

## MINING.

THE CHEMISTRY OF THE CYANIDE PROCESS.

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(Continued.)

Where the sgitation or circulation systems are adopted, the consumption must be still greater, since these methods involve a constant exposure of fresh surfaces.

The tondency of the simple cyanides to form double salts with each other, or with other metallic compounds, must likewise be taken into account. Salts of iron, and to a lesser extent, salts of aluminum, magnesium, calcium and the alkali-metals are likely to cccur in tailings, especially such as have been long exposed to atmospheric influences.

We have said enough to show that, even under the most advantageous circumstances, an enormous waste of cyanide must take place. Some of these losses are doubtless preventible; the use of closed tanks and careful attention to the purity, both of the cyanide itself and of the water used for dissolving it, would reduce the extent of the decomposition in a very marked degree.

Action of Cyanide on Pyritic Material.—Let us now consider what additional decompositions occur when cyanide is applled to the treatment of pyritic ores or tailings. To understand the action of cyanide on these ores, or the products derived from them, we must briefly describe their composition and the chemical changes to which they are hable. The surface ores of the celebrated "banket" formation consist almost exclusively of silica and oxide of iron. These occur is the form of rounded quartz pebbles, imbedded in a softer matrix highly charged with ferric oxide, which imparts its characteristic reddish tinge. The gold is found in this matrix associated with the oxide of iron, or sometimes in small scales on the surface of the pebbles. The pebbles themselves carry little or none. At a lower level this "free-milling" banket passes into an ore precisely similar in structure, but much harder, and containing the iron in the form of sulphide instead of oxide, which gives it a peculiar bluish tint.

There can be little doubt that the free-milling ores have been formed by gradual oxidation of the pyrites through the influence of air and moisture during a long period of time, and in fact we see this same change in progress whenever pyritic material has been exposed to the action of the atmosphere. The first effect observed is the conversion of ferric sulphide into a soluble sulphate, free sulphuric acid being simultaneously produced :

$$F_{tS_{2}} + H_{2}O + 7O = F_{tSO_{4}} + H_{2}SO_{4}$$

Certain insoluble basic sulphates, cf variable and somewhat complex composition, are gradually formed by the action of air on the ferrous sulphate.  $2 \text{ FeSO}_4 + \text{O} = \text{Fe}_2 \text{O}_3 \cdot 2 \text{ SO}_3$  (Wittstein).

A contain amount of soluble ferric sulphate is likely to be produced at the same time :

10  $FeSO_4 + 5O = 2 Fe_2O_3 SO_3 + 3 Fe_2 (SO_4)_3$  (B.1zəlius). (basic sulphate) (ferric sulphate) insoluble.  $\varepsilon$ oluble.

The pyritic ores likewise contain small quantities of arsenic, copper and sometimes cobalt and nickel, but the amount of these foreign metals has so far been so small that they have not practically interfered in the cyanide treatment. We may here note, as a fact observed in the treatment at the Robinson Chlorination Works of pyritic concentrates purchased from the various gold-mining companies, that copper and arsenic seem to occur in graduelly increasing quantities with the increasing depth of the working. These elements may in the future be a source of serious trouble in the application of the cyanide process.

Sappose, now, that we altoupt to treat a charge of partially oxidized pyritic tailings directly with cyanide solution. The moisture in the tailings has a distinct acid reaction, chiefly due to the presence of free sulphuric acid. This of course liberates hydrocyanic acid.

Ferrous sulphate (green vitriol) reacts upon the cyanide with formation of ferrous cyanide, a yellowish-red flocculent precipitate :

$$FeSo_4 + 2 KCy = FeCy_2 + K_2SO_4$$

This, however, is under ordinary circumstances slowly converted into potassium ferrocyanide by the excess of cyanide present.

 $FeCy_2 + 4 KCy = K_4FeCy_6.$ 

If sufficient sold be present the ferrocyanide reacts upon an additional quantity of the ferrous salt, ultimately giving rise to a blue precipitate or coloration (Prussian blue).

 $3 K_4 FeCy_6 + 6 FeSO_4 + 30 = Fe_2O_3 + 6 K_2SO_4 + Fe_7Cy_{16}$ . The appearance of a blue coloration on the surface of the tailings, or in

the colution, is a sure indication that acid iron salts are present, and that an enormous waste of cyanide has taken place.

Forric salte, when present unmixed with any ferrous compounds, decomposs cyanide solution with evolution of hydrocyanic acid and precipitation of ferric hydrate.

Fe<sub>2</sub>  $(SO_4)_3 + 6 \text{ KCy} + 6 \text{ H}_2O = F_2 (OH)_6 + 6 \text{ HCy} + 3 \text{ K}_2\text{S}_4$ This reaction takes place in two stages, the first being the formation of a soluble but very unstable formic cyanide, giving a dark brown solution.

 $Fe_2 (SO_4)_3 + 6 KCy = Fe_2Cy_6 + 3 K_2SO_4.$ 

This decomposes as follows :

 $Fo_2Cy_6 + 6H_2O = Fe_2(OH)_6 + 6HCy$ , giving rise to ferric hydrate, part of which is in a finely divided colloidal condition, and is with difficulty removed by filtration, as it chokes the pores of the filter.