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Pb Isotope Signatures of Polymetallic (Au-Cu-Zn) Deposits of the SW Amazonian Craton and Their Relation to Crustal Evolution

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1. Introduction

The distribution of ore deposits through geological time allows defining the correlation between magmatic, metamorphic and tectonic events and mineralizing processes. Among geochronologic methods, Pb isotope geochemistry is a powerful tool in helping to solve problems of metallogenesis, because they provide informations about the origin of the fluids responsible for the metal concentration (Changkakoti et al., 1986; Crocetti et al., 1988; Deloule et al., 1989; Kerrich, 1989; Kerrich, 1991; Wilton, 1991). As the isotopic ratios yielded a time-integred record of the U/Pb and Th/Pb ratios of the sources in which the lead developed, they also shed light upon the time-dependent geochemical behavior of these elements within the lithosphere (Cumming and Richards, 1975; Doe and Zartman, 1979; Zartman and Doe, 1981; Zartman and Haines, 1988). This work, based mainly on Pb isotopes constitutes a preliminary attempt to correlate the Proterozoic crustal evolution with metalogenetic processes in the southwestern Amazonian craton.

Reported works using U-Pb and Sm-Nd methods in the SW Amazonian craton had led to better understanding about the framework of the Proterozoic terranes (Teixeira et al., 1989, Tassinari and Macambira, 1999). The craton has been divided (Figure 1) into two major domains: the Archean nuclei in which is included the Central Amazonian Province; and the Proterozoic Provinces, represented by the Maroni-Itacaiúnas (ca. 2.2 Ga), the Ventuari-Tapajós (1.95-1.80 Ga), the Rio Negro-Juruena 1.79-1.52 Ga), the Rondonian-San Ignácio (1.51-1.34 Ga), and the youngest Sunsás-Aguapeí (1.24-1.00 Ga).

These provinces have been divided into orogenic belts. In this way, the 1.79-1.74 Ga Alto Jauru and the 1.58-1.52 Ga Cachoeirinha magmatic arcs (Van Schmus et al., 1999; Geraldes et al., 2001, respectivelly) represent the Rio Negro/Juruena Province. The Rondonian/San Ignácio Province is marked by important events involving magmatic arc settings and continental collision processes between 1.51 Ga and 1.34 Ga. These comprise the 1.51-1.48 Ga Rio Alegre, the 1.45-1.42 Ga Santa Helena and the 1.42-1.32 Ga San Ignácio arcs (Matos et al., 2004; Geraldes et al., 2001; Geraldes et al., 2004 respectively). Finally, the youngest Sunsás/Aguapeí Province comprises sequences deposited during basin tectonic (1.1 Ga Nova Brasilândia and 1.0 Ga Aguapeí Group; Rizzotto et al., 1999; Geraldes et al., 1997, respectively) and magmatic products (1.0 Ga. Sunsás; Litherland et al., 1986).

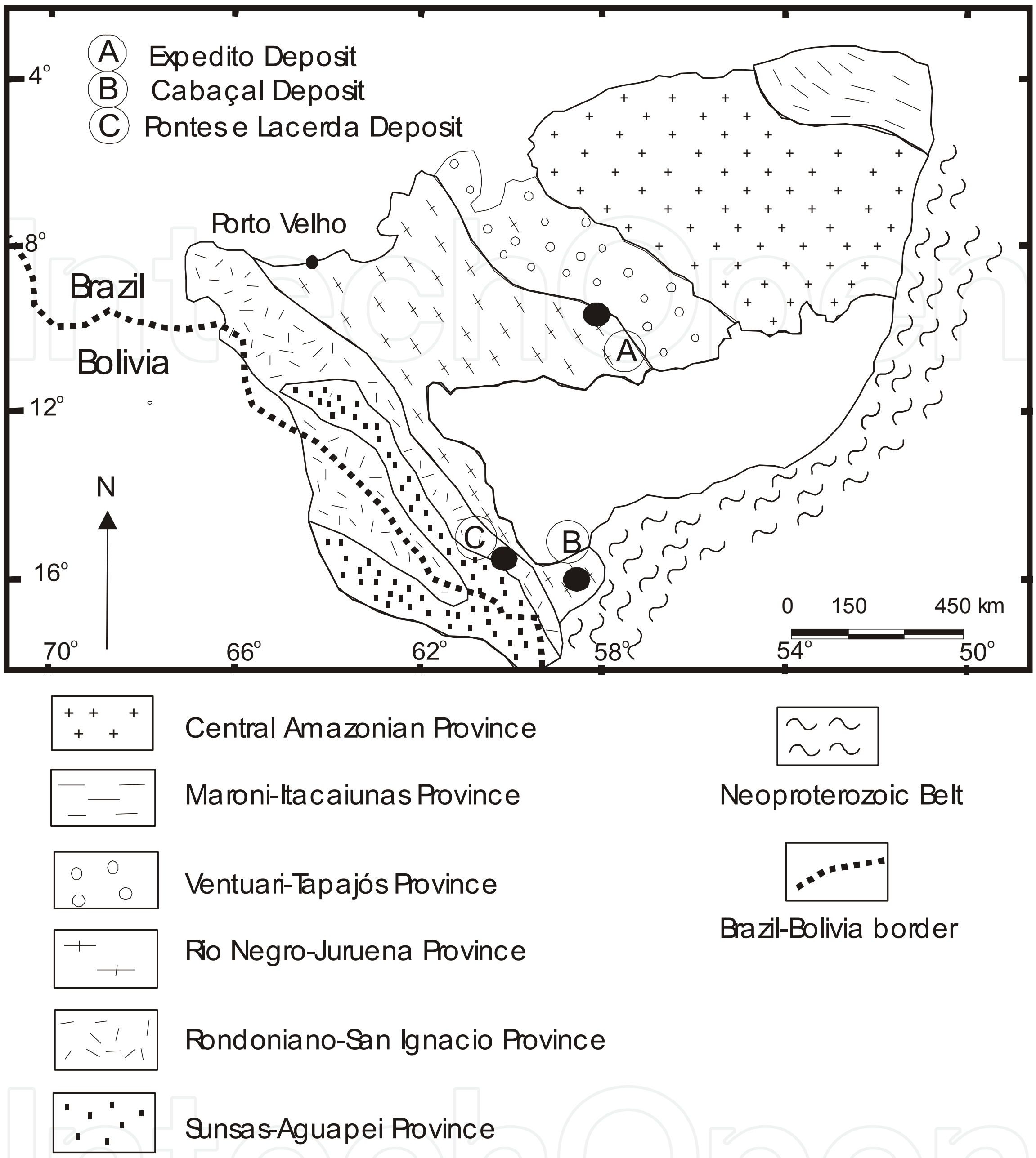

Fig. 1. Mineral deposits location and Geochronological Provinces of the southern sector of the Amazonian craton. The Cabaçal, Expedito and Pontes e Lacerda deposits are located in the map.

The study of SW part of the Amazonian craton Au, Cu and Sn deposits suggests a strong correlation between the time period of the tectonic events and the formation age of mineral concentrations of economic importance (Tassinari and Melito, 1994) and include polymetallic veins, magmatic and VMS types (Souza, 1988; Silva and Rizzoto, 1994; Dardenne and Schobbenhaus, 2000). Paleoproterozoic terranes contain the Moriru Au deposit (related to felsic 1796-1773 Ma volcanic rocks), the Expedito Cu-Au deposit (comprised of a thick pile of 1762-1755 Ma acidic to intermediate volcanic rocks; Pinho et al., 2001) the Cabaçal Zn-Au ore deposit (hosted by ca. 1750 Ma felsic volcanic and volcanoclastic rocks; Pinho et al., 1997; Toledo, 1997). Mesoproterozoic terranes contain the Puquio Norte Au deposit (hosted in Mesoproterozoic greenstone belt; Sáens, 2002); 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 only three (Cabaçal, Expedito and Pontes e Lacerda) dated deposits are discussed below.

2. Analytic techniques

The analysis here reported were carried out during the last 10 years as result of several field and laboratorial works. The samples from the three deposits (Cabaçal, Expedito and Pontes e Lacerda) were prepared and analysed at Geochronological Research Center of University of São Paulo, Brazil. Initially the samples were crushed and sift at 10 mesh and the sulfide crystals were separated from quartz by hand-picking in binocular microscopy. 0,2 g of clean crystals was digest in 9 N HCl during two hours (with heating) and the solute was collected. The Pb was purified using collums of exchance resin in HBr and loaded on rhenium filament using the standart silica gelphosphoric acid technique and analysed in a VG 354 solid-source mass spectrometer at 1,250 ^{o}C. Reproducibility of 0,24, 0,32 and 0,36 per mil (1σ) for $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratio, respectively, and the mass fractionation level of 1,3 per mil per mass unit difference was determined from repeated measurements. Detais of laboratoty procedures may be found in Tassinari et al., (1990), Iyer et al., (1992) and Tassinari and Cavalcanti (1994).

The international standarts of Pb isotopes used during the laboratory were presented in Table 1, with their respective results.

standarts	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
NBS981	16,9371	15,49175	36,7213
NBS982	36,7390	17,19971	36,7449

Table 1. Pb isotope analysis of International standards results used in CPGeo-USP.

3. The Cabaçal Au-Zn deposit

The Cabaçal gold deposit is located in the SW Amazonian craton, 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 (Pinho et al., 1997; Toledo, 1997; Geraldes et al., 2002; Tassinari et al., 2000). The mineralization is hosted within felsic volcanic and volcanoclastic rock of the Alto Jauru rocks. Detailed petrologic and geochemical investigations (Pinho, 1997) indicate that gold deposition is associated with metamorphic fluids migrating along regional shear zones. Hydrothermal solutions in the Cabaçal deposit originated sericitic, biotitic, and chloritic alteration zones. The ore zones are irregularly-shaped, presenting ondulating outlines in general coincident with the principal foliation plane. The ore planes plunge towards in two different directions: SSW, with variable dip and SSE, dipping about 20^{o}. Sericite and chlorite are common minerals alterations related to the concentration of sulfide minerals. Alterations consists of an inner, chloritized core surrounded by an intermediate biotitic zone and a sericitic zone. Sericitic and chloritic alterations commonly occur associated with volcanic-hosted massive sulfide ores.

Sample	Mineral	206/204	207/204	208/204	ref.
Cabaçal Deposit					
CB-01-BC	pyrite	15,461	15,227	35,154	1
CB-01-BX	pyrite	16,245	15,318	35,924	1
CB-04	pyrite	15,531	15,410	35,633	1
CB-05	carbonate	20,463	15,777	39,833	1
CB-07	pyrite	21,208	15,999	39,936	1
CB-09X	chalcopyrite	18,664	15,709	37,975	1
Expedito Deposit					
F16/219	galena	15,861	15,414	35,575	2
F16/257	galena	15,835	15,44	35,685	2
F25/207	galena	16,004	15,652	36,302	2
513	galena	15,955	15,492	35,833	2
514	galena	16,057	15,731	36,607	2
515	galena	15,846	15,432	35,692	2
516	galena	15,304	15,592	36,202	2
517	galena	15,407	15,396	36,603	2
34123	K-felds	16,736	15,459	36,34	2
Pontes e Lacerda					
ONÇA I (a)	galena	15,606	17,585	36,646	3
ONÇA I (2)	galena	15,499	17,675	36,375	3
ONÇA I (c)	galena	15,523	17,677	36,440	3
ONÇA I (d)	galena	15,645	17,768	36,767	3
ONÇA II (a)	galena	15,522	17,584	36,463	3
ONÇA II (b)	galena	15,528	17,657	36,403	3
ONÇAII (c)	galena	15,638	17,660	36,760	3
ONÇA II (d)	galena	15,574	17,666	36,521	3
ONÇA III(a)	galena	15,562	17,498	36,551	3
ONÇA III(b)	galena	15,539	17,734	36,434	3
ONÇA III(c)	galena	15,539	17,668	36,433	3
ONÇA III (d)	galena	15,681	17,934	36,897	3
PL-Au-O2	Gold	18,007	15,674	37,257	1
PL-Mg 01	Magnetite	21,250	15,827	38,393	1
PL-202	pyrite	20,665	15,668	38,687	1
PL-202	pyrite	20,514	15,763	38,601	1
PL-202	pyrite	29,815	16,321	38,542	1
PL-202	pyrite	20,484	15,692	38,134	1
PL-207 res.	pyrite	29,856	16,303	45,090	1
PL-207 L1	pyrite	21,381	15,553	39,336	1
PL-207 L2	pyrite	27,662	16,131	44,807	1
PL-207 L3	pyrite	21,566	15,758	40,272	1
PL-207 L4	pyrite	22,714	15,791	42,443	1
PL-207 L5	pyrite	28,826	16,279	44,136	1
PL-208 res.	pyrite	20,074	15,678	39,069	1
PL-208 L1	pyrite	18,351	15,554	38,075	1
PL-208 L2	pyrite	20,665	15,723	40,222	1
PL-208 L3	pyrite	21,869	15,817	41,399	1
PL-208 L4	pyrite	26,239	16,069	49,555	1
PL-208 L5	pyrite	23,574	15,979	41,029	1

References: (1) this work; (2) Neder (2002); and (3) Geraldes et al (1997).

Table 2. Pb isotopes data form Cabaçal, Expedito and Pontes e Lacerda deposits.

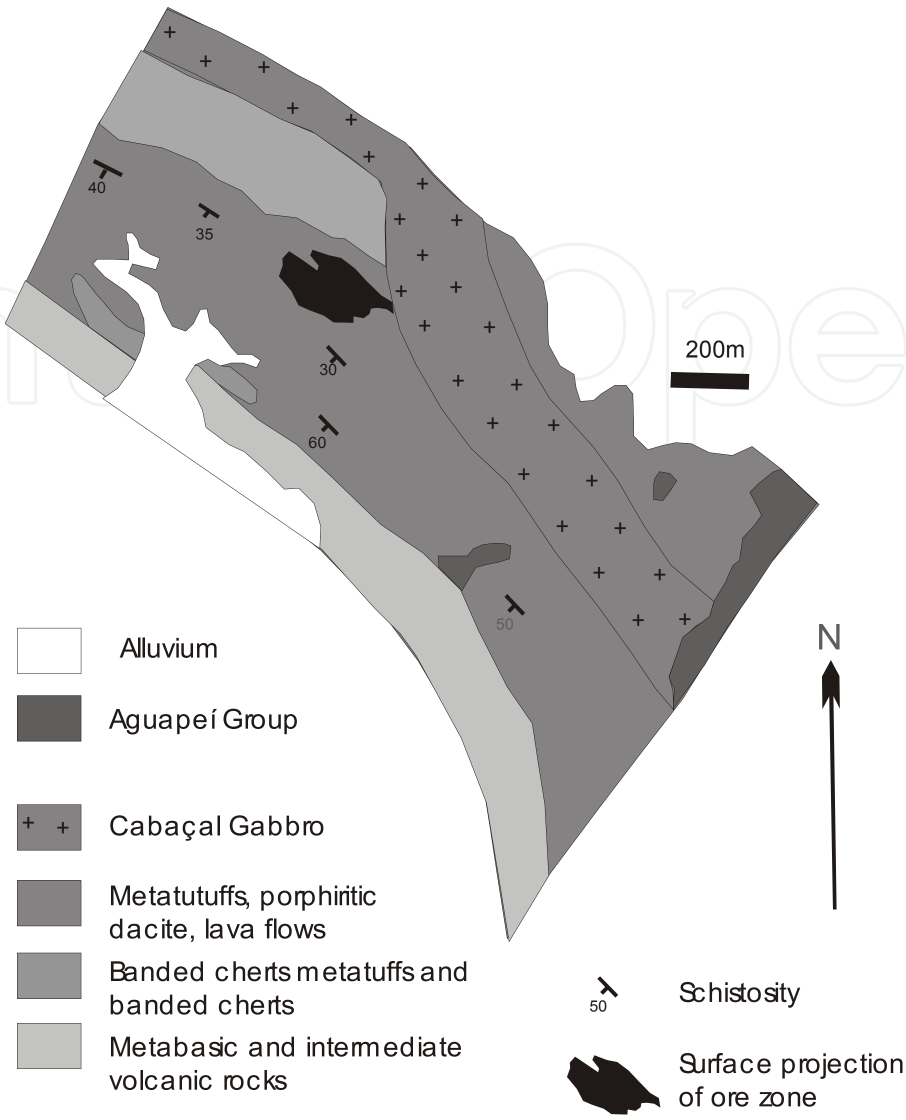

Fig. 2. Local geologic map of the Cabaçal deposit. Adapted from Pinho, (1996).

The ore is represented by concentrations of Cu-Au and Zn-Pb-Cu-Au, where sulfide and selenide minerals, native Bi, and Au-Ag and Au- Bi alloys are important phases. The ore occurs as disseminated, banded, veined, brecciated and massive types. The banded ore shows continuous laminae of sulfide minerals coincident with foliation, and is usually associated with banded tuff, chert and the upper part of the chlorotized zone, suggesting a volcanogenic origin. The veined ore is widespread in all over mineralized area and veins are composed chiefly of milky quartz but carbonate veins also occur. The brecciated ore is represented by fragments of chloritic volcanic rocks, banded cherts, metatuffs, and quartz veins set in a matrix of sulfide minerals. Chalcopyrite is the most common sulfide, followed by pyrite, sphalerite, pyrrhotite, and visible native gold and Bi-Te minerals are common. The massive ore is restricted to the chlorite zone, comprised of chalcopyrite, pyrrhotite and lesser pyrite. Sericites from the hydrothermal zones were dated by the $^{40}Ar/^{39}Ar$ method, using laser step-heating dating in single grains (Geraldes et al., 2003). One sample is from a bore hole 107m deep and yielded a plateau age of 1521.3 ± 1.3 Ma. Another sample is 36.6 m deep, and yielded a plateau age of 1510.4 ± 1.2 Ga. The Ar cooling ages indicate a regional heating during Cachoeirinha suite (U-Pb of 1560-1520 Ma) intrusion which may play an important role in the genesis of the ore deposit due remobilization processes of the original volcanogenic metal concentration.

Pb-Pb signatures for the Cabaçal gold deposit indicate two sources (Geraldes et a., 2003): 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 $^{208}Pb/^{204}Pb$ from 35.549 to 35.630), 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 and and $^{208}Pb/^{204}Pb$ from 35.324 to 35.469). These discordant Pb isotope signature may suggest that more than two Pb components were involved in the formation of the Cabaçal gold deposit. The less radiogenc group may indicate a contribution Pb from volcanic-plutonic host-rocks. According to Dean and Carr, (1982) the similar signature between ore and magmatic country rocks may be interpreted as co-magmatic and coeval origin. The second group of Pb values is characterized by strong radiogenic Pb and may be originated from a source that was external to the main volcanic-related hydrothermal systems. Similar Pb signature has been reported by Relvas, et al., (2001) in Iberian Pyrite Belt and interpreted as multiple source of fluids for the ore deposit origin.

4. The Expedito Cu-Au deposit

The Expedito Cu-Zn deposit (located 20 km northern from Aripuanã city) occurs within a thick pile of acidic to intermediate volcanic rocks of the Uatumã Group. These rocks are believed to be related to the Mesoproterozoic intracontinental rift, hypothesis supported by the 1762 Ma dacitic volcanics, exhalative sediments and a co-genetic granitic intrusion about 1755 Ma (SHRIMP U-Pb zircon age; Neder et al., 2002). The unmetamorphosed volcanic rocks are interlayed with chemical and epiclastic sediments. Base metal and gold are hosted in the transition from the fine to coarse ash, lapilli and crystal tuffs with minor intercalation of sericitized feldspatic siltstone and rhyolitic, dacitic and rhyodacitic rocks .

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. The deposit is enveloped by a hydrothermal alteration halo consisting of chlorite, biotite and carbonate zones and it is interpreted of volcanic origin according to Neder et al. (2002a). $^{40}Ar/^{39}Ar$ data determined in amphibole and biotite from alteration halo over volcanic rocks yielded 1580-1560 Ma (Neder et al., 2003). Zircon U-Pb dating reported by Rizzotto et a., (2002) for intrusive granites of Aripuanã region yielded 1538 ± 7 Ma, suggesting a partial resetting of the Ar was results of heating caused by the intrusive bodies. These geochronologic data indicate an important remobilization that occurred in the volcanic rocks, which may be responsible for Au concentration in shear zones and peculiar (amphibole) hydrothermal alteration.

Pb isotopic compositions of Expedito deposit were determined from sulfides and the values of $^{207}Pb/^{204}Pb$ range from 15.731 and 15.396; $^{206}Pb/^{204}Pb$ values range from 15.304 to 16.057; $^{208}Pb/^{204}Pb$ values range from 35.575 to 36.607 (Neder et al., 2002b). The Pb data plotted in the Stacey and Krammer (1975) lead growth curve yields a model age abound 1.75 Ga which is roughly coeval to the 1762-1755 Ma U-Pb SHRIMP ages of the volcanic and plutonic rocks of the Aripuanã metalogenetic district.

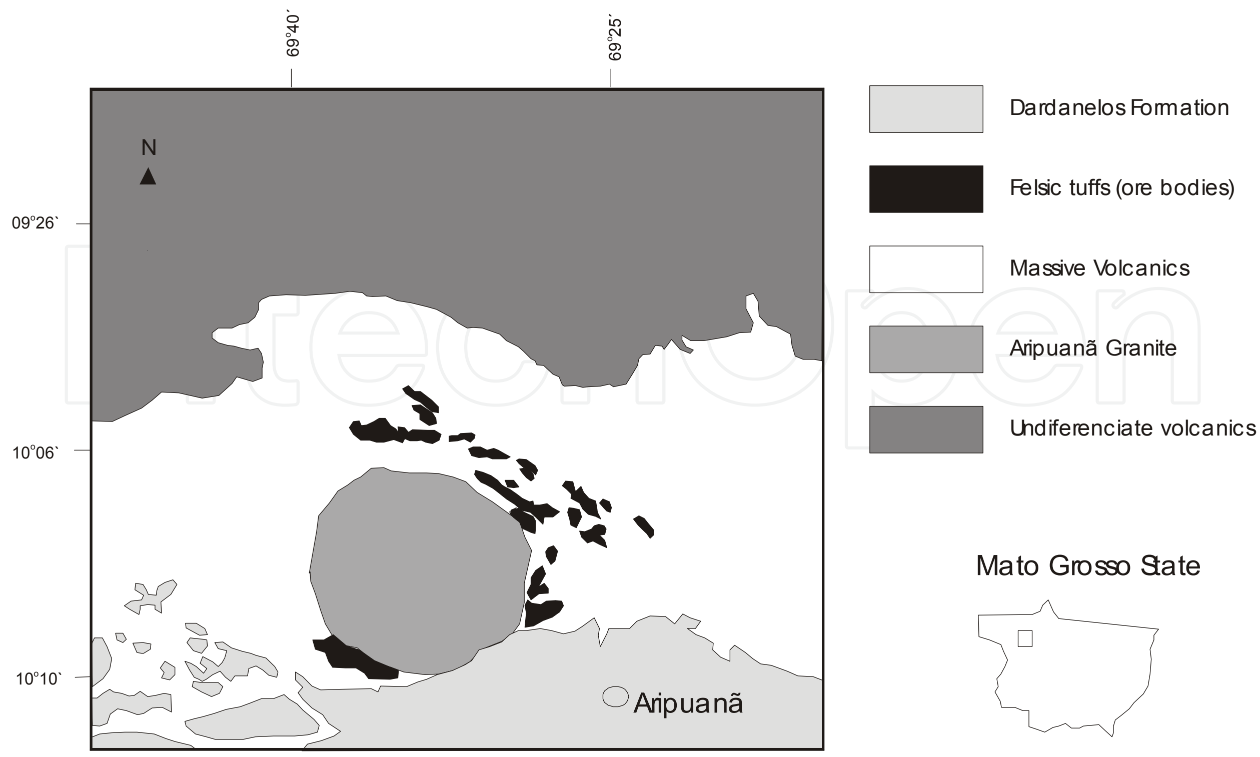

Fig. 3. Geologic map with ores bodies of Expedito deposit. Adapted of Neder (2002).

5. The Au deposits of Pontes e Lacerda region

Gold deposits occur at more than twenty localities in the Pontes e Lacerda region situated between the Guaporé and Jauru rivers in the SW part of Amazonian Craton, State of Mato Grosso, Brazil (Souza, 1988; Saes et al., 1991; and Silva & Rizzoto, 1994; Saes et al., 1994; Geraldes et al., 1997). In the Figure 4 are plotted the following deposits: Ribeiro, Onça, Japonês, Marinho, Lavrinha, Ernesto, Cantina, Pombinha, Nene, João Cumprido and Maraboa. They are distributed along a NW striking, 40 km wide and more than 200 km long shear belt originated during the Middle Proterozoic Aguapeí-Sunsás tectonic event. Mining companies active in the region estimate Ore reserves in ca. 18 t Au.

The sedimentary rocks of the Aguapeí Group include, in the region, metasandstones, metaconglomerates and subordinated metassiltites of the Fortuna Formation overlaid by an intermediate sequence of metapelites (phyllites, low grade siltstone and mudstone, and metapsamite) of the Vale da Promissão Formation, (Figueiredo et al., 1974; Souza & Hildred, 1980) all correlated to the Bolivian Sunsás Group referred to the Middle Proterozoic (1300-950 Ma) by Litherland et al. (1986). Saes & Fragoso Cesar (1994) considered the Aguapeí rock associations and structures as indicative of rifting geological environment which basin had correlation with Sunsas basin in Bolivia.

The Au deposits of Pontes e Lacerda region are related to the occurrence of a NW-SE striking ductile shear zone along which sedimentary rocks of the Aguapeí Group. Tectonics involved oblique overthrusting (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 and Duarte, 1998), Lavrinha deposit (Costa Neto, 1996) and Pau-a-Pique deposit (Fernandes, 1999).

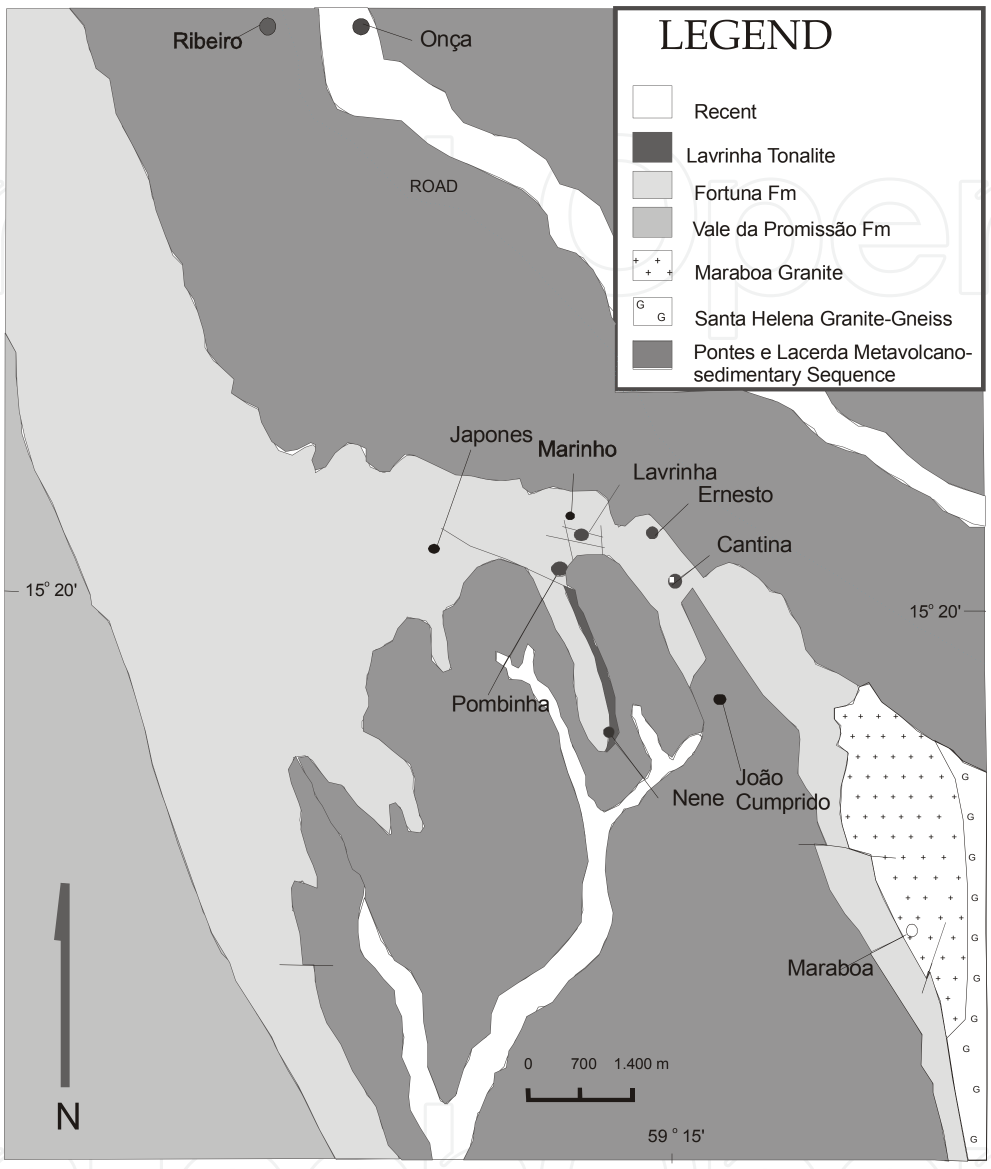

Fig. 4. Geologic map of the Pontes e Lacerda main ore deposits. Adapted from Geraldes et al. (1997).

Most of the gold deposits lay along the tectonic contact between the 1.51-1.49 Ga Rio Alegre metavolcanic-metassedimentary rocks and the Aguapei metassedimentary rocks. Secondarily, some gold deposits are hosted by clastic sedimentary rocks (base unit of the Aguapeí group), schists and granitoids (1,44-1,42 Ga Santa Helena suite). Disseminated and vein controlled mineralization are commonly found in volcanic host-rocks whereas sedimentary rock or granite-hosted deposits are mainly formed by veins. The ore consists of quartz, pyrite and gold, and the hydrothermal alteration zones contain quartz, sericite, pyrite, magnetite (altered to hematite), chalcopyrite, galena and sphalerite.$^{40}Ar/^{39}Ar$ ages obtained in sericite of the hydrothermal veins showed ages from 908.1 ± 0.9 Ma to 927 ± 1 Ma for mineralization (Fernandes et al., 2003; Paulo et al., 2005).

The sulfides from the Pontes e Lacerda Au deposits present values of 208Pb/^{204}Pb from 36.760 to 36.433 and ^{206}Pb/^{204}Pb from 17.734 and 17.498 and 207Pb/^{204}Pb from 15.638 and 15.499 (Geraldes et al., 1997). When the Pb isotope composition are plotted in the ^{207}Pb / ^{204}Pb *versus* 206Pb / ^{204}Pb diagram, they form a step linear trend. The variation in ^{206}Pb / ^{204}Pb and for ^{207}Pb / ^{204}Pb values is much greater than analytical error and must reflect heterogeneity of the source region and/or the hydrothermal fluids forming of these mineralized veins. Its possible to suggest that the ore deposit was deposited by hydrothermal solutions with influence of ultramafic basement which deep solutions originate during the regional metamorphism represented by Aguapei thrusting event.

6. Discussion

Pb isotope determination in ore-forming minerals is particularly useful when they can be directly combined with country rocks and can potentially constrains the crustal or mantle reservoirs that are sampled by the ore-forming system. Pb isotope source tracing relies on a number of assumptions, including: (1) measured or calculated initials ratios correspond to the isotopic composition of the ore-forming hydrothermal system; (2) fluid signatures accurately reflect the isotopic composition of the rock reservoir(s) sampled by the hydrothermal system, and (3) contemporaneous isotopic ratios of all possible reservoirs are known (Kerrich, 1991). In many instances theses assumptions cannot be critically evaluated within the constraints imposed by the geological boundary conditions (Bursnall et al., 1989). Moreover Pb many studies have shown that Pb isotope of ore deposits may be a mixture of hydrothermal contributions (Deloule et al. 1989) and Pb indigenous to the contiguous host rocks (Croceti et al. 1988).

For basement rocks it is usual to analyse k-feldspar. This mineral is enriched in Pb and depleted in uranium and thorium and contains Pb concentration up to several hundreds parts per million while its uranium and thorium content is usually less than 1 ppm. As a result, the bulk isotopic composition of Pb in k-feldspar is practically constant (similarly to galena in mineral deposits), thus maintaining the record of the lead originally incorporated from the melt.

Pb initial isotopic compositions reported in the literature carried out in K-Feldspars are now compiled to allow a correlation with the Pb signature of the mineral deposits discussed above. The Pb results of the followings units are available in the literature: 1.55 Ga rocks of Cachoeirinha suite; ca. 1.8 Ga rocks of the Alto Jauru terrane; ca. 1.75 Ga Aripuanã volcanic rocks; 1.45 Ga rocks of the Santa Helena batholith (granites and augen gneisses). The results are also plotted on a 207Pb/204Pb versus 206Pb/204Pb evolutionary diagram (Figure 5) along with Stacey and Kramers (1975) second-stage evolution curve together with Pb isotope results of the mineral deposits.

Reported Pb isotopic compositions (Geraldes et al., 2001) from the 1.8 Ga Alto Jauru rocks (k-feldspar leaching), including the 1.55 Ga Cachoeirinha suite, plot at ca. 1.55-1.30 Ga on a Stacey and Kramers (1975) second stage evolution curve. The results suggest that Pb in the Alto Jauru terrane rocks evolved along this growth curve from 1.8 to 1.30 Ga, at which time regional deformation and metamorphism caused the Pb to be rehomogenized and the Pb compositions in the K-feldspar have been unchanged since then due to absence of U in the feldspar and absence of a significant, younger metamorphic event. Sr/Sr results have two signatures: concordant carbonate veins yielded values from 0.705 to 0.7029 and discordant carbonate veins yielded values from 0.7144 to 0.7119, also suggesting two sources or remobilization.

These studies added to the Cabaçal deposit Pb isotope data reveal that mineralizing solutions may be originated during the Alto Jauru orogen (1.79-1.74 Ga) where a subduction process generated juvenile magmas in an island arc setting. The metal carried out by the hydrothermal solutions probably were deposited along ductile shear zones synchronously to the calc-alkaline magmatism. These studies reveal that Alto Jauru greenstone belt later on underwent to an important remobilization process, represented by the intrusion of the Cachoeirinha suite (1,66-1,62 Ga) which cooling ages are recorded by $^{40}Ar/^{39}Ar$ about 1,56 Ga. With the available data is not possible to define if the metal concentration was only 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, recorded by the 1.58-1.52 Ga (U-Pb in zircon ages) and 1,56 Ga ($^{40}Ar/^{39}Ar$ cooling ages in biotite).

Only one analysis of Pb isotopes in k-feldspar from Aripuanã region is reported, yielding values of ^{208}Pb / ^{204}Pb of 36.340, ^{206}Pb / ^{204}Pb of 16.739 and 207Pb / ^{204}Pb of 15.459, similar to the Alto Jauru k-feldspar signature. This datum added to the Pb isotopic signature of the sulfides may suggest important metalogenetic implications for Expedito Au-Cu deposit. Lead isotopes composition of sulfides is consistent with upper crust fluid and metal sources. Based upon the Pb isotopic results and the reported U-Pb zircon SHRIMP data for metadacitic rock which results yielded 1762 ± 6 Ma, interpreted as crystallization age, we may suggests that the Expedito massive sulphide deposit probably originated in volcanic environment, and may be included as VMS type deposit.

Pb isotope data from Pontes e Lacerda deposits basement is limited to the Santa Helena suite rocks. The results show a complex behavior and present a large range of isotopic compositions. The Santa Helena rocks have crystallization ages of ca. 1.44-1.42 Ga, but they are strongly deformed (milonitic) with a probable age of deformation about 0.95 Ga, during formation of the Aguapeí thrust belt and coeval to the 0.93 Ga (U-Pb in zircon) Guapé suite. Thus, the linear array formed by the data plot (Figure 5) probably represents growth of radiogenic Pb from 1.45 Ga to 0.95 Ga. These granites had a large range Pb isotope values and their Pb was rehomogenized at 0.95 Ga, with no subsequent growth of radiogeneic Pb in the K-feldspars since that time.

Concluding, in Cabaçal and Expedito deposits there is a strong correlation between country rocks and ore minerals Pb isotopes signatures. Moreover, Cabaçal deposit Pb isotopes suggest that including ultrabasic, basic and felsic volcanics added to gabbros and tonalities of Alto Jauru greenstone belt probably were formed in a magmatic setting. Shear zones (chlorite, sericite and biotite) with intense hydrothermal solutions percolation were the responsibe for the metal deposition. The cratonic volcanosedimentary sequences of the Expedito deposit also had formed thermal flux resulting in hydrothermal solutions percolation and and metal deposition. In the case of Pontes e Lacerda gold deposits, the ore minerals formation is correlated to the hydrothermal fluids percolation during the tectonic event (Aguapei Thrust). The results here presented define regional exploration constraints for the Alto Jauru, Aripuanã and Pontes e Lacerda region of the SW Amazonian craton.

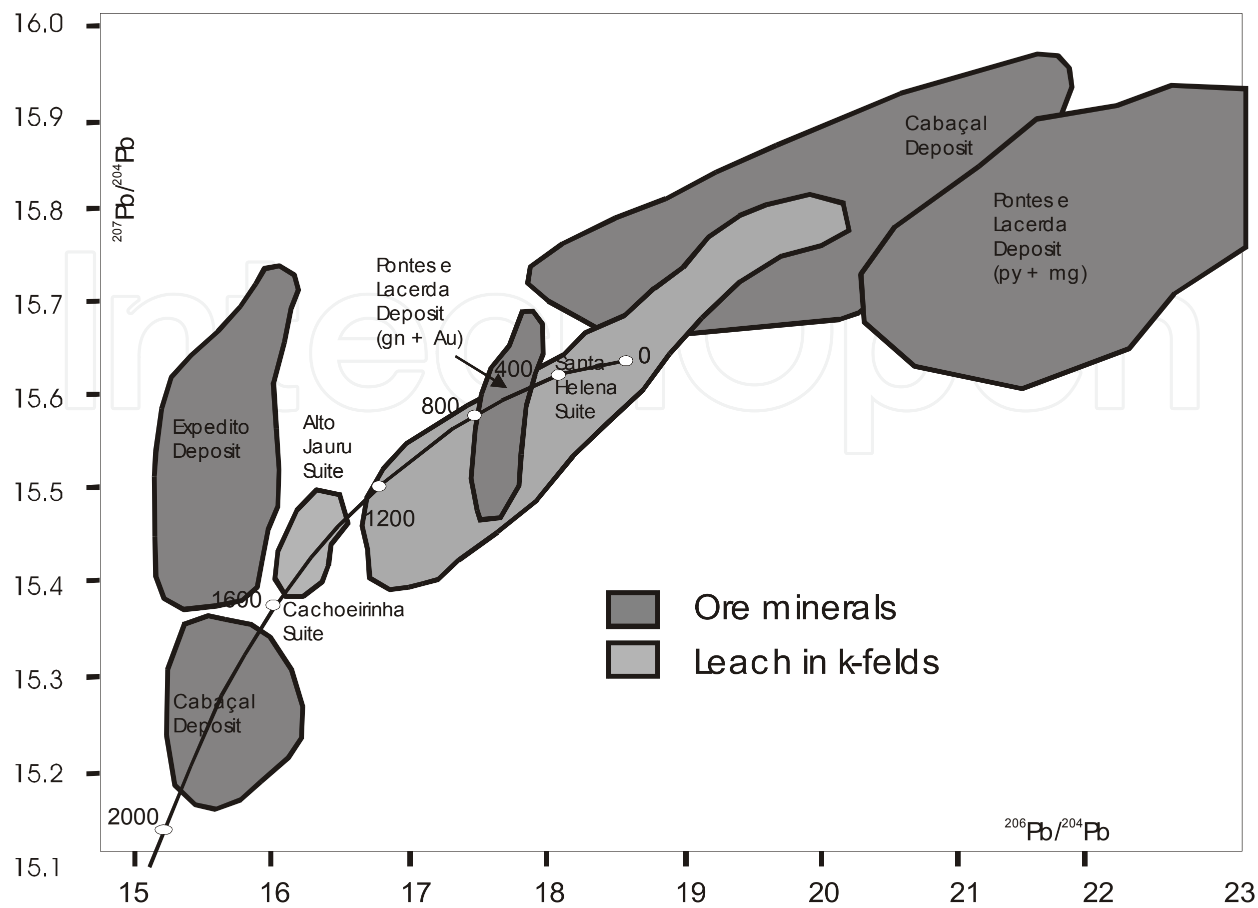

Fig. 5. ^{207}Pb / ^{204}Pb *versus* ^{206}Pb / ^{204}Pb diagram for mineral deposits and rocks from SW Amazonia craton

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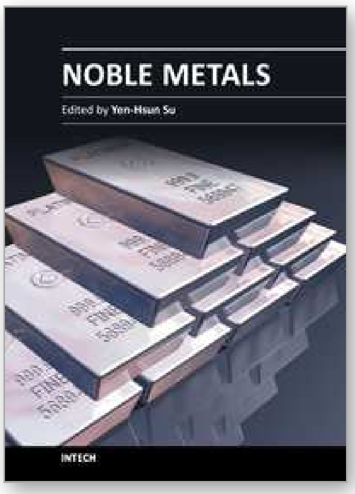

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This book provides a broad spectrum of insights into the optical principle, resource, fabrication, nanoscience, and nanotechnology of noble metal. It also looks at the advanced implementation of noble metal in the field of nanoscale materials, catalysts and biosystem. This book is ideal not only for scientific researchers but also as a reference for professionals in material science, engineering, nonascience and plasmonics.