AIP Mapping of HTEM data

Simcoe Geoscience Limited is pleased to announce a new geophysical service that we are offering to extract Cole-Cole parameters from helicopter time-domain electromagnetic (HTEM) data.

In general the data acquired by the helicopter time-domain electromagnetic (HTEM) systems mainly reflect two physical phenomena of the ground: (1) Electromagnetic (EM) induction, related to the ground conductivity and governed by Faraday's Law, and (2) Airborne Induced polarization (AIP) effect related to the relaxation of polarized charges in the ground. In mineral exploration, potential near-surface sources of AIP are mainly clay sediments through membrane polarization (electrical energy stored at boundary layer), disseminated metallic sulfides and oxides (Kratzer & Macnae 2012, and Macnae 2016) through electrode polarization (electrical charges accumulated through electrochemical diffusion at ionic-electronic conduction interfaces).

Pelton et al. (1978) were the first to use the Cole-Cole impedance model (Cole & Cole, 1941) to explain the frequency dependence of resistivity observed in IP/resistivity surveys. The Cole-Cole resistivity $\rho(\omega)$ can be expressed as,

$$\rho(\omega) = \rho_0 \left[1 - m\left(1 - \frac{1}{1+(i\omega\tau)^c}\right)\right] \qquad (1)$$

where ρ_0 is the low frequency asymptotic resistivity in $\Omega \cdot m$, m ($0 \le m \le 1.0$) is the dimensionless chargeability, τ is the relaxation time-constant in seconds and $\omega = 2\pi f$ the angular frequency, and finally c ($0 \le c \le 1.0$) is the frequency factor. The four Cole-Cole parameters (ρ_0, m, τ and c) are characteristic of the intrinsic polarizability of the ground. In general, the chargeability m and relaxation time-constant π depend on the quantity and size of polarizable material respectively (Pelton et al., 1978). The frequency factor reflects the size distribution of the polarizable elements (Luo and Zhang, 1998). *Sensu stricto* the parameter ρ_0 is related to EM induction and only the parameters (m, τ and c) are associated with the AIP effect.

AIP mapping is the extraction of the four Cole-Cole parameters (ρ_0, m, τ and c) from a single HTEM decay without deriving the depth distribution of the parameters. The extraction of Cole-Cole parameters from field HTEM data has been carried out by Kratzer and Macnae (2012), Hodges and Chen (2014), Kwan et al. (2015), Macnae (2016), Kang et al.(2017), Kaminski and

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Viezzoli (2017) and, more recently, Kwan and Müller (2020). A new AIP mapping method capable of extracting all four Cole-Cole parameters from HTEM data has been developed and presented by Kwan and El-Kaliouby (2020).

The new AIP mapping method is applied to HTEM (VTEM, Witherly et al., 2004) data from Tli Kwi Cho (TKC) kimberlite complex, NWT, Canada. The TKC consists of two pipes, namely DO18 (north) and DO27 (south). The survey was flown at nominal line spacing of 75 m, and the data were made available to the public through the University of British Columbia Geophysical Inversion Facility in 2016. The AIP signatures of the two kimberlites were thoroughly investigated by Kang et al. 2017.

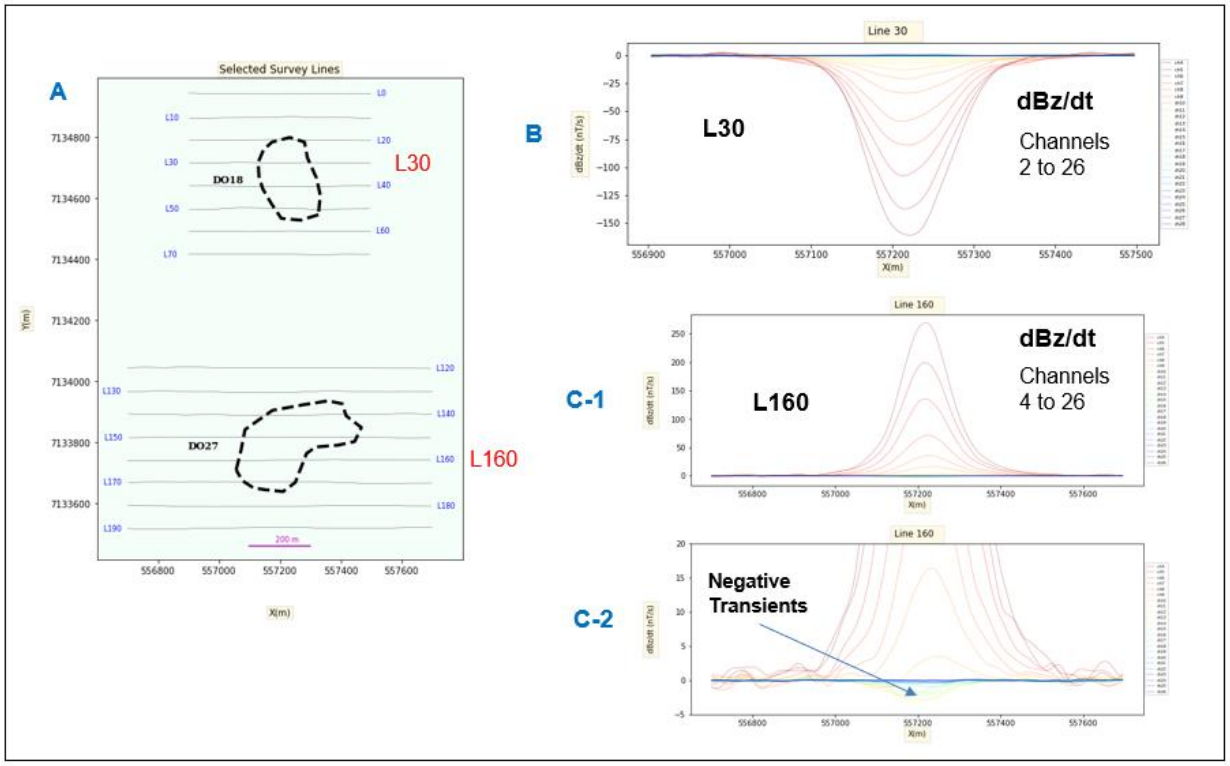

Figure 1: dBz/dt profiles of L30 over DO18 (north) and L160 over DO27 (south).

The derived AIP apparent resistivity and apparent chargeability data are shown in Figure 2. The ground over DO27 are more conductive (~300 $\Omega \cdot m$) than that over DO18 (~1200 $\Omega \cdot m$). The apparent resistivity results over DO27 and DO18 compare reasonably well with those derived by

Kang et al. (2017). The ground over DO27 is relatively more chargeable than DO18. Results derived by Kang et al. (2017) showed that DO27 is more chargeable than DO18 as well.

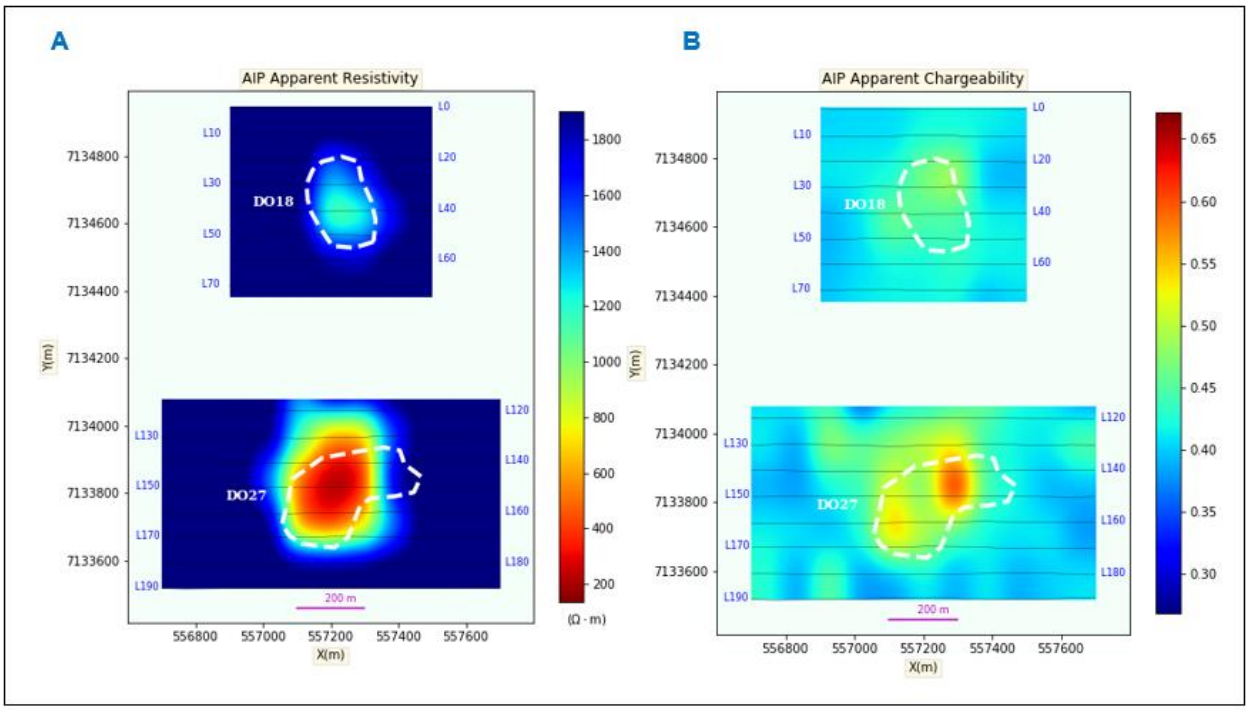

Figure 2: (A) AIP apparent resistivity and (B) apparent chargeability data.

Displayed in Figure 3 are the AIP relaxation time-constant and frequency factor data. The relaxation time-constants are low over DO18 and are relatively high over DO27. The frequency factors over DO18 are higher (~0.8) than those over DO27 (~0.6). The relaxation time-constants and frequency factors of DO18 suggest that the polarizable materials are more uniformly distributed and fine-grained. On the other hand, the sizes of the grains of the polarizable material in DO27 are relatively larger than those in DO18. Kang et al. (2017) suggest that the polarizable source may be a frozen ice/clay mixture at DO-18 and conductive clay for DO-27.

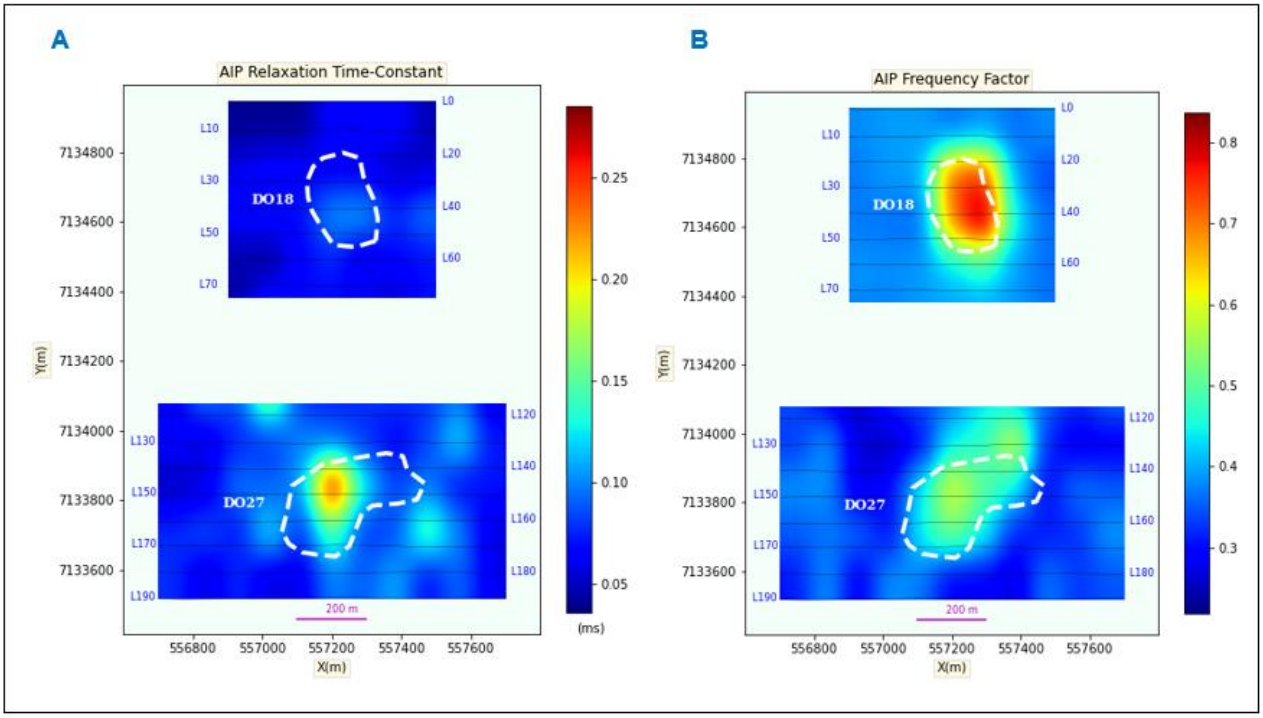

Figure 3: (A) AIP relaxation time-constant and (B) frequency factor data.

The new AIP mapping method can extract subtle IP signatures from HTEM data. The extracted IP responses could be used as vectoring tools for the search for potential hydrothermally related mineralization and economic deposits, such as alkalic porphyry Au-Cu systems (Kwan & Müller, 2020) and Archean lode gold (Müller, Kwan & Groves, 2020, submitted).

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