eral places, both as a negative value in itself and as the cause of inadvertent weather modification that has potentially adverse effects on various aspects of human activity. Thus econometric voices are added to the chorus condemning the blight that economic activity—the production of goods and services—has given rise to.

Regrettably, the book is repetitious and awkwardly written. However, to my knowledge there is no other place where one can find a comprehensive guide to the literature on the costs and losses of adverse weather elements and the possibilities of benefits accruing from intelligent use of currently available weather information and methods of weather modification and from future improved methods of forecasting and modifying the weather.

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Geology Byte by Byte

Computer Simulation in Geology. JOHN W. HARBAUGH and GRAEME BONHAM-CARTER. Wiley-Interscience, New York, 1970. xiv, 576 pp., illus. $24.95.

Today more than ever geologists feel the need to frame their conclusions in more quantitative terms. To some extent, this feeling stems from the ever-increasing amount of quantitative data being collected in geological studies, but in larger measure it reflects the growing trend toward a mechanistic approach in describing the dynamic processes that have shaped the earth's surface, past and present. This new text in quantitative geology is written by geologists for geologists. Actually, as the authors point out in the preface, simulation is not a new concept in geology. Geologists have long been engaged in formulating conceptual models for testing hypotheses concerning earth history. What is new about simulation brought on by the computer is the numerical treatment of geological data in a model framework which has enabled the geologist to portray his data and characterize his results on a scale that heretofore was not possible. Because numerical simulation has developed a methodology of its own, the authors have sought to introduce these techniques to the geologist at a level commensurate with his background.

The first two chapters of the book introduce the reader to a systems viewpoint in geology. Here the classes, uses, and construction of simulation models are discussed. The prime example of a dynamic quantitative model given, that of the study by Briggs and Pollack (1967), who interpreted the pattern of evaporite deposition during Silurian time in the Michigan basin, serves to motivate the reader to learn more about simulation techniques. The techniques are described in chapters 3 through 8, which comprise slightly more than half the book and cover a variety of mathematical methods, most of which are unfamiliar in detail to most geologists. Included are the generation of random variables, Markov chains, fluid flow and diffusion equations and their numerical solutions, control theory, and optimization methods. In each case, the concept underlying the method is introduced and the basic theory outlined briefly; this is followed by a discussion of the application of the method in different situations. In keeping with a practical approach to problem solving advocated by the authors, computer algorithms written in Fortran IV are provided. Problem sets follow each chapter.

Chapters 9 and 10 deal with the application of numerical simulation to problems in geology. Chapter 9 deals mainly with applications in sedimentation, the field of specialization of the authors. It is in this chapter that their firsthand knowledge of the use of computers in geology is most evident. Chapter 10 contains a summary of applications in simulation to other areas of geology, among them ecology, paleontology, geochemistry, petrology, structural geology, geophysics, geomorphology, and hydrology. Perhaps of greatest value in this last chapter is the bibliography given at the end of each section.

It is premature to state what importance numerical simulation will have in influencing geological thinking in the years ahead. It does seem clear, however, that as more geologists come to use computers for processing data, sooner or later they will wish to use the computer as an experimental tool. When they do, it is likely that they will turn to this book for the details.

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New Journals Received

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