

Copper Deposits of New Mexico and Arizona.—Traces of similar ore-distribution in sandstones seem to be not infrequent in the America West. Thus F. M. F. Cazin says of the copper-ores of the probably Triassic sandstones of the Nacimiento Mountains in North-west New Mexico, which J. S. Newberry had described in 1860: "The ore occurs nearly exclusively as the petrification of the leaves, stems, limbs, and trunks of palms. Frequently the ore is coated with a film of jet or coal. It is always easily separated from the rock. The ore is predominantly erubescite, copper-glance, and melaconite, and it appears to be distributed all over the massive stratum, but is more densely collected on seams and cleavages, in some instances forming a single layer of petrified parts of palm-wood."

This occurrence, which is analagous to those in Bohemia, and in the Province of Perm, was declared to possess great economic importance. Its later developments are not known to me.

W. P. Blake has described an analogous occurrence in the sandstones and conglomerates overlying the granites in Copper Basin, Yavapai County, Arizona, where the copper-ores are found unconnected with any organic substances. In the underlying granite, however, there are fissures filled with copper-ores. He thinks it probable that copper sulphides circulating in highly permeable sandstone were precipitated as carbonate by carbonate of soda, while the resulting sulphate of soda escaped in solution, to be concentrated by evaporation, forming deposits of thenardite, which is common in Arizona.

Lower California.—At Boleo, opposite Guaymas, on the Peninsula of Lower California, E. Fuchs has described a remarkable deposit of copper-ores in Tertiary sandstones, conglomerates, and tufas, which must be mentioned under this head. The east slope of the (mostly eruptive) mountain range extending through the peninsula is a plateau, gently descending towards the Gulf of California, and cut by precipitous cañons. It is formed of strata containing characteristic Miocene fossils. Tufas decidedly predominate, and the series contains three or four copper-bearing beds, covering a large area, and outcropping at many places in the cañons. These lie immediately upon conglomerates of pebbles of eruptive rock (different and characteristic for each horizon) and are overlain by clayey tufas. The whole is traversed by several fissures, of which the largest and most important is a fault-fissure, occurring at the western border of the district and striking about parallel with the sea-shore.

In the ore-beds above the ground-water level, disseminated oxidized ores prevail, such as black oxide of copper, and the protoxide, with atacamite ($\text{CuCl} + 3 \text{CuO} + 3 \text{H}_2\text{O}$), azurite, malachite, and chrysocolla, with crednerite ($2 \text{Mn}_2\text{O}_3, 3 \text{CuO}$). In the second ore-bed (counting downwards) there are peculiar globular concretions, like oölites, of copper oxide and carbonate, sometimes several inches in diameter, which are locally called *boleos*, whence the name of the district. Though greatly interested in this type of ore, no specimens have ever been in my possession enabling me to form from the hasty description of Fuchs a clear conception as to its genesis.

The third bed lies in part below the ground-water level, and contains, in addition to the foregoing minerals, the copper-sulphides chalcocine (Cu_2S) and covellite (CuS).

The ore-beds are composed of tufa (the slime, according to Fuchs, of volcanic eruptions), in which ores in disseminated spots and veinlets, as well as globular concretions, are irregularly distributed, with a visible tendency to concentrate towards the bottom of the bed, where they form a compact ore-layer, 6in. to 10in. thick.

With regard to genetic questions, we must bear in mind that the fossils found in these strata indicate an open though not very deep sea: it is, therefore, impossible to assume that iron-, manganese-, and copper-ores were dissolved in it, and were precipitated from it at the same time with the rock. A periodical metallic precipitation, three or four times repeated, in an open marine basin, is out of the question; and we are forced in this case, even more strongly than elsewhere, to assume a secondary origin for the ores. The data necessary for its explanation is still wanting, but can undoubtedly be secured by the further advance of mining work. E. Fuchs contented himself with pointing out the after-effects of eruptive processes, and did not enter upon the genetic question. Certainly the conglomerates underlying the ore-bed must have played an important part, representing, very likely, the channels through which the mineral solutions ascended, to be reduced, probably by the presence of organic matter, in the tufas above.

(b.) *Metasomatic Deposits in Soluble Rocks.*

A metasomatic replacement of the original rock-material was clearly proved long ago for some instances—e.g., calamine-deposits—while in other cases, where proof has not been obtained, analogies in the observed circumstances speak for such an origin. Parts of such deposits, it is true, may be fillings of spaces of dissolution, rendered unrecognisable, as such, by the absence of clearly-defined crustification in the ore-precipitates. We must accustom ourselves to the fact that for many deposits, not yet closely enough studied, it is impossible to determine positively the mode of genesis, and we must often choose provisionally, of the two modes just named, the one which appears to represent better the given data.

Calamine-deposits.—The calamine-deposits of Raibl in Carinthia, Wiesloch in Baden, Vieille Montagne with its vicinity, in Belgium and Germany, and other places, furnish, in the fossils of the limestone which have been transformed into calamine, the clearest proofs of a metasomatic replacement of the carbonate of lime by carbonates and silicates of zinc. Moreover, the structure and form of the ore-deposits is characteristic of this origin, these being mostly bodies of irregular outline, with portions projecting far into the country-rock. Often the progress of the replacement can be traced. Thus, at Raibl (Fig. 85), in places where the process has started from seams, the gradual advance from the seam into the rock may be observed; the outermost portions being relatively the most recent, and lying against a peculiarly uneven, rough surface of limestone.

Sometimes features of the original rock-structure are repeated in calamine, as, for instance, the cellular structure of the so-called *rauchwacke*, which consists of a skeleton of thin, smooth, lime partitions, from among which the limestone has been in part dissolved away, or left only in separate