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## Some Evidence of Recent Progress in Geology

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## SOME EVIDENCE OF RECENT PROGRESS IN GEOLOGY.

GEORGE F. KAY.

(Abstract.)

In a recent publication by President Van Hise it was stated that the data of geology have become so numerous that they are almost unmanageable. With this view all geologists will agree. Not many decades ago it was possible for a geologist to have a reasonably full and satisfactory knowledge of his own science, and, also, to be fairly familiar with the related sciences. Now it is impossible for any geologist to learn all the important facts about all the branches of his own science. Not only is this true, but no geologist can know all the discovered facts of the world, or even of his own country, concerning that branch of geology in which he may be a specialist. The inability of any person to be thoroughly familiar with the whole field is impressed by the fact that during the last ten years more than 12,000 papers have been published on different phases of American geology alone. However, it is possible and necessary that the geologist be familiar with the leading facts and many of the details of that branch of the science in which he has specialized, and, moreover, that in his science as a whole he be acquainted with the tendencies which indicate the lines along which the greatest progress has been and is being made.

During the last decade great progress has been made in all branches of geology. To illustrate this progress reference is made in this paper to some of the outstanding publications in general geology, economic geology and petrology. No reference is made to the advances in other branches of geology.

## GENERAL GEOLOGY.

1. Without doubt one of the greatest influences upon geological thought during the last decade has been the development by Chamberlin and his associates of new and fundamental conceptions of the early stages of the earth's history. These new conceptions have greatly changed our former interpretations of the early atmospheres and hydro-spheres of our earth, the oldest rocks, vulcanism, diastrophic movements, climates, glaciation, the early life of the earth, and many other features.

2. The critical study of sediments has been of great assistance in

the interpretation of past climates. It has been recognized that several of the geological formations belong not to marine deposits, as was formerly thought, but to the continental class of deposits.

3. There have been great advances in stratigraphic geology. For example, the researches of Van Hise and Leith and of others have greatly advanced our knowledge of the Pre-cambrian systems of rock. The work of Bailey Willis and others has been of great value in the correlation and unification of the rock systems throughout the world.

4. The study of radio-activity in relation to the interior heat of the earth has become, in recent years, of great interest to the geologist.

5. The development of physics and chemistry has stimulated new modes of attack in experimental geology.

6. As a result of the investigations of the earthquake commission, our knowledge of earthquakes has been greatly extended.

7. Our knowledge of the geology of the western states has been greatly increased as a result of the new duties placed upon the United States Geological Survey in the classification of the public lands.

#### ECONOMIC GEOLOGY.

1. In recent years it has come to be recognized as never before that chemical work is absolutely essential in connection with the detailed study of ore deposits. Already some excellent researches have been made by Stokes, Sullivan, Wells, and others of the chemical laboratory of the United States Geological Survey, and by Arrhenius, Vogt, Kohler, and others. But the future will see much of this chemical work done on a more systematic basis than has characterized the investigations up to the present time. One of the most interesting illustrations of the great value of experimental chemical work in the correlation of problems connected with ore deposits has been given by W. H. Emmons in a publication entitled, "The Agency of Manganese in the Superficial Alteration and Secondary Enrichment of Ore Deposits in the United States."

2. The chemical study of ore deposits has influenced the interpretations of the genesis of ores. Whereas there were several conflicting but strongly advocated theories regarding the deposition of ores, there now is general agreement. It is now considered by all that some important types of ore deposit are undoubtedly the result of precipitation from meteoric waters, and that many which were formerly thought to belong to this class have been precipitated from magmatic waters. Concerning this latter method of origin, the work of Doctors Day and Shepard of the Geophysical Laboratory in collecting gases unmixed with air from the crater of Kilauea is of fundamental importance. These investigators

have demonstrated the presence in these gases of large amounts of water, thus furnishing direct evidence of a process which many students of ore deposits have for a long time believed to be of fundamental importance, namely, the potency of magmatic waters in contact metamorphism and the formation of mineral veins.

3. Great advancements have been made in the study of ore deposits as a result of microscopic study of rocks and ores. There is now an appreciation of the necessity of microscopic study and the unreliability of observations which are not supported by such testimony. In this connection it is well to refer to the recent application of metallographic methods of study to polished sections of ore. These methods of study are clearing up many points previously uncertain in the history of certain ore deposits and promise to be fully as important in future work on ore deposits as the study of thin sections has become to the petrographer.

4. Lindgren, in a paper on Physical Conditions and Ore Deposition, has made an important contribution to the literature of ore deposits. He shows clearly that there is an intimate relation between the mineral content of an ore deposit and the physical conditions under which the deposition occurred. He has shown that by a study of the mineral associations in an ore deposit it is possible to diagnose whether the deposit was formed under igneous conditions, pegmatitic conditions, contact metamorphic conditions, in the zone of cementation, in the zone of weathering, or under physical conditions which differ from all of these. In his text book on mineral deposits Lindgren has described ore deposits which were formed under each of the conditions mentioned above.

5. In the year 1904 a monumental work was published by Van Hise on the subject of metamorphism. In this he applied the laws of physical chemistry to the outer zones of the earth and showed that the principles of metamorphism have a direct bearing upon ore deposits; in fact, he contended that the deposition of most ores is but a special case of metamorphism which is of exceptional interest to man.

6. During the past few years a distinct advance has been made in the United States in publishing monographs of the important ore deposits of the United States. The geologist makes a thorough study in his particular field and records his results with great detail, thus allowing others to judge whether or not his conclusions are justified. In this connection it is necessary to mention only the excellent monographs issued by the United States Geological Survey on the iron ores of the Lake Superior region, on the copper deposits of Arizona, and on the gold and silver deposits of the West.

PETROLOGY.

1. Notable advances have been made recently in the physical and chemical investigations of rock minerals and rocks. Some of the most important of these are being carried on in the Geophysical Laboratory of the Carnegie Institution of Washington. Of great significance has been the determination of the value of certain minerals, such as quartz, as a geologic thermometer. As has been stated by Iddings, "The synthetic researches of Day and his colleagues, as well as those of Vogt, Doelter, Morozewitz and others, are carrying forward the earlier work of Daubrée, Fouqué and Michel Lévy, and are establishing the laws of formation of the mineral constituents of igneous rocks. Recognition of the character of igneous magmas as solutions has opened the way for the application of modern conceptions of physical chemistry to the elucidation of the phenomena of crystallization and of genetic relationship among igneous rocks."

2. "The Quantitative Classification of Igneous Rocks," by Cross, Iddings, Pirsson and Washington, is a publication which clearly indicates the rapid advance of our conceptions of the classification of igneous rocks. In this classification all igneous rocks are classified primarily on the basis of their chemical composition, and only secondarily according to their mineral constituents, texture, and other characters. In its application detailed chemical analyses of the rocks are required. For the first time in the history of petrology, the fundamental characteristic of the rock, namely, its chemical composition, has been recognized as the basis of classification.

3. The recent publication of text books by Iddings, Daly, Johannsen and others will be of great service to all who are interested in the study of rocks and will stimulate research in petrology.

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