The Albany Graphite Discovery – Airborne and Ground Time-Domain EM

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Summary

On January 19TH, 2012, Zenyatta Ventures Ltd. (Zenyatta) announced the discovery of a very rare type of hydrothermal graphite deposit on its Albany Project. The discovery was based on drill testing of anomalies identified by airborne electromagnetic survey flown in 2010 by Geotech Ltd. using its prototype VTEM^{MAX} time-domain EM system. Crone Geophysics & Exploration Ltd. (Crone) was contracted by Zenyatta to perform surface time-domain EM (TDEM) surveys on the Property during February and March 2013. Crone targeted the drill-confirmed East and West graphitic breccia pipes using an in-loop and out-of-loop configuration to couple with their top and steeply dipping edges, respectively, and successfully outlined their lateral extents.

Introduction

While conducting an exploration program targeting nickel (Ni), copper (Cu), and platinum group metals (PGMs) Zenyatta made the discovery of a very rare type of hydrothermal graphite deposit in 2011 on their Albany Graphite Project located 30km north of the Trans-Canada Highway near Hearst Ontario (Fig. 1). The Albany Project area had been largely unexplored in the past as a result of swamp and the younger Phanerozoic (460-360 Ma) cover rocks, up to 200m thick, overlying the prospective Archean rocks. However, recent advances in airborne electromagnetic (EM) technology had allowed deeper penetration/resolution through the Fe-deficient shallow marine carbonate/clastic sediments to target favourable geological and structural settings within the underlying Archean (see Zenyatta's website www.zenyatta.ca).

This case study describes the airborne time-domain EM (TDEM) and magnetic geophysical survey results from 2010 that lead to the discovery and the subsequent ground follow up in 2013 using surface TDEM that better characterized the two graphite deposits (East Pipe and West Pipe) at Albany.

Geology and Exploration

The Albany graphite deposit is located in the Superior Province of the Canadian Shield, at the terrane boundary between the Quetico Subprovince to the north and the Marmion Subprovince to the south (Ross and Masun, 2014). The geology of the survey area consists of Precambrian paragneissic granitoids and migmatitic metasediments to the south and metamorphosed tonalite to granodiorite to the north. These rocks have been intruded by a younger alkalic intrusive complex (Fig. 2).

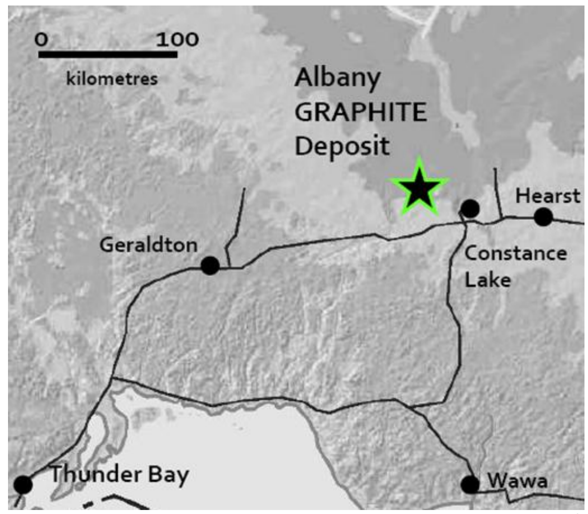

Figure 1: The Albany Graphite property location (ref. www.zenyatta.ca).

These basement rocks are covered with up to 15m of relatively thin flat-lying Paleozoic limestone sandstones, shales, dolostones, siltstones and up to 50m of thick overburden. The Albany graphite deposit is hosted within a younger gneissic to unfoliated alkalic syenite, granite, diorite, and monzonite intrusive suite (Albany Alkalic Complex); Fig. 2) that are cross-cut by younger dykes, ranging from felsic to mafic in composition (Ross and Masun, 2014).

Prior to 2010, the Albany project area had been explored by as many as eight companies, dating back to 1959, though not extensively, due to the Paleozoic limestone cover and thick glacial till (Ross and Masun, 2014). Aeromagnetic and ground EM surveys had defined REE rare earth occurrences in two drillholes in 1964 on the property (Fig. 2-3) and also graphitic breccia in one drill-hole in 1978. Regional aeromagnetic coverage and subsequent interpretation map by the Ontario Geological Survey (Stott, 2008) highlight both the Albany Alkalic Complex on the property and the Nagagami Alkalic Complex further north. Zenyatta became active in exploring for nickel, copper and PGMs in the region based on this evidence, which led to the 2010 VTEM survey and the discovery of extensive graphite mineralization on the Albany Graphite claim block in 2011 (Ross and Masun, 2014).

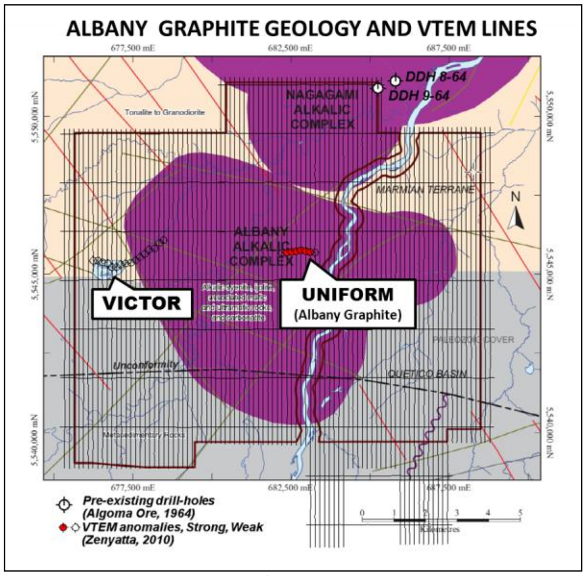

Figure 2: Basement geology of Albany Graphite property, showing VTEM lines and EM anomalies (after Ross and Masun, 2014).

The Albany deposit is a unique example of an epigenetic graphite deposit in which a large volume of highly crystalline, fluid-deposited graphite occurs within an igneous host (Ross and Masun, 2014). The deposit is interpreted as a vent pipe breccia that formed from a CH_4-CO_2-rich fluid that evolved due to pressure-related degassing of syenites of the Albany Alkalic Complex. Graphite occurs both in the matrix, as disseminated crystals, clotted to radiating crystal aggregates and veins, and along crystal boundaries and as small veins within the breccia fragments.

Zenyatta has drilled 63 holes since 2011, totaling more than 26,000m in the deposit area, with up to 360m of graphite mineralization in a single hole and mineralized intersections down to 500m depth (Fig. 3) Graphite mineralization is related to two separate graphitic breccia pipes (West Pipe and East Pipe – Fig. 3) which are typically surrounded by a zone of graphite overprinted syenite. The deposit contains a total indicated resource of 25.1 Mt at 3.89% graphitic carbon (Cg) for a total of 977,000 tonnes (Ross and Masun, 2014).

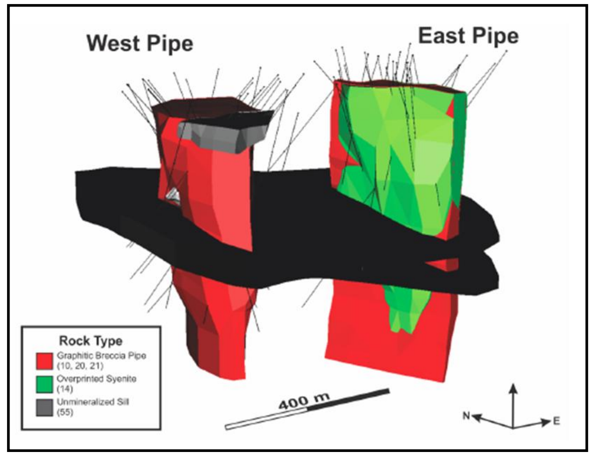

Figure 3: 3D wireframe models of the East and West Pipes forming the Albany Graphite deposit, constrained by drilling (after Ross and Masun, 2014).

Airborne EM-Magnetic Survey

The Albany Project airborne EM-magnetic survey for Zenyatta consisted of >10,000 km of helicopter time-domain EM (TDEM) and magnetics over multiple (28) blocks from March 17 to May 19, 2010 (Legault, 2010). The survey was performed using a higher power VTEM (versatile time-domain electromagnetic; Witherly et al., 2004) prototype that featured a larger loop diameter (35m) and higher dipole-moment (0.84 M nIA) that would later develop into VTEM^{MAX} (ref. Killeen, 2011). The survey was flown along 150m spaced, north-south oriented lines and east-west tie-lines at 700-1500m spacings. The Albany graphite survey claim block (4F) consisted of 1181 km covering 206 m^2 area (see Fig. 2 & 4), flown at an average EM sensor height of 53 m and an avg. magnetic sensor clearance of 75 m.

The VTEM EM and magnetic surveys identified two EM and magnetic targets of significance (Victor & Uniform; Legault, 2010) as shown in Figure 4. They lie in close proximity to a ring-like magnetic anomaly over the Nagagami Alkalic Complex (Fig. 2) and a more subtle zoned magnetic anomaly that corresponds to the Albany Alkalic Complex.

The Albany Graphite Deposit EM anomaly is observed along multiple survey lines that suggest as many as 2 separate zones and with relatively high values of Time Constant (Tau) between 1ms to 3 ms that indicate high conductance (Fig. 5). Resistivity-depth imaging of the VTEM results (Fig. 6) using the transformation scheme by Meju (1998) indicate a large (1400x800m) conductivity high that is consistent with a mineralized bedrock source below the limestone cover (Legault, 2010).

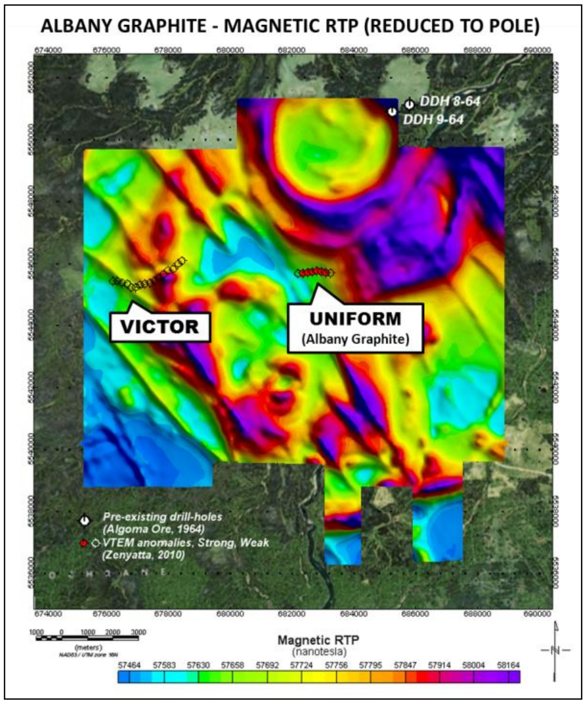

Figure 4: Magnetic RTP image over Albany Graphite property, showing VTEM EM anomalies (after Legault, 2010).

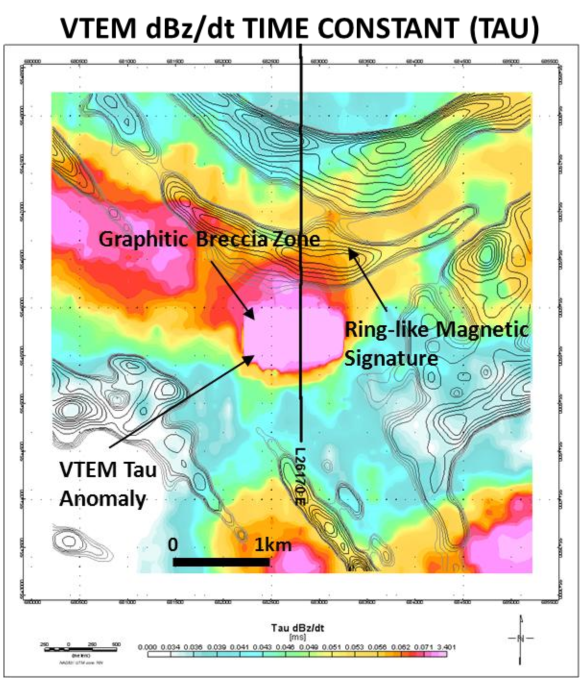

Figure 5: Late channel VTEM dBz/dt time constant with magnetic gradient contours, showing location of L26170E in Fig. 6.

However, the Albany Graphite EM anomaly is also distinguished by its weak magnetic low response (Fig. 3) that is consistent with either remanently magnetized magnetite or pyrrhotite, or possibly diamagnetic graphite, which at the time caused it to be initially less favoured, geophysically, relative to other neighbouring anomalies. In spite of this, the drilling of the Uniform VTEM anomaly for nickel-copper target with drill-hole Z11-4F1 tested a strong, large airborne EM conductor and intersected eight separate and extensive breccia zones consisting of variably sized granitic fragments set in a black matrix containing graphite (Ross and Masun, 2014).

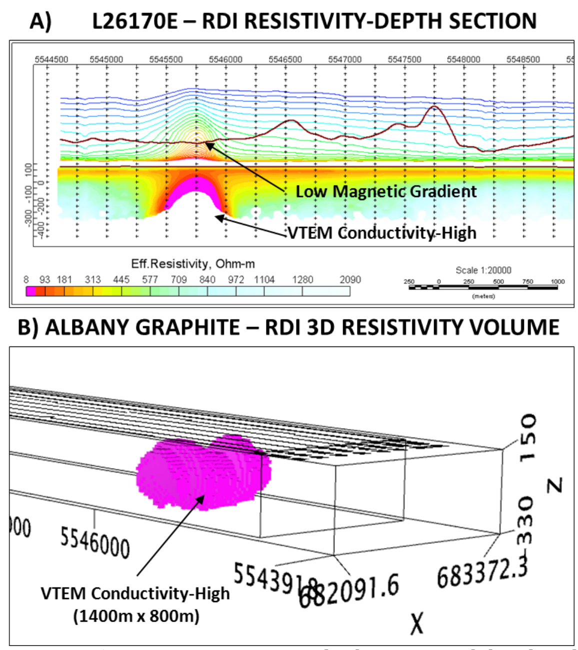

Figure 6: A) VTEM RDI resistivity-depth section, and dBz/dt and vertical magnetic gradient profiles, B) VTEM 3D resistivity volume from RDI imaging results.

Ground EM Survey

The Albany Project ground EM survey consisted of 12 line kilometers surveyed from 2 loop configurations with the Crone Time Domain Pulse EM system using a 50msec time base and a Crone surface induction coil measuring the in-line and vertical components. As the target was described as possible pipe-like structures from previous airborne TDEM results, it was anticipated that surface TDEM surveys could be influenced by both the top, presumably the flat edge of the pipe, as well as the vertical faces if the pipe had a significant depth extent. The survey design incorporated an offset loop mode (to couple with the steeply dipping edges) and an in-loop mode to couple with the top, flat, (or relatively shallow dipping), edge of the body. Loop

1 was surveyed in an in-loop mode with a 1200 m by 1500 m loop, with a peak current of 11 Amps, covering 11 lines ranging from 1000 m to 1100 m in length. Line spacing within the loop was 100 m, with station spacing ranging from 25 m to 50 m. The same lines were resurveyed with and offset loop (Loop 2) at 12 Amps. Loop 2 utilized the Northern 500 m by 1500 m section of Loop 1.

The EM results from Loop 1 and Loop 2 identified two separate conductive features which have been inferred to be pipe-like structures (Figures 7, 8). The Western anomaly is characterized by a rough circular pattern with an approximated depth of 100-120 m to the top of the source and a Tau of approximately 12 msec. The Eastern anomaly is characterized by an oval shaped source with its long axis oriented in the NNW-SSE direction (Figure 9). This zone is described by a slightly higher conductivity; providing a higher Tau value of ~15 msec. Brief modeling studies of Loop 1 data indicated the responses of the two zones were dominated by the top-edge of the conductive features. Multiple bodies of varying thickness were utilized to fit the data, but provided negligible difference in the model fit, suggesting the response was dominated by the relatively flat-lying tops of there bodies.

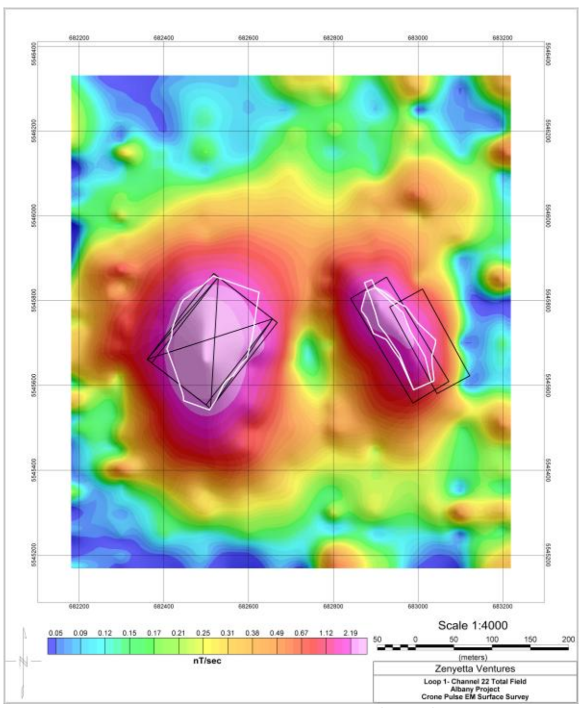

Figure 7: Late time (channel 22), total field for Loop 1 with modeled plates (black) and surface deposit outline (white).

Modeling of Loop 2 revealed that for both the Western and Eastern anomalies had the potential for considerable depth extent. Modeling results for the Western anomaly provided better fits to the data when using the thick plate option within Maxwell and suggesting a minimal depth extent or thickness on the order of 50 m to 100 m to provide good modeling fits. The Eastern anomaly was fitted with a depth extent/thickness of approximately 150 m with poor fits being obtained by anything less than 100 m.

The Loop 2 survey appears to have been most sensitive to the Northern edge of the sources, but difficulty arises when determining the southern limit of the source. The southern boundary is best determined from the Loop 1 models, although this is a crude approximation.

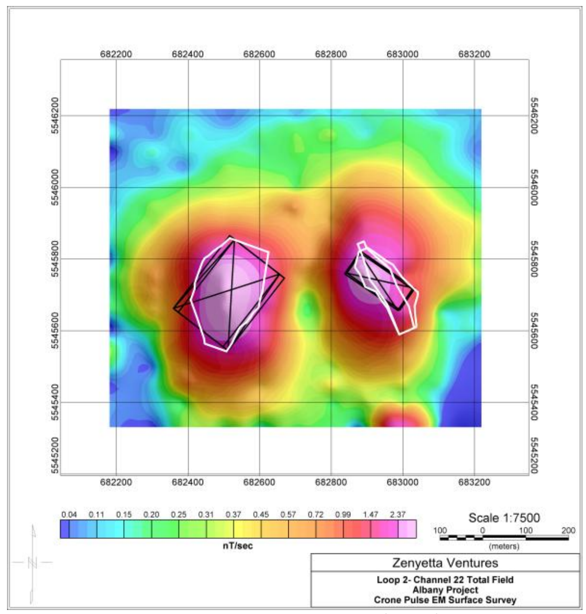

Figure 8: Late time (channel 22), total field for Loop 2 with modeled plates (black) and surface deposit outline (white).

Overall, the modelled plates from Loop 1 and Loop 2 provided a robust model for targeting purposes. After drilling the first few holes, Zenyatta came to the conclusion that the channel 22 contours from Loop 1 provided a close correspondence to the actual outline of the breccia pipes and relied on this extensively for drill planning purposes (Figure 9).

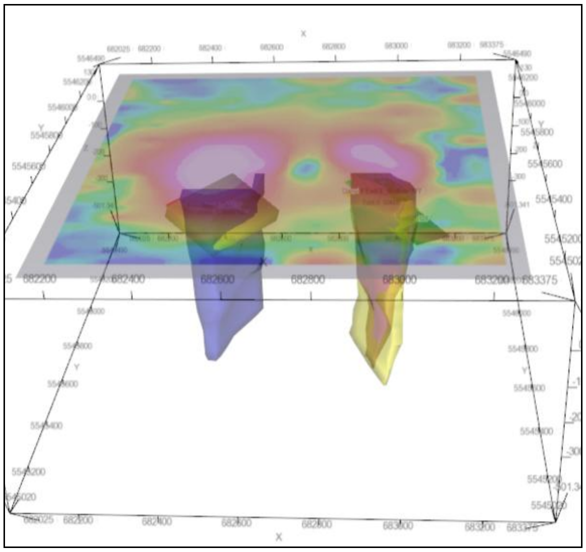

Figure 9: 3D view of Loop 1 total field (channel 22) surface date with modelled plates and deposit.

Conclusions

Prior to the discovery of the Albany Graphite deposit, the area had been largely unexplored in the past due to thick overburden and Phanerozoic cover rocks overlying the prospective Archean basement rocks. The ability of modern AEM systems to penetrate the cover has played an important role in further exploring the area. Arguably, had it been a nickel sulphide deposit, with a strong magnetic and EM correlation, it might have been discovered sooner. Instead, despite its large size and favourable high conductivity, the Albany Graphite airborne TDEM anomaly is distinguished by a weak magnetic low response that is consistent with diamagnetic graphite. This resulted in a lower ranked geophysical target relative to other neighbouring anomalies. Regardless, the presence of a strong AEM anomaly inside a favourable geologic and geophysical structure resulted in it being drill-targeted for nickel sulphides but which instead led to the discovery of these rare igneous-related, hydrothermal graphite deposits. Ground TDEM follow-up was used to constrain the outline and depth extent of the mineralized orebodies. This blind discovery in an underexplored region below extensive cover is testament to the importance of well defined geologic target model and the use of deep penetration airborne and ground-based EM systems.

Acknowledgements

The authors wish to thank Zenyatta Ventures Ltd. for releasing these data, as well as Geotech Ltd. and Crone Exploration & Geophysics Ltd for allowing us to present these results.

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