

These pyritic deposits contain almost all the heavy metals, including platinum and gold, and it is remarkable that the latter here occurs in quartz exactly as it does generally throughout the world.

The untenable character of the explanation above quoted must be evident, and this brief mention of them will be sufficient. Yet it appears that there are other inquirers into the genesis of ore-deposits who purpose to take a similar standpoint.

4. *Hysteromorphous Deposits.*

Under this title are included the deposits formed by the chemical and mechanical influences of the surface region, from the original deposits of which the conditions of origin have been considered above. These formations have been considered and named from various standpoints. Thus the name "deposits of débris" emphasizes the idea of a mechanical crushing or disintegration; the German term "*seife*," like the Spanish and American "*placer*," is based upon the manner in which such deposits are often mined for their metallic contents, and so on. The expression "secondary deposits" satisfies, it is true, the definition given above, but is rendered ambiguous by its frequent use in other meanings connected with the genesis of ores.

The influences of the present surface upon deposits found in the deep region are so characteristic as to permit us to draw conclusions concerning the processes of earlier periods, when the surface occupied a very different position. Unquestionably, effects similar to those of to-day were produced then also, and we must include in our consideration of the subject the hysteromorphism of former geological periods.

(a.) *Chemical Effects.*

The chemical effects proceeding from the present surface have been already discussed in many respects. They involve not only phenomena on the surface itself, but extend beneath it to the ground-water level, and even below that level, so far as the vadose circulation is traceable.

On the surface it is especially the oxidizing effect of the atmosphere, its contained carbonic acid, and the solvent and chloridizing action of atmospheric precipitation, simultaneously aided by the mechanical effects of wind and moving water, which bring about what Justus Roth has called "simple weathering," to distinguish it from more complicated forms of decomposition. In considering not merely rocks, but outcrops of complex ore-deposits, we encounter what Roth calls "complicated weathering."

Decomposition underground, through the action of the same atmospheric constituents of the surface-water, extends, as is well-known, to the ground-water level, where it may manifest itself in a striking way by reason of the frequent occurrence at that level of the alternation of dryness with moisture, which is a factor greatly promoting decomposition.

A similar condition is presented, as was pointed out in Part I., by the workings of mines, where the water-level has been artificially lowered, and a zone of depth previously untouched by the vadose circulation is brought within the domain of that agency. Deep and old metal-mines especially exhibit in a striking way the effects of the vadose circulation, and, in addition, a phenomenon but seldom found in places under the influence of the natural water-level—namely, the effect of the mine-waters upon various surface relations and products.

Limonite Deposit near Rio Tinto, Spain.—One of these rare instances is cited by J. A. Phillips in his group, "Deposits resulting from Chemical Action"—namely, in the vicinity of the great iron- and copper-pyrites deposits of Rio Tinto, in Spain, there occurs a deposit of hydrated ferric oxide, shown by the fossils it contains (which correspond with species still living in the region) to be of recent origin, and undoubtedly produced by the weathering and decomposition of the neighbouring pyritic deposit. It was deposited in a swamp-like basin with peaty matter, and subsequent erosion has left of it two remnants only, at Mesa de los Pinos and Cerro de las Vacas respectively. Evidently, in this case, the detritus of the pyritic deposit has not been mechanically swept away and collected elsewhere, but a chemical action has taken place, removing material in solution, exactly as in the formation of bog-iron-ores. The formation here is certainly earlier than the Roman period, for Roman tombstones have been found made of this recent iron-ore.

Mine-waters contain the solutions of all substances directly or indirectly dissolved by the vadose circulation, and some of these, encountering suitable precipitants, may be thrown down. Thus, ferrous oxide becomes by oxidation hydrated ferric oxide; many metallic sulphates are reduced by organic matter to sulphides; copper-salts may even be thus reduced to metal, &c. These new precipitates will mark the track of the mine-waters.

Finally, while the solutions formed by surface-waters, like those of the mine-waters, mostly find their way to the points where the water-level reaches the surface (drainage-points), yet, as a part of the ground-water penetrates to greater depths, such solutions may very likely produce, in the deep region itself, impregnations, which must, however, differ in character from those produced by the deep circulation proper.

The primitive deposit from which such solutions have come will show remaining in it principally substances not easily soluble, together with such as, like precious stones, resist all atmospheric influences. Meteoric waters carrying oxygen, some carbonic acid, and small quantities of chlorides, will first oxidize whatever is oxidizable, especially the metallic sulphides. On this subject S. H. Emmens has published a clear statement, with some practical deductions. He distinguishes in the order of liability to decomposition the following degrees: (1) Marcasite, (2) pyrite, (3) pyrrhotite, (4) chalcopyrite, (5) bornite, (6) folgerite, (7) millerite, (8) chalcosite, (9) galena, and (10) zinc-blende. The acid ferric sulphate formed from the first members of this series immediately attacks the latter members. The carbonic acid contained in the circulating waters has a high solvent power, and, among other things, dissolves the carbonate of lime as a bicarbonate, which reacts upon the basic sulphates, producing gypsum and free carbonic acid, and ultimately transforming lead-sulphate into carbonate (cerussite). Copper-oxide and, under some circumstances, native copper, may be formed from copper-sulphate, and so on.