

by which the plant makes use of carbon dioxide in building up carbohydrates.

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SCIENTIFIC LITERATURE.

U. S. Geological Survey. Monograph XVIII.

The Marquette Iron-bearing District of Michigan, with Atlas. By CHARLES RICHARD VAN HISE and WILLIAM SHIRLEY BAYLEY. Including a chapter on the Republic Trough by HENRY LLOYD SMYTH. 4to. Pp. xxi + 608. Pl. I.-XXXV. Figs. 1-27. Atlas sheets I.-XXXIX. Price, \$5.75.

The issue of the above monograph marks the completion of another chapter in the investigation of the ancient crystalline rocks of America. The book presents the fullest solution yet attained of one of the most puzzling and elusive of the many problems confronting geologists. The great economic importance of the region early drew attention to it. First the copper excitement and then the development of the iron interests brought settlers in increasing numbers. The pioneer work of Foster and Whitney established the claims of the rocks upon the attention of geologists, and the long and honorable line of investigators who have devoted time and effort to the understanding of them embraces the names of many of the best workers in this branch of science.

The monograph opens with a preliminary abstract of its contents, in which a reader who cannot well peruse all its pages will find a succinct exposition of what follows. A brief introduction then outlines the larger official reports previously issued, the area to be described, the chief geological classification, the distribution of the principal formations and the broad structural features. In Chapter I., W. S. Bayley presents a thorough bibliography of all previous literature in the shape of abstracts of each paper or reports chronologically arranged. This has been a heavy task, for the literature is extensive (the chapter occupying 148 pages), and the cited articles are difficult ones to sum up concisely. Dr. Bayley has, however, done so not only concisely, but with great clearness and thoroughness. In Chapter II. the same writer discusses the Basement Complex. Much light is thrown on this tangle of metamorphosed

eruptives, but no unwarranted hopes of unravelling their stratigraphical relations are encouraged. The Northern Complex is treated under the following subdivisions: The Mona schists, the Kitchi schists, the gneissoid granites, the hornblende-syenite and the intrusives. The Southern Complex is subdivided into the schists, both micaceous and hornblendic, the gneissoid granites, the Palmer gneisses and the intrusives. A few isolated areas are cited within the boundaries of the Algonkian.

In Chapter III., C. R. Van Hise takes up the description of the Lower Marquette series in detail. The Algonkian rocks form a compressed syncline on the whole, with many minor foldings along axes both parallel to the main axis and at right angles with it. The whole series pitch downward to the west, so that as one goes in this direction later and later strata are encountered. The basal formation is the Mesnard quartzite, marking the advance of the sea from the eastward. It also appears to some extent around the northern and southern sides on the east. It is succeeded by the Kona dolomite, the Wewe slate, the Ajibik quartzite; the Siamo slate and the Negaunee formation of sideritic cherts, ferruginous slates, ferruginous cherts, jaspilite and iron ores. The last named is the stratum of the greatest economic interest, as it contains the chief deposits of ores. The derivation of the latter from the cherty carbonates in troughs of some impervious rock, by the replacement of the chert, is well established and is a further application of views already presented for the simpler Penokee-Gogebic district. A stratigraphical break occurs between the Lower and Upper Marquette series.

In Chapter VI., Professor Van Hise treats of the Upper Marquette series. The Upper Marquette begins with the Ishpeming formation, which is subdivided into the Goodrich quartzite and the Bijiki schists. Considerable ore bodies are in the base of the Goodrich quartzite, produced by the erosion of those in the Negaunee formation below, but they are treated under the Negaunee formation, as they are closely associated with it. Above the Ishpeming lies the Michigamme of slates and graywackes, mica-schists and mica-gneisses. Next follows the Clarksburg of effusive basic lavas

and fragmental volcanics, with occasional sediments interbedded. The Clarksburg formation is described by Dr. Bayley, who also, in Chapter V., discusses the various intrusive rocks that preceded the Clarksburg and those that follow it. In Chapter VI., H. L. Smyth describes in detail the interesting trough that runs off from the main Marquette syncline to the Republic mine. While the general relations are much like the large area, there are present of the Lower Marquette series only the Ajibik quartzite and the Negaunee iron-bearing formations, and of the Upper Marquette only the Goodrich quartzite and the Michigamme mica-schist. Minor peculiarities in local geology are also met. In Chapter VII., C. R. Van Hise gives a broad, general, structural discussion of the whole area. The monograph is illustrated by many plates and figures. The former include beautiful, colored reproductions of the rocks of the Negaunee formation that are associated with the iron-ores. An atlas of maps also accompanies the letterpress. Besides a general map there are thirty-five sheets of quarter townships, four inches to the mile.

The entire work is a monument to its authors and of incomparable interest alike to students of metamorphism, of economic geology and of structural geology. The mining operators of the region should find it a suggestive guide in new developments and exploratory work. The book is written in a clear and pleasing style which deserves commendation no less than does the scientific matter.

J. F. KEMP.

The Phase Rule. By WILDER D. BANCROFT. Ithaca, N. Y., The Journal of Physical Chemistry. Large 8vo. Pp. viii+255. Paper. With numerous diagrams. Price, \$3.00.

This interesting volume presents the subject of qualitative equilibrium of heterogeneous substances, on the basis of Gibbs' 'phase rule' and Le Chatelier's theorem. Mathematical theory, electro-chemistry and quantitative equilibrium are not discussed, but diverse phenomena in great variety, including the temperature, pressure and concentration of components are coördinated as examples of a few general principles. The general scope of the work can best be illustrated by a few

subjects, selected from the many experimental data brought under review.

Water in an open vessel is not usually in a state of equilibrium, since evaporation takes place at the surface, and the liquid gradually diminishes in quantity. When the vapor is confined, in a limited space, its mass increases at any given temperature, until it exerts a certain definite pressure upon the surface of the water, and equilibrium results. With any change of temperature, some new pressure will be found before equilibrium is established; and if rectangular coördinates are used to represent the varying temperatures and pressures, some curved line will contain all the points which express conditions of equilibrium. Here is a system consisting of a single component in two phases, and the conditions of equilibrium are expressed graphically by a line. A definite change of either temperature or pressure or the density of water or vapor requires some definite change in another condition also. In this sense the conditions of equilibrium have but one degree of freedom, and the system is *monovariant*. Now, let the water be cooled until it begins to freeze. This implies a fixed temperature (0° C.) and a fixed vapor pressure of about 4.6 millimeters of mercury. If the system includes all three phases it is said to be *nonvariant*, and the conditions are represented by a single point in the diagram. At lower temperature the liquid will all freeze; at higher temperature the ice will melt. With increased pressure at zero all the vapor will be condensed; with diminished pressure all the liquid will gradually vaporize; in either case the system is reduced to two phases. A second curve of pressure can be drawn for ice in contact with vapor, and a third for ice in contact with liquid water, either system of two phases being *monovariant*.

When a salt, as potassium chloride, is added to the system in excess, there are two components, with the possibility of four phases; with the further addition of potassium nitrate, there are three components and may be five phases. In each case, if all components are present in the solid state, together with the saturated solution of all and the superincumbent vapor, the conditions of temperature, pressure and