

Emax conductivity-depth transformation of airborne TEM data

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SUMMARY

Conductivity-depth imaging is a convenient form of presentation for preliminary interpretation of ground and airborne EM data. This paper describes the airborne EM adaptation of the Emax conductivity-depth transformation, originally developed for ground TEM. The transformation proceeds in two stages: first the apparent conductivity is determined at a given delay time; then the depth of the current maximum in a half-space with conductivity equal to the apparent conductivity is adopted as the apparent depth at that time.

The advantage of the Emax transformation is that it is readily adaptable to a wide variety of TEM data. The disadvantage is that apparent conductivity is not unique, nor always defined. In practice this does not usually pose difficulties for transformation of airborne EM.

The utility of the Emax transformation to airborne data is illustrated via application to GEOTEM_DEEP total field data. The total field provides a degree of immunity to receiver mis-orientation.

Key words: airborne EM, conductivity imaging, apparent conductivity

INTRODUCTION

Conductivity-depth pseudo-sections are a convenient form of presentation of EM profiles for first-pass interpretation. A number of schemes have been devised for conductivity-depth imaging (CDI) of airborne EM data, e.g. Sengpiel (1988), Macnae et al. (1991), Eaton (1998). This paper describes the adaptation of a maximum current (Emax) algorithm to airborne TEM data. The method was originally developed for coincident loop and in-loop ground TEM by Fullagar (1989), and later extended to fixed loop and slingram TEM by Fullagar & Reid (1992) and Reid & Fullagar (1998).

The procedure is illustrated via application to 25Hz GEOTEM_DEEP total field dB/dt data. The total field is less sensitive to receiver coil orientation effects than the individual z- or x-components.

Emax CONDUCTIVITY-DEPTH IMAGING

The Emax transformation proceeds in two stages: off-time data are first converted to apparent conductivity, and the depth assigned to each delay time is the depth of the induced current maximum in a half-space with conductivity equal to the apparent conductivity at that time. The procedure is therefore quite analogous to the transformation proposed independently by Sengpiel (1988) for airborne frequency domain EM data.

The advantage of the Emax transformation is that, given its reliance on apparent conductivity, it is readily adaptable to a wide variety of TEM data. The disadvantage is that apparent conductivity is not unique, nor always defined. In practice the non-uniqueness rarely poses difficulties for transformation of airborne EM because the alternative apparent conductivity is usually too extreme to be considered geologically plausible.

Determination of apparent conductivity

Apparent conductivity is computed for GEOTEM data via an extension of the method developed by Fullagar (1985). Apparent conductivity can be computed for the in-line horizontal dB/dt component, vertical dB/dt component, or total dB/dt amplitude. Total dB/dt suppresses errors related to mis-orientation of the receiver coils (Rajagopalan & Fullagar, 1998).

The effects of transmitter waveform, transmitter-receiver geometry, and variation in system altitude are taken directly into account during determination of apparent conductivity. If it is acceptable to trade some accuracy for higher speed, apparent conductivity can be inferred from characteristic half-space response curves.

Time-depth conversion

Given an apparent conductivity at each delay time, the depth of the maximum current in a half-space of that conductivity is required. Depth to induced current maximum after step-current shut-off of a vertical magnetic dipole located above a homogeneous half-space has been computed using an algorithm based on the formulation of Weaver (1970).

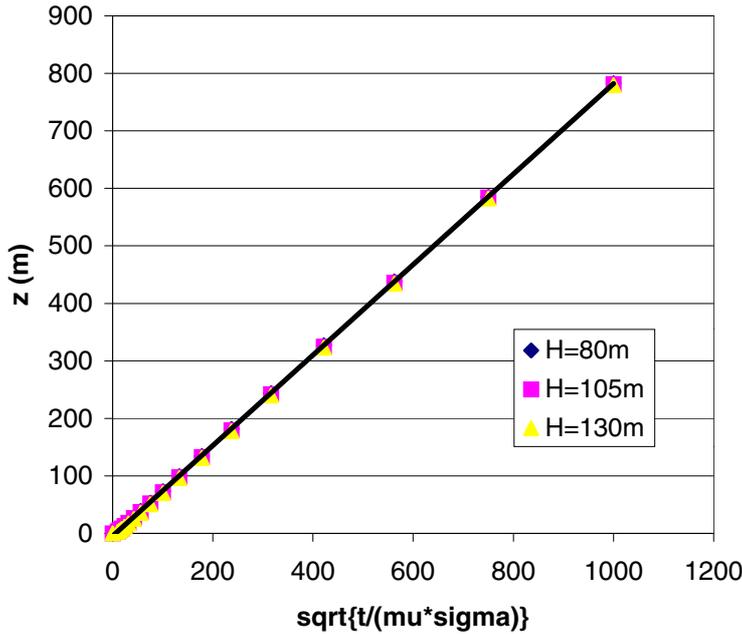
Current maximum depth is virtually independent of transmitter height (Figure 1). The regression line relating current maximum depth (in metres) to diffusion length λ at time t after step shut-off has equation

$$z = 0.787\lambda - 4.64 \text{ (m)} \quad (1)$$

where

$$\lambda = \sqrt{\frac{t}{\sigma\mu}} \quad (2)$$

The influence of the transmitter waveform is accounted for in the apparent conductivity determination. However, the GEOTEM delay time is treated as time elapsed time since step-current shut-off for purposes of depth conversion. The apparent depths therefore do not correspond to the depth of the half-space current maximum induced by the GEOTEM waveform.



Emax TRANSFORMATION OF GEOTEM TOTAL FIELD dB/dt DATA

The maximum current (“Emax”) CDI section for a 25Hz GEOTEM_DEEP line from Australia is shown in Figure 2. The transmitter and receiver were offset, notionally, 114 m horizontally and 42 m vertically. Transmitter moment was $6.65 \times 10^5 \text{ Am}^2$. Data were recorded in nT/s at 20 times, the first four of which were recorded during on-time. Total $|\text{dB}/\text{dt}|$ at the 16 off-times were used to create the pseudo-section, where

$$\left| \frac{\partial B}{\partial t} \right| = \sqrt{\dot{B}_x^2 + \dot{B}_z^2} \tag{3}$$

Off-time window centres ranged from 0.34 to 14.3 ms.

CONCLUSIONS

The Emax conductivity-depth transformation has been adapted for airborne TEM data. Application of the approach to 25Hz GEOTEM_DEEP total dB/dt amplitude data has been

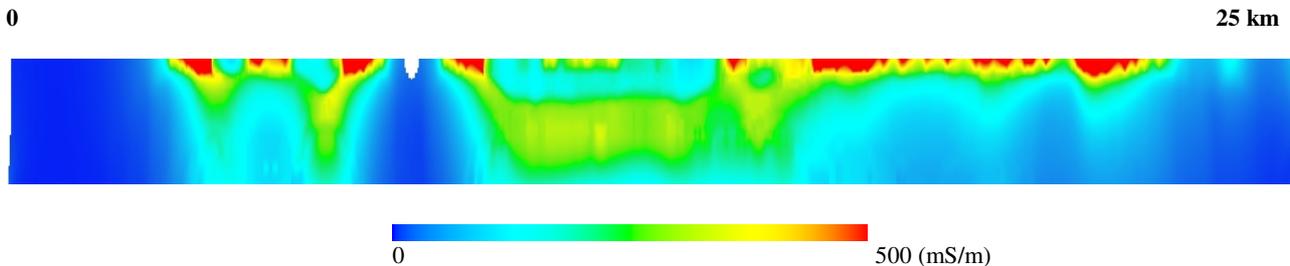


Figure 2: Emax conductivity-depth section for 25Hz GEOTEM_DEEP total $|\text{dB}/\text{dt}|$ profile. Depths range from zero to 250 m; a 10-fold vertical exaggeration has been applied.

illustrated. Extension to B-field data is straightforward, requiring only determination of the apparent conductivity for B-field data. Likewise, transformation of true step-current data is inherently simpler than transformation of GEOTEM data.

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