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TERRAIN CONDUCTIVITY SURVEYS

Electromagnetic induction surveying is a surface geophysical technique used to measure the electrical conductivity of subsurface soils, rocks, and groundwater. The basic principle of operation of the electromagnetic method is shown in the figure below. A transmitter coil radiates an electromagnetic field that induces circular electrical currents (termed eddy currents) in the earth below the coil. These eddy currents in turn generate a secondary magnetic field. A receiver coil detects both the primary field and the secondary field, and the instrument converts the ratio of the two magnetic fields to a measurement of the apparent conductivity (terrain conductivity) of the subsurface. The terrain conductivity represents the cumulative subsurface conductivity from the ground surface to the effective depth of exploration of the instrument.

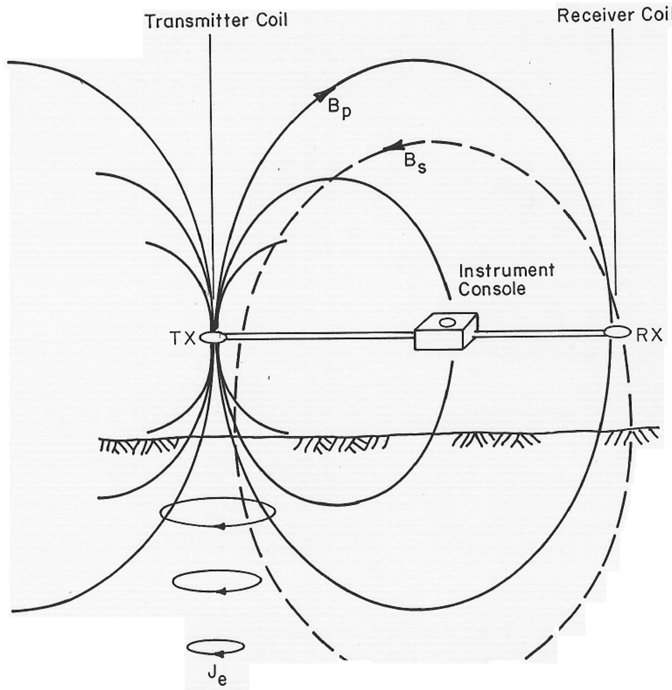
Since in most cases the soil- and rock-forming minerals are electrical insulators, subsurface conductivity arises principally from the flow of electrical currents through the moisture-filled pore spaces within the soil and rock matrix.
The three most important factors affecting terrain conductivity measurements are the following:

1 - Porosity of the subsurface material, 2 - Degree of saturation and 3-Concentration of dissolved electrolytes in the pore fluids.

Subsurface conductivity is also influenced by soil type because of the effects of soil particle size and shape on the geometry of the flow paths that electrical currents must follow around the insulating soil particles. Conductivity generally increases with decreasing particle size due to a more direct current path in finer-grained soils. Thus, silty soils tend to be more conductive than clean sands and gravels. As soil grain size decreases even further to that of the true clays, an additional increase in conductivity (termed ionic conduction) arises due to the large numbers of exchangeable ions that are held on the surface of clay particles.

While it is apparent from the discussion above that terrain conductivity is a complex function of a number of subsurface parameters, it often turns out that the conductivity (specific conductance) of the pore fluids dominates the measurement. This has been found to be particularly true near older unlined landfills, due to large quantities of electrolytes that are added to the unsaturated and saturated zones by leachates emanating from the landfill materials. The geophysical contrast, which these inorganic salts provide has been found to be very useful at a large number of sites for mapping the shape of groundwater contamination, plumes emanating from the landfills.

The electromagnetic induction method is generally not capable of mapping contamination from organic sources, in that organic materials act electrically as insulators. It is often found, however, that the inorganic contaminant plume is an excellent guide to the configuration of the organic contamination plume due to common geologic controls. Thus, EM mapping results are not the final word in terms of definition of groundwater contamination, but they do provide a rapid and cost effective method for locating problem areas and guiding more direct sampling methods.



The portable electromagnetic induction unit creates a primary field Bp that induces eddy currents Je In the ground. These in turn produce a secondary magnetic field Bs. The ratio Bs/Bp is indirectly measured by the receiver and is related to the ground conductivity.