The Influence of Rainfall on the Characteristics of Historic Acid Mine Drainage on the Denniston Plateau, New Zealand

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Abstract

Stream flow rates and water chemistry of legacy AMD from pyritic coalmines have been quantified via continuous flow measurement and intermittent water chemistry sampling over a 16-month period. Data show an overall dilution effect in response to rainfall, but high intensity rainfall events lead to an acid flush effect. Precipitates identified mineralogically with scanning electron microscopy, paired with geochemical modelling, has defined the processes of natural amelioration of the discharges. Calculated discharging acid load is 463 t $CaCO_3$ yr^{-1}, with downstream decrease in the total metal load occurring via dilution and precipitation in stream mixing zones.

Keywords: Acid mine drainage, dilution, precipitation, schwertmannite, dissolved metals

Extended Abstract:

The Eocene Brunner Coal Measures on west coast of New Zealand are pyritic and there is low neutralisation capacity in the coal measures, so there is high acid producing potential. Historic mines located on the elevated high-rainfall Denniston Plateau left a legacy of acid mine drainage (AMD). A series of adits created by modern mining now drain the workings and exude AMD into nearby water courses. The aim of this study is to characterise and quantify the AMD discharges from the historic mines, in order to facilitate downstream water quality management and ecosystem recovery.

Characterisation of the water flow rates and water chemistry has been undertaken with continuously-operating data-loggers at strategically-placed V-notch monitoring points. Chemical parameters from data-loggers have been calibrated with periodic water sampling and laboratory analysis over a 16-month period. Response of the water chemistry to rainfall events was a particular focus of the study.

Increases in stream flow rates in response to rainfall events initially causes some dilution of dissolved load and increase in pH from ≈3.3 to ≈3.6. However, as stream flows decrease during waning rainfall, there is a lag of AMD discharge over 1-2 hours because of enhanced flushing of historic mine workings by infiltrating rain. This flushing results in persistence of low pH and elevated dissolved load. Some of this enhanced flushing is attributable to secondary minerals acting as stored acidity in historic workings.

As acid waters evolve to higher pH in the stream discharge system, a series of precipitates form on the streambeds. Scanning electron microscope (SEM) imagery and associated semiquantitative analysis of precipitates has shown that most consist of ferric oxyhydroxide and/or schwertmannite that form agglomerations of nanometre scale particles. These precipitates form at pH > 3. In waters with pH near 5, aluminium rich precipitate is also visible with the ferric oxyhydroxide. Geochemical modelling of mineral saturation levels in the waters are consistent with the SEM mineralogical observations.

The combination of rainfall dilution and dilution by incoming sidestream waters is effective at raising the pH of the AMD discharges and the resulting precipitates facilitate removal of dissolved metals and sulphur. There is a total discharge acid load of 463 t $CaCO_3$ yr^{-1}, and total metal load is lowered by precipitation and dilution from up to 30 g/m^3 Al, 15 g/m^3 Fe and 360 g/m^3 SO_4^{2-}, down to ca. <3 g/m^3 Al, <1 g/m^3 Fe and <75 g/m^3 SO_4^{2-}.