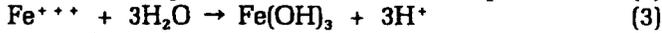
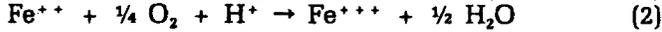


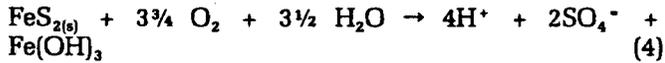
Appendix C

Acid Mine Drainage

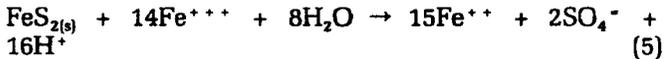
The oxidation of pyritic materials is not completely understood but has often been described by the following equations:



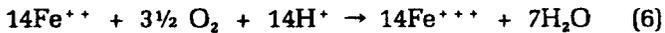
These three equations may be added to give the overall stoichiometric relation:



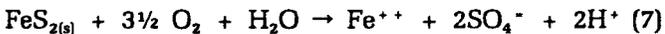
The slow oxygenation of ferrous iron (Fe^{++}) shown in equation 2 has generally been considered to be the rate-determining reaction; however, this rate can increase 500,000 fold in the presence of the iron bacteria *Thiobacillus ferrooxidans*, normally associated with pyrites in mine spoils (Bruynestein and Hackl 1982). This step is followed immediately by the rapid oxidation of more iron disulfide by the newly formed ferric iron (Fe^{+++}). The equation for this reaction may be written:



Rewriting equation 2 to show the oxidation of 14 moles of ferrous iron gives:



Adding equations 5 and 6 gives the overall reaction:



Equations 1 and 7 are identical, showing that by either path (O_2 or Fe^{+++} as the oxidizing agent) the net reaction is the same. In both cases oxygen must be supplied to the

system at a rate equivalent to the rate of iron disulfide oxidation.

When large concentrations of dissolved iron are found in streams or lakes it is almost always in the ferrous form. Ferrous iron exposed to oxygen from the atmosphere will oxidize as shown in equation 6, then hydrolyze to form a ferric hydroxide precipitate as shown in equation 3.

As shown in equation 4, the products of iron disulfide oxidation are: (1) hydrogen ions that lower the pH and increase the acidity of the receiving water, (2) sulfate ions that contribute to the salinity of the receiving water, and (3) ferric hydroxide that is essentially insoluble in water and precipitates as the yellow-orange deposit commonly referred to as "yellow-boy." Complex iron compounds such as basic ferric sulfate and jarosite may also be major components of "yellow-boy" (Bruynestein and Hackl 1982).

Of the three major end products of acid mine drainage (AMD) shown in equation 4, the hydrogen ion (H^+) or acid is the one of greatest environmental concern. AMD commonly has pH values ranging from 2 to 4.5. At these low pH values metals such as iron, aluminum, copper, and nickel enter into solution to further pollute the water. Water of this type supports only limited life, such as acid-tolerant molds and algae; it will not support fish; destroys and corrodes metal piers, culverts, barges, etc.; increases the cost of water treatment for power plants and municipal water supplies; and leaves the water unacceptable for recreational uses.

Enough water to satisfy equations 1, 3, 4, 5, and 7 is usually available in the overburden and coal or from humidity in the atmosphere. Water also serves as the transport medium that removes the oxidation products from the mining environment into streams.