Transient Electro-Magnetic (TEM) sounding

Principle of operation

A large square loop of wire, with side dimensions typically either 25 m or 40 m, is laid out on the ground surface. This serves as a transmitter, generating a primary electro-magnetic wave that propagates into the ground. After several milliseconds of transmission, the primary field is switched off. The EM wave induces eddy currents within buried conductive media that in turn produce a secondary electro-magnetic field. This secondary field decays in amplitude with time (typically over *c.* 10 ms) and migrates downward in a spiral of increasing width (Figure 1). A receiver coil is positioned on the ground surface at a set distance from the source coil and is used to measure the decay of the secondary magnetic field in the time domain (Figure 2). The rate of decay of the secondary field is a function of the electrical properties of the ground being sampled. The measurement is repeated several times at each location to allow summation of results, improving the signal-to-noise ratio. The resultant stacked curve can be interpreted to provide information on vertical variability in ground resistivity. Depending upon the equipment being used and the configuration of the coils, sounding depths of over 500 m can be achieved. Moving the coils along a line and repeating the sounding process enables the operator to construct a 2D cross-sectional profile of the ground. More information on EM techniques is given by Reynolds (2011).

Data acquisition

The complexity of the field data acquisition is such that it should only be undertaken by experienced TEM contractors. Depending upon the field equipment being used and the distance between each sounding location, 25-30 soundings can be achieved in a day under suitable conditions.

Mode of interpretation

Quantitative interpretation of TEM soundings requires specialist software such as the IX1D & TEMIX software packages produced by Interpex Ltd, USA. Data from each sounding curve are inverted to produce a ground resistivity model consisting of a vertical sequence of layers for each of which a true resistivity and thickness are derived (Figure 3). If the results from each sounding are displayed in profile form (Figure 4), a 2D cross-section can be produced showing the lateral and vertical variation in true resistivity along the survey transect. True resistivity is a physically diagnostic property and can be used to differentiate between ground materials.

Applications

TEM surveying is most commonly used in mineral exploration and hydrogeological investigations, although it can also be used in deeper engineering and environmental studies. The technique is especially applicable for mapping deep aquifers and the interface between fresh and saline groundwater, for example, and providing information about geological structure, such as fault displacements.

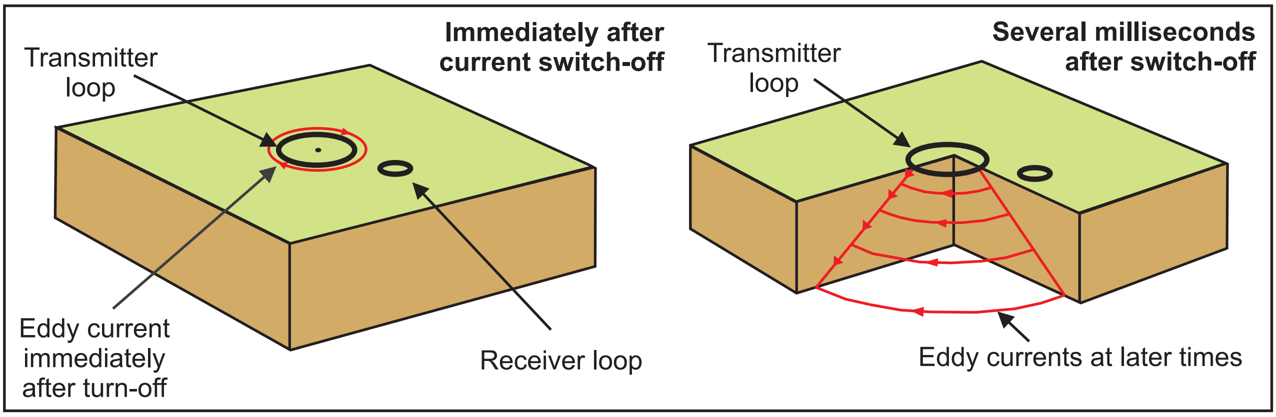

Figure 1: The measurement process for acquisition of TEM data.

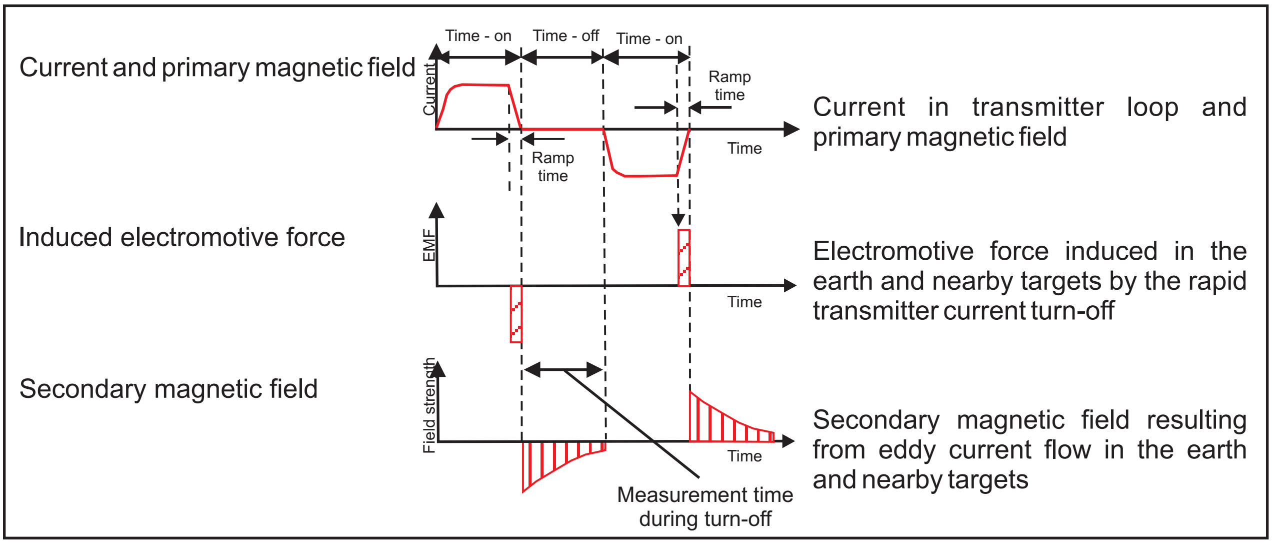

Figure 2: Time domain EM waveforms (courtesy of D. McNeill/SEG).

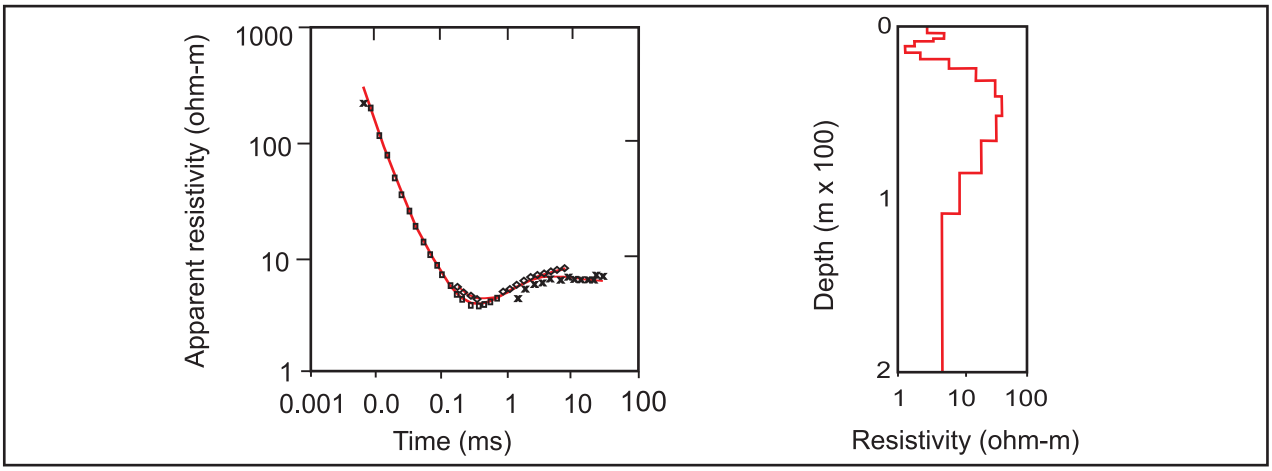

Figure 3: *Right*: A sounding model obtained using TEMIX software derived from the sounding curve (*left*). (Courtesy of Interpex Ltd).

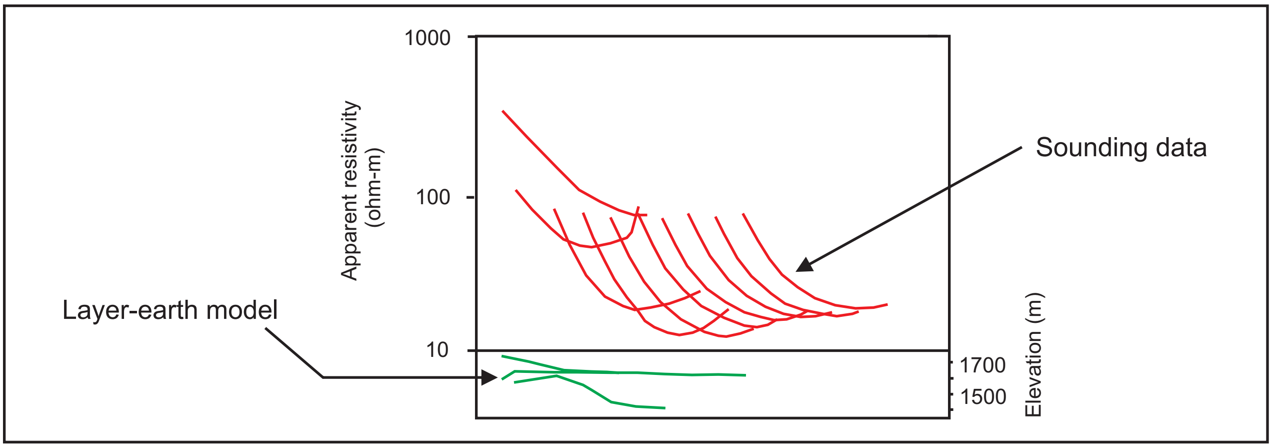

Figure 4: An interpreted layer-earth model derived from a sequence of sounding data along a single profile line, produced using TEMIX software (courtesy of Interpex Ltd).

Reference

Reynolds, J.M. 2011. *An Introduction to Applied and Environmental Geophysics*. John Wiley & Sons Ltd, Chichester, 2nd ed., 712 pp.

