AMHERST COLLEGE

Department of Geology
Geology 41: Environmental and Solid Earth Geophysics
Using Electrical Methods

EQUIPMENT:
- **resistivity meter**
- **large Cu electrodes**
- **battery clips for electrodes**
- **cables:**
  - **2 reels for potential electrodes**
  - **1 reel for current electrodes**
  - **cable with plug for power supply**
- **12 V battery (freshly charged)**
- **tape measure**
- **spare fuse for power supply**
- **spare 9V batteries for multimeters**
- **water bottle**
- **notebook**
- **pen**

We will use a simple resistivity meter to conduct a resistivity survey of the Freshman Quad. We will create a vertical (VES) resistivity profile by systematically expanding the electrode spacing of a Wenner array. From our resistivity profiles, we will interpret the subsurface geology.

OUR SURVEY WILL BE CONDUCTED IN THE FOLLOWING MANNER:
We will work in a single group while conducting the survey. Be sure to rotate duties during the lab, so that everyone has a chance to do everything. The survey will be conducted in a similar manner to the resistivity "surveys" that you ran last week in the sandbox.

Using the instructions below, set up the resistivity meter and a Wenner array near the center of the quad. Start with a narrow electrode spacing (1 m) and systematically increase the electrode spacing (first to 2 m and then by 2 m) until the electrode spacing gets to 20 m. Be careful with the electrode cables -they are long and easily tangled.

USE OF THE RESISTIVITY METER:

1) **DISCONNECT THE POWER SUPPLY:** The resistivity meter consists of two multimeters and a power inverter (converts 12 V DC into 110 V AC) that are housed in a small box. It is powered by a small 12 V battery. Before proceeding, make sure that the power supply is turned off and that it is disconnected from the battery. Before starting, clean the electrodes with sandpaper or steel wool so that they are shiny.

2) **CONNECT THE CABLES TO THE RESISTIVITY METER:** The meter is connected to the electrodes via cables that are made from speaker wire. The left multimeter is used as a voltmeter and the right multimeter is used as an ammeter (current meter).

The current electrode cables have black wires. Plug the black lead of the current electrode cable into the **-COM** jack and the red lead into the **+V ma Ω** jack (right multimeter). Clip the red cable into the jack on the end of the red current electrode cable.

The potential electrode cables are copper colored. Plug the black lead of the potential electrode cable into the **COM** jack and the red lead into the **V/Ω** jack (left multimeter).

3) **PUT THE ELECTRODES IN THE GROUND:** The 4 electrodes in a Wenner array are evenly spaced. Use a steel tape to carefully measure the electrode spacing. Push the electrodes into the sediment to a (near) constant depth of approximately 30 cm. Use a hammer if needed to get good contact with the electrodes. If the ground is dry, wet it with a dilute brine.

4) **CONNECT THE CABLES TO THE ELECTRODES:** In a Wenner array the current electrodes are on the ends and the potential electrodes are in the middle. Check to see that the power supply is disconnected. Clip battery clamps to each of your four electrodes. Use the alligator clamps to connect the current electrode cables (black wire) to the current electrodes. Use the alligator clamps to connect the potential electrode cables (copper wire visible) to the potential electrodes.

5) **TURN ON THE MULTIMETERS:** Turn on both multimeters. The dial on the left multimeter (voltmeter) should be set at **~V** (**AC** should be visible in the upper left part of the meter display). The dial on the right multimeter (ammeter) should be set at **4-40 mA**. Toggle the **SELECT** button to AC (**~** will appear on the left of the display).

Note: the ammeter will automatically shut itself off after 5 minutes.

6) **TURN ON THE POWER SUPPLY:** Connect the battery to the power supply. RED lead to the battery **POS** terminal and BLACK lead to the battery **NEG** terminal. (Connecting the battery up backwards will blow a fuse on the power inverter) Turn on power supply (red switch on the left side of the resistivity meter), a red light should illuminate and a voltage and current should appear on the multimeters.

7) **MEASURE CURRENT AND VOLTAGE:** Let the meter stabilize for between 15 seconds and 90 seconds. Measure the voltage on the left meter and the current on the right meter.

8) **TURN OFF THE POWER SUPPLY:** Turn off power supply using red switch on the left side of the resistivity meter. Disconnect the power supply from the battery.

DATA REDUCTION AND ANALYSIS

1) For each of your measurements calculate an apparent resistivity. For a Wenner array:

$$\rho_{apparent} = 2\pi a \frac{V}{I}$$

a: Wenner electrode spacing
V: voltage difference across potential electrodes
I: current

As usual be very careful with units: for resistivity to be in Ω m, V must be in volts, I in amps and a in meters.

2) For a Wenner array and a constant resistivity with depth, the effective penetration depth is:

$$Z_{effective} = 3/2\ a$$

Make a plot of apparent resistivity (y axis) against $Z_{effective}$ (x-axis).
Use this plot to evaluate how resistivity varies with depth. Based upon variations in apparent resistivity, how many layers can you resolve beneath the quad? The athletic fields? What is the approximate resistivity of the uppermost layer? What are the relative resistivities (higher/lower) of each of the deeper layers? Do you see the same layers beneath the quad and the athletic fields? Are the resistivities the same in both places?

3) The effective depth to a horizontal interface can be estimated by the "cumulative resistivity" method.
To do this:
Calculate the sum of apparent resistivities for each electrode spacing in an expanding array survey. For the narrowest electrode spacing this is simply the measured apparent resistivity at that spacing. For your second spacing it is the sum of the apparent resistivities at the two narrowest spacings, for the third it is the sum of the three narrowest electrode spacings, ...etc.
Plot the sum of apparent resistivities (y axis) against $Z_{effective}$ (x-axis).
Fit the graph with linear segments, each segment corresponds to one of the layers that you identified above. The first segment should pass through the origin. If the lower layer has a lower resistivity the slope of the second line segment will be lower, if the lower resistivity is higher then the slope of the second line segment will be higher. The slopes of other line segments will vary in a similar way depending on the resistivity contrasts.
What are the approximate depths to the interfaces between your layers?

4) What insight (if any) does your electrical resistivity data provide for the nature of Memorial Hill (bedrock knob, sediment pile, or...). Recall your results from the gravity survey lab.