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VTEM airborne EM, aeromagnetic and gamma-ray spectrometric data over the Cerro Quema high sulphidation epithermal gold deposits, Panama

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SUMMARY

In March 2012, a helicopter-borne VTEM electromagnetic (EM), magnetic and radiometric survey was flown over the Cerro Quema high sulphidation epithermal gold deposits in Panama. Geophysical signatures, including Airborne Inductive Induced Polarization (AIIP) effect, characteristic of high sulphidation epithermal gold deposits were observed in the EM, magnetic and radiometric data over the known deposits. This success points to the applicability of regional helicopter EM-Mag-Spec surveys for the exploration of similar high sulphidation epithermal gold deposits to depths <500m in weathered terrains.

Key words: VTEM, high sulphidation epithermal gold, Cerro Quema, AIIP, Airborne Inductive Induced Polarization.

INTRODUCTION

Geotech Ltd. carried out a helicopter-borne VTEM electromagnetic (EM), magnetic and gamma-ray spectrometric survey, in March 2012, over the Cerro Quema high sulphidation epithermal gold deposits and the surrounding areas in the Azuero Peninsula, Panama, on behalf of Pershimco Resources Inc.

The survey comprises a total of 2451 line-kilometres of data, at 200m and 100m line spacing with in-fills, Figure 1. The area selected for this study located near the centre of the survey covers three known gold deposits, La Pava, Quemita and Quema, Figure 2.

Geophysical signatures characteristic of high sulphidation epithermal gold deposits were observed in the EM, magnetic and radiometric data over the known deposits.

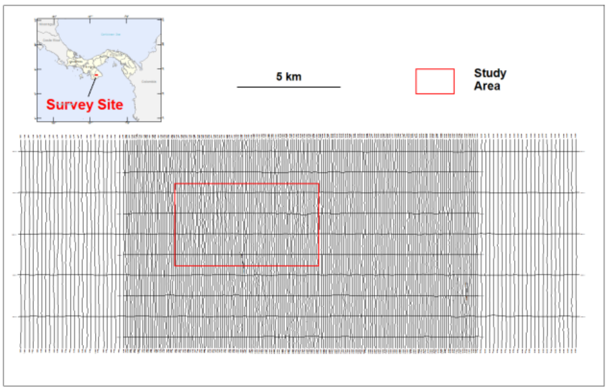

Figure 1: VTEM survey location and the study area.

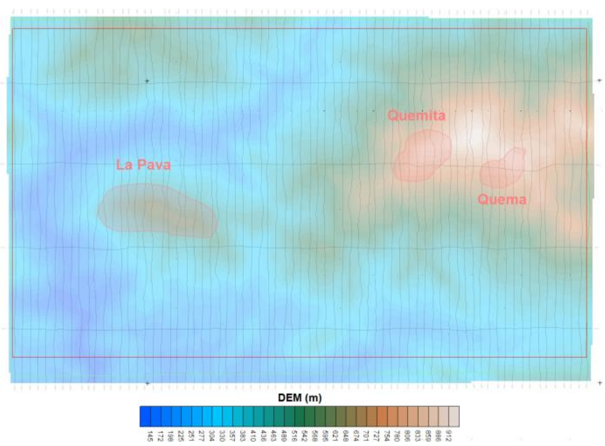

Figure 2: Locations of the La Pava, Quemita-Quema gold deposits, from Valliant, *et al*. (2011).

GEOLOGY AND ALTERATION

The descriptions of geology, alterations and deposit model are sourced mainly from Valliant *et al*. (2011).

The geology of the Azuero Peninsula consists of an assemblage of late Cretaceous through tertiary intercalated volcanics, volcanoclastics, and marine and terrestrial sedimentary rocks, intruded by batholiths of tonalitic composition and numerous quartz diorite stocks/plutons. The Cerro Quema gold deposits are hosted in an east to west trending belt of porphyritic, pyroclastic flows, and lavas of dacitic and andesitic composition, Figure 3.

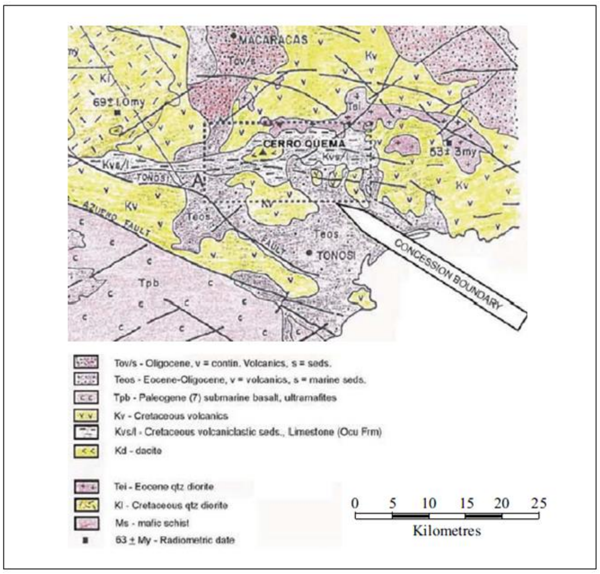

Figure 3: Local geology, from Valliant *et al*. (2011).

Three alteration types are identified by detailed geologic mapping and drill core logging: advanced argillic (silica-pyrite), argillic (clay-pyrite) and propylitic alteration.

The advanced argillic (silica-pyrite) alteration is characterized on surface by a highly fractured, vuggy, locally brecciated rock composed of silica and iron oxides. This oxidized leached cap extends to a depth of up to 150 m. Pyrite is abundant (up to 35% of the rock) beneath the oxidation boundary. The advanced argillic alteration assemblage may contain variable amounts of dickite, pyrophyllite, diaspore and alunite.

The argillic (clay-pyrite) alteration contains illite, smectite, kaolinite, and hematite, characterized in weathered outcrops by its soft, clayey nature and reddish mottled colouring. Abundant disseminated pyrite occurs at depth. Much of the clay seen at surface may have formed during supergene oxidation of the pyrite. Clay alteration forms a boundary between the silicic mineralized core and an outer propylitic alteration zone.

Propylitic alteration forms the outer margins of the deposits. It is characteristically a green rock, which contains chlorite, calcite, siderite, hematite, and illite. At La Pava, down-faulted blocks of propylitic alteration overlie deeper clay and silica-pyrite zones.

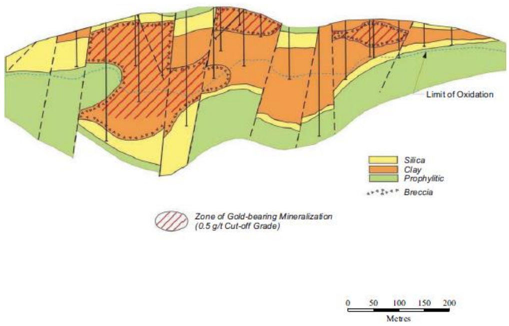

Figure 4: A cross-section of La Pava deposit, looking west, from Valliant *et al*. (2011).

A cross-section from La Pava showing the three alteration types and gold mineralization is shown in Figure 4.

All of the known deposits and prospects in the study area outcrop at the surface, show moderate to strong acid leach alteration and are sulphide-bearing below the oxidation depth. The oxide gold deposits are hosted within mineralized vuggy silica rocks and advanced argillic (silica-clay) alterations topped by acid-leached resistive caps. These high sulphidation deposits formed within late Cretaceous to Tertiary volcanic/plutonic centres of calc-alkaline island arcs in an oceanic convergent plate setting. Host rocks are intercalated and permeable volcanic and volcaniclastic rocks. Principle ore in the oxide zone as gold in iron oxides after pyrite-rich sulphides, and in the sulphide zone as copper and gold associated with pyrite, chalcopyrite, enargite, covellite mineralization. Ore controls are faults, breccias and permeable lithologies. Mineralization post-dates the formation of the leached cap and in shallow (*epi*) depths, and susceptible to erosion.

GEOPHYSICAL SIGNATURES

Electrical (and electromagnetic) methods are well suited to detect the silicic core of high sulphidation deposits and also barren lithocaps (Hedenquist *et al*., 2000). Acid-leached lithocaps have high electrical resistivity. Vuggy quartz is typically a strong electrical resistor in dry conditions. The clay-pyrite alterations surrounding the deposits should have low electrical resistivity because of the conductive clays and pyrite-rich sulphides.

Radioelement ratio, Th/K lows (high potassium counts) usually associated dacitic intrusives are expected to be in the outer margins of the deposits. Th/K highs (low potassium counts) correspond to hydrothermally altered outcrop as a result of intense acid leaching should coincide with the deposits (Goldie, 2000).

Magnetic low due to magnetite-destruction is one of the primary characteristics of epithermal gold deposits (Hoschke, 2011). Although structural control of high sulphidation mineralization and its association with vuggy quartz and massive sulphides are still prominent features of the shallow epithermal environment, lithological permeability and hydrothermal brecciation play much more important roles (Sillitoe, 1999). Magnetic data can help to define local lithologies, geologic boundaries and structures (Hedenquist *et al*., 2000).

VTEM DATA

VTEM electromagnetic (EM) data

The standard helicopter-borne Versatile Time Domain Electromagnetic (VTEM) (Witherly *et al.*, 2004) is a geophysical data acquisition system configured with a horizontal magnetic gradiometer. A gamma-ray spectrometer can be included as an option. The VTEM system utilizes the most recent advances in digital electronics and signal processing for deeper penetration, higher spatial resolution and better resistivity discrimination for a broad variety of conductive targets.

Standard VTEM data processing includes the conversion of the voltage decay data into an equivalent apparent resistivity versus depth cross-section, using the Resistivity Depth Imaging (RDI) technique based on the transformation scheme described by Meju (1998).

An apparent resistivity depth slice at 50m below ground is displayed in Figure 5. Two conductive trends, Quema-La Pava and Quemita-Quema, are identified from the apparent resistivity map. The La Pava deposit is on the Quema-La Pava trend, while Quemita-Quema deposits are either on or close to the Quemita-Quema trend.

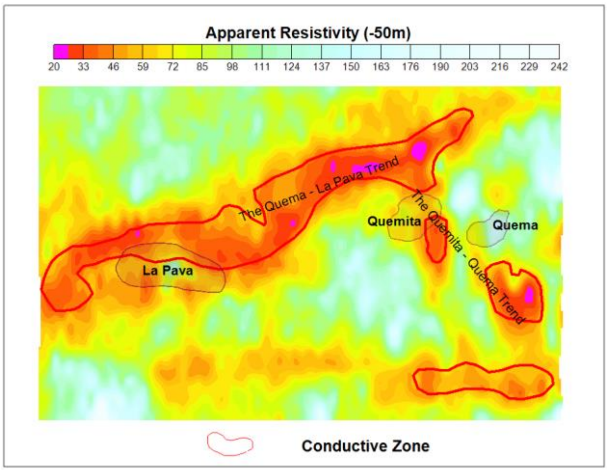

Figure 5: The map of apparent resistivity depth slice at 50m below ground.

The low resistivity of the trends can be best explained by the presence of conductive clay and pyrite-rich sulphides in the clay-pyrite alteration.

Airborne Inductive Induced Polarization (AIIP)

Negative transients observed in airborne time domain EM data (Boyko *et al.* 2001) are attributed to Airborne Inductive Induced Polarization (AIIP) effect. However, the absence of negative transients does not preclude the presence of AIIP, because of the IP effect takes finite time to build up or the IP effect may be obscured by the conductive ground, Kratzer and Macnae (2012).

An AIIP mapping tool, described in Kwan *et al.*, 2014, was used to extract the chargeability from the VTEM data. The Z-component voltage data, from 0.09 to 7.56 milliseconds in off-times, are processed. Negative transients above noise level are not observed in the data. The inverted AIIP apparent chargeabilities, displayed in Figure 6, show a discernable pattern. The relatively high chargeabilities seem to coincide with the clay-pyrite alterations surrounding the La Pava deposit, as well the two conductive trends.

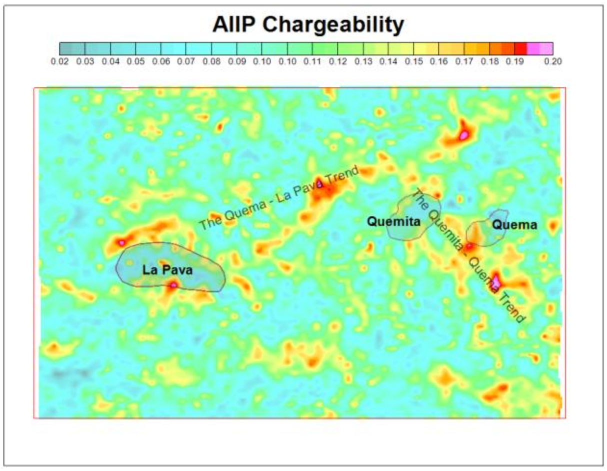

Figure 6: AIIP apparent chargeability.

Radiometric data

Raw gamma-ray spectrometry data in standard potassium, uranium and thorium windows in counts-per-second are processed and converted into equivalent ground concentrations (IAEA, 2003).

The radioelement ratio of equivalent thorium concentration and percent potassium, Th/K, is computed and displayed in Figure 7.

The La Pava and Quemita-Quema deposits coincide with the Th/K highs. The area between La Pava and Quemita-Quema deposits and to the south show low Th/K ratios.

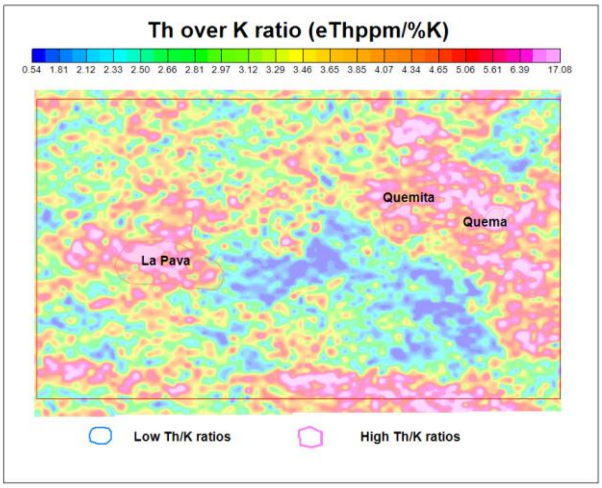

Figure 7: The radioelement ratio Th/K.

Th/K highs are interpreted to correspond to hydrothermally altered outcrop as a result of intense acid leaching (Goldie, 2000). Th/K lows can be attributed to dacitic intrusives surrounding the deposits.

Magnetic data

The processed total magnetic field data are reduced to the magnetic pole (RTP) to facilitate interpretation. The interpreted lithologies, metavolanics (Mv) and metasediments (Ms), along with the RTP, are shown in Figure 8. The La Pava, Quemita-Quema deposits are located in the region of metasediments of low magnetic susceptibility.

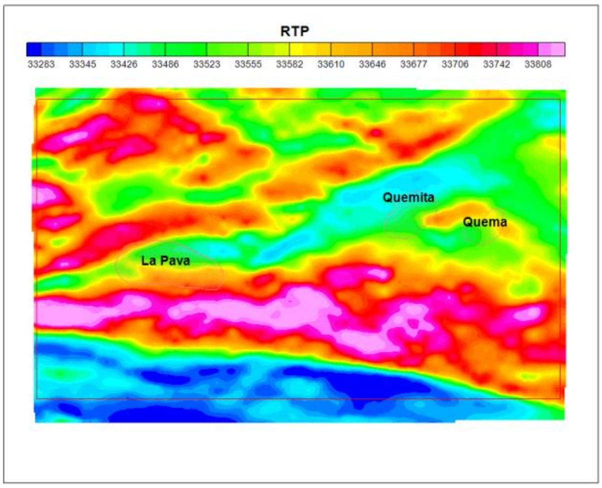

Figure 8: Interpreted lithologies and the RTP.

The faults and contacts are interpreted from the first vertical derivative of the RTP, Figure 9. The interpreted faults run mainly in N70°E and N140°E directions. The contact along La Pave Quemita-Quema trend is sinistrally offset in the middle by strike-slip faulting. The major contact in the south runs in the N100°E direction.

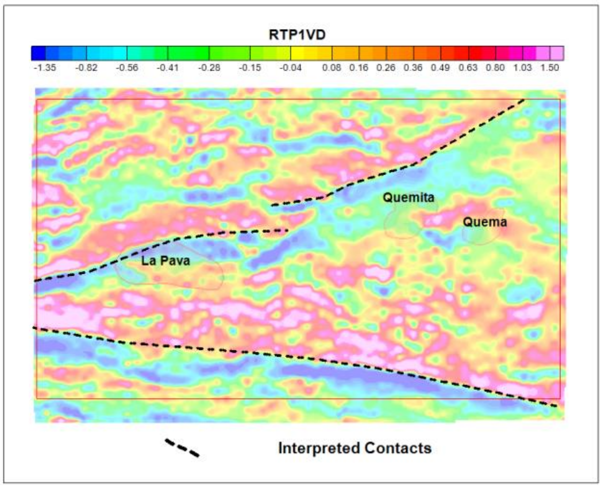

Figure 9: Structural interpretations, over the first vertical derivative of the RTP.

CONCLUSIONS

A helicopter-borne VTEM electromagnetic (EM), magnetic and radiometric survey was carried out in March 2012 over the Cerro Quema high sulphidation epithermal gold deposits in Panama. Geophysical signatures, including airborne induced polarization effect, characteristic of high sulphidation epithermal gold deposits were observed in the EM, magnetic and radiometric data over the known deposits. This success points to the applicability of regional helicopter EM-Mag-Spec surveys for the exploration of similar high sulphidation epithermal gold deposits to depths <500m in weathered terrains.

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