

AMERICAN SCIENCE SERIES

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A COLLEGE TEXT-BOOK  
OF  
GEOLOGY

BY  
THOMAS C. CHAMBERLIN  
AND  
ROLLIN D. SALISBURY

*Heads of the Departments of Geology and Geography  
University of Chicago*



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## PREFACE

THIS text-book on Geology is intended primarily for college students who are already in possession of the elements of physics, chemistry, and biology. It is intended to serve as a basis for a half-year's work; but by the judicious selection of material to be presented and omitted, the volume may be used for briefer courses, and supplemented by the numerous articles and treatises referred to in the text, it may be made the basis for more extended courses.

In the preparation of the volume it has been the purpose of the authors to present an outline of the salient features of geology, as now developed, encumbered as little as possible by technicalities, and by details whose bearings on the general theme are unimportant. The attempt has been made to make the book readable, in the hope that many persons not in colleges or universities may be interested in following a connected account of the earth's history, and the means by which that history is recorded and read.

The general plan of the work has been determined by the experience of the authors as instructors. Little emphasis is laid on the commonly recognized subdivisions of the science, such as *dynamic geology*, *stratigraphic geology*, *physiographic geology*, etc. The treatment proceeds rather from the point of view that the science is a unit, that its one theme is *the history of the earth*, and that the discussions of dynamic geology, physiographic geology, etc., apart from their historical bearing, lose much of their significance and interest. The effort has been, therefore, to emphasize the historical element, even in the discussion of special themes, such as the work of rivers, the work of snow and ice, and the origin and descent of rocks. This does not mean that phases of geology other than historical have been neglected, but it means that an effort has been made to give a historical cast to all phases of the subject, so far as practicable.

Throughout the work the central purpose has been not only to set forth the present status of knowledge, but to present it so that the student will be introduced to the methods and spirit of the science. To this end the working methods of the geologist have been implied as frequently as practicable. To this end also there has been frankness of statement relative to the limitation of knowledge and the uncertainty of many tentative conclusions.

The theoretical and interpretative elements which enter into the general conceptions of geology have been freely used, because they are regarded as an essential part of the evolution of the science, because they often help to clear the complete conceptions, and because they stimulate thought. The aim has been, however, to characterize hypothetical elements as such, and to avoid confusing the interpretations based on hypothesis, with the statements of fact and established doctrines. Especial care has been taken to recognize the uncertain nature of prevalent interpretations when they are dependent on unverified hypotheses, especially if this dependence is likely to be overlooked.

In many cases the topics discussed will be found to be presented in ways differing widely from those which have become familiar. In some cases, fundamentally new conceptions of familiar subjects are involved; in others, topics not usually discussed in text-books are stated with some fullness; and in still others, the emphasis is laid on points which have not commonly been brought into prominence. Whether the authors have been wise in departing to this extent from beaten paths, the users of the volume must decide.

Especial attention is directed to the map work suggested at various points in the text, as on pages 109, 194, 222, 288, 331, 366, 413, 475, 506, 659, 726, 771, and 845. The use of the topographic maps, folios, and other publications of the United States Geological Survey, somewhat as suggested, will be of great service in making the subject real. The reports of the several State Geological Surveys of the states where this book is used, will also be serviceable. It is suggested that instructors who use the maps and folios mentioned in the text will do well to plan for this work before reaching the ends of the chapters where mention is made of this work. The map work should be interwoven with the class-room

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work, rather than added at its close. This adjustment must, of course, be left to the individual instructor.

In addition to the map work it is hardly necessary to emphasize the fact that field work is indispensable to the greatest efficiency. Specific directions for field work, however, even if they were needed, are impracticable, since local fields vary so widely.

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# GEOLOGY

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## PART I

### THE MATERIALS OF THE EARTH AND PROCESSES WHICH AFFECT THEM

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#### CHAPTER I

##### PRELIMINARY OUTLINE

*Geology is essentially a history of the earth and its inhabitants.* It treats of rocks and of the agencies and processes which have been involved in their formation, and from the rocks and their structures it attempts to make out the various stages through which the earth and the living things which have dwelt upon it have passed. It is one of the broadest of the sciences, and brings under consideration certain phases of other sciences, particularly astronomy, physics, chemistry, zoölogy, and botany.

**Subdivisions.** So broad a science has many subdivisions. That phase which treats of the outer relations of the earth is *Cosmic* or *Astronomic Geology*; that which treats of the constituent parts of the earth and its material is *Geognosy*, of which the most important branch is *Petrology*, the science of rocks. That phase which deals with the structural arrangement of the rocks is *Geotectonic*, or *Structural Geology*; that which deals with the forces involved in geologic processes is *Dynamic Geology*; that which treats of the face of the earth, or topographic form, is *Physiographic Geology*; that which concerns itself with the fossils that have been preserved in the rocks, and with the faunas and floras that have lived in the past, constitutes *Paleontologic Geology*, or *Paleontology*. The treatment of the succession of events is *Historical Geology*, which is



worked out chiefly from the succession of beds of rock formed in the progress of the ages.

Besides these general subdivisions, there are special applications of geologic knowledge which give rise to other terms. Thus *Economic Geology* is concerned with the industrial applications of geologic knowledge, and *Mining Geology*, which is a sub-section of economic geology, with the application of geologic facts and principles to mining. Other similar subdivisions might be mentioned.

**Dominant processes.** Three sets of processes, now in operation on the surface of the earth, have given rise to most of its surface features. These processes have been designated *Diastrophism*, *Vulcanism* (or *Volcanism*), and *Gradation*. *Diastrophism* includes all movements of the outer parts of the lithosphere, whether slow or rapid, gentle or violent, slight or extensive. Many parts of the land, especially along coasts, are known to be sinking slowly relative to the sea-level, while other parts are known to be rising. The fact that sediments originally deposited beneath the sea now exist, in some places, at great elevations, together with the fact that certain areas which were once land are now beneath the sea, proves that similar changes have taken place in the past. Earthquakes are another illustration of diastrophism. *Vulcanism* includes all processes concerned with the movements of lava and other volcanic products, whether extruded at the surface or not. *Vulcanism* and *diastrophism* may be closely associated, for local movements are often associated with volcanic eruptions. *Gradation* includes all those processes which tend to bring the surface of the lithosphere to a common level. Gradational processes belong to two categories — those which level down, *degradation*, and those which level up, *aggradation*. The transportation of material from the land, whether by rain, rivers, glaciers, waves, or winds, is *degradation*, and the deposition of material, whether on the land or in the sea, is *aggradation*. *Degradation* affects primarily the higher parts of the lithosphere, while *aggradation* affects primarily the lower.

#### THE EARTH IN THE SOLAR SYSTEM

**The earth as a planet.** Though supremely important to us, the earth is but one of the minor planets which revolve about the