is concerned, scientific men throughout the vast continent will be given every inducement to attend the Toronto meeting.—*The London Times.*

SCIENTIFIC BOOKS

Text-Book of Geology. By Amadeus W. Grabau. Two volumes. Part 1, General Geology, 864 pages, 734 text figures; Part 2, Historical Geology, 976 pages, 1980 text figures. D. C. Heath & Co.

A text-book in science may be written, like other books, for name and fame; or to set forth new truth; or for desired remuneration (which may be in inverse ratio to value); or simply because the author can not help it. This latest ambitious addition to geologic literature is another expression of the mental activity and scientific industry of the author, as it is his third important and voluminous work within a few years. In 1909–1910 he published, in conjunction with H. W. Shimer, two handsome volumes on "North American Index Fossils," covering only the invertebrates, with 1762 pages and profusely illustrated. In 1913 he produced another original work, "Principles of Stratigraphy," with 1185 pages. This latest, if less original, work is even more voluminous.

Facing the writer are several shelves filled with the antiques of English and American geologic literature, text-books and treatises dating back to the early part of the last century. The striking comparison between the old and new invites a brief homily on the development of American geology, as illustrated by the text-books.

These oldest books are amusing and pitiful in their diminutive size, narrow scope, queer ideas, and their occasional illustrations of exceeding crudity. If Science admitted pictorial illustrations a comparison of the old cuts with modern engravings of the same subjects would show the progress of graphic art. The older books antedate photography, which has been the greatest aid in study of nature.

Many of the old books have a theologic flavor, and some close with a pious exhortation. Beginning with Leibnitz (1646–1716) the writers sought to harmonize the facts of the new science with ancient Hebrew philosophy, and in particular tried to prove that Moses really meant "day" when he wrote it (in English). While there are yet people who give to old Hebrew literature more credence than to modern science, the time has gone by when American authors of scientific works have to defer to superstition.

Geology as a recognized branch of study in the schools is less than a century old. As a systemized branch of science and a part of general culture of the educated man geology began with Charles Lyell. His masterly writings (1830–1857) proved the continuity of geologic processes and set the standard for geologic literature. Previous to about 1840 American students relied chiefly on English works, or on American reprints. As late as 1837 Edward Hitchcock republished Dela-Beche's "Researches in Theoretic Geology," a small octavo of 342 pages and with no illustrations.

The oldest American text-book in this file is a little duodecimo of 122 pages, with 17 pages of index and errata, by W. W. Mather, entitled "Elements of Geology for the use of Schools," date 1833. This has a very few small diagrammatic illustrations. The writer's copy has pasted in the front cover a printed commendation by B. Silliman, of date June 18, 1834.

Two other old books are "Outlines of Geology," 1837, 384 pages, by J. L. Comstock; "Elements of Geology," by Charles A. Lee, 1839, 375 pages.

The second period of American geologic literature (1841–1860) began with Edward Hitchcock's "Elementary Geology," 1841. For two decades this was the American authority, and by 1860 it had run to the 30th edition, with 424 pages. The publication of a number of volumes by other authors suggests the stimulus to scientific study. Three of these had the favorite title "Elements of Geology"; by Samuel St John, 1851 (334 pp.); Justin R. Loomis, 1852 (198 pp.); Ayonzo Gray and C. B. Adams, 1853 (354

pp.). "A familiar Compend of Geology" of 150 pages by A. M. Hillside is dated 1859.

The contents of these old books usually justify the modesty of their titles.

The third period of text-book evolution (1860–1904) began with Ebenezer Emmons's "Manual of Geology," 1860. This had only 297 pages, but included many illustrations. Indeed, this was the first book to make very large use of illustrations.

But in a few years Emmons's excellent work and the other books were displaced by the masterly "Manual of Geology" by James D. Dana. This was true to its title, for that time. The first edition, 1862, had 798 pages and 984 illustrations. The fourth edition, in 1895, had 1087 pages and 1575 illustrations. All the geologists of the period including the older geologists now living were "brought up" on Dana's Manual. To meet the demand for a small text Dana published in 1863 his "Text-Book," which was revised in 1897 by W. N. Rice.

The most popular work during this period for class-room use and as a treatise for general reading was Joseph LeConte's "Elements of Geology," first published in 1878. In LeConte's picturesque style, with profuse new illustrations, and emphasizing mountain structure and other features of the western part of the continent, it held the field for three decades, with several revisions; and it is yet in demand, although badly out of date on many topics. LeConte's "Compend," with 399 pages, appeared in 1884.

During the later years of this period several smaller texts appeared; by N. S. Shaler, "First Book in Geology," 1884 (255 pp.); Angelo Heilprin, "The Earth and Its Story," 1896 (267 pp.); R. S. Tarr, "Elementary Geology," 1897 (499 pp.); W. B. Scott, "An Introduction to Geology," 1897 (573 pp.). Some popular works or treatises were: Louis Agassiz, "Geological Sketches," 1866; Alexander Winchell, "Sketches of Creation," 1870; "Sparks from a Geologist's Hammer," 1870; "World Life, or Comparative Geology," 1883; T. Sterry Hunt, "Chemical and Geological Essays," 1875; J. W. Dawson, "The Story of the Earth and Man," 1873; N. S. Shaler, "Aspects of the Earth," 1889.

The year 1888 marks an epoch in American geology, in the organization of the Geological Society of America, and the beginning of a periodical devoted entirely to geology. The *American Geologist* was founded and conducted by N. H. Winchell and existed to 1905, making 36 volumes. The *Journal of Geology,* published by the University of Chicago, began its excellent work in 1893.

The next commanding work, in succession to Hitchcock, Dana and LeConte, was the three volumes of T. C. Chamberlin and R. D. Salisbury, in 1904–1906, aggregating 2,000 pages. This may be regarded as introducing the fourth and present period of American geologic literature.

Other excellent text-books of later years are the following, omitting titles; J. C. Branner, (a syllabus) 1902; W. H. Norton, 1905; Eliot Blackwelder and H. H. Barrows, 1911; Chamberlin and Salisbury (single volume), 1914; L. V. Pirsson and Charles Schuchert, 1915 (1051 pp., 522 figures); W. J. Miller, 1916 (covering only historical geology); H. F. Cleland, 1916.

The above relates only to general geology, but the volume of earth-science literature has been increased by superior text-books in economic or industrial geology, and in physiography. The great mass of publication by the national and state surveys does not belong in this review.

Recurring now to the work in hand; it is in many respects an excellent presentation of geology to date. The writer has good literary style, direct and lucid. Most topics are well handled and many are treated with fullness and in a masterly way. This is especially true of sedimentation problems, of paleozoic stratigraphy, and of the historical part in general.

The illustrations are profuse and usually pertinent. The portraits of eminent geologists of former times will give the student a more lively human element. The paleogeographic maps, in Part II., are drawn in clear outline, and interesting comparison will be

made with the maps by Schuchert, and by Chamberlin and Salisbury. Some of the old and crude woodcuts that have done service in the literature for over half a century might be honorably retired; for example, Figs. 79, 128, 311, 593.

The publisher's part has been well done. More care in the matter of ink and press-work might improve the quality of the half-tones, some of which are poor.

In the order of topics the author does not follow the usual practise of beginning with description of geologic processes open to observation, surficial geology, but uses the philosophical or deductive order of cause and effect. Three short chapters on the nature and scope of the science are succeeded by chapters on the materials composing the earth's crust, mineralogic and chemic geology, and volcanism. This is discussed in the interesting preface.

The many subjects in dynamic and structural geology are covered in the remaining 14 chapters of Part I.; the author's more original matter being on saline deposits (Chapter 11); organic deposits (Chapters 12, 13); and on the deposition, classification and structure of the clastic rocks (Chapters 16–18).

Historical Geology, Part II., does not offer much opportunity for any original treatment. The life history of the past is well emphasized.

The author is strong on classification and terminology, and in consequence of his refined classification some topics are subdivided and treated under different heads. For example, glaciers are discussed in at least four places in the first volume. The student who wishes to find what the book contains on a subject may have to consult the index many times.

A favorite subject of the author is the problems of sedimentation; marine transgression and regression, overlap and offlap, origin of saline deposits, etc. He discusses these in a masterly way. But he does not clearly distinguish between accepted fact and his own plausible philosophy. An elementary text-book in science should contain very little beyond established fact and generally accepted principles. In a comprehensive work like this, intended for advanced students, new theories and perhaps even subjects under sharp discussion may be admitted, but such should be distinctly stated as tentative. This matter needs to be specially guarded by an author who is active in scientific debate. It will be recognized as bad form for an author to use a text-book for propaganda. Students should realize that scientific truth comes by observation and experiment, not by mere thinking. Theorizing is helpful as it points the way for induction. Grabau's discussion of sedimentation, especially as it relates to Paleozoic stratigraphy, will provoke debate and will be stimulating to advanced students.

The work makes very large use of foreign material and of illustrations from foreign literature. Indeed, on many topics the description of foreign features and phenomena is in excess. The work should be a satisfactory text for European students. But American students will be disappointed in the meager discussion and illustration of some interesting features of American geology. Some topics having very inadequate treatment, as noted in the rapid review, are: American geysers with only a few words, but four pages, including four cuts, of geysers in general; two pages on petroleum and rock gas; the glacial lakes and tilted shorelines in the basin of the Great Lakes and the Hudson-Champlain valley receive only a few lines (page 695); only three pages on coal; only four lines to drumlins.

What may be regarded as a defect in the work is the entire absence of references to the geologic literature. Some reference to the more important articles on topics only briefly discussed in the work would be very useful to the reader. And for subjects on which other authorities may differ references to the literature are necessary for impartial study.

The work is too full and too large to be used as a text for beginners. The author evidently had laboratory use in mind. Only the test of actual use can prove its value in competition with other excellent works. The time has passed when all of geologic general science, even for our continent, can be usefully gathered into one or two volumes. That was fairly done by Dana, fifty years ago. Fifteen years ago Chamberlin & Salisbury had to make three

volumes. A present-day book for beginners should contain little more than the basal principles and the more striking and interesting facts and illustrations. For advanced work special treatises on separate branches of the science are desirable. Already the economic or industrial geology has been divorced from general study. The same is true for earth forms or physiography; and partially for paleontology. Further differentiation may cover dynamics and geophysics; surficial processes; sedimentation and structure; meteorologic and glacial geology; with perhaps later division of the historical.

Grabau is now in China, as professor of paleontology in the University of Peking, and Paleontologist to the Chinese Geological Survey, and we may anticipate further enrichment of geologic literature from his prolific and facile pen.

H. L. FAIRCHILD

SPECIAL ARTICLES

A PRECISION DETERMINATION OF THE DIMENSIONS OF THE UNIT CRYSTAL OF ROCK SALT

ALL measurements of X-ray wave-lengths and of crystal structures depend upon the solution of the atomic marshalling of some crystal and a calculation of the dimensions of the fundamental unit of that crystal in terms of its mass and density. The crystal most used in this connection is rock salt (NaCl). It is the purpose of this note to give the side of the unit cube of NaCl in terms of the most accurate data available.

The NaCl crystal was early shown by Bragg to be a cube, alternate corners of which are occupied by Na, the remaining corners being occupied by Cl. Since one half of one Na and one half of one Cl are each associated with one unit cube, the mass of the unit must be

$$1/2\,[A_{Na} + A_{Cl}]\,m,$$

where A_{Na} is the atomic weight of Na,
A_{Cl} is the atomic weight of Cl,
m is the mass in grams associated with one unit of atomic weight.

The 1919 International Table of Atomic Weights gives

$$A_{Na} = 23.00$$
$$A_{Cl} = 35.46$$

If these values should be wrong by .01 the error would be less than .05 per cent. in each case.

m is most easily found as e/F where e is the charge on the electron, F is the Faraday constant in electrolysis. Millikan[1] gives e as 4.774×10^{-10} Abs. E. S. units of charge with a maximum error of .1 per cent.

This gives $e = \log^{-1} 19.20176$
$= 1.591 \times 10^{-19}$ absolute coulombs.

Vinal and Bates,[2] of the Bureau of Standards give

F (Iodine) $= 96{,}515$
(Silver) $= 96{,}494$

Mean $= 96{,}505$ international coulombs.

They have determined the absolute coulomb as being .004 per cent. greater than the international coulomb, and recommend the value in absolute coulombs,

$$F = 96{,}500$$

The maximum error is .01 per cent.

From the above

$$m = e/F = \log^{-1} 24.21723$$
$$= 1.649 \times 10^{-24} \text{ gms.}$$

The density of NaCl is given by Zehnder (1886) as 2.188, by Retgers (1890) as 1.167, by Krickmeyer (1896) as 2.174 and by Gossner (1904) as 2.173. Gossner's work[3] seems to have been done with special care. He measured eleven artificial crystals of NaCl, obtaining densities ranging from 2.171 to 2.175. His measurements on natural crystals gave 2.173. Taking these results in connection with those of Krickmeyer, we may assign to NaCl a density of $2.173 \pm .002$, thus giving a maximum

[1] R. A. Millikan, "A new determination of *E*, *N*, and related constants," *Phil. Mag.*, *34*, 1917.

[2] G. W. Vinal and S. J. Bates, "Comparison of the silver and iodine voltameters, and the determination of the value of the Faraday," *Bull. Bureau of Standards, 10*, 425, 1914.

[3] B. Gossner, "Untersuchung polymorpher Körper," *Zeit. f. Kryst.*, *38*, 132, 1904