Determination and Prediction of Rare Earth Element Geochemical Associations in Acid Mine Drainage Treatment Wastes[1]

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Abstract: Acid mine drainage (AMD) has been proposed as a novel source of rare earth elements (REE), a group of elements that include critical metals for clean energy and modern technologies. REE tend to be sequestered in the Fe-Al-Mn-rich solids produced during the treatment of AMD. These solids are typically managed as waste, but could be a low-cost, readily available REE source. Here, results from field sampling, solids characterization, and geochemical modeling are presented to identify the mechanism(s) of REE attenuation and determine the minerals/solid phases in AMD solids that are enriched in REE. This study reveals that solids produced from low-pH AMD treated by limestone or NaOH contain elevated concentrations of REE with Al, Fe, and/or Mn. AMD solid characterization via sequential extraction and synchrotron microprobe both demonstrate that REEs are mainly associated with Al/Mn phases and only selected REEs (Gd, Dy) are associated with Fe phases, despite the chemical diversity of AMD solids. Additionally, sequential extractions demonstrate that acidic and/or reducing extractions are required to mobilize the REE. Finally, the "CausticTitrationREYs.exe" geochemical equilibrium model developed in this study indicates that the observed dissolved REE attenuation can be explained via surface complexation on Fe, Al, and Mn oxides/hydroxides. The model accurately predicts the pH dependent removal of dissolved REE, and that Al and Mn oxides/hydroxides are largely responsible for dissolved REE removal, consistent with the characterization results. The results presented here can be used to identify conditions favorable for accumulation of REE-enriched AMD solids and possible chemical treatment(s) to mobilize REE. The geochemical model can be applied to active and/or passive AMD treatment systems to predict REE attenuation with Fe, Al, and Mn during treatment and what phases may be enriched in REE. This information can be used to engineer AMD systems to produce specific phases enriched in REE.

Additional Key Words: REE, AMD, geochemical modeling

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