TIME DOMAIN ELECTROMAGNETICS

Methodology

Transient electromagnetics (TEM), also referred to as time-domain electromagnetics (TDEM), is a geophysical method for measuring the electrical properties of the earth without direct ground contact. High frequency electrical current is transmitted into a single conductor wire laid on the ground surface in a rectangular loop. When the current in the wire is rapidly cut-off, electromagnetic induction causes electrical current to flow at the earth's surface. The amount of current induced in the earth is directly proportional to the amount of current flowing in the wire before cut-off, and the effective area of the transmitter loop (area enclosed by loop times number of turns). As the induced current diffuses downward into the earth, an associated secondary magnetic field is detected by a receiver coil. The measured signal is sampled at numerous, closely spaced time intervals (gates), as the secondary magnetic field decays. The sampling is repeated several times in rapid succession as the current in the transmitter loop is turned on and off. The rate at which the on/off cycles are repeated is referred to as the repetition rate. The sampled signals are algebraically summed (stacked) to enhance the signal strength and minimize the influence of spurious noise (interference). The data in each channel can be displayed or printed out in units of voltage, apparent conductivity, or apparent resistivity versus time.

The data obtained at a single station can be interpreted as a vertical electric sounding (VES). This involves using computer assisted inverse modeling techniques to derive a layered earth model indicating the variation in electrical resistivity with depth. Alternatively, the apparent resistivity or conductivity values measured at a series of stations can be plotted as profiles or contoured to indicate the vertical and lateral distribution of electrical properties.

Instrumentation

TEM surveys are typically conducted using a Geonics Protem EM-47. This system consists of a receiver console, a one meter (3-ft) diameter receiver coil, a transmitter console, and a transmitter loop. The transmitter loop is typically created by forming a square loop with a single strand of insulated wire. Depending upon the desired depth of investigation, the sides of the loop can range from 10 to 100 meters (32.8 to 328 ft) long. When access to the survey area is limited, a square five by five meter (16 by 16-ft) multi-turn (8x) transmitting loop is typically used. The multi-turn loop is comparable to a 40 by 40 meter single strand loop.

Data Analysis

The software package GSPX7, written by Geonics Ltd. of Toronto, Canada is used to download the TEM data to a computer. The software package TEMIXGL written by INTERPEX LTD. of Golden, Colorado is then used to invert the data obtained at each VES location to one dimensional layered earth models. The program is initiated by entering a starting model

composed of up to 10 resistivity layers. The program then computes the apparent resistivity values that would be measured above this model, and compares those values with the actual measured (observed) values. The program then adjusts the model to improve the degree of fit. This procedure is repeated through numerous iterations until the best possible fit is obtained. The end result of the inversion process depends to a large extent on the model that is used to start the process. Therefore, it is important to have some previous information regarding the subsurface conditions, or "ground truth", to aid in the interpretation.

Limitations

It is a common feature of all electrical methods that the models derived from vertical electric soundings are not unique. That is, depending on the subsurface geo-electric structure, there may be many models that will produce essentially the same apparent resistivity curve. This is known as the *principal of equivalence*. Computer software programs include routines for evaluating the equivalence of a given model relative to an observed sounding curve, resulting in a model that provides the closest fit to the observed data.