MINING MINNESOTA
RESPONSIBLE DEVELOPMENT of NATURAL RESOURCES

WHAT ABOUT ACID ROCK DRAINAGE?

What is acid rock drainage?

Most of the time, ARD does not occur because other minerals and waters neutralize the acid.

Acid rock drainage (ARD) is the natural result of oxidizing or "rusting" of certain types of sulfur-bearing minerals in the presence of water, air and bacteria. ARD is a very weak form of sulfuric acid. Sulfuric acid is used commercially to make pharmaceuticals, rayon fibers and fertilizers; it also is produced in our bodies when we digest certain proteins. The most common types of acid neutralizing minerals are calcium and magnesium carbonates occurring in nature as limestone and dolomite. In their pure form, these chemical compounds are used to treat stomach acid.

What are sulfur-bearing minerals?

Sulfur-bearing minerals are principally composed of iron and sulfur. The most common sulfur-bearing minerals are the iron sulfides – pyrite (FeS_2) or "fool's gold" and pyrrhotite ($Fe_{1-x}S$). These minerals also may contain small amounts of other metals, such as gold, copper, zinc and nickel, and other elements such as selenium.

Can ARD be a problem?

The acid generated can have a deleterious affect on water quality, both because of the increasing acidity and also because acidity can dissolve the metals that may be present in the sulfur-bearing minerals themselves or in the rocks and other materials with which the acidic waters come in contact.

The effect of the acidity depends on several factors, including the initial acidity of the receiving waters or soils, the actual amounts of acid generated, the buffering capacity of the receiving waters or soils and the amount of dilution of the ARD that occurs.

The dissolving of metals, depending on the concentration, may affect aquatic life. Under specific and very limited conditions additional sulfate in waters may increase the production of methyl mercury which is the type that leads to accumulation of mercury in fish.

Can ARD be caused by human actions?

Yes. Though ARD occurs naturally where sulfur-bearing minerals are exposed to air and water, it also may be produced by human activities such as road cuts, quarrying or mining.

What do we know about ARD in the mining environment?

The chemistry of ARD is now fairly well understood. It is important to understand how that chemistry interacts with the environment and how to prevent potential damage to the environment. This requires comprehensive, site specific and detailed knowledge of the potential acid-producing products of mining and the environment in which they are produced, processed and disposed.

How are these issues assessed and regulated?

The State of Minnesota requires that all non-ferrous mining wastes be subjected to a rigorous waste characterization program. **In this program, comprehensive laboratory tests are conducted over time to determine the rate of pollutant generation from the wastes.** Samples of waste rock are taken from different parts of the deposit to be mined, as well as various waste products from processing.

Based on this program and water quality monitoring, the State, in cooperation with the project proposer, sets out parameters to be met in the design and operation of the project. The State issues water permits that have discharge limits selected to maintain water quality standards.

The State sets water quality standards which must be met by each operator of all industrial facilities.

How are these issues addressed in the design and operation of mining operations?

Each ore body and, therefore, each mining, processing and disposal facility is unique because of the physical characteristics of the sites, differing geology, mineralogy, geometry and different methods of mining and processing of each individual mineral deposit. Therefore, each aspect must be separately engineered in order to meet the water quality discharge limits.

This is true even in Minnesota's copper-nickel-PGM deposits, even though all the deposits are broadly similar, each of the known deposits needs to be treated differently in terms of development, mining, processing and closure.

Addressing the problems of potential ARD may involve such techniques as:

- Excluding air (oxygen) from contacting the potentially acid-generating wastes by placing them underwater or by placing them underground in mined out areas.
- Excluding water from contacting the wastes by caps or underground disposal.
- By adding extra acid-neutralizing materials.
- By collecting and treating seepage from waste materials in water treatment plants or treating them in wetlands treatment systems that neutralize acidity and precipitate heavy metals contained in the water.

What advantages do Minnesota's copper-nickel-platinum group metals projects have that help development of these deposits meet high environmental standards with respect to ARD and related water quality issues?

The Minnesota ores are mostly very low in sulfide content.

- The proposed processes concentrate the sulfur-bearing minerals into a stream of material fed into the processing plant. As a result, there is very low sulfur content in the waste material from processing.
- When the metals are extracted from the concentrate, almost all the remaining sulfur is neutralized by limestone to form gypsum, the material commonly used to make commercial wall board.
- The rock associated with the deposits contains minerals rich in calcium and magnesium, which helps limit the tendency to generate acid when small amounts of sulfur are present.
- A strong and workable regulatory process is in place. The relevant State agencies have experienced staffs and access to outside expertise as needed to ensure the environment is protected.

What is the chemical reaction that takes place?

The sulfur-bearing mineral reacts with oxygen, generally from the air and water, as humidity, to form a metal oxide and sulfuric acid.

The equation for the oxidation of pyrite can be written very simply like this:

Pyrite + Oxygen + Water → Iron oxide + sulfuric acid

The neutralizing reaction that takes place when limestone is added can be written as:

Sulfuric acid + calcium carbonate → Calcium sulfate + Carbon Dioxide + Water

(Calcium sulfate (gypsum) is the mineral used to make drywall)

Acidity and alkalinity are indicated partly by the "pH" of water or other material. A pH of 7 is neutral, while pH's of less than 7 are described as acidic, and pH's over 7 are alkaline. A pH in the range of 6 to 8 is broadly acknowledged as acceptable for all purposes. A change of one pH unit denotes a 10-fold change in acidity or alkalinity.

Natural waters may have an acidic pH because they are pure rain water or because of the presence of organic matter, such as tannic acid. Conversely, natural waters may be alkaline because of their contact with and weathering of calcium or magnesium rich rocks and sediments, such as limestone, dolomite and marl as is true in much of central and southern Minnesota.