

was at variance with his as to the downward course of the mineralising solutions—an opinion which was opposed to the then prevalent belief. The mine-workings have been greatly extended since that time, and Emmons's suggestion has been shown by several mining engineers, on the basis of thorough studies underground, to be untenable; so that the Leadville deposits appear, as regards the origin of their metallic contents, to form no exception to the history of other similar deposits. Mr. Emmons himself must have acknowledged the force of these criticisms, which do not detract in the least from the merit of his accurate investigation of the district.

On the west slope of the Mosquito Range appears a series of undulating Palæozoic strata, with heavy layers and intrusive masses of eruptive rocks, and traversed by numerous faults. This formation covers a large area, only a comparatively small portion of which—namely, the vicinity of Leadville—is ore-bearing—a circumstance which of itself points to a local origin for the ore. As is well known, the series of rocks has the following order downwards: white porphyry, blue limestone, gray porphyry, white limestone, lower quartzite—which will be denoted, for brevity, by their initial letters. The ore-deposits occur chiefly at the contact between the first two members of the series, below the WP. and above the BL. In the upper levels they are oxidized and chloridized (doubtless in this, as in other places, through the action of descending ground-water); in lower levels they appear in their original form as sulphides. That this was the condition in which they were originally precipitated Emmons admits; only their position seems to him to exclude the hypothesis of ascending solutions. He says, "The principal water-channel at the time of deposition was evidently the upper contact of the blue limestone with an overlying porphyry; and from this surface they penetrated downwards into the mass of the limestone. It may be assumed, therefore, that the currents were descending under the influence of gravity, rather than ascending under the influence of heat."

But he omits to explain how he conceives it possible that mineral solutions descending by gravity, and hence certainly having been in contact with the surface-region, could deposit sulphides. Assuming such an explanation to be furnished by reduction through organic substances, the question arises whither such descending currents could go. Here the theory is in conflict with our conception of the underground circulations.

As A. A. Blow has shown, however, a leaching of the WP. cannot by any means have supplied the ore, for this rock is not at all decomposed, as in that case it must have been. On the other hand, there are found in the intrusive beds and dykes of the lower GP. various indications that this rock had more to do with the ore-deposition. Along these dykes lie the ore-shoots—in other words, the channels in which ore was deposited.

It was at first tacitly assumed that the ore occupied the whole plane of the contact, although it was known that the richest bodies occupied particular zones in this plane. The importance of these ore-shoots was recognised later; and we may now consider the Leadville occurrence as presenting, not a single contact-deposit or ore-bed, but a complex group of ore-shoots, such as we have observed in other ore-deposits in limestone. These ore-shoots lie, in Leadville, at the contact between the soluble and the eruptive rock; while in Raibl they appear near the contact of two stratified rocks, one soluble and the other impermeable. The physical process forming these ore-shoots was doubtless the same in both cases. The mineral solutions, ascending under pressure, and seeking a path to the surface, followed, as some would say, the line of the least resistance; or, to express it, there was established in the soluble rock a line of maximum circulation resulting in the dissolving-out of a channel.

Such dissolution, however, occurred, not only on the contact between WP. and BL., but also at other contacts. Thus L. D. Ricketts gives a section of a mine on Carbonate Hill showing a second deeper ore-horizon between the GP. (dyke porphyry) and the underlying limestone. According to Rolker, the BL. of Fryer Hill was relatively thin, and has been replaced with ore and accompanying minerals, all but small remnants of dolomitic sand. These are generally above the ore—*i.e.*, along the upper contact—whereas, according to Emmons's theory, they should be replaced with ore.

The sections given by F. T. Freeland (*l. c.*, Figs. 1 and 6) show two ore-horizons, the thicker of which is below the WP., and the other below an intrusion of GP.; and Mr. Blow's sections from Iron Hill reveal similar phenomena (see Fig. 73, a section through the McKean shaft). The ore-shoots are, of course, irregular in form; but a main general direction can be recognised, which is eastward in Fryer Hill, but north-eastward in Carbonate and Iron Hill, representing the course of the channel through which the mineral solutions circulated.

In the data at hand concerning the structure of the deposits, nothing is said of a distinct crustification. It is to be remembered, of course, that mining operations hitherto have been largely confined to the upper and decomposed zone, whereas this phenomenon, if ever so fully developed, would show itself clearly only in the undecomposed zone. When we read, however, of great "horses" of country-rock encountered in the midst of the ore, we must believe that the deposit is due not so much to a metasomatic replacement of the limestone as to the filling of spaces of dissolution; and hence it should exhibit the characteristic sign of such a filling—namely, crustification. It seems to me that this point has not received the attention it deserves; and it is to be hoped that observations in the undecomposed ore-zones will give more definite data as to structure. It is difficult to believe that metasomatic processes could produce such pronounced ore-shoots as those described at Leadville.

Impressed by Emmons's views, and long before the connection of the ore-deposition with the GP. of the dykes had been shown, it was doubtful, in my mind, whether the ore might not have come somehow from the fault-fissures into the contact-channels. But Mr. Emmons pointed out to me that the faults contain only ore which has been dragged in from the pre-existing bodies, the formation of which was complete before the faulting took place.

Conditions analogous to those of Leadville are exhibited in most of the ore-deposits in limestone occurring in the American West. But, with few exceptions, we have only hasty descriptions of them, and sometimes nothing more than business "puffs."