The Genesis of Exótica, Chuquicamata, Chile

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The oxidation of the Chuquicamata ore is the source for the acid rock drainage that gives origin to the exotic mineralization at the Exótica deposit ("Mina Sur"). The principal copper-bearing minerals are chrysocolla, copper pitch, and copper wad. Copper wad and copper pitch have variable mineralogical and chemical compositions. Sequential extraction combined with sequential X-ray diffraction (SXRD) and ICP analyses on solutions applied to copper pitch samples from the Exótica deposit show the presence of crystalline birnessite in the copper pitch/wad material, together with other crystalline phases as libethenite, atacamite, and gypsum. Manganese contained in copper pitch/wad is distributed between the crystalline birnessite and a chrysocolla-like pseudo amorphous fraction. Chrysocolla/ copper pitch massive veins are thought to form under low flow regime directly from solution, in desiccation cracks or even in surface ponds. Geochemical modeling to determine the thermodynamic stability fields of chrysocolla, copper pitch/wad (using as proxy chrysocolla with coprecipitated birnessite) indicates that copper pitch/wad form in oxidizing conditions (above 0.5 V) at pH between about 4.7 to 9. At slightly more reducing conditions only chrysocolla precipitates. A genetic 4 step model for the evolution of the Exótica deposit is presented: A) During the 2nd Andean Uplift (~ 20-25 Ma) an erosion-dominated regime (900 m of erosion) formed a mature oxidation profile at Chuquicamta with acid rock drainage flowing through the Exótica valley and sediments transported into the Calama basin. B) Fast uplift of the enriched blanked of the Chuquicamata ore body and a subsequent change to a sedimentation regime (<19 Ma) started the deposition of the Fortuna gravels in the Exótica Valley, and triggered the main Cu-Mn-Si rich mineralization stage of the chrysocolla, copper pitch/wad mineralization. C) Increasing uplift (possibly during the 3rd Andean uplift) exposed more the enriched blanket and triggered Cu-Si-rich solutions that formed the southernmost chrysocolla orebody in unaltered gravels. This uplift caused also the relictive perched chalcocite blanket in the Chuquicamata ore body. D) Chloride-rich groundwater ingression during a wetter climatic episode (<3 Ma) is most likely responsible for the atacamite mineralization in the northern and central part of the deposit, as observed during sampling in the south wall of the pit.