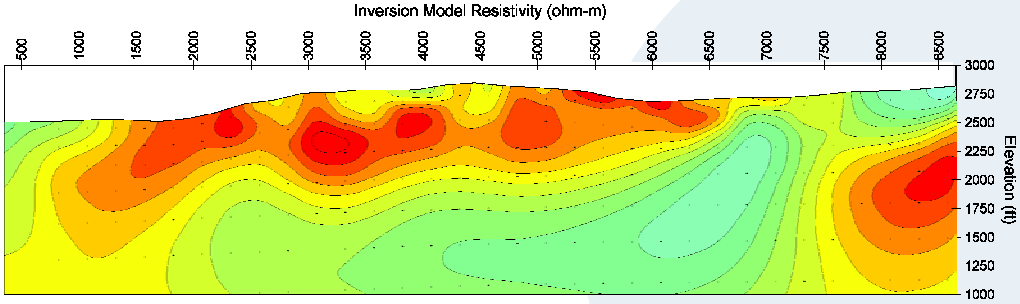
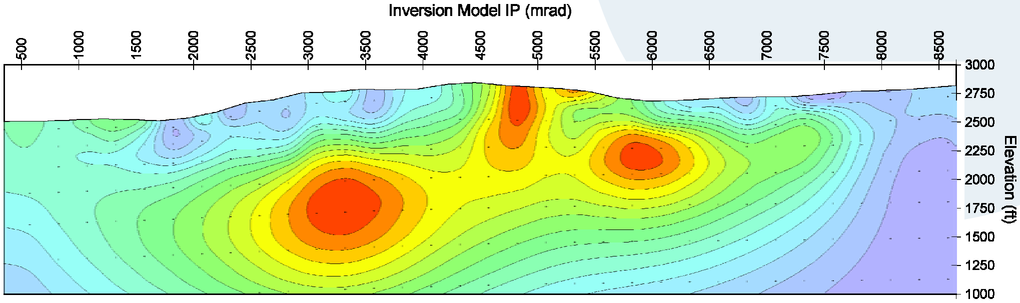
Introduction to IP

NOVEMBER 2009

Overview of IP





Resistivity surveys have been used extensively by the minerals, geothermal, hydrocarbon, and groundwater exploration industries, and IP is commonly used in minerals exploration, as well as environmental studies.

Resistivity and Induced Polarization (IP) surveys are commonly-used, surface-based geophysical methods which provide information about the electrical properties of the subsurface.

Resistivity and IP measurements are made by introducing an electrical current into the ground between two current electrodes and making measurements of the induced voltages between two receiver dipoles. By comparing the transmitted signal to the received signal, electrical properties of the ground can be calculated. A change in ground resistivity (the ability of the ground to conduct electrical current) affects the strength of the received signal. A change in IP (the ability of material in the ground to polarize at interfaces) affects the shape or timing of the received waveform.

The two IP data sets are usually acquired simultaneously during the same survey using the same equipment and array.

Variations in subsurface moisture content, porosity, permeability, and soil or rock type can all affect resistivity measurements. Cultural features (man-made objects such as fences, power lines, pipelines, etc.) can also affect ground resistivity measurements.

Compared to changes in resistivity, there are relatively few subsurface conditions that create an IP response. Metallic mineralization, particularly disseminated sulphides, causes increased IP values. Certain dissolved solids in groundwater have been shown to increase IP response, and in some environments, some types of clay can also increase IP response if the abundance of the clay is within specific ranges (dependent on the type of clay). Like resistivity data, IP data can also be influenced by cultural features.

GDP32– multichannel receiver manufactured by Zonge

No trenching, drilling, road-making, or blasting is involved, and the majority of the survey can be done on foot using backpack-able equipment.

Transmitter used in IP surveys.

Field Logistics

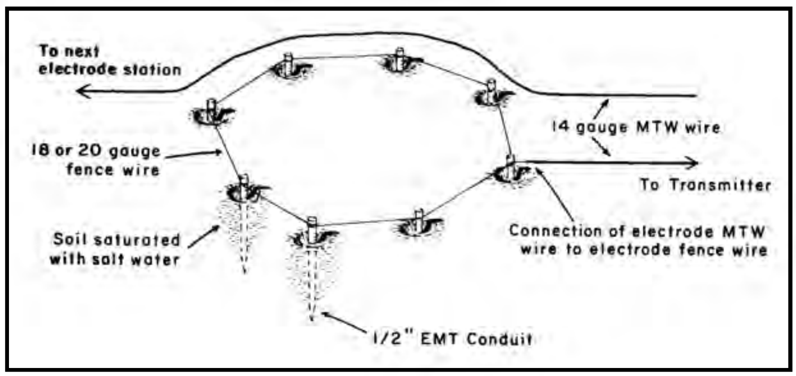
The field crew usually includes 3 to 5 people, with one pick-up truck. The transmitter dipole consists of thin, 14-gauge insulated wire laying on the ground. At each end, the wire is connected to the ground with metal stakes, each about ½ inch in diameter, pounded into the ground about one to two feet. These stakes are doused with saltwater to provide good electrical contact with the ground. Each group is called an electrode (see figure below).

Usually, numerous electrodes in a line are set up and connected by wires to the transmitter equipment at a central location, so that driving is kept to a minimum. The wire is laid out by walking along the ground, and vehicle access along the length of the wire is not necessary. The transmitter equipment is usually in a pick-up truck with a generator mounted in the back or on a small trailer behind the truck. This equipment transmits a very carefully controlled signal at specific frequencies into the ground.

The measurements are made with a backpack-portable system, called a receiver, by connecting to different dipoles. The dipoles for the receiver are also simply wires laying on the ground, but in this case they are grounded using small porous ceramic "pots" about 6 inches tall and two inches in diameter, buried about one inch in the soil.

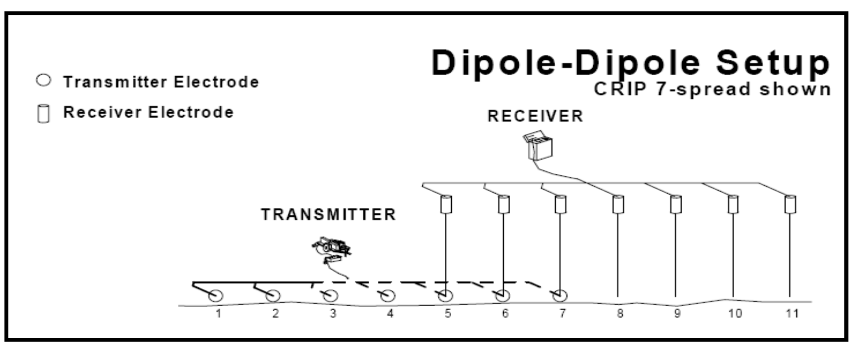
Usually, the receiver equipment is carried by backpack along the survey line making measurements at different locations. By making measurements at numerous stations along a line, a cross section of the earth's electrical resistivity properties can be produced, providing information about subsurface faults, fractures, geologic structures, mineralization, and groundwater.

Typical Transmitter Electrode



Dipole-dipole Array

The geometry between the transmitter and receiver electrodes varies between several different types of electrode arrays. Some typical arrays are dipole-dipole, pole-dipole, gradient, Schlumberger, and Wenner. In North America, one of the most often used configurations is the dipole-dipole array.



For the dipole-dipole array, current is introduced into the ground at two adjacent (current) electrodes and the resulting electric field is measured at two adjacent (potential) electrodes.

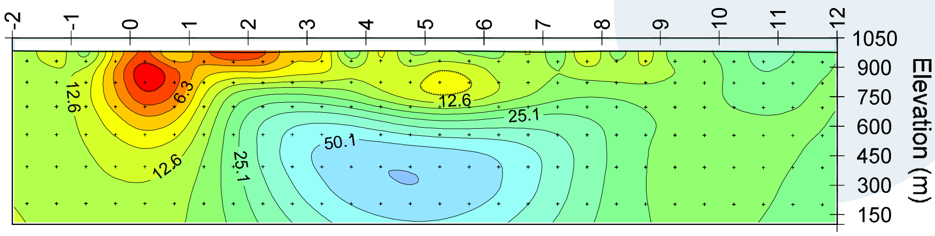
Inversion Models

Resistivity/IP surveys measure apparent resistivity and apparent polarization (apparent chargeability in the time-domain). The measured values are a function of the variation of the intrinsic resistivity and polarization within a volume of earth and do not reflect the intrinsic values at a specific plot point. The distribution of intrinsic values for the resistivity and IP effect is interpreted from the measurements using theoretical curves or computer modeling. Computer programs for modeling and inversion are used to produce results that are more similar to an image of the subsurface electrical structure.

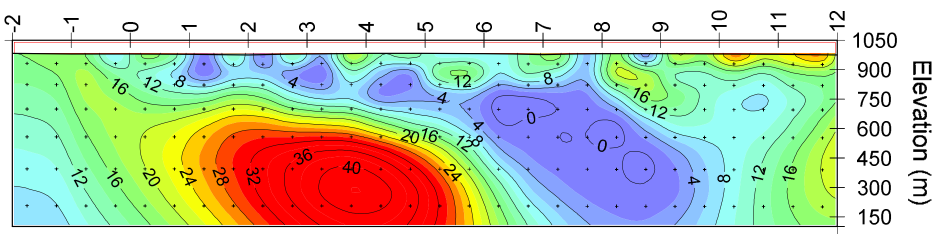
Smooth-model inversion is a robust method for converting resistivity and IP measurements to smoothly varying model cross-sections. Inversion mathematically “back-calculates” (or “inverts”) from the measured data to determine a likely location, size and depth of the source or sources of IP and resistivity changes. Resistivity and IP values in the two-dimensional model section are iteratively modified until calculated data values match observed data as closely as possible, subject to constraints on model smoothness.

2-D modeling programs can be used to convert the measured results to profiles of resistivity or IP versus depth.

Inversion Model Resistivity (ohm-m)



Inversion Model IP (mrad)



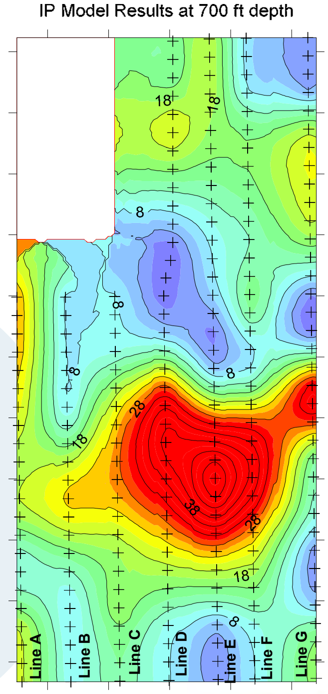
Final Product

The results of processing and modeling the data can be presented in several forms:

- modeled cross sections (Resistivity and IP data)
- plan views
- Fence or 3D diagrams

When stations are collected along several lines in the same area, data can be displayed in plan view plots at a constant elevation or depth. Plan views can help highlight trends between lines.

IP Model Results at 700 ft depth



Field operator at receiver site.

An employee-owned small business, Zonge provides:

- Research and development programs,
- Equipment manufacturing, and
- A wide range of field services.

The integration of these roles allows Zonge to provide their clients complete and innovative solutions to their geophysical problems.

Zonge is a world-renown expert in the development and application of broadband electrical and electromagnetic methods.

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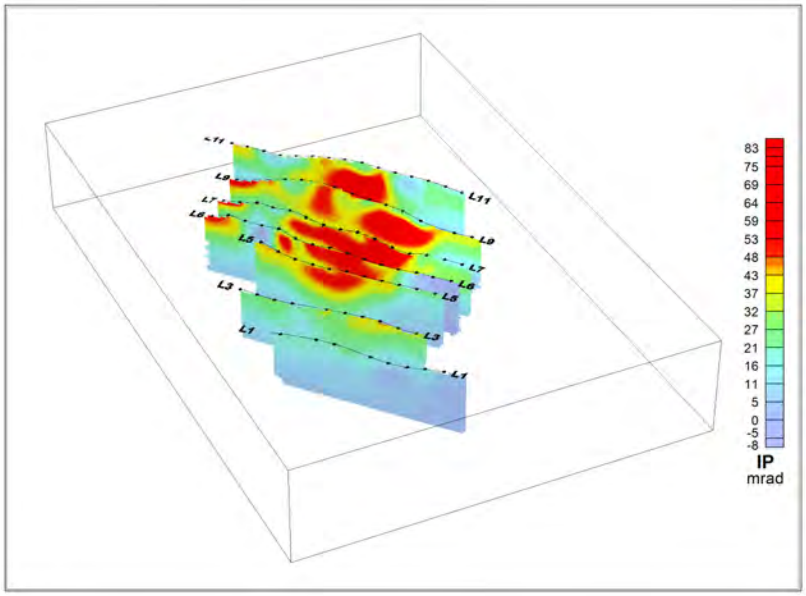
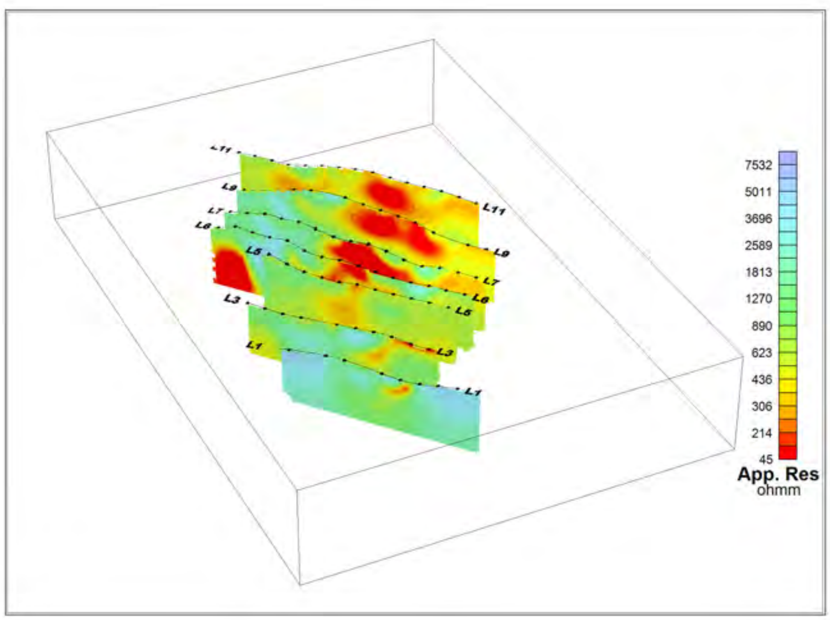


Fence diagrams show 2-D cross sections of the resistivity and IP inversion results in a spatially relevant 3-D context.



IP Reference Material

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(Some parts of this document have been extracted from Practical Geophysics II, Northwest Mining association, 1992)

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