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EM success in the Carajás – Geophysical results of the Jaguar Nickel Deposit, Brazil

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SUMMARY

The Jaguar Nickel Project, located in the Carajas Mineral Province of Brazil, is current classed as a hydrothermal Iron-Oxide Nickel Copper (IONC) deposit with a current resource estimate of 108MT @ 0.87% Ni (Nov 2022). The deposit was discovered in 2007 by Vale S.A. during regional exploration for Ni through geochemical follow up on coincident magnetic and GeoTEM anomalies.

The Jaguar Deposit is rare amongst Hydrothermal sulphide deposits, where nickel is not normally the abundant mineral in these mineral systems. This benefits the use of electromagnetics, with mineralisation located within brittle-ductile structures hosted by felsic subvolcanic and granitic rocks, and not typical magmatic type or associated with black shales. Electromagnetic conductors nearly always directly relate to nickel mineralisation

Centaurus Metals Limited, taking over the project in 2019, initiated a review of historic geophysical data including surface and downhole electromagnetic data previously acquired by Vale between 2006 and 2010. This remodelling and interpretation of the EM data identified strong correlation between known nickel intercepts from drilling and aligning with interpreted structural controls. The improvement in the interpretation gave Centaurus confidence in the technique as a direct sulphide detection method and was hence used as a primary tool in the company's initial exploration strategy

Key words: Electromagnetics, Nickel, Jaguar, EM modelling, case study.

INTRODUCTION

The Jaguar Hydrothermal Nickel Sulphide project, located in the Carajás region of Brazil, was discovered in 2007 by Vale S.A. through systematic exploration lead by analysis of coincident magnetic and electromagnetic signatures. Jaguar represents a rare deposit style, being a Nickel-rich end member of hydrothermal deposits and not directly related to ultramafic rocks. These deposits are rare due to the low solubility of Ni sulphides proven to be the driving mechanism in forming the deposits.

The geophysical signatures and unique geological setting of the deposit makes for an excellent target for electrical geophysics, particularly EM, where both cover and host rocks are devoid of significant conductive response leaving sulphides as the dominant source of EM anomalies.

The most recent JORC (Nov 2022) indicated and measured resource of 108MT @ 0.87% Ni from a cumulative of nine (9) separate deposits over the Jaguar project (Centaurus, 2022).

GEOLOGIC BACKGROUND AND DEPOSIT MODEL

The Jaguar Project is located in the western Carajás region of Brazil, which locally hosts two world class nearby deposits in the banded iron formation of the Serra Arqueada Iron deposit, and the ultramafic hosted lateritic Nickel deposit within the Serra do Puma Complex (Figure 1), both expressed with coincident strong magnetic anomalies.

The current geologic model is that Jaguar is classed as a Hydrothermal Nickel Sulphide Deposit and with links to a potential IOCG subclass. The deposits are considered rare due to its magmatic-hydrothermal origin with high nickel tenor and not directly associated with ultramafic rocks. Suggestions are that the deposits of the Carajás developed from hydrothermal fluid leeching from deeper mafic-ultramafic sources (Filho, 2021).

The Jaguar deposits are structurally controlled along two regional scale faults in the W-NW trending Canaã Fault and the WSW trending McCandless Fault (Figure 2). Deposits are sub-vertical with varying mineral concentrations which are reflected in differing measured EM conductance between the deposits. The project is split into several individual deposits along two main trends, the Jaguar trend and the Onca trend, both containing significant individual deposits in Jaguar South and Onca Preta respectively. Both deposits currently have known mineralisation to at least 500 m depth extent and remain open.

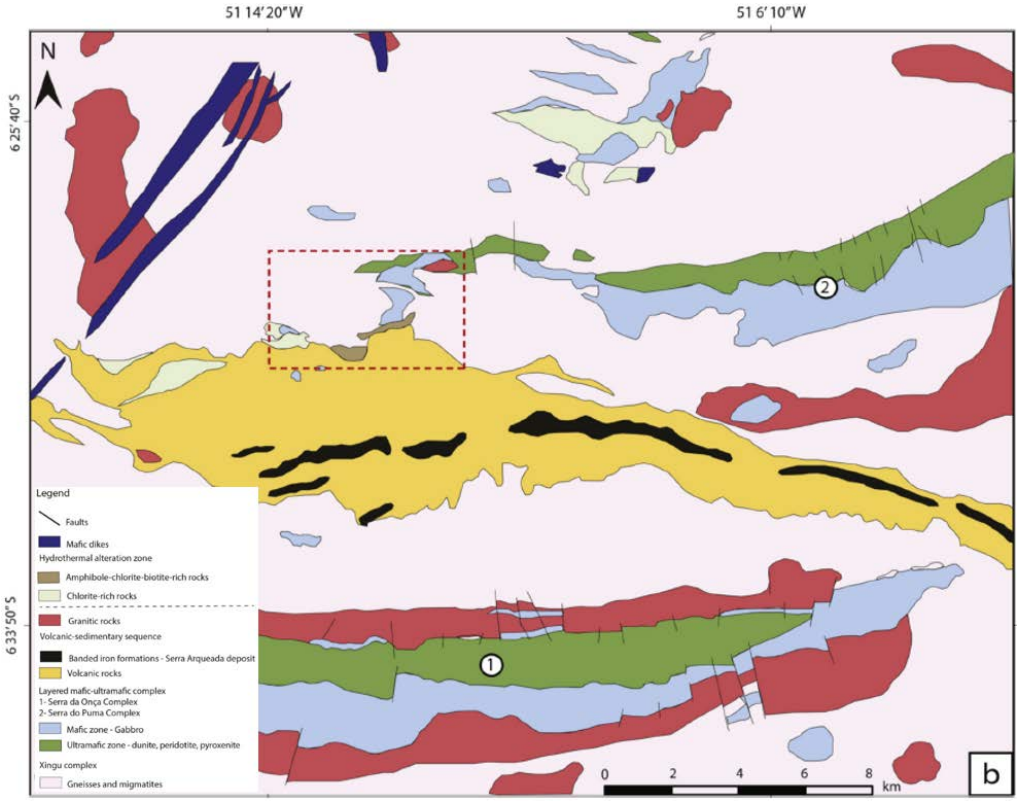

Figure 1. Simplified regional geology showing location of Jaguar Project with Puma and Onca UM complexes and Serra Arqueada BIF (after Filho et al 2021)

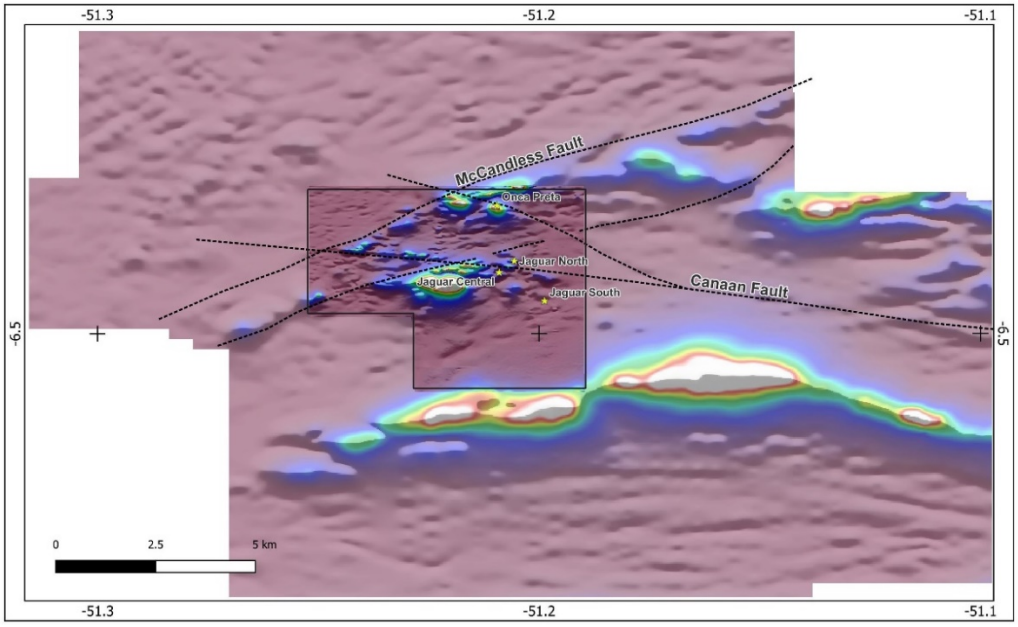

Figure 2. Jaguar Project showing major controlling faults and main deposits over Analytic Singal magnetic image. Strongly magnetised Serra Aqueada BIF to south of Canaã Fault.

DISCOVERY HISTORY

Original holders of the project, Vale S.A., undertook a regional airborne magnetic and radiometric surveys in the area back in the late 1990's, identifying smaller magnetic features with associated discrete U and K anomalies between the two known strongly magnetic Ultramafic of the Puma complex to the north and BIFs associated with Serra Arqueada to the south. A follow up GeoTEM survey in early 2000's identified moderate to strong conductivity anomalies associated with these magnetic anomalies.

A 2005 soil geochemistry survey targeting Ni-Cu-PGE identified significant Ni geochemical anomalies within felsic domains and disconnected from the Puma ultramafic complex. The first hole drilled in 2006, PKC-JAGU-FD003, targeted the Jaguar North deposit and while it did intercept the mineralised structure, did not intercept significant mineralisation.

Additional ground IP and EM was conducted along 2D profiles to better define targets followed by a second drill campaign in 2007 consisting of twelve holes, confirming the presence of Ni mineralisation with high grade areas showing a mineralised corridor up to 2000 m between Jaguar South and Jaguar West.

Early surface EM carried out by Vale S.A. over the project area used a pseudo fixed-loop reconnaissance configuration where adjoining 400 x 400 m loops were surveyed with a single north/south orientated traverse central to the loop. Data were acquired at 40 m stations, effecting 400 m spaced ground EM over the majority of the project. Surveying utilised a coil sensor at 30 Hz with follow up at 3 Hz where late-time responses were observed. Down-hole EM surveying was conducted on select holes spread throughout the project deposits.

Vale S.A. drilled 170 holes at the project between 2006 and 2010 and completed DHEM on 33 of these. After an infill drill campaign between 2008 and 2010 an initial non-JORC resource of 40.4 Mt @ 0.78 % Ni (0.5 % Ni cutoff) was defined.

CURRENT EXPLORATION

In 2019 Centaurus Metals sign an option agreement to acquire the Jaguar Nickel Project from Vale S.A. Priority initially was to review the existing data focusing on the EM. Due to the benefit of having the entire historical EM database from the project, a review of the DHEM data radically advanced the understanding of mineralised structures, forming an excellent agreement with the early-stage geological interpretation.

Electromagnetics

Centaurus identified early on the need to have a continual EM presence on site to parallel with their intended drilling campaign. A coil EM system capable of surface and down-hole EM was delivered to site in early 2020 with training provided to Centaurus personnel to independently conduct surveys. This occurred immediately prior to COVID and with impending issues with the system providing inconsistent data becoming apparent, a decision to replace with a B-field EMIT DigiAtlantis system occurred in mid-2021. To date, well over 100 DHEM surveys have been completed since early 2020, helping to define depth extents of deposits (Figure 3) and assist brownfields exploration targeting.

EM loop design was conducted to couple with modelled conductor plates from historic remodelling and recent results, and where available, utilised existing tracks to increase productivity on site. This translated into surface FLEM traverses aligned north/south only, even when mineralised trends indicated otherwise. The use of a three-component receiver, gridded representation of EM channel times and the use of multi-line conductor plate modelling, meant this did not cause any adverse effects on conductor targeting (Figure 4).

In mid-2022, an opportunity to fly the project with a modern airborne EM system was presented. A HeliTEM survey was flown at 50 m spaced north-south traverses using a 30 Hz base frequency providing a significant update from the GeoTEM data along with an updated airborne magnetic data set.

Induced Polarisation

Re-processing of conventional Dipole-dipole IP, completed by Vale S.A. using an A-spacing of 80 m, recording to N=8, and on 200 m spaced N/S traverses over the main mineralised zones was undertaken. The data showed good basement penetration helped by minimal conductive cover. Resistivity results from the IP showed interpreted basement structures are coincident with resistivity lows, while the chargeability highs were closely related with resistivity lows and identified sulphide zones (Figure 5). The IP configuration used did not have significant depth penetration, however showed mineralisation was both conductive and chargeable.

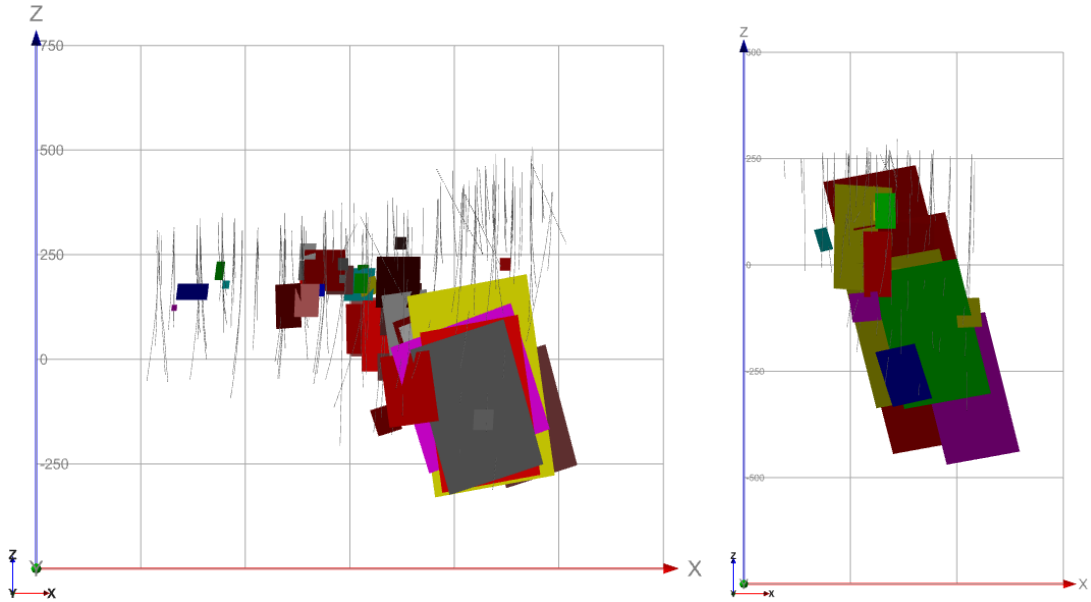

Figure 3. Long section of Jaguar South (LHS) and Onca Preta (RHS) modelled DHEM plates showing current drill coverage.

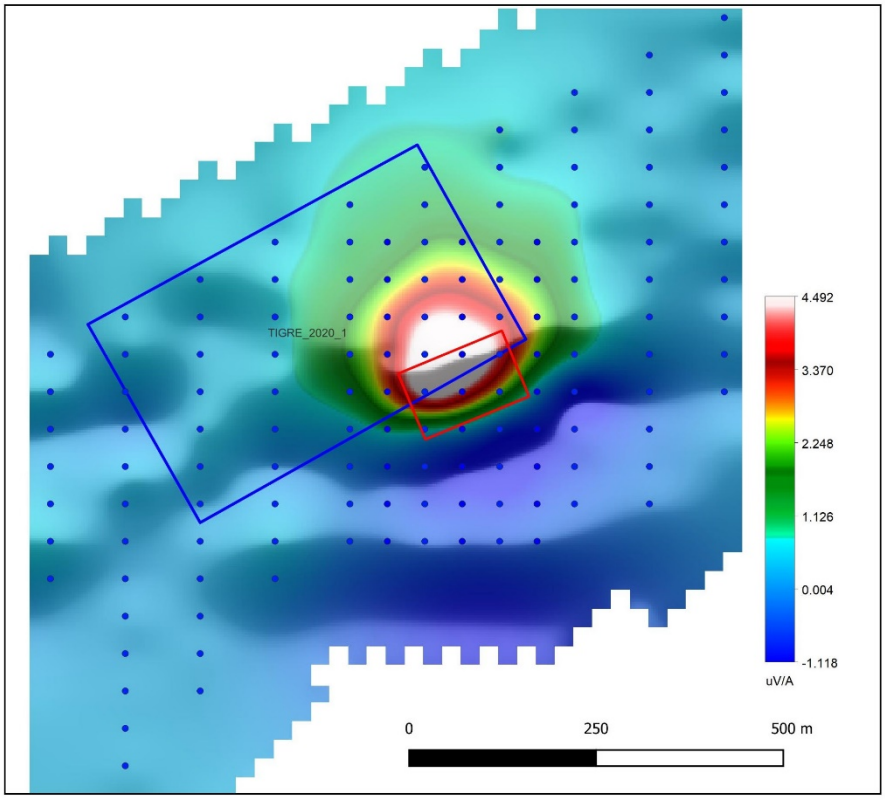

Figure 4. Example of FLEM loop and traverse design over Tigre prospect showing 100 m and 50 m N/S spaced traverses defining a mid-time gridded anomaly modelled with the red conductor plate.

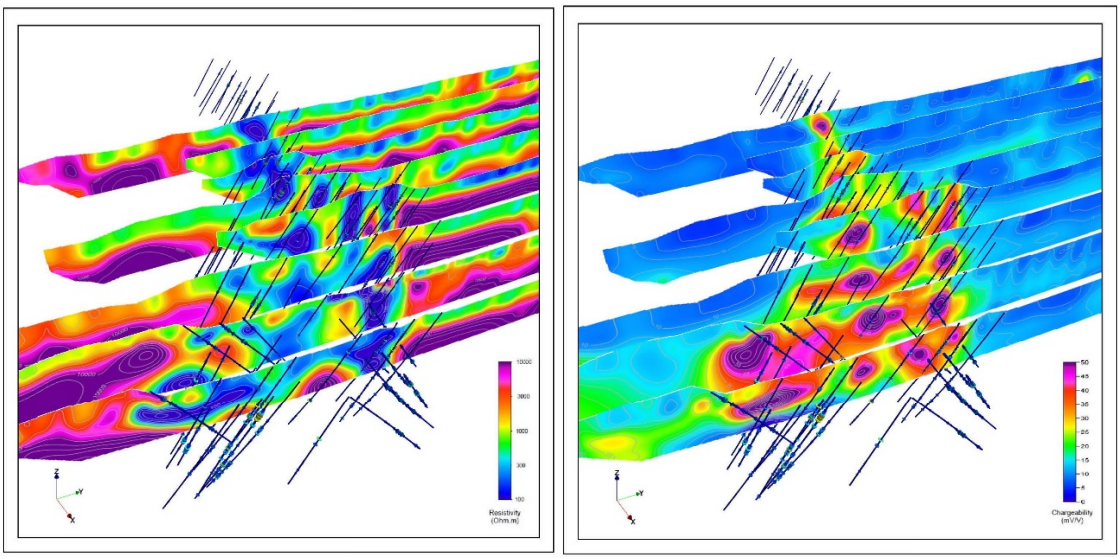

Figure 5. Selection of Jaguar Central 2D IP traverses showing coincidence of resistivity lows, chargeable highs and mineralisation.

CONCLUSIONS

The Jaguar Hydrothermal Nickel Project offers a unique platform for accurate sulphide targeting using EM with the location characteristic of a resistive cover and lack of other conductive basement sources.

Through careful and independent remodelling of historic surface and borehole EM data, conductors have shown to be consistent with updated geologic interpretation of the Jaguar deposits. The application of a modern B-field EM system using in-house personnel continues to allow confident drill targeting several hundred metres offset from existing drilling.

Recent results have shown the project to have significant brownfields potential with the majority of deposits open in several directions, particularly at depth where mineral systems in the Carajás historically have deep plumbing.

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