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New Cu-Pb occurrence in gossan and hydrothermal breccias in the Nova Brasilândia Group, Rondônia State, Brazil: preliminary results, perspectives and interpretations

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Abstract

Copper- and lead-bearing breccia and gossan were found at the outskirts of Rolim de Moura town, southeastern Rondonia State, Brazil, during geological mapping. Gossans and hydrothermal breccias are hosted by the paragneisses of Nova Brasilândia Group, which, at the studied area, is composed of banded iron formation, sillimanite-biotite-muscovite gneiss, metagabbro and metatonalite, deformed and metamorphosed during the Sunsás orogeny. The hydrothermal system consists of strongly oxidized massif sulfide zones (gossans), iron oxide veinlets and stockworks, silicate breccia and quartz veins. Hydrothermal alteration was mapped continuously along a 2.5 km ESE-WNW trend. ICP OES/ICP MS chemical analyses returned values up to 1668 ppm Cu and 46.9 ppm Pb in whole-rock gossan powders. Portable XRF results yielded copper, lead and zinc grades up to 800 ppm Cu, 720 ppm Pb and 150 ppm Zn in whole-rock gossan powders. Programmed petrographic, SEM, XRD and whole-rock geochemistry studies will help to better characterize the mineralization.

Keywords: Gossan, Hydrothermal breccia, Nova Brasilândia Group, Metallogeny.

INTRODUCTION

This technical report presents the discovery of a new prospective target found during field mapping of the Nova Brasilândia ARIM (Area of Relevant Mineral Interest) project, located in southeastern region of the Rondônia State, Brazil, ~460 km south from Porto Velho (Figure 1). This project is conducted by researchers of the Porto Velho office of CPRM – Geological Survey of Brazil. The occurrence, named P16 (coordinates -11°48'6.372'' of latitude and -61°29'53.700'' of longitude, datum SIRGAS 2000), consists of gossanic crust and hydrothermal breccia rich in quartz and iron oxide, with ~2.5 km long and ~500 m width, both associated to high Cu and Pb contents. Despite low Zn contents obtained in the analyzed samples, probably due to its high solubility under lateritization conditions, the gossan and breccia show textural characteristics similar to those found at the polymetallic Pedra-Queimada and DM prospects, currently under research by Mineração Santa Elina Ltda.

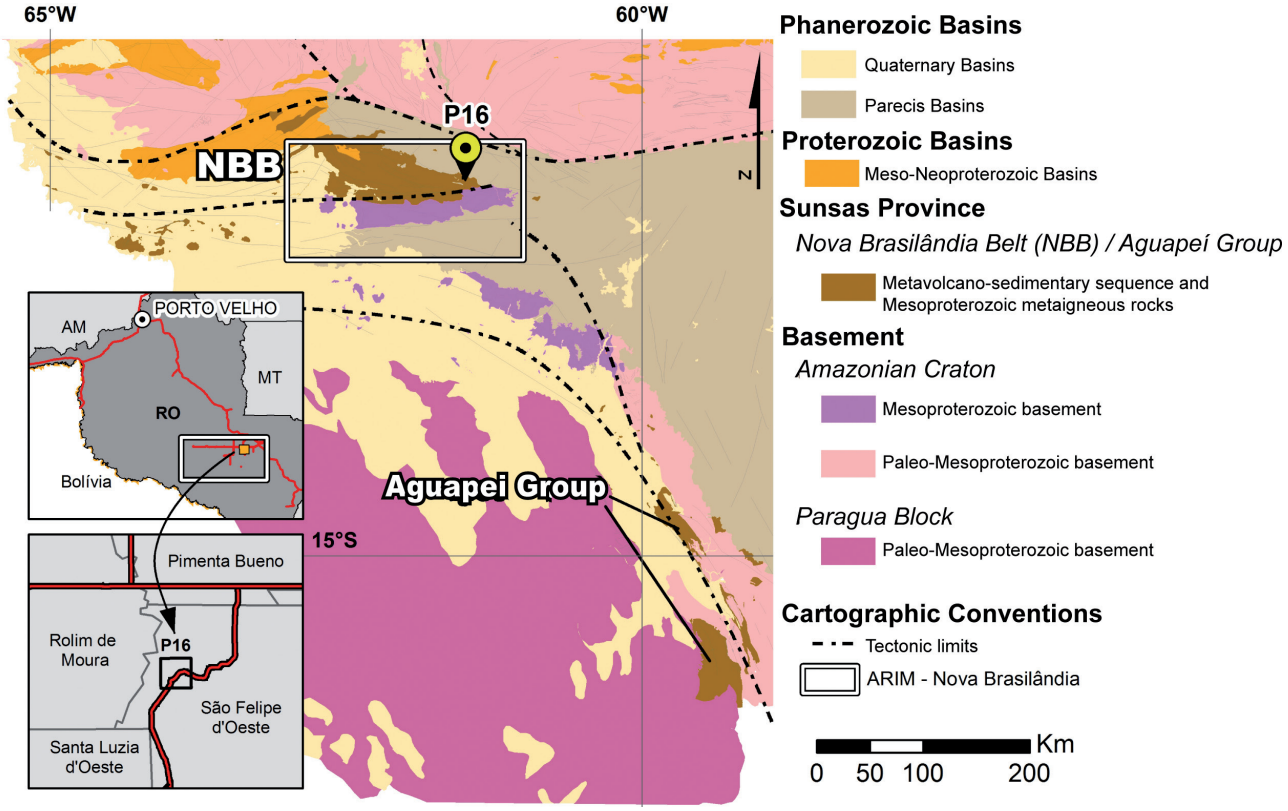

Figure 1*: Southwestern Amazonian Craton simplified map, showing the approximated limits of the main geochronological provinces, mobile belts and tectonic elements. (Adapted from Rizzoto et al., 2014).*

GEOLOGICAL SETTING

The study area is inserted in the southwestern portion of the Amazonian Craton, within the Sunsás geochronological province (Tassinari and Macambira, 2004). This region is characterized as an intracontinental rift with formation of proto-oceans and aulacogens tectonically inverted between 1200 and 950 Ma (Figure 1). The Nova Brasilândia and Aguapeí groups, in Rondônia and Mato Grosso States, respectively (Rizzotto et al., 2014) are related to this taphrogenic event.

The Nova Brasilândia Group comprises the Migrantinópolis and Rio Branco formations. The Migrantinópolis Formation, wall-rock of the occurrence described here, is composed of muscovite-biotite schists, paragneisses, calc-silicate gneisses and quartzites, in addition to dikes and veins of anatetic granites. This rock association is interpreted as being metaturbidites, which underwent medium to higher amphibolite facies metamorphism defined by the quartz-muscovite-biotite-sillimanite-garnet paragenesis (Rizzotto, 1998). The Rio Branco Formation is composed of amphibolites, metagabbros, metagabbronorites and metadiabases with intercalated calc-silicate gneisses and banded iron formations. Two deformation phases (F1 and F2) have been identified in the Nova Brasilândia Group; F1 formed the gneissic banding and low to medium angle foliation oriented dominantly to WNW-ESE, with isoclinal folds having horizontal axis resulting from frontal compressive tectonics verging to the south. The F2 phase represents a progression of the regional deformation, with the development of sinistral transcurrent shear zones, vertical protomylonitic foliation, boudins, horizontal stretching lineation and tight and open folds (Figure 2; Rizzotto, 1999). A post-metamorphic deformational event produced brittle, transcurrent shear zones, defined by breccia zones with great quantity of milky quartz, preferentially developed along portions of strong rheological contrast, such as at the contact between the Migrantinópolis and Rio Branco formations.

METHODOLOGY

The field data collection was made in two periods (August/2015 and May/2016). The first one aimed mainly to map at regional scale the entire project area. In this occasion an occurrence of gossanic crust with breccia zones was discovered nearby the P16 road, western Rolim de Moura town (Figure 1). Due to the importance of this discovery, which directly reflects the increase of the regional mineral potential for polymetallic sulfides, a second field survey was carried out, aiming to map the new occurrence in a detail scale (1:10,000).

Up to now, only one of the gossan samples was analysed by X-Ray Fluorescence (XRF; fusion with lithium tetraborate), ICP-OES/ICP-MS (multiacid digestion) and Au, Pt and Pd determination by Fire Assay – ICP (50g fusion) at the SGS Geosol laboratory, in Vespasiano, Minas Gerais State, Brazil.

Eight samples (AS-067A and B, AS-069, GN-094, LS-098, EG-070A, B and C) were milled and quartered for later analysis by portable XRF (pXRF)

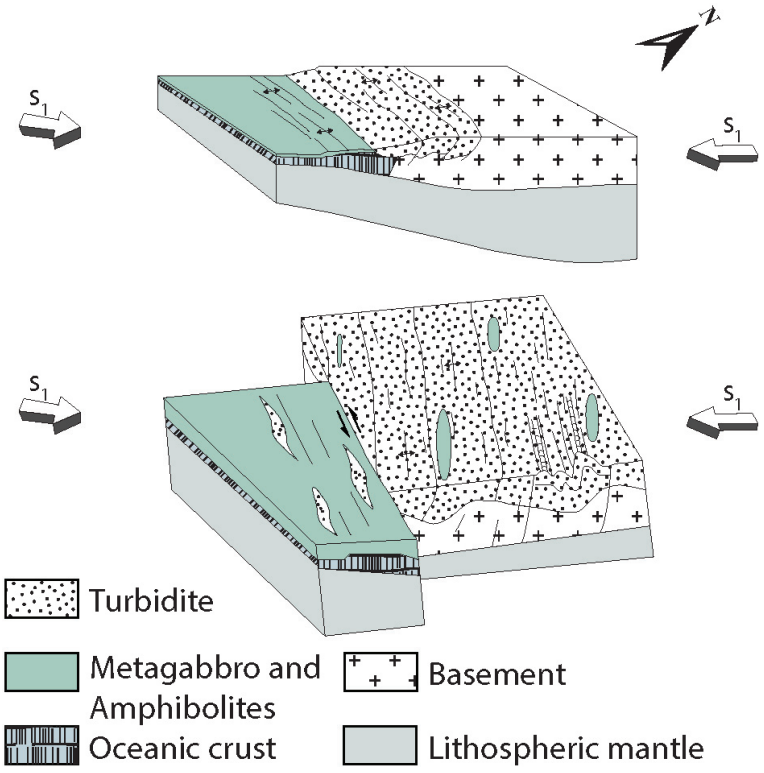

Figure 2*: Schematic model (not to scale) of the regional structural evolution showed by Rizzoto (1999).*

equipment, Olympus Delta X 6000C model. The analyses by pXRF were submitted to calibration with referenced standard sample (BRP-1; Nardy, 2008).

GEOPHYSICAL SIGNATURE

The P16 occurrence is situated at a 2.7 km long strong magnetic anomaly striking WNW-ESE, associated to steep topographic elevation (Figure 3A and B). This anomaly is part of a ~50 km long regional magnetic lineament (Figure 3A) related to transcurrent shear zones developed along the contact between the Migrantinópolis and Rio Branco formations during the F2 deformation phase. The magnetic anomaly field reconnaissance led to the discovery of iron oxide-rich gossan and breccias along the topographic elevation.

The gamma spectrometric map (Figure 3B and D) shows relative enrichment in thorium along the gossan. Although this gamma spectrometric signature is characteristic of highly weathered regions with, it might also suggest hydrothermalism, thus deserving investigation as a prospective tool.

P16 OCCURRENCE GEOLOGY

The polymetallic occurrence (Figure 4) is situated at the contact between Migrantinópolis Formation rocks, composed mainly of aluminous schists with muscovite and biotite, and, sometimes, sillimanite/cyanite, intercalated in quartz-feldspar paragneisses with muscovite and biotite, situated to north of the elevation (Figure 5A), and metagabbros, metatonalites and metanortosites of the Rio Branco Formation, to the south of the occurrence (Figure 5B).

At surface, the mineralization comprises siliceous breccias rich in iron oxide and oxidized sulfides. Close to the mineralized zone, the Migrantinópolis Formation metasedimentary rocks are also hydrothermally altered and rich in iron oxides and oxidized sulfides (Figure 6). To the south, toward the contact with the Rio Branco Formation, there is a predominance of paragneisses with intercalations of parallel and laterally continuous layers of metapelites and metapsamites with matrix rich in iron oxides and massif iron oxide lenses (Figure 6A and B). Less expressively, 0.5 to 2 cm thick, subvertical tabular veins of oxides oriented to E-W were observed in these rocks. Milimetric to centimetric cavities, sometimes with rectangular shapes, are observed within the oxide-rich zones. These cavities show iridescent material films and also inner botryoidal surfaces, possibly related to the goethite supergenic crystallization (Figure 6A and C).

Milky quartz veins predominate nearby the breccia, being intensely fractured and showing angular fragments of the wall-rock schist (Figure 6E). The breccia central portion is marked by increase of vein fracturing and iron oxide infill. In these portions richer in iron oxides rectangular grains of ochre material were observed, which could be limonite and/or goethite, possible pseudomorphs of oxidized sulfide crystals (Figure 6D).

Based on microscopic characteristics, two phases of hydrothermalism were observed. The first phase is represented by silicification, indicated by quartz-rich veins and breccias formation, with wall rock fragments. The second phase comprises sulfide formation/oxidation, which is evidenced by quartz fracturing with hematite and sulfides infill (Figure 6F).

The contact between the Migrantinópolis and Rio Branco formations is abrupt, possibly tectonic, being interpreted as occurring through an oblique reverse fault. Both formations show mylonitic foliation parallel to the compositional banding (Sn), which strikes to WNW-ESE and dips at moderate to high angle to the north, indicating that the two formations were submitted to the same deformation sequence associated to the basin inversion.

In outcrops, the principal foliation is marked by Sn schistosity subparallel to the S0 compositional banding, with attitude 010/60, evidenced by lepidoblastic fabric of millimetric to centimetric muscovite and biotite crystals (Figure 5A and B). Inclined isoclinal folds with horizontal axis, verging to south, and axial plane Sn, are often observed in the Migrantinópolis Formation rocks. A subvertical crenulation cleavage, Sn+1, with attitude 030/80, was observed in some outcrops (Figure 5A).

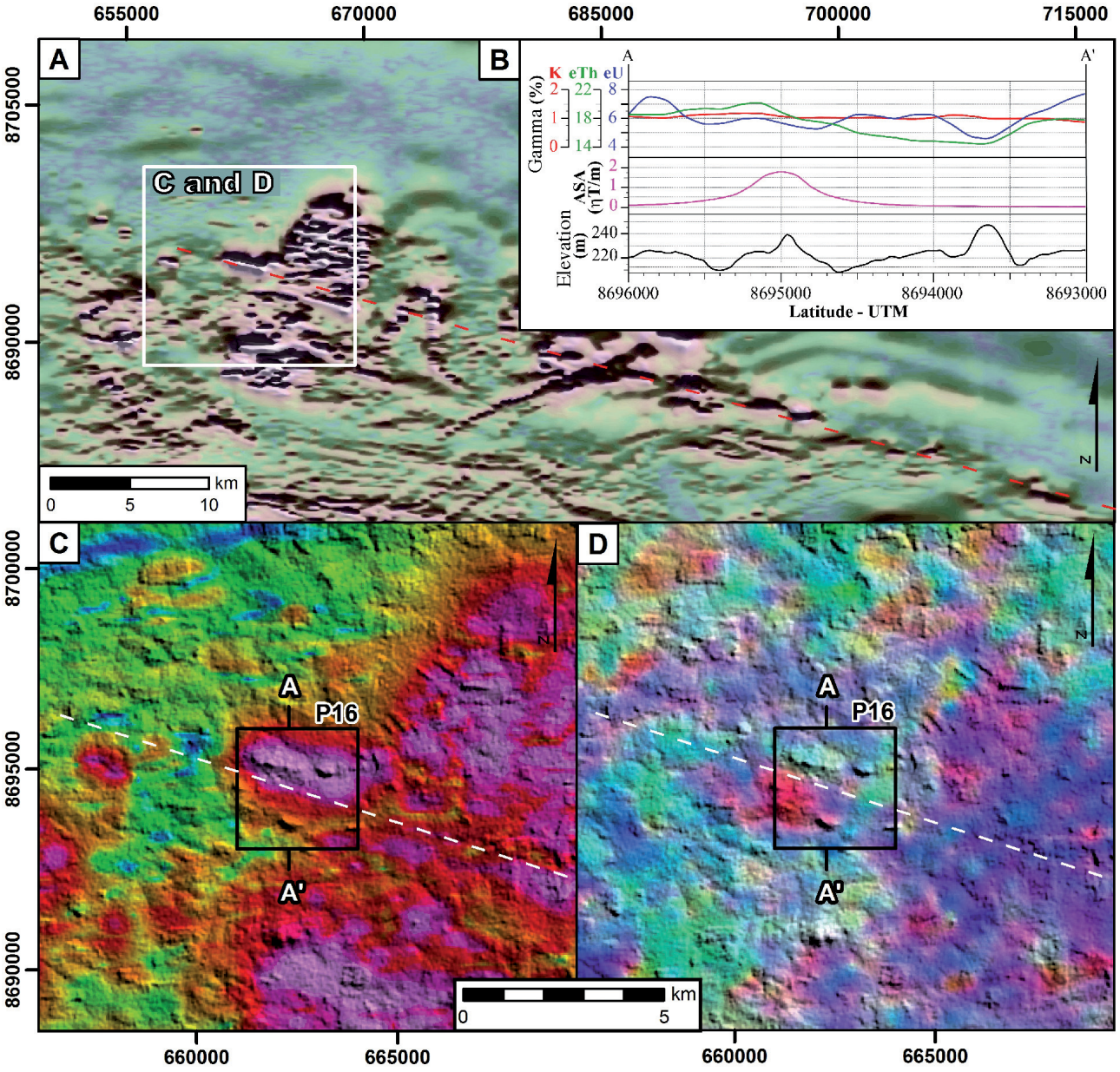

Figure 3: *A) Magnetometric map showing Analytical Signal Amplitude (ASA) in transparency, and First Vertical Derivative (DV) at the background. The dotted red line represents the regional magnetic lineament. B) Geophysical response (gamma spectroradiometry and magnetometry) and A-A' profile altitude. C) Magnetometric map of ASA. D) Gamma spectrometric map with colored composition of the K, eTh, eU channels (red, green and blue, respectively). The detail mapping area of the P16 occurrence is highlighted. Both these products are merged with the shaded relief map (SRTM, ~30 m). The dotted white line represents the regional magnetic lineament.*

CHEMICAL ANALYSES

The samples analysed by portable X Ray Fluorescence show up to 1279 ppm Cu and 726 ppm Pb, in addition to Fe contents varying from 45% to 63%. In two samples, AS-067B and EG-070A, which show the greatest Si and lowest Fe contents, 156 ppm Ag was detected (Table 1). These samples have preserved paragneiss texture, and show greater quantity of muscovite, biotite and quartz.

The sample sent for analysis at SGS-Geosol laboratory showed high Cu (1668 ppm) and Fe_2O_3 (56.7%) contents, but low content of Pb (46.9 ppm) and Zn (56 ppm). The sample is also slightly anomalous in Pt (15 ppb) (Table 2). We highlight that all analysed samples are strongly weathered.

FINAL REMARKS

The Nova Brasilândia ARIM Project is focused on the 1:50,000 Migrantinópolis Formation geological mapping, due to its potential for polymetallic sulfide mineralizations. Ongoing works include, also, petrographic (including scan electronic microscopy), lithogeochemical and X-ray diffraction studies of the known mineralized zones, in addition to advanced geophysical modeling to define the regional structural framework and mineralization controls. During early mapping work a new Cu-Pb occurrence was discovered at the locality named P16. The element contents, which are so far relatively low, but anomalous, are associated to strongly hydrothermally altered rocks, with abundant iron oxides and oxidized sulfides,

characteristics that are very similar at surface to those known occurrences to the east.

The characteristics and extension of the hydrothermally altered zone, in addition to regional controls, indicate that the Migrantinópolis Formation, especially its contact with the Rio Branco Formation, constitutes a geological unit with high potential for polymetallic sulfide mineralization, deserving investigation by licensed private companies.

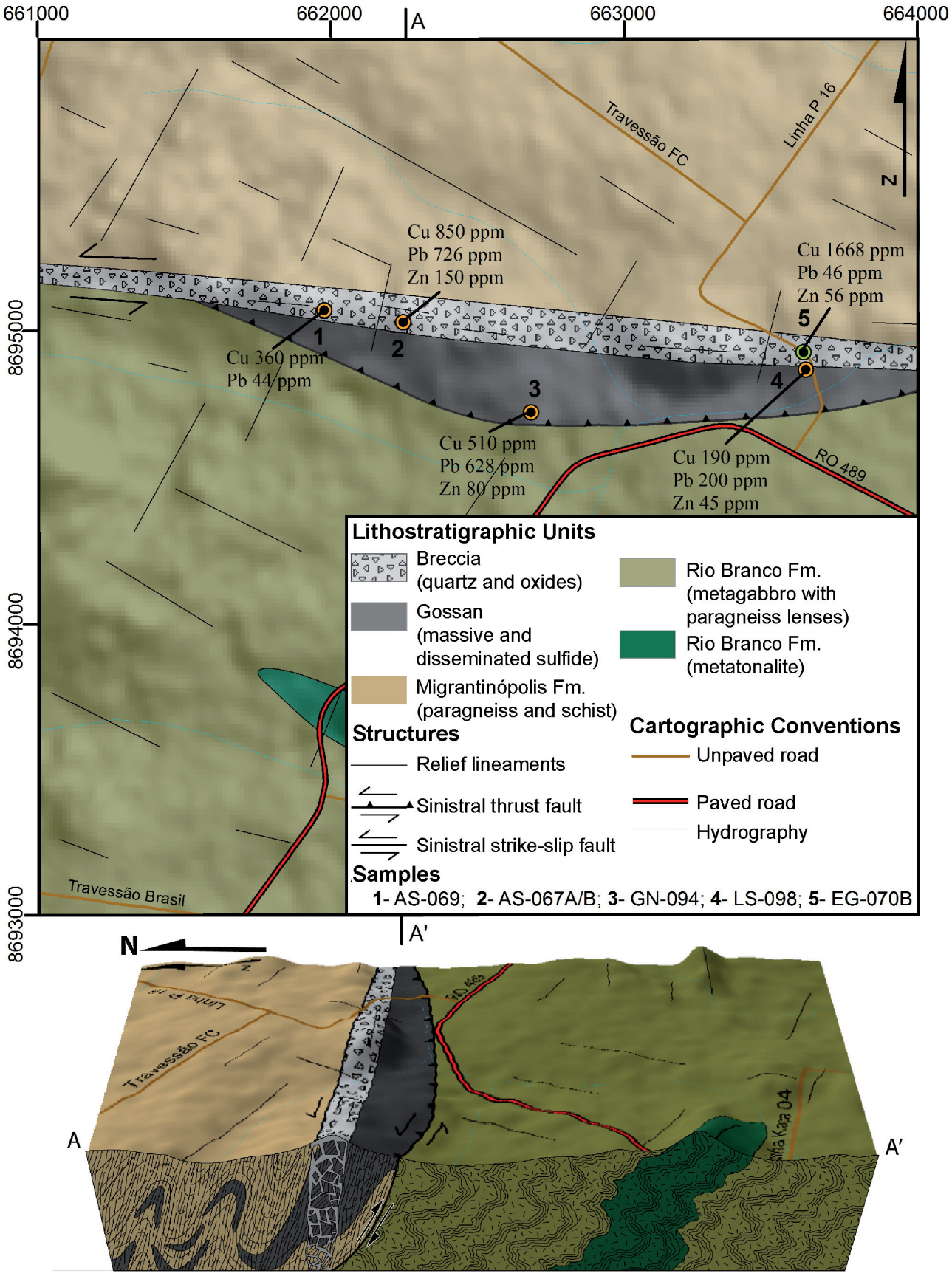

Figure 4: *P16 gossan location map, with detail geological map (1:10,000) and schematic block diagram.*

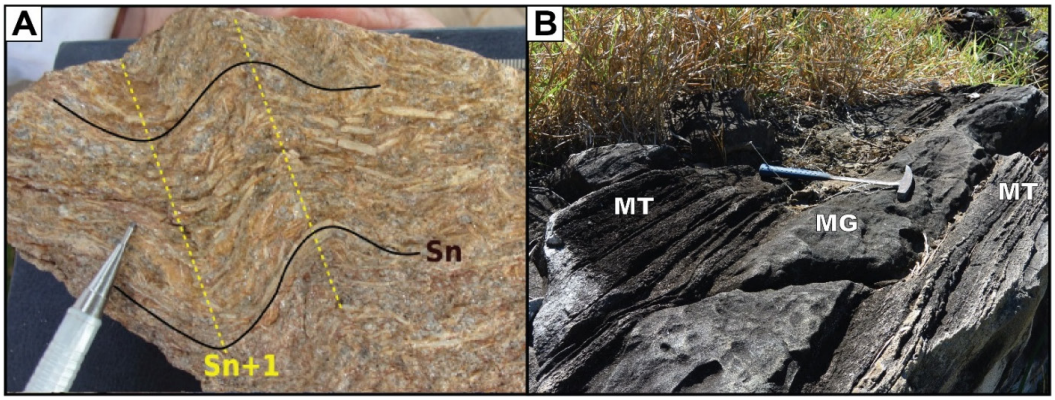

Figure 5: *A) Migrantinópolis Formation cyanite-muscovite-biotite paragneiss, highlighting the Sn foliation crenulated by the Sn+1 foliation. B) Metagabbro (MG) intercalated with metatonalite (MT) of the Rio Branco Formation.*

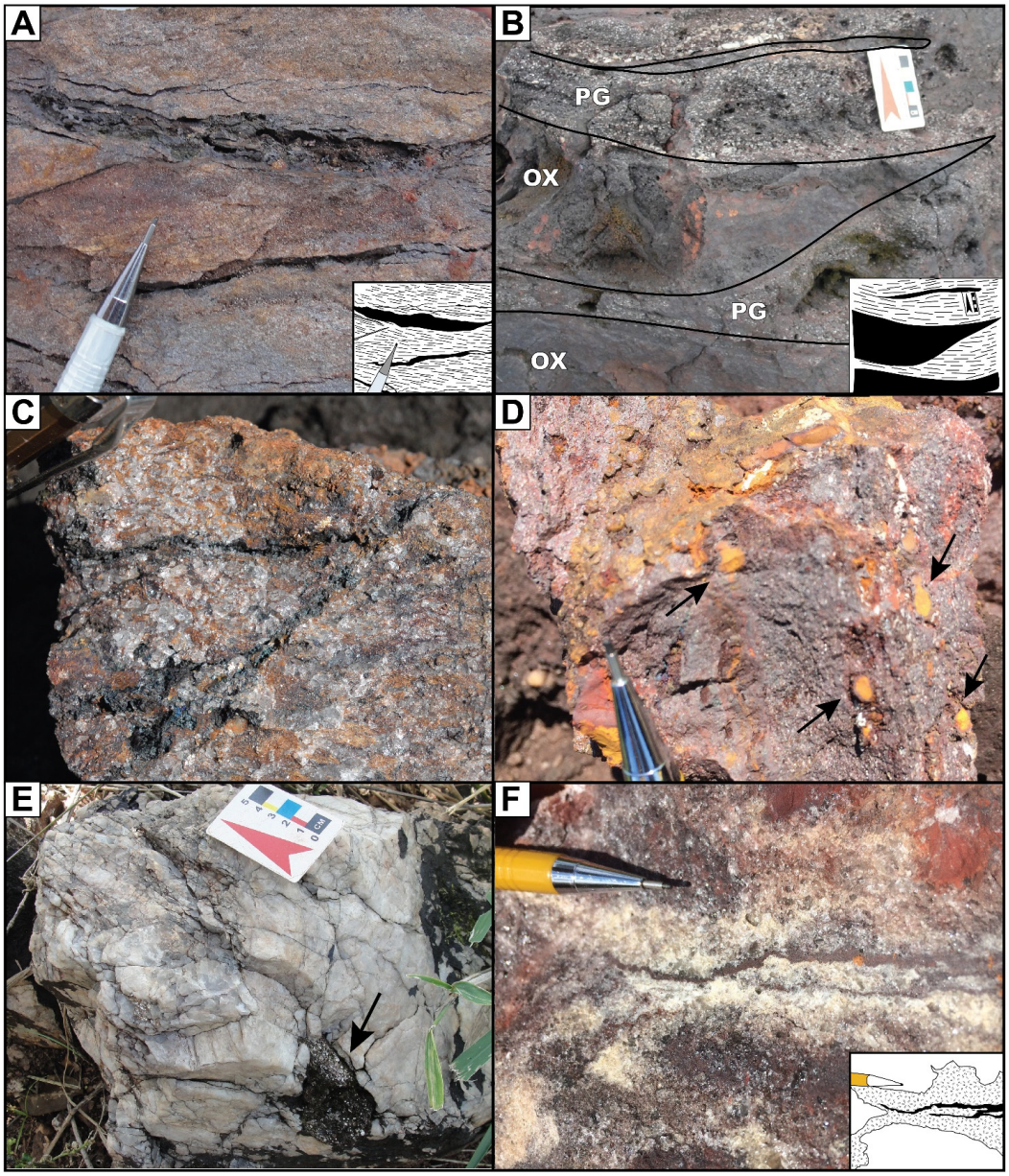

Figure 6: A) Iron oxides with pervasive and fissure-filling texture in muscovite schist; the veinlets are mainly hosted by the Sn and Sn+1 foliations. B) Field aspect of paragneiss (PG) outcrop with massif iron oxide lenses (OX). C) Hydrothermal breccia. Detail of sulfides/oxides veinlets with millimetric thickness and random strike. D) Hydrothermal breccia with approximately rectangular sulfide ochre pseudomorphs (arrows). E) Quartz vein at the gossan external zone. Detail of muscovite schist fragment (arrow) of the Migrantinópolis Formation. F) Vein with two stages of formation: outer silicate and inner oxidized portions.

Table 1: *Si, Al, Fe, Cu, Pb, Zn, and Ag contents obtained by portable XRF.*

Sample	Grades						
	Si (%)	Al (%)	Fe (%)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)
AS-067A	1.81	1.36	63.34	850	726	150	-
AS-067B	33.68	0.17	4.20	89	-	9	156
AS-069	12.14	0.71	42.43	360	44	-	-
GN-094	6.92	0.91	61.69	510	628	80	-
LS-098	17.86	1.99	39.48	190	200	45	-
EG-70A	42.77	4.06	3.91	202	38	-	173
EG-70B	19.00	7.05	43.61	1,279	49	47	-
EG-70C	10.61	1.69	58.82	543	97	52	-

Table 2: *SiO_2, Al_2O_3 and Fe_2O_3 contents obtained by portable XRF; Cu, Pb, Zn, and Ag contents obtained by ICP OES/ICP MS (multiacid digestion) and Pt content obtained by Fire Assay – ICP (fusion of 50 g).*

Sample	Grades							
	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)	Pt (ppb)
EG-70B	22.4	9.95	56.7	1,668.8	46.9	56	-	15

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