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A singular type of High Sulfidation Cordilleran Base Metal Lode Deposits: extensive replacement of Zn-Pb bodies in carbonate rocks and its temporal setting within porphyry-style systems

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It has been known for long time that polymetallic veins occur in the upper part of porphyry copper systems. Einaudi (1977, 1982, 1994) termed these veins as "Cordilleran base metal lodes". They are characterized by the following features (e.g., Einaudi, 1982): (i) advanced argillic to sericitic alteration, (ii) strong ore mineral zoning with Cu cores (with massive enargite-pyrite) and external Zn-Pb(Ag) ores, (iii) massive texture and sulfide content of up to more than 50 % in volume, considerably higher than in other porphyry-related ore type, and (iv) basically a common suite of enriched metals, this is, Cu-Zn-Pb±(Ag-Au-Bi). Other terms used are "Butte-type vein deposits" and lately also "zoned base metal veins" (Einaudi et al., 2003) because of their well-marked zoning. The latter authors also note that the vein cores may display mineral assemblages typical of very high sulfidation states and the outer parts of medium to low sulfidation states.

Less well known was that when high sulfidation Cordilleran veins enter in contact with carbonate rocks, may develop not only Cu cores with high sulfidation assemblages (essentially pyrite-enargite/famatinite) but also extensive Zn-Pb ores which are associated to advanced argillic mineral associations and which are characterized by the presence of Fe-poor sphalerite which is typical of high sulfidation mineral assemblages. This is the case of several deposits in the polymetallic belt of central and northern Peru, including significant base metal mineralization in the very large Colquijirca and Cerro de Pasco districts (Fontboté and Bendezú, 1999; Bendezu and Fontboté, 2002; Bendezú et al., 2003, Baumgartner et al., 2003). The zoning Cu to Zn-Pb appears to be essentially controlled by temperature drop and only subordinately by neutralization as the main part of the Zn-Pb ores in the studied examples are associated to advanced argillic to argillic alteration minerals (including significant amounts of hypogene alunite and other APS minerals). Logically, the external parts of the Zn-ores grade into intermediate and low sulfidation mineral assemblages, including magnetite or hematite as well as Mn-Fe-Zn carbonates.

Cross-cutting relationships from different parts of the world indicate that numerous Cordilleran base metal lodes are superimposed on the upper parts of porphyry copper deposits and cut earlier veins of the potassic and phyllic alteration assemblages (e. g., Einaudi 1977, 1982, 1994, Meyer and Hemley, 1967; Brimhall, 1979; Fréraut et al., 1997; Brathwaite et al., 2001). Geometric and $^{40}Ar/^{39}Ar$ geochronological evidences at Colquijirca (Bendezú et al., 2003) indicate also that high sulfidation Cordilleran base metal lodes and replacement deposits are post (~ 0.5 My) high sulfidation epithermal disseminated precious metal mineralization occurring in the same district. Muntean and Einaudi (2001) have shown at Maricunga on the basis of detailed mapping and $^{40}Ar/^{39}Ar$ geochronology that high sulfidation epithermal ores and porphyry-related late stage "D" veins are temporally and genetically linked and both postdate by several hundreds of thousands of years the early A veining (related to potassic alteration). Combining the Maricunga and the Colquijirca $^{40}Ar/^{39}Ar$ results as well as the consistent geometric evidences in these and other districts, it can be hypothesized that within a given porphyry-style district the following different mineralization types are not simultaneous but they represent subsequent stages which may be separated each by several hundreds of thousands of years:

1) Potassic alteration and related A and B veins and/or skarn
2) "D" veins and high sulfidation precious metals epithermal
3) Cordilleran lode and replacement base metal deposits

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