A GROUND PENETRATING RADAR INVESTIGATION OF ARCHAEOLOGICAL SITES IN VARNIAI REGIONAL PARK, NORTHWESTERN LITHUANIA

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Abstract

The Varniai Regional Park, located in Northwestern Lithuania, is considered a hub of Mesolithic and Neolithic Baltic culture and contains many sites of importance to Lithuanian history. In July of 2016, non-invasive archaeological investigations were conducted at two different sites in the Varniai Regional Park by means of ground penetrating radar (GPR).

The two sites share a similar research goal. In prehistoric times, people settled at or near lake shorelines leaving cultural remains behind. As lake levels changed many of these shorelines became buried under a layer of peat. Due to difficulties in conducting archaeological excavations in this peaty environment, knowing the location of an ancient shoreline is important. Four GPR transects of varying lengths were collected with Sensors and Software PusleEKKO 100 and PusleEKKO 1000 GPR systems at 100, 200, and 225MHz with step sizes of 0.5, 0.05, and 0.05 meters respectively. Topographic data collected with a TopCon laser leveler was used to geometrically correct the GPR data. The resulting transects reveal the truncation of continuous horizontal layers by dipping reflections which are interpreted as ancient buried shorelines. GPR data collected from these two sites have proven useful in identifying desired locations for future archaeological excavations.

Introduction

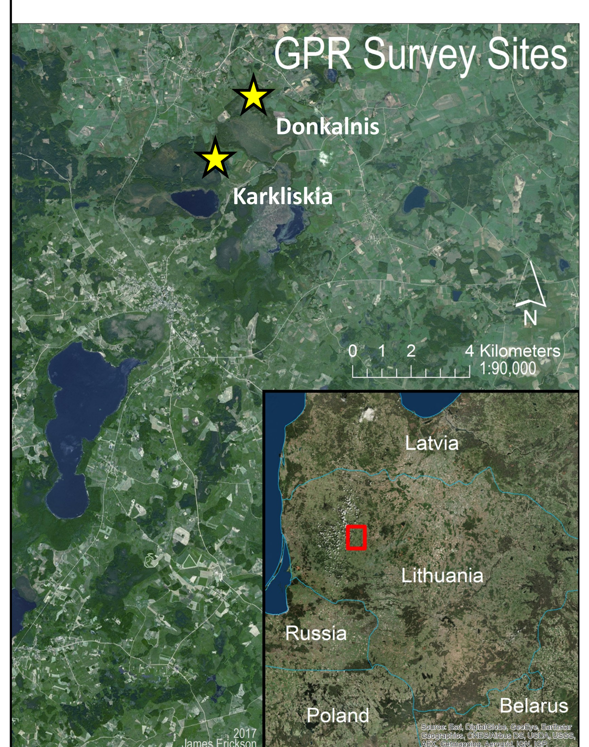
The area now known as the Varniai Regional Park in Northwestern Lithuania is considered by many to have been a hub for all different human cultures. Archeological evidence suggests that humans consistently inhabited the area following the retreat the ice sheets (~9-10 thousand YBP) well into the historical era (Stancikaite, et al. 2004) These early people settled close to the newly formed lakes in the region leaving cultural remains behind for archeologists to investigate. Recently, numerous environmental changes have occurred, notably a decrease in lake water level, meaning that areas which were once water are now peat bogs which have covered the original position of many lakeshores in the region (Stancikaite, et al. 2004).

These bronze and iron age artifacts found in Southeast Lithuania are constructed of organic material which is well preserved from being buried in peatbogs like those in this research project. 1. wooden spoon, 2. axe handle, 3. bast cord fragment, 4. wooden household item (Pranckenaite 2014)

This environment offers both challenges and opportunities for archeologists. Artifacts made out of easily decomposable organic materials are typically well preserved due to the anaerobic nature of the peat bog environment prevalent in the region. Unfortunately, this terrain type makes excavations time consuming and costly as pumps are required to remove excess water from excavation trenches. In the summer of 2016, a GPR survey produced several transects (GPR images) at two different sites in the park: Karkliskia, a peat bog which used to be a straight of water that ancient people would have likely settled, and Donkalnis, an old lake island which was used as a gathering place and burial mound. The data collected during these surveys can be used to pinpoint ancient buried shorelines. The location of these shorelines can be utilized by archaeologists to plan future excavations.


Excavation trenches quickly fill with water without specialized equipment which adds expense to a project. Knowing where to dig can save valuable time and money.

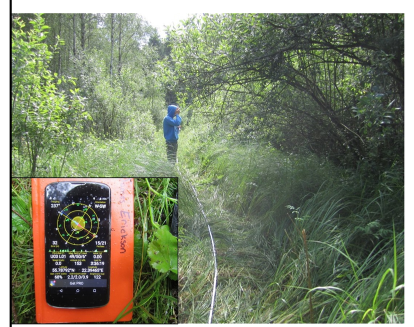
This poster is presented as a synopsis of the methodology used to collect, process, and interpret data used to locate ancient shorelines in Varniai Regional Park, Lithuania.



GPR Survey site locations: *Karkliskia, a peat bog which used to be a straight of water which ancient people would have likely settled, and Donkalnis, an old lake island which was used as a gathering place and burial mound.*

Methods

Each GPR survey was created in four steps which include data collection, correction, and display congruent with the real world features.


Experts in the field determine where to collect a GPR transect by placing a survey line. Location and direction are then recorded with GPS and compass bearings.

1. Determine the survey area.

- Survey reels were used to denote the survey area for each transect; measurements for both GPR and topographic surveys used these distances.
- A combination of GPS, compass bearings, and distance measurements were used to tie each transect line to its real world location.

2. Collect Ground Penetrating Radar data.

GPR data collection was accomplished using various techniques with Sensors and Software's pulseEKKO 100 and pulseEKKO 1000 GPR systems.

- Data was collected with 100, 200, and 225 Mhz antennae at respective step sizes of 50, 25, and 5 cm.
- Approximate signal velocities between 0.05 m/ns and .75 m/ns were determined from common mid-point (CMP) surveys at both sites (Conyers 2004).


A PulseEkko 100 GPR system sends information to a computer display allowing researchers to identify subsurface features in the field.

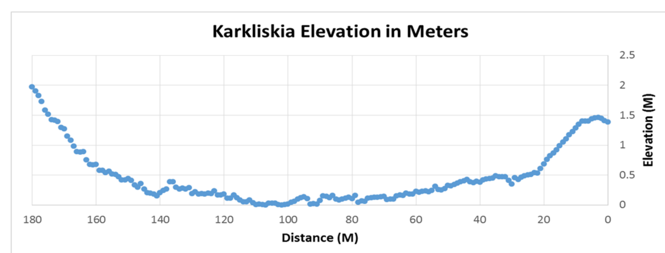

A Topcon laser leveler being used to collect elevation data for a transect. This topographic information will be used to correct the relief of the GPR transect.

3. A topographic survey was collected with a TopCon Laser Leveler in order to geometrically correct the GPR survey data.

- Relief relative to meter mark zero measured every one meter.

4. Processing

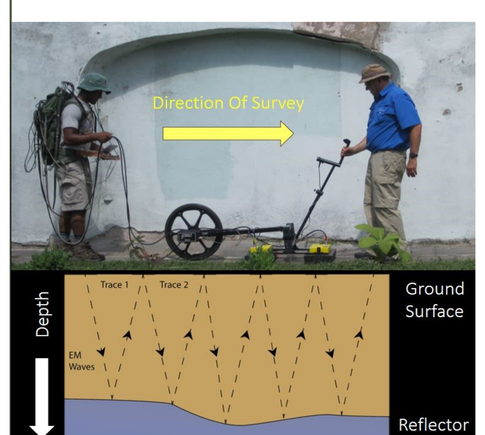
Sensors and Software's EKKO_project 4.2 computer software was used to display GPR data with AGV gain and geometrically correct each transect.



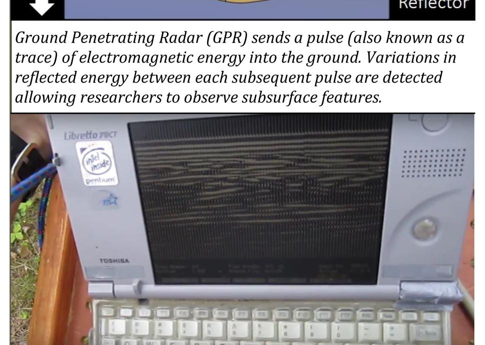
Elevation of the Karkliskia transect after normalizing data in an Excel spreadsheet.

What is Ground Penetrating Radar?

Ground penetrating radar uses two antenna tuned to specific frequencies. The first antenna sends an electromagnetic pulse through the surface of earth, and the second antenna receives signals from the original pulse that are reflected back off of soil layers or buried objects (Bristow and Jol 2003). The signal is then recorded and displayed by a computer system in real-time at the field site. This allows for immediate data interpretation while still storing the data for additional processing at a later time. There are many different GPR systems available on the market today, and performance is largely determined by the environment they are used in. One can tell what kind of data a GPR system will provide depending on the frequency of the antenna. Generally speaking, the higher the frequency, the more detail, or the higher the resolution of the returning data will be (Conyers 2004). A lower frequency will produce less detailed data but will penetrate the surface further (Conyers 2004). GPR systems with antenna ranging from 100 - 300 MHz are most commonly used for archaeological applications (Conyers 2004). A GPR survey of an area can provide sufficient detail to answer many questions that researchers may have. For example, one can find features such as building foundations, buried walls, grave sites, and possible anthropogenic soil disturbances (Conyers 2004; Feder and Park 2007). In this poster, GPR is used to locate ancient buried shorelines and areas with significant human manipulation of the environment.



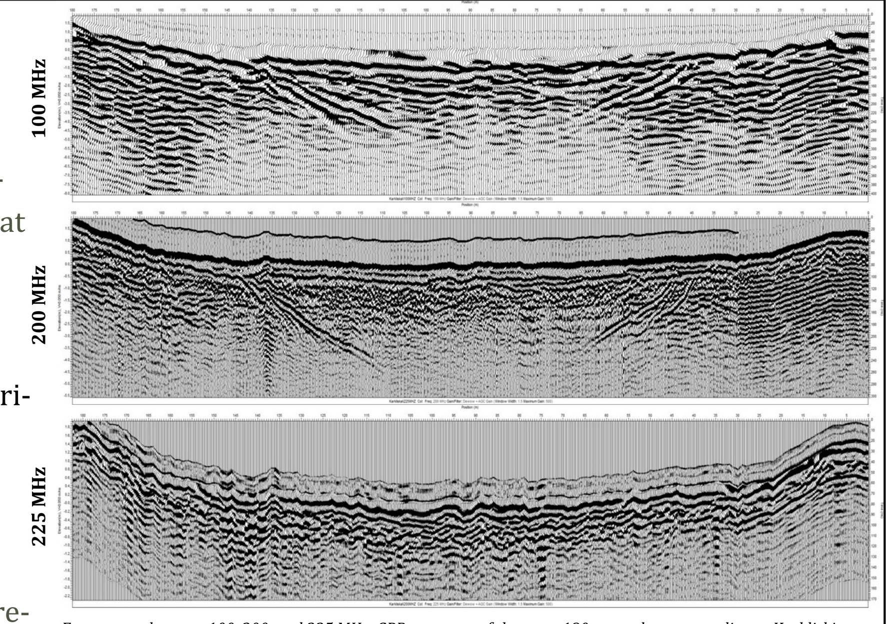
Ground Penetrating Radar (GPR) sends a pulse (also known as a trace) of electromagnetic energy into the ground. Variations in reflected energy between each subsequent pulse are detected allowing researchers to observe subsurface features.


GPR data collected and displayed in real time on this computer screen allows for initial interpretations to be made on site.

Results

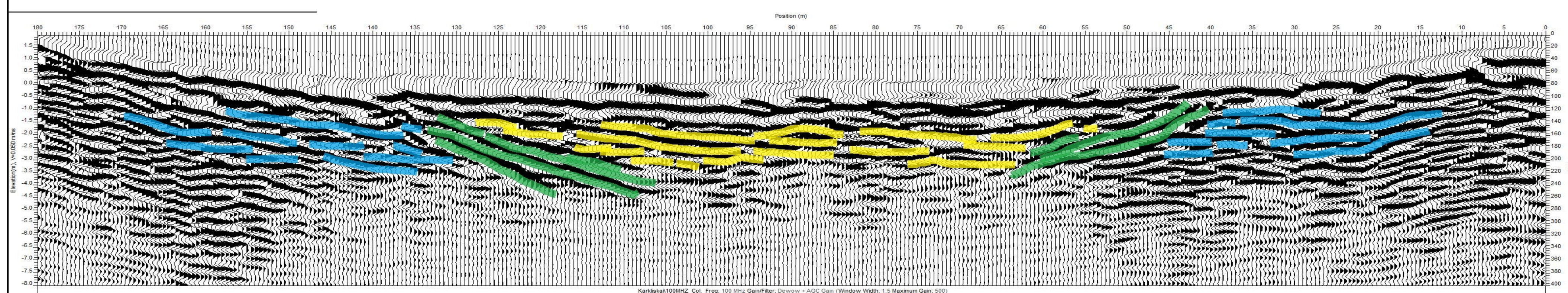
Karkliskia is a bog which used to be a straight of water between a lake island and the mainland. It is located north of the Lithuanian village of Varniai in the Varniai Regional Park. This part of Lithuania was at one time host to many rivers, forests, and streams which gave ample resources, trade opportunities, and protection to early human inhabitants of the area dating as far back as 9000 years ago (Stancikaite et. al. 2006, Butrimas 2012, Butrimas and Šimėnas 2015). Ancient peoples living in this area settled on or near the shores of the numerous lakes and left cultural remains behind in high concentrations. In recent years water levels have become lower which has turned many lakes into swamps which have buried the ancient shorelines under a layer of peat. Knowing where these buried shorelines are is important to archeologists as they not only have high concentrations of artifacts, but those artifacts are often well preserved.

This 180-meter long spans over a peat bog which used to be a straight between a lake island and the mainland. A GPR survey of this line was conducted to locate the lake's buried shoreline, an area which may contain many artifacts from ancient peoples. This information is invaluable to archeologists.



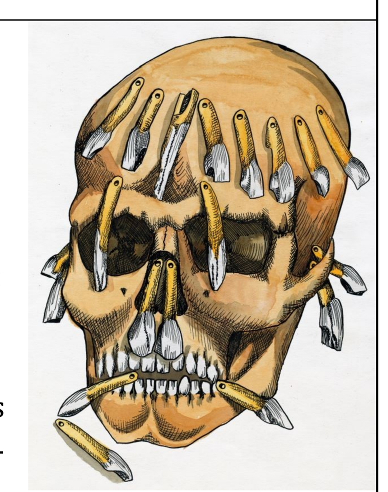
From top to bottom: 100, 200, and 225 MHz GPR transects of the same 180-meter long survey line at Karkliskia. Note the differences between frequencies as those with lower MHz ratings penetrate much deeper underground but show the same features with less detail.

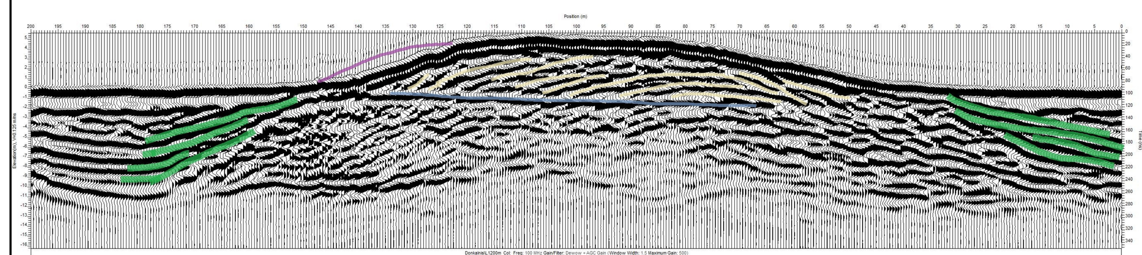
Ground penetrating radar has reveled many details of the subsurface at Karkliskia: semi-continuous horizontal layering exists near the outside boundaries of the transect image. This layering is truncated by two inclined reflections which form a 'U' shaped channel. These two observations are interpreted as the ancient lake's original boundary.

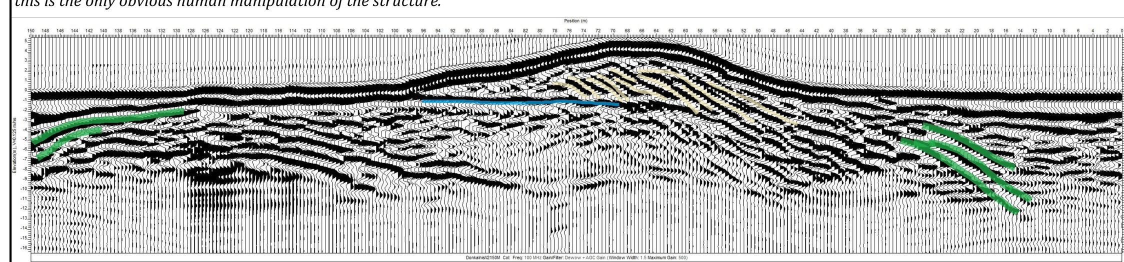


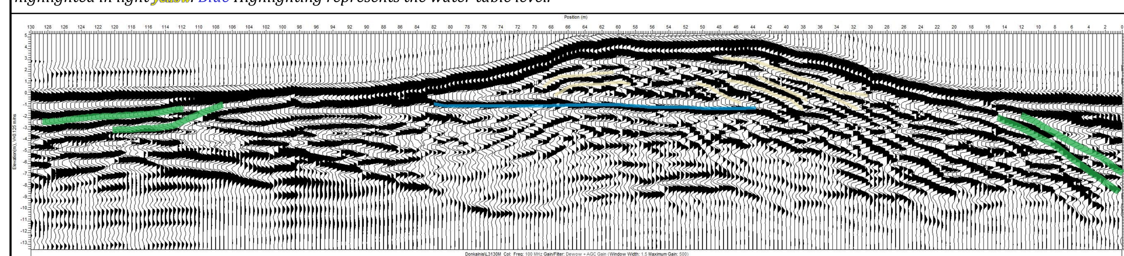
The 100 MHz transect of the Karkliskia survey site shows continuous horizontal layering (blue) truncated by inclined reflections (green) which form a "U" shaped channel and indicate that a shoreline existed here at one point. Layers of peat, highlighted in yellow, have filled the former lake bed and cause radar signal attenuation as is apparent by the lack of data directly beneath the peat layers.

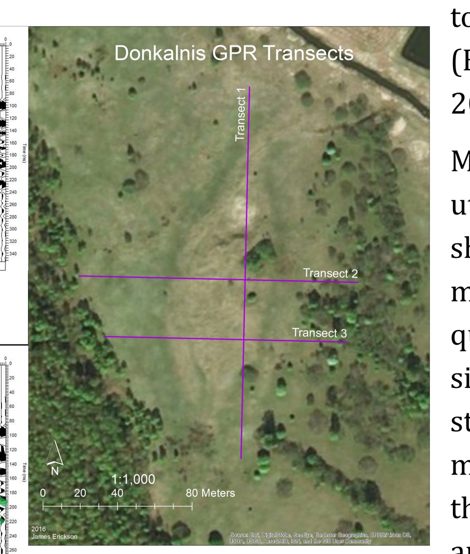
Donkalnis is located roughly two kilometers northeast of the Karkliskia survey site. Donkalnis is a glacial kame that used to be an island on Lake Biržulis (Butrimas 2012). In the 1950's farmers mined the north end of the mound for gravel. Shortly after starting they stopped due to uncovering ancient burials (Butrimas 2012). From many archeological excavations, it became apparent that the Donkalnis kame was used as a burial mound from approximately 9000 to 5000 years before present (Butrimas and Šimėnas 2015). 24 burials, one of which is the oldest known burial in Lithuania, were found in this kame formation in 17 different oval shaped graves (Butrimas 2012; Butrimas and Šimėnas 2015). This site is of significant cultural importance for Lithuania as it has given much insight into how Mesolithic and Neolithic people lived through the study of not only the physical human remains, but of the grave goods associated with each burial such as red ochre, stone tools, and modifided animal bones. (Butrimas 2012; Butrimas and Šimėnas 2015).


The Donkalnis Soothsayer is one of the 24 human burials found within the Donkalnis burial mound. He is the oldest, and most famous Mesolithic burial in Lithuania. This artists rendition shows symmetrically placed animal teeth around the skull. (Butrimas 2012)


Donkalnis Transect 1: This 200-meter-long, 100 MHz, transect provides substantial depth of subsurface penetration. Highlighted in green are inclined reflections which indicate the presences of a buried shoreline. The internal structure of the glacial kame formation is highlighted in light yellow. Blue Highlighting represents the water table level. A purple line to the left of the Kame formation is assumed the shape of the kame before it was mined for gravel, this is the only obvious human manipulation of the structure.


Donkalnis Transect 2: This 150-meter, 100 MHz GPR line shows differences in shore line angles between the West and East sides of the former lake island. Highlighted in green are inclined reflections which indicate the presences of a buried shoreline. The internal structure of the glacial kame formation is highlighted in light yellow. Blue Highlighting represents the water table level.


Donkalnis Transect 3: This 130-meter, 100 MHz GPR line shows similar features to the other GPR transects of the Donkalnis burial mound. Highlighted in green are inclined reflections which indicate the presences of a buried shoreline. The internal structure of the glacial kame formation is highlighted in light yellow. Blue Highlighting represents the water table level.



Three GPR transects were collected at the Donkalnis site in order to answer two questions: Where is the old shoreline buried? Can GPR detect human manipulation of this glacial formation turned burial mound?

Much like at Karkliskia, GPR has been utilized to locate the ancient buried shoreline of the Donkalnis burial mound. Three GPR transects at a frequency of 100 MHz were collected on site. These transects reveal the internal stratigraphy of the glacial kame formation and show Inclined reflections that are interpreted as being the lake's ancient buried shoreline.

Conclusions

Knowing the location of ancient buried shorelines is essential for conducting archaeological research in the Varniai Regional Park as a great quantity of cultural remains were likely deposited on or near lakeshores by human settlements. Ground penetrating radar technology has proven to be a viable technique to locate buried shorelines in the swampy environment prevalent in the Varniai Regional park. The GPR data used in this project, in conjunction with other investigative techniques, has already been used by Lithuanian archeologists to secure funding for on site excavations at Karkliskia in the summer of 2017.

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The Varniai Regional Park: for allowing our research team unprecedented access to numerous, beautiful locations within the park.

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