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Water management for acid mine drainage control at the polymetallic Zn–Pb–(Ag–Bi–Cu) deposit Cerro de Pasco, Peru

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ABSTRACT

The geochemical and mineralogical study of the Quiulacochoa tailings impoundment has shown that the hydrological connection of the three studied mine-waste systems at Cerro de Pasco (Pyrite-rich waste-rock dump Excelsior, old tailings impoundment Quiulacochoa, and the active tailings impoundment Ocroyoc) is a critical concern for effective acid mine drainage (AMD) control and mine-waste management. The Quiulacochoa tailings covered 114 ha, comprising 79 Mt of tailings, which contained ~50 wt.% pyrite, and are located at 4340 m altitude in a tropical puna climate with about 1025 mm/a rainfall and 988 mm/a of evaporation. The tailings were partially overlain by the Excelsior waste-rock dump, which contains about 26,400,000 m³ of waste rocks that cover 94 ha and contained ~60 wt.% of pyrite, which origin from a massive pyrite-quartz replacement body. Therefore, these two mine-waste deposits had a direct hydrological connection, resulting in the export of AMD produced at Excelsior towards Quiulacochoa. In the Quiulacochoa impoundment there are two different types of tailings recognized, that interact with the AMD from Excelsior: 1) Zn–Pb-rich tailings and 2) Cu–As-rich tailings. During the sampling, the Zn–Pb-rich part of Quiulacochoa was not producing important excesses of AMD from the oxidation zone, since the pH increased to near neutral values at 1 m depth. The underlying tailings were still able to neutralize the acidity produced in the oxidation zone through sulfide oxidation by the carbonates (mainly dolomite and siderite) contained in the Zn–Pb mineral assemblage. The main source of AMD in this mine-waste system is the Excelsior waste-rock dump. Its acid seepage infiltrates into Quiulacochoa forming a Fe–Zn–Pb plume with a pH 5.5–6.1 and containing up to 7440 mg/L Fe, 627 mg/L Zn, and 1.22 mg/L Pb. The plume was detected at 10–13 m depth in the stratigraphy of Quiulacochoa tailings. Additionally, the AMD seepage outcropping at the base of the Excelsior waste-rock dump was channeled on the tailings surface into the Quiulacochoa pond (pH 2.3), which covered the Cu–As-rich tailings. Infiltration of this Fe(III)-rich AMD increased tailings oxidation in the southwestern part of the impoundment, and subsequently liberated arsenic by enargite oxidation. Additionally, the AMD collected in the Quiulacochoa pond was pumped into the active Ocroyoc tailings impoundment, where sulfide oxidation was strongly enhanced by the input of dissolved Fe(III). Therefore, the AMD management and a hydrological separation of the different mine-waste systems could be a first step to prevent further extension of the AMD problem in order to prevent increased sulfide oxidation by Fe(III)-rich solutions.

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1. Introduction

There is no doubt that metal production has and will continue to be in the future a key parameter for the development and wealth of a modern society. However, metal production produces important environmental impacts on other vital resources, especially the formation of metal-loaded acid solutions resulting from sulfide and coal mining, better known as acid mine drainage (AMD)

or acid rock drainage (ARD), which are classified by the United States Environmental Protection Agency (EPA) as one of the three top ecological-security threats in the world. Although in the last decades AMD received a great deal of attention from the scientific community (e.g. Nordstrom, 1982; Singer and Stumm, 1970 and references therein), only a few, scarce studies focus on the geochemical processes occurring in the very early stage of AMD formation at active mine sites in order to prevent its formation (e.g. Smuda et al., 2006). Especially, the management of the Fe(III)-rich solution in an active mine site has not received the necessary attention, even when Fe(III) is known as an extremely efficient oxidant especially for sulfide minerals like pyrite, which are not acid soluble (Schippers, 2007).

To fill this gap, we present here a detailed mineralogical and geochemical study of the inactive Quiulacochoa and the active Ocroyoc

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