Resistivity Survey

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Introduction

We performed a resistivity survey with two objectives: to determine the resistivity along a line that had been used for a seismic survey on August 18th, 2017 and to identify the depth of the underlying bedrock. We designed four different resistivity surveys by varying electrode spacing and array type. This was to achieve variation in lateral and vertical resolution, respectively (Milson and Eriksen, 2011). Furthermore, the two different arrays used, Wenner-alpha and dipole-dipole, vary in their resolution capabilities. In general, Wenner-alpha arrays generate a better vertical resolution and Dipole-Dipole arrays generate a better lateral resolution (Milson and Eriksen, 2011). Wenner-alpha is also better used for noisy survey areas while dipole-dipole is better used for quiet survey areas (Milson and Eriksen, 2011). Because we had no prior knowledge of the complexity of our survey area, and to achieve resolution variation, we used both arrays.

The survey was conducted in the woods behind the cabins at Ogilvie's Camp, Deep River Ontario. The camp is accessed through Melleur's Road just off of HWY 17, 10 minutes north of Deep River. The survey line was in the forest to the south and parallel to the 'Potato patch' along a seismic survey line used on August 18th, 2017. The survey site is in the Grenville province, in a graben. Glaciation in the area has led to a layer of till over the Grenville bedrock, and sand overlaying the till in most places. The sand has created an aquifer in the area and the glaciation left several notable features including an esker north west of the camp.

The line runs from the starting peg at 0 metres, UTM 18 T 0297706 5115343, to an end peg at 47 metres, UTM 18 T 0297746 5115360, with an intermediate peg at 25 metres, UTM 18 T 0297723 5115352, the GPS had an accuracy of +/- 3m. There were three piezometers along the line, #40 at 23 metres, #48 at 34 metres, and #42 at 46 metres from the starting peg. There is a small creek that runs parallel to the line about a meter south of the starting peg and then curves southward further up the line. The site was still fairly saturated with water as it rained overnight, but at the time of the survey it was warm with light cloud cover in the morning which gave way to sun by afternoon.

Figure 1: Satellite image of Ogilvie's camp

Method

A 47-metre transect was setup using a 90 metre measuring tape from the start peg at the west end of the footpath. It ran in a straight line along the footpath, until reaching the end peg at the east end of the footpath. It passed the intermediate peg halfway through the transect.

We performed four different resistivity surveys by varying electrode spacing, either 0.5 or one metre, and array type, either Wenner-alpha or dipole-dipole. Table 1 describes these trials in more detail as well as the instrument specifications. To measure resistivity, we used a Syscal Junior Switch-48 Resistivitymeter (IRIS Instruments, France). Multi-electrode mode was used for all trials.

Once electrode spacing and array type was chosen, electrodes were hammered 2-3 inches into the ground at the chosen spacing. An electrode cable was run parallel to the electrodes and alligator clips were attached to electrodes and cables.

To analyse resistivity data collected on the resistivitymeter, we used ElectreII and Prosys software.

	Survey 1	**Survey 2**	**Survey 3**	**Survey 4**
Array type	Wenner-Alpha	Dipole-Dipole	Wenner-Alpha	Dipole-Dipole
Name of array on instrument	WA48-a	DD48-a	WA48-a	DD48-a

Electrode spacing (metres)	0.5	0.5	1	1
Start point (metres)	0	0	0	0
End point (metres)	23.5	23.5	47	47
Voltage (V)	12.75	12.5	12.58	12.42
Highest resistivity recorded during res-check (kΩ)	7	N/A	11.8	12
Lowest resistivity recorded during res-check (kΩ)	2.1	N/A	2.4	2.4

Table 1: Resistivity survey design. A res-check was not performed for Trial 2. Start point specifies the position of the first electrode while end point specifies the position of the last electrode. Res-check (resistivity-check) is a function of the resistivitymeter that checks the resistance between subsequent electrodes to ensure all electrodes are connected properly.

Data

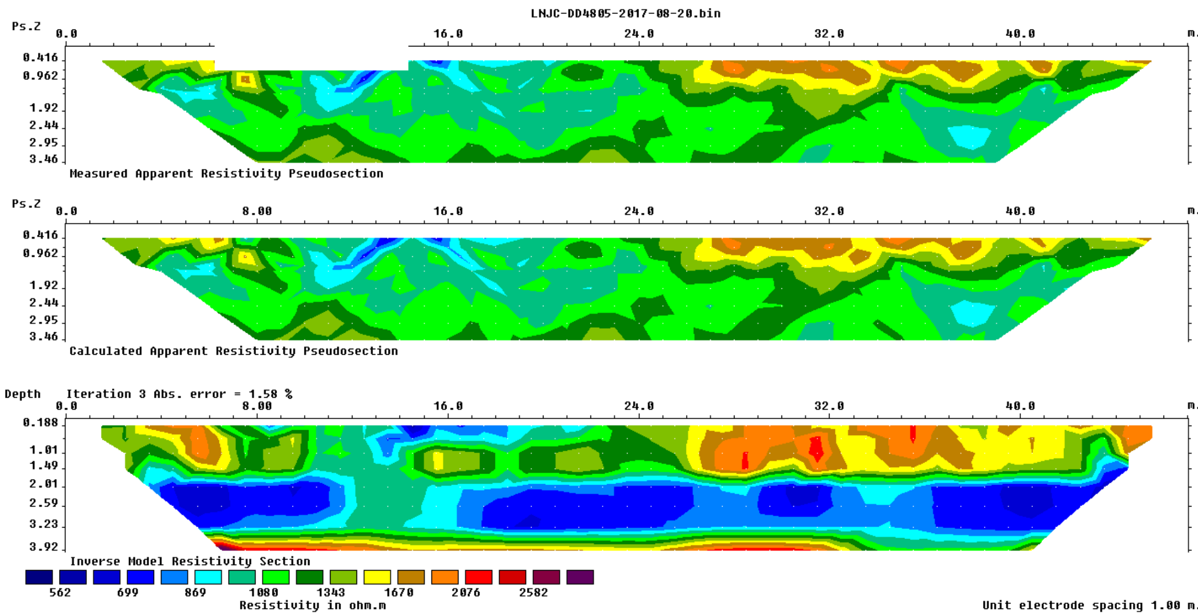

Figure 1: Resistivity line from 0 to 23.5 metres with electrode spacing of 0.5 metres using dipole-dipole array.

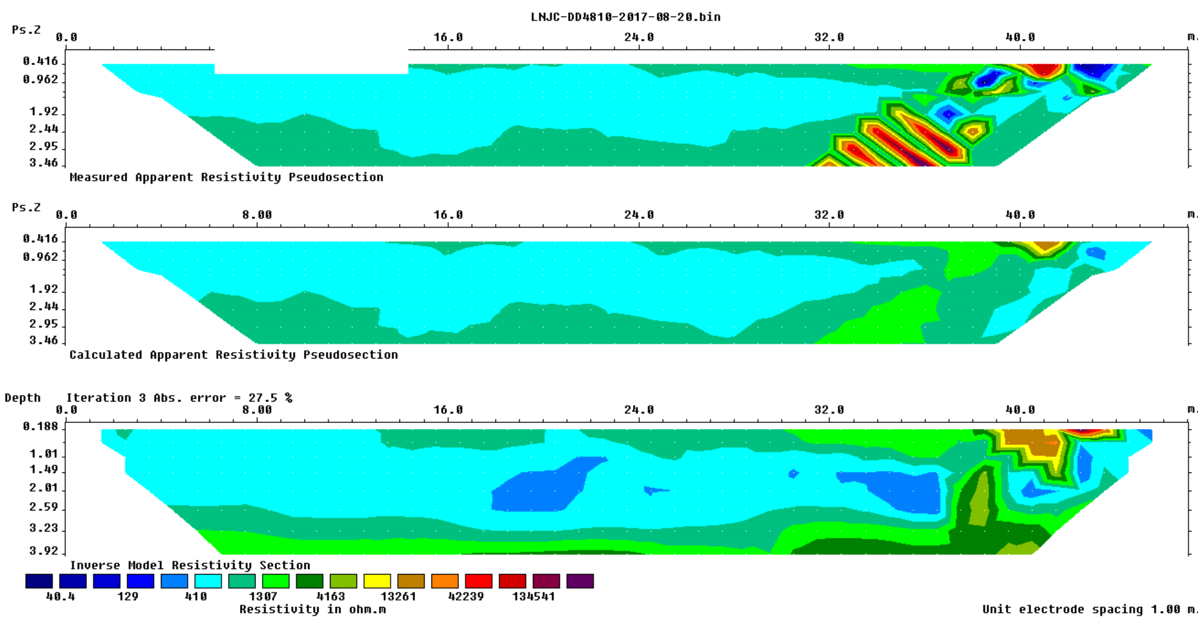

Figure 2: Resistivity line from 0 to 47 metres with electrode spacing of 1 metre using dipole-dipole array.

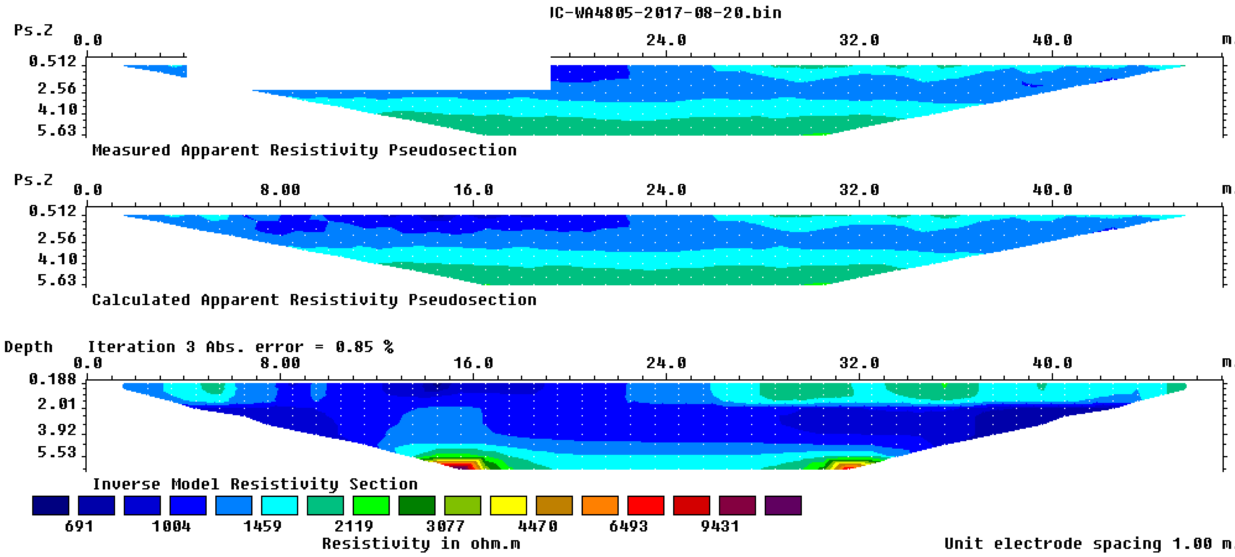

Figure 3: Resistivity line from 0 to 23.5 metres with electrode spacing of 0.5 metres using Wenner-Alpha array.

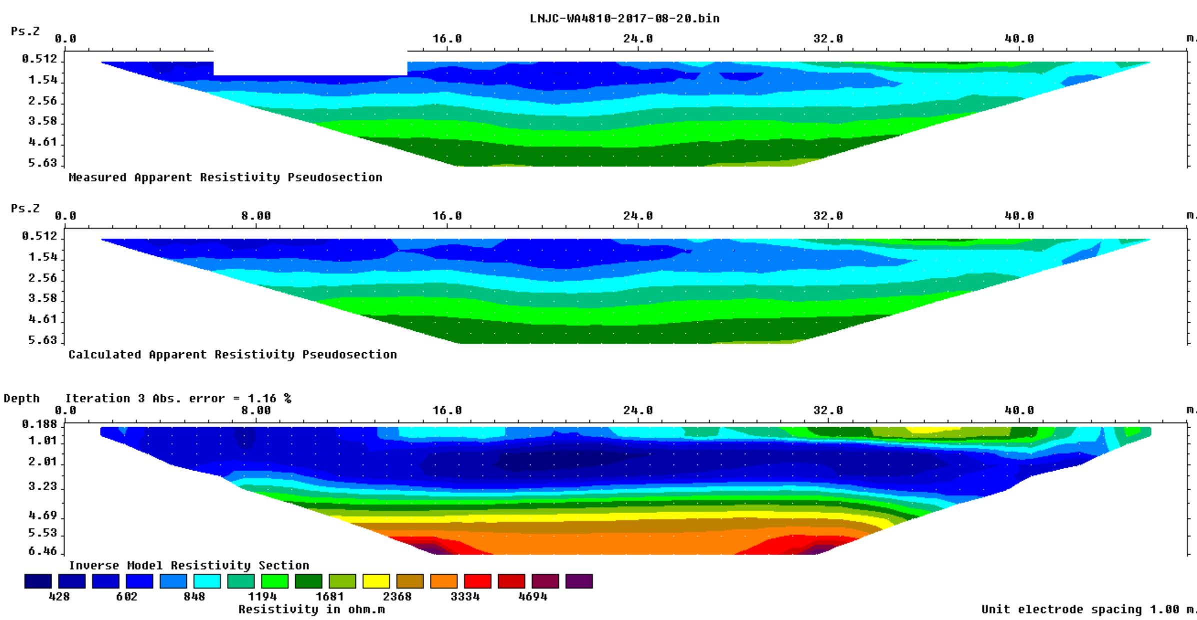

Figure 4: Resistivity line from 0 to 47 metres with electrode spacing of 1 metre using Wenner-Alpha array.

There is some higher resistivity, reaching up to around 2000Ωm near the surface around 2 metres and near the surface between 32 and 48 metres. Then there is a layer of lower resistivity, on the order of 10^2, from just below the surface to around 3 metres in depth. Below that the resistivity becomes higher again, and is on the order of 10^3.

Discussion

Figures 1-4 all show resistivity on the order of $10^2 \Omega m$ for the majority of the surface to about a 3-metre depth. This is in the range of sand resistivity (Bank, 2016), and sand would be expected as the first layer in this area.

The Grenville bedrock in this area is mainly monzanite which has a range of resistivity values that fluctuate by several orders of magnitude depending on how saturated the rock is with water. Although data is not readily available for the resistivity of monzanite, due to similarities in mineralogy we assume that it is similar to that of granite or diorite which fall into the range of 1.3×10^6 Ωm (dry) – 4.5×10^3 Ωm (wet) (Telford et al., 1990). Along the bottom of **Figure 1** and **Figure 2**, at a depth of around 3.5 metres the range of wet granite is reached, and we hypothesize that this could be the interface between sand and bedrock suggested by previous seismic surveys of the same area.

When running the 47-metre dipole-dipole resistivity line, we left the survey area and returned after 45 minutes. When we returned, we found that three of the alligator clips around the 42-metre mark had been pulled off the electrodes. This can be seen in the 'trouser leg' pattern around 42 metres in **Figure 2**.

There is a small anomaly near the surface around 2 metres which can be seen most clearly in **Figures 1** and **3.** This could be due to the electrode being placed partially into an old stump at that point. There is also a layer near the surface of higher resistivity roughly between 32 and 48 metres which could point to drier soil in that area. The creek that runs close to the start of the line curves southward around 15 metres along the profile. Below this layer is another layer with lower resistivity (on the order of 10^2 Ωm). This layer is at or near the surface, close to the beginning of the profile but trends downwards as it proceeds to the east. Together, this suggests that, what we presume to be sand, may have a higher water content in this region from a higher water table.

Conclusion:

We achieved our two objectives of performing a resistivity survey along this transect and potentially identify the underlying bedrock. However, we suggest some improvements to this survey; The positioning of the electrodes is not entirely in a straight line. The presence of tree roots underneath ground forces several electrodes to be placed a few centimetres away from the alignment of the electrodes. Hence, the electrodes are not placed directly on the line, which might slightly alter the resistivity measurements.

For future surveys in the same area, it may be worthwhile to use a more widely spaced Slumberger array, as this would provide better depth penetration and perhaps allow us to more effectively image what we believe to be the bedrock. A GPR survey could also be run over the same line with a large two-way time interval for the purpose of sounding the depth of the sand-bedrock interface.

References

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Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990. Applied Geophysics 2nd Ed. Cambridge University Press. Page 290.