Electrical or D.C. Resistivity

INTRODUCTION

D.C. resistivity (electrical resistivity) techniques measure earth resistivity by driving a direct current (D.C.) signal into the ground and measuring the resulting potentials (voltages) created in the earth. From the data the electrical properties of the earth (the geoelectric section) can be derived. In turn, from those electrical properties we can infer geologic properties of the earth.

In geophysical and geotechnical literature, the terms "electrical resistivity" and "D.C. resistivity" are used synonymously. The term "vertical electric sounding" (VES) is also used to refer to soundings using the D.C resistivity method. The terms "resistivity" or "electrical" are often used to refer to the same methods or techniques, although "electrical" is sometimes used to encompass a broader range of techniques including the electromagnetic methods.

APPLICATIONS

Electrical resistivity of soils and rocks correlates with other soil/rock properties which are of interest to the geologist, hydrogeologist, geotechnical engineer and/or quarry operator. Several geologic parameters which affect earth resistivity (and its reciprocal, conductivity) include:

- clay content,
- groundwater conductivity,
- soil or formation porosity, and
- degree of water saturation.

D.C. resistivity techniques may be used in the profiling mode (dipole-dipole surveys) to map lateral changes and identify near-vertical features (e.g., fracture zones), or they may be used in the sounding mode (e.g., Schlumberger soundings) to determine depths to geoelectric horizons (e.g., depth to saline groundwater).

Figure 1 - D.C. Resistivity Crew In Operation

Common applications of the D.C. resistivity method include

- delineation of aggregate deposits for quarry operations
- measuring earth impedance or resistance for electrical grounding circuits or for cathodic protection,
- estimating depth to bedrock, to the water table, or to other geoelectric boundaries, and
- mapping and/or detecting other geologic features.

D.C. resistivity and electromagnetic (EM) techniques both measure electrical properties of the earth, and hence both are used for many of the same applications. Conductivity, which is often reported by EM instruments, is the reciprocal of resistivity.

THEORY OF OPERATION

Figure 2 is a schematic diagram showing the basic principle of D.C. resistivity measurements. Two short metallic stakes (electrodes) are driven about 1 foot into the earth to apply the current to the ground. Two additional electrodes are used to measure the earth voltage (or electrical potential) generated by the current.

Depth of investigation is a function of the electrode spacing. The greater the spacing between the outer current electrodes, the deeper the electrical currents will flow in the earth, hence the greater the depth of exploration. The depth of investigation is generally 20% to 40% of the outer electrode spacing, depending on the earth resistivity structure.

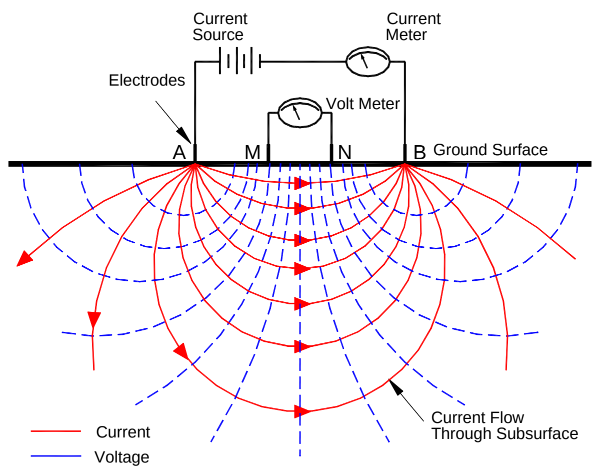

Figure 2 –Schematic Illustrating Basic Concept of Electrical Resistivity Measurement

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DATA ANALYSIS & INTERPRETATION

Apparent Resistivity:

Instrument readings (current and voltage) are generally reduced to "apparent resistivity" values. The apparent resistivity is the resistivity of the homogeneous half-space which would produce the observed instrument response for a given electrode spacing. Apparent resistivity is a weighted average of soil resistivities over the depth of investigation.

For soundings a log-log plot of apparent resistivity versus electrode separation is obtained. This is sometimes referred to as the "sounding curve."

Modeling:

Resistivity data is generally interpreted using the "modeling" process: A hypothetical model of the earth and it's resistivity structure (geoelectric sections) is generated. The theoretical electrical resistivity response over that model is then calculated. The theoretical response is then compared with the observed field response and differences between observed and calculated are noted. The hypothetical earth model is then adjusted to create a response which more nearly fits the observed data. When this iterative process is automated it is referred to as "iterative inversion" or "optimization."

Uniqueness

Resistivity models are generally not unique; i.e., a large number of earth models can produce the same observed data or sounding curve. In general, resistivity methods determine the "conductance" of a given stratigraphic layer or unit. The conductance is the product of the resistivity and the thickness of a unit. Hence that layer could be thinner and more conductive or thicker and less conductive, and produce essentially the same results. Hence constraints on the model, from borehole data or assumed unit resistivities, can greatly enhance the interpretation.

Deliverables

The end product from a D.C. resistivity survey is generally a "geoelectric" cross section showing thicknesses and resistivities of all the geoelectric units or layers. If borehole data or a conceptual geologic model is available, then a geologic identity can be assigned to the geoelectric units.

A two-dimensional geoelectric section may be made up of a series of one-dimensional soundings joined together to form a two-dimensional section, or it may be a continual two-dimensional cross section. The type of section produced depends on the acquisition parameters and the type of processing applied to the data.

Figure 3 is a two dimensional geoelectric section from a dipole-dipole survey in Alaska. The resistivity survey, part of a water resources investigation, was conducted in order to identify fracture zones with increased porosity. The geophysical objective was to locate conductive fracture zones in the more resistive bedrock. The zone with lower resistivities (1500 to 2000 ohm-meters), which is seen in Figure 3 between 90m and 100m, is indicative of increased water content due to higher fracture porosity in that region.

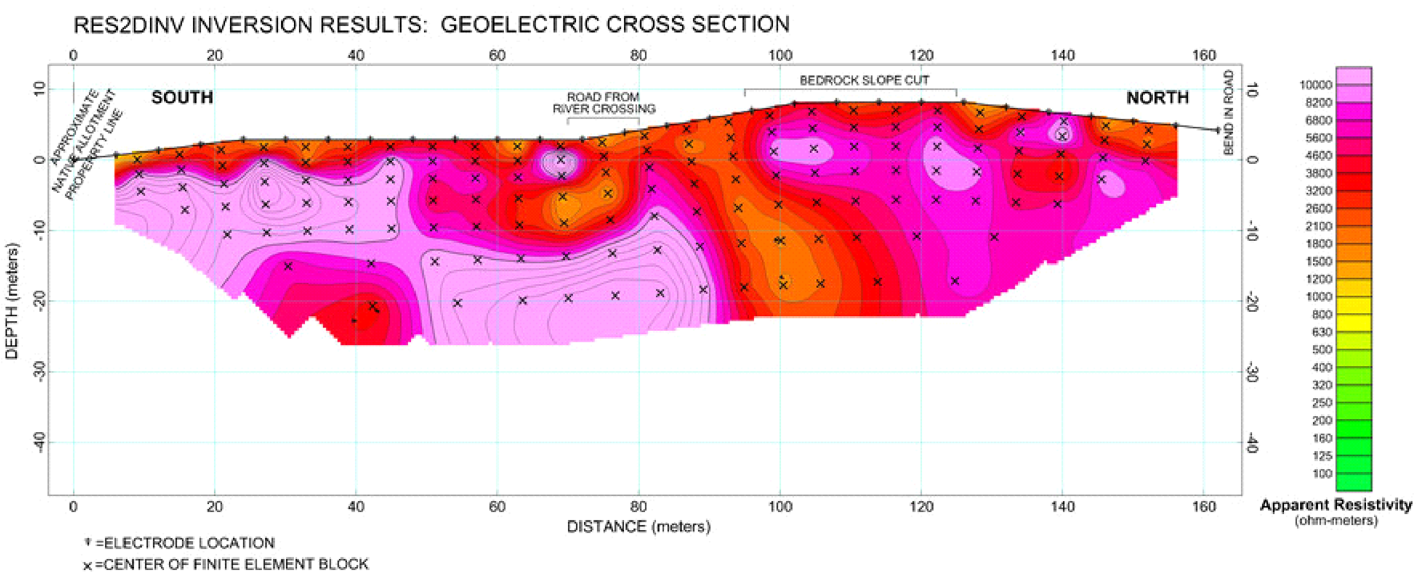

Figure 3—Geoelectric Model from Dipole-Dipole Resistivity Survey

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