

## LITHOSTRATIGRAPHIC CONTROL OF THE CANGAS-POCONÉ LINEAMENT AURIFEROUS DEPOSITS (PARAGUAY BELT): IMPLICATIONS FOR REGIONAL EXPLORATION

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### Abstract

The Cangas-Poconé deposits are hosted in the metasedimentary rocks of the Cuiabá Group, into the inner portion of the Paraguay Belt (Brazil). They occur in a belt (~1200 m) where the host rocks are graphitic phyllites, metadiamicrites, metasiltites and sandstones metamorphosed in greenschist facies. In these deposits gold occurs free or included in pyrite related to three types of quartz veins, parallel to  $S_n$  (V1), parallel to  $S_{n+1}$  (V2) and orthogonal (V3) which are rich in gold. The study of outcrops in regional profiles, open mines for gold exploration and drilling holes in the Cangas-Poconé alignment indicate that the preferential location of gold mineralization at (Cangas Facies) is related to the existence of strong lithological control of the mineralizations.

The Cangas facies present low permeability of rhythmite, structural arrangement of permeability barriers  $S_0$  and  $S_1$  at high angle with respect to the fluid migration path and mainly the presence of ferruginous levels acting as geochemical barriers for precipitation of metals in solution in the fluid. The knowledge that gold concentration is related to sedimentary control is important for regional exploration and is a guide for local miners.

**Keywords:** Gold. Sedimentary Control. Cuiabá Group. Paraguay Belt.

### 1. Introduction

Auriferous deposits in quartz veins, hosted in turbiditic sequences are common throughout the planet (Boyle, 1986). Although well recorded in the literature, there are controversies about some aspects related to these deposits, the characterization of mineralizing fluids and the physicochemical conditions in hydrothermal environments, during transport and ore deposition. In an attempt to establish reliable exploratory criteria, one of the main issues to be solved is related to the geological-structural characterization of the deposit, but a decisive aspect is the definition of lithological and stratigraphic parameters of the mineral deposits host rocks, as well as their evolution.

The Paraguay Belt borders the S-SE portion of the Amazonian Craton and lies east of the Rio Apa Block (Almeida, 1984; Alvarenga et al., 2004). This tectonic unit shows ages correlated to the orogenesis developed in the Neoproterozoic, when the closure of many oceans was responsible for the supercontinent Gondwana amalgamation (Brito Neves, 2003). This belt has an N-S (southern sector) and W-E trend in the Nova Xavantina (eastern sector), Mato Grosso region (Fig. 1), which is approximately 1,500 km long and 300 km wide.

The region has been the target of investigations on tectonic (Alvarenga and Trompette 1993, Trompette 1994; Nogueira et al., 2003; Geraldes et al., 2018), stratigraphic and geochronological studies (Luz et al., 1980; Barros et al., 1982; Pires et al., 1986; Alvarenga and Saes, 1992; Alvarenga and Trompette, 1992; Boggiani et al., 1993; Broggi et al., 1994; Costa et al., 1998; Hortensi, 1999; Alvarenga et al., 2000; Geraldes et al., 2001, 2003; Silva et al., 2002; Alvarenga et al., 2004; Boggiani and Alvarenga, 2004; Barboza et al., 2006; Tokashiki and Saes, 2008; Dantas et al., 2009) and metallogenetic studies (Campos et al 1987; Alvarenga, 1990; Pinho, 1990; Miranda 1997; Martinelli 1998; Silva et al 2006; Geraldes et al., 2008; Barboza et al., 2018).

Three structural zones were characterized by: internal, external and platform structural domains (Alvarenga and Trompette, 1993). The first domain consists of turbiditic and glaciogenic sequences folded and metamorphosed into the green schist facies and intruded by granitic bodies. In the outer zone occur glaciogenic, carbonate and siliciclastic rocks at the top, which are gently folded and not metamorphosed.

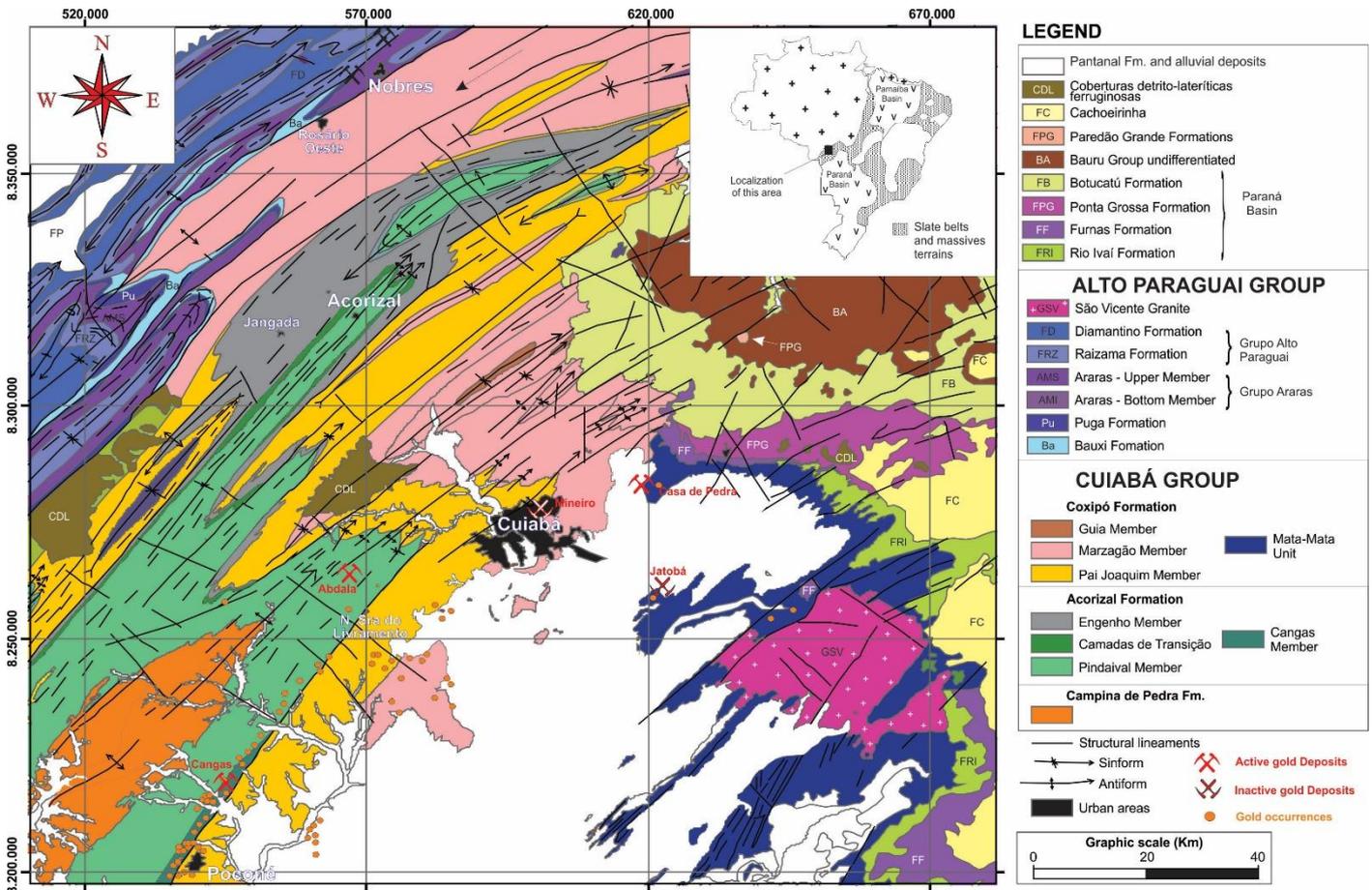


Fig. 1. Geological map of the Paraguay Belt in the Cuiabá region.

These sequences cover the Amazonian Craton whose edge defines the boundary between the inner and outer zone, marked by inverse and normal faults.

The sedimentary rocks were deposited and subsequently metamorphosed under conditions of the green shale facies. By analyzing the variation of the illite crystallinity, Alvarenga (1991) proposes a W-E metamorphic zonation, indicating a thermal increase for east. Thus, this author classified the internal zone and the external zone, confirming Almeida (1984) suggestion. More localized, only in the inner portion of the Paraguay Belt, Silva (1999) detected three characteristic mineralogical associations of metamorphism (chlorite + muscovite + quartz; chlorite + biotite + muscovite + quartz; biotite + muscovite + quartz) and described for the Cuiabá Group an increase in the metamorphic degree of NE to SW through the gradual replacement of chlorite by biotite.

The Cuiabá Group rocks were divided into nine subunits (Fig. 1), as proposed by Luz et al. (1980). These authors indicated the following sequence from bottom to top: sericitic phyllite with alternations of graphite and metasandstone (subunit 1); feldspar metasandstone and greywacke, graphite with alternations of limestone (subunit 2); phyllite with metaconglomerate and metagreywackes,

with alternations of quartzite and lenses with hematite and magnetite (subunit 3); metadiamicctite with clasts and silty matrix (subunit 4); phyllite, sericitic phyllite with alternations of feldspar-rich metasandstone and conglomerate (subunit 5); conglomerate phyllite (subunit 6); diamictite with subordinate sandstone (subunit 7); dolomite lenses and metapelites (subunit 8); and sericitic phyllites, metasilites and quartzites (undivided subunit).

Alvarenga and Trompette (1993) used stratigraphic sequence concepts that allowed the identification of four units. The lower unit is similar to subunits (1) and (2) (according to Luz et al., 1980); the intermediate represents distal facies, intermediate facies including subunits (3) and (5), and proximal facies (Bauxi and Puga formations) correlated with subunits (4) and (7). The Carbonated Unit occurs over the cratonic area as the Araras Group and is correlated with the subunit (8) represented by the Guia carbonate rocks in the inner zone. The upper unit occurs only over the cratonic area represented by the Raizama Formation, consisting of feldspathic sandstones, conglomerates and claystones, and the Diamantine Formation which includes siltstones and claystones.

Another proposal for the subdivision of the Cuiabá Group performed by Tokashiki and Saes (2008), presents

three lithostratigraphic units (Fig. 2) separated by important interruptions in the depositional regime: Campina, Acorizal and Coxipó Formations. The recognized units have stratigraphic sequences character and can be subdivided into smaller ones with the recognition of depositional cycles and erosion surfaces internal to the larger units. According to Tokashiki and Saes (2008), the Campina de Pedras Formation records the first stages of the tectono-sedimentary evolution of the Paraguay passive margin, after the beginning of the dispersion of the Rodinia Supercontinent, during which lacustrine continental sediments, rich in organic carbon, have accumulated. According to these authors, the metagreywackes, at the top of the succession represent the progradation of delta lobes over the lacustrine basin.

The deposition of the Acorizal Formation, as observed in Cangas-Pocone lineament, occurred in a marine-glacial environment, indicating the gradual passage from a proximal to a distal environment, in open sea conditions, with

deposition of fine rhythmites with concentration. This layer is composed of thick and thin rhythms, interspersing massive diamictites, with strong evidence of drop-stones. The Acorizal Formation corresponds to the subunits 3, 4 and 5 of Luz et al. (1980), consisting of metarhythmites on different scales associated with diamictites. It presents economic importance due to gold concentration. This layer is composed of thick and thin rhythms, interspersing massive diamictites, with strong evidence of glacially influenced sedimentation. The lithofacies of laminated diamictites correspond to the Leo Magnetic Zone marked by levels of magnetites, a result of the possible increase of dissolved oxygen in seawater during periods of deglaciation, corroborated by the presence of drop-stones from floating ice masses.

This work aims to present the results of investigations carried out in the last two decades of research in several auriferous deposits in the Cuiabá region, hosted in the Paraguay Belt rocks.

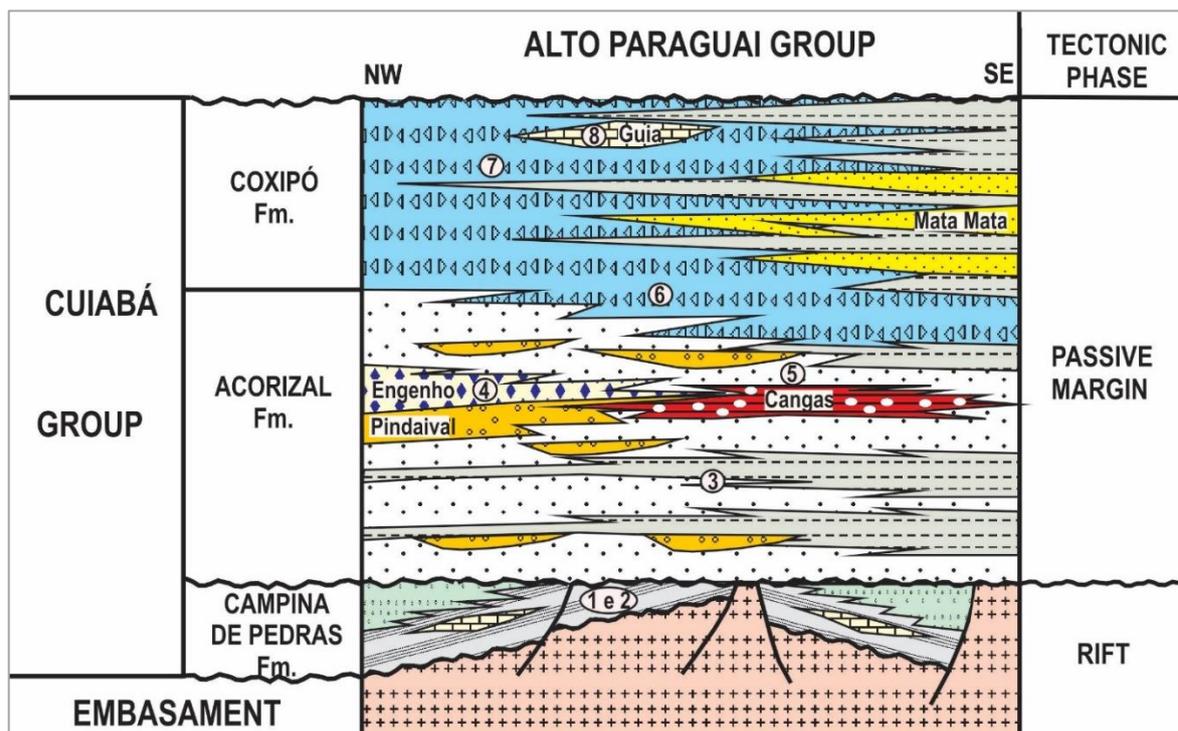


Fig. 2. Stratigraphy proposed by Tokashiki and Saes (2008) for the Paraguay sediments in the Cuiabá region.

## 2. Materials and methods

The study is located in the Cuiabá region, Mato Grosso State, at the Midwest region of Brazil.

The methodology employed in this work was: (i) mapping of the mining fronts, as well as (ii) key outcrops where the main types of mineralized veins were studied and their characteristics were identified aiming to distinguish from the non-mineralized veins. We present a detailed description of the mineralized bodies, with geometry and compositional

features. The host sedimentary rocks were described and a proposition of genesis model for the hydrothermal solutions responsible for the gold concentration was proposed. The nomenclature adopted in this paper to relationship between the folds, the planar structures associated with the deformation phases and quartz veins is represented in Fig. 3.

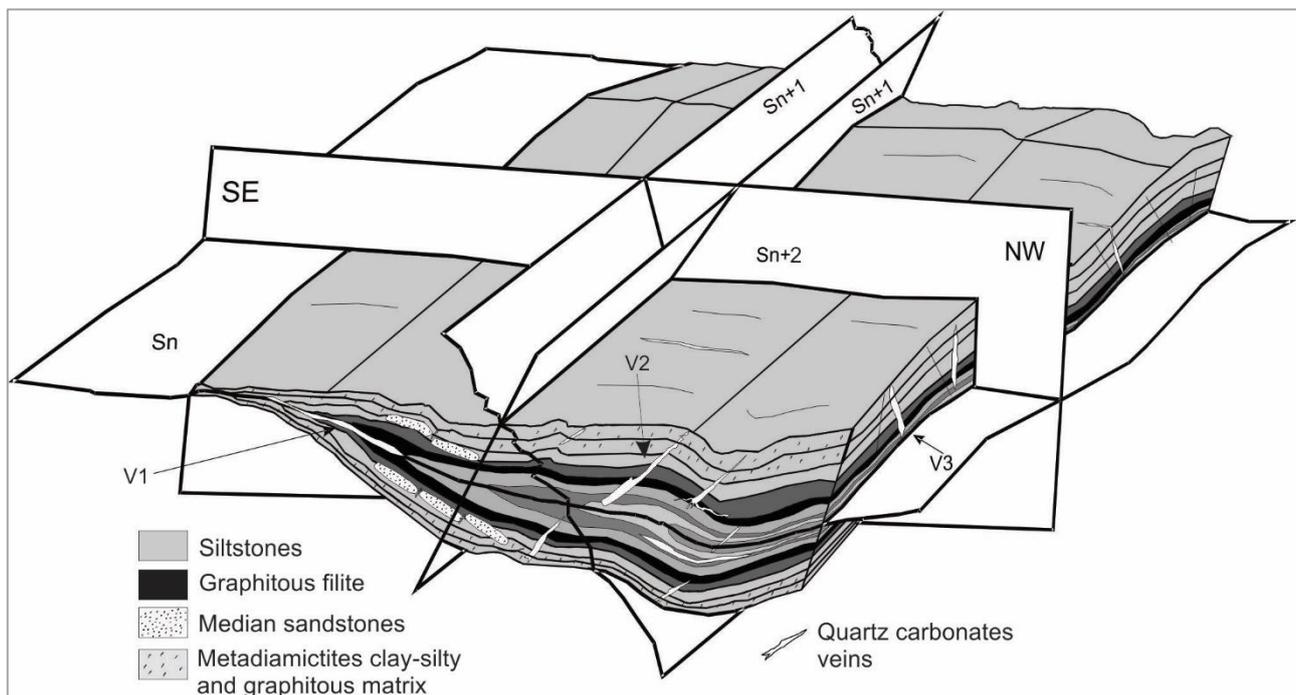
Images as well as semi-quantitative analyzes of hydrothermal minerals were acquired with Joel Scanning Electron Microscope (JSM - 5800) and Energy Dispersive System (EDS). IG / UNICAMP microscopy laboratory.

### 3. Results and Discussion

#### 3.1 Ore bodies characterization

The mineralized bodies of the study region correspond to quartz veins and the textural and mineralogical features are important for the identification of mineralized areas. In this sense, Alvarenga (1990) and Silva (1999) proposed a classification for the quartz vein types of the Baixada Cuiabana gold deposits. According to these authors, there are sub-parallel (Type 1) veins, sub-parallel to main foliation (Type 2), both NE-SW direction, and NW-SE direction

orthogonal veins, parallel to  $S_{n+2}$  (Type 3). Quartz veins with the best gold content are orthogonal to the Paraguay Belt structure and were interpreted as late-orogenic by Pires et al. (1986), Silva (1990), Alvarenga (1990), Alvarenga and Gaspar (1992), and Alvarenga and Trompette (1993). Subsequently Silva et al. (2002) used structural aspects as criteria and suggested that orthogonal veins are extensional structures related to the first phase of deformation. Data obtained in this work allowed to verify that the spatial orientation, geometry and field relations allowed to recognize three types of quartz veins (Fig. 3).



**Fig. 3.** Relationship between the folds, the planar structures associated with the deformation phases and quartz veins classified as V1, V2 and V3.

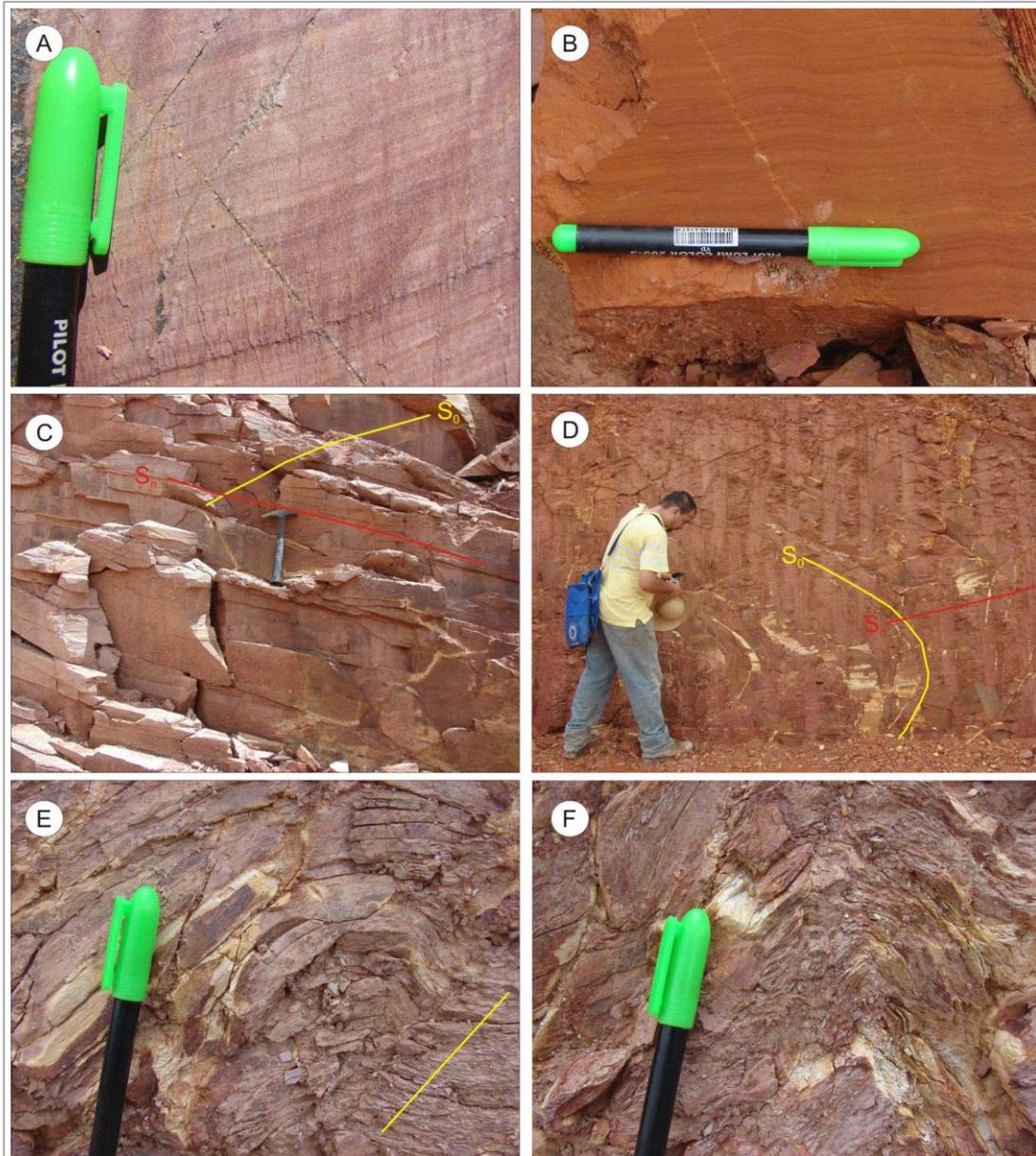
The V1 and V2 vein types were grouped in a single generation, since the large bend amplitude makes  $S_0$  parallel to  $S_1$ , and the same is true for the veins that still cut the  $D_n$  fold hinges. The remaining veins are those hosted in coaxial extensional fractures at the first two stages of deformation and the last type coinciding with type 3 according to Alvarenga (1990) those authors, orthogonal to the others and rich in gold. V1 veins probably formed from the quartz segregation of the metamorphic rocks during the development of the first deformation phase, since they are folded and are parallel to  $S_n$ . It was observed sub-parallel and orthogonal veins related to V2 type direction, characterized by T fractures according to the criteria of Tchalenko (1968). They are veins in extensional fractures, oblique to foliation, may form at any time during shear evolution. The chronology of the formation of these veins explains the fact that these structures were described with sigmoid forms in the Português mine (Silva, 1990) and are

straight in Cangas. In the Português Mine these veins are early compared to those described in Cangas. Following a description of quartz veins observed in Cangas, whose textural aspects follow the criteria of Dowling and Morrison (1989).

The V1 veins are boudinated and in agreement with the main foliation ( $S_n$  and  $S_0$ ) (Fig. 4A). They are hundreds of meters long, along which they may have discontinuities probably generated by boudination although pinch and swell structures are common. The thickness ranges from 1 cm at the necks to 40 cm at the thickest portions. Quartz has a massive drusen texture. Inside the veins there are fragments of the hosting and siderite that preserve the rhombohedral habit (Fig. 4B) or very weathered, and in these cases called “coffee powder” by the miners. Chlorite, white mica and albite are also common. Among the sulfides predominates pyrite, more rarely chalcopyrite and they are usually weathered. Oxides are represented by specular hematite,

usually near the veins. The V1 veins type are oriented according to N30-45E and present varied dipping for both NW and SE (Fig. 4C). V2 veins are the rarest and present sub-parallel to  $S_{n+1}$  geometry, although they are restricted to dipping plans for SE, probably sin to late  $D_{n+1}$ , and cut  $F_n$  fold flanks (Fig. 4 D). They are continuous for up to 10

m and are usually thicker at the base where they can reach up to 2 m in thickness. The predominant textures are similar to V1 (massive and druse type). Inside these veins occur rock fragments and pyrite grains up to 2 cm in diameter. In addition to quartz and pyrite, siderite and biotite are also common but less abundant.

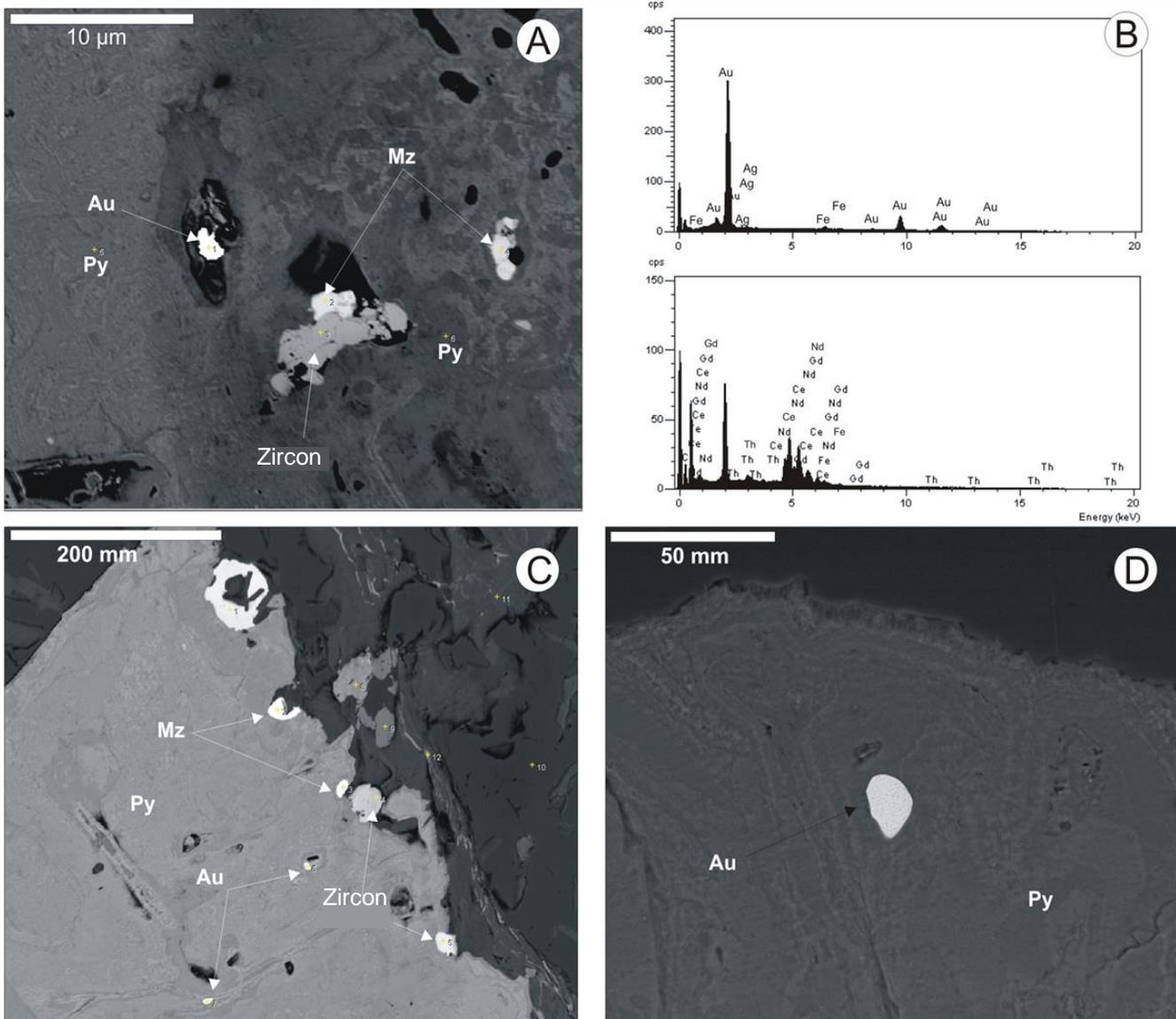


**Fig. 4.** Structures in the Jatobá deposit pit. A and B - sedimentary bedding  $S_0$  with reddish and orange, varying according to the degree of weathering of the phyllite. C - relations between  $S_0$  and  $S_n$ . D -  $S_0$  folded with  $S_n$  axial plane. E and F -  $S_n + 1$  axial plane folds.

The orthogonal quartz vein, i.e. NW-SE direction, are here called V3 and contain the best gold content and are usually tabular or have lenticular ends. They are discontinuous along the outcrops, have a length up to 20 m and the most common is about 5 m. Some have textural alternations, mostly of the massive and fibrous texture (Fig. 4E), as well as the drusen texture, suggesting a distensive

setting. Gold is found free, usually associated with or included with pyrite (Fig. 4F).

Other accessory minerals are tourmaline, monazite, zircon, albite, biotite and chalcopryrite. The SEM/EDS analyses allowed to identify inside the pyrite (predominant sulfide) Au inclusions, monazite, zircons and more rarely chalcopryrite (Fig. 5).



**Fig. 5.** Scanning Electron Microscope images of mineralized veins. (In B) an EDS analysis showing the elements present in the sample.

It is noteworthy that in this study, information on fertile and sterile veins was obtained through verbal communication with the miners of this region. Among the criteria used to differentiate the veins, miners look for a rust orange color found in the veins and adjacent rocks, which was probably generated by sulfide alteration. These orange points are fickle along the vertical veins and when found are sampled. As is already a tradition in the region, NW-SE vertical veins have the best gold grades, but according to the miners the sub-horizontal NE-SW veins may contain expressive gold concentration, although very rarely.

### 3.2 Sedimentary and stratigraphic controls of gold deposits

The village of Cangas (Poconé municipality) is located 80km SW of Cuiabá (Fig. 6). In the 1990s, the estimated gold production of the Baixada Cuiabana reached 5 t / year

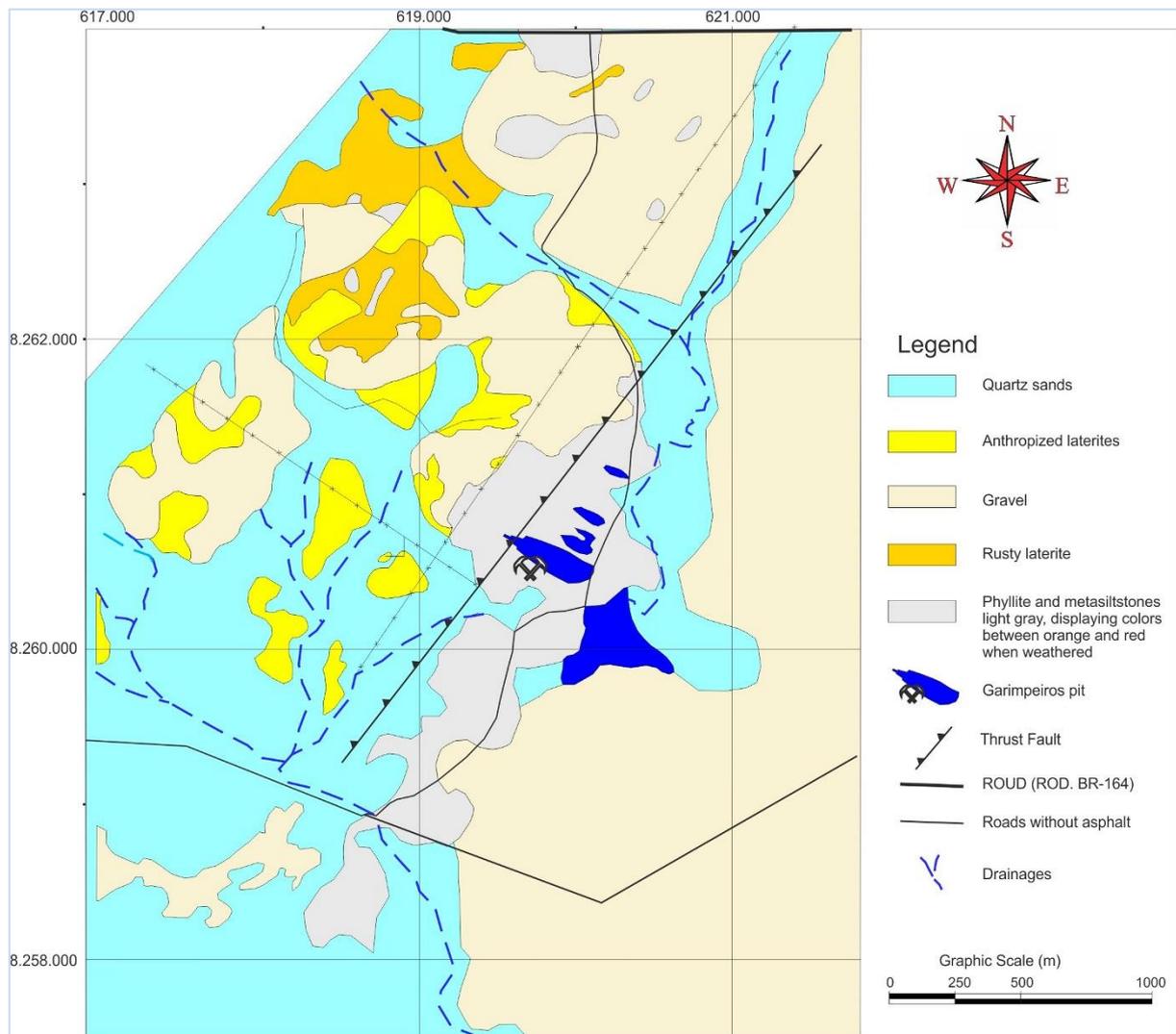
(Fernandes and Miranda, 2006) and part of this production was extracted from the Cangas region. The levels obtained in quartz veins analysis conducted by the mining company Bauxita Ltda. mentioned gold production values between 0.67 and 4.65 g / t (0.7 g / t, in average).

Gold is mined in NW-SE-directed sub-vertical quartz veins, according to field data and direction of the pits in this direction, viewed on map (Fig. 6) and satellite imagery. On a local scale, it is possible to verify that these pits are sub-parallel and were made transversally to the regional structure (Sn) mainly along a range of approximately 1,200m of N40°E direction, where carbonate phyllites, metatillites and magnetite rich phyllites arise related to the top of subunit 3 (Luz et al. 1980). In general, the open pits are approximately 10 to 20 m wide by about 200 m long (Fig. 7A, B), whose access ramps form angles up to 30 ° inclined with respect to the topography and reach depths up to 60 m.

In the area, the rocks of subunits 1, 2 and 3 (Luz et al. 1980), considered the oldest in the Cuiabá region, correspond to the Inferior Unit of Alvarenga and Trompette (1993). Subunit 1 mainly includes sericitic phyllites and metasandstones (Fig. 7C). The sericite phyllites are very altered, with colors ranging from light gray to greenish gray. They show very fine granulation and well-developed lamination and consist essentially of sericite, quartz and

weathered sulfides, tourmaline, zircon and plagioclase as accessory minerals.

The metasandstones are greenish gray to dark gray, with fine to medium granulation, and a mineralogical assembly consisting essentially of quartz, feldspar (plagioclase and microcline) and sericite. Subordinately occur biotite, zircon, titanite, apatite, pyrite and iron oxide.

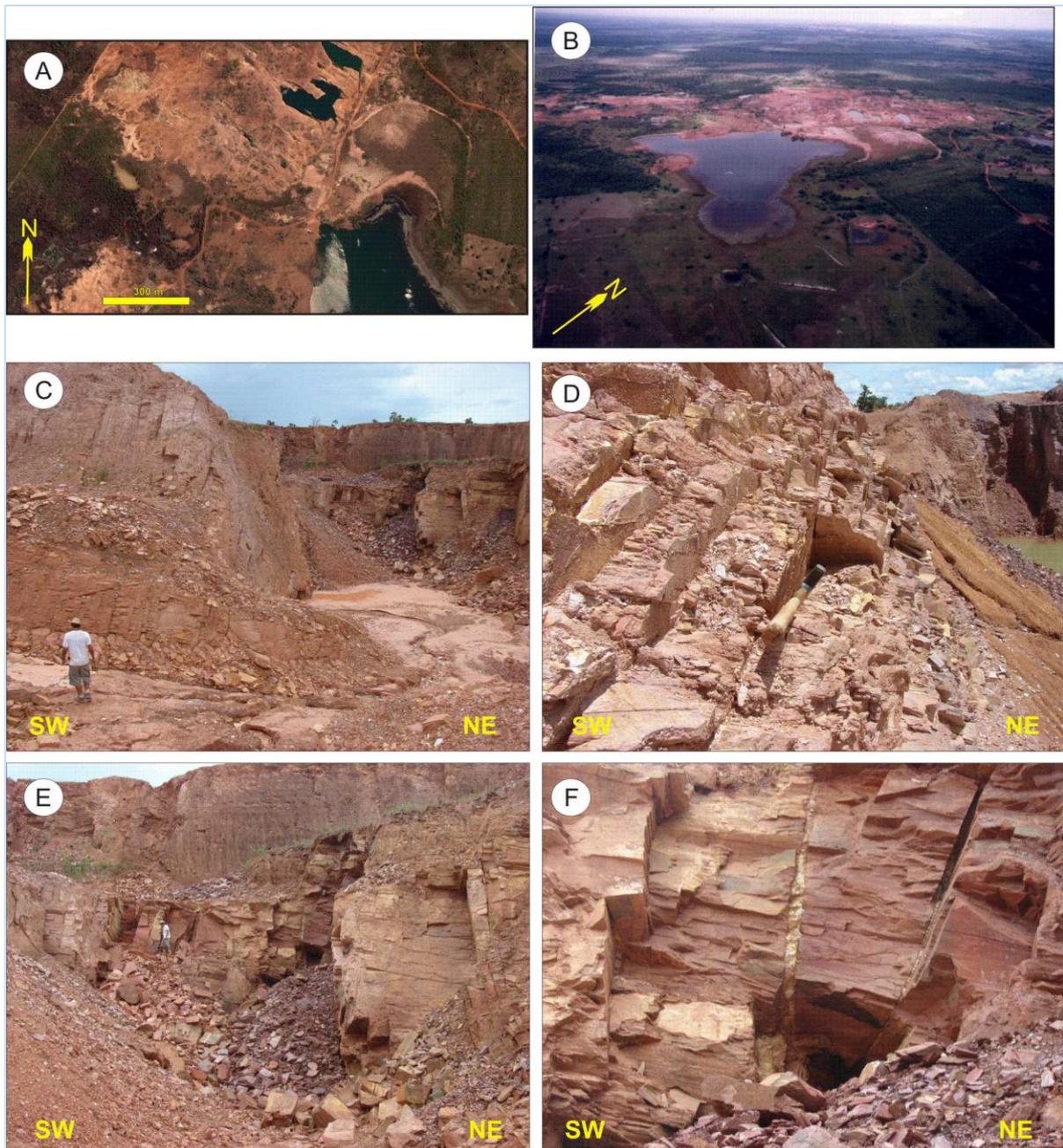


**Fig. 6.** Geological map of the Jatoba gold deposit area showing the main sedimentary facies (V3). Open pit directions (N40W) in concordant with Au-rich V3 vein type.

Subunit 2 rocks comprise a sequence of calciferous metasandstones, graphite phyllites and marble (Fig. 7D). Metasandstones have colors ranging from dark gray to greenish gray, fine to coarse graining, low rework and poor grain selection. These rocks are formed by quartz, feldspar, sericite, biotite and iron oxide, in addition to carbonates in the calciferous terms. As accessories occur titanite, epidote, zircon and apatite. In addition to the particle size difference from metasandstones, the graphite is dark gray to black in

color and occur commonly intercalated with very fine to fine grained arkosian and calciferous metasandstones.

They consist essentially of muscovite, quartz, pyrite and to a lesser extent feldspar, white mica and zircon. The carbonate marbles are gray and are cut by fractured calcite veins and venules. These rocks consist mainly of recrystallized carbonate, quartz, plagioclase, sericite, opaque (pyrite and  $\pm$  chalcopyrite), apatite and zircon.



**Fig. 7.** Jatoba Deposit. A - satellite image (note direction NW-SE); B - Aerial photo of the deposit area C, D and E - Sn+2 spaced fracture cleavage in the Jatobá deposit pit; F - Sn+2 fracture cleavage filled with quartz vein (V3).

Subunit 3 in the mineralized area is composed of phyllites, metasiltites, metadiamicities, metaconglomerates, metasandstones and magnetite phyllites (Fig. 7E and F) that have light gray to greenish gray colors and fine to very fine granulation. Petrographic analyzes in the carbonaceous phyllites show a predominance of quartz, chlorite, muscovite and locally biotite. As accessories there are tourmaline, zircon, epidote, apatite, pyrite, magnetite and clay minerals. Variations of these phyllites with more quartz and carbonate facies are common. In terms of matrix, they show characteristics similar to those of the phyllites, differing only

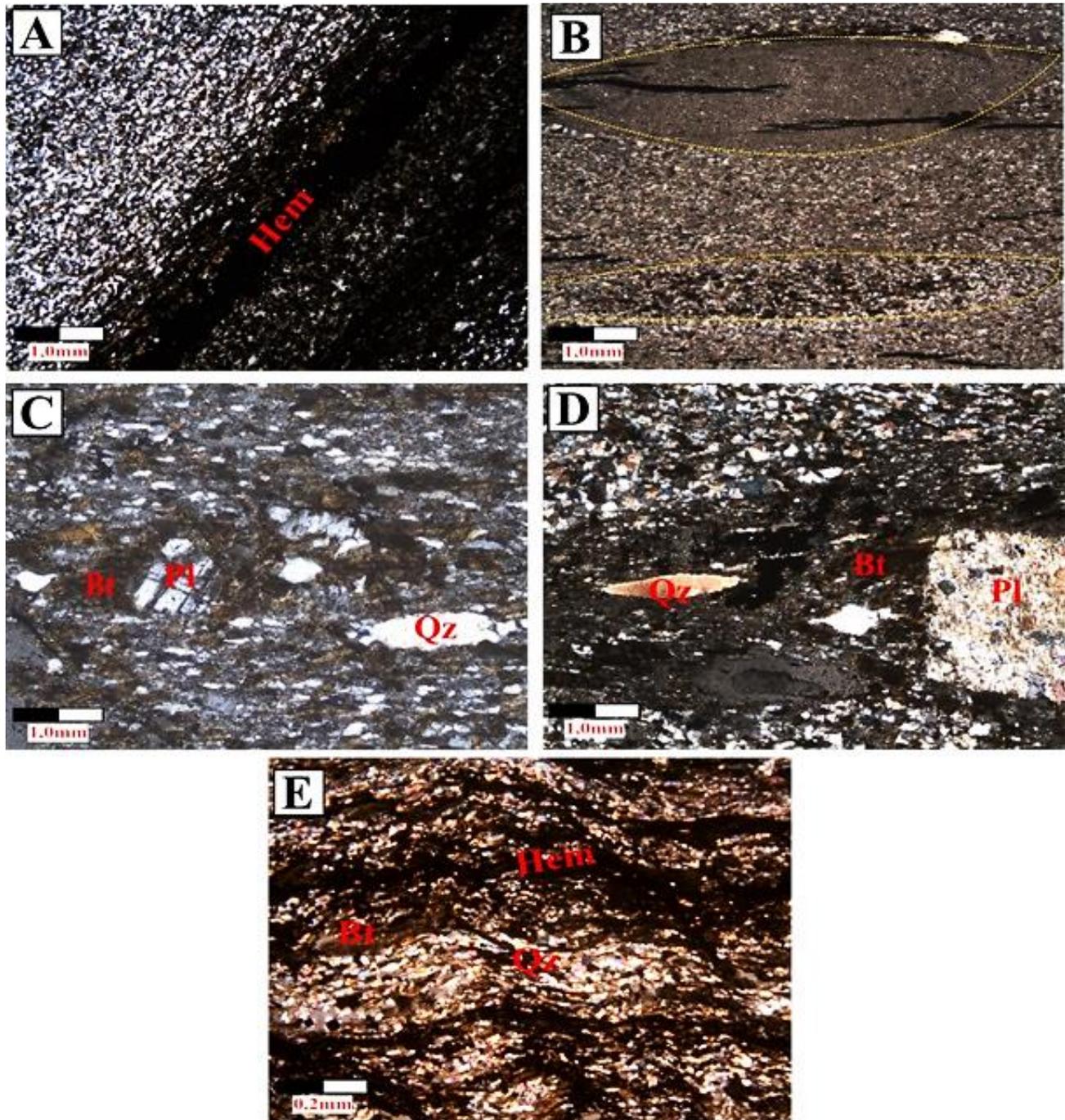
by the addition of rock fragments comprised of quartzite, metasandstone and generally sub-round granite rocks. Under the microscope, thin matrix lenses are observed to intersect with sandy micaceous lenses, consisting of recrystallized granules of quartz, feldspar and rock fragments.

The metaconglomerate have reduced distribution, occurring in the form of lenses that generally concentrate in the intermediate part of this package, with thickness ranging between 1 and 5 m. Petrographically (Fig. 8A), they are formed by magnetite (Fig. 8A), quartz (Fig. 8B and C),

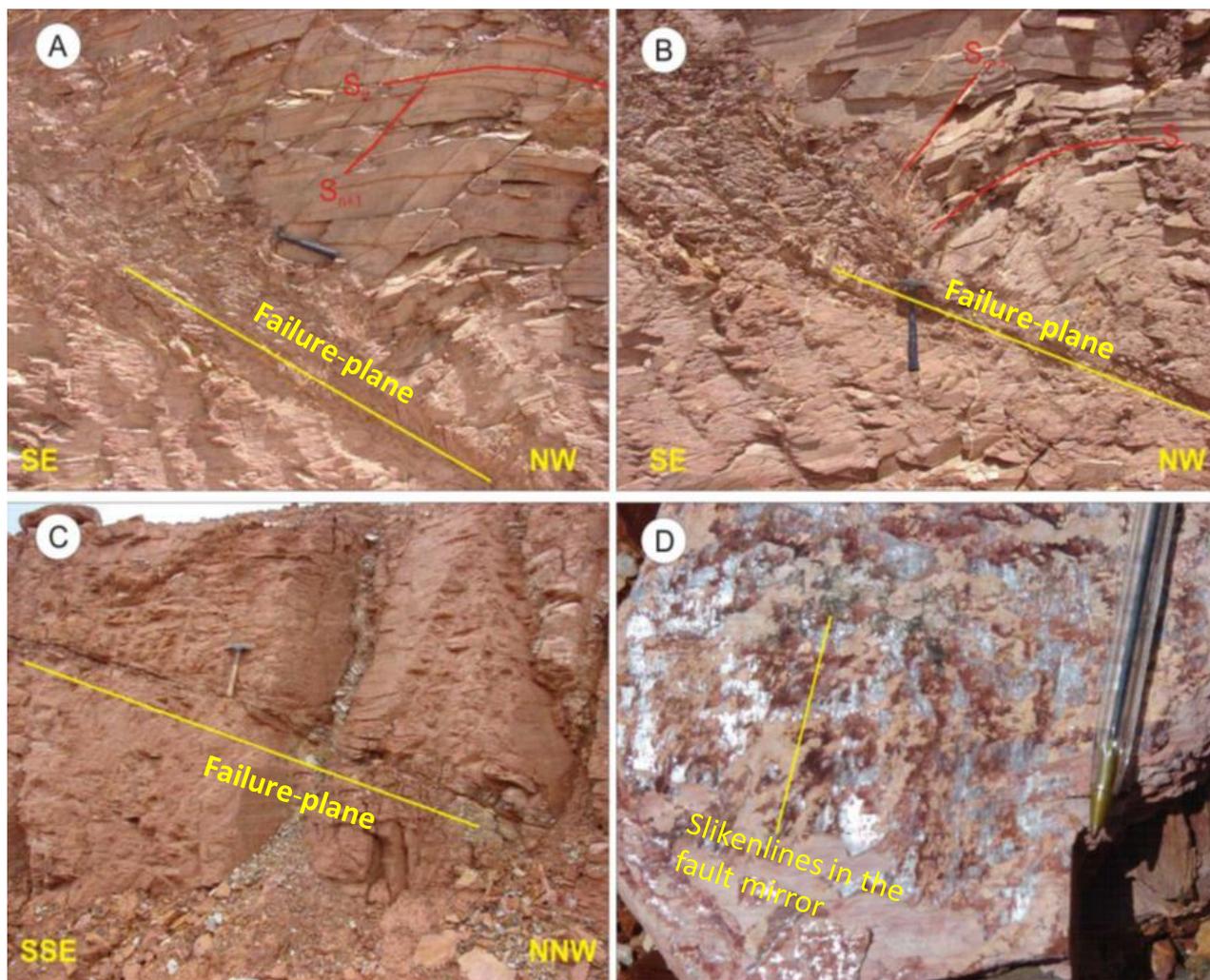
feldspar and biotite (Figs D and E), cemented by carbonates. As accessories minerals occur zircon, tourmaline and biotite. Meta-limestone outcrops in the form of lenses of a thickness not exceeding 10 m, a dark gray color with massive and very fractured aspect, consisting essentially of carbonates and quartz. Calciferous phyllites occur in the

form of lenses. In the open-pit of the Jatoba deposit, a NE-SW fault was observed (Fig. 9).

The kinematic indicators of these faults are drag folds at  $S_0$ ,  $S_n$  and  $S_n + 2$  (Figs 9A-C), as well as slickenlines (striae) present in the fault plane (Fig. 9D). In the fault plane adjacencies, the phyllites are extremely fractured and the pre-failure structures are destroyed.



**Fig. 8.** Images of petrographic microscopic thin section of the sedimentary rocks embedded in the auriferous deposits studied here from Acorizal formation. A) Alternation of sericitic bands and Fe oxide rich bands in ferruginous filite; B) Porphyroclast of carbonate rock in lepidoblastic matrix with sericite, quartz and Fe oxide; C) quartz porphyroclast; D) Porphyroclast of carbonate rock and hydrothermal carbonate fracture filling. E) Layers of synkinematic biotite alternating quartz and sericitic levels.



**Fig. 9.** Structures related to Jatobá deposit failure plans. A and B - failure plan with drag folds; C - Fault plane cutting veins V3. D - slickenlines in the fault mirror.

### 3.3 Contribution to metallogenic models

In the Jatobá deposit there are two types of quartz veins sub-parallel to S<sub>n</sub> (V1) and (V3). V1 veins occur continuous sub-horizontally up to 10 m and thicknesses ranging from 1 to 20 cm (Fig. 10). These bodies have elongated geometry with lenticular endings along the S<sub>0</sub> and S<sub>n</sub> to parallel along their extension. The quartz of these veins is massive and milky.

V3 veins occur embedded in the S<sub>n</sub>+2 fracture cleavage, that is, they are sub-vertical. The outcropping length is around 1 to 2 m, but its vertical depth continuity is not always visible. Along its length may occur bipyramidal quartz crystals up to 5 cm in length. In the Abdala deposit gold is extracted from this type of veins, as in all other primary gold deposits in the Baixada Cuiabana. These veins may occur without any apparent hydrothermal alteration in the hosting rocks (Fig. 11A and B) or with pyrite box works, weathered carbonates, and with a narrow adjacent to the vein with yellow to reddish hues that suggest a weathered hydrothermal alteration (Figs 11 C and D).

In the Mineiro mine located in the urban area of Cuiabá, at 1:1,000 scale geological mapping was carried out, where units A, B and C were recognized. Metasandstones in general are very altered, with a coloration ranging from greenish to grayish when fresh and whitish to pinkish when altered. It has a sandy matrix with quartz clasts, which are often recrystallized, with potassium feldspar and plagioclase subordinate. Outcrop observations show well rounded grains with sphericity ranging from high to low.

Most grains fall into the medium sand granulation (between 0.5 - 0.25 mm). Microscopically observations notice a heterogeneous texture and the clasts are of quartz, feldspar and more rarely opaque and zircon. The size ranges from 0.5 to 5 mm. They are clasts, which preserve reminiscences of an original spherical sedimentary form, but predominate the elongated form that supports the defining of foliation. The matrix is mainly formed by white mica and biotite and occurs oriented in the spaces around the anastomosed clasts. In these rocks predominate the clasts in relation to the matrix, in an approximate ratio of 9:1.

Unit B is observed in outcrops invariably altered comprised of finely laminated pink-colored quartz phyllites. They consist of quartz, mica and opaque minerals. Observation of slides reveals that quartz and white mica occur in practically equal percentages, where white mica and quartz grains show a strong orientation that defines Sn foliation.

Unit C is basically composed of metadiamicrites, sometimes occurring with intercalations of feldspathic metasandstone layers. Metadiamicrites have colors ranging

from greenish to grayish when fresh, and yellowish tones when altered. It presents a matrix composed of phyllosilicates mainly white mica, chlorite and biotite, with contributions of quartz. Clasts have a granulation that varies from granule to pebble.

In general, they correspond to quartz crystalloclasts and quartzite, granite, amphibolite, phyllite and marble lithoclasts. These show pressure shades composed of quartz, white mica, biotite or more rarely chlorite.



**Fig. 10.** Quartz veins sub-parallel to Sn (V1) in the Jatobá deposit pit.

Geologically, the Abdala mining area is located in subunit 3 of Luz et al. (1980), consisting of a set of metasediments that include leaky pebbled phyllites, phyllites, thin metasandstones and metasiltstones. They can be separated into two distinct lithological sets. The first one is composed of phyllites with dripping pebbles, which are usually in greenish tones from light to dark. They show a prominent bedding, composed of layers of approximately 10 cm.

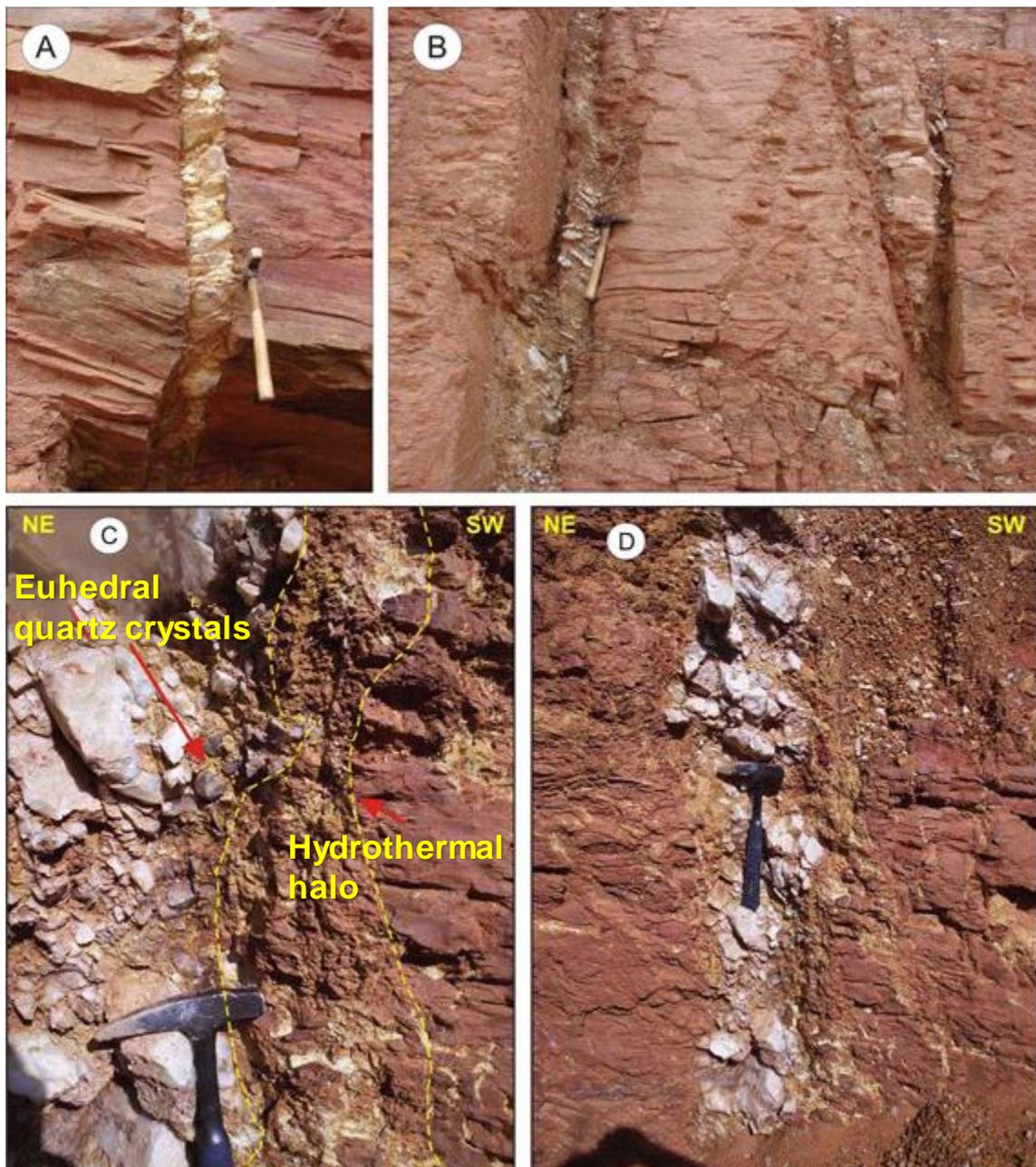
The composition of the clasts is diverse, occurring quartz, feldspar, granitic rocks, quartzite, basic rocks and phyllites and the pebbles show a gentle stretching parallel to the fold axes. The matrix is basically composed of phyllosilicates, mainly white mica and sometimes biotite and quartz.

The second lithological set consists of phyllites interlayered with metasandstones and metalimestone. The phyllites usually have a light green to dark green color, changing to reddish colors, being basically composed of white mica, quartz, carbonate, biotite and chlorite. The metalimestone have colors ranging from white to light gray, appear as a granulation rock composed basically of carbonate (50-60%), quartz and opaque, and fine white mica reeds. Some portions of the rock have a large percentage of opaque grains, which has two origins, altered carbonates and other minerals such as quartz and mica. White mica is dispersed between the grain boundaries of other minerals. Metasandstones are usually whitish, with granulation ranging from fine to medium sand. They consist essentially of

polygonised quartz, with small contributions of carbonates and white mica occurring between grain boundaries or defining micaceous bands.

The Casa de Pedra Mining is characterized by the occurrence of a centimeter layer between metasilites and metapelites, giving rise to a banded phyllite. Chlorite phyllites and metasilites occur as major lithologies. Chlorite is gray to dark gray in color, very fine grained and define a fine lamination locally recognized. Its basic composition is chlorite, white mica and less quartz, with chlorite predominating over white mica. Some chlorite and

carbonate porphyroblasts occur. The carbonates in surface samples are generally transformed into hydroxide, and fresh core samples have been found to overgrow Sn foliation. Another mineral that occurs very often in some portions is pyrite. The whitish to yellowish metasilites are very fine grained, basically composed of quartz clasts and chlorite porphyroblasts, which predominate over the matrix formed by white mica, chlorite and quartz. In this mining are recognized three metasedimentary successions, the bottom to the top: laminated metasilites with intersections of metadiamicite and ferrous metadiamicite.



**Fig. 11.** Orthogonal quartz veins type V3 in the Jatobá deposit open pit. A and B - veins with no apparent change in the host rocks; C and D - veins with euhedral quartz crystals and weathered hydrothermal alteration.

The Cuiabá Group comprises a thick metasedimentary pile accumulated on the southeastern bank of the Amazonian Craton and affected by the Brasiliano-Panafricano Orogenic Cycle. They form the basis for proposing a lithostratigraphic division of the Cuiabá Group in the Campina de Pedras, Acorizal and Coxipó formations. Along the Cangas-Poconé alignment (Fig. 12), an association of facies with predominance of dropstones, metarhythmites, with a strong magnetic signature, here denominated as facies Cangas in the middle portion of the Acorizal Formation, is recognized, having a probable chronocorrelation with the facies Engenho, both deposited under strong glacial influence.

This lithofacies occurs associated with (meta) conglomerates, sandstones and pelites and subordinate horizons of massive diamictites. The observed rocks are suggestive of accumulation in a glacially influenced marine environment, where metarhythmites are interpreted as deposited over a long period of deglaciation, sea-level eustatic elevation and release of coarse fragment from floating icebergs.

The sedimentary rocks were affected by regional metamorphism in green schist facies, reaching biotite zone, deformed in recumbent folds and subjected to intense hydrothermal activity, with remobilization of quartz veins, sericitization, sulfidation and gold-bearing fluids precipitation (Fig. 13). Gold mineralization is considered to be the product of a combination of factors, all contributing to the flow trapping of hydrothermal fluids, such as the low permeability of the hosting rocks. These rocks also reveal a texturally immature nature, with angular grains and recrystallized clay matrix such as muscovite and biotite. The textures observed were palimpsestic (blastopsephitic-psamitic), in which it is still possible to recognize a bimodal distribution of grain size. Metamorphic paragenesis, consisting of biotite – muscovite – K-feldspar – plagioclase – quartz, indicates conditions compatible with greenschist facies, biotite zone and the degree of alteration by hydrothermalism is evidenced by the presence sericite + magnetite + pyrite + carbonates.

The definition of a metallogenetic model for mineral deposits contributes essentially to direct resource applications in mineral research, to establish exploration strategies and to evaluate perspectives. The most common parameters used to classify them are: (i) host rock types; (ii) tectonic environment; (iii) mineralogical and metal association; and (iv) types and origin of the fluids present. These parameters provide subsidies to match new targets with deposits already well known in the (world class) literature and thus verify their economic potential by forecasting ore tonnages.

In this study, it was preferred to interpret the structural characteristics observed in the study area, indicating the

formation of gold deposits during the geological evolution of the Paraguay Strip, so that the mineralized veins are correlated with probably extensive Sn+2 structures. These features allowed to classify the studied deposits as orogenic to post-orogenic. In this tectonic context, the estimated temperatures suggest that the deposits are of the mesozonal type. The term orogenic gold deposits (Groves et al. 1998) is used in publications to describe a group of auriferous deposits widely interpreted as late in relation to an orogenic cycle to which they are spatially related. These should have been formed from metamorphic fluids originated in the middle to lower crust.

#### 4. Final considerations

The gold deposits located in the Cangas region are hosted in the rocks that make up the top of subunit 3 (according to Luz et al., 1980) and span approximately 1,200 m (in plant) thickness along the NE-SW regional region. Locally the Subunit 3 is represented by a sequence of graphite phyllites, metadiamictites, metasiltites, and metasandstones, as well as thin layers of high magnetite concentration.

The presence of gold in V3-type veins can be explained by the greater interaction between V3-forming fluids with the hosting rock during their vertical ascent due to the higher efficiency found in the rhythmic alternations of graphite and rich magnetite layers to destabilize the hydrothermal fluid and precipitate the ore. Therefore, mineralization has a lithological control as results of the host lithotypes, and a strong structural control because the higher gold content is concentrated in late veins at Dn of NW-SE direction.

Similar descriptions were made by Goldfarb et al. (1998) for gold occurrences in quartz veins hosted on sandstone alternating with phyllites in the Otago region (New Zealand) featuring a turbiditic sequence that differs from subunit 5 of the Cuiabá Group by the thickness of the alternations, but which could be favorable for gold deposition as phyllites (including graphites) can be highly reactive with mineralizing fluids and sandstones representing sites of higher porosity.

The acquired data set suggests that the gold deposits of the Cangas-Poconé lineament are similar to those described by Groves and Foster (1991) and Alm et al. (2003) who classified them as mesothermal and hosted in turbidites, respectively. This classification is based on the tectonic context and turbiditic nature of the host rocks. The study of outcrops in regional profiles, open mines for gold exploration and drilling holes in the Cangas-Poconé Alignment indicates that the preferential location of mineralization at Cangas facies suggests the existence of strong lithological control for gold mineralizations.

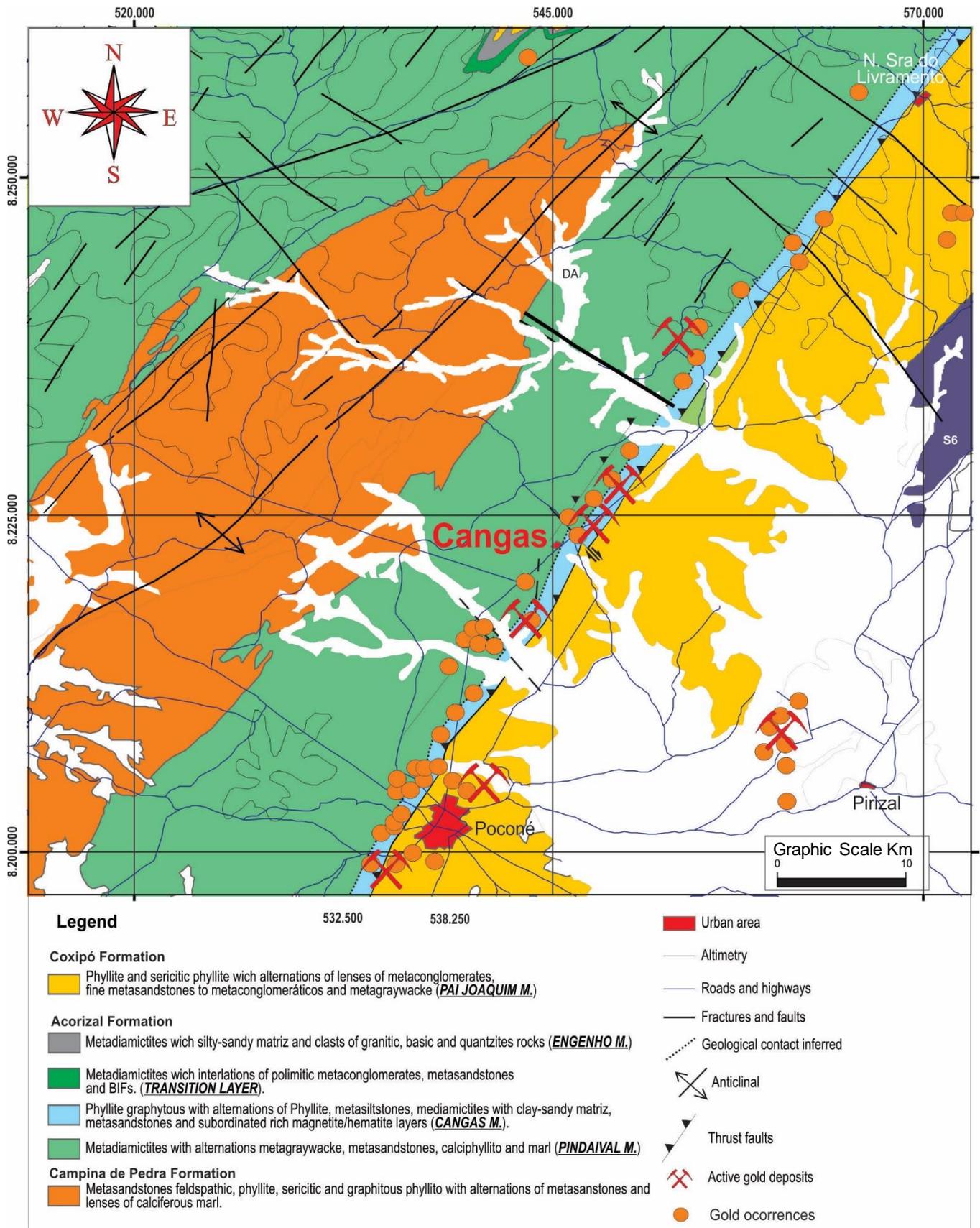
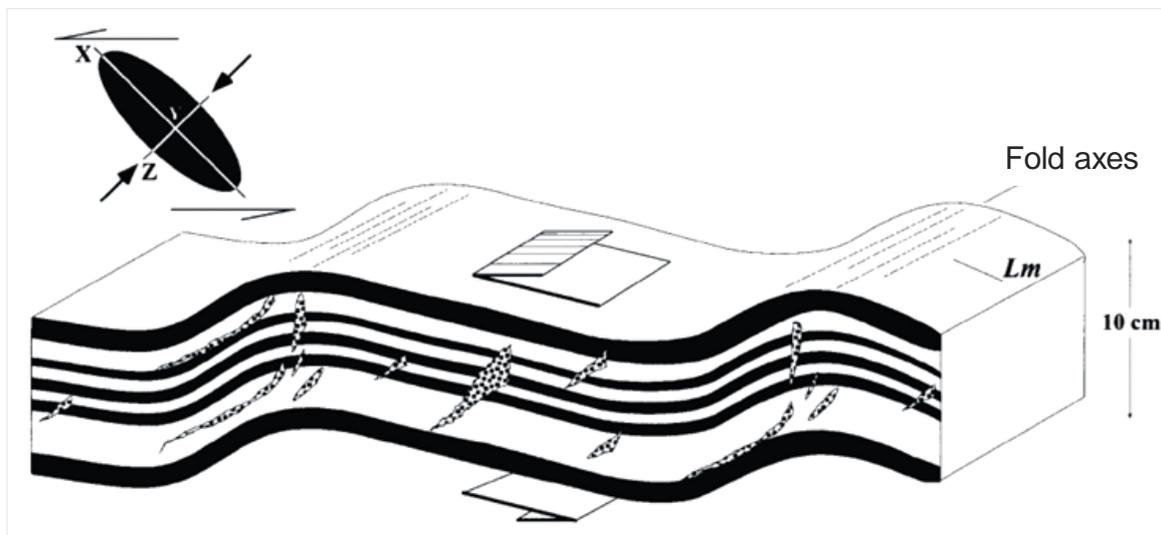


Fig. 12. Cangas-Poconé Alignment where the main gold deposits are located.



**Fig. 13.** Scheme of fluid migration from bedding to different one-fold domains in the ferrous quadrilateral (extracted from Hippertt et al., 2001).

The Cangas facies present low permeability of rhythmite, structural arrangement of permeability barriers S0 and S1 at high angle in relation to the fluid migration trajectory and mainly the presence of ferruginous levels acting as geochemical barriers for precipitation of metals in solution in the fluid. Thus, the lithological control allowed the trapping of sulfide and auriferous hydrothermal fluids.

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