The Geologic Systems

Preston E. Cloud, Jr.

The growing wealth of isotopic (or radiometric) ages for rocks older and younger than those as yet generally dateable by fossils has quickened interest in the Precambrian and the Quaternary throughout the world. Interscience Publishers proposes to meet the need for a modern summary of these contrasting divisions by a series of books, *The Geologic Systems*, beginning with nine announced volumes on the Precambrian and five on the Quaternary.

The Precambrian [Interscience (Wiley), New York, 1963. 303 pp. Illus. $8.95], volume 1, edited by Kalervo Rankama, is the first of the series to appear. It deals with the Fennoscandian or Baltic shield, often taken as a paradigm for the Precambrian shield areas of the world. Its distinguished contributors have provided very useful condensations, in English, of the scattered, multilingual, technical literature dealing with Fennoscandian geology.

The demonstration of the great antiquity of the earth and the gradual unfolding of its long Precambrian history is put into perspective as the great intellectual achievement that it is in a sparkling introduction by Arthur Holmes (pp. xi-xxiv). Once the significance of radioactivity was grasped, what had seemed mere folly became reasonable inference. Almost simultaneously, R. J. Strutt in England (1906) and B. B. Boltwood in the United States (1907) began to follow up on Rutherford's suggestion (1903) that the ratio of radiogenic end products to mother elements could be used as a measure of time elapsed. Pleochroic haloes around radioactive particles in biotite were found by Joly to have radii corresponding to the ranges of alpha particles responsible for them, thus providing geological assurance that the rate of radioactive disintegration is invariable. So began the geochronological revolution, whose present precision and built-in checking system became possible with A. O. C. Nier's epoch-making researches, in the late 1930's, on the isotopic composition of uranium and lead. As a result we now know that there are terrestrial rocks more than 3.6 billion (3.6×10^9) years old, and that the solar system and probably the earth is around 4.6 to 5 billion years. There have been many lesser surprises. Rocks once thought to be very young Precambrian are turning out to be very old, and others have interchanged position. The whole Precambrian edifice is being restructured and vastly expanded; the greatest advances are yet to be made.

Four descriptive chapters of disparate length and structure delve into the details of the Precambrian record for Fennoscandia: 25 pages on Denmark by Arne Noe-Nygaard; 54 on Norway by T. F. W. Barth and P. H. Reitan; 63 on Sweden by Per Geijer; and 119 on Finland by Pentti Eskola.

Except for a few borehole records, the Precambrian of Denmark is all found on Bornholm Island, as isolated horst-extension in the Baltic Sea to the south of Sweden, where metasediments, granitic rocks, and ultrabasic dikes, in that inferred sequence, occur beneath 260 meters or so of Cambrian and Eocambrian sediments. No age determinations are given, however, and the only evident reason for a separate chapter is jurisdictional.

Norway is divided into northern and southern parts for discussion. Age determinations available for the Precambrian rocks of southern Norway, according to Barth and Reitan, run around 0.8 to 1.1 billion years. These rocks are believed to comprise a related complex, involving an interval of granitization and tectonism, pervasive metamorphism, volcanism, and igneous invasion, followed by erosion. No mention is made here of the widespread Eocambrian "Sparagmite" formation or series, of southern Norway, although its Swedish correlatives are discussed later (pp. 134 and 135). Granitization is widespread. Some postorogenic granites are diapir-like. Temperature of metamorphism is estimated as 300° to 660°C, although higher figures have been published by others. Metalliferous deposits are common, and of persisting economic importance in the Kongsberg-Bamble (iron, titanium, and nickel) and Arendal (iron) districts.

The Precambrian of northern Norway is divided on stratigraphic and petrologic grounds into three main subdivisions, for no isotopic ages are available despite the potential economic significance of the region and the progress in dating here emphasized. All units, however, are believed to be pre-Karelian or Karelian, and that is dated as more than 1.8 billion years in Finland. Main subdivisions for northern Norway then become: (i) Karelian supracrustals, mainly metasediments with greenstones, spilites, and other volcanics; (ii) pre-Karelian plutonic basement rocks; and (iii) granulites of the eastern facies.

The Swedish Precambrian also is classified under three main subdivisions by Geijer. The oldest is classed as Archean, consisting mainly of Svecofennian and possibly equivalent Karelian metasediments, granites, greenstone dikes, and migmatites, as well as Gothian granites and metasediments and pre-Gothian gneisses. Dates on the Svecofennian and Karelian are in the range of 1.7 to 1.8 billion years. Above is the post-Archean, represented mainly by the rather widespread, reddish, Jotnian orthoquartzites, with associated other clastic sediments and basic effusive rocks, as well as sub-Jotnian crystallines, including the rapakivi granites. The latter give potassium-argon ages of 1.5 to 1.6 billion years. Clear at the top are the Eocambrian Varegian and Sparagmite "formations." The Jotnian is of special interest because of its similarity to the Keweenawan sequence of North America and the well-preserved sedimentary features that imply origin in shallow, partly or wholly nonmarine waters under conditions of seasonal rainfull variation and subaerial oxidation. Another sediment of interest in the intensifying effort to reconstruct Precambrian environments is the Grythyttan graphitic slate of early Svecofennian age, containing carbon and apatite of possible organic origin in quartz nodules.

Eskola's chapter on Finland is twice

The reviewer is a professor in the Department of Geology and Geophysics at the University of Minnesota.

as long as the chapter on Sweden and almost as long as the rest of the book. It also tends to intersperse within the main narrative sections of primarily local or historical interest. It is only in Finland, however, and mainly owing to the work of American and Russian geochronologists, that a sufficient number of radiometric ages are available to warrant the *raison d'être* offered for this book. Most of the dates based on rubidium-strontium or potassium-argon ratios cluster around 1.7 to 1.9 billion years, indicating a metamorphic event that reset the biotite clock throughout the Svecofennian and Karelian terranes. Lead-uranium and lead-lead ages give a greater spread, from 2.8 to 1.8 billion years. Russian geochronologists recognize three intervals of sedimentation, metamorphism, and magmatism in the Svecofennian and older rocks: (i) Katarchean, 3.6 to 2.8 billion years ago; (ii) Lower Archean, 2.7 to 2.2 billion years ago; and (iii) Upper Archean, 2.1 to 1.6 billion years ago. Post-Svecofennian rocks include the rapakivi-type of granites, 1.6 billion years old, and the (pre-sparagmitic) Jotnian sediments, 1.3 billion years old, including red quartz-sandstones. Above these are only Pleistocene sediments, except for sandstone "dikes" from one of which is reported a Cambrian brachiopod. A useful feature of this chapter is the chemical analyses of rocks, given as an appendix. Among other things this substantiates the contention, made at several places, that some of the very old Jatulian, Kalevian, and other orthoquartzites are indeed very pure quartz sediments.

Scattered through the book is considerable discussion of granites and granitization, the not-surprising concensus of which is that there are both magmatic and metamorphic granites—the magmatic mainly primorogenic or anorogenic, the granitized often migmatitic. Noe-Nygaard considers all of the Bornholm granites to result from granitization. The others see a range of types. Eskola presents the rapakivi granites as a classic example of a magmatic, anorogenic granite.

Although mention is made of various metals and ore deposits, economic geology is not stressed in this volume. One point of interest was the use of electromagnetic prospecting to locate copper deposits and graphitic zones beneath the Pleistocene cover.

The promised series will be a welcome one, for all the reasons so aptly summarized by Holmes. This first volume, however, is premature, in the sense that the numbers here cited are insufficient to meet in a really meaningful way Rankama's stated central aim—to "emphasize the classification, subdivision, and correlation of the Precambrian on the basis of exact ages" (p. vi). Future volumes would profit from a better balanced treatment of individual regions, a subordination of geographic boundaries, and a higher degree of focusing on the stated objectives. A treatise of this type also deserves bigger and better maps and a more comprehensive index.

Biochemistry

The Proteins. Composition, structure, and function. vol. 1. Hans Neurath, Ed. Academic Press, New York, ed. 2, 1963. xiv + 655 pp. Illus. $22.

The welcome appearance of the second edition of *The Proteins* comes after a decade of unprecedented advances in the elucidation of the amino acid sequence and the three-dimensional structure of proteins. As the subtitle implies, the purpose is to relate the composition and structure of proteins to their function. This is the first of four volumes planned; it deals largely with experimental methods for amino acid analysis, peptide synthesis, and sequence analysis, and with the intramolecular bonds of proteins. Later volumes will cover the interactions and properties of proteins as macromolecules, their tertiary structure, and the characterization of protein systems of biological interest. Throughout, the focus will be on the interrelationship of the molecular structure and specific activity of proteins.

Although this is a multiauthored treatise, the content has been carefully selected and is well integrated. As evidence of the new viewpoint, none of the contributors to the first edition are represented in this volume with the exception of G. R. Tristram, who (together with R. H. Smith) has updated the tabular summary of the amino acid composition of proteins.

The first chapter, by Albert Light and Emil L. Smith, critically reviews methods of amino acid analysis, emphasizing preferred procedures and singling out special problems. The outstanding chapter by Klaus Hofman and P. G. Katsoyannis begins with an extensive critique of the methods and conceptual approaches to peptide synthesis; this is followed by examples of the synthesis and selective substitution of biologically active polypeptides to delineate the relationship of sequence and function. In an excellent chapter, R. E. Canfield and C. B. Anfinsen outline concepts and experimental approaches to the determination of the primary structure of proteins. Thereafter, intramolecular bonds are treated extensively, first from the chemical viewpoint by R. Cecil, who considers the role of sulfur in proteins, and then from the thermodynamic point of view by H. Scheraga, who evaluates the controversial subject of noncovalent bonds. The biological problems posed by the complexities of protein structure are presented in a historical review of protein synthesis by J. S. Fruton, who emphasizes the chemical aspects rather than the coding mechanism. Although extensive tables and many line drawings and formulas are included, pictorial illustration is sparse; only one colored and three halftone figures are included, and the structural formulas of proteins are set in too small type. This economy is more than compensated for by the wealth of material and the excellence of its presentation. Though wholly new in conception and execution, the second edition is a worthy successor to the first edition of this classic treatise. Because of its unified, critical, comprehensive approach, *The Proteins* will long provide invaluable stimulus and authoritative opinion in the rapidly developing field of protein structure.

FRANK W. PUTNAM
Department of Biochemistry, University of Florida, Gainesville

Ion Propulsion Systems

Ion Propulsion for Space Flight. Ernst Stuhlinger. McGraw-Hill, New York, 1964. xviii + 373 pp. Illus. $17.50.

In this book Ernst Stuhlinger shows that electrostatic or ion propulsion systems can be practical for use in the vacuum of outer space for vehicle accelerations of the order of 1 mm/sec^2, and propulsion periods of months or years. Such vehicles will accommodate payloads of 40 to 50 percent on flights to nearer planets, and