sometimes a short distance below. But normally a zone of highly enriched copper sulphide cre is encountered at water level, consisting of bornite, chalcocite and covellite associated with chalcopyrite. The covellite is rare, but the two former minerals are almost invariably found. Often the chalcocite is present in an amorphous form, sometimes constituting a black band of high grade ore. The distance to which the chalcocite and bornite extend downwards is extremely variable, in some instances as much as 2,000 feet from the surface. Below this zone comes the normal vein, carrying chalcopyrite, the copper contents of the ore decreasing as the bornite and chalcocite disappear. Frequently the quantity of chalcopyrite will thence decrease, until the vein matter contains iron pyrites only.

The re-actions given by Prof. Van Hise to account for the observed facts are the following:

Chalcopyrite would be formed when copper sulphate came into contact with iron pyrites, thus:

$$Cu SO_4 + 2 Fe S_2 + O_4 = Cu Fe S_2 - Fe SO_4 + 2 SO_2$$

and bornite by the re-action of copper sulphate upon the chalcopyrite, as shown by the formula

2 Cu Fe
$$S_2$$
 + Cu SO_4 + O_2 = Cu₃ Fe S_3 + Fe SO_4 + SO_2

or by re-action upon iron pyrites alone, when cuprous and cupric sulphates were present, expressed by

$$Cu_2 SO_4 + Cu SO_4 + 3 Fe S_2 + O_6 = Cu_3 Fe S_3 + 2 Fe SO_4 + 3 SO_6$$

The chalcocite would be formed by the action of cuprous sulphate upon iron pyrites, as follows:

 $Cu_2 SO_4 - Fe S_2 + O_2 = Cu_2 S + Fe SO_4 + SO_2$

In a similar manner the enrichment of the higher portions of gold and silver and lead veins may be explained, the re-actions for the latter being

> Pb SO₄ + Fe S₂ + O₂=Pb S + Fe SO₄ + SO₂ and Pb CO₃ + Fe S₂ + O₂=Pb S + Fe CO₃ + SO₂.

It will will be observed that iron pyrites constitutes the precipitating agent for many salts of the base metals. Ferrous sulphate, on the other hand, is probably the chief precipitant of gold and silver, throwing them down in the metallic form, with the production of ferric sulphate in the solution.

The recognition of a secondary enrichment of metalliferous veins is of the utmost practical importance. It explains many hitherto obscure phenomena which have puzzled men engaged in actual mining operations, and it affords a means for determining how far exploratory work may be carried with any hope of success in many mines. The deductions of Profs. Van Hise, Emmons, and Weed, therefore, merit the careful consideration of mining engineers directing practical work.

Of no less importance is the clear explanation given by Prof. Van Hise of the manner of vein filling. The details are too numerous and complex to admit of a comprehensive summary here, but we may call attention to his division of the zone of fracture of the upper rocks of the earth's crust into two other zones, which he calls respectively the zone of weathering and the zone of cementation. In the belt of weathering the processes of carbonation, hydration, oxidation, and solution are constantly going on, "the minerals which remain are usually few and simple; the volume of the rocks is diminished; they soften and degenerate; and they are finally destroyed as coherent solids." The process of carbonation is of peculiar importance. It produces carbonates of the alkalies, of the alkaline earths, and of iron, and less abundantly the carbonates of other metals, all of which are readily soluble, with or without the aid of carbonic acid. Moreover, in the carbonation of the silicates the silica separates as silicic acid,

and the amount of silicic acid thus liberated is enormous. This passes into solution, and is redeposited below in the fissures, joint planes, and fissility planes of the rocks in the belt of cementation. To state the matter boldly, the quartz of the quartz veins discovered in the earth has been derived by a process of leaching from the superficial rocks due to the action of percolating waters carrying carbon compounds resulting from the decay of vegetable matter on or near the surface. No satisfactory explanation of the solution of silica by the deeper seated waters has ever been given, but through carbons don due to downward-moving waters the concentration of silica in fissures from above downwards is rationally and fully accounted for. It does not follow that the concentration of metalliferous minerals in the quartz necessarily occurred at the same time and as a part of the same process, though Prof. Van Hise inclines to the view that a great many metal bearing veins were thus produced, although more probably the the larger number of original sulphide concentrations were effected by deposition from ascending solutions, the sulphur being mainly derived from the sulphides present in igneous rocks, oxidized to sulphites and sulphates by the descending waters, and then reduced to sulphides in the presence of organic matter on the return flow of the solutions through trunk-chaunels toward the surface.

This brief review will serve to show how revolutionary is this latest statement of the theory of ore-deposits. It is, however, but the logical deduction from the accumulated facts of experience, a setting in order of our knowledge and the derivation therefrom of controlling laws. The final word on this question of course is not yet spoken, but but that we are emerging from a period of conflicting theories to one of true scientific explanation of the origin of ores, is manifest.

Some New Developments in Jigging.

In the concentrating works at Great Falls, Montana, which today stand as the most perfect example of modern methods in America or even in the world, a peculiar departure has been made from the old system of jigging, which seems to negative many of the results which have been obtained concerning the laws of jigging in the past. Perhaps the best exposition of the laws operative in concentration with jigs which has ever been made, was that set forth by Prof. Robert H. Richards in his "Cycle of the Plunger Jig" (Trans., A. I. M. E., Vol xxvi, pp. 1-32). He there enumerates and discusses the four laws, viz.: 1. The law of free settling particles; 2. The law of hindered settling particles; 3. The law of acceleration; 4. The law of suction. According to Rittinger, the law of free settling particles (which he calls the law of equal settling particles), and the law of acceleration, are those which determine the separation of ore from its gangue. In accordance with this view the best results should be obtained when the ore was sized, and consequently the mills of Germany and other European countries introduced a system of close sizing before jigging, which has been largely copied in America, but which gave rise to a great deal of criticism, and was finally abandoned by the most progressive mill-men on this side of the Atlantic. An elaborate experimental investigation by Prof. Munroe, of Columbia University, New York, established a third law of hindered settling particles, by showing that particles of ore falling en masse, as actually happens in the bed of material on the jig screen, are impeded in settling by falling through interstitial spaces, which is equivalent to their falling through narrow vertical channels of circular cross section. As the interference in creases with the size of the ore particle relatively to the diameter of the interstitial space through which it falls, it is evident that small particles of heavy ore, which would be equal settling with considerably larger particles of gangue, will enjoy a superior opportunity of