THE FORMATION OF METALLIFEROUS DEPOSITS*

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Modern works, many of which have been written by Norwegians and Americans, accentuate the relation between metallic ores and eruptive rocks. This interdependence has led to the classification of metalliferous deposits into several groups. If the fundamental hypothesis of relation between ores and eruptives from their origin be accepted, we are induced to establish a corresponding connection between the nature of the deposits and the depth at which they are formed.

Let us consider an eruptive rock that is in course of crystallization under cover of sedimentary strata. If the magma contains minerals they will manifest a tendency to ascend in the guise of metallic exhalations. Analyses prove that eruptive rocks possess traces of many metals, and that in the case of iron they include as much as 7 or 8 per cent. These metals first form an unimportant aggregation of small disseminated grains that have received the name of "inclusion deposits." Some metals thus distributed have been found exploitable, as, for example, platinum, iron, chrome and nickel, and even the diamond.

After the inclusions, the elements group themselves more densely in the midst of the eruptive rock and still at a considerable depth, and we have "deposits of metallic segregation." These have a practical importance, since mineralized masses over 150 feet thick occur. They are deposits which have been formed at great depths, and can only be encountered in very primitive rocks, such as exist in Scandinavia and Canada, where they are well developed.

Succeeding these magmatic segregations, confined to the eruptives, there follows a different process, that of the deposition of metallic exhalations on the exterior of eruptive rocks. This is commenced by the appearance of sulphide ores massed at the contact of the eruptive with other rocks. They are designated as "peripheral sulphide segregations." In the mass of eruptives are found only small quantities of sulphides but plenty of oxides, whilst at the junction rocks sulphides concentrate and crystallize abundantly. These types of segregation, up to now very rare, constitute important deposits of copper, nickel, etc., which are, for example, successfully exploited in Canada.

Still at a considerable depth, deposits have been produced that appear in the form of lenticular bodies with transverse veins. This type, termed "diffused impregnations," is of great consequence. There are certain regions with veins enclosing sometimes copper and often gold; they are troublesome to work, since they are very irregular and prone to peter out suddenly. Notwithstanding, they are considerably exploited on account of concentrations, due to earth movements, and give rise to alluvial deposits through disintegration.

We now reach the true fissure type of mineral deposition, at first those which are directly connected with eruptive crystallized at great depth, then with more superficial deposits associated with micrugranites, and, lastly, microlithic. With granites exhibiting white mica, tin and its group is developed, sometimes accompanied by copper; then follows copper associated with lead and zinc, and, still higher, mercury—all in the true fissure group.

At surface little ore is formed directly from the rocks; these are only the results of mineral concentration derived from the denudation of previously existing deposits. The predominating proportion of minerals appear to have been crystallized at immense depths under varying conditions of heat, pressure, etc.

We have just remarked that the occurrence of mineral deposits may be classed as inclusions, segregations, peripheral segregations, impregnations, and veins of fracture. A question arises, have these different deposits remained from the time they were deposited in the same state as we now find them, and are they produced in any region where similar conditions prevail? It is to be observed that deposits are not the same in all regions; and if a miner, for example, were transported from the basin of the Mediterranean to Norway, he would fail to recognize the types to which he had been accustomed, and if he endeavored to apply brusquely the empirical results of his previous experience to these new types, he would have every chance of going wrong. Each region possesses, then, its own peculiar aspect, generally very different from others, and this is especially the case in passing from the north to the south of Europe. On the other hand, some parts remote from each other display certain analogies. Thus the same types obtain in the Central plateau, Bohemia, or Saxony, and the geologists of Freiberg have noticed in Asia, especially in the Altai, deposits similar to those in their own district.

We can, therefore, arrange deposits in metallogenic provinces which are adjusted to the age of the corresponding tectonic zones, and that have successively permanently crystallized under the influence of regional metamorphism, which have since suffered only vertical movements and have usually remained without any further mineralizing action. In Europe there can be distinguished from north to south a Huronian zone, a Caledonian zone, a Hercynian zone, and a zone influenced by the folding of the Alps; their equivalents exist also in other continents. In the Huronian and Caledonian of Scandinavia, the types of inclusions, segregations and impregnations are exceeding well represented, and their equivalents are present in Canada, Brazil, India, Siberia and Central Africa. In the Hercynian of Central Europe has been developed the petrographic type of porphyries harmonizing with a semi-profoundity characterized by the occurrence of veins containing blende, galena and pyrites. More to the south are the folded Tertiary formations, accentuated by numerous volcanic intrusions, in which are found auro-argentiferous minerals and also mercury, a metal that is able to deposit itself in proximity to the surface. If we examine a particular region, outside the deeply-seated igneous masses, we shall find metalliferous aureoles showing an analogous succession—first tin, followed by copper, zinc and lead, and finally mercury. It should be observed that for each of the types we are led to class the metals by groups which overlap each other, the natural sequence, however, persisting. It must not be imagined that each metal occurs as an isolated deposit, but as forming part of a whole, so that it would be a blunder to have a concession for a single mineral.

We now pass to another question. As deposits are not independent of their position in space, neither are they so in their place in time. Since formation metalliferous deposits have undergone modifications and

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