tions have occupied stratigraphers for more than a century. Almost from the beginning, even before radioactivity was discovered, there was a great urge to put numbers on the stratigraphic table and thereby to endow the table with meaning in absolute time. The task turns out to be most difficult, but that has not damped the enthusiasm. Few things in geology are read so avidly as a paper on the time scale, and "Time Scale" on the program of a geologic meeting is sure to pack any hall. These must have been the thoughts that prompted the Geological Society of London to organize the symposium on the Phanerozoic time scale.

Its product is an impressive-looking, handsomely printed book, consisting of a foreword, 22 articles, and a long list of data. Among the papers, I found a scholarly review of the history of the time-scale concept by L. R. Wager, a concise summary of the rubidium-strontium method of age determination by Stephen Moorbath, and a calmly incisive analysis of the problems of potassium-argon dating of sedimentary rocks by Halfdan Baadsgaard and M. H. Dodson. In a group of stratigraphic papers, B. M. Funnell gives a detailed chronology for the Tertiary period, E. H. Francis and A. W. Woodland present fresh conclusions relating to the Carboniferous period, and H. B. Whittington and Alwyn Williams critically reexamine the definition of the Ordovician period. The rest of the stratigraphers either admit that the information at their disposal is inadequate or struggle on without saying it.

Almost half the book (193 pages) is devoted to an annotated list of nuclear age determinations which the editors deemed pertinent to the time scale. It is love's labor lost. The list is arranged in "the order in which the original abstracts were received by the editors," which makes the first few items Devonian, then some Permian, followed by Triassic, Paleocene, Permian again, and so on. Included is a profusion of now discredited interpretations, such as the uranium-lead "ages" of Colorado pitchblendes, the Swedish kolm, and the Chattanooga shale; potassium-argon results on sylvite, old glauconite, and illite; and even the ill-fated single-shot lead-alpha "age" of the Martinsburg bentonite. Apparently the editors overlooked the basic lead-alpha paper by H. Rose and T. W. Stern (*American Mineralogist*, 1960) and chose to disregard the good advice given by Baadsgaard, Dodson, and Moorbath in this very volume. The data, and in fact the whole book, are steeped in a jumble of multiple decay constants. In an effort to cope with the chaos, the editors invented a complex symbology which only furthers the muddle.

Owing to the magic of its title, the book is likely to sell to a large market, and many geologists will have the satisfaction of finding in it numbers that suit them. In that sense it is a contribution, if only to comfort. To those who join me in my long-standing admiration for Arthur Holmes, I would suggest reading his newly rewritten *Principles of Physical Geology* (Nelson, London, 1964). It is a masterpiece of geologic writing.

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Radioactive Isotopes

Radiotracer Methodology in Biological Science. C. H. Wang and David L. Willis. Prentice-Hall, Englewood Cliffs, N.J., 1965. xviii + 382 pp. Illus. $16.

The vast accumulation of knowledge in the biological sciences during the past two decades has been made possible, in large measure, by the availability of radioactive isotopes. Although various aspects of radiotracer technique have been treated in textbooks, review articles, and symposia, no single volume has treated all facets of this powerful research tool. The need for such a work has now been fulfilled by Wang and Willis in their book *Radiotracer Methodology in Biological Science.*

The work owes its quality, in no small degree, to the special training that each author has had; Wang has long been active in the field of tracer methods and Willis in vertebrate biology, appropriate ingredients for a treatise of this kind.

For a scientific text, this book is unusually well written; by the use of well-chosen words and a style that is compact and clear, the authors have avoided the dull repetitiousness often encountered in scientific publications. The scope of subject is especially wide, and it is treated in great depth. A section is devoted to theoretical principles of radioactivity, another to description and theory of all practicable methods of measurement with most emphasis appropriately on liquid scintillation counting, statistical analysis of counting data, health hazards in the handling of radioisotopes, radiotracer laboratory design, experiments in radiotracer techniques, and other useful information. Each chapter is well documented with abundant bibliography, and, where applicable, chapter material is illustrated with mathematical problems.

One application of liquid scintillation counting of which no mention could be found, possibly owing to its late advent in the literature, is the use of Čerenkov radiation in measuring high-energy nuclides such as sodium-24 and phosphorus-32 where aqueous systems can be counted without contamination by fluor.

Although the book is generally well organized, the inclusion of operational directions for various counting systems in the experimental chapters seems arbitrary because such manipulation is not actually experimental. Similarly, the statistical experiment could have been combined with analysis of data.

Except for a single miscaptioned figure (6–7), the format is excellent. A statement to the contrary notwithstanding, the old style of isotope designation with superscript following symbol persists in several diagrams.

The overall impression that I gained from reading this book is that the biological scientist at any level of training and experience has at hand, in this volume, a valuable and an essentially completely up-to-date source of information in radiotracer methodology.

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Geologic History

Geological History of Western Canada. R. G. McCrossan, R. P. Glaister, Grey H. Austin, and S. J. Nelson, Eds. Alberta Society of Petroleum Geologists, Calgary, Canada, 1965. x + 232 pp. Illus. $25.

This book is a magnificent cooperative achievement. Forty-four authors —mostly from oil companies but including a number of contributors from universities, the Geological Survey of Canada, the research councils of Alberta and Saskatchewan, and independent geologists—have cooperated to

produce a remarkably well-balanced summary of what is known of the geology of western Canada. The area considered extends from the edge of the Precambrian of the Canadian Shield to the Pacific, and from below the International Border to the 61st Parallel, more than a million square miles. As the editors remark, ". . . this project demonstrates to the full the value of a technical society. It shows that such a group can coordinate the resources of industry, universities and government to carry out projects whose magnitude would make them impractical or impossible for any single organization." Half a dozen governmental agencies supplied direct financial support, and 21 different groups furnished assistance with the tremendous task of drafting. The editors deserve great credit for maintaining remarkably uniform standards of treatment with so many, and such diverse, cooperating groups.

The book presents a summary, period by period, of the history of this huge area, as far as it had been deciphered to about the close of 1962. (There are a few references to later work.) Each system is treated uniformly, in much the same manner as in the *Paleotectonic Map Series* of the U.S. Geological Survey, with a paleogeologic map, lithofacies maps of the recognizable stratigraphic intervals, isopachs, cross-sections showing onlaps and offlaps, many graphic logs, and finally, analytical and interpretive summaries of depositional and orogenic history and paleogeography. Colored maps, mostly on a scale of 1 : 5,000,000, have been profusely used. Many of the 217 numbered illustrations are multiple, and some have as many as four separate parts; there must be well over 500 separate drawings in the book. Their quality, and that of the map reproduction, is excellent.

The Tertiary and Quaternary, being of relatively slight economic importance, are not given as detailed treatment as most of the other subdivisions; nevertheless both sections include much new information in useful summary. The remainder of the geologic column is handled in a remarkably uniform way, considering the very large number of contributors and the variable amounts of information available. Naturally the systems with the greatest proved economic importance have been penetrated by the most wells and are therefore best known in detail. The discussions of the Upper Devonian, Triassic, and Cretaceous units are thus especially noteworthy, but it must be emphasized that all the units are very well summarized.

In addition to consideration of the more usual geologic features, there is an excellent discussion of formation fluids in the Plains area: petroleum, natural gas, and formation waters. Brian Hitchon, of the Alberta Research Council, has summarized the results of nearly 20,000 analyses in a series of most informative graphs. It is clear that much geologic information can be wrung from such analyses.

This work is an outstanding contribution to an understanding of the geologic history of the North American continent, and it will be quoted for many years. Few, if any, geological organizations south of the 49th Parallel have the capacity to carry through so complex and ambitious a program. The Alberta Society of Petroleum Geologists, and all who were concerned with this project, have placed the entire geologic profession in their debt.

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Survey and Review

Concepts in Quantum Mechanics. F. A. Kaempffer. Academic Press, New York, 1965. xvi + 358 pp. Illus. $9.75.

The multiplicity of available texts on quantum mechanics causes one to ask whether an additional one would be of value. In this case, however, the answer is in the affirmative due to the author's novel and desirable approach to his subject matter, combined with a very refreshing mode of presentation. First, quantum mechanics is presented in a deductive fashion where, as the book title suggests, emphasis is on the formal conceptual structure of the subject. Dirac notation is introduced at the very beginning, and the first six sections are essentially a lucid treatment of the theory of measurement in quantum mechanics. Sections 7 through 15 consider the dynamical aspects of the theory, the topics covered being those traditionally associated with a first-year graduate course in quantum mechanics. They include the Heisenberg, Schroedinger, and interaction pictures; uncertainty principle; invariance principles; and conservation laws. The theory of photons and electrons is introduced in sections 16 through 19 where boson states, fermion states, and the Dirac theory of the electron are presented. This serves as a basis for the second half of the book, which treats more advanced topics. Quantum electrodynamics provides an opportunity for the introduction of Feynman graphs, followed by a treatment of perturbation theory and propagators, selection rules, parity, and permutation symmetry. The book concludes with topical sections on strong interactions and on quasi particles.

The fact that there are 30 sections in this 350-page book gives a hint about the author's style. Each section is written in a terse, forthright manner, with mathematical formalism taking precedence over elaborate discussion. Applications of the theory to concrete problems are few, and examples are chosen to illustrate the theory only where deemed necessary. In spirit the book appears to parallel some parts of Messiah's text. Messiah, however, is more discursive, and Kaempffer's text has the advantage of a more direct and concentrated approach to many important elements of quantum mechanics which are found distributed throughout Messiah's two volumes. This is not to say, however, that this book merely parrots portions of Messiah. Although his text is not as extensive as that by Messiah, the author presents quantum mechanics in such a way that the mathematical structure and useful concepts of the theory appear in sharp relief, and he also treats some topics not found in Messiah, for example, superfluidity.

This book would be excellent for use in graduate courses on quantum mechanics, if a supplementary text such as that by Landau and Lifshitz be used to supply, among other things, supporting application of the theory. For those who are familiar with one or more of the practical applications of quantum mechanics, this book provides a very readable survey and review of basic principles.

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