1. Background

The Savanna Terrace, a prominent geological feature, exhibits a distinct stratigraphy and sedimentology. The Savanna Terrace can be traced for approximately 1,000 km along the Mississippi River, from Pepin County, Wisconsin to Jackson County, Illinois (Figure 1a & b, Flock, 2009). This terrace is a result of glacially-derived sediment along the Mississippi River, slackwater environments developed within its tributaries. Incision by the Paleo-Rush Creek completed the process of forming the Savanna Terrace (Johnson, 2009). The Savanna Terrace can be traced for approximately 1,000 km along the Mississippi River from Pepin County, Wisconsin to Jackson County, Illinois (Figure 1a & b, Flock, 2009).

2. Research Objectives

Electrical resistivity works well in clay terraces for determining sediment types and detecting boundaries. Ground-penetrating radar signals are attenuated through conductive clay units, but provide the best resolution (Hirsh et al., 2008). The objectives of this project are:

1) To perform ground-penetrating radar (GPR) and electrical resistivity (ER) analysis to confirm the depth of contact between the Equality Formation slackwater materials and the Henry Formation fluvial sands (see sediment core SVS-25).

2) To verify the contact depth calculated from previously gathered core and electrical conductivity (EC) data to GPR and ER imaging.

3) To evaluate how each geophysical method (EC, ER, or GPR) can contribute the most accurate results in clay dominated terraces.

3. Methodology

1) The GPR survey was conducted with a pulseEKKO 100™ radar unit manufactured by Sensors & Software Inc. provided by Northern Illinois University (Figure 3). Two walk-away GPR surveys with 50-MHz and 100-MHz antennas were conducted along a 20 m transect oriented north and south along the terrace (Figure 1). The CMP profiles were conducted along the same transect with 2 m spacing between 50-MHz and 1 m spacing between 100-MHz antennas.

2) ER data were collected with an ABEM Terrameter SAS 300B system in a Schlumberger Array electrode configuration. Vertical Electrical Soundings (VES) were conducted along the GPR transect which was extended 40 meters each end.

3) An EC log was taken with a Geoprobe 6600 direct push rig using a SC500 sonde (Figure 4).

4) Geophysical data was correlated with previously conducted Dual Tube-22 continuous core samples gathered in 1.25 inch liners.

4. Results

4.1. Core Analysis

Sediment core SVS-25 used for comparison was taken east of the geophysical survey lines with a Geoprobe ™ Direct 6600 push rig owned by the University of Wisconsin-Eau Claire, 105 Garfield Avenue, Eau Claire, WI 54702-4004 (715)836-3732, highestit@uwec.edu. Thanks to the Office of Research and Sponsored Programs at the University of Wisconsin-Eau Claire for the funding. Also, thanks to Dr Phil Carpenter and Eduard Breuer from the Department of Geology and Environmental Geophysics at Northern Illinois University for assisting with the data collection and processing, and Dr Beth Johnson for establishing “Cousin George” he barns.

4.2. Ground-Penetrating Radar

Although complicated by air-wave reflections from trees (70 meters west of profile) and the console box, the 50-MHz profile reveals what may be a reflector at approximately 3 meters deep, but is not entirely clear due to interference with the ground-wave. GPR profiles processed by Dr. Phil Carpenter at the University of Northern Illinois.

4.3 Electrical Conductivity

The Equality to Henry Formation boundary is marked by peak EC values (Johnson, 2009). The EC log (SVS2) from core SVS-25 illustrates a transition from variably conductive slackwater materials to fluvial materials at approximately 2.97 meters deep (Figure 5). Peak slackwater values of about 120 mS/m likely indicate an initially clay-rich environment. The lower portion of the log likely consists of fluvial channel bar sequences peaking at 45 mS/m and conductivities as low as 8.5 mS/m (Johnson, 2009).

4.4 Electric Resistivity

While ER images from the current project are being processed, the relationship between core and resistivity data were compared from a previous site 0.4 km north-west of the project site using the same methods (Figure 1). Core data (SVS-30) describes the first major grain size change from clays and silts to coarse sands around 1.90 meters (Figure 6). The resistivity sounding portrayed an increase in resistivity at a similar depth as the sharp contact from fines to sands shown in the core (Figure 7, Johnson, 2009).

5. Conclusion

Combining the geophysical data and core analysis, a boundary between slackwater and fluvial depositional regimes can be distinguished around 3 meters. This project also suggests that:

1) GPR can discern the boundary between slackwater and fluvial deposits despite high clay content provided that the clay-rich materials are only a few meters thick.

2) Electrical conductivity portrayed the variability of sediment sorting and concentration within units.

3) Resistivity results provided depths for changes in boundaries marked by sediment changes.

6. References


7. Acknowledgments

Thanks to the Office of Research and Sponsored Programs at the University of Wisconsin-Eau Claire for the funding. Also, thanks to Dr Phil Carpenter and Eduard Breuer from the Department of Geology and Environmental Geophysics at Northern Illinois University for assisting with the data collection and processing, and Dr Beth Johnson for establishing “Cousin George” he barns.