rate of discovery of new reserves, and an assumed level of ultimately recoverable reserves. But problems with the geographic distribution of China's energy resources, limits on China's capability to absorb foreign technology and equipment, continued reluctance to allow significant foreign participation in energy development, and lack of economic incentives to raise low levels of efficiency of energy resource utilization are glossed over. These and other complex factors will be the major determinants of China's energy production and should absorb the efforts of those who wish to predict China's energy future.

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Terrestrial Processes

The Continental Crust and Its Mineral Deposits. A Volume in Honour of J. Tuzo Wilson. Proceedings of a symposium, Toronto, May 1979. D. W. STRANGWAY, Ed. Geological Association of Canada, Waterloo, 1980. viii, 806 pp., illus. $30. Geological Association of Canada Special Paper 20.

The concept of crustal mobility or "plate tectonics" opened a new era in the earth sciences by offering a single global process that could account for a remarkable range of geologic features. One landmark paper that brought together evidence from many disciplines within the geologic sciences, "Did the Atlantic close and then re-open?" (*Nature* **211**, 676 [1966]) by J. Tuzo Wilson, laid the groundwork for recognizing the effects of continental rifting and collision. As illustrated by many of the 41 papers contained in this book, Wilson's ideas on the importance of continental drift to crustal evolution have flourished in the earth sciences.

The papers in the volume are grouped into six sections. Section 1, The Early Earth, provides an informative discussion of the mechanics and thermal consequences of planetary accretion and core formation. Surprisingly lacking in this section is reference to evidence obtained from the study of other terrestrial planets, particularly the moon, where the effects of early planetary differentiation and meteorite bombardment on crustal formation are clearly displayed. The absence of these observations leads to discussions of early isotopic and tectonic evolution of the earth that are both incomplete and overly simplified.

Some of these deficiencies are remedied in section 2, Evolution of the Precambrian Crust, which vividly illustrates the diversity of opinions concerning the origin and evolution of the materials that make up the continental crust. Various papers stress the importance of "gravity" or vertical tectonics as opposed to "Wilson cycle" lateral mobility. With respect to the subject of continental "growth" and the rates thereof, estimates are presented that range from constant erosion by sediment subduction to continual growth by the addition of new, mantle-derived, sialic material. Enough pertinent data are presented that the reader may judge the strengths and weaknesses of the various arguments.

The structure of the crust is the subject of the third section. One paper discusses the intriguing observation that continental fragmentation seems to reoccur predominantly along pre-existing zones of crustal weakness. However, on the subject of crustal structure, this section contains only a single paper utilizing seismic refraction and reflection data and lacks any discussion of field evidence relating to this subject. Hence it does not give the reader a true feeling for the variable and complex structure of the continental crust.

The next section, Crustal Motions, details the evidence for, and results of, continental mobility. By the use of paleomagnetic, geochronological, and field structural data and biogeographic constraints, the various papers provide interesting and informative descriptions of a wide range of complex structural configurations interpreted as resulting from continental drift. There are also a series of papers dealing with the association of certain petrologic and metallogenic conditions with different plate tectonic environments. These discussions perhaps would fit better into the next section, The Global View, which also examines the effects of plate motions in determining the structural regimes that control magmatic and metamorphic conditions along plate boundaries.

The final section concerns itself primarily with the genesis of sulfide ore deposits. These papers give an interesting overview of ore genesis in a manner that keeps the presentations comprehensible to readers outside the field of economic geology. Again, though, this section concentrates on the origin of particular ore types and should not be considered a thorough discussion of the many mechanisms involved in ore genesis in the crust.

In summary, the papers contained in the book provide discussion of a broad range of topics from a variety of disciplines. However, by putting so little emphasis on important topics such as the crustal sedimentary record and the variable and complex nature of crustal structure and on crustal features in areas outside the Precambrian of North America, the book does not adequately represent several critical aspects of the nature and evolution of the continents. As long as the reader realizes that the volume concentrates on a rather limited region of the continents and that some of the papers present rather controversial interpretations, the volume and the comprehensive reference lists that follow each of the papers provide a good starting point for the study of various aspects of the continental crust.

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Theoretical Particle Physics

Unification of the Fundamental Particle Interactions. Proceedings of a conference, Erice, Italy, Mar. 1980. SERGIO FERRARA, JOHN ELLIS, and PETER VAN NIEUWENHUIZEN, Eds. Plenum, New York, 1980. xii, 728 pp., illus. $79.50. Ettore Majorana International Science Series (Physical Sciences), vol. 7.

The currently accepted theories of electromagnetic, weak, and strong interactions are all "gauge" theories. They view the fundamental interactions as being mediated by vector bosons (the photon, weak bosons, and gluons), which are coupled to the currents implied by the local symmetries of these theories. The general theory of relativity, which describes the gravitational interactions, has a similar mathematical form, at least classically. Since the structure of these theories is so similar, it is easy to speculate that there should exist some super theory that manifests all the known interactions in a correct and unified way. The search for that theory is more difficult. It has attracted much attention, and there has been some progress. There are theories proposed to unify electromagnetic, weak, and strong interactions that incorporate observed results in an economical fashion and predict novel effects such as proton decay and neutrino masses. The more ambitious goal of including gravity has been (so far) less successful, but there are models with gravity that appear to have a germ of truth in them. Papers discussing both of these endeavors are contained in this book; such knowledge may be necessary to carry out the search for a truly unified theory. We are in an

extremely exciting period of physics just because the answer is not yet known.

This volume contains 41 lectures given at a Europhysics Study Conference. The papers are research reports that (with a few exceptions) are not intended for the uninitiated theorist. They are of as high quality as those in any research journal; conference and workshop proceedings like this one have become a well-accepted way to communicate results in particle physics.

The book includes: discussion of theoretical and experimental aspects of proton decay and neutrino masses and the formulation of unified models of electromagnetic, weak, and strong interactions; mathematical details of the construction of supergravity theories, including several efforts to make sense out of the phenomenology and structure of "$N = 8$" supergravity; and a range of comments on the application of supersymmetry to particle physics.

There has been little effort by the editors to arrange the papers in a pedagogically helpful order. The review and summary papers are spread throughout the book, and it takes some effort to sort out the specific topics that are covered. Nevertheless, serious readers will find this a trivial shortcoming; the book is not meant to be read serially.

An elegant review, "Supersymmetry, particle physics and gravitation," by Pierre Fayet gives an overview of the applications of supersymmetry to fundamental theories. This kind of algebraic system appears to be crucial for formulating theories that unify gravity with the other interactions. Important technical background material on supersymmetry is reviewed by Bruno Zumino in "Superspace." Peter van Nieuwenhuizen in "What is supergravity and which of its goals have been reached?" provides an economical presentation of background material and an overview of supergravity theory.

Many of the papers are reports of individual research. As often happens in science before a grand synthesis is made, there are many conjectures and much technical detail to be digested. This is not an elementary book, but many papers in it discuss ideas that may have lasting worth. One paper of this type deserves special attention: "Attempts at superunification" by John Ellis, Mary K. Gaillard, Luciano Maiani, and Bruno Zumino. The particle spectrum in $N = 8$ supergravity (the most embracing theory known at present) falls short of the mark if the elementary fields are associated with the observed elementary particles. These authors propose to identify the known quarks, leptons, and vector bosons with the currents of hidden symmetries of the theory. The particles we call elementary would then actually be composites. The logic of the authors' efforts is not totally satisfying, but the paper is provocative and inspiring; already several other papers (including some in this volume) have attempted to tighten up their arguments. Before the fundamental particle interactions are unified, many more such imaginative ideas may be required.

This volume is dedicated to Joel Scherk, one of the more valued contributors in this field of research; it is certainly a fitting memorial to him.

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Paleobotany

Biostratigraphy of Fossil Plants. Successional and Paleoecological Analyses. DAVID L. DILCHER and THOMAS N. TAYLOR, Eds. Dowden, Hutchinson and Ross, Stroudsburg, Pa., 1980 (distributor, Academic Press, New York). xii, 260 pp., illus. $27.50.

Biostratigraphy, or the sequencing, separation, and correlation of rock units according to their fossil content, is essential for determining the history of evolutionary change. Unfortunately, after initial interest—and some damaging mistakes—by paleobotanical pioneers such as Lesquereux, Ward, Newberry, and White, stratigraphic paleobotany tended, until the advent of palynology, to be neglected in favor of the biologic study of specific plants or floras. This collection of nine papers is symptomatic both of reawakened interest in and of long neglect of stratigraphic concepts among megafossil paleobotanists.

From the outset, Dilcher and Taylor seem uncertain whether their book will deal with biostratigraphy, as its title promises, or with paleoecology, as its subtitle and introduction indicate. To be sure, the two are closely related, yet biostratigraphic analysis is largely antecedent to environmental inference. Inclusion of the lucid but demonstrably nonstratigraphic review of the biochemistry of plant remains by Brooks and Niklas further obscures the editors' aims. In addition, it is most unfortunate that Dilcher and Taylor choose to broaden the term "paleosuccession" to mean "progressive changes in the ecosystem." They thus confuse the shift toward vegetational equilibrium that was the basis of Clements's concept of succession with much longer-term responses of plant assemblages to climatic, evolutionary, or tectonic events.

Despite this, the chapters by Banks on the Siluro-Devonian, by Phillips on the Carboniferous, and by Schopf and Askin on the Permo-Triassic are excellent biostratigraphy and likely to become the standard references for their respective time periods. In each of them, zones are clearly defined in terms of plant assemblages or ranges of taxa based on large samples and the career-long experience of the authors, who are fully aware of distributional patterns and successional trends that act to compromise zonation schemes. In addition, Banks's summary of the sequence of appearance of important structural features such as leaves, wood, megaspores, and seeds will be of great importance in determining the onset of major competitive, productive, and reproductive strategies in the rapidly radiating land flora. The chapters by Phillips and by Schopf and Askin are masterly demonstrations of the interplay of environmental and evolutionary factors acting on floras. In his massive summary, Phillips documents the change from lycopsid to seed-fern and cordaite domination in the Late Carboniferous, and Schopf and Askin grapple with the question of diachronism in the appearance of the *Glossopteris* flora on the southern landmass after glacial retreat in the late Pennsylvanian.

The other biostratigraphic papers in the volume are disappointing in various degrees. Pfefferkorn and Gillespie offer an extensive bibliography and summary of previous literature but no details of the zonation or occurrence of specific taxa in North American Pennsylvanian strata. Ash's Upper Triassic zones seem to have a rather shallow taxonomic base, with none of the possible climatic or regional influences on plant distribution taken into account. The reader is not reassured by an added note shifting the Santa Clara Formation of Mexico from the highest to the lowest of his three zones.

The two papers forming the paleoecological component of this volume are a study in contrast. The highly quantitative evaluation by Spicer of the influence of fluid versus biotic sorting of plant megafossils in a deltaic setting points up the dangers of intuitively reconstructing vegetational patterns by simple observation in such sediments. On the other hand, Taggart and Cross's largely palynological analysis of the Miocene Succor Creek flora is seriously compromised by