Targeting epithermal Au-Ag using helicopter VTEM time domain electromagnetic, magnetic and radiometric data at Lawyers Project, North-Central BC, Canada.

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SUMMARY

In September 2018, Geotech Ltd. completed a VTEM helicopter time-domain electromagnetic, magnetic and radiometric survey on behalf of Benchmark Metals Inc. over the Lawyers property, in northcentral BC. The magnetic results reveal a strong spatial relationship between sharp magnetic lineaments and the known mineralization. Radiometric results show that mineralization is characterized by hydrothermal alteration resulting in potassium enrichment, manifested as K/Th highs. The VTEM electromagnetic results identified local EM anomalies representing both discrete and structural conductors. However, none of the EM anomalies making up conductive zones coincide with the known epithermal mineralization, instead all the known Au-Ag deposits and occurrences are located in zones of high apparent resistivity. Subsequent analysis of the VTEM data analysed using AIIP mapping revealed that all the known Au-Ag mineralized zones coincide with moderate to high Cole-Cole time constant (TAU) anomalies, consistent with relatively coarse-grained polarizable material, such as disseminated sulphides or hydrothermally altered clays. The previous targeting approach focused on individual analyses of magnetic, structural, radiometric, EM resistivity and AIIP results, then arriving at a targeting model, based on geologically and geophysically based considerations. A new approach for targeting uses a semi-automated, machine-learning (ML) assisted approach that includes: Structural Complexities (SC), Self-Organizing Map (SOM) classifications, and Supervised Deep Neural Network (SDNN) targeting of the geophysical data. The new targeting approach has further reduced the number of priority targets from previous five (5) to three (3), which includes most of the known epithermal Au-Ag occurrences, as well as two areas for follow-up.

Keywords: Epithermal, time domain, electromagnetics, resistivity, magnetics, radiometrics, mineral-targeting

INTRODUCTION

Benchmark Metals' Lawyers Gold-Silver Project, situated 45 km northwest of Kemess South Mine in BC's Golden Horseshoe region (Figure 1) of north-central British Columbia, is host to a large, low sulphidation epithermal system known as the Lawyers Trend that contains a total indicated mineral resource of 40.3 Mt at 1.19 g/t Au and 38.7 g/t Ag. At the heart of the Lawyers Trend are the structurally-controlled Cliff Creek, Dukes Ridge, Phoenix and AGB zones that are located within a large 5 km by 8 km radiometric anomaly that is coincident with potassic alteration associated with the low-sulphidation epithermal system. The property straddles an important stratigraphic horizon between the Upper Triassic Stuhini Group and Lower Jurassic Hazelton Group that defines an important geological unconformity that hosts many of the deposits in the Golden Horseshoe (Stone et al., 2021).

Originally explored in the late 1960's, mineralization at Lawyers was identified by the 1980's and lead to the development of the Lawyers gold-silver mine that operated from 1989-1992 and produced 171,200 oz gold and 3.6M oz silver in that 4-year period. In the years following, exploration had focused on targeting high grade veins within the large epithermal system. Benchmark Metals has been actively exploring the Lawyers property since 2018, with a low- grade bulk tonnage targeting model approach, using extensive geological mapping, drilling, soil and rock geochemistry, ground, drone and airborne geophysics, which led to a NI 43-101 compliant mineral resource estimate in 2021 (Stone et al., 2021).

The Stone et al. (2021) report documented the targeting approach on helicopter TDEM, aeromagnetic and spectrometric data (Khaled et al., 2018) performed by Kwan et al. (2019), which was subsequently presented in Legault et al. (2022). This paper presents a new targeting approach that uses a semi-automated, machine-learning (ML) assisted approach that includes: Structural Complexities (SC), Self-Organizing Map (SOM) classifications, and Supervised Deep Neural Network (SDNN) approach to mineral targeting.

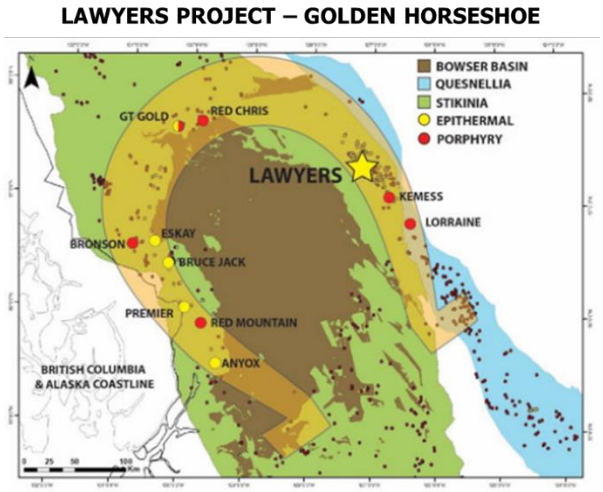

Figure 1: Lawyers Project property location, and schematic of Golden Horseshow mineral district in northwestern British Columbia (modified after www.benchmark metals.com).

Geology and Mineralization

Lawyers property is predominantly underlain by a shallow northwest-dipping sequence of volcanic and sedimentary rocks of the Lower Jurassic Toodoggone Formation (Hazleton Gp). The Lower cycle Toodoggone rocks are comprised of thick sequences (>300 m) of dacitic and andesitic tuffs and flows. The most dominant structural features are NW-NNW (310-340°) striking faults that are subvertical to steeply SW or NE dipping (Figures 2 & 3). These host the mineralized epithermal systems NW structures and associated mineralization are locally offset by E-W and SW-NE trending strike-slip faults (Stone et al., 2021).

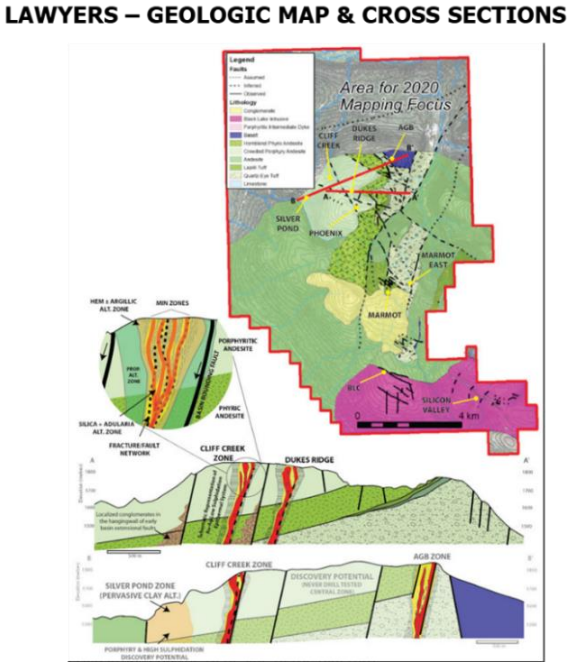

Figure 2: Lawyers Project geologic map (top) and schematic geologic cross sections (modified after www.benchmark metals.com).

Lawyers rocks are typically weakly altered, but gold-silver mineralization is associated with intense silicification and potassic alteration. Advanced argillic and qtz-sericite also present in some zones. Mineralization includes both low sulphidation (LS) in central & east (AGB, Cliff Ck, Duke Ridge) parts of the property and high sulphidation (HS) in the western (Silver Pond) part of the block, as shown in Figure 3 (Stone et al., 2021).

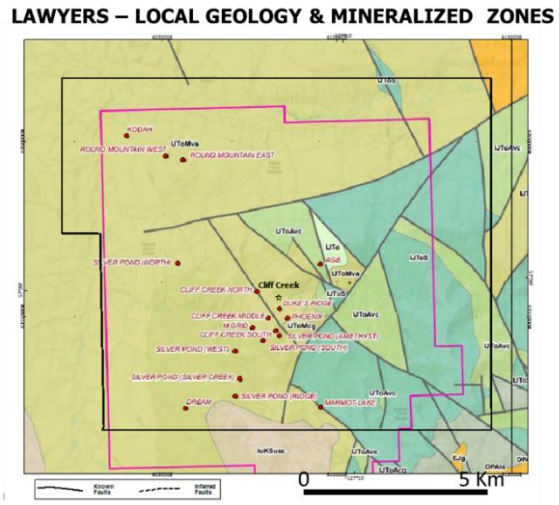

Figure 3: Lawyers Project local geology, mineral occurrences, and deposits, and known faults (modified after www.benchmarkmetals.com).

Method and Results

Helicopter TDEM, Magnetic and Radiometrics

In September 2018, Benchmark contracted Geotech Ltd. to complete a VTEM (Witherly et al., 2003) helicopter time-domain electromagnetic, magnetic and radiometric survey over the central and northern parts of the Lawyers property (Khaled et al., 2018). A total of 1,272 line-km was flown over a 115 km^2 area along 100 m spaced EW lines and 1 km spaced NS tie-lines. The VTEM Terrain system consisted of a 17.6m diameter, 4-turn transmitter loop (250k NIA @ 30Hz), a coincident-coplanar Z-component receiver (40ch 0.036-9.3ms), a caesium magnetometer, and RSX-5 spectrometer. The survey objectives were to map resistivity, magnetic susceptibility, and gamma radiation related to low to high sulphidation epithermal gold and silver targets in Lawyers camp.

The total field magnetic results (Figure 4) reveal a strong spatial relationship between sharp magnetic lineaments, magnetic lows, and the known mineralization. In order to quantify the structural elements, the magnetic data were

subjected to a structural complexity (SC) analysis, using the Geosoft CET (Centre for Exploration Targeting) grid analysis extension (www.seequent.com). The magnetic ridges shown in Figure 4 have been derived using the method described in Holden et al. (2012). The structural complexity highs are in the SW region concentrated with known Au-Ag occurrences.

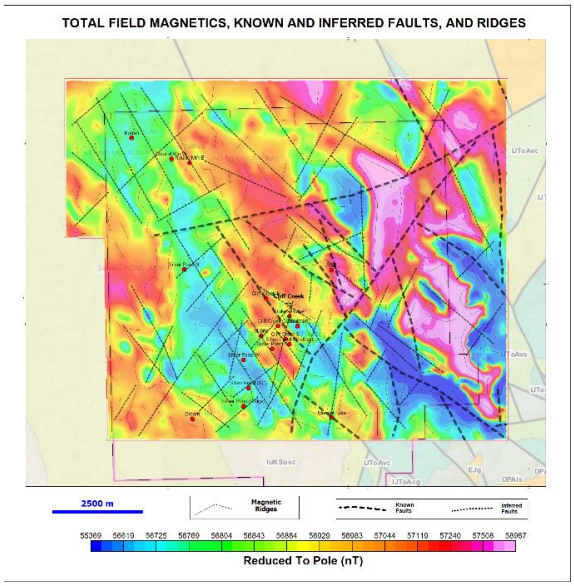

Figure 4: Total field magnetic intensity, over mineral occurrences & known/inferred faults (dashed lines), and magnetic ridges obtained from CET analysis.

Radiometric results show that the Lawyers Property mineralization is characterized by hydrothermal alteration resulting in potassium enrichment, commonly manifested as K/eTh highs (Figure 5).

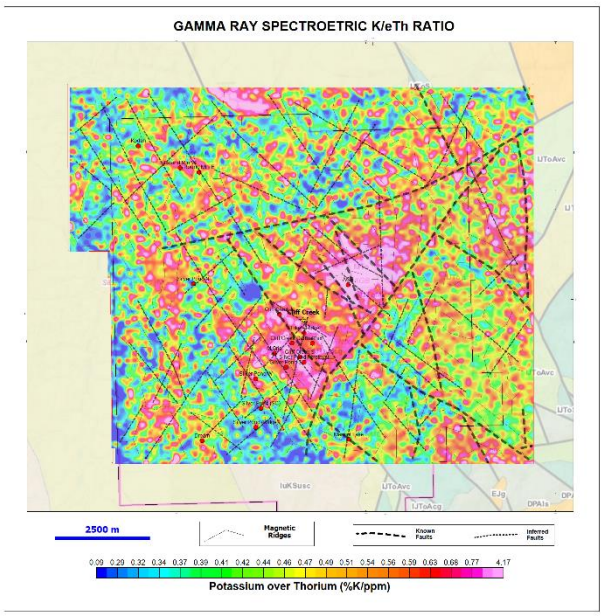

Figure 5: Gamma Ray Spectrometric K/eTh Ratio, over mineral occurrences & known/inferred faults (dashed lines), and magnetic ridges.

The VTEM dBz/dt EM decay constant map in Figure 6 includes the location of local EM anomalies centres represented by both large area and structural conductors. However, as shown, none of the EM anomalies making up conductive zones coincide with the known epithermal mineralization. Instead, all the known Au-Ag deposits and occurrences are located in zones of low TAU corresponding to high apparent resistivity (Figure 77a).

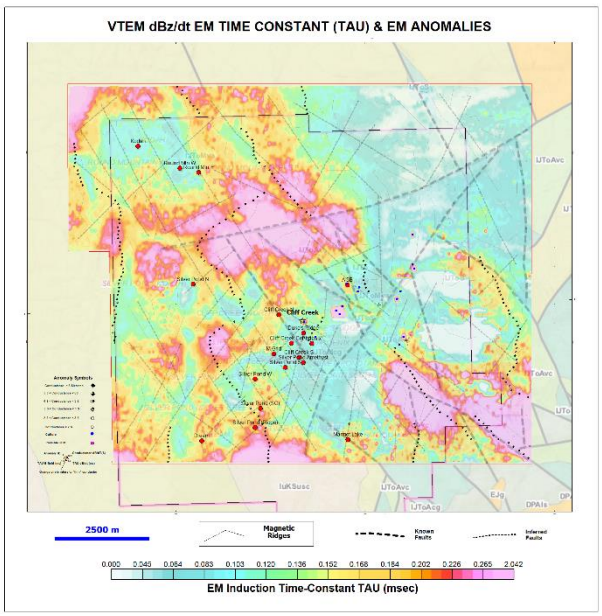

Figure 6: VTEM dBz/dt EM time constant TAU and EM anomaly picks, over mineral occurrences & known/inferred faults (dashed lines), and magnetic ridges.

VTEM AIIP and 1D Inversion Results

Layered Earth (LE) 1D inversions of the VTEM data were carried out using GALEI code. The VTEM data were analysed for AIP effects (Kratzer and Macnae, 2012) using the AIIP (airborne inductively induced polarization) mapping tool (Kwan et al., 2015, 2016, 2018). The 1D resistivity -100 m depth slice and the AIIP Cole-Cole apparent resistivity data are displayed in Figure 7a & 7b, respectively. The two resistivity maps are different because the 1D inversions do not account of AIIP effects in the VTEM data.

The AIIP mapping revealed that all the known Au-Ag mineralized zones coincide with moderate to high Cole-Cole time constant (TAU) anomalies in resistive zones that are consistent with relatively coarse-grained polarizable material, such as disseminated sulphides or hydrothermally altered clays. The product of the AIIP apparent resistivity and the Cole-Cole TAU (termed ResTau), presented in Figure 8, has proven to be a useful

parameter for identifying low sulphidation epithermal Au-Ag mineralization elsewhere on the property.

Mineral Targeting Epithermal Au-Ag Deposits

Previous targeting of VTEM results at Lawyers (Kwan et al., 2019; Legault et al., 2022) focused on individual analyses of magnetic, structural, radiometric, EM resistivity and AIIP results, then arriving at a targeting model, based on geologically and geophysically based considerations, resulting in five (5) priority targets. A new mineral targeting approach, based on recent examples of semi-automated, machine-learning (ML) assisted targeting (Kwan and Legault, 2023; Legault et al., 2023ab) has been tested for epithermal gold-silver using the Lawyers VTEM, magnetic and radiometric survey results.

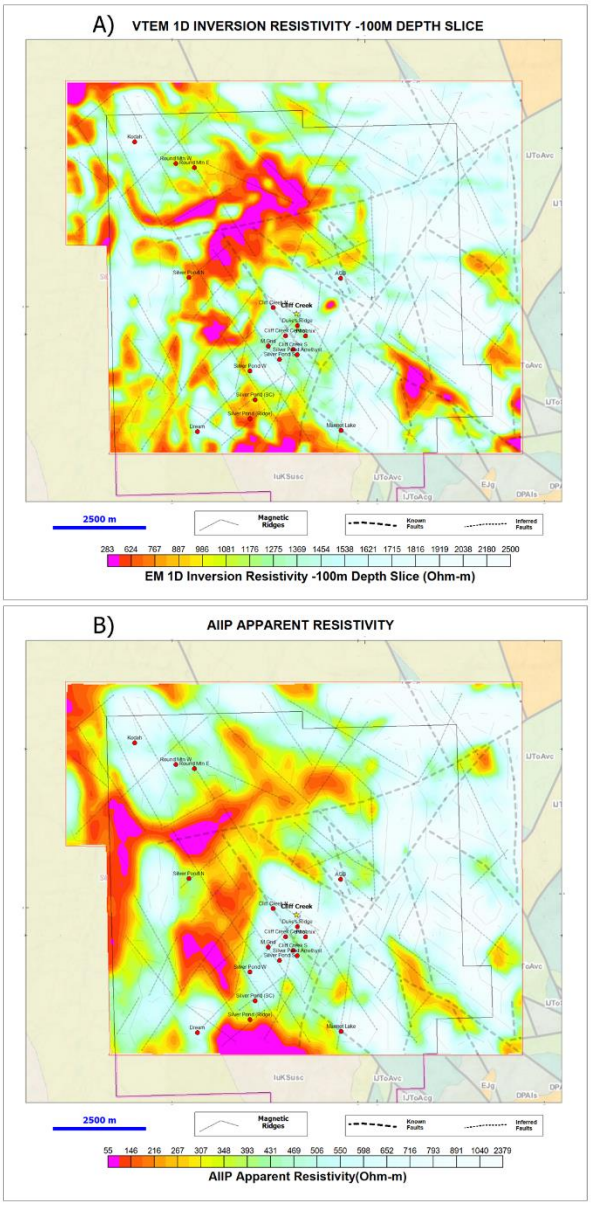

Figure 7: (A) VTEM 1D Inversion resistivity depth slice (-100m), and (B) AIIP Cole-Cole apparent resistivity, over mineral occurrences & known/inferred faults (dashed lines), and magnetic ridges.

The approach includes: 1) Structural Complexities (SC), 2) Self-Organizing Map (SOM) classifications, and 3) Supervised Deep Neural Network (SDNN) targeting of the geophysical data.

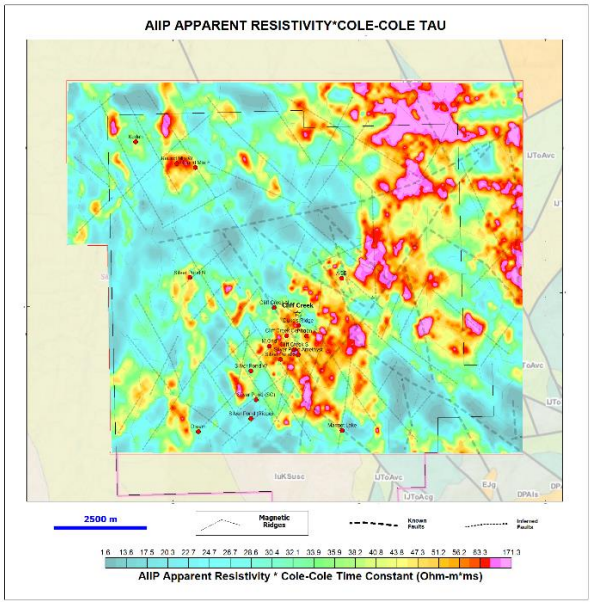

Figure 8: VTEM AIIP ResTau (Resistivity*Time Constant) Product, over mineral occurrences & known/inferred faults (dashed lines), and magnetic ridges.

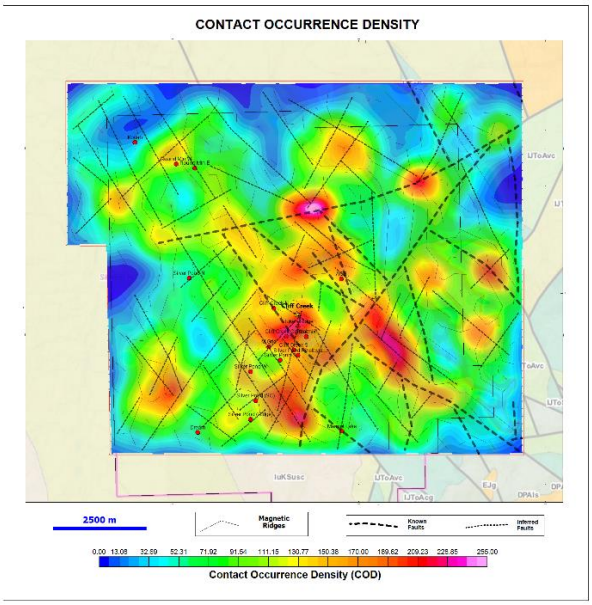

Figure 9: Structural complexity (SC) analysis of magnetic data, showing the Contact Occurrence Density (COD), over mineral occurrences &

known/inferred faults (dashed lines), and magnetic ridges.

As mentioned earlier, the RTP magnetic data have been analysed for structural complexity using the Geosoft CET grid analysis tool (Holden et al., 2012). The CET SC analysis tool outputs two parameters: i) the Contact Orientation Density (COD), and the Orientation Entropy (OE). Figure 9 presents the SC-derived COD image. As shown, the structural complexity highs are mainly found in the southcentral region that coincides with known Au-Ag occurrences.

Self-Organizing Maps (SOM) are a potent tool in analysing and classifying multiple datasets. The SC data, the K/eTh, and the AIIP apparent resistivity and Cole-Cole Tau products are classified using the Geosoft SOM GX tool (https://geosoftgxdev.atlassian.net). The SC data, the K/eTh, and the AIIP apparent resistivity and Cole-Cole Tau products are classified using SOM. Most of the anomalous SOM classes (9 to 17) coincide with the known Au-Ag mineralization in the SW and central regions of the Lawyers property (Figure 10).

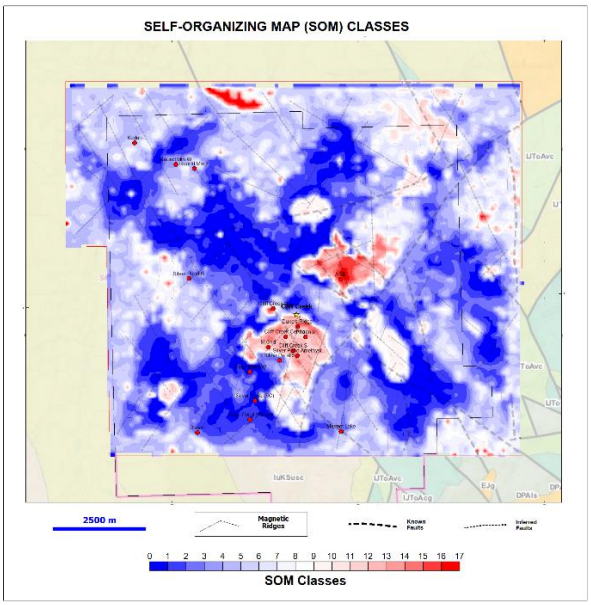

Figure 10: The anomalous SOM classes cover most of the known Au-Ag occurrences.

The final targeting preparation was done using the Google TensorFlow version TF 2.30 (https://www.tensorflow.org/) and its Supervised Deep Neural Network (SDNN) module. The training of the SDNN was performed using the SC, SOM, K/eTh, and AIIP apparent resistivity-tau product from an area with known Au-Ag deposit (Cliff Creek), Figure 11A. The top 6% probability is selected for Au-Ag targeting, Figure 11B.

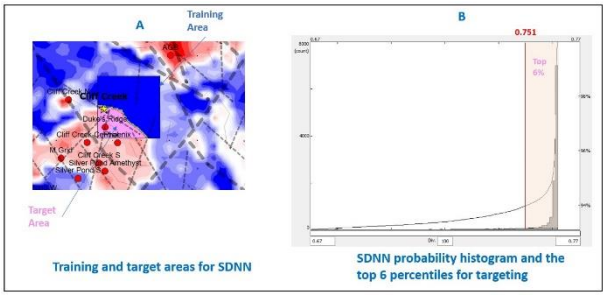

Figure 11: (A) Training area for SDNN, (B) top 6% target probability cut-off for targeting.

The top 6% targeting probabilities over the DEM data, and the selected targets, LET_1 to LET_3 are presented in Figure 12. The selected targets are in topographic highs and therefore unlikely to be overburden related.

CONCLUSION

Structural complexity analyses of the magnetic data at Lawyers Project have identified a strong spatial relationship between the known and inferred faults and calculated ridges and the known mineralization. Analyses of the EM results has shown that none of the observed conductive anomalies coincide with known epithermal Au-Ag showings. Instead, all the known mineral occurrences are located in zones of high resistivity. Gamma ray spectrometric results have shown that the known mineral occurrences are located in high to moderate K/eTh ratio anomalies. AIIP results at Lawyers Project suggest that the product of AIIP apparent resistivity and Cole-Cole time constant (Res*Tau) could be a useful targeting tool.

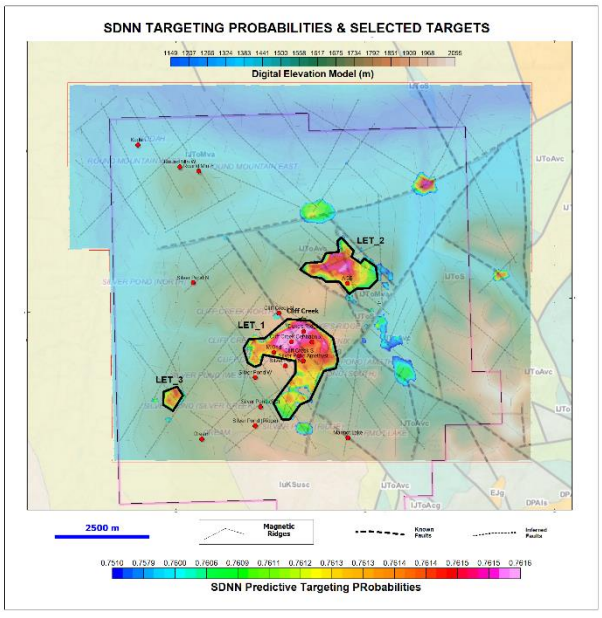

Figure 12: The SDNN top 6% probabilities over the DEM data and the selected potential epithermal Au-Ag targets.

Previous targeting of VTEM results at Lawyers (Kwan et al., 2019; Legault et al., 2022) focused on individual analyses of magnetic, structural, radiometric, EM resistivity and AIIP results, then arriving at a targeting model, based on geologically and geophysically based considerations, resulting in five (5) priority targets. A new approach for targeting, presented here, uses a semi-automated, machine-learning (ML) assisted approach that includes: Structural Complexities (SC), Self-Organizing Map (SOM) classifications, and Supervised Deep Neural Network (SDNN) targeting of the geophysical data.

Using SOM and SDNN results, the previous five (5) have been reduced to just three (3) priority targets, which include most of the known epithermal occurrences and include other areas for follow-up. It is also worth noting that the targeting of epithermal Au-Ag mineralization is done by a semi-automated processes which require little human intervention or bias. Importantly, the structural complexities, computed using known and inferred faults, also played a critical role in targeting.

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