# PRELIMINARY REPORT ON HELICOPTER-BORNE ZTEM TIPPER AFMAG SURVEY RESULTS over SHEA CREEK TEST BLOCK, on behalf of AREVA RESOURCES CANADA LTD.

## April 2009

## Introduction

In April 2009, ZTEM (Z-Axis Tipper Electromagnetic) surveys were conducted, on behalf of AREVA Resources Canada Ltd. (Saskatoon, SK), over the Shea Creek Test Block that is situated in the Cluff Lake region of the western Athabasca Basin. The ZTEM survey consists of airborne Tipper AFMAG (audio frequency magnetic) measurements, as well as aeromagnetics using a caesium magnetometer. The survey consisted of twenty four (24) 18km long, NE-SW oriented (N-060$^{O}$E) flight lines, totaling 432 line-km, that were obtained at 400m nominal line spacings over an approximately 9 x 18km area. The area was chosen because it hosts the well known Shea Creek uranium deposits (Figure 1), it is overlain by a significant thicknesses of Athabasca sandstone (650+ metres) cover, it hosts a major graphitic horizon and sandstone alteration zones at depth, and has been the focus of extensive airborne and ground geophysical coverage (Figure 2).

SHEA CREEK PROPERTY & SURVEY LOCATION

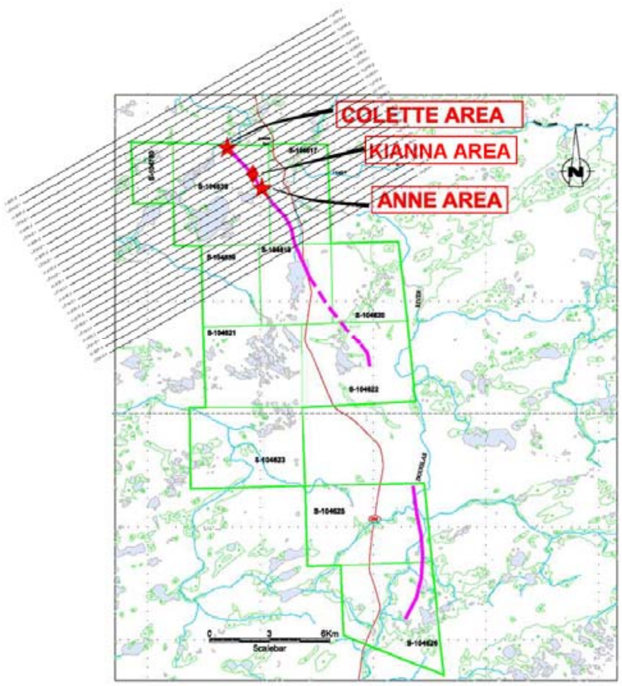

**Figure 1: Location map showing uranium deposits and ZTEM flight lines (courtesy AREVA Res. Can. Ltd.)**

The Z-axis tipper measurements of the vertical (Z) component were obtained using Geotech's patented ZTEM aircoil system, suspended at approximately 70m elevation above ground level. The vertical component data ($H_Z$) were then ratio'd to fixed horizontal field measurements ($H_X$-$H_Y$) obtained using identical reference coils, that were oriented in the in-line (X) and cross-line (Y) directions, in order to obtain the tipper functions Z/X and Z/Y. The In-Phase and Quadrature components of the tipper ratio data were extracted using Fourier-based, digital signal processing analyses, at 5 frequencies, between 30Hz and 360Hz.

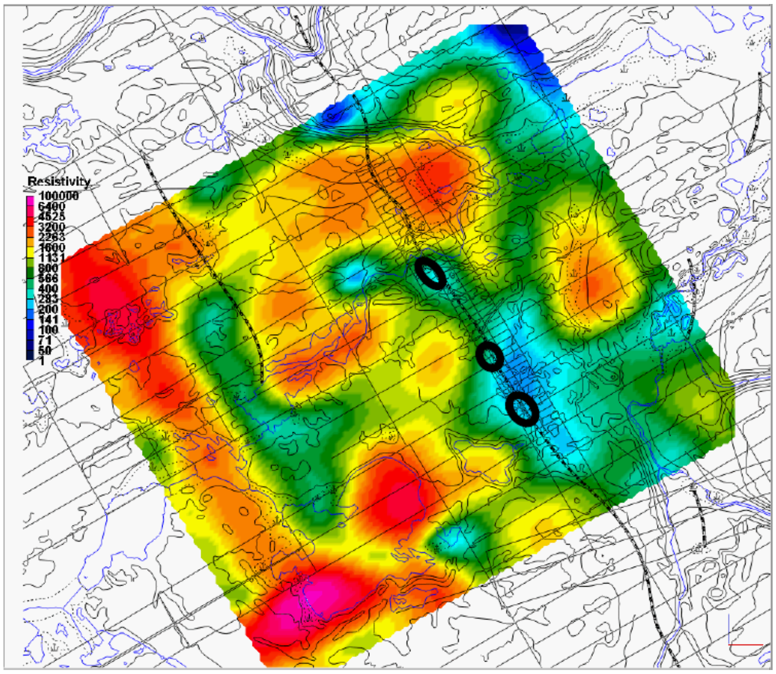

**Figure 2: Ground resistivity survey results showing conductive sandstone alteration zones (blue) above graphitic EM conductors (striped lines) and deposits (circles) at Shea Creek (courtesy AREVA Res. Can. Ltd.)**

## General Theory

The ZTEM airborne AFMAG system measures the anomalous vertical secondary magnetic fields that are created by the interaction between naturally occurring, plane wave audio frequency EM fields and electrical heterogeneities in the earth. Because the primary fields are naturally occurring, ZTEM requires no transmitter. The fields resemble those from VLF except that they are lower frequency (tens & hundreds of Hz versus tens of kHz), hence provide significantly deeper penetration (approx. 7x-25x) and are not strongly directionally polarized. These AFMAG EM fields, derived from world wide atmospheric thunderstorm activity, have the unique characteristic of being uniform, planar and horizontal, and also propagate vertically into the earth – to great depth, up to several km, as determined by the EM skin depth, which is directly proportional to the ratio of the bedrock resistivity to the frequency. At the frequencies used for ZTEM, the EM skin depths likely range between <1km to >3km in this region of the Athabasca Basin, according to the following equation for skin depth (Vozoff, 1972):

$$\mathbf{\delta_s = 503 * \sqrt{(\rho_A / f)}\ \text{metres}}$$

$$\textbf{if } \rho_A = \textbf{1k ohm-m, } \delta_s \approx \textbf{800m at 360Hz and \textasciitilde3.0km at 30Hz}$$

The other unique aspect of AFMAG fields is that they react to relative contrasts in the resistivity, and therefore do not depend on the absolute conductance, as measured using inductive EM systems, such as VTEM – hence poorly conductive targets, such as alteration zones and fault zones, can be mapped, as well as higher conductance features, like graphitic units. Conversely, resistive targets can also be mapped using AFMAG – provided they are of a sufficient size and contrast to produce a vertical field anomaly. Hence AFMAG can be effective as an all-round resistivity mapping tool, making it unique among airborne EM methods.

## Data Presentation

The nature of the AFMAG fields is such that, as with VLF, buried, tabular conductors and resistors produce cross-over responses. As such, although the field results are shown as cross-over profiles, additional post-processing is applied to convert these cross-overs into peak responses, to make them more useful as mapping tools. These include 2 types: the Total Divergence (DT), which is a summative horizontal derivative process method that combines both the Z/X and Z/Y results (Kuzmin et al., 2005), and the 90-degree Phase-Rotation (Lo and Zang, 2008), shown here, which is a Geosoft-based FFT process applied to grids of the individual Z/X and Z/Y component data - only the In-Phase Z/X In-line preliminary results are presented in the current study (Figures 3).

## Data Analysis

The In-line (Z/X) component of the In-Phase Tipper data are shown as 90-degree Phase-Rotated grids in Figures 3, with the high (360Hz) and low-frequency (30Hz) spectrum shown together, for depth-comparison purposes. The Z/X (In-Line) component results shown in Figure 3 are most sensitive to structures orientated perpendicular to the In-Line direction. Geologic and geophysical features of interest from Figure 2 are also shown as overlays.

The Shea Creek test area ZTEM results, in particular, showcase the relatively good data quality, in terms of high signal/noise and well defined anomaly resolution. Particularly given the fact that a) the data were obtained in early April, and therefore not at the peak season of sferic activity – hence at best moderate-weak natural field levels expected; b) the data were obtained using aircraft flying at ~80km/hr, and receiver clearance approximately 70m above ground level – hence without additional stacking or significant processing applied, and c) the strength of response obtained from geologic targets at >650-700+ metre depths.

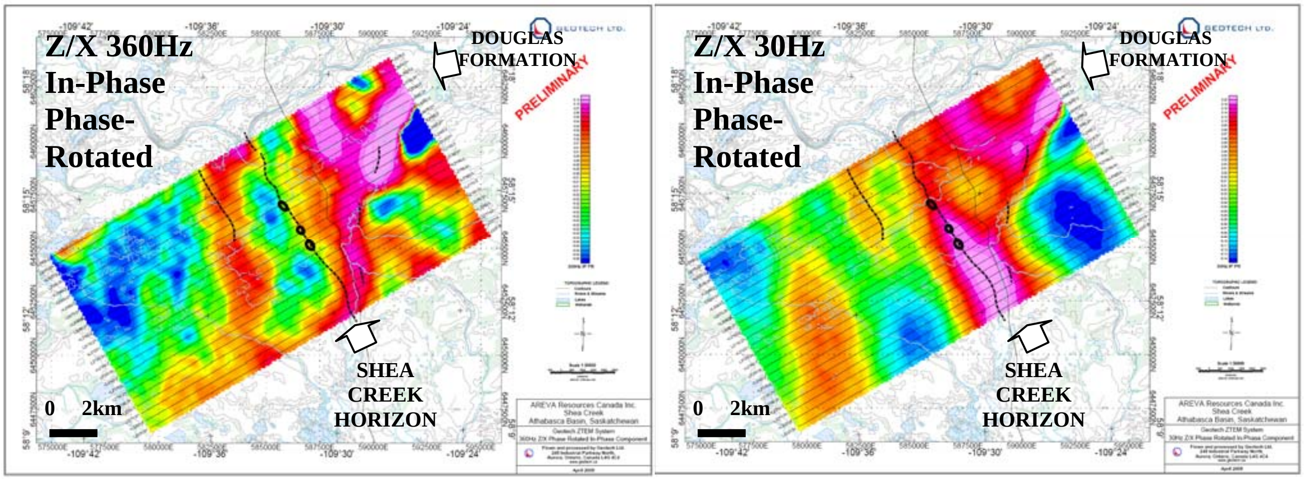

**Figure 3: Shea Creek: Phase-Rotated In-Phase Z/X component at 360 Hz (left) and 30 Hz (right) with geologic and geophysical features of interest from Fig. 2.**

There are notable differences in the frequency-dependence of the responses that implies a difference in the vertical source depth. Specifically, the higher frequency Z/X results (Fig. 3 left) appear to be more strongly influenced by north-south drainage patterns, which reflects their shallower penetration (<1km); whereas the lower frequency Z/X results (Fig. 3 right) appear to most influenced by more NW-SE trending basement stratigraphies that occur at >650-700m depths. In particular, the strongest ZTEM response corresponds to the Shea Creek graphitic horizon that occurs in the center of the block, which agrees with the known geology. As well, to the northeast, a V-shaped low resistivity zone that is also observed in the high frequency data corresponds to an inlier of Douglas Formation mudstones, that lie at relatively shallow depth (<500m); the weakening response in the lower frequency ZTEM results appears to confirm that these Douglas mudstones are depth-limited, in comparison to the Shea Creek graphitic response.

## Conclusion and Recommendations

The ZTEM test results performed over an unconformity-type uranium target in the western Athabasca basin has highlighted the deep penetration and resolution capability of the technology as well as the high quality and high accuracy of the AFMAG data obtained.

The ZTEM results appear to agree very well with the inferred/known geology, in particular the presence of a major NW-SE trending conductive zone that likely corresponds to main Shea Creek graphitic horizon that is known to occur at depths exceeding 600-700m, and had previously proved to be a challenge in terms of depth-penetration for airborne and ground geophysical techniques.

In addition, the ZTEM results appear to easily differentiate between shallow and deep seated target geology – notably overburden drainage patterns and Douglas Formation mudstones that are more strongly felt in the high frequency/shallow penetration data; versus the Shea Creek basement graphites that are easily detected in the low frequency/deep penetration data, below 650m-700m depths.

We recommend that these ZTEM results be compared with the available geoscientific data, in order to better explain the observed correlations with the known geology. This might include comparisons with any geophysical survey data, in particular, ground EM and possibly also magnetotelluric and tipper MT results. We also recommend that additional interpretation of the ZTEM data be attempted, including 2D-3D inversions.

Respectfully submitted

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