# Predicting the effects of coal mines on aquatic environments

**Key points of this fact sheet**

- At coal mines acid mine drainage (AMD) can form when pyrite bearing rocks are exposed to water and oxygen
- AMD is a subset of acid rock drainage (ARD); ARD from a mine = AMD
- Not all coal mines disturb pyrite bearing rocks, so not all coal mines make AMD
- We can predict the potential for AMD qualitatively and quantitatively
- Water quality downstream of a coal mine can be predicted by integrating site specific hydro-geology data, mine plans and information on rock geochemistry.

## Where is South Island coal mined?

The two main coal mining areas in the South Island are in Southland and on the West Coast. The main actively-mined coalfields in Southland include Ohai and the Eastern Southland Lignites. The Eastern Southland lignite field is volumetrically the most important, but the least productive currently. The Ohai coalfield has been a major producer since the 1940s and is still producing.

On the West Coast current mining mostly takes place in the Greymouth, Buller, Reefton, and Pike River Coalfields. Mostly rocks mined for coal belong to either the Brunner or Paparoa sedimentary sequences.

Coal mining can have negative impacts on stream chemistry and ecology and the worst of these problems is acid mine drainage (AMD). AMD does not occur at all coal mines and it can be predicted, mitigated and remediated.

## What is Acid Mine Drainage?

Acid mine drainage (AMD) forms when rocks that contain the mineral pyrite are disturbed by mining and are exposed to water and oxygen. Pyrite breaks down under these conditions and releases acid, trace elements, and dissolved iron. These products in turn react with other minerals to produce a chemically complex acidic mixture of dissolved metals and dissolved trace elements. The low pH and elevated concentrations of metals and trace elements in AMD can have substantial environmental impacts downstream of the mine (Figure 1).

AMD is a subset of a broader term acid rock drainage (ARD). The same process described above at mine sites also occurs naturally, usually at a slower rate, with less acid and much lower concentrations of metals and trace elements. The impact of ARD is that natural streams that drain pyrite bearing outcrops of coal measures have acidic pH and higher concentrations of metals and trace element than more pure water (say rain water or water draining less reactive outcrops).

**Figure 1:** AMD downstream of a coal mine, pH is about 3 and dissolved metals and trace elements are elevated. A precipitate of iron and aluminium minerals with elevated trace elements coats the stream bed.

## Do all coal mines make AMD?

Not all coal mines make AMD. The main factor that determines if a mine will make AMD is the pyrite content of the rocks surrounding the coal. If the pyrite (Figure 2) content is high, it is likely AMD will form. If the pyrite content is low, it is likely that reactions between the water and rock disturbed by mining will have little effect on downstream water quality. At mines that do not produce AMD there might still be water quality impact, however, these will not relate to acidity.

## Can we predict which mines will make AMD?

We can predict which mines will make acid on two levels:

**1**: Qualitatively; relationships between a mine and regional geology is a good guide to the potential for a mine to make AMD. In addition, field observations and examination of neighbouring mines can be useful. In general, relating regional geology and field observations to AMD can provide one of three outcomes:

- AMD is very likely
- AMD is unlikely
- AMD potential is uncertain

This fact sheet is part of series relating to a framework for predicting and managing the environmental impacts of mining.

The framework was developed as part of a collaborative research programme aimed at helping mining companies, councils and other end-users make more informed decisions about the possible environmental effects of mining and how to reduce those effects. Stakeholders and end-users assisted in the development of the framework which explains:

- how you can assess the likely water quality coming from a mine,
- the impacts that mine water will have on stream life,
- options for management or treatment of mine drainage
- guidance on how best to monitor mine discharges and
- guidance on rehabilitating mine sites.

**2**: Quantitatively; measurement of the pyrite content and presence or absence of other reactive minerals is required to assess if rocks disturbed by mining will produce acid. There is a series of standardized laboratory testing procedures referred to as Acid Base Accounting analyses that are used to measure the acid producing potential of rocks. These analyses split rocks into two groups, potentially acid forming (PAF) and non-acid forming (NAF).

**What controls the occurrence of pyrite?**

In a general sense, the pyrite content of coal and surrounding rocks is determined by the proximity of coal forming environments to the sea.

All coal is formed from plants that grew on land, mainly in river valley or estuarine settings. These river valley and estuarine deposits were then buried by several kilometres of overlying sediments to compact and chemically change plant material into coal and were later brought back up to the surface by tectonic processes.

Coal and coal bearing rocks that were deposited close to the sea usually have high sulphur (up to about 5%) because sulphur is abundant in sea water. This sulphur can form pyrite during chemical changes that occur as the coal and surrounding rocks are buried by overlying sediments. Pyrite can release acid and trace elements when we subsequently mine the coal.

**Will AMD formation cause downstream water quality issues?**

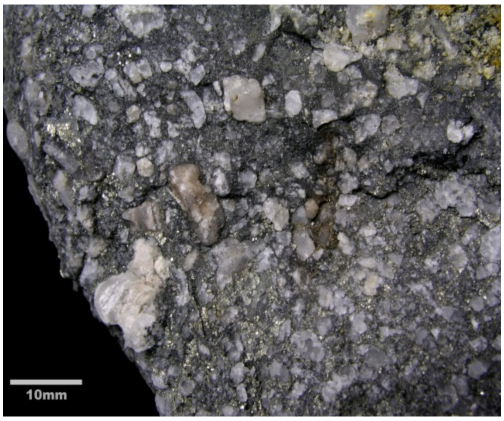
The severity of downstream impacts from AMD formation is related to many different site specific conditions. The flow, volume and chemistry of the AMD determine how much acid and metal/trace element enriched water is released from the mine. The flow, volume and chemistry of the receiving environment determine the ability of the receiving environment to absorb AMD.

So, prediction of the intensity of chemical impacts downstream of a mine site requires good knowledge of site hydrogeology, and this directly influences the intensity of biological impacts (See fact sheet 3 in this series). In addition, management, mitigation and remediation activities can be employed on a mine site to prevent AMD formation.

The impact of AMD on the downstream environment must be assessed on a case-by-case basis and this should include assessment of site management and operational practices.

**More information on the framework and underlying research is available from other fact sheets in this series and at:** http://www.landcareresearch.co.nz *(keyword: mining factsheets)*

**Figure 2** (above) and **3** (below)**:** Pyrite in rocks from coal mines.




This work was funded by the Foundation for Science, Research and Technology (FRST) grant CRLX0401 in collaboration with CRL Energy, Landcare Research, the University of Canterbury and the University of Otago.

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