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The Jurema Mafic-Ultramafic Complex: discovery of a Fe-Ti ± V ± Co mineralized body at Betânia, State of Pernambuco, Brazil, Transversal Zone, Borborema Province

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Abstract

The Transversal Zone of the Borborema Province (BP) stands out for the occurrence of mineralized mafic-ultramafic complexes and the so called Floresta Titaniferous District. This short paper deals with the discovery of a mafic-ultramafic complex, the Jurema Complex (CMUJ), and presents preliminary geological, geophysical and geochemical results. The discovery, located in Betânia, State of Pernambuco, is a consequence of integration of several remote sensor data conducted in the westernmost portion of the Alto Moxotó Terrane of the BP. The Jurema Mafic-Ultramafic Complex crops out as a 2.5 x 0.6 km ellipsoidal, zoned/stratiform mafic-ultramafic intrusion with possible concealed lateral extension of at least 6 km to ESE, according to geophysical modelling. From core to rim, the intrusion shows igneous zoning of metaperidotite, cumulatic metapyroxenite, garnet-metagabbro and metahornblendite. Massive Fe-Ti oxide occurrences were found dispersed all over the complex. Fe-Ti oxide mineralization is composed of polygonal massive clusters of martitized magnetite and ilmenite occurring in similar modal proportions. First analyses performed using portable X-ray fluorescence yielded Fe (52.89-52.02%), Ti (10.65-9.80%), V (0.36-0.33%) and Co (0.38-0.29%) contents. The discovery and the preliminary characterization of the CMUJ expand the prospective area of the Floresta Titaniferous District into a kilometric-scale linear belt.

Keywords: Mafic-ultramafic complexes; Titanium; Vanadium; Cobalt.

INTRODUCTION

This work reports the confirmation of the new occurrence of a mafic-ultramafic body mineralized in Fe-Ti ± V ± Co, named Jurema Mafic-Ultramafic Complex (JMUC), among other potential anomalies selected by the Novas Fronteiras: Alto Moxotó Project, carried out by the Regional Superintendence of Recife (Pernambuco State) of the Geological Survey of Brazil – CPRM. The mineralized body is located in the Betânia municipality, State of Pernambuco, nearby Jurema locality. The center of the body has coordinates 8°25’51’’ of latitude S and 37°59’43’’ of longitude W, and is cut by the Mandacaru creek.

Economic occurrences, mines and deposits of ferro-titanium ore similar to the described here are known at the Floresta mining district since the 1980 decade (Lima et al., 1985; Beurlen et al., 1992).

Among these, the Riacho da Posse deposit, containing 54 Mt with 13% Ti, is under development at the Floresta region, Pernambuco, by the Grupo Tavares de Melo company, with perspective to initiate the operations in 2019.

TECTONIC-GEOLOGICAL SETTING

The JMUC is inserted in the Transversal Zone Domain of the Borborema Province (Sá, 1994), at the limit between the Alto Moxotó and Alto Pajeú Terranes (e.g., Paiva, 1997) (Figure 1).

The Alto Moxotó Terrane comprises Rhyacian to Orosirian supracrustal (Sertânia Complex) and orthoderived (Floresta Complex) rocks, in addition to Calymmian anorogenic plutonism (Santos, 1999). In the Alto Pajeú Terrane, Tonian supracrustal (São Caetano Complex) and metagranitoid (Recanto – Riacho do Forno Suite) rocks predominate, in addition to Brasiliano-aged (830-480 Ma) granitoids (Santos, 1999). In this domain, the mafic-ultramafic Serrote das Pedras Pretas Suite (Veronese et al., 1985) predominate. The suite is composed of metaperidotite, cumulate metapyroxenite, garnet-bearing gabbro, and amphibolite, which host Fe-Ti and Ni-Cu mineralizations (Beurlen et al., 1992; Lages & Dantas, 2016).

LOCAL GEOLOGY

The massive Fe-Ti occurrence of the JMUC is hosted by metaperidotites, metagabbros (with or without garnet), metapyroxenites and metahornblendites, which are remarkably similar to the mafic-ultramafic rocks from the Serrote das Pedras Pretas Suite of the Floresta municipality (Pernambuco State) occurrences.

The JMUC was emplaced within supracrustal rocks (garnet-muscovite schists) of the São Caetano Complex. In this area, Tonian intrusive rocks (Recanto – Riacho do Forno Suite) and Brasiliano-aged (830-480 Ma) granitoids also occur, and they are concordant to the ESE-WNW structural trend, dipping to NE (Figure 2).

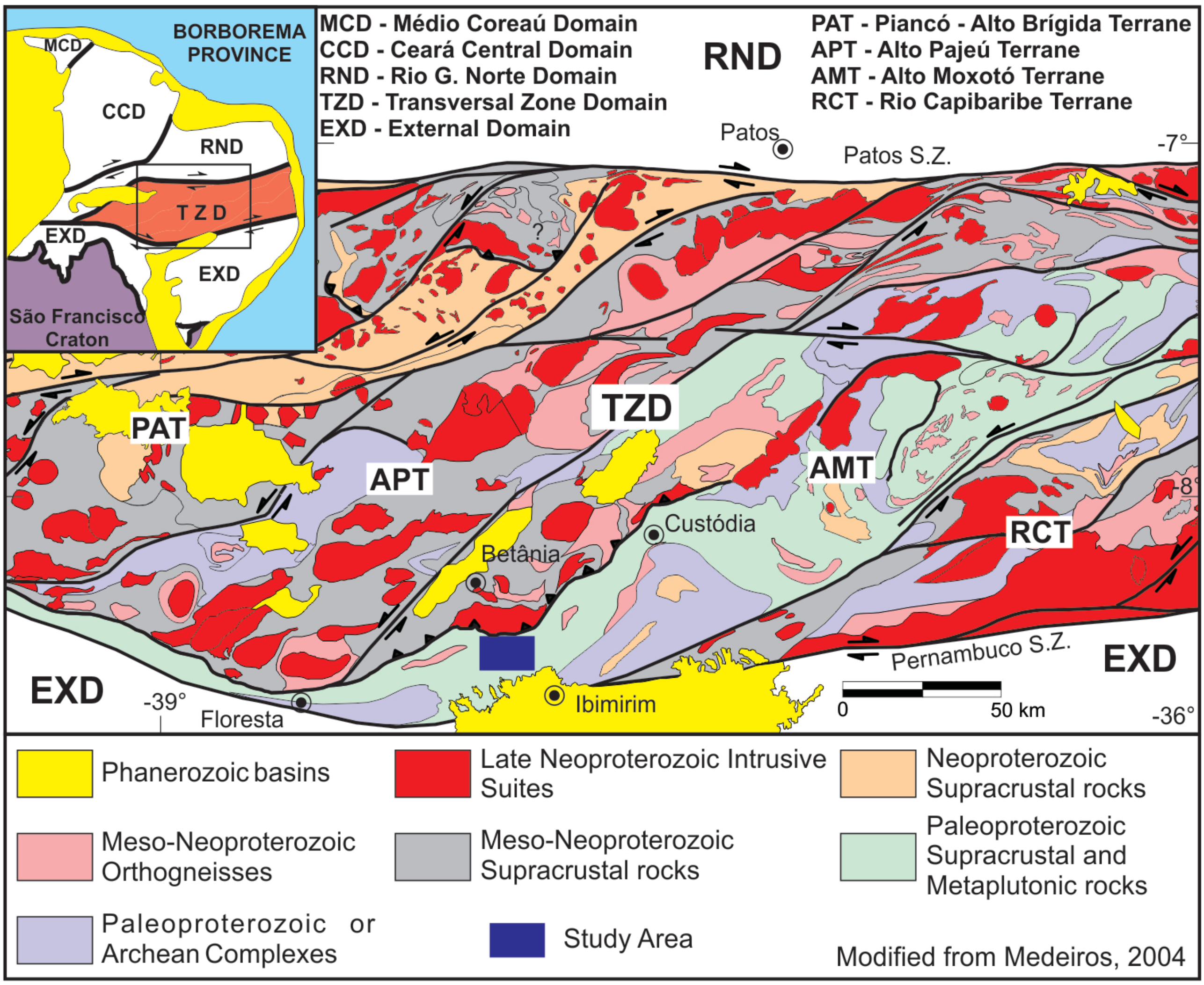

Figure 1: *Simplified geotectonic setting of the Transversal Zone (TZD) indicating approximate limits of the Alto Moxotó (AMT) and Alto Pajeú (APT) Terranes/Domains, and study area location; modified from Medeiros (2004).*

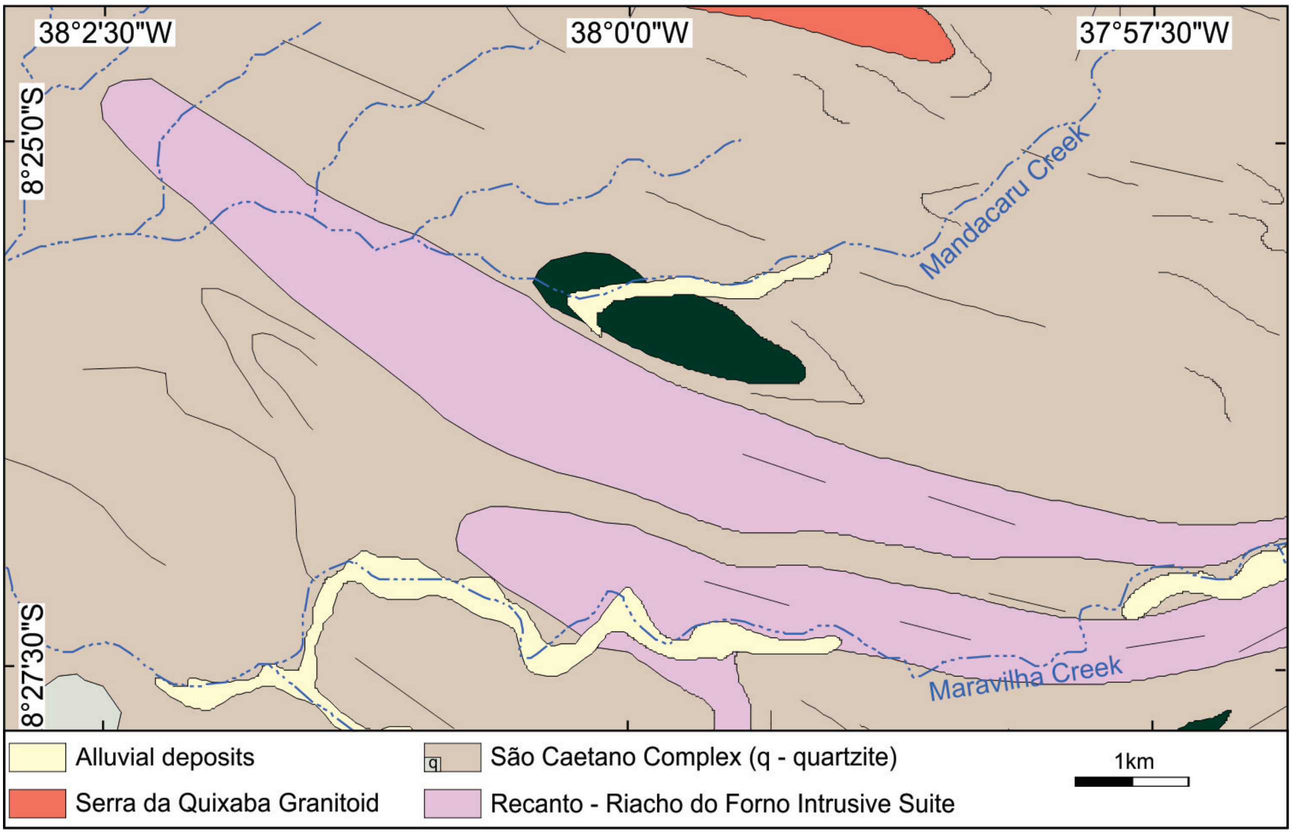

Figure 2: *Simplified geological map of the Jurema Mafic-Ultramafic Complex (JMUC) occurrence area with location of the mineralized outcrop (FJ-064 station).*

REMOTE SENSORS AND AEROGEOPHYSICS

In order to identify target areas with potential for Fe-Ti mineralization, magnetometric and gamaspectrometric data of Pernambuco – Paraiba Aerogeophysical Project by CPRM – Geological Survey of Brazil, and orbital optical remote sensing from Operational Land Imager (OLI) sensor images of the Landsat-8 satellite were used.

In the RGB color composition image of the spectral bands 6, 5 and 3 of the Landsat-8/OLI sensor, centered respectively on wavelengths of 1.61 µm, 0.865 µm and 0.483 µm (Figure 3), it was possible to identify a strong contrast between the ultramafic rocks signature and that of their host rocks.

From the K, eTh and eU gamma spectrometric data (Figure 4A), the RGB ternary composition map shows low radioactive content, highlighted by black color in the outcropping area of the rocks (dashed line on Figure 4A). These rocks show correlation with analytical signal amplitude anomalies of the anomalous magnetic field, having elongation to ESE-WNW, with average wavelength of 800 m and intensity ≤ 0.40 nT/m (Figure 4B). The 3D Euler modeling of these anomalies, using structural index equal to 2, indicated continuation of the body in subsurface for ~6 km to ESE (Figure 4C).

OCCURRENCE DESCRIPTION

The JMUC can be distinguished at surface by soil color contrast, which defines the body limit relative to its wall rocks (Figure 5). The body has elliptical shape and outcropping extension of ~2.5 x 0.6 km (Figure 6), it is metamorphosed and deformed, showing foliation with N70°W/50°NE strike, which is concordant with the wall rocks trend. In the field, loose blocks of coarse-grained metahornblendite predominate at the margins, grading towards the intermediate portion to dispersed blocks of metagabbro and garnet-bearing metagabbro (Figure 6A), with garnet + quartz symplectites. This distribution apparently represents a compositional zoning, but a stratiform geometry cannot be discarded.

In the transition to the central part of the body, sub-angular blocks of metapyroxenite with intercumulus plagioclase (Figure 6B) crop out. In the center of the body occur altered metaperidotite blocks (Figure 6C).

The ilmenite-magnetitite occurs along the entire body, predominantly in its intermediate and central portions, as centimetric, subangular and sub-rounded loose blocks, dispersed on the soil, presenting low magnetic susceptibility (Figure 7).

PETROGRAPHY

Under the microscope, metahornblendite minerals have plane contacts, with x-shaped texture. Amphibole crystals are prismatic, elongated, with sizes varying between 2 and 10 mm. Several hornblende crystals are twinned, indicating preserved igneous texture (Figure 8A). At the rims of some crystals occur quartz and rutile.

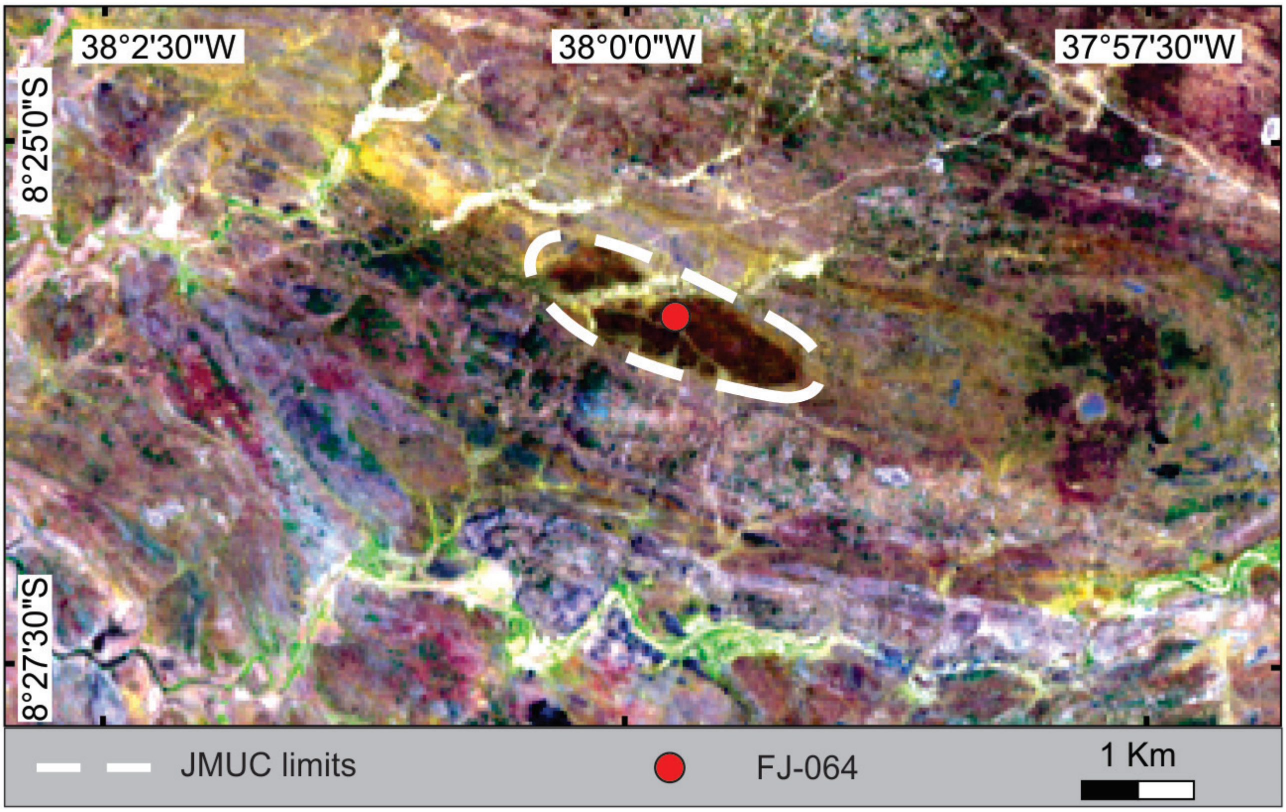

Figure 3: *R6G5B2 composition Landsat-8/OLI image with linear contrast magnification of the JMUC outcropping area.*

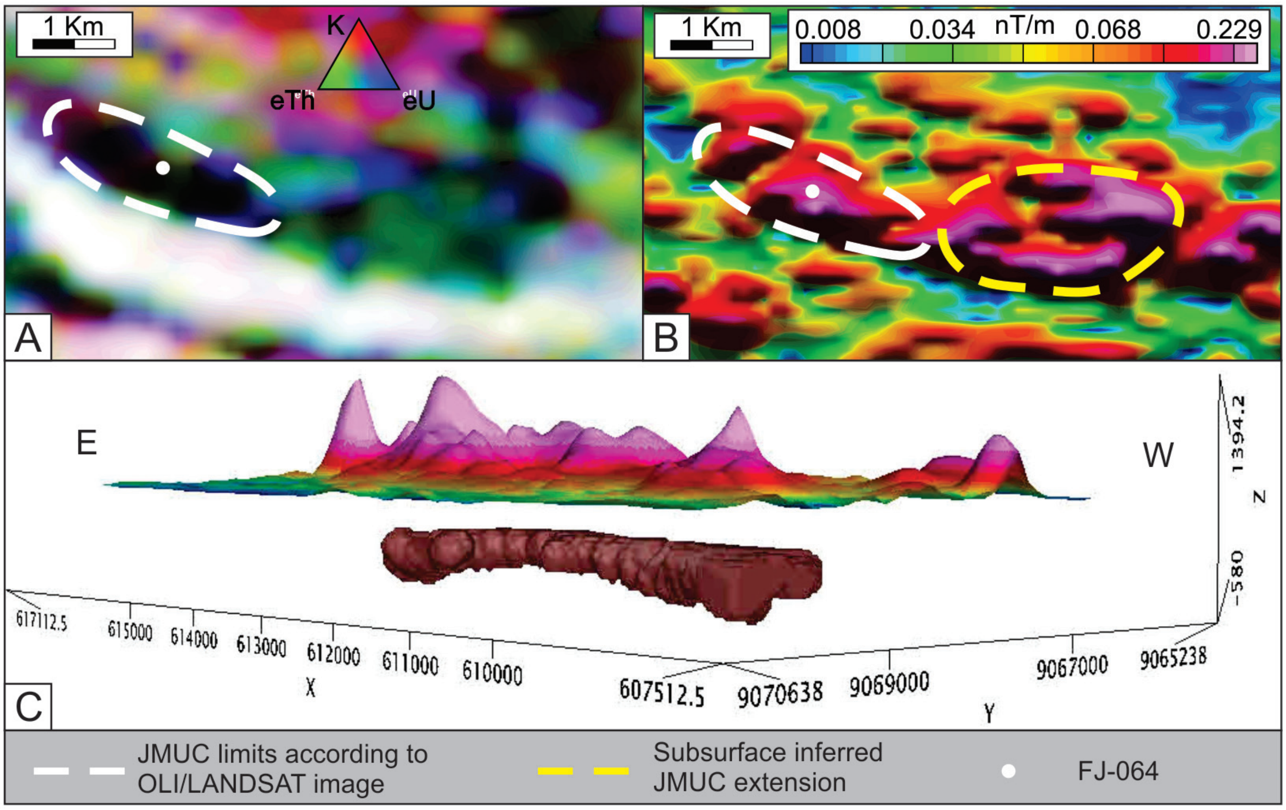

Figure 4: *Geophysical products. A) RGB ternary composition of gamma spectrometric data (K, eTh and eU) showing the body low radiation (black color); B) Analytical signal amplitude anomalies, showing an anomaly prolongation outside the outcropping area toward ESE; C) 3D Euler modeling indicating body extension, at subsurface, around 6 km.*

Figure 5*: Contrast between altered soils: JMUC (dark brown in color) and its wall rock (light brown in color).*

Figure 6*: Lithotypes composing JMUC. A) Garnet-metagabbro with garnet + quartz symplectite (sample FJ-064C); B) Metapyroxenite with intercumulus plagioclase (sample FJ-064B); C) Anthophyllite metaperidotite occurring in the body center (sample FJ-064A).*

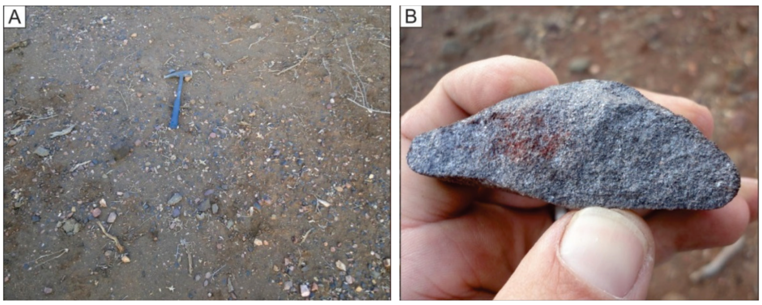

Figure 7*: Massive ilmenite-magnetitite (sample FJ-064D). A) Ilmenite-magnetitite pebbles and blocks dispersed at surface; B) Detail of one of the fragments with massive texture.*

The (garnet) metagabbro and cumulate metapyroxenite show textures related to high grade metamorphism, as the corona symplectite texture of pyroxene + amphibole + epidote + quartz (Figures 8B, 8C and 8D).

The metaperidotite shows a rare assemblage composed of anthophyllite + cordierite-like mineral (Figure 9A). Olivine occurs as pseudomorphs of serpentine + talc + opaque mineral (Figure 9B).

The mineralized rock (FJ-064D sample) is formed by polygonal array of magnetite and ilmenite. The mineral contacts are plane and in triple junctions, and form a magnetite + ilmenite mosaic (Figure 10A). Accessory minerals, such as other spinel type, occur in interstices. Magnetite is almost completely martitized, while ilmenite is limpid, with small lamellas of hematite exsolution only in one of the growth planes (Figure 10B).

CHEMICAL ANALYSES

Punctual analyses by X-Ray Fluorescence (XRF) were performed in the massive ilmenite-magnetitite, using portable equipment (Olympus Delta X Professional model). One sample was powdered, sieved to 200# and homogenized, yielding similar result to that obtained by in situ outcrop analysis for the same group of elements (Table 1). The contents obtained were: 52.89 – 52.02% Fe; 10.65 – 9.8% Ti; 3629 – 3281 ppm V and 3848 – 2933 ppm Co.

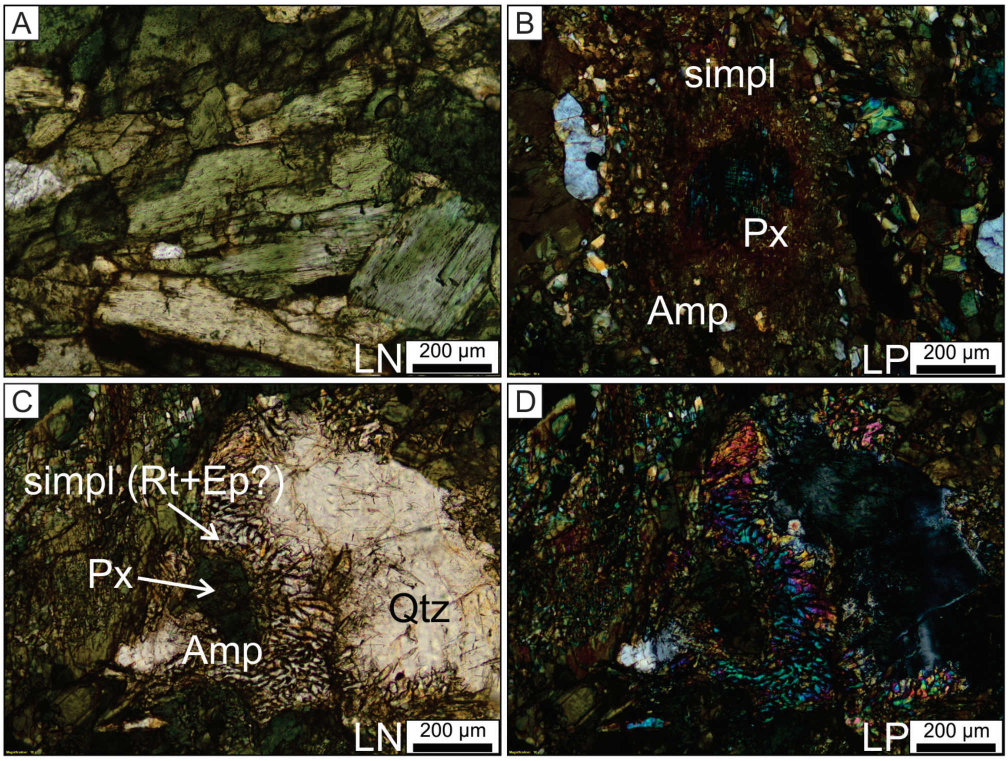

Figure 8: Photomicrographs from JMUC mafic and ultramafic varieties. A) Prismatic, X-shaped hornblende crystals in metahornblendite with preserved faces and twinning; B, C and D) Corona textures denoted by cores of pyroxene (Px) + amphibole (Amp) plus symplectite intergrowths of rutile (Rt) + epidote with high birefringence (Ep) and quartz on rims (Qtz). LN = Natural light; LP = Polarized light.

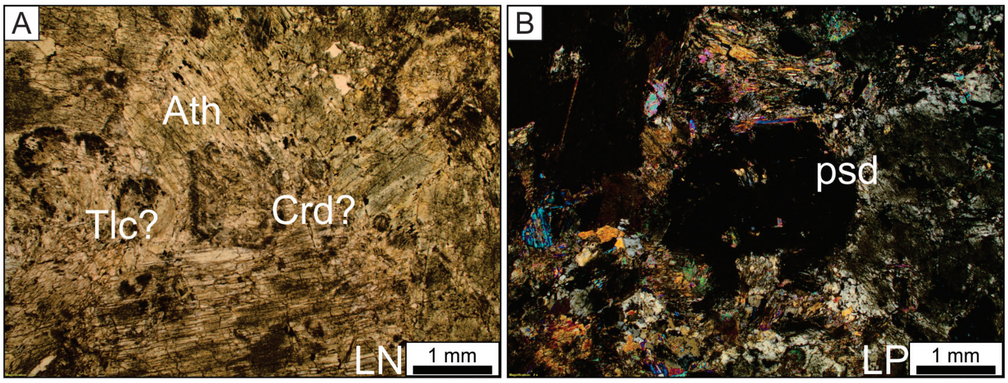

Figure 9: *JMUC metaperidotite photomicrographs. A) Peridotite metasomatic assemblage with talc (Tlc) + anthophyllite (Ath) and probable cordierite (Crd); B) Olivine pseudomorph under extinction position (psd) in altered serpentinite. LN = Natural light; LP = Polarized light.*

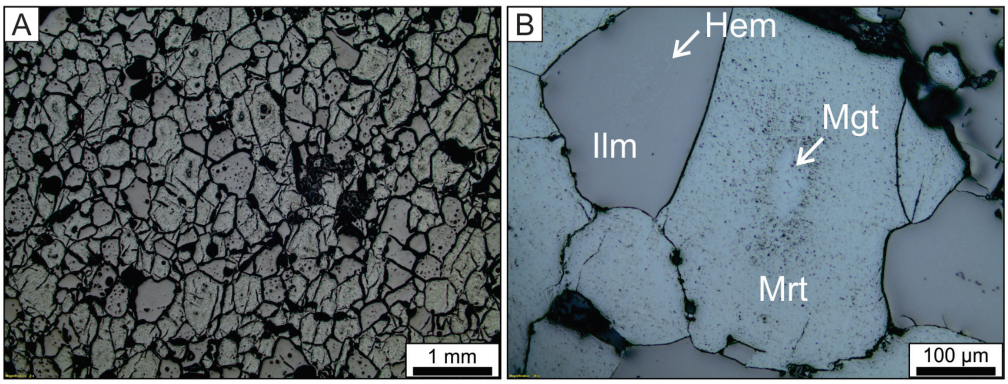

Figure 10: Massive ilmenite-magnetitite polished section (sample FJ-064D) under reflected light. A) Granular polygonal mosaic of martitized magnetite + ilmenite with similar modal proportions; B) Detail of magnetite (Mgt) almost all transformed into martite (Mrt) and ilmenite (Ilm) grains with very fine lamellae of hematite (Hem) exsolution.

Table 1: *Ilmenite-magnetitite (sample FJ-064D) chemical analysis by portable XRF. Values in %*

	P	Al	Si	S	**Ti**	**V**	Cr	Mn	**Fe**	**Co**
Pulverized Sample 200#	0.87	1.37	7.07	ND	**9.8**	**0.3629**	0.1375	0.179	**52.02**	**0.2933**
***In natura* Sample**	ND	6.15	19.37	ND	**10.65**	**0.3281**	0.2082	0.1453	**52.89**	**0.3848**

ND: not determined

Lages & Dantas (2016) analysed, by ICP-MS and XRF, massive Fe-Ti ore samples from several mines and deposits of the Serrote das Pedras Pretas Suite, in Floresta (Pernambuco State) region. The obtained values were up to 26.5% Ti, 53.7% Fe, and 3600 ppm V. The authors identified cobalt-vanadiferous magnetite, with V contents two times higher than those found in ilmenite.

FINAL CONSIDERATIONS

The discovery of a mafic-ultramafic body containing Fe-Ti ± V ± Co, ~70 km east of the deposits from Floresta Titaniferous District (e.g., Riacho da Posse Deposit, Serrote das Pedras Pretas Mine, and ~20 occurrences and prospects), opens a new frontier (greenfield) for Fe-Ti deposits prospection, since the mafic-ultramafic body shows petrographic characteristics similar to those presented by the Floresta mining district.

The characterization of the Jurema body indicates a continuous trend of mafic-ultramafic bodies of the Serrote das Pedras Pretas-type along a kilometric-scale linear belt.

According to the magnetometric data, the body shows considerable non outcropping extension, amplifying the potential to the discovery of new mineralized zones. The low contents evidenced by XRF analyses can be related to the portable method limitations. Results by ICP-MS are pending and can reveal values greater than those obtained here.

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