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## **Abstracts**

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## COPPER BEHAVIOUR IN LATERITIC WEATHERING OF CUPRIFEROUS ORE DEPOSITS IN BRAZIL

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Three copper deposits, located between the 5° and 24° South Latitude, were selected in Brazil to study copper behaviour during lateritic weathering. In each area, petrological and geochemical analyses with a geochemical and mineralogical balances were carried out.

In the Chapada Grande area (central Brazil), under a wet savanna climate, a thick lateritic layer (40m), partially covered by an Fe-crust, was investigated. The chalcopyrite and pyrite mineralization, is poor (0,4% Cu) and disseminated into proterozoic metasediments.

The copper is leached in the whole profile. The leaching is less significant at the bottom and increases gradually toward the upper part. In the weathering products, (smectite at the base, goethite and kaolinite at the top) an association Fe-Cu appears. In the saprolite, the microprobe analysis of weathering products shows a significant linear correlation coefficient Fe-Cu which increases towards the upper part of the saprolite. In the surface horizons (Fe-crust and the underlying horizon) where the rock structure is destroyed the Fe-Cu correlation disappears. However, Kinetic selective extractions of Fe oxihydroxides, with Tamm U.V., indicates that the Fe-Cu association still exists, but only for 20 to 50% of the Cu of these horizons. The formation of a non-identified Cu phase, independent of goethite and, also, of the single Al mineral (kaolinite), is proposed. The mean Cu content in goethite is low (about 1%).

The disseminated and poor mineralization results in low  $\text{Cu}^{2+}$  in weathering solutions. Moreover, in the weathering profile (1) goethite is the main supergene mineral which fixes Cu, (2) the Cu content in goethite is low, and, (3) the goethite concentration is low (15% in the Fe-crust). Therefore, the Cu is leached.

In Salobo 3A (Carajás mineral province, North Brazil), under an equatorial climate, the weathering cover is thick (50m). The chalcopyrite and bornite mineralization (0.8% Cu) is associated with a proterozoic schist formation and located on the steep, slope of a hill.

In the saprolite, the Cu contents don't show significant variations with those of the fresh rock. The saprolite is a potential ore. Cu is strongly leached only in the upper part of the profile where the rock structure is destroyed. The Cu released by weathering of sulfides, which are

concentrated in the magnetite rich facies, is redistributed in the weathering products of the different facies. The Cu is mainly trapped by an interstratified biotite/vermiculite (Ib/v) formed by weathering of biotite.

As a matter of fact, in the saprolite, 70 to 80% of the Cu is associated with Ib/v where 15 to 25% is associated with goethite and about 6% with smectite. Therefore, the Cu behaviour is essentially related with that of Ib/v. Indeed, (1) in the upper part of the profile, only the destruction of the IB/V allows the release and the leaching of the Cu (-89% as compared with fresh rock), (2) at the base the lower proportion of Ib/v, where sulfides are completely weathered, results in the leaching of 50% of the initial Cu. It can be noted that Ib/v is the main secondary mineral of the weathering of a biotite rich facies, which is considered as sterile in the fresh rock.

The special structure of the fresh rock, the foliation plains which are perpendicular to the slope direction, certainly results in a slow percolation of the weathering solutions, inducing the formation of Ib/v and the slight leaching of the Cu. Moreover, the ferruginous primary paragenesis favour the formation of an important quantity of goethite. In this special context, the initial stock of Cu is a globally held in saprolite horizons.

In Santa Blandina (Souther Brazil), the mineralization occurs as massive sulfides (chalcopyrite, bornite) pockets or veins in a skarn formed by 67% (in weight) of garnet (grossular, andradite). Under a sub-formation of a saprolite with a significant porosity (70%). A karst is formed by the weathering of a marble lenses embedded in the skarn. The weathering of massive sulfide pockets leads to the formation of a gossan, and the Cu released accumulates at the base of the profile. In the first stage, on the quartz is dissolved;  $\text{Cu}^{2+}$  and  $\text{H}_4\text{SiO}_4$  are high enough to precipitate chrysocolla. In the second stage, garnet is dissolved together with quartz, and the Si and Al released react with Cu to form clay like products. They are composed of a mixture of chrysocolla and clay minerals (smectite and interstratified smectite-kaolinite). Near the karst, the leaching increases, but the contribution of Cu coming from the upper horizons allows the stability of chrysocolla at the expense of the clay minerals.

The special mineralogical context of Santa Blandina induces higher  $\text{Cu}^{2+}$  and  $\text{H}_4\text{SiO}_4$  in the solutions as



compared to the other areas, and leads to the formation of chrysocolla. The Cu is accumulated.

In the weathering profiles of the three studied areas, four secondary minerals trap the Cu: (1) field and laboratory observations indicate that Cu is absorbed on goethite. (2) smectites fix the Cu as an exchangeable form. (3) In the interstratified biotite/ vermiculite, Cu is not exchangeable, and located in interlayer positions in a bivalent form and is in 6-fold coordination (Ildefonse et al. 1986). (4) In a special mineralogical context (Santa Blandina) chrysocolla is precipitated.

In the lateritic profiles developed in a special structural and mineralogical context, the Cu behaviour depends on:

- the nature and quantity of secondary products

- the capacity of these products to trap Cu
- $\text{Cu}^{2+}$  and  $\text{H}_4\text{SiO}_4$  in weathering solutions

This study shows that a particular structural and mineralogical context can lead to the formation of economic Cu concentration in a lateritic environment. In terms of geochemical exploration, in this environment goethite is the mineral which best maintains the memory of a possible Cu mineralization up to the surface.

## REFERENCES

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