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SULFUR AND LEAD ISOTOPE CHARACTERISTICS OF THE PONTES E LACERDA GOLD DEPOSITS, SW AMAZONIAN CRATON BRAZIL

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INTRODUTION

This work deals with the characterization of the S and Pb isotope signatures in sulfides from the Pontes e Lacerda mesothermal gold deposits located in the SW sector of Amazonian craton. Stable and radiogenic isotopes have played an important role in the study of ore deposited and hydrothermal processes and they are most useful when can be used together. The purpose of this study is to constrain the sources and the mechanisms of gold deposition in Pontes e Lacerda region which may be a helpful contribution to an exploratory model in the area.

PONTES E LACERDA GOLD DEPOSITS

Gold deposits occur at more than twenty localities in the Pontes e Lacerda region situated in the SW part of the Amazonian craton, State of Mato Grosso, Brazil. They are distributed along a NW striking, 40 km wide and more than 200 km long shear belt considered to be related to the Mesoproterozoic 1.0 Ga Aguapeí-Sunsás tectonic event.

The western part of the Amazonian Craton is a multi-orogen region formed between 1.8 and 1.0 Ga where successive magmatism, metamorphism and deformation occurred (Tassinari et al., 2000). The following accretionary crustal events were defined in the region: the Alto Jauru orogen (1.79 to 1.74 Ga), the Cachoeirinha orogen (1.56 to 1.54 Ga), the Santa Helena orogen (1.45 Ma to 1.42 Ga) and the Rio Alegre orogen (1.52 to 1.47 Ga). The sedimentary rocks of the Aguapeí Group cover the units described above and include metarenites, metaconglomerates and metassiltites overlied by a sequence of mica-schists and phyllites. The sedimentation and metamorphism of these rocks is correlated to the Sunsás Cycle (1300-950 Ma) described in Bolivia by Litherland et al. (1989).

Gold ores have been exploited in the region in placer, lateritic and hydrothermal filonar deposit types (Saes et al., 1991; Silva e Rizzoto, 1994; and Geraldes et al., 1997a). Among 23 known hydrothermal gold deposits in the Pontes e Lacerda region, 11 lie along the tectonic contact between the Aguapeí Group rocks and the Rio Alegre metasedimentary rocks, 6 are hosted into the Aguapeí Group rocks, 3 by the Rio Alegre metasedimentary rocks and 3 by granitoids (Santa Helena batolith). The most important mineralized area is located 20 km south of Pontes e Lacerda, where 11 gold deposits are located: Ribeiro, Japones, Marinho, Pombinha, Lavrinha, Ernesto, Onça, João Cumprido and Maraboa, Nene and Lavrinha.

Gold mineralization is closely related to mylonitization and hydrothermal alteration of wallrocks and formed at ca. 1000 Ma (K/Ar in sericite; Geraldes et al., 1997a). The chemical compositions of some altered metabasalts and metandesites investigated by Geraldes and Figueiredo (1996) point to enhanced contents of K_2O, F, Fe_2O_3 and LREE and losses of CaO, MgO and FeO for the altered rocks. Among the more immobile oxides are Al_2O_3, SiO_2 and TiO_2. Fluid inclusions study carried out in the Onça deposit indicates a aquocarbonic composition to the hydrothermal solution, low salinity (1 to 8 % NaCl-equivalent) originated probably

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from metamorphic fluids and deposited in shear zones at the temperature around 300 °C (Geraldes et. al., 1997b).

The ores consist of quartz, pyrite and gold in quartz veins and also disseminated in the wallrocks. In the Onça deposit chalcopyrite, galena and sphalerite also occur within an 8 meters wide qz-vein. Parallel to these veins there are hydrothermal alteration halos formed by quartz, sericite and, minor pyrite, magnetite and hematite. Magnetite often occurs as milimetric idiomorphic crystals partially transformed to hematite. There is a zonation in the alteration halo with pyrite closer to the veins, and magnetite (hematite) in the outer zone where pyrite is absent. Pyrite and galena from Onça deposit and pyrite from the host rocks (Pombinha and Ernesto deposits) were collected for S and Pb isotope analysis.

S ISOTOPE RESULTS

The sulfur stable isotopes results of Pontes e Lacerda gold deposits show $\delta^{34}S$ values in the range from +1.0‰ to +5.5‰ in galenas from mineralized quartz-vein. Pyrites collected in host rocks (Aguapeí Group) shows $\delta^{34}S$ values in the range from +6.9‰ to +10.0‰. Galena samples were collected in an 8 m thick quart-vein Au-rich in Onça deposit associated with pyrite, chalcopyrite and sphalerite. Textural relationships between sulfides suggest equilibrium and origin from the same hydrothermal solution. The pyrite samples, in other hand, were collected in the conglomerate host rock between shear zones filled by mineralized qz-veins. $\delta^{34}S$ values in this group of pyrites are higher than $\delta^{34}S$ values in galenas from the mineralized veins and suggest an influence from the sedimentary rocks and probably are result of a mixing between the mineralizing fluid sulfur and minerals deposited under marine influence. This hypothesis is corroborated by the presence of barite in contact with pyrite grains (as observed in electron microscopy).

The similarity of the gold deposits of Pontes e Lacerda region with other hydrothermal gold deposits allows correlating the $\delta^{34}S$ values in pyrites to the interaction between the hydrothermal solution with sedimentary country rocks. Figure 1 shows variations of $\delta^{34}S$ values of sulfides from Pontes e Lacerda deposits comparated with other similar gold deposits where the influence of sedimentary host-rocks is suggested to explain the high $\delta^{34}S$ values in sulfides of the gold deposits.

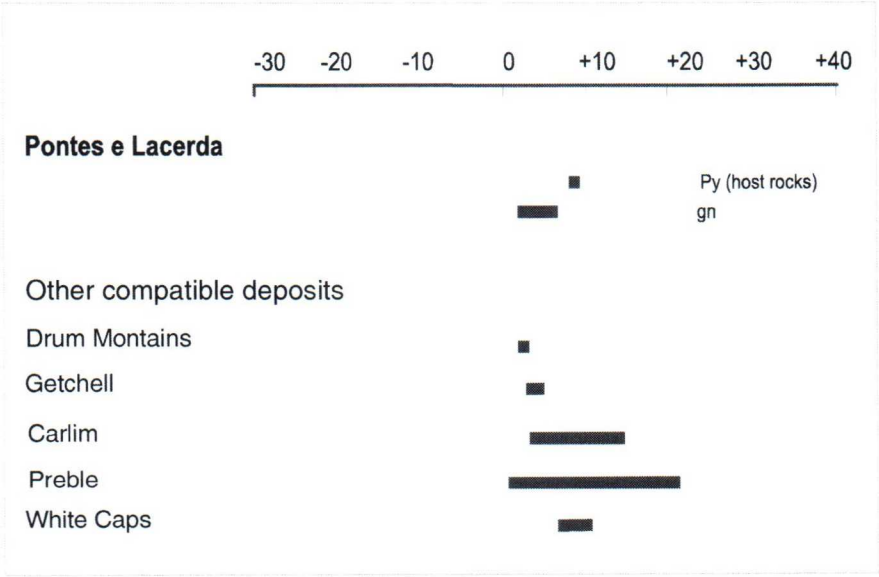

Figure 1. S isotope results in galena and pyrite from Pontes e Lacerda gold deposits.

Pb ISOTOPE RESULTS

Three galena samples from the Onça deposit ore were separated in aliquots for Pb isotope analysis. In the first three aliquots galenas were dissolved totally and in the second group of aliquots they were leached (using 1,0 N, 2,5 N and 9,0 N HCl). Galenas show higher Pb isotope composition variations among samples than in the lecheates. One sample of pyrite from qz-vein yielded the similar Pb isotopic composition of the galenas which suggests an isotopic equilibrium between both sulfides or that it is a result of the presence of blebs of galena into the pyrite grains.

When the Pb isotope results from galenas and pyrites are plotted in the $^{207}Pb/^{204}Pb$ *versus* $^{208}Pb/^{204}Pb$ diagram they form a linear trend. Several hypothesis can be proposed to explain changes in the Pb isotopic composition with continuing deposition. The first hypothesis suggests that radiogenic Pb probably was collected as a contaminant by an isotopically homogeneous ore fluid. When the fluids passed through a given fracture or similar permeable zone would extract preferencially radiogenic lead. Later fluids passing through the same conduits should encounter a decreasing amount of extractable radiogenic Pb adjacent to thefracture. As consequence, the fluids show decreases in their radiogenic content as time progresses (Casavedall and Ohmoto, 1977).

The second hypothesis is based upon the assumption of an isotopically non-homogeneous source for the mineralizing solutions. Thus when the ore solutions leave the source area, the more radiogenic Pb component may be deposited at different portions of the ore (Austin and Slawson, 1961). In the present study, the trend (Figure 2) may indicate the significant influence of old continental crust in the hydrothermal solution, i.e., $^{207}Pb/^{206}Pb$ isotope ratio variations suggest contamination sources sources with different μ_1 values (from 9.7 to 10.2). Prabable regional unit candidate to be the gold source is the ca. 1. 1.50 Ga Rio Alegre metavolcanosedimentary sequence comprised of mafic and ultramafic volcanic rocks, chemical sedimentary rocks and mafic to felsic intrusive rocks metamorphosed at greenschist facies. The contamination of the fluids (originated in a mantle-derived protolith according aqueous carbonic fluid inclusions available data; Geraldes et al., 1997b) by Pb from crustal rocks may have taken place when the hydrothermal solution intruded throughout the supracrustal host rocks.

The Pb isotopic results in galenas plot along the two-stage average-crustal growth curve (Stacey and Krammers, 1975), indicating ages from 669 to 772 Ma, quite distinct from the sericite K/Ar ages (ca 1000 Ma). However, when these isotopic data are referred to the plumbotectonic diagrams of Zartman and Doe (1981), they consistently fall within 1000-800 Ma age interval, indicating a multi-stages evolution to the Pb before incorporating in the galena crystals. These Pb model ages for galena are broadly consistent with the K/Ar ages and may represent the age of the mineralizing solution precipitation.

Four pyrites from Pombinha and Ernesto hosts rocks (conglomerated also mineralized for gold) were analyzed (total dissolution) for Pb isotope ratios. Three of the same samples were separated for step-leaching dissolution and the results are plotted in Figure 2. The plot indicates a much more radiogenic signature for the pyrites (from the host-rocks) than that for galenas (from the Au-bearing qz-vein) and the Pb composition probably is a result of the U-bearing minerals in the pyrite grains (as observed in electron microscopy studies) or the presence U in the pyrite lattice.

CONCLUSIONS

The results of this study illustrate that genetic process(es) describing the origin of the Pontes e Lacerda gold-bearing veins system must take in account a heterogeneous source fluid, as documented by the Pb isotopic data.

The sulfur isotopes results in sulfides from mineralized veins reflect a complex history where ore solutions interacted with the conglomerated host-rocks, which is indicated by the shift in of $\delta^{34}S$ values from the sulfides from the vein and the sulfides from the host-rocks.

The Pontes e Lacerda gold deposits must have formed in the course of the Aguapeí-Sunsás event in the SW part of the Amazonian Craton and the studies here reported states for an important metallogenic epoch in the Pontes e Lacerda region in the Mesoproterozoic time.

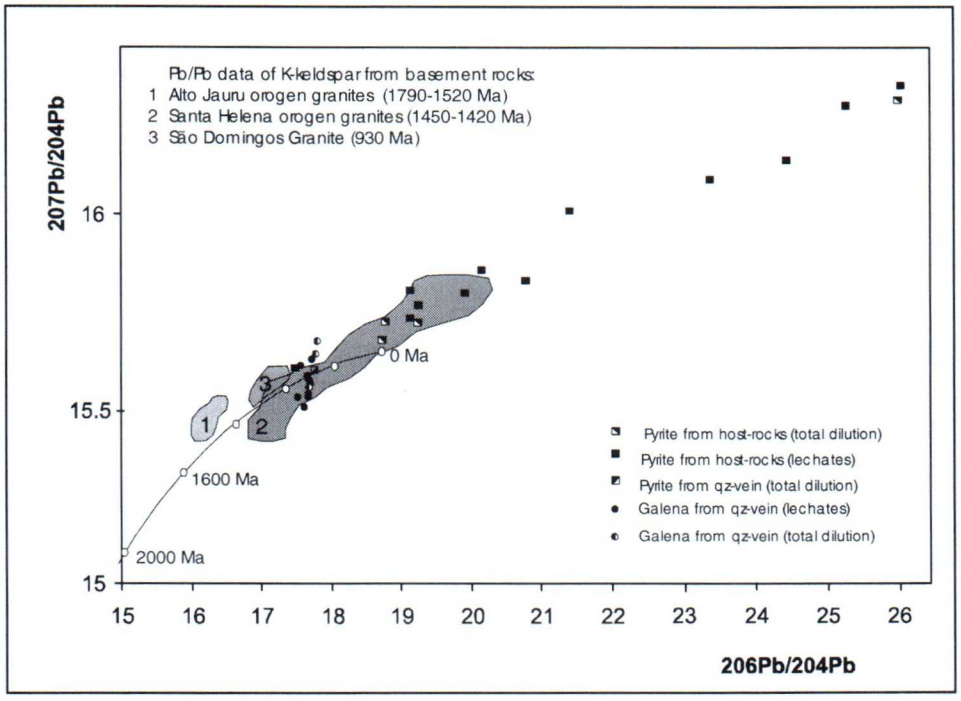

Figure 2. ^{207}Pb / ^{204}Pb *versus* ^{208}Pb / ^{204}Pb diagram for galena and pyrite from the Pontes e Lacerda gold deposits.

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