books

Down-to-earth physics

Physical Processes in Geology

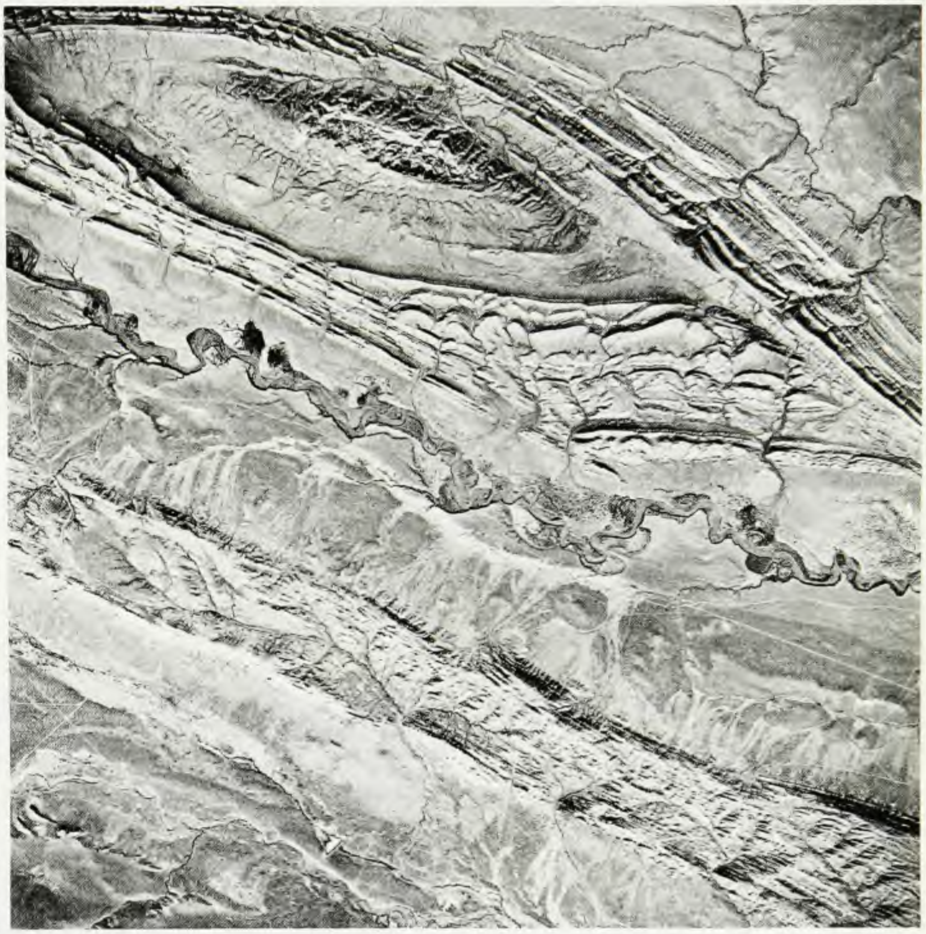
By A. Johnson
590 pp. Freeman, San Francisco. 1970. $14.75

Reviewed by Ralph O. Kehle

Exploration of the oceans during the last decade uncovered data that led to the discovery of sea-floor spreading and the formulation of theories of plate tectonics. These findings revolutionized our concept of the physical world and stimulated work in many related disciplines. Geologists in many fields abandoned their former reluctance to use quantitative models to analyze geologic problems, and were rewarded by the success of their attempts to solve many important problems. The time-worn statement that geologic problems are too complicated and natural conditions too variable to allow quantitative understanding was contradicted time and again when yet another intractable problem succumbed to analysis. Thanks to these successes, our knowledge of physical geology and the processes that shape the earth have advanced dramatically in recent years.

Similar advances may be expected in the decade to come. But the geophysicist wishing to contribute to this growth of knowledge is faced with a formidable task. Not only must he become an accomplished geologist, he must develop skills in mathematics and applied mechanics sufficient to qualify himself as an expert in these fields. Until now this commonly has been a difficult, time-consuming and inefficient process. The student or professional has had to gain these alien skills outside of geology departments. Much of what is learned is of no value in geophysics, typically because simplifying assumptions used to solve problems in other disciplines may be unacceptable in studying earth processes. On the other hand, a geologist may neglect essential topics because no informed counsel directs him otherwise. Perhaps most disheartening, the geologist rarely sees an application for these new-found skills until well after the course of study is complete.

US GEOLOGICAL SURVEY



Geology of a river basin. The strata of this Wyoming anticline were folded, and the top subsequently eroded away.

Most of these problems are solved with the publication of *Physical Processes in Geology.* The book does not diminish the difficult task of learning mathematics and applied mechanics. But it does tell the student why these skills are needed and how they may be applied in solving geophysical problems. Moreover, the book presents the mathematical and mechanics topics as skillfully as an engineering text of comparable level. These topics include a thorough introduction to strength-of-materials, the Mohr circle, the Mohr–Coulomb fracture criterion, Griffith cracks, two-dimensional theory of elasticity including strain energy solutions and polar coordinates, slow viscous flow, and the theory of plasticity.

For many potential geologic applications, the above theories are adequate; for others they are too ideal. More sophisticated theories must be employed in these cases. Consequently the reader is also provided with coverage of selected topics from continuum mechanics including visco-elasticity, power-law fluids and Bingham plastic materials. These are advanced theories requiring a substantial knowledge of applied mathematics, yet the student need only have a working knowledge of differential and integral calculus plus a cursory acquaintance with simple differential equations to make his way through the text. The additional mathematical skills needed to follow many of the examples and to work the numerous problems are developed in the text. Specifically, the reader is introduced to more advanced topics in ordinary and partial differential equations, Fourier series and the use of characteristics in solving plasticity problems. Unfortunately, the text does not emphasize that solving many geologic problems requires the use of numerical methods. The student may be led to believe that most problems can be solved analytically. This comfortable feeling will probably vanish when the student attempts to apply these methods to other, as yet unsolved, geologic problems.

Regardless of the breadth and adequacy of its coverage of mathematical and mechanics topics, this book is still primarily a geology text—one that treats many important and interesting geophysical problems. Arvid Johnson has exercised remarkable skill in selecting and organizing the geologic problems that make up the framework of the book. He begins with a study of the formation of laccoliths, then moves on to the treatment of five distinctly different folding problems, problems of fault patterns, dike patterns, and the formation of sheet structure in granite. Then follows a group of problems involving fluid flow, including the formation of debris flows and transport of boulders by debris flow, the properties of ice and lava flows and the formation of U-shaped valleys. A number of these topics represent original work by Johnson and his students, work that has not been previously reported. They are important contributions in their own right, but are overshadowed by the importance of the text as a teaching tool. Each geologic problem, once stated, requires for its solution the introduction of new, typically more sophisticated, mathematics and mechanics. Thus the reader is always motivated by a problem to acquire new analytic and conceptual skills. He is never faced with the nagging possibility that the mathematical topics have no relevance. This excellent pedagogical technique is further strengthened by the inclusion of many problems, each designed to illustrate a geologic point or to strengthen an analytic skill. In a few places, Johnson changes sign conventions without warning, and in some others typographical errors interrupt an otherwise smooth development, but regardless of these minor shortcomings, the book ought to be an excellant teaching text.

Throughout the text, Johnson suggests models to explain geologic phenomena, analyzes them and, if they are inadequate, discards them in favor of other models. He champions other workers who have solved important problems in the past and emphasizes that the reader can solve others in the future. In his closing comments he states: "The methods we have developed are applicable to a much broader class of problems—the problems of describing the physical processes of geology." The text supplies not only the necessary techniques and solutions, but also gives considerable encouragement to an aspiring geophysicist. The content of the book is proof that geologic processes can be modeled quantitatively. You may find the book fills a gap in your curriculum and decide to offer a course based on its content. I already have.

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Survey of the Universe

By D. H. Menzel, F. L. Whipple, G. de Vaucouleurs
860 pp. Prentice-Hall, Englewood Cliffs, N. J., 1971. $16.50

Fifteen years ago, when I first enrolled in a beginning undergraduate astronomy course, the choice of textbooks available to my instructor was small. The next fall marked a turning point: on 4 October, 1957, the Soviet Union launched *Sputnik I*, and the demand for astronomy courses and for new and better texts rose rapidly. Several good new texts appeared in the late 1950's and early 1960's; then in 1964 a flood of new books started, beginning with two books of unusual thoroughness and outstanding authoritativeness: George Abell's *Exploration of the Universe*, and Stanley Wyatt's *Introduction to Astronomy*. I have on my desk now a pile of ten books that appear in editions with copyright dates 1966 or later. It is in the light of the contents of this stack that one must view the present text.

The team of Donald Menzel, Fred Whipple and Gerard de Vaucouleurs brings together interests and experience that cover the entire spectrum of astronomical research. In addition, each of the authors has written previously one or more books for a general audience. As a result of this talent, *Survey of the Universe* is a generally accurate, broad text.

Despite the authors' claim, in their preface, that the book is aimed at "readers having no training in mathematics or science beyond a modest secondary school level," I feel that the text would not be appropriate for a course designed for liberal-arts students. The overall level of sophistication and the amount of material seems better suited to a year-long course for science majors.

The book begins on a low key, moving from a very naive discussion of the scientific method to a survey of the history

"Trifid" nebula in Sagittarius. (Photo by the Hale Observatories.)