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The nature of Zn-phyllosilicates in the nonsulfide Mina Grande and Cristal zinc deposits (Bongará District, Northern Peru): The TEM-HRTEM and AEM perspective

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Abstract

Zn-phyllosilicates are common minerals in nonsulfide Zn deposits and can give crucial information about the genesis of these oxidized mineralizations. They seldom represent the prevailing economic species but might have a significant impact on mineral processing. This study has been carried out on the Mina Grande and Cristal Zn-sulfide/nonsulfide deposits, which occur in the Bongará district (Amazonas region, northern Peru). The Cristal and Mina Grande orebodies are hosted by the sedimentary (prevailingly carbonate) successions of the Pucará Group (Condorsinga formation, Lower Jurassic), in an area affected by Neogene tectonics and characterized by Late Miocene and Pliocene-Early Pleistocene uplift phases (Andean and Quechua tectonic pulses). The Cristal deposit consists of both sulfide (sphalerite with minor pyrite and galena) and nonsulfide concentrations. The nonsulfides consists of smithsonite, hemimorphite, hydrozincite, chalcophanite, goethite, and greenockite, locally associated with Zn-bearing phyllosilicates. The Mina Grande deposit consists almost exclusively of Zn-oxidized minerals in limestone host rocks. The nonsulfides association consists of hydrozincite, hemimorphite, smithsonite, fraipontite, and Fe-(hydr)oxides, also containing a clayey fraction. The study deals with TEM-HRTEM and AEM investigations on clayey materials, to determine their crystal-chemical features and the origin of the complex Zn-clays-bearing parageneses. In both deposits, Zn-bearing illites ($1M_d$ and $2M$ polytypes) and I/S clay minerals (I3) are the main detected phases, with few compositions close to (Zn-bearing) muscovite. In the clayey fraction at Mina Grande, fraipontite, a Zn-bearing mica called K-deficient hendricksite, and (Zn-bearing) kaolinite also occur. Zn-illites and smectites (always containing Zn in variable amounts) characterize the mineral association at Cristal. The investigated compositional gap between di- and tri-octahedral Zn-phyllosilicates gives indications on the genetic relationships between them and advances on the knowledge of these species. The present work gives an insight into the Zn-bearing phyllosilicates systems by determining the amount/mode of metal incorporation in their lattices and understanding the relationships of natural occurring clay-rich complex associations, which can act as models for possible synthetic counterparts.

Keywords: Zn-phyllosilicates, Bongará, Cristal, Mina Grande, Peru, TEM-HRTEM, AEM