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CONTEMPORARY RELATIONSHIP BETWEEN MINERAL DEPOSITS AND PALEO- AND MESOPROTEROZOIC OROGENIES IN THE SW AMAZONIAN CRATON

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Abstract. The study of SW part of the Amazonian craton mineral deposits suggests a strong correlation between the time period of the tectonic events and the formation age of mineral concentrations of economic importance. Mineral deposits include polymetallic veins, magmatic and VMS types. Paleoproterozoic terranes contain the Moriru Au deposit (related to felsic 1796-1773 Ma volcanic rocks), the Expedito Zn-Cu deposit (comprised of a thick pile of 1762-1755 Ma acidic to intermediate volcanic rocks) and the Cabaçal Zn-Au ore deposit (hosted by ca. 1750 Ma felsic volcanic and volcanoclastic rocks). Mesoproterozoic terranes contain the Puquio Norte Au deposit (hosted in Mesoproterozoic greenstone belt); the Rondônia Tin Province (comprised of bimodal intraplate rapakivi suites); and the Au deposits of Pontes e Lacerda (related to the occurrence of a 927-908 Ma NW-SE striking ductile shear zone).The Cachoeirinha, Santa Helena, Rio Alegre, Nova Brasilândia and Sunsás orogens have no associated mineral deposits reported up to now. The distribution of ore deposits through geological time allows defining the correlation between orogenic events and mineralizing processes. Both aspects are important tool to define a metalogenetic models of mineral deposits and thereby provide constraints for regional exploration.

Keywords. Amazonian craton, mineral deposits, Paleoproterozoic, Mesoproterozoic.

Resumo. Estudos de depósitos minerais no SW do cráton Amazônico sugerem uma forte correlação entre as idades dos eventos orogênicos e da formação dos depósitos minerais. Os depósitos minerais desta região incluem veios polimetálicos, depósitos de filiação magmática e vulcânica. Nos terrenos paleoproterozóicos observam-se o depósito de Au de Moriru (relacionado a rochas vulcânicas de idade 1796-1773 Ma), o depósito de Zn-Cu do Expedito (composto por uma espessa pilha de rochas vulcânicas ácidas de 1762-1755 Ma) e o depósito de Zn-Au de Cabaçal (encaixado em rochas vulcânicas de 1750 Ma). Os terrenos mesoproterozóicos incluem o depósito de Au de Puquio Norte (hospedado em greenstone belt mesoproterozóico); a Província Estanífera de Rondônia (composta por suites bimodais rapaquivíticas); e os depósitos auríferos da região de Pontes e Lacerda (relacionados ao cavalgamento Aguapeí de idade de ca. 927-908 Ma). Os orógenos Cachoeirinha, Santa Helena, Rio Alegre, Nova Brasilândia e Sunsás não apresentam depósitos minerais importantes. A distribuição de depósitos pelo tempo geológico define uma correlação entre os eventos tectônicos e os processos de mineralização. Ambos aspectos são importantes para a caracterização de modelos metalogenéticos para os depósitos minerais e contribuem com parâmetros para explorações regionais no SW do craton Amazônico.

Palavras-chave. Cráton Amazônico, depósitos minerais, Paleoproterzóico, Mesoproterozóico.

INTRODUCTION. Determination of radiometric dating of carefully selected rocks is important for testing metalogenetic models of mineral deposits of Precambrian shields. Nevertheless, the age, origin and isotopic signature of many mineralizations cannot be attributed to only one event either of primary formation or reworking, because the measured ages may reflect not only syngenetic mineralogy (Tassinari & Melito 1994), but also epigenetic hydrothermal overprint. On the other hand, the timing of mineral deposits may be constrained by direct radiometric dating key mineral phases, supported by precise geochronology of the host-rocks, and detailed information of the tectonic setting.

Several mineral deposits occur in the SW Amazonian craton, including the states of Rondônia and Mato Grosso (Brazil) and part of Bolivia (Souza 1988, Silva & Rizzoto 1994, Dardenne & Schobbenhaus 2000). Deposits of this region include polymetallic veins, magmatic and VMS types and the main mineral deposits are: the Moriru Au deposit; the Expedito Zn-Cu deposit; the Cabaçal Zn-Au deposit; the Puquio Norte Au deposit; the Rondônian Sn Province; and the Au deposits of Pontes e Lacerda region. Several minor occurrences are described in the region, such as the Au prospects in Rondônia and Mato Grosso states, and younger (Mesozoic) diamond deposits associated with the Juina (MT) and Colorado do Oeste (RO) kimberlites and sedimentary covers.

The tectonic environment provides a basis for understanding the distribution and origin of mineralization in space and time. In addition, the distribution of ore deposits through geological time allows defining the cor-

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relation between orogenic events and mineralizing processes (Tassinari *et al.* 1984). The determination of radiometric dating is an important tool in defining a metalogenetic models of mineral deposits. Although the age of many deposits cannot be attributed to only one cycle of formation, because the measured ages may reflect not only syngenetic ores (Tassinari & Melito 1994), but also epigenetic hydrothermal overprint. On the other hand, ages of mineral deposits may be constrained by direct radiometric dating and by considering the age of the host-rocks.

Four main accretionary periods (Tassinari & Macambira 1999) can be established for the continental crust evolution of the SW part of the Amazonian craton. According to the general evolution described by Teixeira *et al.* (1989), the region has been divided in geochronological provinces (Figure 1): the Ventuari-Tapajós (2.20 Ga to 2.0 Ga); the Rio Negro-Juruena (1.79 Ga to 1.52 Ga) comprising two orogenic cycles (the 1.79-1.74 Ga Alto Jauru and the 1.58-1.52 Ga Cachoeirinha orogens); the Rondônian-San Ignácio encompassing the 1.51-1.48 Ga Rio Alegre orogen, the 1.45-1.42 Ga Santa Helena orogen and the 1.41-1.32 Ga San Ignácio orogen. Finally, the youngest Sunsás province comprises metasedimentary sequences (1.1-1.0 Ga Nova Brasilândia and 1.0 Ga Aguapeí orogens), and granitoids (1.0 Ga Sunsás orogen).

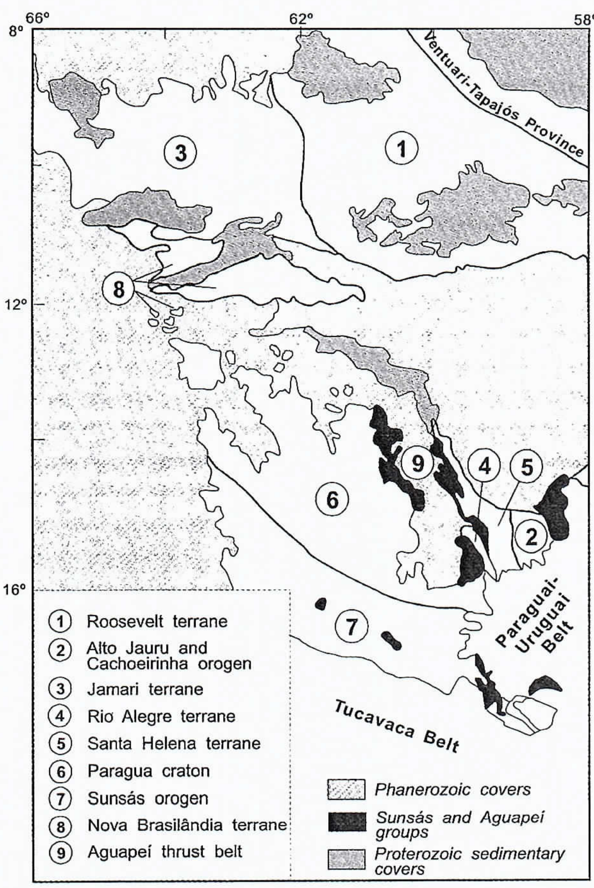

Figure 1. Simplified tectonic framework of the SW sector of the Amazonian craton. Modified after Scadolara *et al.* (1999), Bettencourt *et al.* (1999), Rizzoto (1999), Saes, (1999), and Geraldes (2000).

This study is a tentative of recognition of time-bond characteristics of the major SW Amazonian craton mineral deposits and their correlation with crustal accretionary processes. For this purpose we describe geologic characteristics about mineral deposits of this region, including type of mineralizations, tectonic setting, host-rocks and ages.

PALEOPROTEROZOIC. The Alto Jauru Orogen. The Zn-Au Cabaçal gold deposit is located in the SW Amazonian craton (Figure 2), Mato Grosso State, Brazil, where the Alto Jauru orogenic rocks (U-Pb ages from 1790 Ma to 1744 Ma) and Cachoeirinha orogenic rocks (U-Pb ages from 1580 Ma to 1520 Ma) occur (Van Schmus *et al.* 1999, Geraldes *et al.*, 2001a). The mineralization is hosted by felsic volcanic and volcanoclastic rocks and occurs as (Monteiro *et al.* 1988): (i) bands concordant with the mylonitic foliation, (ii) breccias, (iii) quartz-carbonate veins and (iv) disseminations. The ore is polymetallic and consists of chalcopyrite, pyrite, marcasite, pyrrhotite, sphalerite, and minor galena, bismuth, selenides and tellurites. The mineralization is related to hydrothermal alteration and includes quartz, chlorite, carbonate, sericite and biotite (Pinho 1996, Pinho *et al.* 1997).

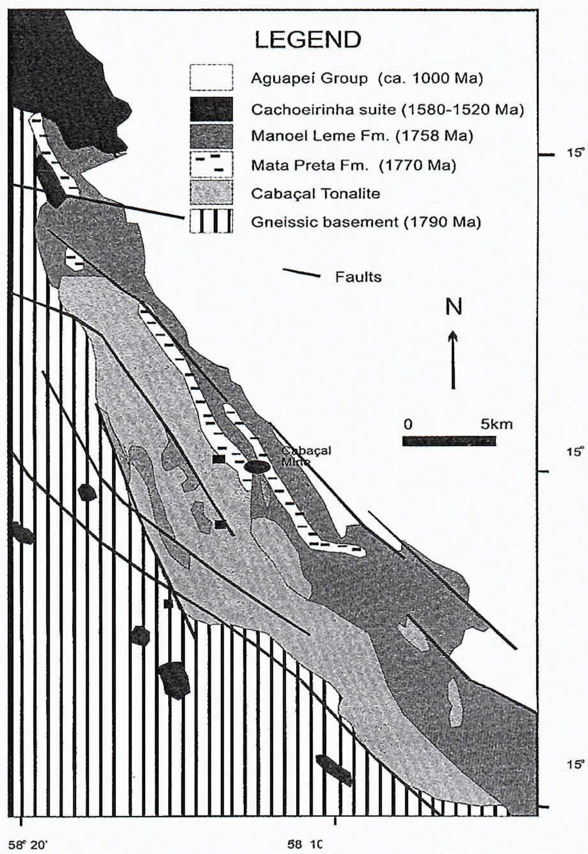

Figure 2. Geology of the Cabaçal Au/Pb deposit location.

According to Monteiro *et al.* (1988) the metavolcano sedimentary sequence may be characterized as a greenstone belt comprised of the Manoel Leme Formation (botton), Mata Preta Formation (top) intruded by granite, granodiorites and tonalities. Relatively few U-

Pb ages there exist from older rocks of the Alto Jauru rocks. Zircon grains recovered from a sample of banded silicic volcanoclastic metasediment from the Cabaçal gold mine yield an U-Pb age of 1758 ± 7 Ma, which is interpreted as the crystallization age of the volcanic rock; this age is probably close to the depositional time of the metasedimentary sequence (Van Schmus *et al.* 1999). U-Pb SHRIMP data reported for individual zircons from a metavolcanic unit in the area (Pinho *et al.* 1997) yield two age groups of 1769 ± 29 Ma and 1724 ± 30 Ma. These results are consistent with volcanism and deposition at ca. 1750 Ma, and could be related to the Alto Jauru geologic evolution. The Sm-Nd TDM model age of 1.87 Ga with εNd of +2.4 determined on these metasedimentary rocks indicates its source was largely juvenile at 1750 Ma (Geraldes *et al.* 2001a). The Alto Jauru metasedimentary sequence presents an extension to the Rondônia state represented by the Rossevelt terrane described by Scandolara *et al.* (1999). According to these authors rocks of the Roosevelt terrane yield U-Pb ages of about 1.75 Ga, similarly to the rocks or Alto Jauru region.

Detailed petrologic and geochemical investigations indicate that gold deposition is associated with metamorphic fluids that migrated along regional shear zones (Pinho *et al.* 1997, Monteiro *et al.* 1986). Sericite flakes from the hydrothermal zones were dated by the $^{40}Ar/^{39}Ar$ method (Geraldes *et al.* 2002), using laser step-heating dating in single grains. One sample from a bore hole 107m deep yield a plateau age of 1521.3 ± 1.3 Ma. Another sample 36.6 m deep yield a plateau age of 1510.4 ± 1.2 Ga. Taking into account these dates, previously reported K-Ar ages of these samples (1643 ± 78 Ma and 1615 ± 65 Ma, Toledo 1997) are probably meaningless.

Pb isotopic data for the Cabaçal gold deposit (Toledo 1997, Geraldes *et al.* 2002) allowed to determine a model age about 1.7 Ga for its formation and indicate two sources of Pb: one more radiogenic ($^{206}Pb/^{204}Pb$ from 15.941 to 16.600 and $^{207}Pb/^{204}Pb$ from 15.527 to 15.600) and other less radiogenic ($^{206}Pb/^{204}Pb$ from 15.650 to 15.843 and $^{207}Pb/^{204}Pb$ from 15.318 to 15.376). $^{87}Sr/^{86}Sr$ results have two signatures: concordant carbonate veins yield values from 0.705 to 0.7029 and discordant carbonate veins yield values from 0.7144 to 0.7119, also suggesting two sources or remobilization. These studies reveal that the Cabaçal gold deposit may have originated during the Alto Jauru orogen (1.79-1.74 Ga), having undergone later on an important remobilization process. With the available data is not possible to define if this second event was related to the late evolution of the Alto Jauru orogen, recorded by the 1724 ± 30 Ma U-Pb SHRIMP age, or linked to the Cachoeirinha orogen (1.58-1.52 Ga).

Cratonic Volcanic Covers. The Moriru Au deposit located in the NW of Mato Grosso state is hosted by acidic to intermediate volcanic rocks (Pinho *et al.* 2001) which are ascribed to an intra-plate event dated at 1796-1773 Ma (U-Pb in zircon). The mineralization is related to felsic volcanic rocks with intense hydrothermal alteration characterized by sericitization, chloritization, carbonatation and silicification. The mineralization is chiefly disseminated and comprises pyrite, chalcopyrite, galena and ilmenite with average content of 1.26 ppm of Au.

The geology of the Moriru region, within the Ventuari-Tapajós geochronological province (Figure 3), is composed of two domains: 1) undeformed bimodal volcanic rocks, and 2) deformed granitic-gneiss-migmatite rocks that also include a small occurrence of slightly

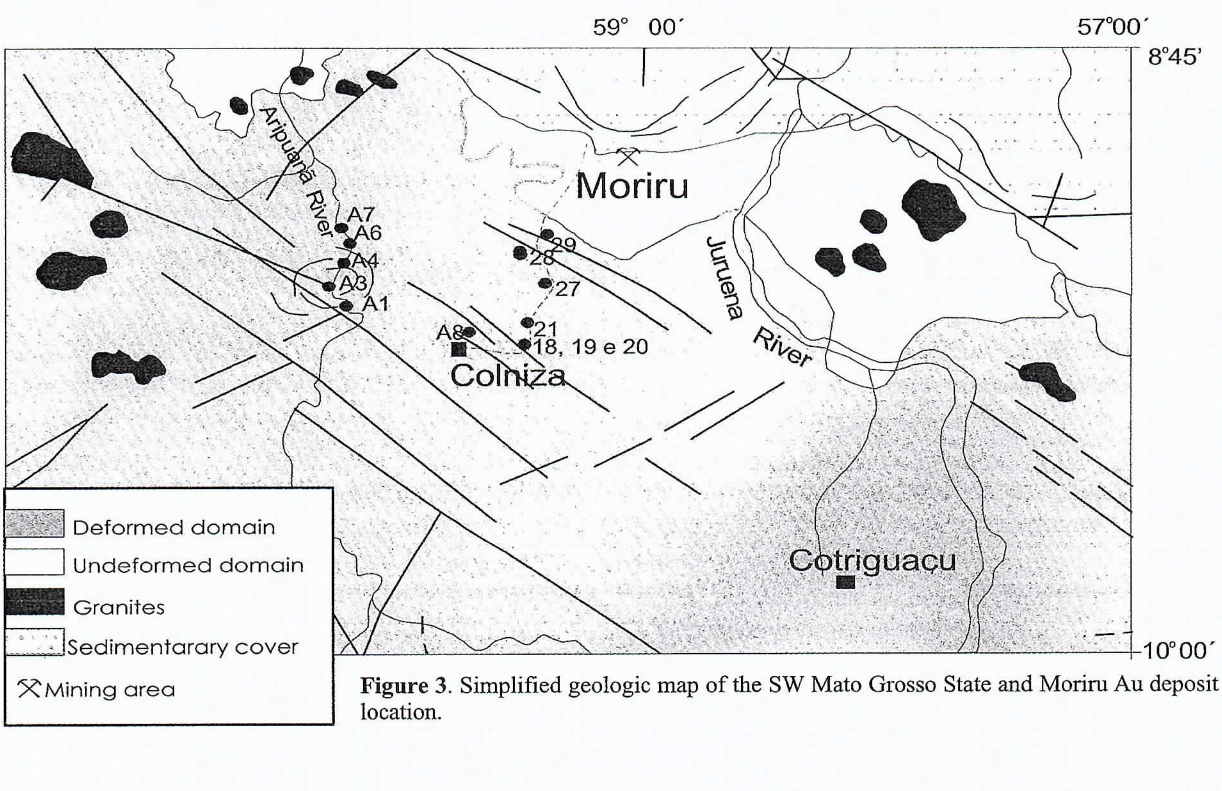

Figure 3. Simplified geologic map of the SW Mato Grosso State and Moriru Au deposit location.

deformed rhyolite. The undeformed domain is composed of felsic to mafic flows and volcanoclastic sediments; the felsic flows are essentially explosive deposits classified as ignimbrites, however coherent flows occurs interlayered. The composition of felsic flows are rhyodacite and dacite. Mafic flows are tholeiitic basalts and have within-plate petrological and gechemical characteristics. Felsic rocks are calc-alkaline in composition and ages ranging from 1.76 to 1.80 Ga and T_{DM} model ages range from 2.02 to 2.16 Ga (Pinho 2002).

Gold occurs associated with pyrite (90%) chalcopyrite (9%) and galena (1%). The sulfide zone occurs disseminated in a coarse grained granite which is completely replaced by hydrothermal minerals. The dominant process of hydrothermal alteration is sericitization which occurs pervasively in the volcanic felsic rocks and granite. The mineralized granite appears as a shallow intrusion coeval with the rhyodacite and dacite. Plagioclase change to carbonate due the alteration and neorformed albite is converted to white mica with the progress of the alteration. Silicification is the second most important type of alteration in the felsic rocks. This kind of alteration is present as veins cutting the rocks or around sulfides. Carbonates occur either altering pyroxenes and plagioclase or in veins of different directions. Basalts show propilitization with epidote, chlorite, albite, carbonate and magnetite as the main mineral association. These petrological patterns in the studied rocks allow to suggest that gold occur in two distinct phases: 1) in disseminated sulfide (grading into massive sulfide), and 2) as remobilization of the first stages filling veins and fractures in later stage. A simple model for the evolution of the area and the mineralization was proposed by Willians & McBirney (1979) and includes a composite volcano which contains mafic intrusive sills and a sub-vulcanic mineralized body in the central part of the volcano.

The Expedito Cu-Zn deposit (located 20 km northern from Aripuanã city; see Figure 4) occurs within a thick pile of acidic to intermediate volcanic rocks dated at 1762-1755 Ma (SHRIMP U-Pb zircon) (Neder *et al.* 2000 and 2002). The ore is hosted by dacitic lapilli and crystal tuff interlayered with massive dacitic porphyritic flows, carbonate and chert layers. The deposit consists of several discordant and discontinuous lenses of massive and disseminated pyrrhotite, pyrite, sphalerite, galena, chalcopyrite and arsenopyrite (Neder *et al.* 2000). The deposit is enveloped by a hydrothermal alteration halo consisting of chlorite, biotite and carbonate zones and it is interpreted of volcanic origin (VMS-type). The 40Ar/39Ar data determined by Neder *et al.* (2003) in amphibole and biotite from alteration halo over volcanic rocks yield 1580-1560 Ma, indicating an important remobilization that occurred in the volcanic rocks, which is responsible for Au concentration in shear zones and peculiar (amphibole) hydrothermal alteration. This hypothess is corroborated by the U-Pb ages of granitic intrusions of about 1.57 Ga (Rizzotto, personal communication).

MESOPROTEROZOIC. The Cachoeirinha Orogen. Granitic rocks of the Cachoeirinha orogenic event have widespread distribution (Figure 5) in the Jauru region, adjacent to the granite-greenstone terrane, where granitoid yield U-Pb ages of about 1580-1520 Ma (Tassinari *et al.* 2000, Geraldes *et al.* 2001a), constraining the timing of the Cachoeirinha orogen. Six Sm-Nd analyses in granitoid rocks of the Cachoeirinha suite yield TDM model ages of 1.88-1.75 Ga (εNd values of –0.8 to +1.0). In addition, three post-tectonic plutonic rocks yield U-Pb ages from 1485 Ma to 1389 Ma (TDM of 1.77-1.74 Ga and εNd values from –1.3 to +1.7).

Variations in major and trace elements of the

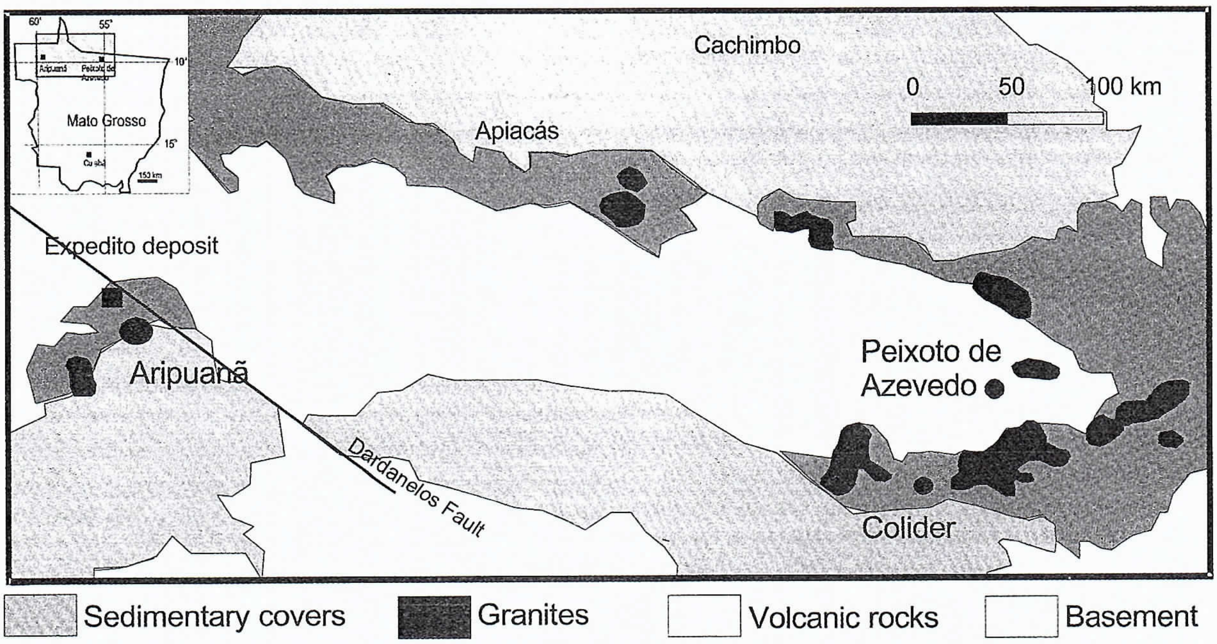

Figure 4. Simplified geologic map of th SW Amazônia Craton showing the Expedito Au-Cu deposit location.

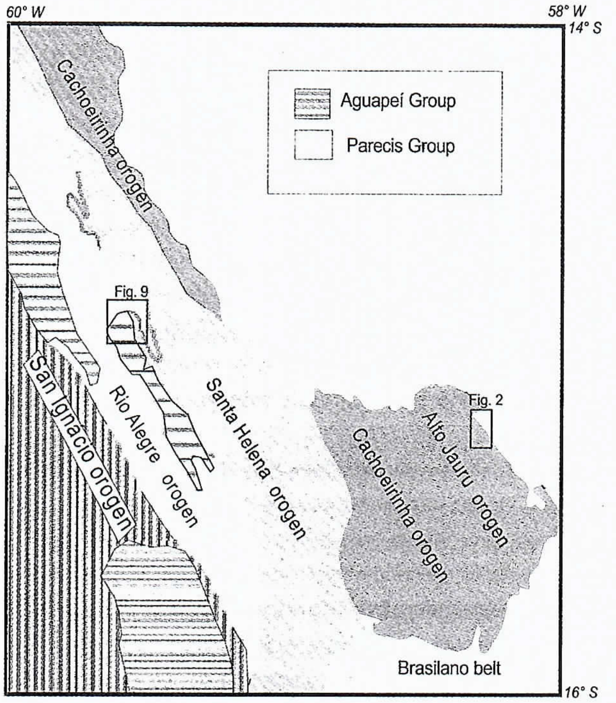

Figure 5. Simplified geologic map of the SW Mato Grosso State (SW Amazonian craton) showing the Alto Jauru, Cachoeirinha, Santa Helena, Rio Alegre orogens.

Cachoeirinha suite rocks indicate fractional crystallization process and magmatic arc geologic setting in agreement with the Nd juvenile signature of the investigated rocks. These results suggest the following interpretations: (1) The interval of 1590-1390 Ma represents an important magmatic activity in SW Amazonian Craton. (2) TDM and arc-related chemical affinity support the hypothesis that the rocks are genetically associated with a east-dipping subduction zone under the older (1.79-1.74 Ga) continental margin. Up to now, no mineral deposits are known to be related to this orogenic event.

The Rio Alegre Orogen. The volcano-sedimentary rocks of the Rio Alegre arc (Figure 5) comprise mafic and ultramafic volcanics, chemical sediments and mafic to felsic intrusions, metamorphosed to green-schist facies (Matos *et al.* 2001, Matos *et al.* 2004). Petrographic, chemical and isotopic studies allow to divide the unit into three formations: (1) The Minouro Formation (botton) comprising abundant mafic-ultramafic volcanic rocks (peridotites, olivine-gabros and serpentinites) and subvolcanic intrusive rocks associated with cherts and banded iron formations; chemical data indicate an ocean-floor tectonic setting for the origin of these rocks; (2) The Santa Isabel Formation (middle) comprising intermediate and acid lavas and pyroclastic rocks. Chemical results suggest the origin of their magma generated in an island arc setting (Matos *et al.* 2001); (3) The São Fabiano Formation (top) is composed of metasedimentary rocks with chemical signature similar to that of the volcanic rocks, suggesting that the latter are the source of the metasedimentary rocks. According to Matos *et al.* (2004), associated mafic-ultramafic intrusive rocks are differentiated gabbroic rocks and serpentinites and chemical data indicated the influence of the fractional crystallization process in the evolution of these rocks. U-Pb zircon dating in these rocks yield ages from 1509 Ma to 1494 Ma. Sm-Nd data (TDM of 1.67 Ga to 1.48 Ga and εNd(t) values of +4.5 to +2.5) suggest also a mantle-derived magma. U-Pb zircon analyses carried out in associated intrusive mafic and felsic rocks yield ages of 1.48-1.46 Ga. TDM ages vary from 1.53 Ga to 1.50 Ga and εNd(t) values from +3.7 to +4.1 suggesting a magmatic arc environment for their generation.

The lithologic association, chemical and isotopic evidence suggest that volcanic and subvolcanic mafic and ultramafic rocks originated in back-arc or ocean ridge tectonic setting; mafic to intermediate rocks were formed in an island arc tectonic setting at 1.51-1.50 Ga. These rocks were subsequently intruded by mafic and felsic rocks originated (1.48-1.46 Ga) in a magmatic arc setting. Metamorphism under green-schist to lower amphibolitic facies (biotite zone to garnet-kyanite zone), and mylonitization (N20°W foliation) were associated with the collision of the arc against the Amazonian craton during Mesoproterozoic times, according to $^{40}Ar/^{39}Ar$ data reported by Tovher *et al.* (2000) which ages indicate a metamorphic cooling ages of about 1.34 Ga.

There is not any reference to extensive exploration work carried on this terrane. However, it is important to remark that the rock association related to an ocean floor expansion is most favorable for metalic occurrences such as Au, Cu, Ni, PGE and associated metals. This assertion is corroborated by the presence of extensive banded iron-formations, cherts, and gossan (Neder *et al.* 1984) and superficial Ni concentrations as in Morro do Leme and Morro Sem Boné (Colorado-MT), where garnieritic mineralization presents 1.4% of Ni (Angeli 1997).

The Santa Helena Orogen. Mesoproterozoic country rocks ascribed to Santa Helena orogen (Figure 4) were firstly recognized by Saes *et al.* (1984), who coined the term Santa Helena batholith for the granitic rocks. Later on, these granites were studied in a more detailed level by Menezes *et al.* (1993) and Lopes *et al.* (1992) and based on geochemical data, they renamed the batholith as Santa Helena Granite-gneiss, and classified the rock associations as intraplate A-type granites.

Additional geological, geochemical and geochronological studies on this unit carried out by Lopes *et al.* (1992) and Geraldes *et al.* (2001a), made it possible to recognize an igneous suite and propose the term Santa Helena Suite. These authors characterized a calc-alkaline arc-related suite of 1480 to 1420 Ma (U-Pb ages) to supersede the former names. The extensive arc-related magmatism, high grade metamorphism together with the new U-Pb ages provided a consistent documentation for this event, and no mineralization related to this units has been reported.

The San Ignácio Orogen. The San Ignácio cycle was first proposed by Litherland & Bloomfield (1981) and later on discussed at length by Litherland *et al.* (1986 and 1989) and Darbyshire (2000) covêring na important área in Bolívia (Figure 6). According to them, the formation of the San Ignácio Group (Rb-Sr metamorphic age of 1344 ± 18 Ma) was accompanied by a significant syn to post-tectonic granitoid magmatism represented by potassic calc-alkaline complex (Rb-Sr ages about 1.32 to 1.28 Ga) and by the El Tigre alkaline Complex (1286 ± 46 Ma). The San Ignácio Orogeny is an important spatial magmatism over eastern Bolivia, where the c.a. 1300 Ma orogenic dates are preserved in both Rb-Sr and K-Ar system. This age is not well constrained, once the datapoints include samples of diferents units (regional isochron). The presence of these rocks allowed to the authors to propose the existence of the Parágua Craton, comprised of paleoproterozoic rocks sorrounded by the younger San Ignácio belt.

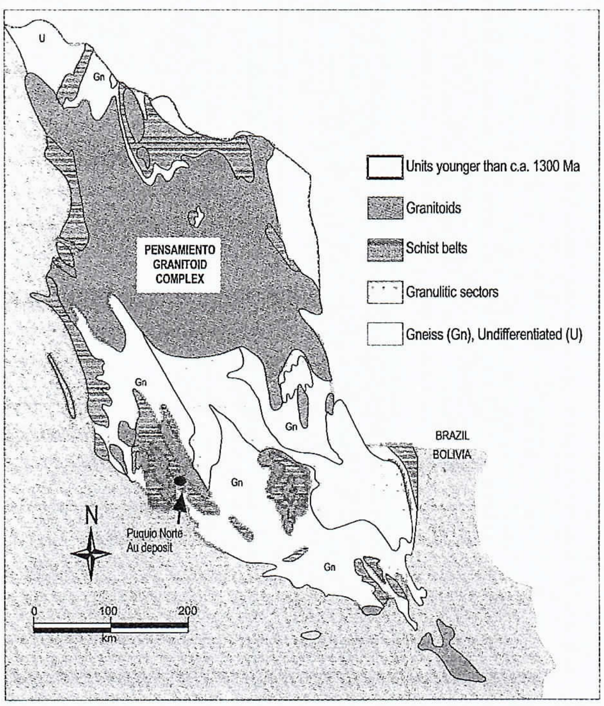

Figure 6. Major geological units of the San Ignácio schist belts eastern Bolivia, modified after Litherland *et al.* (1986). The El Tigre alkaline complex and Naranjal Group are included in the Granitoid unit. Puquio Norte Au deposit location is also shown.

Within the San Ignácio Group are found the *greenstone belts* of Guarayos, Puquio Norte, Zapoco and Nuflo Chavez (Sáens 2002b). According to Litherland *et al.* (1986) the basement of San Ignácio orogen are represented by gneissic and granulitic rocks with Rb-Sr ages of about 1.9 Ga. According to Saens (2002a) the Puquio Norte greenstone belt is located in the southwestern sector of Bolivia within the San Ignácio schist domain (Figure 6) and presents the main gold deposit (completely mined out) reported in Bolivian Precambrian. Other Au prospects include Guarayos, San Javier, Al Toro and Dom Mario. Puquio Norte deposit is hosted by volcano-sedimentary rocks comprising schists, komatiitic basalts, chert, BIF and tholeitic pillow lavas. The Naranjal group occurs locally and consists of black shales, carbonatic filites, hematite banded iron formation and pelites metamorphosed at green-schist fácies. These rocks show vertical foliation and milky secondary quartz parallel to the bedding. Deformed quartz-veins and sulfide-veins indicate that mineralizing solutions were coeval to the deformational processes and gold precipitation restricted within filite country rocks was stratigraphically controlled by the banded-iron formations.

The Sunsás Orogen. According to Litherland *et al.* (1986), the Sunsás granitoids occur in Bolívia (Figure 7) and include both syn- to late-kynematic granitoids related to shear zones and late to post-kynematic types. According to these authors, syn- to late-kynematic types, are mainly medium to coarse-grained biotite or biotite-muscovite syenogranites. The granitoids may show gradational contacts with nebulitic Sunsás migmatites gneisses, foliated margins or mylonitic zones as a result of frictional melting. The observed units are: Espiritu Granite, Santa Catalina Zone Granites, Las Palmas Granitoids, La Palca granitoids, San Miguel Granite, Motacucito Granite, San Pablo Granite, El Carmen Granite, and Nomoca Granodiorite. There are also few syn-kynematic granitoids, which resemble deformed intrusive plutons such as La Palca granitoids of tonalitic composition and Nomoca Granodiorite, and subordinate monzonites and trondjhemites. According to Saes & Fragoso César (1998), several granitic intrusions within Sunsás province represent the record of a subduction zone evolved during the colision between the Amazonia and Laurentia during the amalgamation of the Rodinia supercontinent.

The late to post-tectonic granitoids are aligned within the Sunsás Orogen across the San Diablo shear zone (Figure 7) and are represented by the Casa de Piedra Granites, Talcoso and Tapéras Granites, and Salinas and Tasseoro Granites, and also in the southeast fringe by the San Pablo Granodiorite, and Luma Granite, but data are sparse about these bodies, and further studies are needed. They are circular intrusive contacts and little or no signs of internal foliation and dominantly medium to coarse-grained biotite monzogranites. The age measurements are still fragmentary and only the Casa de Piedra Granite dated (Rb-Sr isochron of 1005 ± 12 Ma). According to Teixeira and Tassinari (1984), the K-Ar and Rb-Sr ages of the Sunsás granitoids (reported by Litherland *et al.* 1986) are in good agreement with those obtained for the Young Granites of Rondônia in Brazil.

Most of the mineralizations of the Sunsás Orogeny are associated with pegmatite bodies and aplite veins related to post-tectonic granites, which emplacement affected the country schist rocks (Litherland

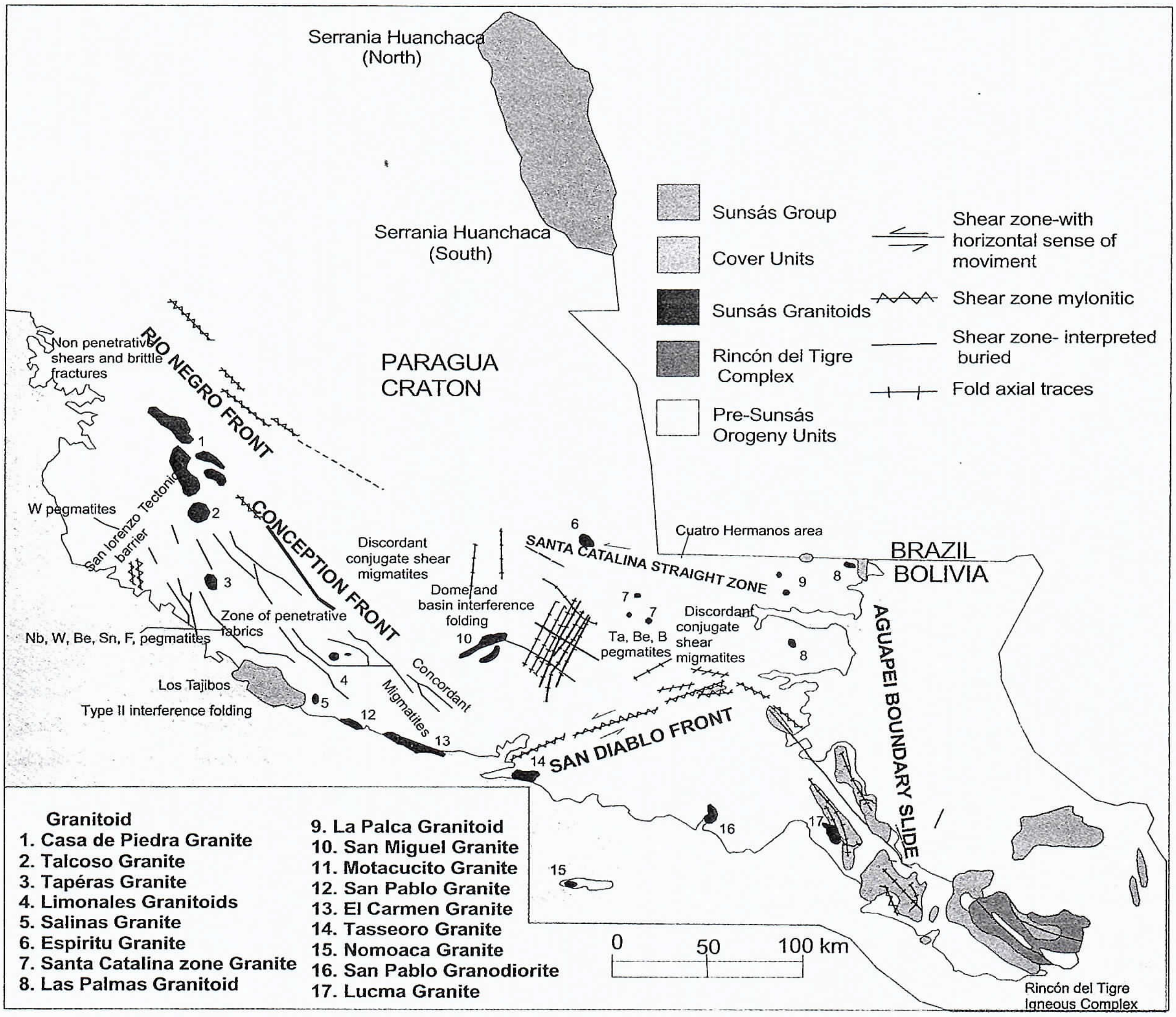

Figure 7. Main units of the ca. 1000 Ma Sunsás Orogeny in eastern Bolivia, modified after Litherland *et al.* (1986).

et al. 1986). The pegmatites are of simple to complex composition, show a regional zoning, varying from tantalite-beryl to columbite-scheelite-beryl-topaz and cassiterite-topaz-fluorite-scheelite. Tin mineralization is reported in the Ascension de Guarayos tin field where it is associated with pegmatites of Sunsás age (1000 Ma), quartz vein and incipient greisenization. In this area, the staniferous pegmatites are related to a syn to late-kinematic granites and to the adjacent metasedimentary rocks.

Columbite and tantalite have been recovered from two pegmatite fields: La Rella and Los Patos. Complex zoned pegmatites containing columbite, beryl, muscovite, traces of cassiterite, scheelite and topaz occur in the first sector. In the second one, only steeply deeping lenticular pegmatite bodies yield tantalite, beryl and muscovite. Beryl occurs as discordant bodies within muscovite-schists. Accessory pyrochlore occurs in the plutonic rocks and dykes of the Sunsás alkaline complexes. Lanthanides as well as ytrium and scandium are found in pyrochlore, fergusonite, samarskite and euxenite in pegmatites, as well in cerite and cerianite. Major amounts of monazite are found in placer deposits and bastnaesite is recovered from carbonatites (Litherland *et al.* 1986).

Nova Brasilândia Orogen. The name Nova Brasilândia metavolcano-sedimentary sequence (Figure 8) was first introduced by Silva *et al.* (1992) for a group of amphibolite-facies metamorphites represented by mica-quartz schists, biotite paragneiss, calc-silicated rocks, and amphibolites whitin the Jamari terrane (Rondônia state). These rocks occur within the Nova Brasilândia and Alta Floresta region (SE Rondônia), formerly recognized and coined Comemoração Epimetamorphites by Leal *et al.* (1978). More recently it was well documented by Rizzoto (1999) and Rizzotto *et al.* (1999) and the whole sequence was redefined as a distinct tectonic unit with limits extending to the NE and SE regions of the state of Rondônia.

Based on detailed geological and reconnaissance U-Pb and SHRIMP geochronological data, Rizzoto (1999) coined the name Nova Brasilândia Group to embrace a main lithostratigraphic unit encompassing amphibolite facies, dominantly mafic association (metagabbro, metadiabase and amphibolite), a metaplutonic-sedimentary sequence (biotite-feldspar quartz gneisses, mica schists and calc-silicate rocks), intruded by several high-

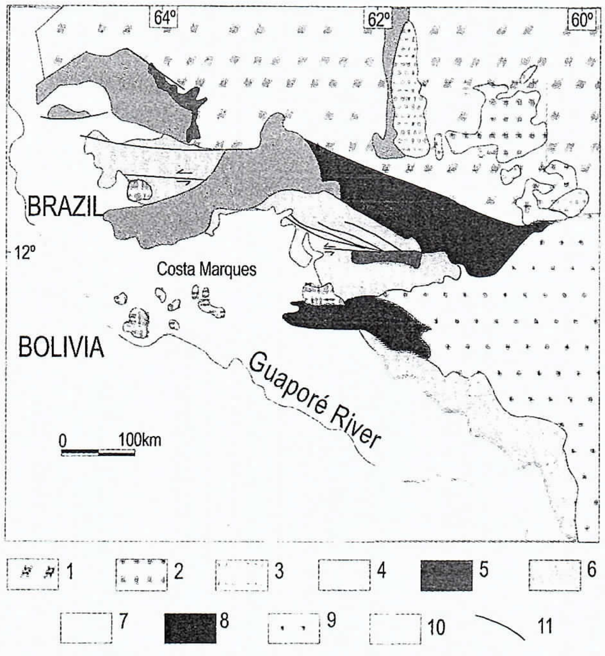

Figure 8. Major units of the Nova Brasilândia Group. (1) Jamari Terrane; (2) Roosevelt terrane; (3) Serra da Providência Intrusive suite; (4) Nova Brasilândia volcanosedimentary sequence; (5) Mafic rocks; (6) Undeformed Sunsás sedimentary cover; (Late-to post-tectonic granitoids); (8) Paleozoic cover; (9) Mesozoic cover; (10) Recent cover; and (11) Faults.

level late tectonic A-type granite plutons. However, the informal name Nova Brasilândia Terrane was proposed by Scandolara *et al.*, (1999) to supersede the terms previously applied to these rocks.

Accretion of juvenile material related to a intracontinental rifting and a proto-ocean floor expansion, granite plutonism and thermal effects suggesting a continental margin arc, were interpreted by Rizzoto (1999) as correlated to the Sunsás Orogeny of Litherland *et al.* (1986). According to Rizzoto (1999), the Nova Brasilandia Group is the host of mineralized areas and Au, PGE, Pt, Ni, Zn and Sn ocurrences which were identified during a exploration program carried out by CPRM (Companhia de Pesquisa de Recursos Minerais), Projeto platina (Rizzoto 1999). The main types of mineralization include the following: a) Dissemined Au either in metamafic rocks or associated to shear zones in metasedimentary rocks; b) Ni-Cu sulphides and PGE associated to mafic bodies either as disseminations or microfractures infill. The main sulphide phases are represented by pyrite, pyrrhotite and smaller amounts of chalcopyrite, pentlandite, violarite, bravoite, arsenopyrite and cobaltite; c) Centimetric to metric Au-quartz veins controlled by NW-SE regional trending and N40E microfactures, associated with hydrothermally altered paragneiss.

It seems clear that the mantle-related mafic rocks and regional shear zones favored the concentration of Ni-Cu sulphides, PGE and Au, respectivelly, and would be targets for regional exploration. The clearer understanding of the bedrocks geology may contribuite for a more favorable interpretation and certainly stimulate a ressurgence in most sucessful exploration.

Anorogenic Granites in Rondônia (The Rondônia Tin Province). The magmatism ascribed to the Rondônian event in the Rondônia Tin Province (Figure 9) comprises bimodal intraplate rapakivi suites intruded in the ca. 1.75-1.53 Ga Rio Negro/Juruena crust (Bettencourt *et al.* 1999). The magmatism episodes are defined by U-Pb geochronology and represented by the following suites: the Santo Antônio-Teotônio (1406 Ma), Alto Candeias (1347 to 1338 Ma) and São Lourenço-Caripunas (1314 to 1309 Ma), Santa Clara Intrusive suite (1082 Ma); and Younger Granites of Rondônia (998 Ma to 991 Ma).

The Sunsás orogen in northern Rondônia region and adjacent areas (Mato Grosso and Amazonas states) spanned from 1.15 to 0.97 Ga. It includes mainly metamorphic imprint and deformation from 1156 to 1100 Ma and emplacement of rapakivi granites, mafic dikes and plutons between 1080 to 970 Ma in rocks of older geochronological provinces resulting in economically important Sn anomalies. The magmatism at 1080-997 Ma in northern Rondônia is composed of rapakivi granites and associated mafic rocks, including the Santa Clara Intrusive suite (1.07-1.08 Ga) and Younger Granites of Rondônia (1.0-0.97 Ga).

The Sn mineralization comprises cassiterite-rich greisen related to granites which compositions are mostly subalkaline, metaluminous to peraluminous and show geochemical features of A-type within-plate granites (Bettencourt *et al.* 1999). The main Sn regional mineralizations are related to the Santa Clara Intrusive suite, which encompasses the granites from the following massifs: Santa Clara, Oriente Velho, Oriente Novo, and Manteiga. The older rock association is composed of porphyritic quartz-monzonite, monzonite and syenogranite with subordinate amounts of quartz-monzonite and less pyterlite. Biotite and minor hornblende are the main mafic minerals and zircon, apatite, ilmenite, magnetite, allanite, fluorite and sphene are accessoryl minerals. A younger association includes syenite, trachyte and peraluminous and peralkaline granites.

Isotopic analysis carried out in the granites related to tin mineralizations allow important constraints on their origin. The Younger Granites of Rondônia shows $\varepsilon_{Nd(t)}$ values of +0.33 to −3.25, T_{DM} between 1.66 to 1.73 Ga, $Sr_{(i)}$ in the range of 0.707 to 0.709, $\delta^{18}O$= +81 to 9.5 ‰ and has $^{206}Pb/^{204}Pb$ of 17.7-20.6 and $^{208}Pb/^{204}Pb$ of 37.3-43.2 indicating that older crustal rocks were clearly involved in granite genesis. Oxygen isotopes indicate a calc-alkaline magma component or assimilation of high-level crustal material (Bettencourt *et al.* 1999). $^{40}Ar/^{39}Ar$ plateau ages on hornblende foliated granitic gneisses and augengneiss provided by Bettencourt *et al.* (1996) defined ages of 1156.2 ± 36 Ma and 1149.8 ± 35.5 Ma., respectively and suggest a Sunsás metamorphic overprint. The progressively slightly younger dates obtained on

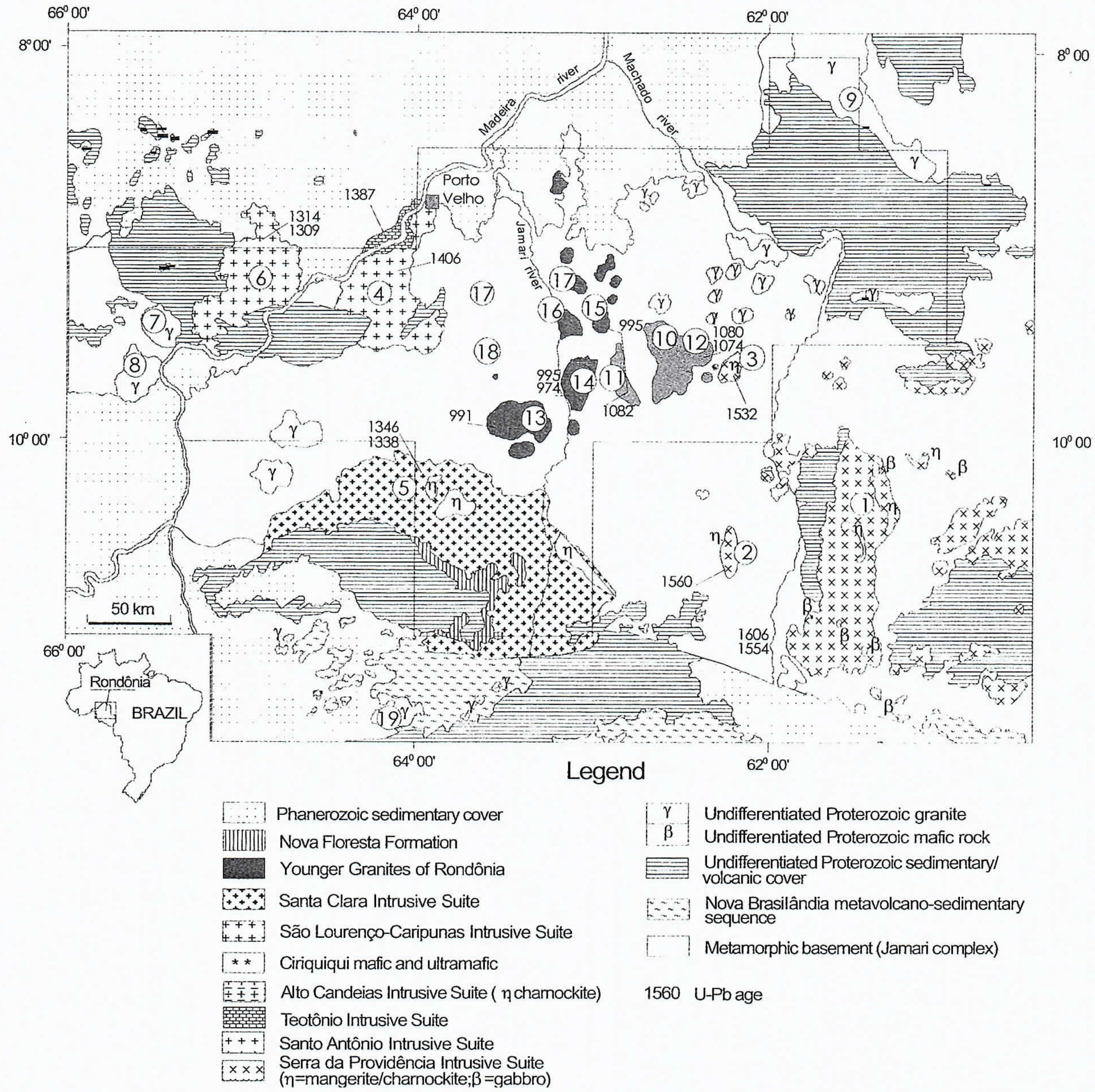

Figure 9. Simplified geologic map of Rondônia Tin Province and adjacent areas, showing a distribuition of 1.6 to 0.97 Ga rapakivi granite suites: 1. Serra da Providência Batholith; 2. Ouro Preto Charnockite; 3. União Massif; 4. Santo Antonio Batholith; 5. Alto Candeias Batholith; 6. São Lourenço-Caripunas Batholith; 7. São Simão Massif; 8. Abunã Massif; 9. Igarapé Preto Massif; 10. Santa Clara Massif; 11. Manteiga massif; 12. Oriente Novo massif; 13. Massangana Massif; 14. São Carlos Massif; 15. Pedra Branca Massif; 16. Caritianas Massif; 17. Santa Barbara Massif; 18. Bom Futuro hill and Palanqueta hill; 19. Costa Marques Group. Modified from Leal *et al.* (1978) and Bettencourt *et al.* (1999).

the biotite, 1001.5 ± 33 Ma and 912.8 ± 30.5 Ma, and more feldspar (antiphertite), record slow cooling rates during the proposed metamorphism and are consistent with K-Ar ages observed in the Younger Granites of Rondônia.

The Aguapei Thrust. The Sunsás Cycle was characterized by an important continental distension followed by an alkaline plutonism and the deposition of the Sunsás and Vibosi groups (constrained by Litherland *et al.* 1986, about 1300-950 Ma) and probably represent a extension of the same basin of Aguapei Group in Brazil (Saes 1999). According to Souza and Hildred (1980) and Saes *et al.* (1991), the Aguapei Group includes three formations: a sandstone and conglomerate unit (Fortuna Formation); an intermediary pelitic unit (Vale da Promissão Formation) and an upper sandstone unit (Morro Cristalino Formation). The sequence of the Aguapei Group records a complete cratonic oscillation, with a (1) transgressive phase with tide-dominated deposition of sandstone and conglomerate deposition. (2) a marine progradation allowing the psamitic deposition in na oceanic, current-dominated environment. (3) an upper unit recording a marine regression with deposition of sandstones in a fluvial system.

Gold deposits in the region of Pontes e Lacerda (MT) (see Figure 10) have been exploited in the SW Amazonian Craton from placer, lateritic and hydrothermal quartz vein deposits (Souza 1988, Saes *et al.* 1991 and

Silva & Rizzoto 1994). Statistics of Mineral Production National Department (DNPM 1995), indicate a production of gold of about 5 ton between 1991 and 1993. The gold ore bodies are hosted in contact of Aguapeí Group rocks and the basement represented by metavolcanic, gneiss-granite, quartzite, tonalite and granite units. Tectonics involved oblique overthrusting (from NE to SW which led to formation of recumbent folds and thrusts (pathways for the mineralizing fluids), upright folds and faults with dominant strike-slip component. These unconfomities are potential sites for mineralization as in the main exploted deposits reported: São Vicente deposit (Scabora & Duarte 1998), Lavrinha deposit (Costa Neto 1996) and Pau-a-Pique deposit (Fernandes 1999).

The sulfur stable isotope values of the Pontes e Lacerda gold deposits range from +1.0 to +5.5‰ in vein-hosted and from +8.9 to +11.6 ‰ in quartzite-hosted pyrites (Aguapei Group metasedimentary rocks) suggesting a mixing of sedimentary sulfur of probable biogenic origin with sulfur probably from mafic ultramafic metamorphic rocks of the Rio Alegre metavolcanosedimentar sequence (Geraldes *et al.* 2001b). The K-Ar dating of hydrothermal sericites from gold deposits veins yield ages in the range 960 to 840 Ma which may indicate the age of original crystallization of sericite. $^{40}Ar/^{39}Ar$ ages obtained in sericite of the hydrothermal veins in the Pau-a-Pique and Ellus deposits, northern and southern portions of the Corredor Shear Zone, showed 908.1 ± 0.9 Ma and 927 ± 1 Ma for mineralization (Fernandes *et al.* 2003). Pb-Pb dating in galena yield model ages in the range 1000 to 800 Ma for the Onça deposit, in agreement with K-Ar ages. These ages indicate hydrothermal fluids circulation in the Aguapeí Group metasedimentary rocks during the final stage of the Aguapeí thust, suggesting an orogenetic origin for those deposits. The Pontes e Lacerda gold deposits yelded ages correlated to Aguapei event and they were probably formed during a Proterozoic contractional tectonic period in SW part of Amazonian Craton (Geraldes *et al.* 1997), which characterizes an important metallogenic epoch in the Pontes e Lacerda region.

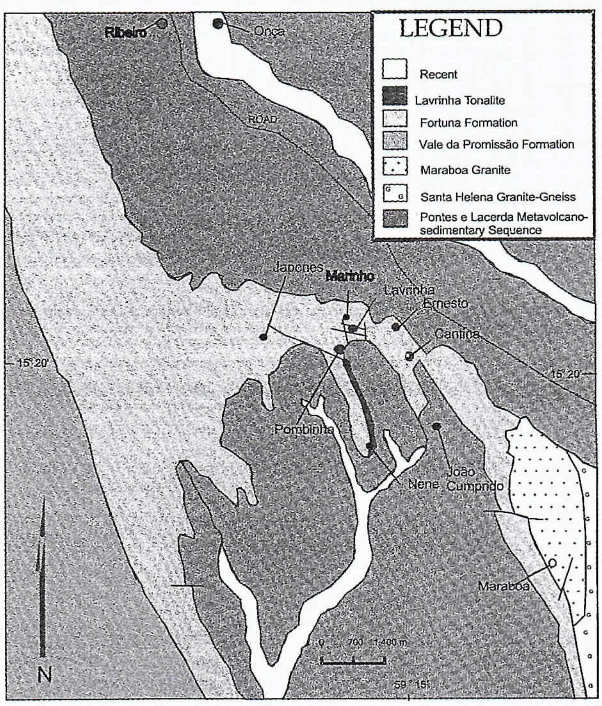

Figure 10. Major Au deposits of the Lavrinha area within the Aguapeí thrust belt. The deposit São Vicente (northern) and Pau-a-Pique and Ellus (southern) are nor shown in the map.

CONCLUSIONS. The SW part of the Amazonian craton is a multi-orogen region formed between 1.8 and 1.0 Ga, which experienced intraplate, recurrent magmatism, meta morphism and deformation. Such a framework was responsible for originating mineral concentrations in time and space. The results here presented suggest a strong correlation between the time period of the tectonic events and the formation age of mineral concentrations of economic importance (Figure 11). In this way, each geologic environment is characterized by specific mineral deposit type and thereby provides constraints for regional exploration. According to the geologic informations here reported we may suggest the following concluding remarks: a) Mineral deposits in SW Amazonian Craton include important economic ores characterized by polymetallic veins, magmatic and VMS types; b) The Moriru Au deposit mineralization is chiefly disseminated and comprises pyrite, chalcopyrite, galena and ilmenite. Mineralizing processes are related to felsic volcanic rocks with intense hydrothermal alteration (sericitization, chloritization, cabonatation and silicification). Correlated acidic to intermediary volcanic rocks are ascribed to intraplate event compriesed of bimodal magmatism dated by U-Pb at 1796-1773 Ma (U-Pb in zircon); c) The Expedito Zn-Cu deposit consists of several discordant and discontinuous lenses of massive and disseminated pyrrhotite, pyrite, sphalerite, galena, chalcopyrite and arsenopyrite. These deposits are enveloped by a hydrothermal alteration halo consisting of chlorite, biotite and carbonate zones and occurs within a thick pile of acidic to intermediate volcanic rocks dated at 1762-1755 Ma (U-Pb zircon analyzed by SHRIMP); d) The Cabaçal Zn-Au ore deposit is polymetalic and comprised of chalcopyrite, pyrite, marcasite, pyrrhotite, sphalerite, and minor galena, bismuth, selenides and tellurites. The mineralization is hosted by felsic volcanic and volcanoclastic rocks and occurs as (i) bands concordant with the mylonitic foliation, (ii) breccias, (iii) quartz-carbonate veins and (iv) dissemination. The mineralization is related to hydrothermal alteration and includes quartz, chlorite, carbonate, sericite and biotite. U-Pb SHRIMP data reported in the literature for individual zircons from a metavolcanic unit in the area yield two age grouping of 1769 ± 29 Ma and 1724 ± 30 Ma; e) The available data allow to identify the correlation between the continental volcanism dated at 1.79-1.75 Ga with Au (Moriru) and Cu-Zn-Au (Aripuanã) mineralizations of VMS-type. In contrast, the

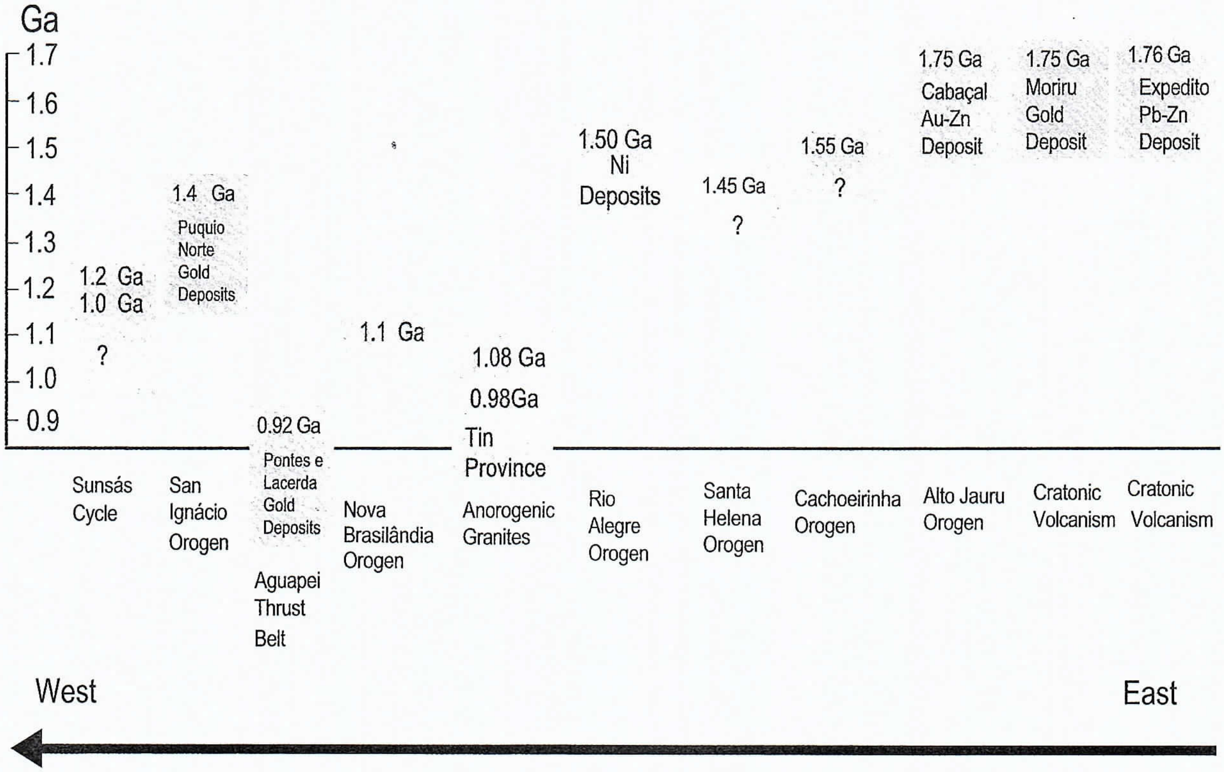

Figure 11. Chart correlating orogens and mineral deposits of the SW Amazônia Craton.

Cabaçal Zn-Au deposit was formed coeval to an orogenic event characterized by lateral (juvenile) accretion during the evolution of 1.79-1.74 Ga Alto Jauru island arcs; f) The Puquio Norte Au deposit is located in the southwestern sector of Bolivia and it consists of quartz and sulphides-veins hosted in banded iron formations of the greenstone belt terrain probably formed during the San Ignácio orogen (1600 to 1280 Ma). The host-rocks are comprised of low to medium grade carbonatic shales, hematite banded iron formation and pelites metamorphosed at green-schist facies. Both ore and host-rocks show vertical foliation and the mineralization is correlated to zoned hydrothermal activities; g) The Rondônia Tin Province is comprised of bimodal intraplate rapakivi suites (the Santa Clara Intrusive suite and Younger Granites of Rondônia) intruded in the ca. 1.75-1.53 Ga Rio Negro/Juruena crust. The economically important Sn anomalies involve cassiterite-rich greisen related to magmatic episodes defined by U-Pb at 1080-997 Ma and 998-991 Ma. Isotopic data of the granites related to tin mineralizations indicate that older crustal rocks are clearly involved in granite genesis; h) The Au deposits of Pontes e Lacerda region are related the occurrence of a NW-SE striking ductile shear zone along which volcanic and sedimentary rocks of the Rio Alegre orogenic rocks overthrusted clastic sedimentary rocks of the Aguapeí Group, as part of a continental tectonic event (Aguapeí-Sunsás Event). This low-angle tectonics was followed by folding, faulting and local transcurrent movements of dextral character. $^{40}Ar/^{39}Ar$ ages obtained in sericite of the hydrothermal veins showed ages from 908.1 ± 0.9 Ma to 927 ± 1 Ma for mineralization; i) The Cachoeirinha, Santa Helena, Rio Alegre, Nova Brasilândia and Sunsás orogenies have no mineral associated deposits reported up to now.

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References

Angeli N. 1997. A pesquisa de Ni no Morro do Chapeu, Vila Bela-MT. *In:* SBG, Bol. do 6° Simp. de Geol. do Centro-Oeste, Cuiabá. 1: 49-5.

Bettencourt J.S., Onstot T.C. and Teixeira W. 1996. Tectonic interpretation of $^{40}Ar/^{39}Ar$ ages on country rocks from the central sector of the Rio Negro-Juruena Province, southwest Amazonian Craton. *Intern. Geol. Rev.* **38**:42-56.

Bettencourt J.S., Tosdal R.M., Leite JR. W.B. and Payolla B.L. 1999. Mesoproterozoic rapakivi granites of the Rondônia Tin Province, southwestern border of the Amazonian craton, Brazil – I. Reconnaissance U-Pb geochronology and regional implications. *Precamb. Res.*, **95**:41-67.

Costa Neto M.C. 1996. Estudo da Interação Fluído-Rocha no Distrito Aurífero de Pontes e Lacerda, MT. Dissert. de Mestrado, Instituto de Geociências, Universidade de Campinas.

Darbyshire D.P.F. 2000. The Precambrian of Eastern Bolivia – a Sm-Nd isotope study. *In*: 31° Intern. Geol. Cong., Rio de Janeiro, Abstract Vol.(CD-Room).

Dardenne MA, Schobbenhaus C. 2000. *Metalogênese do Brasil*. Ed. Universidade de Brasília, 302 p.

DNPM 1995 Produção garimpeira de ouro por município no estado de Mato Grosso. Transferência da cota parte de IOF sobre ouro. DNPM-Basília. Divisão de Planejamento e Economia Mineral. Serviço de Estatística e Análise Econômica. Tabelas avulsas.

Fernandes C.J. 1999. *Geologia do Depósito Pau-a-Pique e Guias Prospectivos para Ouro no Grupo Aguapeí, Sudoeste do Estado de Mato Grosso*. Dissertação de Mestrado, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, 134 p.

Fernandes C.J., Geraldes M.C., Tassinari C.C.G. and Kuyumjian R.M. 2003. Idades $^{40}Ar/^{39}Ar$ para a Faixa Móvel Aguapeí, sudoeste do estado de Mato Grosso, fronteira Brasil-Bolívia. *In*: SBG- Núcleo Centro Oeste, Anais 9° Simp. de Geol. do Centro Oeste, p. 45-47.

Geraldes M.C., Figueiredo B.R., Tassinari C.C.G., and Ebert H.D., 1997. Middle Proterozoic vein-hosted gold deposits in the Pontes e Lacerda region, southwestern Amazonian craton, Brazil. *Intern. Geol. Rev.*, **39**:438-448.

Geraldes M.C., Van Schmus W.R., Condie K.C., Bell S., Teixeira W. and Babinski M. 2001a. Proterozoic Geologic Evolution of the SW Part of the Amazonian Craton in Mato Grosso State, Brazil. *Precamb. Res.*, **111**:91-128.

Geraldes M.C., Tassinari C.C.G., Babinski M. and Iyer S. 2001b. Sulfur and Lead isotope characteristics of the Pontes e Lacerda gold deposits, SW Amazonian craton, Brazil. *In*: Anais do 3° Simp. de Geol. Isotóp. da Amer. do Sul, p. 167-170.

Geraldes M.C.,Tassinari C.C.G., Babinski M. and Pinho F.E.C. 2002. U-Pb and $^{40}Ar/^{39}Ar$ age constraints of the Cabaçal gold deposit, SW Amazonian craton. *In*: Bol. de Res. Simp. de Vulcan. e Rochas Assoc., p. 38.

Leal J.W.L., Silva G.H., Santos D.B., Teixeira W., Lima M.I.C., Fernandes C.A.C. and Pinto A.C. 1978. *Geologia. Projeto Radambrasil. Folha SC.20*. Porto Velho. Rio de Janeiro, MME/DNPM, 19-184.

Litherland M. and Bloomfield K. 1981. The Proterozoic History of eastern Bolivia. *Precamb. Res.*, **15**:157-179.

Litherland M., Annels R.N., Darbyshire D.P.F., Fletcher C.J.N., Hawkins M.P., Klink B.A., Mitchell W.I., O'Connor E.A., Pitfield P.E.J., Power G. and Webb B.C. 1989. The Proterozoic of eastern Bolivia and its relationship to the Andean mobile belt. *Precamb. Res.*, **43**:157-174.

Litherland M., Annels R.N., Appleton J.D., Berrange J.P., Boomfield K., Burton C.C.J., Darbyshire D.P.F., Fletcher C.J.N., Hawkins M.P., Klink B.A., Llanos A., Mitchel W.I., O'Connors E.A., Pitfield P.E.J., Power G. and Werb B.C. 1986 The Geology and Mineral Resources of the Bolivian *Precamb. Shield*. British geological Survey. Overseas Memoir 9. London, Her Majesty's Stationery Office. 140 p.

Lopes Jr. I, Pizzato L.G, Menezes R.G. and Silva L.C. 1992. Geoquímica do Granito Santa Helena na Folha Pontes e Lacerda, MT. *In*: Anais do 37° Cong. Bras. de Geol., 52-65.

Matos J.B., Schorscher J. H. D., Geraldes M. C. and Souza M. Z. A. 2001. The Rio Alegre Volcanosedimentar Sequence (SW Amazonian Craton, Brazil): Chemical and Isotope (U/Pb and Sm/Nd) constrain and tectonic implications. Geology of the SW Amazonian Craton: State-of-the-Art". *Extended Abstract*, p. 56-59.

Matos J.B., Schorscher J. H. D., Geraldes M. C., Souza M. Z. A. e Ruiz A.S. 2004. Petrografia, geoquímica e geocronologia das rochas do orógeno Rio Alegre, mato Grosso: um registro de crosta oceânica Mesoproterozóica no SW do Cráton Amazônico. Rev. Bol. do Instituto de Geociências, Universidade de São Paulo, p.75-90.

Menezes R. G., Lopes I. e Bezerra J.R.L., 1993. *Folha Pontes e Lacerda 1:100.000, Carta Geológica e Texto Explicativo*. Programa de Levantamentos Básicos, CPRM-DNPM, 176p.

Monteiro H., Macedo P.M., Silva M.D., Moraes A.A. e Marcheto C.M.L. 1988. O greenstone belt do Alto Jauru. *In*: Anais do 34° Cong. Bras. de Geol., **2**:630-646.

Neder R.D., Resende W.M. e Rondon S.L. 1984. Projeto Rochas Máficas/Ultramáficas das Cabeceiras do Rio Guaporé. *Relatório Interno da Companhia Matogrossense de Mineração- MRTAMAT*. 26pp. (Inédito).

Neder R.D.N., Figueiredo B.R., Beaudry C. e Collins C, Leite J.A. D. 2000. The Expedito Massive Sulphide Deposit, Mato Grosso. Rev. Bras. de Geoc., **30(2)**; 222-225.

Neder R.D.N., Leite J.A. D., Figueiredo B.R. e McNaughton N.J. 2002. 1.76 Ga volcano-plutonism in the southwestern Amazonian craton, Aripuanã-MT, Brazil: Tectono-stratigraphic implications from SHRIMP U-Pb zircon data and rock geochemistry. *Precamb. Res.*, **119**:171-187.

Neder R.D., Geraldes M.C., Figueiredo B.R. e Tassinari C.C.G. 2003. $^{40}Ar/^{39}Ar$ ages of brittle tectonic in the Aripuanã igneous rocks in SW Amazonian Craton: tectonic and metalogenetis implications. In: Bol. de Res. do 9° Simp. Nac. de Est. Tect., p. 342-344.

Pinho F.E.C., 1996. *The origin of the Cabaçal Cu-Au deposit, Alto Jauru greenstone belt, Brazil.* University of Western Ontario, London-ON, Canada, Ph.D. thesis, 211p.

Pinho F..E.C., Fyfe W.S. and Pinho M.A.S.B. 1997. Early Proterozoic evolution of the Alto Jauru greenstone belt, southern Amazonian craton, Brazil. *Intern. Geol. Rev.*, **39**:220-229.

Pinho F.E.C., Fernandes C.J. and Santos C.A.R.R. 2001. Cabaçal belt, southern Amazonian Craton, a vast camp for exploration of gold-asociated maasive sulfide deposits. *In*: SBG-NO, Contribuições a Geologia da Amazônia, **3**:191-198.

Pinho M.A.S.B. 2002. *Petrografia, geoquímica e geocronologia do magmatismo bimodal paleoproterozóico ocorrente no norte do estado de Mato Grosso*. PhD dissertation, Universidade Federal do Rio Grande do Sul, Brazil. 162p.

Pinho M.A.S.B., Van Schmus W. R. and Chemale Jr. F. 2001 Nd isotopic compositions, U-Pb ages and geochemistry of Paleoproterozoic mgmatism of thesouthwestern Amazonian craton-Mato Grosso-Brazil. Workshop on " Geology of the SW Amazonian Craton: State of the Art". p. 83-85.

Rizzoto G.J. 1999. *Petrologia e Ambiente Tectônico do Grupo Nova Brasilândia-RO*. Dissertação de Mestrado, Universidade Federal do Rio Grande do Sul. 136 p.

Rizzotto G.L., Chemale Jr. F., Lima E.F., Van Schmuss R. e Fetter A., 1999. Dados isotópicos Sm-Nd e U-Pb das rochas da Sequência metaplutonovulcanos-sedimentar Nova Brasilândia (SMNB)–RO. 6° Simp. de Geol. da Amaz., *Ext. Abstract Bull*, p.490-493.

Saes G.S., Leite J.A.D. e Weska R.K. 1984. Geologia da Folha Jauru (SD-21-Y-C-III): Uma Síntese dos Conhecimentos. *In*: 33° Cong. Bras. de Geol., **5**: 2193-2204.

Saes G.S. 1999. *Evolução Tectônica e Paleogeográfica do Aulacógeno Aguapeí (1.2-1.0 Ga) e dos Terrenos do seu Embasamento na Porção Sul do Cráton Amazônico*. Tese de Doutorado, Universidade de São Paulo, 135 p.

Saes G.S. & Fragoso Cesar A. R. S. 1996. Acresção de terrenos mesoproterozóicos no SW da Amazônia. *In*: 39° Cong. Bras. de Geol., p.348.

Saes G.S., Pinho F.E.C. e Leite, J.A.D. 1991. Coberturas Sedimentares do Proterozóico Médio no Sul do Cráton Amazônico e suas Mineralizações Auríferas. *In*: SBG-Centro Oeste, Anais do 3° Simp. de Geol. do Centro Oeste, p. 45-52.

Sáens R., 2002a. *Geología exploración y minería del Yacimiento de Puquio Norte*. Tesis de Grado, Universidad Mayor de San Andres, p. 52.

Sáens R., 2002b. El greenstone belt de Puquio norte. Memorias del 15° Cong. Geol. Boliviano, Santa Cruz, p.65.

Scabora J.A. & Duarte C.L. 1998 A Jazida de Ouro de São Vicente - Município de Nova Lacerda - MT. *A Terra em Revista*, **4**:32-42.

Scandolara J.E., Rizzotto G.J., de Amorim J.L., Bahia R.B.C., Quadros M.L. and C.R. da Silva. 1999. *Geological map of Rondônia 1:1,000,000*. Cia. de Pesq. de Rec. Min.

Silva C.G. Lima M.I. de, Andrade A.R.F. de, Isler R.S., Guimarães G., Leal J.F.V. Basei M.A.S., Dal'Agnoll R., Teixeira J.B.G. e Montalvão R.M.G. de, 1974. *Folha SB-22 (Araguaia) e parte da Folha SC-22 (Tocantins)*. Projeto RADAMBRASIL. 143p.

Silva C.R., Bahia R.B.C. e Silva, L.C. 1992. Geologia da região de Rolim de Moura- sudeste de Rondônia. *In*: SBG, Bol. de Res. Exp. do 37° Cong. Bras. de Geol., São Paulo, **1**:152-153.

Silva C. R. & Rizzoto G. J. 1994. Província Aurífera Guaporé. 38° Congr. Bras. de Geol. Camboriú., **3**:323-325.

Souza N.P. 1988. Principais Depósitos de Ouro do Estado de Mato Grosso. 35° Cong. Bras. de Geol., **1**: 116-129.

Tassinari C.C.G., Siga Jr. O. and Teixeira W. 1984. Épocas metalogenéticas relacionadas a granitogênese do craton Amazônico.*In*: SBG, Anais do 33° Cong. Bras. Geol., Rio de Janeiro, **6**:2963-2977.

Tassinari C.C.G. & Melito K. 1994 The time-bound characteristics of gold depósits in Brazil and their tectonic implications. *Comunicaciones*, **45**:45-55.

Tassinari C.C.G. & Macambira, M.J.B. 1999. Geochronological Provinces of the Amazonian Craton. *Episodes*, **22**(3):174-182.

Tassinari C.G., Bettencourt J.S., Geraldes M.C., Macambira M.J.B. and Lafon J.M., 2000. The Amazon craton. *In* Cordani U., Milani E.J., Thomaz Filho A. and Campos D.A., eds., Tectonic evolution of South America, *31st Intern. Geol. Cong.*, Rio de Janeiro, 41- 95.

Teixeira W. and Tassinari C.C.G. 1984. Caracterização geocronológica da Província Rondôniana e suas implicações geotectônicas. Actas do 2° Symp. Amaz., p. 87-102

Teixeira W., Tassinari C.C.G., Cordani U.G. and Kawashita K. 1989. A review of the geochronology of the Amazonian craton: tectonic implications. *Precamb. Res.*, **42**:213-227.

Toledo F.H. 1997. *Mineralização e alteração hidrotermal do depósito de ouro do Cabaçal, Mato Grosso*. Dissertação de Mestrado, Universidade de Campinas, 86p.

Tohver E., Van Der Pluijm B.A., Scandolara J.E. and Geraldes M.C. 2000. Rodinia and the Amazonia-Laurentia Connection: preliminary D.P.T. results in western Brazil. GSA Anual Meeting, Denver. *Abstract Volume*.

Van Schmus W.R., Geraldes M.C., Fetter A.H., Ruiz A., Matos J., Tassinari C.C.G. and Teixeira, W., 1999. Jauru Terrane: A late Paleoproterozoic orogen in SW Amazon craton, Mato Grosso State, Brazil. European Union of Geosciences Meeting (EUG-10), *Jour. of Confer. Abstracts*, **4**:129-130.

Willians H. & MacBirney A.R. 1979. *Vulcanology*. Freeman, Cooper and Co. San Francisco. 397p.