

# Acid Rock Drainage



## Analysis and Testing Services

### What is Acid Rock Drainage?

Acid Rock Drainage (ARD – also known as Acid Mine Drainage – AMD) describes the formation of acid when sulphide-bearing mine wastes (principally pyrite, but also pyrrhotite and chalcopyrite) are exposed to oxidising conditions, typically in the presence of water, due to groundwater, rain and run-off.

Potential sulphide-bearing materials include waste rock from overburden, interburden or partings and processed ore (tailings). In some situations, low-grade ore stockpiles, open pits and exposed rock in underground mines may also generate acidic conditions.

ARD can cause major long-term environmental problems at mine sites if appropriate prevention and/or management strategies are not adopted. In order to effectively manage ARD and minimise the risk of long-term liability, it is

necessary to gain a thorough understanding of the materials to be disturbed by mining activities. There are considerable advantages for mining companies taking a proactive approach to the management of ARD. Remediation of advanced ARD is considerably more difficult and expensive than early prevention. The effective use of geological modelling, appropriate waste characterisation testwork and attention to the degree of environmental risk are integral to developing a strategy for the safe handling and subsequent rehabilitation of mine wastes.

Mineralogical knowledge of the sample is an important augmentation to the initial ARD screening tests. Not all mining operations that expose sulphide-bearing rocks result in ARD. In some situations the sulphide minerals may be non-reactive or there may be sufficient inherent buffering capacity within the rocks to neutralise any acid released from sulphide oxidation. Samples with abundant neutralising minerals such as calcite and dolomite may act to increase the material's pH and prevent or mitigate acid drainage and metal run-off. Some samples may contain minerals which are not sulphide but which are acid-producing, and there are non-carbonate pH buffering minerals such as biotite and chlorite.

# How is the acid generation potential of mine wastes predicted?

The first step in managing mine wastes should be to identify the wastes that are potentially acid generating.

The identification of potentially acid generating wastes typically involves a step-by-step process of preparing geological models, examining comparative information, sampling, laboratory analysis and classification. As this process unfolds a predictive model of waste behaviour (eg. relative acid generating capacity and acid neutralising capacity) should be developed along with appropriate waste handling and management protocols.

## → Geological Modelling

Geological, chemical and geotechnical information should be used to provisionally identify distinct waste units within the proposed mine plan.

## → Comparative Information

Regional geological and geochemical information should be included in the geological model. This comparative approach is particularly applicable to coal mines where a higher degree of stratigraphic continuity can be expected.

## → Sampling

Effective sampling is critical to any waste characterisation program. Representative samples should be taken of all provisional waste units. The number of samples required to adequately assess an area is site specific and should reflect the nature of the potential ARD problem being assessed.

## → Laboratory Analysis

Chemical analyses undertaken in the laboratory can include initial screening tests, geochemical static tests, solubility tests and kinetic tests.



# Why does Acid Rock Drainage Occur?

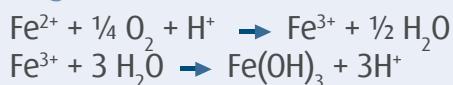
The principle cause of ARD is the oxidation of sulphide minerals, predominantly pyrite.

The pyrite oxidation process is complex and involves several chemical, biological and electrochemical reactions. The rate of reaction is dependent on several factors including the surface morphology of the pyrite, the oxygen concentration, the pH, the presence of bacteria and the presence of acid-consuming materials. The reaction process can be exposed by the three reaction stages for the oxidation of pyrite:

## Stage 1



## Stage 2



## Stage 3



The impacts associated with ARD are primarily caused by the generation of acidity and the subsequent release of acid dissolved metals, either directly from sulphide minerals or by acid attack on associated minerals within the rock.

## What laboratory analytical tests are available to characterise mine wastes?

Good, reliable and reproducible analytical data is essential if a true assessment of potential ARD problems and liabilities is to be made.

ALS has an in-depth understanding of ARD and provides a full range of relevant analytical services to help the ARD investigator assess and monitor this potential problem. ALS methods are based on the AMIRA International ARD Test Handbook methodologies.

Initial Screening methods applicable to the evaluation of ARD potential and the processes involved include the following:

### MPA – Maximum Potential Acidity – ALS Method TBA

MPA (also referred to as Acid Production Potential – APP) is a measure of the total sulphidic acid producing potential of a material, irrespective of whether that material may also have the potential to produce alkali. MPA is determined from the analysis of total sulphur in the sample and is calculated assuming a total conversion of sulphur to sulphuric acid. MPA is reported as kg H<sub>2</sub>SO<sub>4</sub> per tonne, which essentially states the mass of sulphuric acid that could potentially be produced per tonne of material sampled.

### ANC – Acid Neutralising Capacity – ALS Method TBA

ANC measures the capacity of a sample to neutralise any acid that is produced. In the ANC analysis a finely ground sample is reacted with a known amount of hydrochloric acid. The resultant solution is back titrated to pH 7.0 with sodium hydroxide to determine the amount of acid neutralised by

the carbonates and other acid consuming minerals present in the original sample. ANC may be reported as either kg CaCO<sub>3</sub> or kg H<sub>2</sub>SO<sub>4</sub> equivalent per tonne.

### NAPP - Net Acid Production Potential – ALS Method TBA

NAPP is useful for screening samples into potential acid producers (positive result) and non-acid producers (negative result). NAPP suffers from the tendency to over predict the acid production potential because it does not differentiate between acid producing and non-acid producing forms of sulphur. NAPP is calculated as the difference between Maximum Potential Acidity (MPA) and Acid Neutralising Capacity (ANC) and is reported in units of H<sub>2</sub>SO<sub>4</sub> per tonne. A positive result indicates excess acid production (potentially acid forming) and a negative result indicates excess acid consumption (non-acid forming).

### NAG - Net Acid Generation – ALS Method TBA

NAG (also referred to as Net Acid Production – NAP) uses hydrogen peroxide to oxidise any sulphides present in the sample. The acid produced from the oxidation reaction may subsequently be partially or totally consumed by acid neutralising components of the sample – hence the reference to Net generation. Any remaining acidity is determined by back titration to both pH 4.5 and 7.0 to provide further information on the source of the acidity, and the result is reported as NAG, expressed in kg H<sub>2</sub>SO<sub>4</sub> per tonne. Reaction kinetics of both acid production and acid consumption within the sample can limit the accuracy of this test and in cases of high sulphide or organic matter content, additional methods may be required to better understand the potential ARD of the sample.

# Forms of Sulphur

## Total Sulphur – ALS Method S-IR08

The Maximum Potential Acidity (MPA) uses a measure of total sulphur by high temperature furnace combustion with Infrared detection as an estimate of “sulphide sulphur”. This determination does not take into account any oxidised or partly oxidised sulphur (e.g. Sulphates & Sulphites) nor the presence of organic sulphur (eg. in coal mine tailings) but rather reports a total sulphur result.

Better estimations of sulphide can be made from one of the following:

## Sulphide – ALS Method S-IR07

Separation of the sulphide from the oxidised sulphur species, followed by direct measurement by combustion furnace / IR. A sodium carbonate leach is used to convert metal sulphates into soluble sulphate and insoluble metal carbonates. The residue is filtered and washed to separate the soluble sulphates and the residue is analysed for sulphur content.

## Sulphate – ALS Method S-CAL05

Sulphate can be reported as the difference between total sulphur and sulphide.

## Soluble Sulphate – ALS Method TBA

Water soluble sulphate can be measured on a 1:2 solid: water leach. Along with changes in pH, soluble sulphate is useful in monitoring the production of sulphuric acid through the oxidation processes.



# Forms of Carbon

## Total Carbon – ALS Method C-IR07

Total carbon is a direct measurement using high temperature furnace combustion with Infrared detection. This method determines all forms of carbon, including carbonates, graphitic carbon and organic carbon species.

## Organic (Non Carbonate) Carbon – ALS Method C-IR17

Organic (Non Carbonate) carbon may be present in tailings or in topsoil. It is routinely measured by high temperature combustion furnace with a CO<sub>2</sub> infrared detection, after prior treatment of the sample with acid to drive off the inorganic carbonates.

## Inorganic Carbon

Inorganic carbon (carbonate) is important as a source of acid consuming capacity. Inorganic carbon is determined as the difference between total carbon and organic carbon as measured above.

## pH – ALS Method TBA

The pH value indicates whether the material is acid or alkaline. A pH below 5.5 suggests that prior acid generation may have occurred. pH is routinely analysed on a 1:2 sample / water extract, however, paste pH is available as an alternative.

## Electrical Conductivity (EC) – ALS Method TBA

The electrical conductivity indicates the level of soluble salts (salinity) readily leached from the material and is analysed on a 1:2 sample / water extract. Electrical conductivity is reported in  $\mu\text{S}/\text{cm}$ . Total Soluble Salts (in mg/kg) can be calculated from the electrical conductivity.

## Further detailed assessment

Following assessment using these initial screening tests, ALS also has a broader range of kinetic and leach column procedures to further assess the ARD risk and treatment requirements. Contact your local ALS office for further information or email [csgph@alsglobal.com](mailto:csgph@alsglobal.com)



Please contact us for any testing enquiries you may have.