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Chemistry as a Tool for Optimization the Mineral Processing in the Central Andean Tin Belt

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INTRODUCTION

The Central Andean tin belt (also referred to as the Bolivian tin belt) is a metallogenic province, well-known by Sn, Pb, Zn, Ag and W. However, in the Bolivian sector the potential by strategic elements still uncertain.

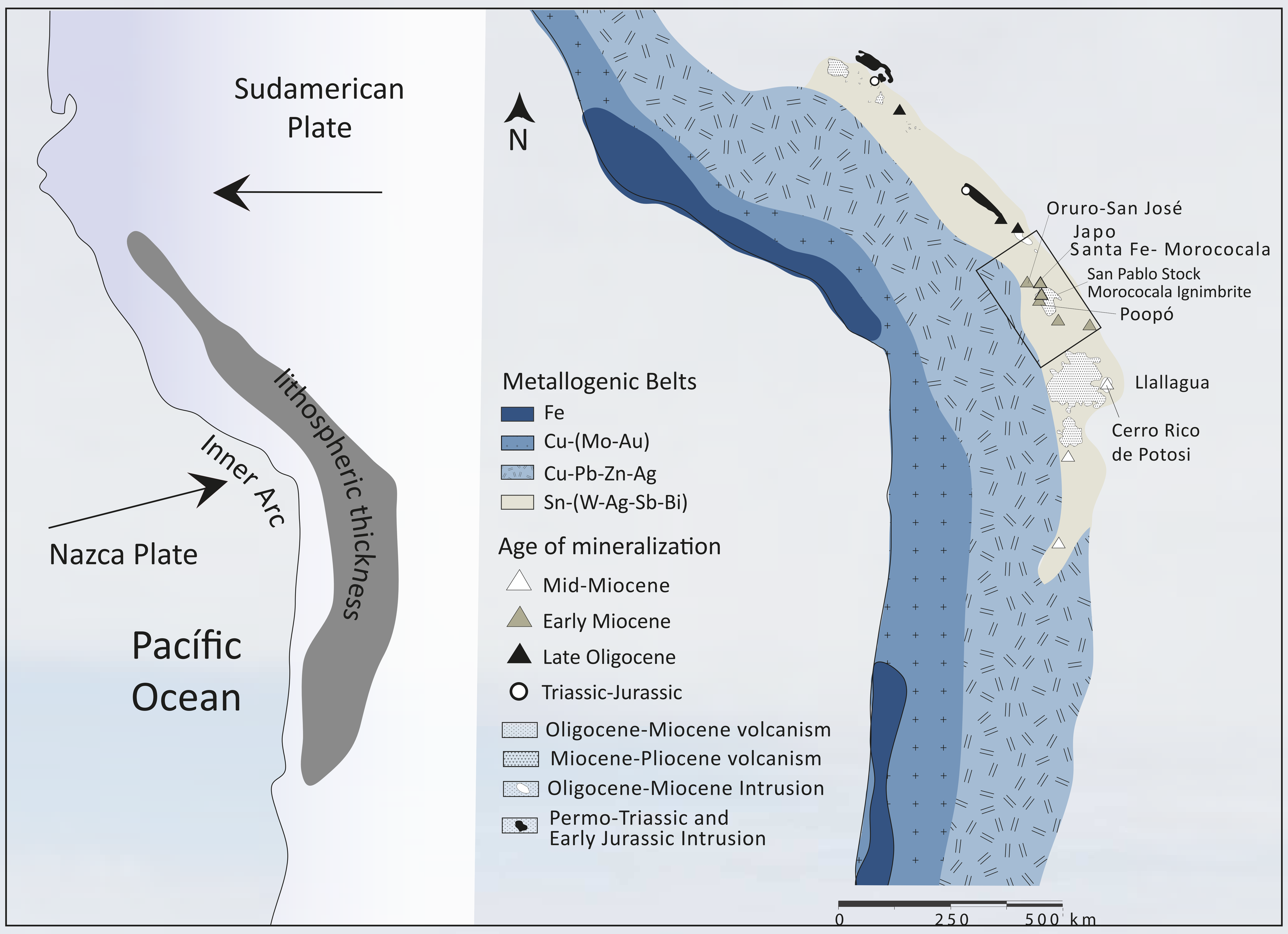
The present study, was carried out in order to characterizer several deposits in this province, to have a better approach about the economic potential of strategic minerals based on the study of mineral assemblage.

A lot of samples from the Poopó, Oruro, and Santa Fe mine districts were analized by X-ray diffraction, scanning electron microscopy (SEM) with X-ray dispersive energy analyzer (EDS) and EMPA. This work is focused in the determinatioin of metal amounts to evaluate the real extractive potential in them.

GEOLOGICAL FRAMEWORK

The Central Andean tin belt extends along approximately 900 km in a NW trending toward Eastern Bolivia. This belt is extent through Peru and Chile as an extension of the Eastern Cordillera. There is an important geographic feature of the Central Andean tin belt precisely in the central segment of an arcuate mountain range, which represents a marked landward broadening of the Andean orogen. This region, referred to as the Inner Arc (Clark et al., 1990), is restricted to the Eastern Cordillera of the centermost Andes, and lies to the east of the zone of high intra-Andean plateaus (Altiplano-Puna), which marks an interface between the oceanward, Main Arc (Western Cordillera) and the South American craton.

The Inner Arc is composed of early Paleozoic, marine sedimentary rocks, experienced extensive Cenozoic crustal deformation and anataxis; and it is because these processes that ultimately occurred the accumulation of large amounts of metals distributed in metallogenic belts (Sillitoe; 1976; Lehmann, 1979; Mlynarczyk and William-Jones, 2005).



Main tectonic features and relationship with metallogenic of the Central Andes. Plate tectonics, volcanism and lithospheric thickness (~10-15 km). Relevant ore deposit with time in the Central Andean tin belt (after Mlynarczyk and William-Jones, 2005; Sillitoe, 1976; Lehmann 1979, 1990).

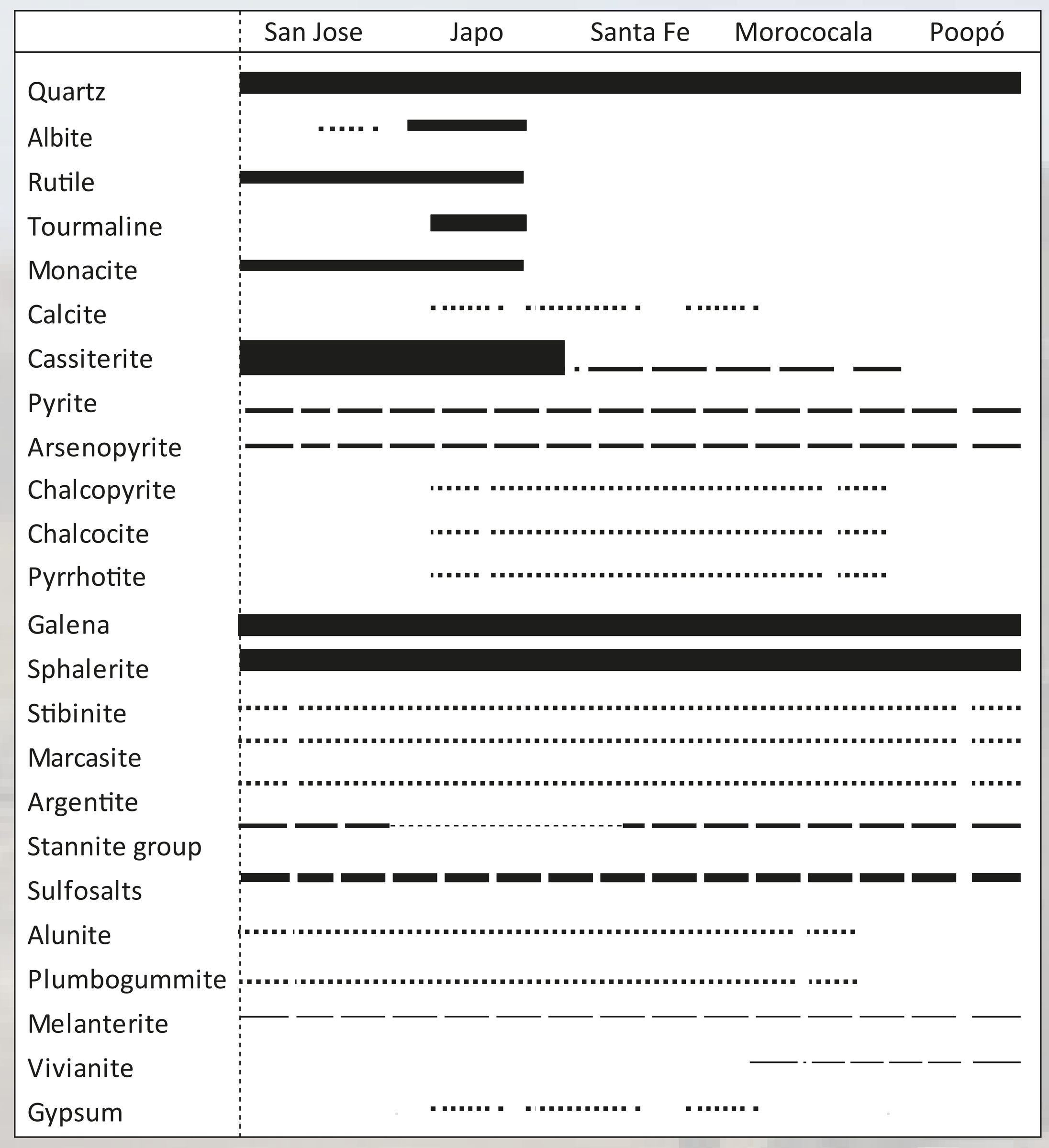
MINERALOGICAL CHARACTERIZATION

Ore mineral assemblage in the Central Andean Tin Belt is represented by oxides, sulfides and sulfosalts. Cassiterite constitutes the earliest mineralization. Subsequently, several generations of galena, sphalerite ± pyrite, chalcopyrite, arsenopyrite and chalcocite occurred. Sn is also present in sulfides as several members of stannite group, such as stannoidite ($Cu_8Fe_3Sn_2S_{12}$), hocartite ($Cu_8Fe_3Sn_2S_{12}$), kësterite [$Cu_2(Zn.Fe)SnS_4$], petrukite [$(Cu.Ag)_2(Fe.Zn)(Sn.In)S_4$], sakuraiite [$(Cu.Zn.Fe)_3(In.Sn)S_4$], pirquitasite ($Ag_2ZnSnS_4$) and stannite ($Cu_2FeSnS_4$).

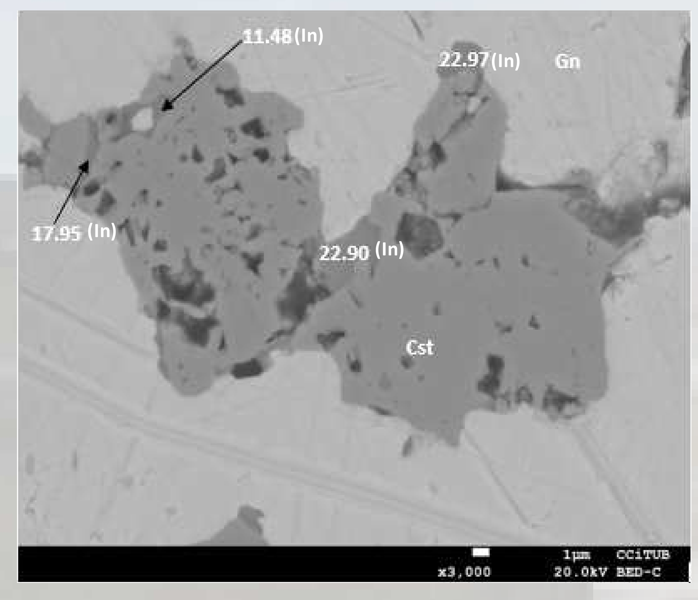
An important bunch of sulfosalts rich in Sn, Pb, Ag, Cu, Sb and Bi, such as franckeite [$(Pb,Sn)_6FeSn_2Sb_2S_{14}$], potosíite ($Pb_6Sn_3FeSb_3S_{16}$), berndtite ($SnS_2$), teallite ($PbSnS_2$), tetrahedrite ($Cu_{12}Sb_4S_{13}$), freibergite ($Ag_6Cu_4Fe_2Sb_4S_{13-x}$), tennantite ($Cu_{12}As_4S_{13}$), gustavite ($AgPbBi_3S_6$), andorite ($AgPbSb_3S_6$), ourayite ($Ag_3Pb_4Bi_5S_{13}$), miargyrite ($AgSbS_2$), cylindrite ($FePb_3Sn_4Sb_2S_{14}$), boulangerite ($Pb_5Sb_4S_{11}$), jamesonite ($FePb_4Sb_6S_{14}$), zinckenite ($Pb_9Sb_{22}S_{42}$), viaeneite [$(Fe.Pb)_4S_8O$], bismuthinite ($Bi_2S_3$) and bismite ($Bi_2O_3$) also were found in high amounts with grains size of a few µm. Zn, Pb and Ag are recovering from majority phases, recovery from sulfosalts is poor or non-existent.

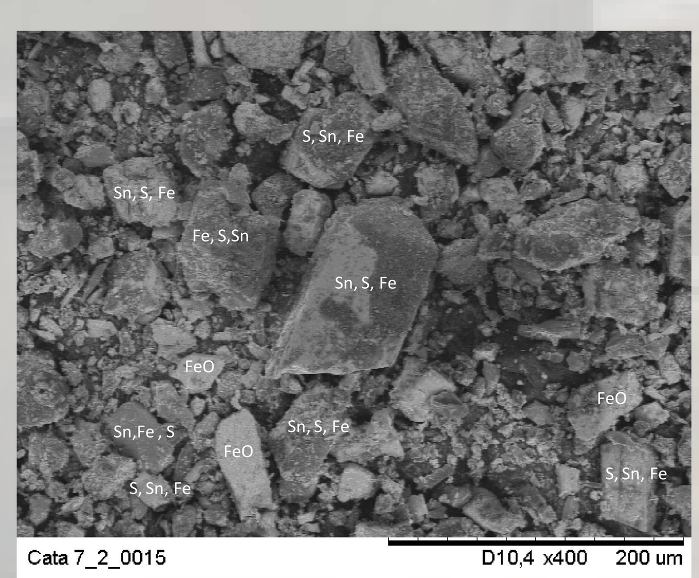
Sn recovery is moreless effective in cassiterite concentration, when Sn is in sulfide form, ore concentration is not successful. Samples of ore mineralization, concentrate and tailings were analized by X-ray diffraction in order to identify even very fine phases. In the analyzed ore samples (before concentrate processing) is evident that proportion between stannite vs cassiterite phases is 2:1. However, processing mineral in all mines in the Central Andean Tin Belt (especially in artisanal mines) is carrier on by high oxide minerals as cassiterite. Results reveal that concentration processing is not efficient in any case. In ideal conditions, cassiterite percent by gravity recovery should be ~60% (Turner and Hallewell, 1993). In the analyzed samples, cassiterite recovery is only of 34% in the concentrate, where stannite percent recovery is negligible. The extreme case occurs in the Poopó mine, where Sn is not exploited although geochemistry characterization revels high amounts of Sn, thus it is found as stannite minerals. Element concentrations in Poopó samples also show anomalous content in Ag, Zn, Fe, Sb and As.

RESULTS

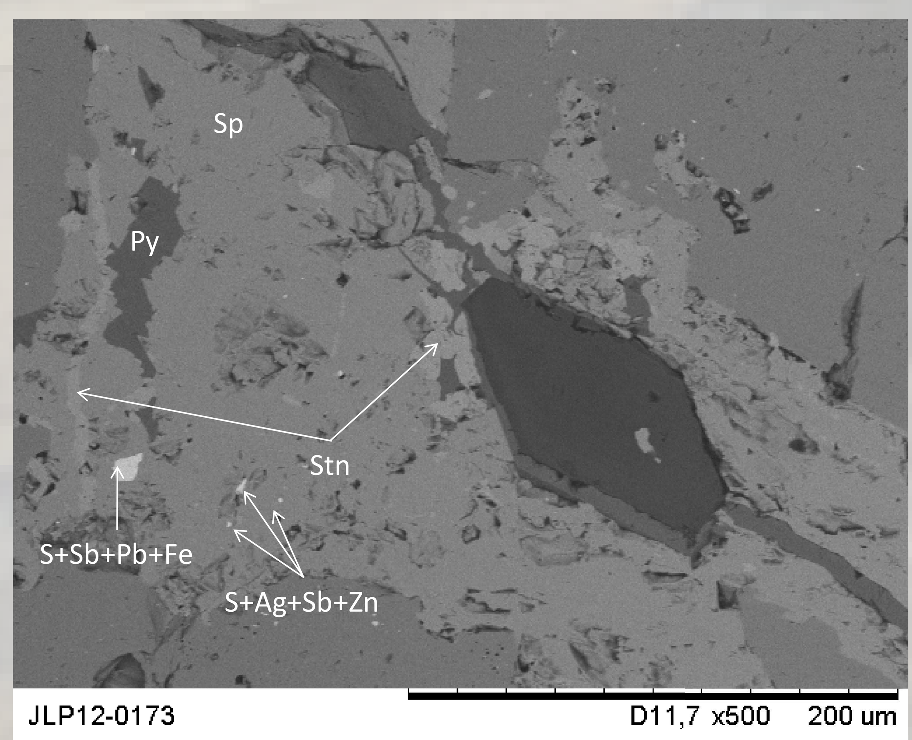


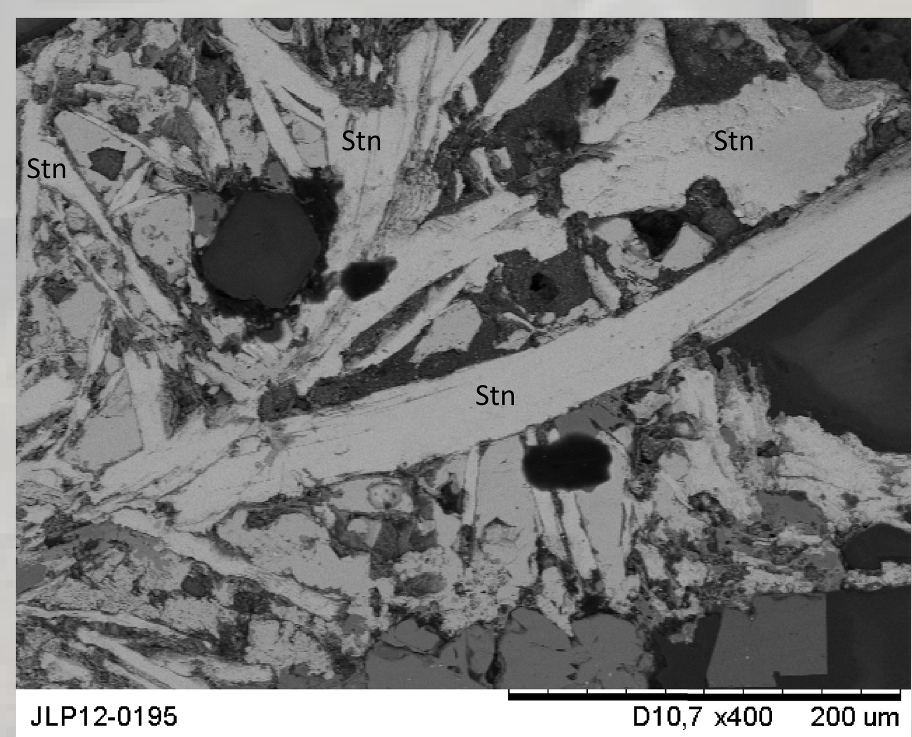
Comparision between different mineral assemblage of some deposits of the Central Andean Tin Belt



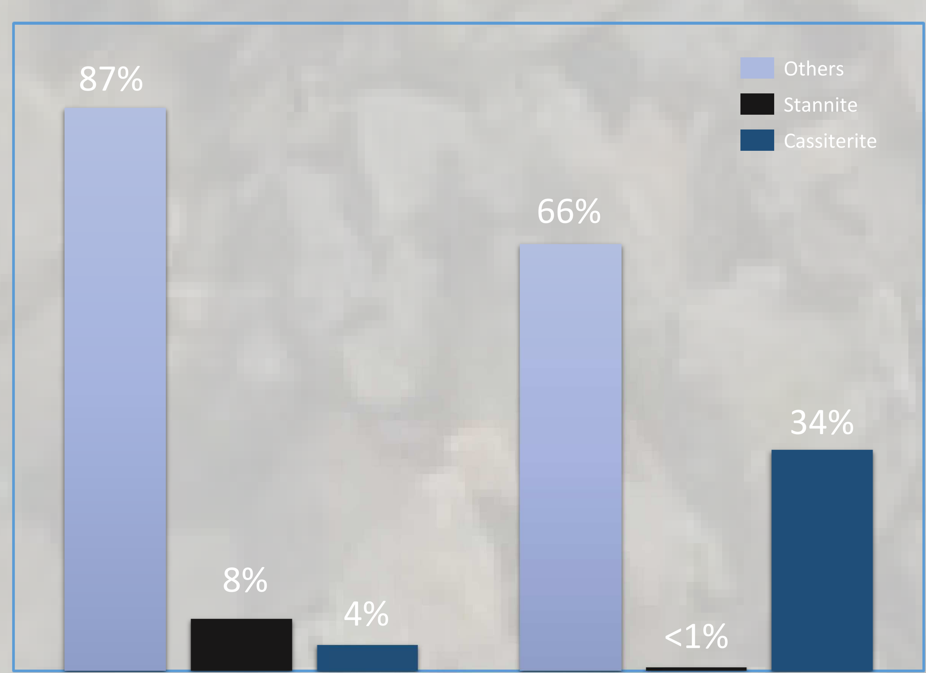


Top. Stannite minerals (sakuraiite-petrurkite) from the San Jose deposit. Bottom. Commimuted mineral from the Morococala deposit

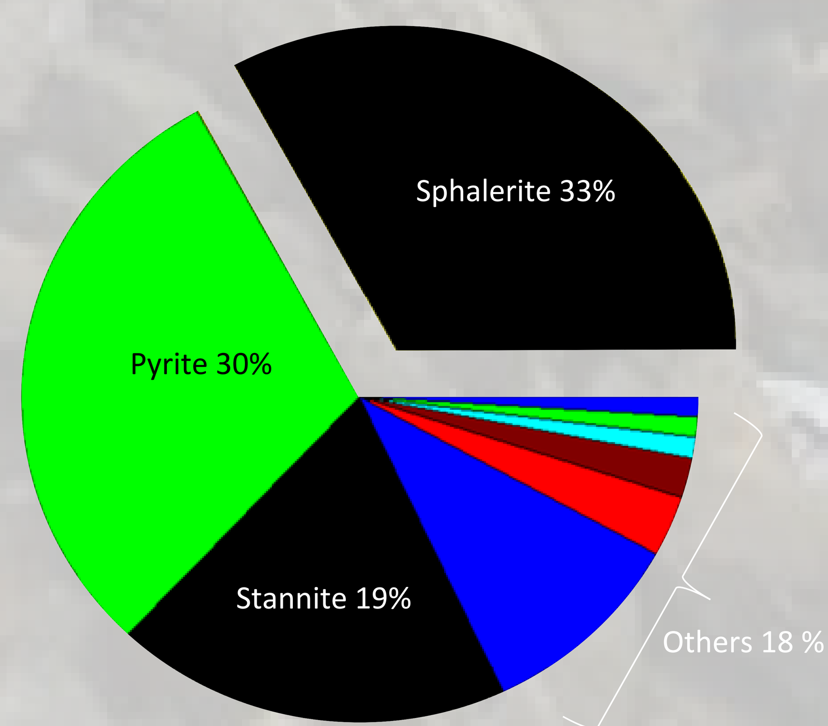




Two different samples from different adits in the Poopó deposit. Both samples show several phases of stannite group. Stannite is one of the more abundant ore minerals i n this deposit



Content (wt.%) of ore minerals before and after recovery concentration. Concentrate shows poor efficiency in recovery of cassiterite and total loss of stannite. The "others" are gangue minerals.



Semi-quantitative stimation of the ore minerals in samples from the Poopó deposit.

CONCLUSION REMARKS AND RECOMMENDATIONS

Geochemistry characterization is an effective tool to resolve processing issues and even to improve mineral process and grade of concentration products. Improve Sn recovery as cassiterite and, at the same time, implementing recovery of stannite as strategic elements-bearing mineral could considerably increase the economic and strategic potential of this region.

Quantification of the potential ore reserves was not part of this study, however, results of the mineralogical study and semi-quantitative results are (a priori) a target. There is an obvious exploration/exploitation potential for strategic metals in all deposits in the Central Andean Belt.

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