Airborne Time-Domain Electro-Magnetic (TEM/TDEM) surveying

The earliest known Airborne Electro-Magnetic (AEM) system was developed in Canada in 1946. There are two types of electromagnetic techniques: time domain/pulse-transient EM (TDEM/TEM) and frequency domain EM (FDEM/FEM). Both types can be operated from aircraft. TEM systems can generally probe more deeply but have poorer vertical resolution than equivalent FEM systems. AEM surveying is now routinely used in mineral prospecting around the world, as well as for hydrogeological surveys and UXO detection. More detailed information is given by Reynolds (2011).

Principle of operation

Airborne TEM equipment can be either mounted directly on an aircraft or in a towed instrument pod (or 'bird') which is suspended from the aircraft. Two wire coils, the transmitter and receiver, are mounted on the aircraft or in the pod. An electrical current is passed through the transmitter coil, causing an EM field to be generated. This field causes secondary electrical currents to be generated within conductive bodies that lie within its influence. These secondary currents in turn generate a secondary EM field, which is detected using one or more receiver coils. The strength of this secondary field and the time taken for it to develop and to decay are diagnostic of the conductive material.

Data acquisition

However the transmitter and receiver coils are mounted, surveying is carried out by flying the aircraft along parallel flight lines. The flying height determines how much of the ground lies within the influence of the primary EM field. The flying height and line spacing are chosen based on the target depth and required survey resolution.

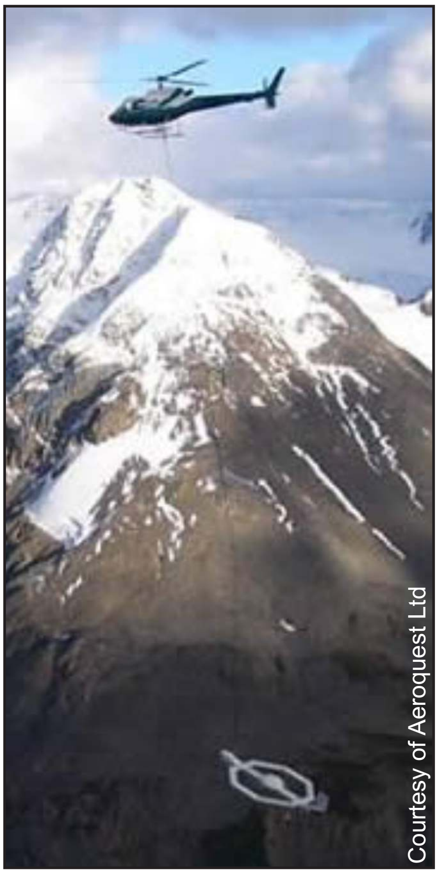


Figure 1: (*Right*) AeroTEM, Aeroquest Ltd's Helicopter-borne TEM (HTEM) system .

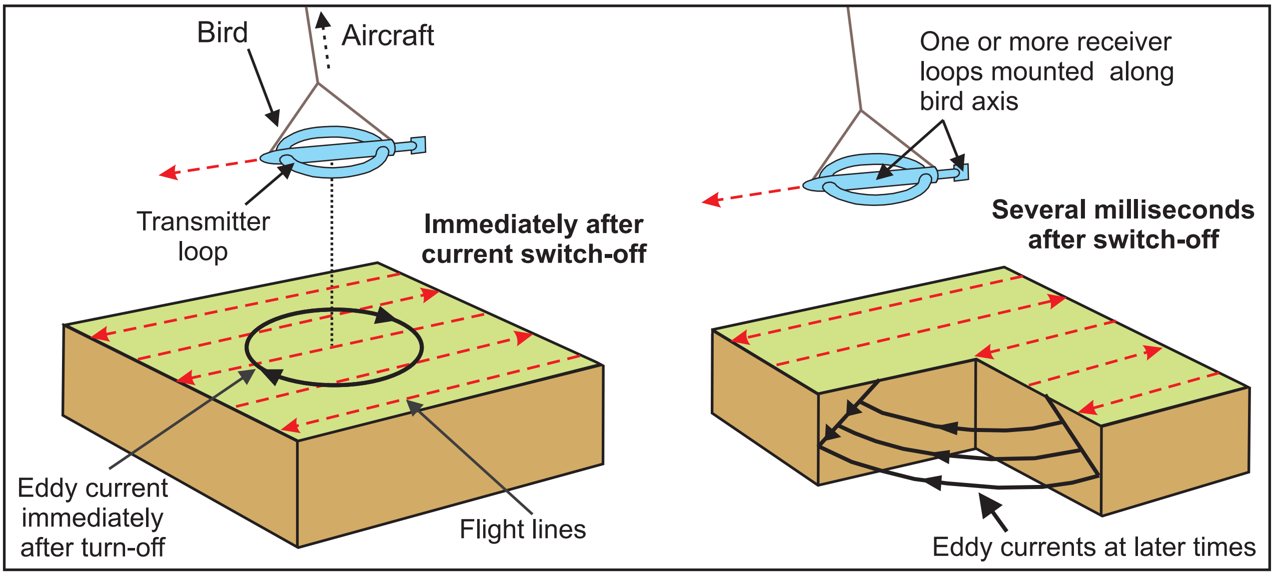
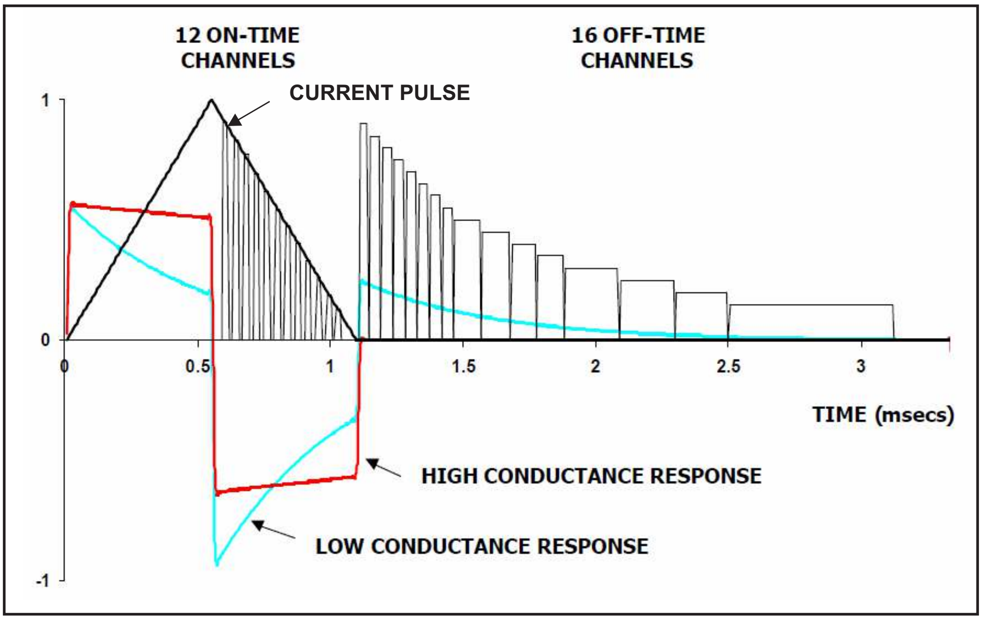


Figure 2: The measurement process for acquisition of TEM data using a towed bird (not to scale).

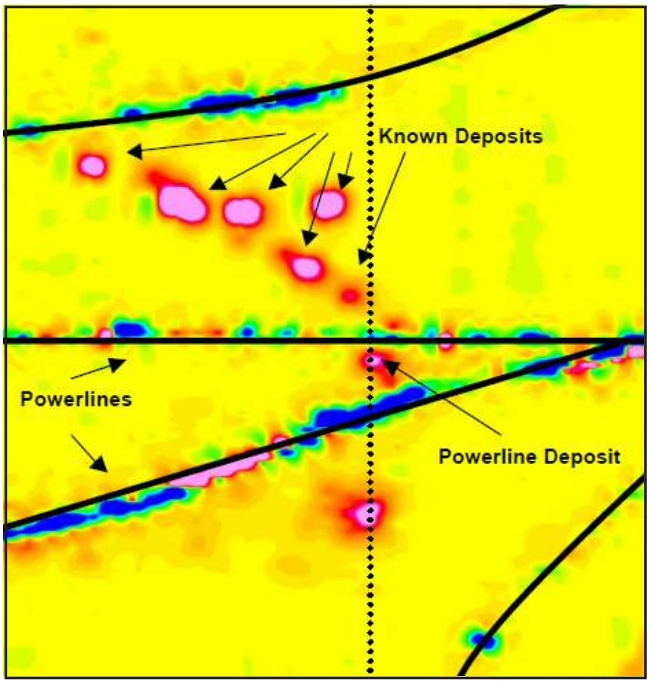
The secondary EM field builds up develops while the transmitter is turned on, then decays after it is turned off. The field may be measured during either just during the off-time periods, or during both the on-time and off-time periods in order to obtain more information. The field behaviour is measured for each receiver coil over several time gates or channels in order to see how the field decays with time (Figure 3). The shapes of the decay curves are diagnostic of the ground conditions.



<u>Figure 3</u>: The Aeroquest Ltd AeroTEM system waveform for the 150 Hz base frequency for the positive current pulse (after Balch *et al.*, 2003). The system generates a repeated positive/negative pulse pair.

<u>Interpretation</u>

The TEM data recorded for each channel along each flight line can be viewed as a separate profile. However, flight plans are designed such that line data can be interpolated to form 2D maps of the secondary EM field behaviour as it decays (or develops). Commonly, airborne TEM data are interpreted by jointly interrogating TEM profiles and interpolated 2D magnetic maps from the same survey area. Detailed interpretation is carried out through further analysis of the appropriate TEM profile responses, with modelling and inversion carried out as required. Interpolated 2D maps for individual TEM channels may also be generated to aid in the interpretation (Figure 4).



<u>Figure 4</u>: (Right) Secondary field response for Z-axis receiver coil, early off-time channel (after Balch *et al.*, 2003).

<u>References</u>

Balch, S. J., Boyko, W. P. and Paterson, N. R. 2003. The AeroTEM airborne electromagnetic system. *Leading Edge,* **22**(6):562-566.

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

