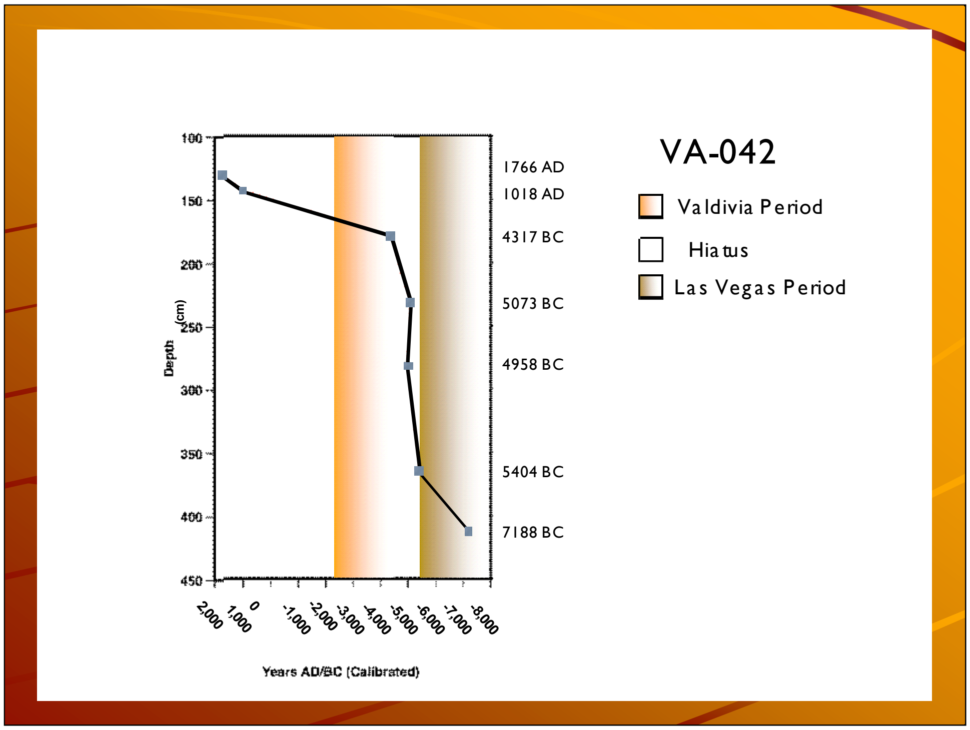
To explore this issue further, we now focus on the Valdivia core. The coring locality is located just north of the modern town of Valdivia, on the edge of the lagoon.

The Valdivia type-site, G-31, was excavated in the 1950s and 60s by Meggers, Evans, and Estrada. It is located on a low spur on the westernmost end of a range of hills forming the southern boundary of the Valdivia valley (point to the location). The spur is 12 m above the adjacent level surface.

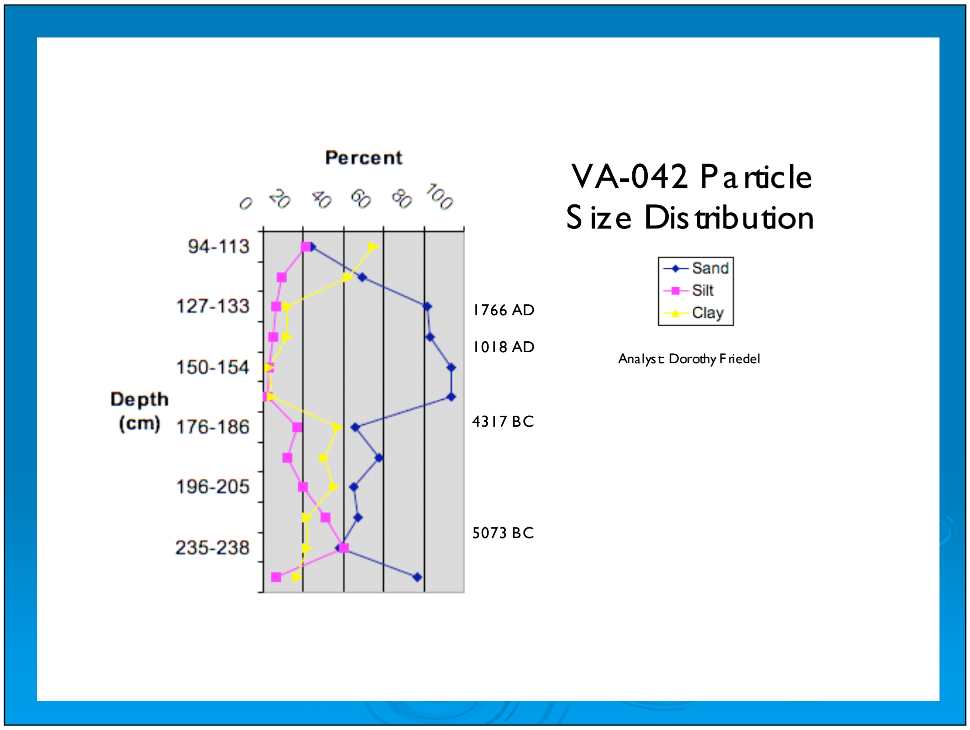
Village of Valdivia, looking towards Pacific and river outflow



In the 1950s and 60s the modern village of Valdivia lay largely north of the site between the spur, the shore, and the lagoon. This photograph from Meggers et al. 1965, was taken from the site looking north. The Valdivia river skirts the spur before turning north to flow into the narrow lagoon paralleling the beach and formed by a low sand bar. The river's current outflow is on the north end of the lagoon. We cored on the edge of the lagoon in that area (point to it).

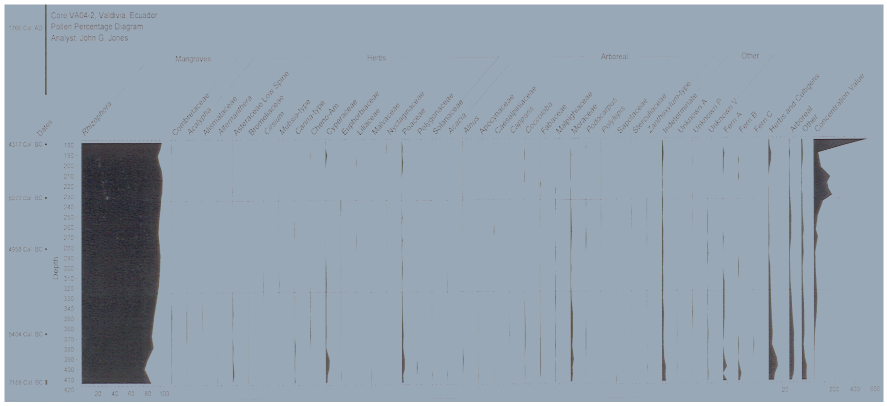


Here is the age/depth diagram for the Valdivia core. Note that the change in sedimentation documented in the core occurred before the Valdivia site was occupied.

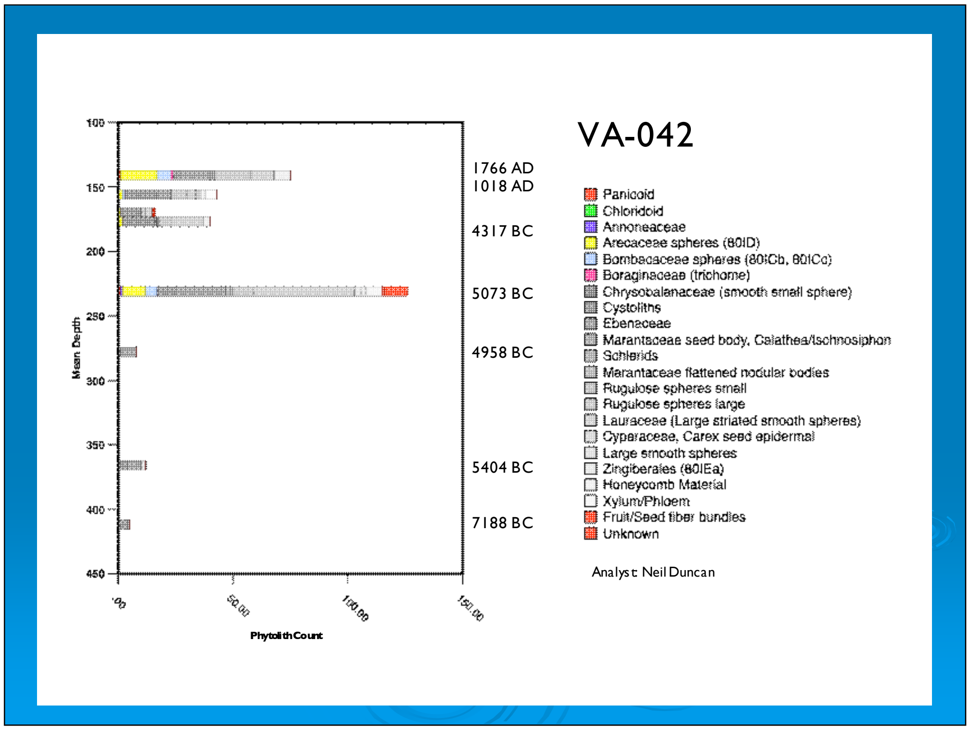


We have sedimentation data from most levels of the Valdivia core. Core sediments laid down during the sedimentation event have variable amounts of sand, silt, and clay, but are distinctively more silty-clayey than the overlying deposits. This indicates that the coring locality was a relatively quiet-water environment during the event. The event was not the result of a catastrophic flood, which would have deposited coarser sediments. The particle size analysis has not been completed for the lower levels, and it will be interesting to see when this quiet-water environment was established.

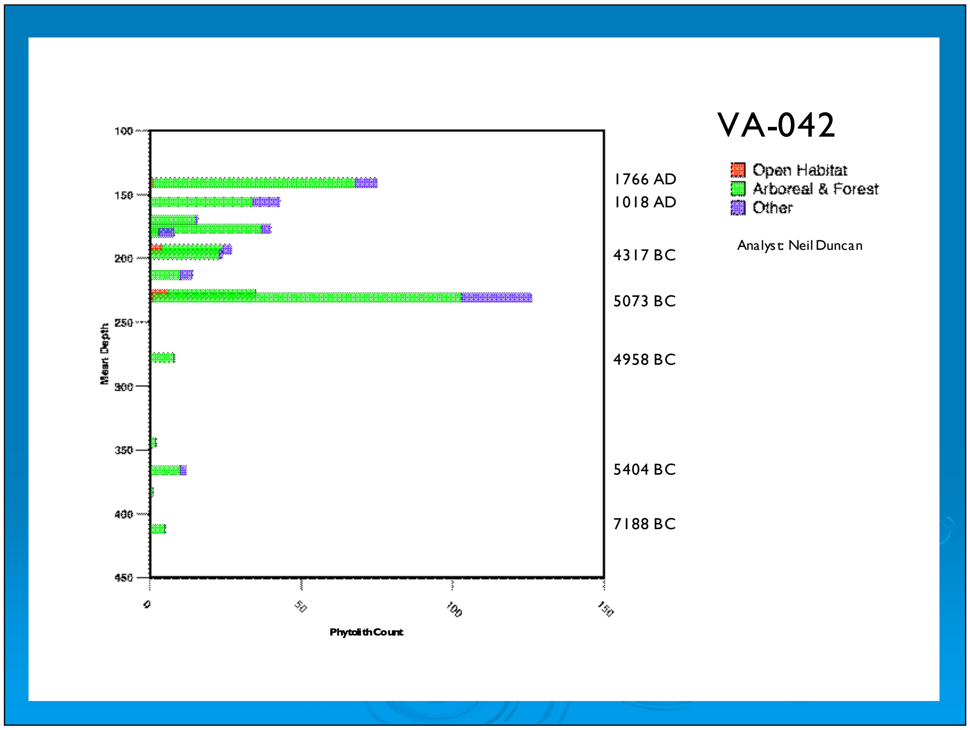
Pollen results, VA -042



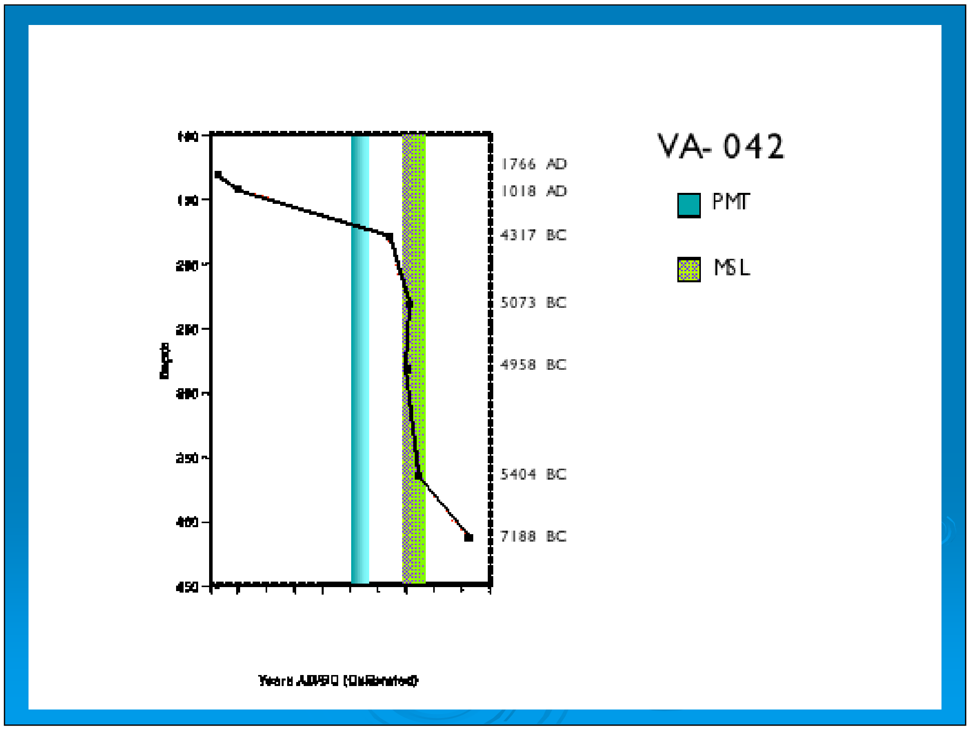
Pollen data show that mangroves (the first column) were present in the coring locality from the base of the core to the end of the quiet-water environment. Pollen was not preserved in the sandy, later deposits. These results indicate that the river flow/sea level dynamics created an environment in the coring locality in which mangrove could live from before 7100 to 4300 cal BC. If we look at the pollen concentration data (far right column), however, we can see that pollen is scant before 5000 cal. BC, and most abundant towards the top of the silty-clayey zone under discussion. This perhaps dates when the most favorable environment for mangrove—the right blend of quiet fresh water and brackish water—occurred in the coring locality.



The phytolith data from the Valdivia core show a similar pattern: very few phytoliths are present before 5000 cal. BC.



Phytolith data also indicate a predominantly forested environment (green indicates arboreal and forest taxa), with few indicators of open habitats.

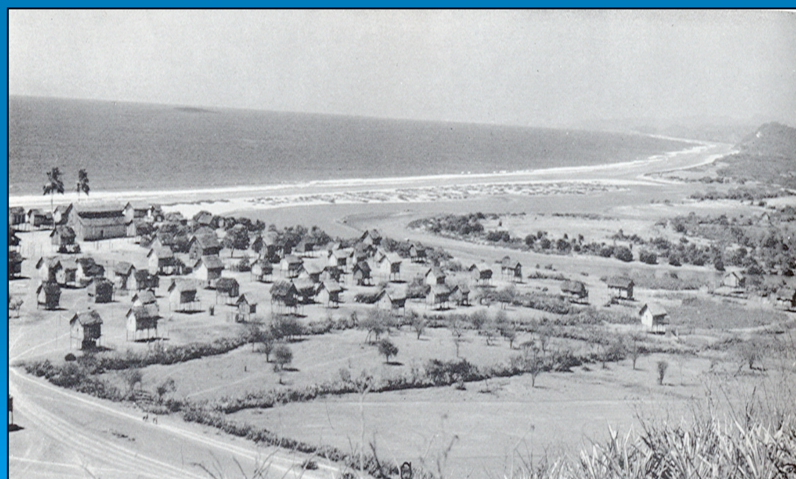


This environment was created, we believe, by the establishment of modern sea level (MSL) along the SW Ecuador coast, including the Valdivia coring locality. Decades of research along the tectonically stable Brazilian coast, summarized by Angulo et al (2006), date MSL between 4900-5700 cal BC (purple on this graph). The rise of sea level to MSL during the mid-Holocene warm period altered the dynamics of the Valdivia river outflow, slowing it to permit rapid build up of fine sediments in the coring locality, a much more rapid deposition that either before or after that time. This resulted in a thick deposit being laid down over a relatively short period of time.

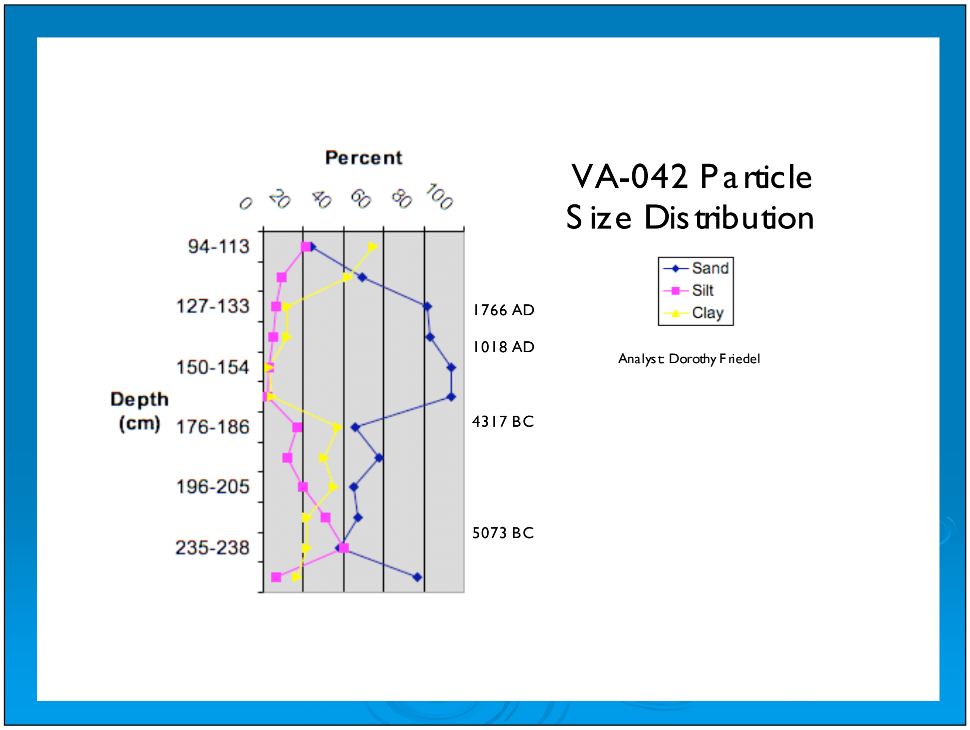
Sea level continued to rise above modern sea level, reaching the mid-Holocene marine transgression (PMT), between 3100-3700 cal BC (blue on this graph). Our results suggest that the current Valdivia lagoon was part of the beach during the PMT: our core is ca. 4 m elevation, so just above the sea level high stand (2-3.5 m). Mangrove would have migrated inland and up the flooded river mouth—the coring locality was no longer in the mangrove swamp. The topography is basically flat for over a km straight inland from the current shore, so there is room for a large mangrove swamp on the north side of the river. Notice that sedimentation changes at 4317 cal BC, some 600 years before the PMT. We therefore also need to consider possible tectonic effects on sedimentation.

As Federici and Rodolfi and Ficcarelli et al. have discussed, the mid-Holocene marine transgression laid down sand deposits all along the Ecuadorian coast. Through littoral drift sandy lagoonal barriers were formed. When sea level dropped again, this resulted in the characteristic narrow lagoons of the modern shoreline.

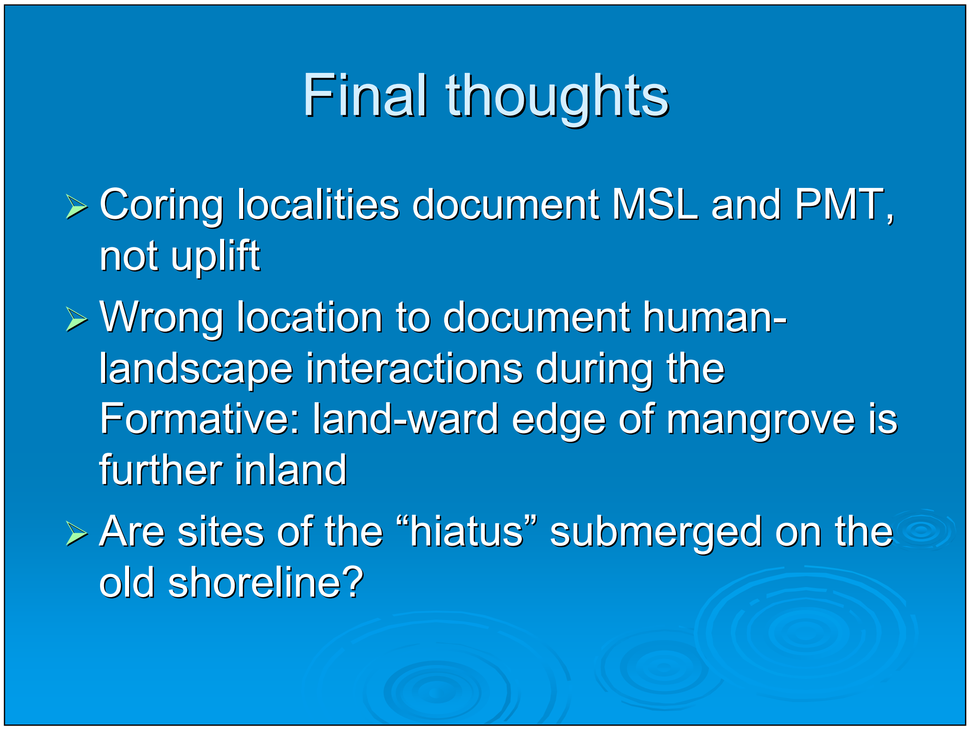
Village of Valdivia, looking towards Pacific and river outflow



In this photo taken from the Valdivia site, the sandy lagoonal barrier is faintly visible, and the river exits to the sea at the north end of the lagoon. It is possible that before the formation of the sand bar, the river exited directly to the sea at the foot of the spur on which the Valdivia site is located. The site was established during the mid-Holocene marine transgression on high ground near the river mouth, and across the river from a large mangrove swamp. Such estuary/riverine settings provided numerous resources, and agricultural land was nearby. After the sea level high stand, the river outflow likely moved away from the site.



Research indicates that world-wide following the sea level high stand, sea level drops progressively as drier climates are established until modern level is reached. In all our coring localities, this process is obscured: note how the sediments remain dominated by sands in the Valdivia core until after 1766 AD, and that little sediment is present. We suspect that sediments were removed by increased velocity of river flow as sea level dropped after the PMT, and by the movement of the river mouth to its current position. The modern mangrove swamp, indicated by the sediments above 127 cm, post-dates AD 1766.



We still have much to do to complete the analyses for this project. Age/depth relationships of the cores suggest that our sequence documents modern sea level and the mid-Holocene marine transgression in this region, and that these events impacted human use of the landscape. While there is evidence for uplift in SW Ecuador, the youngest documented event is late Pleistocene in age. Basal sediments from the Valdivia core are terrestrial, not marine. If this is also the case for Punto Carneiro and Chanduy, significant Holocene-uplift is not indicated, counter to Damp’s arguments.

But it also looks like we are in the wrong locations to document human-landscape interactions during the Valdivia period: we need sequences from the land-ward edge of the high-stand mangrove, not the current mangrove. We have one unanalyzed core from near the Real Alto site, 3 km inland, that may serve this purpose.

Finally, the timing of modern sea level and the Vegas-Valdivia “hiatus” is suggestive: if Real Alto and Valdivia were located for access to both estuarine and riverine resources, including agricultural land, perhaps this pattern is more ancient, and sites of the “hiatus” are submerged on the old shoreline.