Ground Penetrating Radar Provides Evidence for the Previously Unrecognized Danaher Channel near Seney, MI

KLEINSCHMIDT, Alexander S.[1], HYNEK, Madeline R.[1], JOL, Harry M.[1], SEAMANS, Jackelyn M.[1], LOOPE, Walter L.[2], JOL, Connor E.[3], (1)Department of Geography and Anthropology, University of Wisconsin – Eau Claire, (2)U.S. Geological Survey, Munising, Michigan (3)Delong Middle School, Eau Claire, WI

Abstract

It is common belief that glacial meltwater from Lake Superior flowed to the Atlantic Ocean through a northeasterly channel before the Sault Ste. Marie channel existed. However, recent geomorphological evaluations of Upper Michigan suggest that a Holocene-era channel (Danaher Channel) cut through Upper Michigan, which provided a path for the meltwater from present day Lake Superior to Lake Michigan (Loope et al., 2014). Ground penetrating radar (GPR) data (800 meters in length) were collected roughly 11 kilometers southeast of Seney, MI, to provide subsurface evidence for this theory. GPR is a survey method that utilizes antennae that transmit electromagnetic (EM) energy into the ground, which reflect off materials of different dielectric properties (Conyers, 2013). The reflected EM waves return to the antennae and create an image of the subsurface. A Sensors and Software pulseEkko100 GPR system was used to collect two transects with step sizes of 0.5 meters and an antennae frequency of 100MHz. Using the EKKOproject software program, line views of the transects were processed by adding wiggle traces and using Dewow+AGC gain to precisely image the stratigraphic properties of the facies. Semi-continuous layers truncated by sub-horizontal layers provide evidence for the Danaher Channel. Further GPR lines are proposed to more accurately determine the path of this channel.

Background

Rapid climate change in the northern hemisphere has been linked to the final retreat of the Laurentide Ice Sheet. How the glacial meltwater from the ice sheet was originally conveyed from the Great Lakes Basin to the Atlantic Ocean prior to ca. 9 ka is being reconsidered (Yu et. al. 2010, Loope et al. 2014). Holocene era Lake Minong (Figure 1) is believed to have drained through Sault Ste. Marie prior to ca. 9 ka, which had been dammed by theNadoway Drift Barrier (NDB) (Dyke et al. 2003). Research conducted by Loope et al. 2010 support Yu's interpretation that the breaching of the NDB was unlikely and that another channel must have existed.

Loope et al. 2014 provide evidence of a channel that cut through Upper Michigan, which conveyed meltwater from Lake Mining to Lake Chippewa (Figure 1). This study used ground penetrating radar (GPR) to survey the subsurface with the goal of finding evidence to further show the existence of the Danaher Channel. The GPR survey was conducted at a site that would provide crucial evidence for the proposed channel (Figure 2). A previous GPR survey was conducted directly north of Danaher, Michigan, which had provided evidence of the channel. This GPR survey is a continuation of that research.

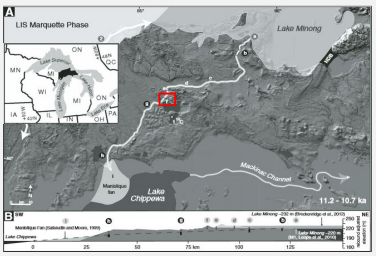


Figure 1. The white line is the proposed channel (Loope et al. 2014). The red box highlights the study area of this GPR survey.

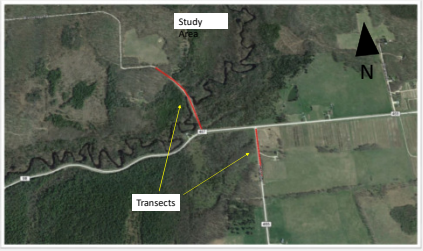
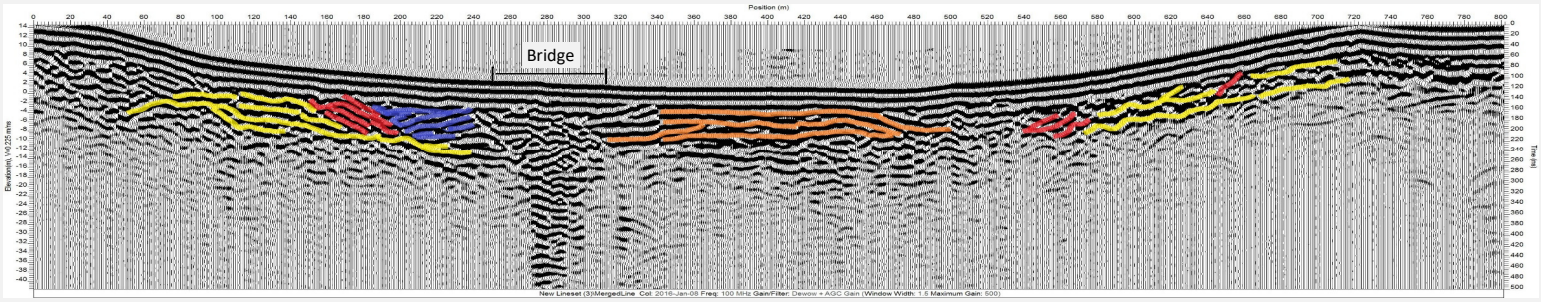


Figure 2. This Google Earth image shows where the two GPR transects were collected. These lines were merged during processing.

Results/Interpretation



The reflections highlighted in yellow are continuous to semi-continuous and slightly dipping patterns that are interpreted as sandy alluvial deposits. The reflections highlighted in red are sub horizontal to dipping patterns that are interpreted as an even greater deposition of sandy sediment which demonstrates an event of aggradation. The reflections highlighted in violet are semi continuous erosional truncations. These erosional infills were likely deposited after the transgression of Lake Minong. A sixty meter bridge suggested that some anthropological forces may have affected the subsurface.

Methods

Data Collection

Ground penetrating radar is a non-invasive geophysical survey method that utilizes electromagnetic (EM) energy to image the subsurface (Jol & Bristow 2003). GPR uses one antenna to emit electromagnetic energy into the ground and another to receive the energy that was reflected off subsurface features (Figure 3). Once the energy received it is sent to a computer which displays the reflections in real time. (Figure 4).

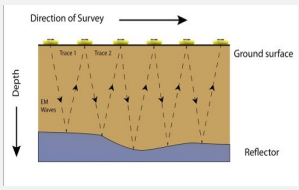


Figure 3. Data was collected every 0.5 meters with an antennae frequency of 100Mhz.

Figure 4.This GPR survey used a Sensors and Software pulseEkko100 GPR system.

The depth of penetration is dependent upon the wavelength of the electromagnetic energy; the lower the wavelength, the deeper the penetration (Conyers 2013). The sediment composition also plays a role in depth of penetration. Two transects were collected with a total length 800 meters.

Topographic profiles were also collected to provide elevation data to create a geometrically corrected GPR profile. A Topcon laser leveler collected elevation data every two meters along the GPR transect in areas of great relief change and every five meters in areas of low relief change. The data was put into a MS excel spreadsheet where they were normalized.

Processing

The GPR data was processed using Sensor and Software's EKKO Project 4. In EKKO Project, the 2 transects were merged, filtered, had a gain applied, and were adjusted according to velocity in order to reduce signal attenuation and increase resolution of the data. Using the merge tool, the two lines were merged into one and were filtered using a horizontal spatial filter to adjust resolution based on step size. A vertical temporal filter was also applied to remove high frequency signals which increase resolution and a DEWOW filter that removes low frequency signals. An Automatic Gain Control was applied to reduce the attenuation of signals. A common midpoint (CMP) survey was conducted to determine that velocity at which the EM energy traveled through the subsurface. The velocity was determined to be .225 meters per nanosecond.

Discussion

The results showed sub-surficial patterns that are consistent with an event of aggradation within the first 250 meters of the GPR transect. This sediment was likely deposited during the transgression of Lake Minong and the eventual disappearance of the Danaher Channel. The last 300 meters of the GPR transect show little evidence of the proposed channel, however, the transect was effected by telephone poles along the road which can interfere with the signal of GPR system. To provide more evidence in this study area another GPR survey should be conducted directly south of the initial 500 meters of transect taken in a southeasterly direction. More GPR transects should be taken along the proposed path in order to provide more evidence for this channel.

References

Conyers, L. B., 2013, Interpreting ground-penetrating radar for archaeology

Dyke, A.S., and Prest, V.K., 1987, Late Wisconsin and Holocene history of the Laurentide Ice Sheet: Géographie physique et Quaternaire, v. 41

Jol, H. M., and Bristow, C. S., 2003, GPR in sediments: advice on data collection, basic processing and interpretation, a good practice guide.

Loope, W. L., Jol, H. M., Fisher, T. G., Blewett, W. L., Loope, H. M., and Legg, R. J., 2014, A previously unrecognized path of early Holocene base flow and elevated discharge from Lake Minong to Lake Chippewa across eastern Upper Michigan: Geological Society of America Special Papers Online First, Geological Society of America Special Papers.

Yu, Shi-Yong, Colman, S. M., Lowell, T. V., Milne, G. A., Fisher, T. G., Breckeridge, A., Boyd, M. and Teller, J. T., 2010, Freshwater outburst from Lake Superior as a trigger for the cold event 9300 years ago: Science, v. 328

Acknowledgments

This project was funded by Student Differential Tuition funds through the University of Wisconsin-Eau Claire Diversity Mentoring program. I would like to thank the Ronald E. McNair Post-baccalaureate Achievement Program for funding this research through the summer research institute. Thank you Dr. Harry Jol for being my mentor and Walt Loope for lending his expertise.