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SIGNIFICANCE OF THE OCCURRENCE OF MINUTE QUANTITIES OF METALLIFEROUS MINERALS IN ROCKS.

BY CHARLES R. KEYES.

The present consideration of the occurrence of many of the more common metals in minute quantities in the rocks had its foundation in an inquiry started by Messrs. Winslow and Roberson, in connection with the investigation of the Lead and Zinc deposits in Missouri, undertaken by the geological survey of that state. Although the work of these authors ended with their general report, the special phases of the investigation were not dropped by the survey. While the later results are by no means complete as yet, owing at that time to circumstances entirely beyond the control of the scientific corps of the organization, it is believed that there were some points reached in sufficient detail to make a general statement worthy of representation in synoptic form.

The lead and zinc deposits of southern Missouri and the contiguous parts of the adjoining states are of more than ordinary interest at this time, for the reason that they present, in an exceptionally fine way, many of the most instructive phases of ore-genesis.

The recent discussions on the ore deposits by the geologists have awakened a new interest in the whole subject, and clearly indicate that the time is opportune to begin the consideration of systematic plans of inquiry, to devise special methods of work, and to formulate critical criteria which will enable all investigations to be brought to a satisfactory basis for comparison.

The observations herein recorded are offered chiefly in criticism of certain methods of inquiry which are com-

monly followed in attempting to determine the amounts of ore materials that rock masses are supposed to contain. The endeavor is further to show that in the usual analysis of rock materials for the metallic content, as an explanation of the immediate source of the ores, there is a serious fundamental error, both in manner of procedure and in the premises of the logical inference. In many cases the results obtained have been not only indecisive in their nature, and misleading in fact, but they have, in reality, millitated directly against the very propositions they were intended to prove.

Stelzner and Posepy, in their attempts to show that the results of Sandberger, Becker and others are in error regarding the mineralogical source of ore minerals, have manifestly allowed their zeal to swing the pendulum as much too far in the opposite direction as they believed their opponents had in the other. In particular cases, Sandberger may be wrong in his conclusions, and his methods may be indecisive in character, as Posepy claims. But some of the assumptions of the latter regarding the primary nature of certain metallic rock-forming minerals cannot only not be proved, but the exact contrary has been thoroughly demonstrated. There is an element of probable error in the methods of these rivals; and it only differs somewhat in kind.

Some of these features may be pointed out later in connection with the references to the modern microscopical examinations of rocks. While it may be shown that the metallic content of igneous rocks is a far more important factor than is often supposed, the attainment of definite data is an effort much more complex than has been generally believed.

At the present time, it is generally conceded that an important primitive or ultimate source of the metals is the igneous rocks, either those already at the surface or deep-seated bodies, solid or molten, but it is not considered that the concentration of the metallic substances into ore-bodies is in any way always connected necessarily with volcanic activity.

The explanation of ore-deposits lies neither wholly within an aqueous theory, nor wholly within an igneous theory. It lies rather between the two, or combines both.

The most recent rock analyses, in which the rarer elements have been especially tested for, show appreciable amounts of substances which ordinarily are calculated in with more abundant compounds. In these new experiments the microscope has been of inestimable value. These more modern refinements in rock analysis demonstrate beyond all doubt that many of the less common metals and rare earths exist in some form or other in nearly all crystalline rocks, and in most of them in much greater abundance than has been generally supposed.

In the old pre-Cambrian igneous rocks of Missouri, which have not been affected by orogenic movements to any appreciable extent, and where surrounding conditions appear to preclude the secondary introduction of metallic salts, Robertson found measurable quantities of lead, zinc, copper and manganese. It is a noteworthy fact that the percentages of the metals increased rapidly with the increase in the amount of ferro-magnesian silicates present, in the rocks. The diabases contained five times as much metal as the granites poor in dark mica. Another feature to be noted is the fact that while lead and zinc occur in about equal proportions, amounting to, in some cases as in the diabase of Shrainka, one-half of one per cent of the constituents soluble in nitro-hydro-chloric acid, the last mentioned is almost wholly absent among the ore deposits of the eastern slope of the Ozark dome, where the first mentioned metal is the chief ore.

Most of the attempts to determine the metallic element of the rocks have been through chemical analysis. For the purpose of reaching definite conclusions, the results as a whole have been far from being satisfactory. So far as the chemical methods and manipulation go, results have been exact enough, but there are sources of error which have not been guarded against which lie beyond the sphere of the chemist.

In the long list of published analyses of the crystalline rocks, the feature most striking to the student of ore deposits is the apparent absence of metallic elements. Several factors contribute to this apparent anomaly. In the first place the majority of rock analyses have been made primarily to establish the relationships of the non-metallic elements composing the rock forming materials. The percentage sum of the minerals leaves a very small margin for the minerals which from a strictly metallurgical standpoint are important. With the exception of iron and one or two other metals, no account is taken of the metallic elements which may be present.

The fact is well illustrated by the Missouri rocks. The Graniteville granite, when analyzed for petrographical purposes showed no metals other than iron and maganese. When tested by more refined methods, the identical rock was found to contain 0.00126 per cent of lead, 0.00216 per cent of zinc and 0.00176 per cent of copper.

Owing to the usual methods of analysis these, if they be present, are calculated as iron or some other metal. This is sufficiently close for the immediate purpose of petrography. It is in fact all that is demanded of the rock student. Analysis more refined is entirely unnecessary in rock investigations.

It is a fact that has attracted wide attention that the results of the more recent rock analyses present a very different aspect from that of the earlier and majority. Some of these have been undertaken with the express purpose of determining those metallic elements which occur in very minute quantities; others have been made with the view of getting more exact statements for special features. In nearly all of these the presence of several of the rarer metallic compounds is a feature that is quite noteworthy.

An exhaustive critical review at this time, of what has been done in regard to this phase of the subject, would be out of place. The comparatively few examinations which have been made with the special object in view of determining the character of the metallic contents of rocks have

all been singularly indecisive in results. The extraneous sources of error have not been guarded against. Far too much has been assumed. Not only has the work been not determinative, but in the published accounts the most important point of all, that of the geological conditions, has been scarcely ever touched upon.

To be sure, problems of this kind are beset with many difficulties. Many factors have to be taken into consideration. There are theoretical conditions imposed that have to be fully satisfied before actual examinatians can be of much value. Singularly enough, existing critical data on the subject have not come from those sources in which special effort has been made to obtain the desired results. They have been derived entirely in connection with microscopical petography, incidentally, as it were. There are strong logical reasons, as well as practical reasons, for believing that in the case of the igneous rocks the question can only be definitely disposed of through means of the microscope.

GENESIS OF CERTAIN CHERTS.

BY CHARLES R. KEYES.

As regards origin, the cherts which occur so abundantly throughout the limestones of the lower carboniferous of the Mississippi valley have been the subject of much speculation. The same problem has received attention from every quarter of the globe. While the explanations offered differ very much from one another they in general agree in that they are regarded as formed contemporaneously with the geological formations in which they occur. The writings of Prestwich, Irving, Van Hise, Hull, Benard, Hinde, Hardman, Hovey, and many others corroborate this statement.