

Appendix 3

Preliminary Ground Penetrating Radar Survey

Conducted by Howard Mooers and Nigel Wattrus
University of Minnesota Duluth

Report prepared by Howard Mooers
Professor of Geology
Department of Geological Sciences
University of Minnesota
10 University Drive
Duluth, MN 55812

Introduction

One of the recommendations of the EJ Project Groundwater Expert Panel was that better characterization of the site stratigraphy would aid in the study of contaminant transport. A specific recommendation was better characterization of the surface of the till confining layer beneath the site. It was suggested that topographic undulations common to till surfaces could be serving to pool dense contaminant phases (DNAPLS) in low areas. The panel suggested that in this case it might be possible to recover some of the contaminants or at least better model their fate. The recommendation of the panel was to use ground penetrating radar to determine the microtopography of the till surface.

In rebuttal, consultants for Champion International Corporation suggested that the till surface was essentially a plane without any topography, and that if DNAPLS were present they would be expressed as a thin film on the level till surface and be unrecoverable.

To investigate the nature of the surface of the confining till layer, ground penetrating radar was used to survey the stratigraphy. The survey was done by the Department of Geological Sciences at the University of Minnesota Duluth under the direction of Howard Mooers and Nigel Wattrus. The results of the survey are presented below.

Till Basics

Deposition of till in glacial systems occurs by several mechanisms. These mechanisms are typically divided into four main groups: lodgement, meltout, flow till, and deformation tills.

- a) Lodgement – the process where sediment melting out of ice at the base of a glacier is “lodged” into place by the weight of the overlying ice. This process

- leads to the deposition of dense sediment with low hydraulic conductivity (hence a confining layer).
- b) Meltout till is formed by the melting of debris-laden stagnant ice. Sediment is simply let down and deposited as interstitial ice melts.
 - c) Flow till is typically an ice-surface meltout till that is redeposited by mass movement such as gravity flows.
 - d) Deformation till is formed from the subglacial deformation of sediment beneath an actively flowing glacier.

The till at the St. Regis site in Cass Lake is the Hewitt Till, which is defined as a lodgement till by Goldstein (1986, 1989, 1998). The topography of lodgement till surfaces typically ranges from undulating to hilly and can be characterized by a variety of landforms such as drumlins, flutes, etc. It is the very nature of lodgement till surfaces to be undulating, reflecting the conditions at the glacier base. A survey of lodgement till surfaces around Minnesota and Wisconsin, in particular a survey of the topography of the Hewitt till where it is exposed a few 10s of miles to the south of Cass Lake, reveals that that there are several scales of topography. At the large scale the till is drumlinized and at smaller scales the surface undulates. The typical undulations or microtopography, are on the order of a few meters (5-15 m) apart with vertical scales of 0.5 to 1 meter.

Ground Penetrating Radar (GPR) Survey

After consultation with the Tribe, it was decided to conduct a GPR survey on a privately-owned property adjacent to the St. Regis site (Figure 1). An area was chosen that was level, free of trees, and along a public street adjacent to the site. A reference marker was placed at the SE corner of the area to be surveyed from which all measurements, both spatial and vertical, were made. Transects were laid out in an east-west orientation along which the radar survey was made. Transects were 36 meters long and spaced 0.5 meters apart (Figure 1). It was calculated that the ideal spacing for the transmitting and receiving antennas was 2 meters, and that for best resolution the radar soundings should be made every 0.5 meters. A tape divided into 0.5-meter increments was laid out along each transect. Antennas were then moved and soundings made every 0.5 meters for a total of 72 sounding per transect. The elevation of each of the points at which sounding were taken was then surveyed with an optical level relative to the reference marker.

The GPR soundings were made with a Pulse Ekko system manufactured by Sensors and Software using 100MHz antennas. The data were then processed using PulseEkko Ekkotrace and SU seismic processing software from Colorado School of Mines. The data were reformatted to SEG Y, the industry standard. Gains were applied, geometry was added, and the data were loaded into a seismic interpretation software, TKS by Seismic Micro Technology, where the data are treated as a 3-D seismic data volume.

Results

Figure 2 is an example of the radar profiles and Figure 3 is a color shaded contour map of the till surface below the study location adjacent to the St. Regis site. The microtopography on the till surface at this location is similar to that elsewhere on the Hewitt Till. Undulations have spatial dimensions of 5-15 meters; the vertical relief is up to 1.5 meters. These undulations are of the scale that was anticipated by the members of the Groundwater Panel, and their characterization would constitute an important component of site geological assessment. Given the scale and relief of the microtopography on the till surface, there is certainly the possibility that pools of DNAPLS are present at the site.

References Cited

- Goldstein, B. S. 1985. Stratigraphy, sedimentology, and Late-Quaternary history of the Wadena drumlin region, central Minnesota. [Ph.D.Dissertation], University of Minnesota.
- Goldstein, B. S. 1989. Lithology, sedimentology, and genesis of the Wadena drumlin field, Minnesota, U.S.A. *Sedimentary Geology* 62(2/4):241-277.
- Goldstein, B. S. 1998. Quaternary stratigraphy and history of the Wadena drumlin region, central Minnesota. In: *Contributions to Quaternary Studies in Minnesota*. C.J. Patterson and H.E. Wright, Jr. Eds. Minnesota Geological Survey Report of Investigations 49.

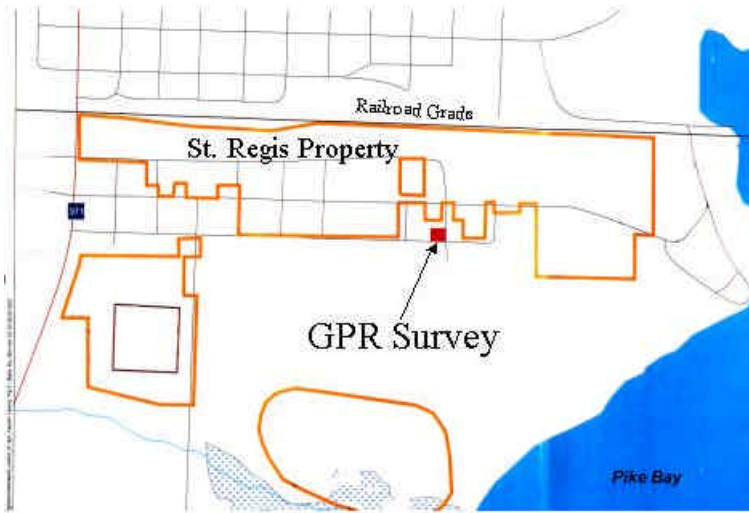


Figure 1. Location of GPR survey.

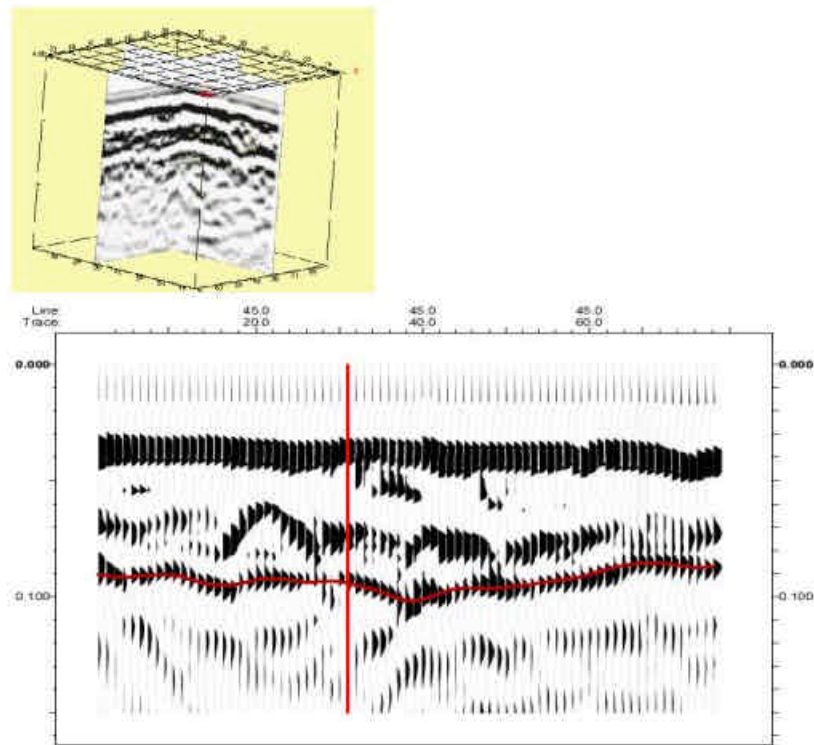


Figure 2. This is an example of the type of data collected during the site survey. Figure 2a is two intersecting sliced through the seismic volume and Figure 2b is a single line trace. Darkly shaded areas are those where there is a large impedance contrast caused by abrupt changes in material properties. The red line denotes the surface of the till confining layer.

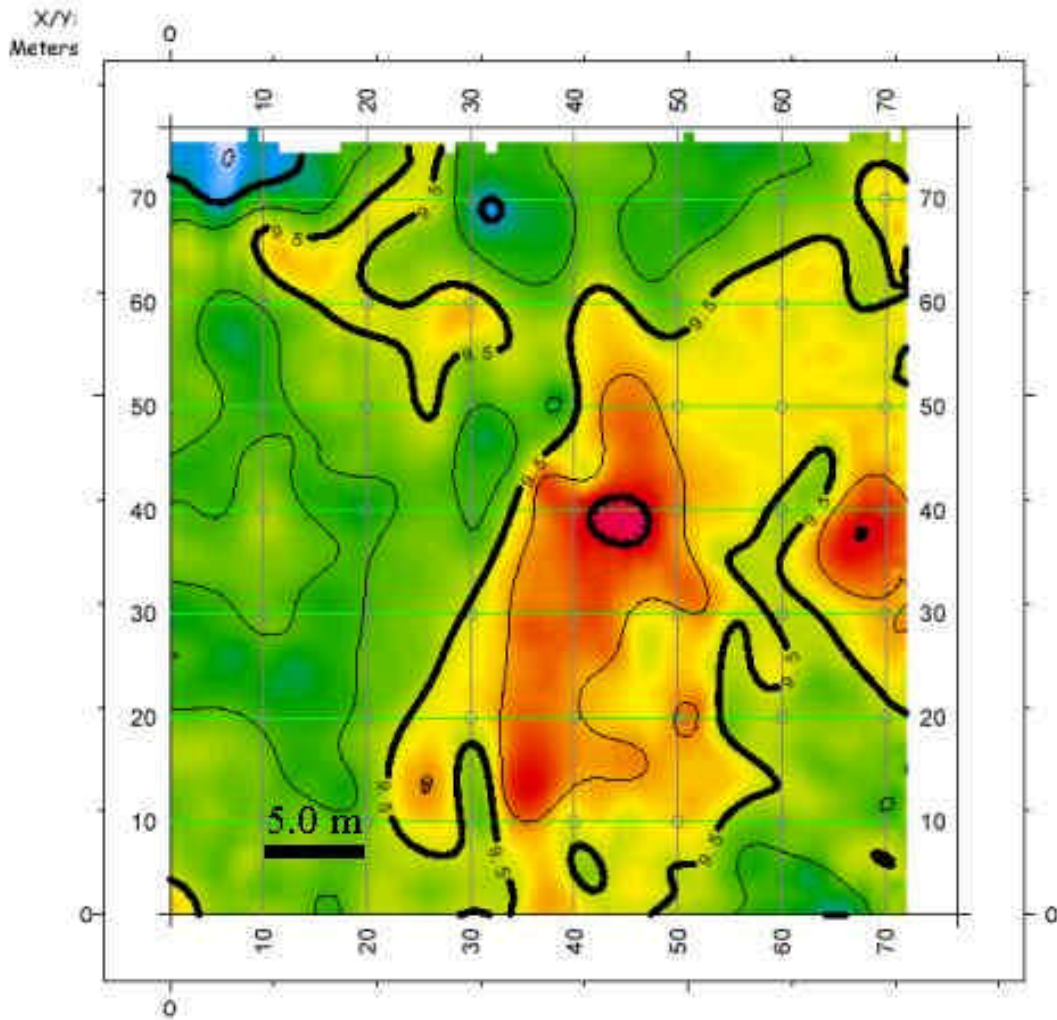


Figure 3. Color shaded contour map of the surface of the till confining layer. Contour interval is 0.5 meters with bold contours every one meter. Note that the maximum relief on the surface is approximately 2 meters with 1.5 meters. Bar scale is in meters. Numbers along the side of the diagram are seismic lines, each spaced 0.5 meters apart.