Acid release decay curve for Brunner Coal Measures high walls

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Abstract

Wall wash samples were collected from Brunner Coal Measures highwalls with ages spanning 3 days to 18 years. The chemistry of the samples is similar to Brunner Coal Measures AMD that has been reported in other studies with the exception of some trace elements that are unusually enriched in some samples. The trend in acidity released from highwalls with time indicates slightly increasing acid release over the first year and then decreasing acid release with time. If the decreasing acid release rate is extrapolated to the time when concentrations would be the same as streams draining Brunner Coal Measures, then the period of enriched AMD lasts for between 10 and 165y. When these data are averaged and a regression is applied, then the time for which AMD released from highwalls is more enriched than streams is between 55 and 105 years. There are uncertainties in this data related to selective sampling of areas with an appropriate slope and smoothness and the accuracy of the age estimates. However, this dataset can be used as a basis for future studies and could be grown and improved by similar sampling at sites of different ages, especially if older sites can be identified.

Keywords: Acid Mine Drainage, Brunner Coal Measures, acid release rate.

Introduction

Long term trends (>20 y) in release of acid and trace elements from mine sites are poorly quantified. Published studies with long term field datasets are not common with some exceptions (Cravotta III, 2008a, b).

We present wall wash data from five Brunner Coal Measures highwalls with different ages spanning 3 days to 18 years. The sample sites are located at Cypress Mine (3 days and 1 year) Echo Mine (3-5y), Grand Canyon road cut (10y) and Island Block (18y) (Figure 1). Trends in AMD chemistry in wall wash from these sites can be extrapolated to provide a long term prediction of AMD chemistry for Brunner Coal Measures under atmospheric oxygen concentration and with water available at typical West Coast levels.

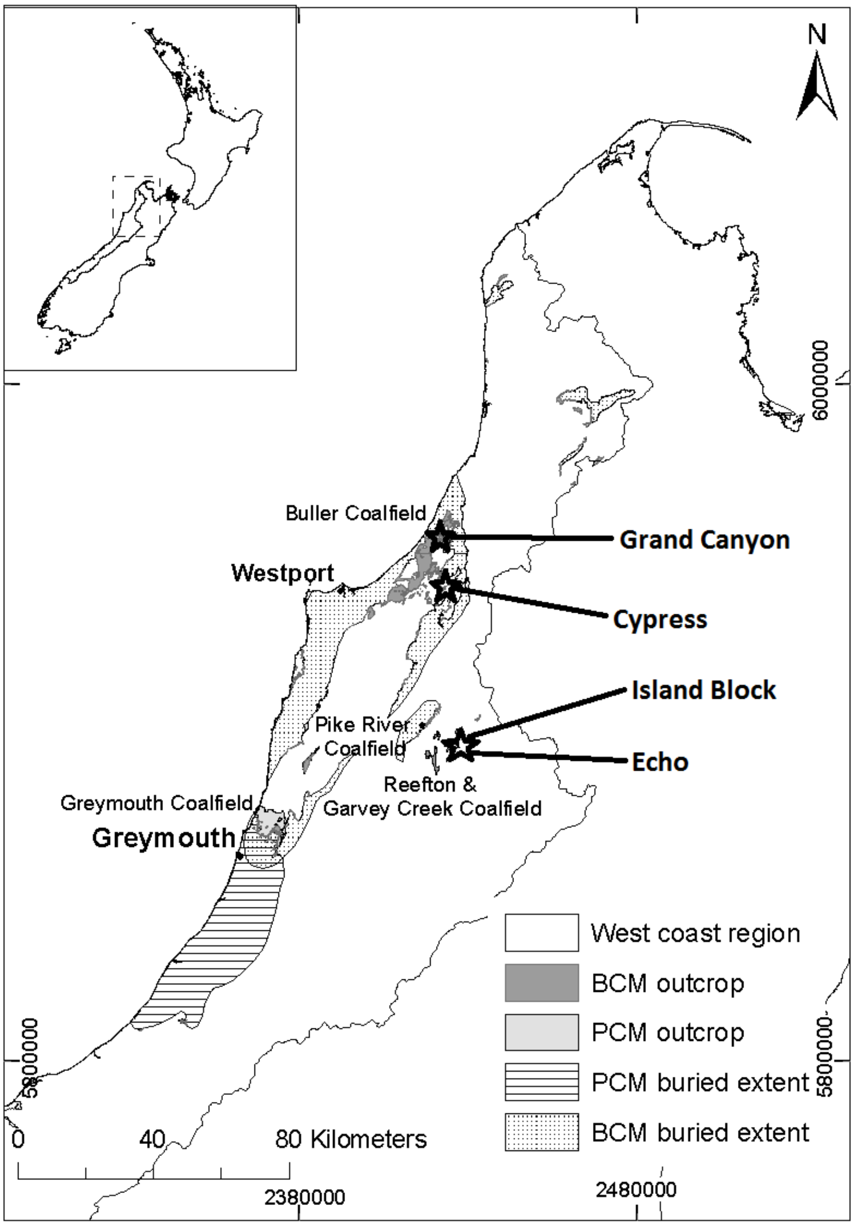

Figure 2. Sites where wall wash was collected.

Methods

Wall wash samples

Samples of wall wash were collected from Brunner Coal Measures outcrops at the high walls of 3 mine sites and one road cut. Wall wash was generated by application of 500ml of distilled water to an area about 50 cm by 50cm and collection of as much run off as possible in a large plastic sampling bag sealed to the outcrop with duct tape. About 40 to 80% of the wall wash was retrieved in the sampling bag with some lost due to rough surfaces and wetting.

Application of this volume of water to ~ ¼m^2 reflects about a 6-10 mm rainfall event depending on the slope of the high-wall which is between 70º & 80º at the sites selected. This size of rainfall event is common on the West Coast. Climatic conditions prior to sampling had been dry for at about 1 month except for foggy conditions.

Sample sites

Cypress Mine (Stockton)

Cyprus mine is a small discrete pit east of the main Stockton mine workings in the Buller Coalfield that has been operating for about 3 years and overburden rocks include a thin sequence of Brunner Coal Measures (~2-5mthick) above coal and beneath Kaiata mudstone. Wall wash samples were collected from high wall exposures that were 3 days old and ~ 1 year old. The samples from Cypress were from slaking muddy sandstone that occurs immediately above the coal seam. Samples from the 1 y old exposures had iron oxy-hydroxide staining (probably jarosite and schwertmannite) as well as white secondary mineral precipitates (unidentified). Samples from the 3 day old exposure had blue-grey-white muddy precipitates and crushed rock that had not been cleaned by rain water since stripping activities.

Echo

Echo mine operates in the Garvey Ck Coalfield and includes a sequence of complexly folded and faulted Brunner Coal Measures. High walls where access was possible were between 3 & 5 y old. Wall wash samples were collected from mudstone and sandstone rock types that occurred above the main target coal seam and interbedded with smaller coal seams. All sample sites had a mix of iron-oxyhydroxide precipitates (probably jarosite and schwertmannite) and white precipitate (unidentified – similar to Cypress).

Grand Canyon Road Cutting

The Grand Canyon is local term for a road cutting through Brunner Coal Measures that occurs on the road close to the entrance of Stockton mine. The cutting is about 10 years old and it is difficult to relate to coal seams because they are not exposed at this site. Wall wash samples were collected from sandstone and muddy sandstone rock types some of which were slaking. Most sites had iron oxy-hydroxide staining (probably jarosite and ferryhydrite), rarely white precipitates were also present.

Island Block

Island Block mine occurs in Garvey Creek Coalfield about 2 km north of Echo Mine in Brunner Coal Measures. Access is available above the main target seam although other small seams are present in the sequence exposed in the Island Block Highwall which is 18 y old (pers. com. Phil Lindsay). In addition, a bed up to 20cm thick composed almost completely of pyrite cemented sand is present in this high wall with a lateral extent of > 20m. Wall wash samples were collected from sandstone rock types and iron oxy-hydroxide minerals (probably jarosite and schwertmannite) were present. White precipitates (unidentified) were rarely present on the Island Block high wall but were not included in wall wash samples.

Analysis methods

Samples placed in 250ml sample bottles (un-acidified and un-filtered). The samples often included a small amount of solid material (sediment, precipitates ± organic material). In the laboratory (several days later) samples had pH measured, and were filtered and acidified prior to dispatch to the laboratory. These sample collection processes are similar to field conditions where solid material is washed off mine high walls along with runoff mine drainage water.

Analyses were conducted for major cations, and trace elements including K, Na, Ca, Mg, Al, Fe, As, Sb, Cu, Cr, Co, Mn, Ni & Zn at an accredited laboratory by ICP-MS.

Results and Discussion

Wall wash chemistry

The wall wash analyses have chemistry that is variable but similar to AMD produced by the Brunner Coal Measures and reported in previous studies (McCauley et al., 2010; Pope et al., 2010b; Weber et al., 2006). Acidity is elevated, low pH, abundant Fe and Al, and trace element concentrations are elevated Mn > Zn > Ni > Co, Cu, As. The main difference is that the maximum concentrations of trace elements (which occurs in wall wash samples from Echo Mine) are higher than is typical in Brunner Coal Measures AMD.

	pH	**Fe**	**Al**	**Mn**	**Zn**	**Ni**
Max	2.06	420	220	90	31	43
Min	5.04	1.38	0.074	0.068	0.026	0.004

Long term acid release

The data collected provide an indication of the changes in acid release with time from Bruner Coal Measures. The high walls included in this study range from 3 days old to 18 years old and two trends in acid load with time are present in the data (Figure 2).

1) For the first year the acid load release from the highwalls is slightly increasing with time.
2) After about one year the acid load decreases with time.

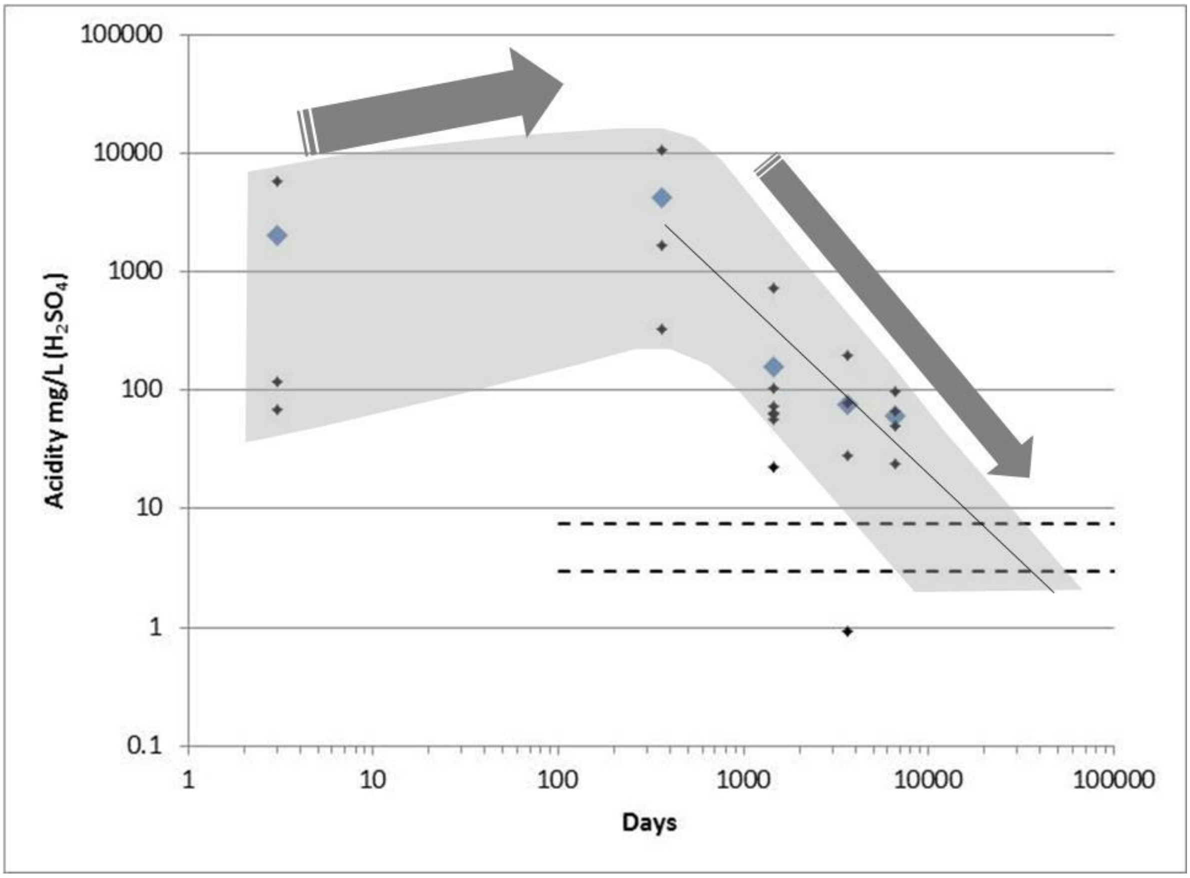

Figure 2. Acidity in wall wash samples (calculated - pH, Fe & Al). Small diamonds (calculated data), large diamonds are averaged. Arrows indicate trends in acidity with time. Dotted lines indicate a range of acidity values measured in natural streams draining Brunner Coal Measures.

The range of acidity values at each highwall spans between 0.5 and 2 orders of magnitude and the total range of acidity in the data is 4 orders of magnitude. Extrapolating the data collected related to acid release with time (grey area on graph) indicates acid production at levels above maximum acidity level measured in streams will occur for between 10 and about 165 years. If a regression to the average data is applied, then the time taken for acid load from high walls to decline to similar levels found is streams is about 55 to 105 years.

There are some uncertainties within this dataset and its interpretation. The age of the highwalls is approximate (except the three days for some Cypress samples) and therefore the position of data points could shift horizontally on Figure 2 and this would impact the slope and position of the regression. The interpretation that the change in the trend in acid production from gently increasing to decreasing takes place at ~ 1 year occurs simply because this is the age of the high wall where the maximum acid concentrations have been measured. It is equally possible that the peak in acid release from highwalls occurs at 6 months or 2 years, or more likely over a range of ages. This uncertainty could also change the position of the regression line.

Wall wash sample collection was not random, it was constrained by highwalls where slope and smoothness made it possible to collect samples easily. This study also assumes that Brunner Coal Measures AMD is regionally consistent, however, previous studies demonstrate that there is variability in BCM AMD chemistry (Pope et al., 2010a). In addition, this study targeted zones where different types of precipitates could be observed rather than a random or representative suite of samples. Finally, it is possible that the unusually long dry period before sampling influences the wall wash chemistry in a manner that means it is not representative of the high wall chemistry under more typically wet conditions.

Despite the uncertainties, this dataset provides an estimate of longevity of AMD for Brunner Coal Measures highwalls. It is likely that this estimate of longevity can be compared directly AMD generation in waste rock where oxygen is at atmospheric concentration and water is available based on climatic conditions. At sites where oxygen is excluded or partially excluded such as within capped dumps or where or where water is limited by low permeability zones, AMD generation will proceed at lower rate and likely for a longer period.

This dataset can be used to form the basis for future wall wash studies where prediction of long term AMD chemistry is the objective.

Summary

Wall wash chemistry from Brunner Coal Measures highwalls of 5 different ages is broadly similar to AMD chemistry from these rocks. Although, there is elevation of trace element concentrations from Echo mine in the wall wash samples that exceeds the values from previous studies of Brunner Coal Measures AMD. The acidity of the samples spans 4 orders of magnitude and the acidity of each group of samples from each highwall spans 0.5 to 2 orders of magnitude.

The acidity released from high walls has two trends that occur with time. For about the first year the acidity slightly increases and then acidity decreases with time. The decrease in acidity released with time can be extrapolated to predict the time when the chemistry would be similar to natural Brunner Coal Measures drainages. Based on the distribution of wall wash data, AMD released from highwalls will reach ambient conditions between 10 and 165 years, if averaging is applied to this data then then highwall acid generation reaches natural levels after 55 to 105 years.

There are uncertainties in this dataset related to estimates of the age and selection/availability of sampling sites. However, this dataset will form the bases of predictive data set that can be improved with time and as opportunity arrises. It is likely that there are links between the data set presented here for highwalls and waste rock dumps where oxygen and water are readily available.

Acknowledgements

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