This presentation provides an overview of the technical methodologies and initial results of a pioneering research project that attempts to reconstruct the relationship between Swahili actions and intertidal geomorphology on the East African island Songo Mnara.
This research tests the hypothesis that Swahili land-use strategies modify erosional processes which, in turn, influence the character of intertidal areas. If confirmed, this hypothesis leads to two inferences: first that geomorphological impacts of social action can be modeled from intertidal zones and; second that such areas offer an entirely overlooked source of information regarding social change. The data for this research is derived from a series of geoarchaeological cores from intertidal mangrove forests adjacent to the urban settlement of Songo Mnara. I evaluate the cores using particle size and phytolith analyses to identify whether or not Swahili action caused anthropogenic erosion on Songo Mnara.
The theoretical program of historical ecology motivates this project. Historical ecology is an interdisciplinary research program concerned with understanding spatial and temporal dimensions in the relationships between human societies and local environments. The research program situates social and ecological action within a landscape—in this case “landscape” indexes the material manifestation of all interaction between people and biophysical environments. Several postulates form the crux of historical ecology: (1) Humans have impacted all environments on the Earth since the beginning of the Holocene. (2) Human nature is not programmed to augment or diminish species diversity or ecological parameters within a landscape. (3) Heterogeneous social forms create dissimilar varieties of landscape change. Finally (4) Human action and biophysical environments can be approached as simultaneous phenomena. I constrain the landscape of this research to be intertidal mangrove forests surrounding urban Songo Mnara between the 14th and 16th centuries AD. The following discussion aims to outline the social and environmental influences that may be manifest within this landscape.
As we have heard throughout this panel, Songo Mnara was an urban settlement located on a nearshore island occupied between the late 14th and early 16th centuries AD. Evidence suggests that the Swahili population of this island engaged in agriculture for food and craft production as well as the harvest of wood, particularly mangrove trees, to meet fuel and construction needs. The short occupation period coupled with these anthropogenic factors leads me to expect a definitive and acute change in erosion rate and sediment constitution associated with site formation and occupation.
I summarize anthropogenic change in sediment delivery with a model of reciprocal interaction between Swahili actors and intertidal geomorphology. The model begins with Swahili actively engaged in activities including clearing a landscape, harvesting wood, and tending agricultural plots. Each of these activities actively displaces sediment. Unsettled sediment becomes vulnerable to erosion, a natural process which removes soil from the landscape. Soil-in-flux can eventually be delivered to coastal areas where it is either deposited in inter-tidal, nearshore, or offshore zones.
Mangrove trees are intertidal species which influence the area of deposition because the morphology of mangrove roots increases the bottom-roughness of intertidal areas and reduces the speed of moving water. The amount of sediment carried by water is directly proportional to velocity; thus as water passes through mangrove roots it slows and sediment is deposited in-situ.

The deposition and accumulation of sediment leads to the reciprocal aspect of this model. Mangrove trees are unable to colonize areas without an initial layer of sediment—causing initial location to be highly contingent on coastal geomorphology. Anthropogenic activity on the landscape at Songo Mnara delivers sediment to the intertidal areas and facilitates increased deposition within and around extant mangrove forests. This ultimately leads to a situation of seaward expansion of said forests. The increased range of mangrove forests creates additional woodfuel or construction resources available to Swahili people.

Mangrove trees are a well-documented economic resource in Swahili historic literature. The export of mangrove poles represented a highly lucrative portion of the Swahili international economy until legislative restrictions in the 20th century. There is no clear indication that residents of Songo Mnara engaged in the international export of mangrove poles. However, historic analogs are important here because they indicate that Swahili would only remove wood poles and leave root systems intact. If this was the case, harvested areas would be quickly repopulated and sediment would remain within the intertidal system. Further, microenvironments harbored within mangrove sediments create adhesive detrius which provides an additional obstacle to erosion from intertidal areas. These points all corroborate with the idea of anthropogenic seaward expansion of mangrove forests.
The only obvious obstacle to seaward expansion comes in the form of a specific organism that inhabits mangrove microenvironments. This worm-like organism is a potent fishing lure and Swahili are keen to dig up roots and displace trees with hopes of obtaining the bait. The effects on a mangrove forest can be catastrophic and certainly promote erosion out of the intertidal areas. With these points in mind, I now move to the technical explanation of methods necessary to conduct this research.
Result of Root Removal

Former mangrove forest 6-8 months after intensive bait harvest. Songo Mnara 2009.
Throughout the course of this research I cored the seaward edge of mangrove forests with the specific aim of targeting the area between tree-line and ultimate low water mark. Samples were collected using a Russian Peat Bog Corer. I selected this specific instrument because it is designed to sample super-saturated soils like those characteristic of intertidal zones. The Russian corer features a side-filling sample chamber which protects soil samples from compression or shortening during recovery. This human-powered corer produced uncompromised samples; however, it limited the areas available to core. I had initially planned to place transects through the mangrove forest itself. Unfortunately, my colleague and I were completely unable to penetrate subsurface root mat. Therefore this research was relegated to sediment that lay at the seaward end of the mangrove forests. Because the samples were taken between tree-line and ultimate low water mark, I was only able to sample during low-tide and while the tide was moving out. I created transects of cores every 10m moving from the tree-line to low water mark; new transects were begun every 50m moving east to west.
Cores terminated upon arrival to impenetrable substrates, which almost always took the form of limestone from fossilized coral reefs that dominate the coastline of Songo Mnara. The cores range in depth from 30cm to a maximum of nearly 2.5m with an average of nearly 70cm. Cores were taken wherever possible with no discrimination regarding ambient mangrove type, although Red Mangroves bounded a majority of the cores.
Immediately after extraction, a battery of measurements and analyses were performed on sediments. The core itself was measured and munsel chart applied to map any apparent stratigraphic layers. These layers were then manipulated in order to give a rough in-field designation of soil type. After the sample was recorded and profile drawn, the entire sample was placed into plastic wrap and a protective PVC plastic casing. One core from each transect remained intact while each of the other cores were disassembled in the field and transported back in increments of 5cm or less, based on the munsel derived stratigraphic profile. Manual disassembly was necessary to transport back to the University of Virginia.

Upon return to UVa I selected a single transect for in-depth analysis. This 20m transect is directly adjacent to the urban settlement of Songo Mnara and includes a core that extends to 200cm below the surface. I will first address the analytical methodology necessary for particle size analysis and then outline phytolith analysis. Particle size analysis is a technique which allows the researcher to identify any change in type of soil delivered to the area. By this I mean a transition between sand, clay, or silt. I used a laser particle size analyzer to reconstruct the soil profiles of each core. I analyzed the intact core centimeter by centimeter while the previously disarticulated core was sampled on the basis of each of the 5cm. Phytolith extraction processes were performed on soil prior to analysis in the PSA in order to remove organics and shellfish. I chose to use the phytolith extraction regimen because other options require extensive bleaching. Bleach etches and can even destroy phytoliths, whereas the preparation protocol I followed requires a single procedure to produce both phytolith and soil samples.

I conducted phytolith analysis of these cores in order to identify the botanical communities that inhabited sediments prior to erosion processes. I explicitly wanted to obtain evidence that indicates whether sediment delivered to intertidal zones was from agricultural plots or covered by scrub or other plant communities. The phytolith portion of this research was conducted under the supervision of Dr Deborah Pearsall at the University of Missouri.
The initial results of this research were quite encouraging as stratigraphic layers were clearly tangible based on both sediment color and texture in most every core immediately after extraction. Unfortunately, the laboratory analyses did not support with the initial observations. I compare the results of particle size analysis to the international soil size classification parameters. These parameters classify any soil particle below 0.002mm (2 microns) as clay; soil particles between 0.002 and 0.05mm as medium silt; 0.05 to 0.2mm as fine sand; 0.2 to 2.0mm as coarse sand; and soil particles above 2mm as gravel or stone. At this point I consider only the mean soil size in this discussion. Throughout the transect the cores demonstrate an almost entirely homogeneous distribution of fine sand moving from the contemporary surface of intertidal substrate down to the impenetrable fossilized coral. Two exceptions to the fine sand exist as the bottom of the tree-line core and midway point of the seaward core demonstrate a lens of coarse sand. It is not entirely out of the question that these cores demonstrate a related lens of coarse sand. However, it is just as likely that the measurements are entirely unrelated.

I conducted phytolith analysis to ascertain the botanical communities supported by the sediment which I expected to be eroding from the landscape down to the intertidal areas. I was unable to identify any diagnostic phytoliths to indicate a particular genus or species of plant present in the intertidal substrate. Instead, the phytoliths demonstrated a large and blocky morphology characteristic of undiagnostic mangrove phytoliths. Evidence of intertidal species within the intertidal context comes as no surprise. The lack of clear indication of plants on the landscape decomposing and washing away with loose soil indicates that the soil under consideration was not delivered to intertidal areas the result of anthropogenic erosion.
Analysis did not reveal the clear lens of anthropogenic soil I expected nor did it show any indication of Swahili induced erosion. These results force me to reject my initial hypothesis that Swahili land-use strategies modify erosional processes which, in turn, influence the character of intertidal areas. Further, I cannot support the claim that geomorphological impacts of social action are captured within intertidal substrates. It appears as though the initial optimism of color and texture based stratigraphy throughout cores was heavily influenced by the organic communities harbored within the sediment. The coloration appears to have been staining from organic plant materials whereas the grit and texture differences result from heavily abraded and broken down calcium carbonate organisms. I will briefly address potential explanations for the homogeneous fine sand cores before moving to the conclusion.

The most likely explanation is that the seaward edge of mangrove forest is not as geomorphologically related to settlement as the landward edge. Related phytolith studies conducted in the Americas have successfully uncovered evidence of anthropogenic erosion within mangrove forests by coring this “landward” edge of forests. Disturbed soil may not have been able to move through the entire mangrove forest—in some areas upwards of 200m wide—in the time since Songo Mnara was occupied. Additionally, the seaward edge of the mangrove forest is exposed to more intense wave energy. This energy may have been great enough to strip certain size soil particles, leaving only the relatively homogenous fine sand in place.

A separate explanation would be that I did not sample a functioning drainage area. If disturbed sediment is removed from the landscape by rainwater, than I expect it to be deposited in areas directly adjacent to water drainage channels. Prior to arrival on Songo Mnara I applied Geographic Information Systems software to topographic maps of the island. I was unable to identify any convincing drainage channels associated with the settlement, nor was I able to find any by manual survey upon arrival. Without any clear drainage areas, I assumed equal chance of deposition across the survey universe. In order to test whether this assumption negatively affected the research, I would need to analyze additional survey transects. It is completely possible that a formerly active drainage area has silted up and been over taken by mangroves- causing it to be invisible in the contemporary landscape.

Actions by subsequent Swahili people may have also erased any record of anthropogenic erosion in the intertidal zone. The practice of digging up mangrove roots in hopes of obtaining fishing bait disrupts sedimentary stratigraphy and removes mangrove trees from the area. If the transect under consideration had been subjected to such a practice, then any evidence of anthropogenic erosion would have already been washed offshore.

The last potential explanation for these results is inappropriate processing methodologies. The researcher must first remove all organic materials and sieve shell and other exotic materials prior to analysis in order to ensure the PSA exclusively samples soils. Extensive bleaching is one option for organic removal, but this practice etches and may eventually dissolve phytoliths. For this reason, I simultaneously removed organics from the sample and prepared phytoliths for extraction. The phytolith extraction procedures involve exposure to multiple chemicals as well as intense regimen of sieving, I am afraid exposure to either may have altered the size profile of these samples.
To briefly review, this research project was a first attempt at methodology geared exclusively toward intertidal geomorphology with specific interests towards articulating intertidal change with Swahili land-use practices. While the project has ultimately been unsuccessful, evidence for the proposed model of reciprocal relations between Swahili land-use, anthropogenic erosion, and mangrove expansion may still lay within the mangrove forest off Songo Mnara.

Conclusions

- Evidence cannot support the claim that geomorpholocial impact of social action is captured within intertidal substrates.
- While these results cannot articulate with growing body of Historical Ecology, the model of reciprocal relation between land-use practices, anthropogenic erosion, and mangrove expansion may be tested elsewhere.
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