



ENVIRONMENTAL & EXPLORATION GEOPHYSICS

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ELECTRICAL RESISTIVITY SURVEYS

Electrical resistivity is a geophysical method in which an electrical current is injected into the ground through steel electrodes in an attempt to measure the electrical properties of the subsurface.

Most soils and non-ore bearing rocks are electrically resistive, (i.e., insulators). Soil moisture and ground water are often electrically conductive due to contained dissolved minerals. Therefore the resistivity measured in the ground is predominantly controlled by the amount of moisture and water within the soil and rock (a function of the porosity and permeability), and the concentration of dissolved solids (salts) in that water.

The basic method requires at least 4 steel electrodes be driven into the ground. An electrical current is then applied to the outer electrodes by a battery or generator. A voltage is measured between the 2 inner electrodes using a simple voltmeter. Through Ohm's Law ($V=IR$) and by knowing the input current, the measured voltage and the geometry of the electrode array, a value known as resistance can be calculated. Resistivity, measured in Ohm-meters, is resistance times area divided by distance.

Because the actual current flow is highly influenced by conductive layers, the value measured is known as the "apparent resistivity". In its simplest terms, it represents an average value encompassing all of the different materials within the volume (half-space) of materials being measured. Most modern resistivity meters calculate apparent resistivity once the geometric parameters are input.

Applications at Engineering and Environmental Sites include:

- **Stratigraphic Surveys**
- **Ground Water Mapping Surveys**
- **Grounding Surveys**

For these applications, the basic method used is to set up electrical arrays at several locations on a Site, and measure changes in resistivity as a function of depth. This is accomplished by increasing the electrode spacing while leaving the center of the array at the same location. Generally the "a" spacing starts at 1 foot or meter, and is doubled for each successive measurement. A very general rule of thumb is that the depth of the investigation is equal to about 1/2 to 1/3 the "a" spacing. This method is known as the "**vertical electrical sounding**" and would be the method used to determine the depth of a clay layer, ground water, or bedrock.

- **Leachate Mapping Surveys**
- **Sand and Gravel Exploration Surveys**
- **Fracture Zone Exploration Surveys**
- **Areal Surveys (exploring for voids, caves and buried, contaminant filled trenches)**

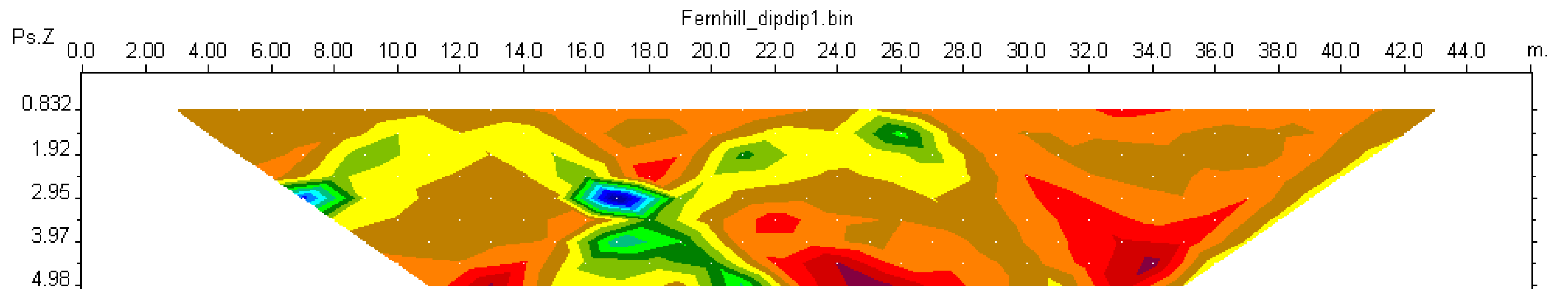
Once the depth to a feature of interest is determined using the sounding method, the feature may be tracked by moving the array across a Site, keeping the "a" spacing the same. This method of exploration is called "**profiling**" and might be used to locate a conductive leachate plume, an old stream channel, or a trench. Some resistivity units make it easy to "steer" the array across a Site by comparing data from the left half of the array with the data from the right half.

Advantages

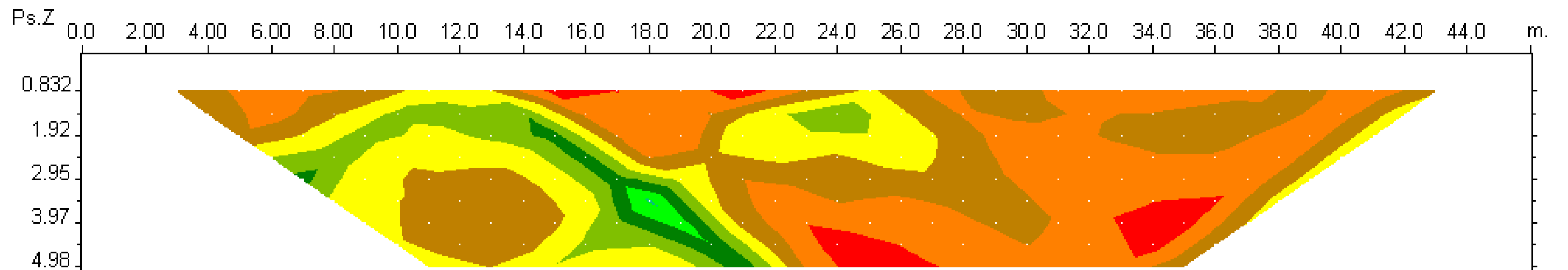
- Soundings can be used to determine the depth and thickness of subsurface layers, depth to the water table, and bedrock.
- Profiling can be used to detect and locate contaminant plumes.
- Resistivity values can be used to estimate geological formations.

Limitations

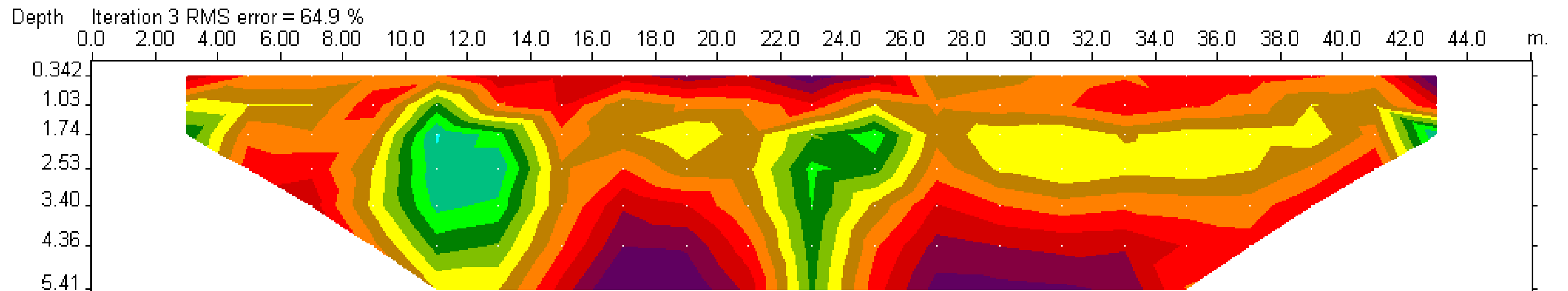
- Like all geophysical methods resistivity data are ambiguous, meaning that many different “models” can produce the same data. To narrow down the number of possible models, other geological information is needed (borehole and/or monitoring well data).
- Electrical resistivity is slow because electrodes must be driven into the ground between measurements.
- Arrays cannot be oriented parallel to buried electrical power lines, utilities and fences since the current injected into the ground will flow more easily through the metal feature.
- Data are influenced by near surface conductive layers. The current will always travel most easily along highly conductive layers. If the surface is highly conductive it may not be possible to collect data below the top layer.



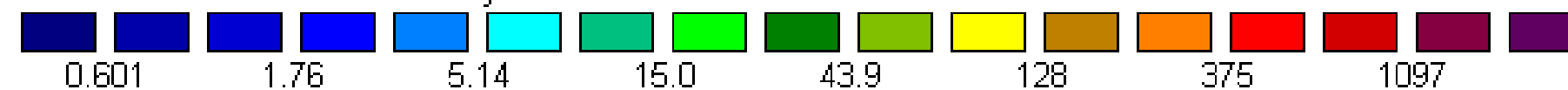
Measured Apparent Resistivity Pseudosection



Calculated Apparent Resistivity Pseudosection



Inverse Model Resistivity Section



Resistivity in ohm.m

Unit electrode spacing 2.00 m.