ORE FLUIDS RESPONSIBLE FOR THE NORTHERN RANGE CARAJÁS IRON DEPOSITS: CONSTRAINTS BASED ON FLUID INCLUSIONS OF VEIN MINERALS, FOOTWALL MAFIC ROCKS

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Fig. 1 – Geological map of the Carajás Mineral Province with major mineral resources (Figueiredo e Silva et al. 2008 after Bizzi et al. 2001).

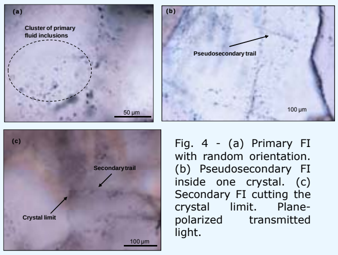

Fig. 4 - (a) Primary FI with random orientation. (b) Pseudosecondary FI inside one crystal. (c) Secondary FI cutting the crystal limit. Plane-polarized transmitted light.

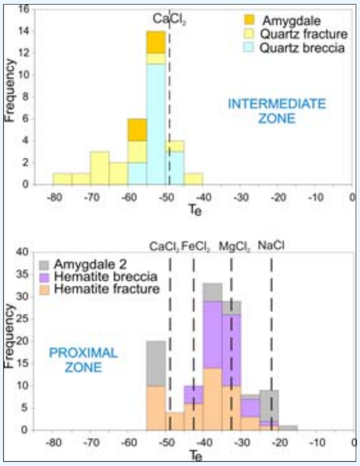

Fig. 5 – Histograms of eutectic temperatures (T_e) of fluid inclusions in quartz at intermediate and proximal alteration zones.

1 - Introduction

The Carajás Mineral Province comprises Archean metavolcano-sedimentary sequences that are grouped into the Itacaiúnas Supergroup (Fig. 1). The iron deposits are hosted by the metavolcano-sedimentary rocks of the Grão Pará Group, which consists of basalts and basaltic volcaniclastic rocks, intercalated with rhyolites (2760 ±7 ma; SHRIMP U-Pb zircon age) and tuffs. These rocks under- and overlain jaspilites, that host high-grade iron ore bodies (>65% Fe) with minor intercalated mafic volcanic rocks. Iron ores are banded, massive and brecciated, and are associated with hematite (±martite). The volcano-sedimentary sequence is overlain by sedimentary clastic rocks. The sequence underwent submarine hydrothermal alteration, greenschist-facies regional metamorphism and hematitic hydrothermal alteration. As a result of the hydrothermal iron mineralising event, the mafic rocks were chloritised and hematitised at the contacts with the iron ores deposits**.**

2 – Fluid Inclusion Data

The basalts are subdivided into three alteration zones based on petrography and geochemical studies (Fig. 2): (i) distal (least altered rocks: metabasalts with chlorite), (ii) intermediate (chlorite metabasalts), and (iii) proximal (highly altered rocks: hematite-chlorite metabasalts).

Primary and pseudosecondary fluid inclusions-FI in quartz and minor carbonate from intermediate and proximal alteration zones were analysed. The FI are hosted by amygdale, fracture fill and breccia vein types (Fig. 3). They occur as isolated inclusions, clusters or internal trails (Fig. 4). They are mostly two-phase aqueous, liquid-rich (10-20 vol% vapour), with irregular shapes, and 4-8 μm average size. Three types of FI have been recognised based on eutectic temperatures (T_e) and saline systems (Fig. 5). Type I inclusions have $T_e \leq -50^{O}C$, low to high salinity (4.1-28.4 eq. wt% $CaCl_2$), and they are common in the intermediate zone. Type II inclusions have $-49^{O}C \leq T_e \leq -30^{O}C$, low to high salinity (0.2-25.8 eq. wt% $CaCl_2$), and they are common in the proximal veins. Type III inclusions show $T_e \geq -29^{O}C$, low salinity (1.4-7.2 eq. wt% $CaCl_2$; 3.3-4.6 eq. wt% NaCl) and they occur in the proximal zone. The measured homogenisation temperatures ($T_{hTOT(L)}$) occurred between 133-323°C and, because of the lack of evidence for boiling, they represent the minimum trapping temperatures. Thus, a pressure correction of ~90°C was applied in order to constrain the true trapping temperature (Fig. 6).

3 – LA-ICP-MS and Ion Chromatography

Laser ablation ICP-MS and ion chromatography analyses were performed on fluid inclusion in vein quartz from the intermediate and proximal zones. The data show higher Cl, K, Na, Ca, K, Li, Mg, Sr, Ba, Cu, Zn, Pb, and Mn concentrations at the intermediate zone, whereas Fe is higher at the proximal zone. Fluid inclusion data display mixture of a magmatic fluid (high salinity) and meteoric water (low salinity). LA-ICP-MS analyses show mineral precipitation together with fluid dilution, supporting mixture of magmatic and evolved meteoric fluids causing hematite precipitation. Since the Cl/Br and Na/Br molar ratios do not follow the sea water evaporation line, an evaporitic hydrothermal fluid source is excluded.

4 – Acknowledgments

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Fig. 2 - Photographs of diamond drill core showing the increasing of hematitic hydrothermal alteration. (a) Distal zone, basalt with chlorite; (b) Intermediate zone, chlorite basalt with carbonate and chlorite veins; (c) and (d) Proximal zone, hematite-chlorite basalt with chlorite and hematite filling veins, replacing the rock matrix and amygdales.

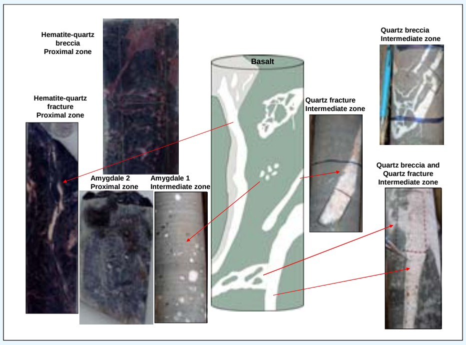

Fig. 3 – Schematic diagram showing classification and timing relationships of the veins.

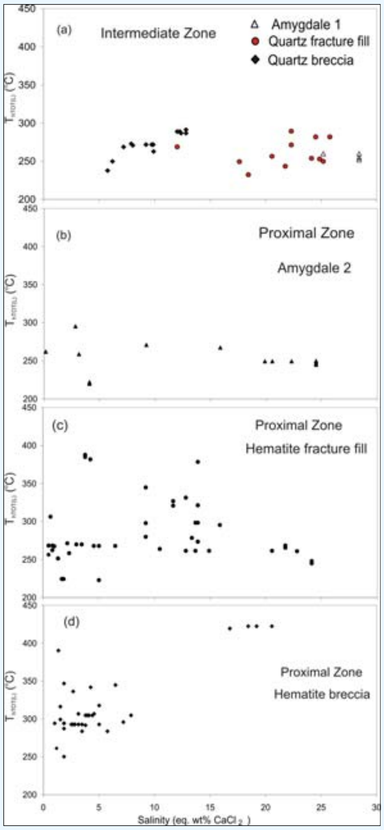

Fig. 6 – Temperature (°C) of corrected homogenisation (T_{hTOT}) versus salinity (eq. wt% $CaCl_2$).

5 - REFERENCES

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