MINING.

THE CHEMISTRY OF GOSSAN.

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

(*Continued.*)

Secondly, it must be remembered that carbonic acid gas is present in the atmosphere, and that water falling through or exposed to the air becomes more or less charged with it. The carbonated water has a powerfully solvent action upon limestone, which is present to a greater or less degree in most rocks and soils. Hence, among the chemical influences to which the outcrop of a mineral vein are exposed must be reckoned that of water charged with carbonate of lime. This acts upon the precipitated basic sulphate thus:

$$Fe_2\ O_3\ (SO_3)_2 + 2\ Ca\ CO_3 = 2\ Ca\ SO_4 + Fe_2\ O_3 + 2\ CO_2$$

forming a deposit of sulphate of lime (*anhydrite* when anhydrous, and *gypsum* when containing water) and ferric oxide, and setting free the carbonic acid. If other sulphates be present and be decomposed by the carbonate of lime, the tendency is to form carbonates of their metals rather than for the carbonic acid to escape. Thus, in the case of sulphate of lead (*anglesite*), which is virtually insoluble in water, and therefore remains in the place previously occupied by its parent, galena, the reaction is

$$Pb\ SO_4 + Ca\ Co_3 = Pb\ CO_3 + Ca\ SO_4$$

The lead carbonate (*cerusite*) thus formed is soluble in water charged with carbonic acid gas, but is much less soluble in the same water if containing carbonate of lime. Accordingly, the tendency will be for the lead to be carried away from the outcrop and to be deposited in the form of carbonate wherever the transporting water comes into contact with limestone.

Copper sulphate is in like manner converted into copper carbonate, which is found in the form of *malachite* and *azurite*; zinc sulphate furnishes zinc carbonate (*smithsonite*), and nickel sulphate takes the form of a hydrous basic carbonite known as *zaratite*.

Copper, however, in addition to the normal sulphate, is capable of forming a basic sulphate, $Cu\ SO_4 . 3Cu\ (OH)_2$, which, under the name of *brochantite*, is frequently found in nature associated with malachite and native copper, and has been artificially produced by Meunier (*Compt. Rend.* 86, 686, 1878) by the action of a solution of normal copper sulphate upon galena for 11 months. In the case I have supposed, therefore, a formation of brochantite will occur, and this, when acted upon by a solution of carbonate of lime, will produce malachite or azurite, together with cupric hydrate $Cu\ (OH)_2$ or $Cu\ O, H_2\ O$, which is the ordinary tenorite or black copper of the miners, a soft, pulverulent, black, earthy mass, always found in the upper parts of veins that have contained chalcopyrite.

Again, it must be borne in mind that the first stage of oxidation of sulphur is the formation of So_2, which is capable of combining with bases to form sulphites. Hence, calcium sulphite is one of the agents to whose influences our supposed vein outcrop will be subjected. The combined effect of this and calcium carbonate upon copper sulphate is as follows:

$$2\ Cu\ SO_4 + 2\ Ca\ CO_3 = Ca_2\ O + 3\ Ca\ SO_4 + 2\ Co_2$$

or, in other words, we have a production of free carbonic acid, *anhydrite* (or *gypsum* when hydrated), and *cuprite* ($Cu_2\ O$), the ordinary "red oxide" so frequently found in mines. And this cuprite, when acted upon by sulphuric acid, will yield a deposit of metallic copper, thus:

$$Cu_2\ O + H_2\ SO_4 = Cu\ SO_4 + H_2\ O$$

so that the occurrence of particles and flakes of native copper may be looked for in our gossan.

This separation of native copper may also be effected by the action of ferrous sulphate on cuprite, as may be seen by the following equation:

$$3\ Cu_2\ O + 3\ Fe\ SO_4 = 6\ Cu + Fe_2\ O_3 + Fe_2\ (SO_4)_3$$

so that in this case a deposit of ferric oxide would take place in addition to the formation of native copper.

No similar reaction takes place with nickel or zinc compounds, and therefore we should not expect to find these metals in our gossan in the native state. Lead, however, is occasionly found native in small quantities; and as it is capable of forming a sub-oxide $Pb_2\ O$, which, by the action of $H_2\ So_4$, is decomposed into lead sulphate and metallic lead, the formation may be similar to that described in the case of metallic copper. It is, however, customary to regard native lead as having probably been found by the deoxidizing action of the arsenious anhydride $As_2\ O_3$. Gossans rarely, if ever, contain it. With gold and silver the case is different. The first-named of these metals is a frequent constituent of pyrite, while the latter is an equally frequent constituent of galena and blende. Whether, when thus occurring, they exist in a free state as metallic particles mechanically included in the surrounding ore, or whether they are in chemical combination with some other element or elements, is a moot question. If they be native, they will for the most part remain in the gossan, by reason of their being comparatively inoxidizable and insoluble. And if they exist as sulphides and pass into solution, they are at once precipitated in the metallic state by the action of ferrous sulphate, thus:

$$Ag_2\ SO_4 + 2\ Fe\ SO_4 = Ag_2 + Fe_2\ (SO_4)_3$$

Accordingly, it may be expected that whatever gold and silver the original vein matter contained will ultimately be found in the gossan, an expectation which is always completely realized.

(*To be continued.*)