THE METASANDSTONE-HOSTED Au-PGE MINERALIZATIONS OF THE SERRA PELADA DEPOSIT, SERRA DOS CARAJÁS (PARÁ STATE, BRAZIL): A STABLE ISOTOPE RECONAISSENCE STUDY

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Financial support: FAPESP and CNPq

Keywords: Stable isotopes, Au-PGE mineralizations, Serra Pelada deposit, Serra dos Carajás

INTRODUCTION

The Serra Pelada Au-PGE rich deposit, located at the Serra dos Carajás Mineral Province, is worldwide known and has been object of several investigations, in the past, but recent details about geological and geochemical indications for mineralizing process modelling are mainly dealt with by Tallarico et al. (2000), Moroni et al. (2001), Cabral et al. (2002a), Grainger et al. (2002), among others The present study reports mainly the results of bulk whole-rock oxygen, carbon and hydrogen isotope compositions of the main ore zone rock facies.

GEOLOGICAL CONTEXT

The Serra Pelada Au (Pt-Pd) deposit is host in a late Archean low-grade metasedimentary sequence namely the "Rio Fresco Formation, a fluvial to shallow-marine sequence in origin, composed of metaconglomerate, metasandstones, metasiltstone and dolomitic marble (Tallarico et al., 2000) (Fig. 1). In the Serra Leste sector these rocks overly older Archean basement rocks as well as supracrustal Archean metavolcano-sedimentary rocks of the Rio Novo Sequence (mafic-ultramafic schists, felsic rocks, iron formation and chert) (Tallarico et al., 2000). This sequence is intruded by the Luanga Complex (2763 2 Ma; Machado et al., 1991), which host and/or is genetically related to a diverse number of metallic commodities (Cr, PGE). The area has been affected by an early anorogenic magmatic episode (Cigano Granite) at 1883 2 Ma (Machado et al., 1991), followed by dioritic and granodioritic plugs, mafic dikes and sills of unknown ages, and referred to one intrusive episode (Tallarico et al., 2000).

THE ORE ZONE

The Au-(Pt-Pd) mineralization is distributed over a thickness of about 150 m at depth, is located in a ringe zone of a tectocnically controled recumbent sincline, at the eastern segment of the ENE-WSW steeply deeping Cinzento strike-slip system. The mineralized and non mineralized rock facies consist of low-grade: (1) metasandstone and Mn-bearing metasandstone beds, (2) ferruginous, kaolinised carbonaceous siltstone and gray metasilstone containing variable proportions of amorphous carbon (2 to 10 wt%), (3) red laminated metasiltstone (Fe-oxide enrichment), (4) laminated black-brown earthy friable rock facies called "hidrotermalito", (5) breccia levels alternating with hydrothermalized silicified and hematite-rich metasiltstone and metasandstone, and (6) quartz-dolomitic marble. According to Grainger et al. (2002), Au-PGE mineralization is associated with magnetite and hematite-rich hydrothermal breccias, zones of hematite metasomatism, and intense sericite-kaolin metasomatism, siderite veining, and jasperoid envelope of amorphous silica alteration-bearing disseminated pyrite.

SUGGESTED GENETIC MODELS

Tallarico et al. (2000), recalls that the Au - (Pd-Pt) mineralization with thorite and REE minerals might be, associated with a hot, saline, oxidized and possibly acid fluid; the primary mineralization is tentatively related to hydrothermal alteration associated with

In: Simpósio de Geologia da Amazônia 10, Porto Velho 2007 dioritic intrusions (intrusion-related model), later overprinted by supergene alteration. As for Cabral et al. (2002a), the mineralogical and chemical characteristics favor an origin of the near-surface high-grade Au-(Pd-Pt) mineralization, from a sulfur-deficient hydrothermal system; the deposit is probably hypogene, despite the deep lateritic weathering. For Moroni et al. (2001), the original hydrothermal mineralization was intensely overprinted by deep-reaching (> 200 meters) supergene alteration during long-lasting laterisation process, along the ore-bearing structures, resulting in strong precious metal enrichment in a geological context probably already anomalous for Au and PGE. Grainger et al. (2002) postulate that the Au-PGE ores are epigenetic, though there is evidence of preservation of the original hydrothermal alteration, despite the deep tropical weathering. The ore metal association (Au-Pd-Pt) suggests that metal transport has taken place in acid, oxidizing, chloride-rich fluids. For these authors the deposit represents a distal equivalent to the Fe oxide Cu-Au deposits.

METHODS

Isotopic analyses of O, C and D/H were undertaken on thirty one samples of the representative rocks from the sedimentary column, including dolomitic marble, least altered and altered mineralized mestasandstone and metasiltstone, "hidrotermalito", carbonate fractions, and quartz. Oxygen and carbon isotopic analyses from carbonates samples were performed at the Stable Isotope Laboratory of the Instituto de Geociências da Universidade de São Paulo, and at the Geochron Laboratory a division of Krueger Enterprises, INC, U.S.A. Isotopic ratios were reported in notation (per mil %) in relation to the SMOW standard for 18 O/16O ratios and to PDB standard for 13C/12C ratios.

Stable isotope results:

Samples were collected at surface and over the maximum depth range of 748 meters level. Whole-rock samples were analysed for D and 18O (n=15), 13C and 18O on carbonates (n=13), and 18O (n=3) in quartz (not discussed). A summary of the isotope results is presented in Figures 2 and 3. Due to de fineness of the Au-PGE host rock facies, the analyses were carried mostly on whole-rock samples.

DISCUSSION AND CONCLUSIONS

Carbon-oxygen relationships

According to Ohmoto and Rye (1979), carbon in hydrothermal fluids may originate from a magmatic source, from decarbonation or leaching of carbonates, or from the oxidation, decarboxylation, or hydrolysis of reduced carbon in sedimentary or metamorphic rocks. Also according to Kerrich (1990), interaction of CO2-bearing fluids with graphitic rocks may potentially result in 13C depletion in precipitated carbonates. In our case the carbonaceous material, in the deposit, is associated with black carbon-rich "hydrotermalito" interbeded with gray metasiltstone, graphitic-rich layers interbeded with hydrothermalized metasandstone/metasiltstone, graphitic laminated clay-rich hydrothermalyzed metasiltstone, and graphite bearing laminated metasiltstone. Accordingly, some of the study rocks exhibit strong 13C depletion (Fig. 2), which might be explained by the processes referred above.

In the 18O versus 13C space (Fig.2) the dolomitic marble (samples CAR-7; AM-1; AM-3; AM-4; AM-5; AM-6; SLFD-112AB; SLFD-75A), exhibit a covariance of the oxygene and carbon isotopic values. This variation suggests mixing of infiltrating hydrothermal fluids with dolomitic marble; this process depends on several factors: temperature, isotopic composition of the initial fluids and rocks, the concentration of carbon and its speciation in the fluid, mixing of water and enriched CO2 from decarbonation reactions (Taylor, 1987). Also the concomitant operation of decarbonation, and combined fluid infiltration and devolatization during metasomatism or mixing of H2O and enriched CO2 from decarbonation (Valley, 1986; Rumble, 1982) may explain the shift in the 18O of C-O-H hydrothermal fluids (Taylor, 1987) (Fig.2). In addition, samples CAR-7, AM-1 and AM-3 record average 13C carbonate values of +6.1 to +6.3 ‰ isolated from carbonates from samples AM-4, AM-5 and AM-6, which show homogeneous average 13C carbonate of +1.2 ‰ within the 13C (range of -2 to +3 ‰) characteristics of Archean marine carbonates (Schidlovski, 1998; Veizer et al., 1989). The high 13C carbonate values (see Buick et al., 1998), could also indicate a high positive carbon isotope excursion, but additional samples are required for a reliable interpretation.

The general isotopic trend shown by samples CAR-1, CAR-9, SL-13, SL-12 and SL-8 (Fig.2), is compatible with a conbined fluid infiltration and devolatization during hydrothermal processes. Also the observed negative shift may reflects a partial isotopic equilibration between 13C depleted organic C, which according to Schidlowski (1988) is –26 7 ‰ throughout the geological record, and aqueous hydrothermal C species (Kerrich, 1990).

Deuterium-oxygene relationships

At Serra Pelada, quartz, kaolinite, hematite and goethite with minor residual muscovite, are the dominant phases in mineralized and non-mineralized rock facies and may comprise more than 90% of the rock samples. All of them are minerals retentive of their original isotopic compositions at low temperature (e.g., Kyser, 1987; O'Neill, 1987). The high 18O observed in all rock samples (Fig.3) probably expresses mixed 18O signatures of the overall mineral phase components namely detritic quartz, hydrothermal silica, kaolinite, Fe hydroxides and other hydrous silicate mineral.

One sample of mineralized sandstone (SL-12) (Fig.3) lends support to a meteoric fluid infiltration within the deposit. The D values of the remaining samples are over –79 ‰ and in the range of D –79.0 ‰ to –60.0 ‰, and the 18O values of the altered and mineralized rocks are in the range of +13.2 to +16.5 ‰ (Fig.3). This narrow range of δ18O values reflects an isotope homogeneization due to the hydrothermal alteration, and the overall δ18O and D/H isotopic characteristics may depend on various factors: (1) presence of Fe hydroxides (ex: goethite at low temperatures), resulting in lower D and 18O than clays, (2) influence of the isotopic composition of quartz contained in the samples (18O values from three quartz samples associated with marble vary from 14.0 to 15.2 ‰), (3) influence of the isotopic composition of clays; (4) oxidation of pyrite.

The mineralized samples from the Serra Pelada deposit, represented by altered metasiltstones, metasandstones and "hidrotermalito", all tend to show higher 18O (Fig. 3) values, i.e. closer to the weathering line reported for supergene clays (Taylor, 1979), thereby suggesting that in mineralized samples the "supergene" isotopic imprint is dominant.

A broad comparison may be made in relation to the isotopic compositions of quartz from those Au-PGE-bearing deposits (e.g., Coronation Hill, etc.), in which the action of low-temperature saline, aggressive meteoric solutions overprinting primary mineralization has been recog nized (Mernagh et al., 1994).

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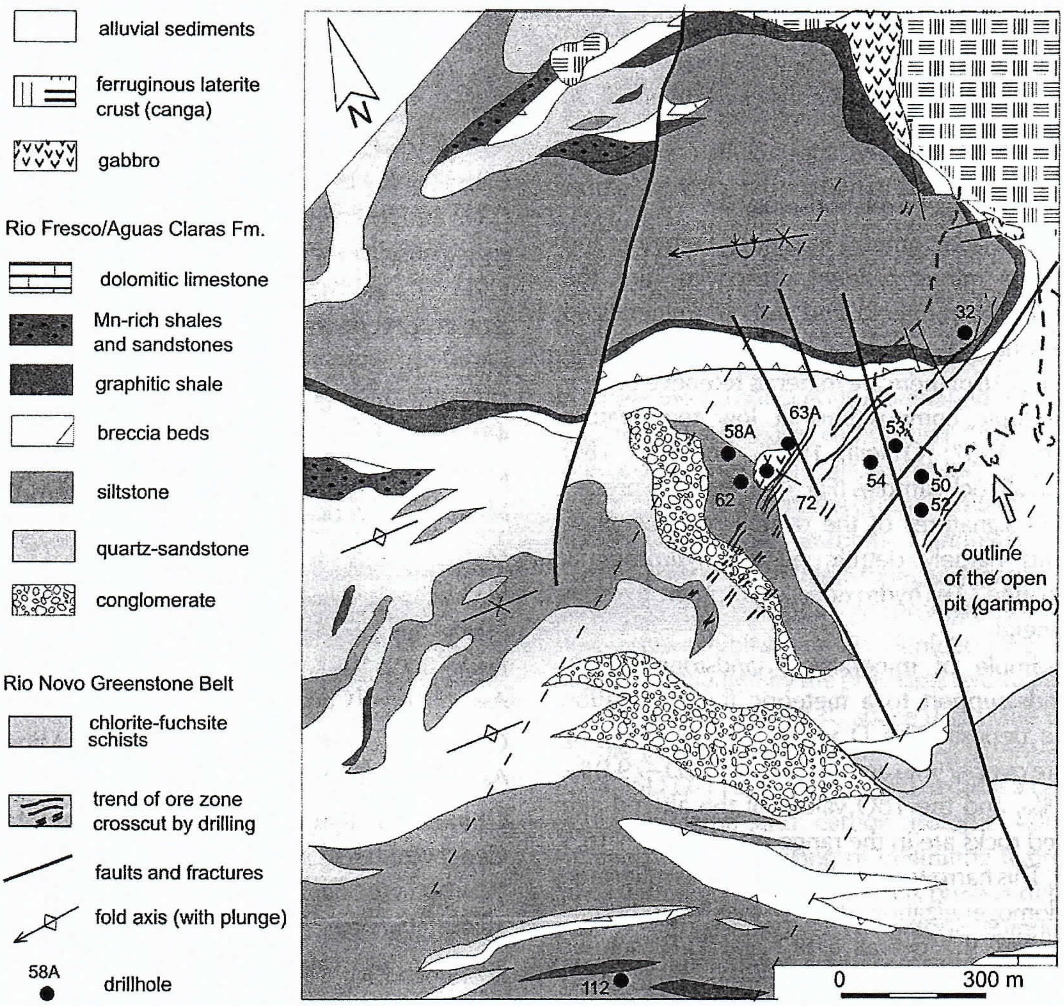
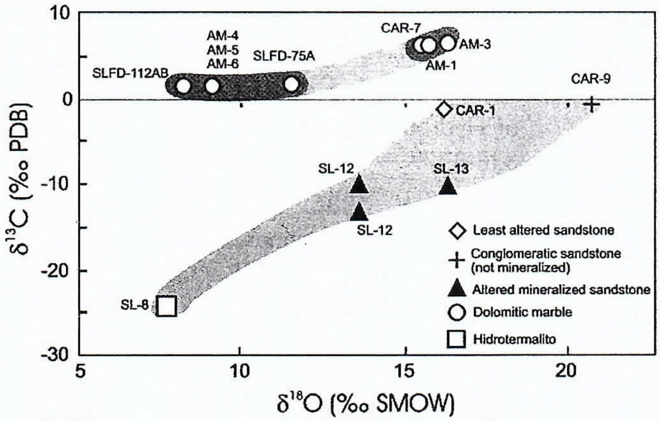


Figura 1 - Geological sketch map of the Serra Pelada Mining area showing the trend of the ore zone and drill hole locations. (Modified after Docegeo, 1988; Moroni et al. 2001).



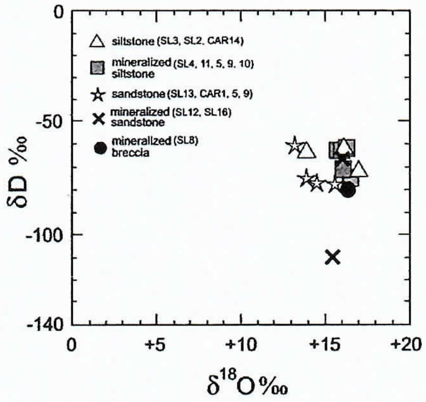


Figura 2 – Stable isotope data from the study deposit: general isotopic shifts in δ 13C and δ18O carbonate values.

Figura 3 –Stable isotopic data from the study deposit: δD-δ18O characteristics of the main ore zone rock facies, and recognized domains.