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Investigation on the oxygen transport mechanisms in the Sarcheshmeh waste rock dumps

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Introduction

Pyrite oxidation and acid mine drainage (AMD) are the serious environmental problems associated with the mining activities in sulphide ores. The rate of pyrite oxidation is governed by the availability of oxygen (Borden, 2003). Therefore, the identifying oxygen supplying mechanism is one of the most important issues related to the environmental assessment of waste rock dumps (Cathles and Apps, 1975; Jaynes et al., 1984; Davis and Ritchie, 1986). Although comprehensive researches were performed on the mathematical description of oxygen transport processes using the numerical modeling (Morin et al., 1988; Blowes et al., 1991; Wunderly et al., 1986; Elberling et al., 1994; Jannesar Malakooti et al., 2014), so far, the interactions between these processes and geochemical and mineralogical characteristics has not been studied especially in waste rock dumps. Therefore the main objective of this study is to identify the evidences for knowing the oxygen transport mechanisms in the waste dumps and also, its role in intensity of pyrite oxidation. It is expected that such these structural studies could be useful for better understanding of dominant processes in numerical modeling and also providing environmental management strategies in the study area and other sites by similar characteristics.

Materials and Methods

In this study, thirty solid samples were collected from six excavated trenches in the waste rock dumps No. 19 and 31 of the Sarcheshmeh porphyry copper mine. Collected samples were studied using several methods such as XRD, ASTM-D2492, paste pH and grain size distribution. The results obtained from these methods were used with the field observations in order to characterize some detail information about oxygen supplying mechanisms for oxidation reactions in the waste rock dumps.

Result

The main minerals found by the XRD analysis were quartz and muscovite which were present in all samples. Pyrite, orthose, albite, and chlorite were also present in some samples. The carbonate content as the major neutralizing agent was zero in all samples. Due to the presence of sulfide minerals, mainly as pyrite, and also lack of any carbonate minerals, the AMD generation from the Sarcheshmeh waste rocks during the weathering reactions is predictable. At the Sarcheshmeh mine waste, several secondary minerals such as butlerite, jarosite and gypsum were detected by XRD at some depths. Moreover, amorphous iron oxyhydroxide minerals visually observed in waste dumps were not detected by XRD due to being negligible and low level of crystallinity. Hence, they were measured in terms of ($Fe_{o\text{-}h}$) by ASTM standard test method. The ASTM-D2492 standard test showed that pyrite, sulphate and iron oxyhydroxide minerals ($Fe_{o\text{-}h}$) are present in all samples. Against the XRD method, the test even detected the negligible content of the minerals. The paste pH tests showed that 15 samples were acid-producing because they had pH lower than 4. On the basis of moisture content results, the samples by name A6, A7, B1 and B2 showed high

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level of moisture which can be sign of the particular status in them.

Discussion

According to the field observations, channels with a strong flow of warm and humid air were detected in the depth of 3 to 5 meters of the investigated waste rock dumps. High content of humidity (8.25 and 13.43 percent) and sulfate (4.5 and 7.02 percent) were observed together with low content of pyrite (1.5 and 6.23 percent) and acidic paste pH values (3.13 and 2.88) around these channels. Therefore, from the relation of these occurrences, it can be inferred that the air convection is important for supply oxygen to pyrite oxidation in the waste dumps of Sarcheshmeh.

The results also indicate that, two main factors including grain size distribution and formation of hardpan layer on top of old weathered rocks are responsible for the decreasing of oxygen transformation rate via the molecular diffusion mechanism through the waste rock dumps.

Considering the presence of coarse grain and poorly graded material as a proper media for air convection and also hardpan layer as a confining factor in molecular diffusion of oxygen, it can be deduced that the air convection is the main important mechanism to supply oxygen for weathering and oxidation reactions in the waste rock dumps. The abundance of oxygen and high temperatures in such conditions are also favorable for bacterial activities, which can then accelerate the pyrite oxidation in lower depth of dump.

It is expected that the results of this study could be useful as a basis for providing the remediation strategies to control acidic drainage. So that knowing the domination of air convection and presence of hardpan justify controlling the flux of oxygen from the coarse material in bottom of waste dump. Therefore, it would be wrong to construct the impermeable layer on the surface of waste dump for arresting the oxygen diffusion as a traditional method in the remediation.

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