of physical properties. Bridgman was constantly concerned with the theoretical meaning of the properties that he had been studying. There are a good many papers on the theoretical implications of what he had found, going back as far as his paper in the *Reviews of Modern Physics* in 1935, "Theoretically interesting aspects of high pressure phenomena," and extending on to much later papers. These general review articles would amply repay study by any young theorist of the solid state; we are very far from having explained all the phenomena Bridgman felt were interesting and significant.

By the time we get to the last volume, we are coming to topics of recent interest. We come to the very high-pressure range, where the pressure was not purely hydrostatic (for there are no liquids that remain liquid at these extreme pressures), and therefore where it is much harder to estimate the pressure, but where nevertheless many interesting phenomena appear. We come to papers on such popularly interesting topics as synthetic diamonds, in which Bridgman made some of the early steps. We learn that he made measurements on the compressibility and phase transitions of plutonium during the wartime Manhattan District, though the results could not be reported until much later. But also we follow up to his last years additional measurements on less exciting topics, but nonetheless topics on which he had been working for many years.

The concluding paper was not intended for this volume by Professor Bridgman. It was his introductory essay, "General outlook on the field of high-pressure research," for the book *Solids Under Pressure*, edited by W. Paul and D. M. Warschauer, two of his former students, and published by McGraw-Hill in 1963. That book is a monograph on high pressure, mostly written by other workers. It is an eloquent demonstration of the fact that after a career of more than 50 years, Bridgman's field of high pressure has at last ceased to be a one-man show, and has come to represent a technique so familiar that now many laboratories are equipped to reach pressures that even Bridgman, early in his career, would have regarded as impossible. It is now a valuable and established field of physics, one for which Bridgman received his Nobel prize, and a field that in all probability would not soon have reached anything like its present mature state if this uniquely able, ingenious, and persistent man had not built it up.

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Paleoclimatology: Controversy, Chaos, and Confrontation

Paleoclimatology today is a snipe hunt, and one is very likely to find himself holding the bag, wondering where all the continents went. At the moment, it is also chaos, as any system without constraints must be, and one is reminded of the traffic jam that results when the red light on the street corner fails to function. The traffic problems caused by drifting continents have seldom been more evident than in **Problems in Paleoclimatology** [Interscience (Wiley), New York, 1965. 705 pp. $18], for though there is far more to paleoclimatology than continental drift, that fact is, in this volume, frequently brushed aside by a wandering pole.

The strong slant of the volume is no failing of its editor, A. E. M. Nairn, who, despite the handicap of extremely heterogenous subject matter, has succeeded in introducing a measure of order. Rather it was inherent in the symposium whose proceedings this book contains. Perhaps it was inevitable because of the necessity of fixing some physical configuration of the continents, ocean basins, and poles before real progress can be expected in paleoclimatology and because the symposium was held in Newcastle-upon-Tyne, the home port of many a drifting continent. In any case, the bias, once recognized, in no way impairs the utility of the volume and, in fact, lends interest for, after all, what is more interesting than the controversial?

Perhaps—and this is a serious problem—the existing chaos in paleoclimatology has come about because the field lacks tangible form. There is no such thing as paleoclimatology in its own right. Almost no one professes to be a paleoclimatologist, though many excellent geologists, biologists, meteorologists, chemists, and physicists profess an interest. Scientists who work in the field often do so on an occasional basis and commonly as a by-product of some other interest. The result is both the strength and the weakness of the subject: strength because paleoclimatology interacts with and draws from such a diversity of flanking disciplines; weakness because few of its practitioners can comprehend its whole structure and because few critical studies designed to solve uniquely paleoclimatic problems are ever made.

Despite shortcomings that this book inevitably shares with many a symposium volume, it carries an underlying tone of excitement. It is, I think, the excitement of an area of science beginning to recognize that it is a focal point for investigators in many fields. A great value of the NATO Paleoclimate Symposium and of this book is that both brought together the ideas of students working in many fields. As a result, one's imagination is stimulated, and one's admiration aroused, by the diverse and clever means by which paleoclimatic problems can be approached. The price paid for this benefit is that few will be able to read the entire book with full

comprehension (and I am among those who cannot). Its pages contain more than 50 papers reporting the results of detailed investigations that include topics as diverse as geological field studies, the physical chemistry of evaporating brines, mathematical treatment of the physical background of climate, discussions of the physiology of fossil animals, details of clay mineralogy, and a host of other subjects. To minimize the problems thus created, the editor has prepared and placed at the beginning of each chapter a statement outlining that chapter's scope. In addition, many chapters contain one or more papers that are essentially general reviews.

Although this volume ranges over a vast spectrum of topics, it contains, for this very reason, something of interest to almost everyone concerned with the "problems in paleoclimatology." In an introductory chapter, the late Walter Bucher speaks not merely of controversy but of confrontation. He regards the related problems of continental drift and polar wandering as representing a confrontation between geology and geophysics, likely to be ultimately resolved by paleoclimatic data. Although the confrontation is perhaps more directly between continental drift and continental stability than between geology and geophysics, Bucher is probably right. As parts of this book make clear, seeds of this confrontation are already germinating. At the moment, however, it is chaos, not confrontation, that seems to pervade paleoclimatology.

With the tone of the volume set, it proceeds through a series of topical chapters, each consisting of several papers that often exhibit broad variations in approach, philosophy, and significance. Although a sense of excitement, new techniques, critical evaluation of evidence, and an increasingly quantitative approach are often in evidence in *Problems in Paleoclimatology*, these characteristics do not pervade all areas equally. One chapter, "The use of fossil plants in paleoclimatic interpretation," suggests in some degree all of these qualities. By contrast, the following one, "Evidence of climate from coal and coal measures," indicates that the subject is little better understood than it was a decade (or perhaps many decades) ago. And more distressing still is the fact that no paper seems really to point toward an approach likely to prove fruitful.

The chapter entitled "The recognition of ancient glaciation" seems not so much to tell us how glaciation may be recognized as to suggest, by an admonition in almost every paper, that usually it can not be recognized. Insensitive to this warning, the succeeding chapter, "Precambrian glaciation," perhaps comes as close as any to revealing the turmoil in which the field of paleoclimatology finds itself at the present time. Here two papers report studies of the Precambrian "glacial" beds of Normandy, and although Dangeard finds them glacial, Winterer does not. The nonglacial interpretation seems clearly to come away the winner, but the lack of a significant number of really definitive criteria is painfully evident.

These chapters cause one almost to want to see the ice before accepting an ancient glacial, and at the least they leave one with a most suspicious outlook. Yet these very chapters contain discussion of Infra-Cambrian "glacial" beds considered sufficiently distinctive to warrant a suggestion that the entire earth underwent glaciation at this time. Since Montana's famous Belt Series, long cherished as a classical Infra-Cambrian sequence, has bowed before the geochronologists magic wand and admitted to a venerable 1200 million years (Gulbrandson and others, 1963), one wonders just how precisely Infra-Cambrian deposits can be placed in a time sequence by the methods of physical stratigraphy alone. One becomes extremely reluctant to accept as more than speculation the suggestion put forward by Harland that questionable "glacial" deposits of uncertain age represent a distinctive climatic event servicable in correlation and subdivision of the Late Precambrian.

Problems in Paleoclimatology includes occasional flights into the realms of speculation, but it includes as well its share of scholarly, well-conceived, cleverly executed, and sometimes highly imaginative studies. One of the best of these, a masterful paleoecologic study by Lowenstam, is hidden for some reason in a chapter entitled "Geophysical techniques and ancient climates." Here, at last, we come to grips with paleoclimatology and feel its promise for the future as the reality of a glacial-interglacial sequence is demonstrated by paleotemperature measurements made on marine beds from Western Australia. This positive step forward is balanced by the chapter "Devonian climate" in which the evidence of climate, whether paleontologic or paleomagnetic, seems inconclusive.

But this, too, is offset by Lamb, who, in the chapter "Theoretical considerations and quaternary climates," provides us with a skillfully interwoven tapestry of climatic events that have affected man and the course of his affairs during the last few millennia.

A serious difficulty, repeatedly evident in the papers that comprise *Problems in Paleoclimatology*, is a failure to develop, or at least to apply, a suitable "Recent model" which would permit interpretation of past events. In the chapter "Recognition of arid climates and wind direction studies" for instance, McKee pleads for the fuller understanding of Recent dunes and their structures, which might permit interpretation of ancient analogs. Several subsequent papers ignore this plea and not only indicate the prevailing directions of ancient winds but are occasionally willing, as well, to shift continents on the basis of such evidence.

An inquiry into the possible utility of carbonates and evaporites (chapter 10) is generally disappointing in its failure to reduce the suggestive distributions of these special sediments to a quantitative scheme applicable to paleoclimatic study. Richter-Bernburg, however, suggests an appealing method of searching for evidence of short-term climatic cycles in widely distributed, varved evaporite deposits.

The type of uncompromising confrontation that Bucher visualized between a paleomagnetic model of the earth and a present-day model develops in a chapter "Permian climate." A group of three papers makes clear the very basic nature of the confrontation. A paper by Nairn (a contributor as well as the editor) develops the paleomagnetic evidence, which seems to require both continental drift and polar wandering, and favors a Permian north polar position in the vicinity of 40° to 45° North. In another paper, Stehli shows that a surface mathematically fitted to the diversity gradient of two groups of Permian marine invertebrates requires a north pole at or very near its present position and will not allow large-scale continental drift across lines of latitude. A third paper, by Helsley and Stehli, points out that both lines of evidence seem to be internally consistant and that disagreement may in-

dicate that the presently favored model for the earth's magnetic field as an axial dipole may require review.

The final chapters of this volume are "Paleontology and climate" and "Problems of sediments and soils." In the former, Teichert interjects a timely note of warning by suggesting that distribution patterns of fossils and of sediments can as well represent the circumstances of control as any real pattern. And in the latter, red beds are subjected to yet another review in which Van Houten seems to find little real promise that these sediments can provide unequivocal indications of any special climatic regimen.

Problems in Paleoclimatology suggests that the principal problems of the field are occasioned by emergence from uncomfortable adolescence. This is an emergence in which the whole scientific community may take heart, for it will lead to substantial advances. Certainly, as human population increases, the importance of long range planning will increase and the significance of learning enough to predict and possibly someday to modify the intensity, direction, and rate of climatic change is evident. *Problems in Paleoclimatology* tells us of the ground that we have so far traversed, of the chaos in which we are presently ensnared, and occasionally points hopefully to a direction we may take in order to achieve real advances in our knowledge of climate and climatic change.

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Techniques in Organic Chemistry

Applications of NMR Spectroscopy in Organic Chemistry: Illustrations from the Steroid Field. Norman S. Bhacca and Dudley H. Williams. Holden-Day, San Francisco, 1964. x + 198 pp. Illus. $7.95.

A major reason for the recent rapid development in organic chemistry has been the availability of instrumental techniques for structure determination, analysis, and similar purposes. Twenty years ago commercial ultraviolet spectrometers completely changed the way in which chemists studied unsaturated compounds. Fifteen years ago infrared spectroscopy changed the approach to qualitative functional group analysis, and 10 years ago nuclear magnetic resonance (NMR) spectroscopy made it possible to study the chemical environment of protons in organic compounds.

Several books dealing with NMR spectroscopy have appeared during the last 10 years, but none of them are really satisfactory in guiding the chemist to make maximum use of this technique or in illustrating the wealth of information that may be obtained from a detailed consideration of the spectrum of a given compound. The present volume is successful on both scores, and is recommended for all but the most experienced among NMR spectroscopists.

The authors have chosen to use the spectra of steroids to illustrate the approach that may be used. At first, this may seem strange because the spectra of these compounds are often very complex. However, as the authors point out, the steroids have relatively fixed conformations, permit functional groups to be placed in a variety of positions with respect to a given proton, and are readily available with a variety of substituents. The authors begin with a discussion of the relatively simple bands that result from angular methyl groups and illustrations of the effect of the environment of the methyl groups on its chemical shift. Methylene and olefinic protons, which add the complexity of spin-spin coupling between protons, are considered. The treatment of extra complications that arise from long-range spin-spin coupling precedes an excellent discussion on the use of NMR spectroscopy on the determination of configuration and conformation. The last chapter is concerned with solvent effects.

Throughout, the book contains useful illustrative spectra and many tables that summarize important data concerning chemical shifts, coupling constants, and their relation to structure. This appears to be a very useful, well-organized, and well-written book. It cannot illustrate all of the potential applications of NMR spectroscopy to organic chemistry, but it does well in covering those related to structure determination.

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General Relativity

Introduction to General Relativity. Ronald Adler, Maurice Bazin, and Menahem Schiffer. McGraw-Hill, New York, 1965. xvi + 451 pp. Illus. $12.50.

The Theoretical Significance of Experimental Relativity. R. H. Dicke. Gordon and Breach, New York, 1964. xii + 153 pp. Illus. Paper, $1.95; cloth, $4.95.

For more than 20 years, Bergmann's textbook has remained (in my opinion) the most readable and balanced introduction to general relativity. This has been true partly because the foundations of the subject have changed so little, partly because Bergmann's breadth of view could accommodate the shift of areas of research since 1942. Most recent books have seemed too personal, or too advanced, to be useful as beginner's textbooks for senior or graduate physics students. Owing to its catholic content and its attention to pedagogical details, *Introduction to General Relativity*, by Adler, Bazin, and Schiffer, is, I feel, the likeliest to supersede Bergmann. It is based upon a lecture course given at Stanford University by Schiffer. In addition to standard treatments of Riemannian geometry, the field equations, the Schwarzschild solution, gravitational fields in hydrodynamic and electromagnetic media, and implications for cosmology, there are excellent accounts of recent work on the Cauchy problem and Rainich theory. I should also mention the admirably clear chapters on conservation laws and the linearized equations.

It is a pity that the authors were reluctant to use 20th-century mathematics. It would be helpful to be told just what tangent spaces or differential forms are, because such terms are occasionally used here. Curiously, they offer as explanation their desire not to prejudge future theoretical developments. The authors also confess misgivings (and well they might!) about the inclusion of the old Lenz derivation of the Schwarzschild solution out of flat space and the equivalence principle. Apart from these minor objections, I found this book a pleasure to read, and one that can be recommended as a textbook for use in a lecture course or by those who wish to study on their own.

The Theoretical Significance of Ex-