

## Lithogeochemistry and stable isotopic geology (C,S,O) of the Cristalino Cu(Au) Deposit, an archean IOCG-type, Carajás Province, Pará, Brazil

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Lithogeochemistry and stable isotopic data from country rocks and sulfide ores of the Cristalino Cu(Au) deposit (CD) were studied. The CD occurs in the Carajás Province, Brazil. It is a world class IOCG-type (estimated resources >500Mt @1.0%Cu and 0.3 g/t Au), Archean in age (ca. 2.7Ga), located in a low-grade volcano-sedimentary sequence (Itacaiúnas Supergroup) that was hydrothermalized: alkalization; chloritization; carbonatization; Fe-metassomatism; and sulfidation. Ores occur in breccias, stockworks, disseminations, and stringer to massive types in the host (mafic and felsic volcanic) rocks. Diorites and quartz diorites crosscut these supracrustals and could relate to Cu(Au)-mineralization. Lithogeochemistry (mass balance and Harker diagrams) of these rocks determined enrichment or depletion for several elements. Na, K, Ca, Fe, Mg, Mn, P, Sr, Ba, Ni, Co, Cu were severely hydrothermally mobilized whereas Al, V, Ti, Y and Zr were more immobile. Discrimination diagrams (mainly using Y, Zr and Ti) for metamafigs associated them to an intraplate (rift) environment with magmatic affiliation of MORB-type. Stable isotope data come from calcite (whole rock samples) and from chalcopryrite and pyrite (separated grains) from mafic and felsic volcanics, and “hydrothermal breccias”. They all show  $\delta^{34}\text{S}_{\text{(CDT)}}$  (0.6 to 1.5‰) values closer to mantle sulfides and to MORB values.  $\delta^{13}\text{C}_{\text{(PDB)}}$  (-7.2/-4.4‰) and  $\delta^{18}\text{O}_{\text{(SMOW)}}$  (+8.1/+9.3‰) values plot on primary carbonatite field. CD data set corroborate former proposals of other researches [1] which suggested a bimodal tholeiitic magmatic affiliation for these IOCG-type deposits in Carajás Province and an Archean intracontinental rift environment for the Carajás Basin (Pará, Brazil).

## Stable isotope signature of the Middle Holocene climatic change in the SW Iberia

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Between 7.5 kyr and 4 kyr a fluvial limestone tuffs system developed in the south-western corner of Iberia. This system is characterised by a segmented up to 60 meters thick limestone sequence dated by radiocarbon.

The system is calcite dominated, and the other coeval mineral constituents comprise iron oxides and hydroxides and clay minerals. Other mineralogical components such as quartz and feldspar are seldom and detrital, from the surrounding Upper Carboniferous and Upper Triassic formations.

Most of the tuffs are well banded, with a layering which ranges in thickness from the micrometric scale to the centimetric scale.

The different centimetric layers were sampled and bulk  $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  were determined. The oxygen and carbon isotopes were used as recognized proxies for paleoenvironmental conditions and the Sr isotopes with the purpose of understanding the residence time of the meteoric waters in the surrounding carbonate formations.

The main results point to: (i) the hydrologic conditions of the system were not suitable for the waters from which the limestone tuffs precipitated to equilibrate with the Mesozoic carbonate formations; (ii) the probability of having ‘old carbon’ in those waters is very low increasing the reliability of the  $^{14}\text{C}$  age determinations; (iii) the composition in stable isotopes of the waters were probably close to the meteoric water composition for the period under consideration; (iv) between 7.5 kyr and 4 kyr the oxygen isotopic composition of the limestone tuffs show a gradual depletion in  $^{16}\text{O}$  with the values of  $\delta^{18}\text{O}$  increasing from -5‰ to -3.5‰ probably related to an increase in the importance of the evaporation in the hydrological system; (v) during the same time interval the  $^{13}\text{C}$  composition of the limestone tuffs remains crudely constant reflecting the stability of the vegetation cover.

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