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HALIFAX, Oct. 27th, 1892.

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(Signed) PETER LYNCH.

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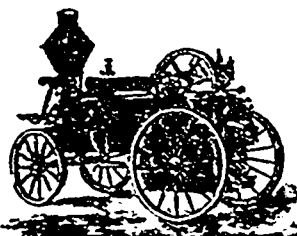
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## MINING.

### THE CHEMISTRY OF GOSSAN.

Written for the Engineering and Mining Journal by Steven H. Emmens.

Cornish miners have a saying that "gossan rides a high horse," and the German miners declare

"Es ist nie ein Gang so gut  
Der trägt nicht einen eisernen Hut."

The gossan of gozzin, or *eisernen Hut*, or *chapeau de fer*, as the French miners call it, is the iron cap that surmounts so many mineral veins in the form of a more or less porous, cellular and reticulated mass of hydrated ferric oxide mixed with rocky matter. It is usually regarded as a promising indication, and in the majority of cases a body of ore is found underlying the gossan. This arises from the fact that the gossan itself is the residue or skeleton, as it were, of a whilom mass of ore that has decayed and partially disappeared through the action of the atmosphere and moisture. If, then, the original body of ore extended to a depth below the region of atmospheric action, or if the outcrop of the vein has not been exposed to such action for any relatively long period, the gossan will be found surmounting unaltered ore. If, on the other hand, the original body of ore were of comparatively small dimensions, the gossan indication may not lead to any discovery.

The "brown ores" of the Southern gold mines and other districts are the best known representatives in this country of the "gossans" of Cornwall. They have been produced by the same natural forces acting in the same way; and as the industrial future of the South will be greatly influenced by the attention or inattention given to her gold mines, the study of the natural philosophy of gossan becomes a matter of national importance, if thereby the intelligence of capitalists can be awakened to the facts and probabilities of the case.

Let us suppose that the outcrop of a mineral vein is composed of rocky matter (gangue), carrying crystals and specks and patches, and larger bodies of pyrite, marcasite, pyrrhotite, chalcocopyrite, blende, galena, chalcocite, bornite, millerite and folgerite.

It is known that part of the sulphur in pyrite and marcasite is held in combination by a comparatively feeble chemical force. This is proved by the ease with which one half of the sulphur is driven off by the application of very moderate heat, while the balance is difficult to separate from the iron. In marcasite the union is feebler than in pyrite. In pyrrhotite, chalcocopyrite and bornite also there is a molecule of sulphur in excess of iron monosulphide, and this extra molecule is removed with comparative ease. But in blende, millerite, folgerite, galena and chalcocite the constitution is that of either a monosulphide or subsulphide. It follows, therefore, that the oxygen of the atmosphere will, on the principle of producing the most heat, attack the respective sulphides in the following order:—

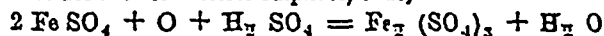
- |                    |                |
|--------------------|----------------|
| 1. Marcasite.      | 6. Folgerite.  |
| 2. Pyrite.         | 7. Millerite.  |
| 3. Pyrrhotite.     | 8. Chalcocite. |
| 4. Chalcocopyrite. | 9. Galena.     |
| 5. Bornite.        | 10. Blende.    |

In nature all the minerals would be attacked simultaneously, because the surface of each would be more or less exposed independently to the atmosphere; and the selective action of the oxygen would be manifested by the varying speed and extent of the attack. For the purpose of the present discussion, however, we may consider the attack to begin with the oxidation of part of the marcasite, thus:—

1.  $\text{FeS}_2 + \text{O}_2 + \text{H}_2\text{O} = \text{FeSO}_4 + \text{H}_2\text{SO}_4$
2.  $\text{FeS} + \text{H}_2\text{SO}_4 = \text{FeSO}_4 + \text{H}_2\text{S}$
3.  $\text{FeS}_2 + \text{O}_2 + 2\text{H}_2\text{S} = \text{FeS} + 2\text{H}_2\text{O} + 3\text{S}$
4.  $\text{S} + \text{O}_2 + \text{H}_2\text{O} = \text{H}_2\text{SO}_4$

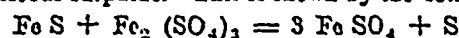
That is to say, the oxygen of the atmosphere and the moisture of the ground and air convert part of the sulphur into sulphuric acid and leave a residue of iron monosulphide, which is then attacked by the sulphuric acid with formation of ferrous sulphate and evolution of sulphuretted hydrogen. This latter reacts with the sulphurous anhydride formed (together with sulphuric acid) by the oxidation of the sulphur in the marcasite, and produces water and free sulphur, the latter of which is in its turn oxidized and produces a further quantity of sulphuric acid, and so on. Hence, as the result of the first attack on the ores, we should expect to find ferrous sulphate, sulphuretted hydrogen, free sulphur and sulphuric acid.

Now, a solution of ferrous sulphate eagerly absorbs atmospheric oxygen and sulphuric acid to form ferric sulphate, thus,



and therefore, although I have spoken of ferrous sulphate and free sulphuric acid as amongst the first results of the gossan-forming action, they are rapidly converted into a solution of ferric sulphate; and it is in this latter form that they are usually found in mine-waters and the like. In some cases, however, where local circumstances impede peroxidation, ferrous sulphate remains in considerable quantity, as, for example, in the manufacture of copper by exposing large heaps of pyrite to the action of the atmosphere and moisture.

Let us next consider what will be the action of the ferric sulphate upon the remaining ferrous sulphide. This is shown by the following equation:



or, in other words, one molecule of ferric sulphate will abstract one molecule of iron from ferrous sulphide, forming 3 molecules of ferrous sulphate and setting free the sulphur. That this change is feasible and, indeed, necessary (if we accept the Law of Maximum Work), may be shown by a consideration of the forces concerned as measured by their heat equivalents.

(To be continued.)