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Mapping Floodplain Stratigraphy at an Archaeological Site in Upstate New York Using Shallow Sub-Surface Geophysics

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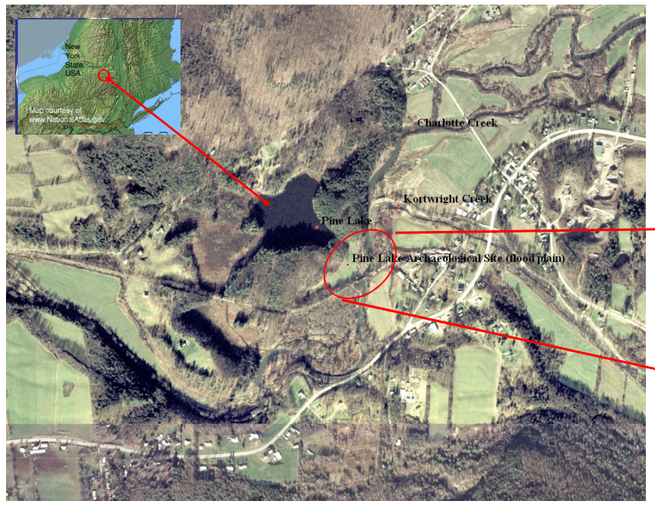
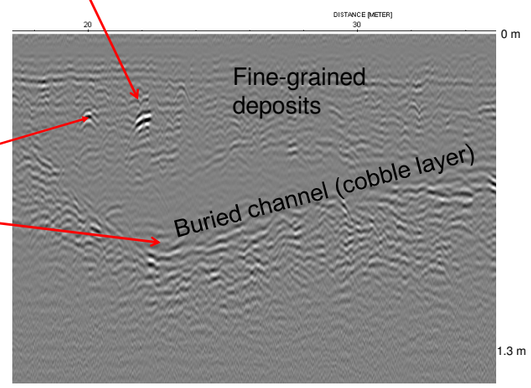




Abstract

The Pine Lake Environmental Campus of Hartwick College in West Davenport, New York comprises a floodplain nestled between a kame moraine (formed between 14 to 12 Kyr before present) and Charlotte Creek. This setting provided a home to Native American peoples at several times during the Holocene. There is evidence for older (pre-5000 BP) human occupation on the moraine and on the floodplain immediately adjacent to the moraine. Occupation on the moraine is associated with a Kirk serrated style point, known to date between 9700-8000 BP. On the floodplain, pre-5000 BP occupation is documented only in a small area immediately adjacent to the moraine toe. In this area there was a fire hearth and a few (non-temporally diagnostic) stone artifacts associated with a paleosol (A horizon) at approximately 80 cm below the present land surface. Another occupation with very limited artifacts dating to about 5000 BP rests about 25-30 cm above the fire hearth level and in close proximity to the moraine.

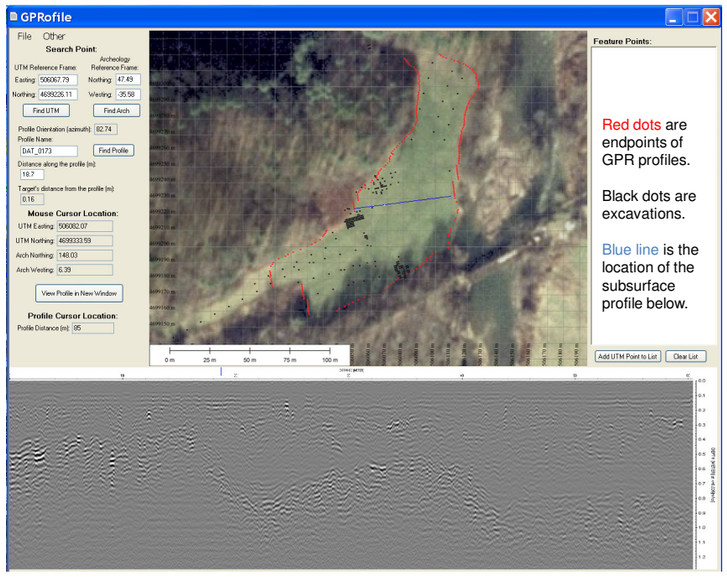
Most artifacts unearthed from the floodplain cluster in age at 4000 BP and 1000 BP. The older artifacts were recovered closer to the moraine, while the younger artifacts occupy an area farther onto the floodplain and closer to the present location of Charlotte Creek. An historic dump from the early 20th century occupies the shallow subsurface (<0.5 m depth) in a small part of the floodplain. Based on historic artifacts, floodplain accretion since the arrival of Europeans is not likely to exceed 0.2 m on average in this area. The association of artifact age with distance from the moraine is suggestive of floodplain development via lateral accretion, a model which supports the idea that Native Americans preferred to occupy locations in close proximity to an active channel.

We developed a test for this model of floodplain development via lateral accretion by characterizing sub-surface stratigraphy using ground penetrating radar (GPR). We pushed a 500 MHz GPR system back and forth across the floodplain collecting 1 meter-spaced profiles. We surveyed endpoints of each profile using global positioning system receivers and a total station electronic distance measurement tool. Thus, we could hang the profiles in a geospatial reference frame, and combine our data with other georeferenced data sets. The profiles extend to roughly 1.3 m depth, at which point the signal was strongly attenuated. A strongly reflective irregular surface, which we interpret as channel and bar structures, can be traced for considerable distance across the floodplain in the subsurface. The buried channels run approximately parallel to the modern channel. They are not obviously related to the shallow flood channels on the modern floodplain.

Our results rule out a simple growth of the floodplain via a laterally sweeping channel. The presence of multiple channels and bars implies abrupt shifts of the main channel. Modern channel and floodplain features nearby exhibit similar channel and bar structures with floodplains etched by small flood channels, thus providing a direct analog for understanding the subsurface features at the Pine Lake floodplain.

We performed a GPR survey 150 profiles separated by 1 m, shots taken every 2.5 cm along each profile.

We surveyed each profile endpoints with a total station, and we surveyed control points with a differential GPS and total station.

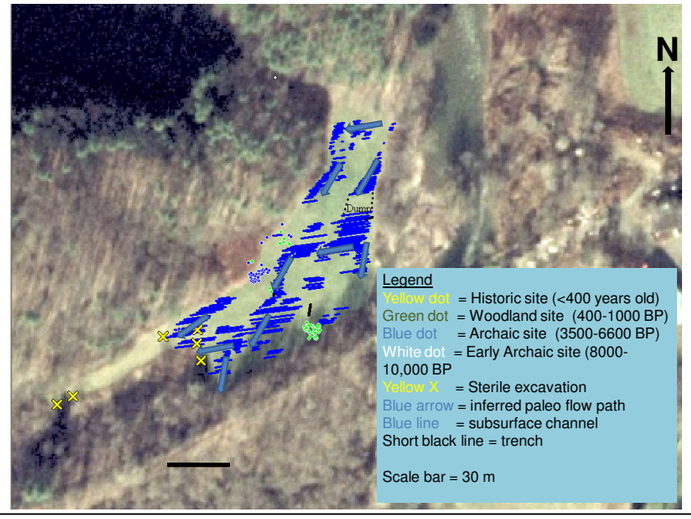


Red dots are endpoints of GPR profiles.

Black dots are excavations.

Blue line is the location of the subsurface profile below.

We converted the GPR profiles and archaeological sites into UTM coordinates to facilitate mapping. Overlaying the subsurface features and excavation sites onto aerial imagery provides a visual means of identifying correlations between fluvial geomorphology, stratigraphy, and occupation sites. See map below.



We developed a software package (GPRofile) to view subsurface profiles and the profile location on a map view (created by Emmon Johnson as an undergraduate research project). Using this software, we extracted subsurface channel edges, and plotted these in a GIS (Global Mapper). See map above.

Our initial hypotheses

- The floodplain has grown via continuous lateral accretion as the channel migrates
- Hunter-gatherers used gravel bars in the immediate vicinity of active channels for fishing and food processing

Observations from Archaeological Excavations

- Archaeological sites increase in age with distance from the modern channel
- The site is an active modern floodplain
- Modern channel exhibits longitudinal bar patterns
- Historic sedimentation on the floodplain is < 20 cm, and often <<20 cm

New findings from the geophysical survey

- Ground penetrating radar (500 MHz antenna) elucidates an irregular but traceable reflector in the subsurface marked by troughs and humps. This reflector aligns well with a gravel unit exposed in the cutbank of Charlotte Creek, and with a gravel unit exposed in a trench/excavation.
- Swales on the modern floodplain surface do not coincide with subsurface channels.
- We think cobbles on buried channels and bars generate the reflective unit in the GPR profiles.
- Rich archaeological sites overly buried bars, while barren sites tend to occur over buried channels.

Conclusions

- The braided pattern of buried channels coupled with ages of occupation imply a step-wise lateral movement of the channel, not a continuous lateral sweep of the channel.
- The surface of this active floodplain exhibits diachroneity spanning 1000s of years.
- Modern channels and the buried channels show similar patterns of longitudinal bars, implying comparable stream processes over time.