mitment to the geomorphology he knows and trusts. There are recurrent references to the "true nature" of landforms and their causes. Although Davies struggles valiantly to depict thinkers of the past on their own terms, the story he tells is heavily marked as a pathway to the present. Most readers will not be distracted by this, for the more blatant forms of historical intolerance (such as Davies's reluctance to believe that Buckland accepted some of his own arguments because they were so ridiculous [p. 207]) are rare.

More subtle expressions of historical terminalism do intrude, however. Although a major theme in this book must necessarily be a search for a balanced understanding of views foreign to most of us regarding the relations of science and religion, a lack of sympathy with the tenability of such views is demonstrated in excessive use of the term "bibliolatry." The prominence of certain normative terms in Davies's lexicon leads one to suspect that he has not thoroughly digested the lesson, so well taught by the history of science, that the theoretical requirements imposed by one set of principles necessarily represent inhibitions of others.

Another observation that can be made about *The Earth in Decay* probably applies equally well to contemporary geological science as a whole. Both display an emphasis on the supreme importance of fieldwork that one is tempted to regard as justified as much by sacred tradition as by the genuine and permanent necessities of the science. One of the results of this emphasis in Davies's account is a curious tone of apology for the great theoretical leaps of a Hutton or an Agassiz, as though these leaps were somehow the less legitimate for their authors' shortcomings at times in field observation. (Hutton went out to inspect geological evidence seldom, and for the most part only in the wake of his main theoretical formulations, although with great success when he did, and Agassiz willingly set forth his ice age theory before acquiring more than a modicum of supporting evidence.) Undoubtedly some of the theoretical baggage of distinguished figures in the history of geological thought would be embarrassing to most modern scientists —Davies views Hutton's deistic and teleological commitments with some disapproval—but how can one regard such baggage as anything other than essential to the theoretical achievements of its bearers? Davies's inclination to diminish the significance of Hutton seems to me to proceed wrongly from his distaste for the metaphysical bases of Hutton's theories.

Possibly a day is coming when the historical sciences will display a more candid awareness of the theoretical foundations upon which their empirical methodologies rest. That day, if it arrives, will probably bring with it a historical understanding of the development of geomorphology that will have superseded Davies's book. In the meantime, *The Earth in Decay* stands as a work from which we can greatly profit.

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Survey of a Continent

The Geology of Western Europe. M. G. RUTTEN. Elsevier, New York, 1969. xviii, 522 pp., illus. $22.50.

In 1957–58 the author of this weighty volume—almost five pounds of book —discovered, in conducting a course on the geology of Western Europe as a visiting professor at the University of Michigan, "how scattered the literature on European geology is, and how strong, moreover, is the influence of the language barrier." Motivated by the desire to remove these obstacles for English-speaking students and colleagues and to enable geologists in the New World to become familiar with the outlook of European geologists, Rutten undertook to produce this compendium. He completed it in 1966.

As Rutten observes, "the days of E. Suess, in which a single geologist could write about *Das Antlitz der Erde* (3 vols., 1885, 1888, 1901) are over." It is no wonder that Rutten has limited his study to certain regions and problems. Iceland has been omitted because it belongs geologically to the Atlantic Ocean and the British Isles are excluded "because there exist so many reviews and guide books in English that it seemed unnecessary to rehash this information."

Rutten has something to report on most other regions of Western Europe. The discussions vary widely in length, the variations at least for some regions certainly reflecting the amount of attention given them by geologists. Nearly half the book deals with Alpine Europe. A sizable part is concerned with Hercynian Europe. Scandinavia receives a modest treatment. Rutten excuses himself from a long discussion of the lowlands and low plateaus, since "these regions have received so much interest from stratigraphers, that there are now several general accounts," including those by Gignoux, Brinkmann, and in the *Lexique Stratigraphique International.*

Tectonics and sedimentology are the subjects that come to the fore in the succession of regional summaries, with stratigraphy supplying supporting information. In conclusion of his round of discussions, Rutten presents a survey of the Cenozoic volcanics. The thumbnail sketches of different occurrences may seem too brief, but perhaps they are intended to stimulate readers to delve into the original literature.

Rutten's work is as much a study in documentation and communication as a compendium of geologic information. Surveying his references, we find that he offers almost 1000 titles in the lists that come at the end of the chapters. There are repetitions, but the net must still attest to a very intensive study of the literature. Rutten gives consideration to older key publications, but his references date preponderantly from the last two decades. Of the references cited, 39 percent are written in French, 32 percent in German, and 24 percent in English. The remaining 5 percent are mainly in Italian and Spanish. Quite naturally the predominant language of literature on the Ardennes, the Armorican Massif, the Massif Central, the French Alps, the Jura, and Lower Provence is French. Similarly, literature on the Rheinisches Schiefergebirge, the Swiss Alps, and the Austrian Alps is mainly in German. The surprisingly high percentage of English titles indicates the growing acquiescence of Western European scientists to the unwillingness of English-speaking people to cope with foreign languages.

The "scattering" of literature that Rutten found to be an obstacle to its use by Americans must refer both to the multiplicity of sources and to the difficulty of access to them. On the whole the sources, regardless of number, are not obscure. That they are lacking in many libraries in English-speaking countries is a greater problem.

At the end of the book, Rutten supplies a catalog of sources of geologic information on Western European countries. Unfortunately this catalog is marked by errors and omissions. For

example, *Geologie, Zeitschrift für angewandte Geologie*, and *Hallesches Jahrbuch für mitteldeutsche Erdgeschichte* are not West German serials but East German. The *Geologische Rundschau* is not a society, but a journal published by the Geologische Vereinigung of West Germany, which happens to be shown on the next line in the listing. The very important geological map of southwestern Germany at the scale of 1 : 600,000, revised and published in 1954 by the Geologisches Landesamt Baden-Württemberg, is not mentioned. The geological map of Austria at the scale of 1 : 500,000, prepared by Vetters and published by the Geologische Bundesanstalt in 1923 and reportedly revised in 1968, is not cited.

In his preface, Rutten includes an engaging invitation to American geologists to visit Western Europe for geological field trips and other pleasures. He speaks of road maps, guidebooks, accommodations, and cost, and ends with reassurances concerning the quality of drinking water and bottled milk.

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Thermodynamics

The Computation of Chemical Equilibria. F. VAN ZEGGEREN and S. H. STOREY. Cambridge University Press, New York, 1970. xiv, 178 pp. $8.50.

This book deals with the following problem in thermodynamics: Consider a macroscopic system of one or more phases which (i) is free of external macroscopic fields of force, of anisotropic stress, and of the effects of curvature; (ii) is at all times closed; (iii) has at all times a composition defined by the mole numbers of a set of chemical species; (iv) is at all times in thermal and hydrostatic equilibrium; and (v) is initially not in chemical equilibrium. Now let this system reach chemical equilibrium at prescribed values of temperature and pressure (or, less often, of temperature and volume), imposed of course by suitable manipulation of external conditions. The problem then is: for any particular case, defined by numerical values of the initial mole numbers and of the final temperature and pressure (or volume), compute, from appropriate data, the numerical values of the final mole numbers. The needed data consist of the standard free energies, at the final temperature, of the species involved, or equivalent information in terms of equilibrium constants. To obtain the solution from these data alone one must neglect effects of pressure upon the chemical potentials of species present in condensed phases.

Awareness of this problem goes back more than half a century, and in the early 1940's a drive to solve it efficiently began in Germany, under the goad of rocket technology. Since then, this and other needs have led to impressive growth of the subject, mostly in the United States. Today the chief applications are to propellants and rocket motors, explosives, chemical processing, and biology, as in the study of cell chemistry, of the formation in nature of organic compounds from inorganic, and so of the origin of life. In all but the simplest cases the computations are impracticable manually. Their development could therefore not have occurred without the concomitant development of computers, and the authors even suggest that the latter development owes something to the former.

The authors group the techniques now available into two main types: (i) optimization methods, and (ii) methods based on the solution of nonlinear equations. Methods of type i proceed by finding the values of the mole numbers that make the value of the Gibbs (or in the temperature-volume case, the Helmholtz) free energy a minimum. Methods of type ii usually consist in solving the mass-action equations for the individual reaction-equilibria known or assumed to subsist. The boundary between the two types is not sharp, in that for instance a procedure starting out to minimize Gibbs free energy may lead to a set of nonlinear equations needing to be solved (this case is allocated to type ii). The two types are of course logically equivalent, and the authors give a proof confirming this.

In two central chapters the methods belonging to the respective types are individually discussed. This discussion is especially valuable for its running comparison of merits and defects of the various methods. The main conclusions from this comparison are usefully summarized in a table near the end of the book (p. 156). The discussion is valuable further for its copious and knowledgeable references to the literature. There is a bibliography of 154 items, of which 106 date from 1960 or later.

In their preface the authors express the hope that the book will be useful in three ways: as a guide to the available methods, for those who have specific problems to solve; as a graduate level text, particularly for students of chemical engineering; and as a summary of the current state of the field. This reviewer believes the authors have succeeded in the first and third objectives but not in the second. The main reason for the failure is that no specific examples are worked out in the text, and no problems are given for students to work. A further reason is, regrettably, the sloppiness of a good deal of the thermodynamic discussion, especially in chapter 1, entitled "Foundations." Thus the steps leading to the formula (1.2.26) for the chemical potential of a species in an ideal gas—a formula fundamental to most of the sequel—are specious.

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Sulfur Metabolism

The Biochemistry of Inorganic Compounds of Sulphur. A. B. ROY and P. A. TRUDINGER. Cambridge University Press, New York, 1970. xvi, 400 pp., illus. $18.50.

The appearance of this book at this time insures that a similar book written ten years hence will have answers, now lacking, to many problems in the biochemistry of inorganic sulfur compounds. The book is needed and well done. What is known, and not known, of the biochemistry of inorganic sulfur compounds is presented in a lucid, accurate, and well-organized manner. The coverage of the biochemical literature within the self-defined limits of the book appears essentially complete as judged from the sections within the ken of the reviewer. For the most part the authors are content with a direct reporting of the literature, and little attempt at synthesis is made. This is understandable in light of the primitive state of knowledge of many of the areas discussed. The authors are cautious in their conclusions and gentle, perhaps sometimes too gentle, in their criticisms.

The book starts with a brief consideration of the nomenclature of sulfur-containing compounds which not only is