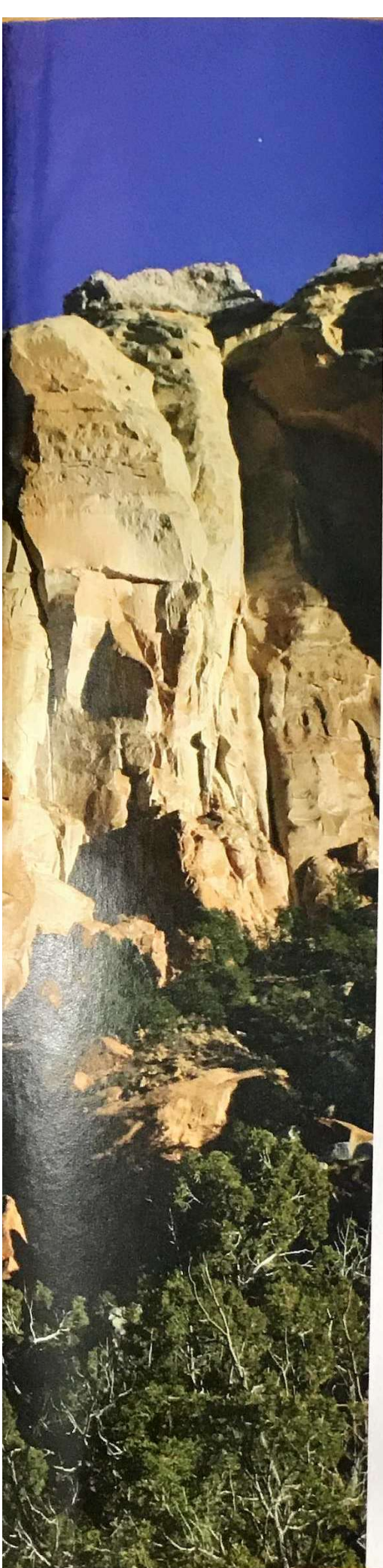


4TH
EDITION

EARTH

PORTRAIT *of a* PLANET

Stephen Marshak



EARTH

Portrait of a Planet

FOURTH EDITION

Stephen Marshak

UNIVERSITY OF ILLINOIS



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Preface

NARRATIVE THEMES

Why do earthquakes, volcanoes, floods, and landslides happen? What causes mountains to rise? How do beautiful landscapes develop? How have climate and life changed through time? When did the Earth form and by what process? Where do we dig to find valuable metals and where do we drill to find oil? Does sea level change? Do continents move? The study of geology addresses these important questions and many more. But from the birth of the discipline, in the late eighteenth century, until the mid-twentieth century, geologists considered each question largely in isolation, without pondering its relation to the others. This approach changed, beginning in the 1960s, in response to the formulation of two “paradigm-shifting” ideas that have unified thinking about the Earth and its features. The first idea, called the *theory of plate tectonics*, states that the Earth’s outer shell, rather than being static, consists of discrete plates that slowly move relative to each other so that the map of our planet continuously changes. Plate interactions cause earthquakes and volcanoes, build mountains, provide gases that make up the atmosphere, and affect the distribution of life on Earth. The second idea emphasizes that our planet’s water, land, atmosphere, and living inhabitants are dynamically interconnected as the Earth System. Materials constantly cycle among various living and nonliving reservoirs on, above, and within the planet. Thus, we have come to realize that the history of life is intimately linked to the history of the physical Earth.

Earth: Portrait of a Planet, Fourth Edition, is an introduction to the study of our planet that uses the theory of plate tectonics and the concept of the Earth System throughout to weave together a number of narrative themes, including:

1. The solid Earth, the oceans, the atmosphere, and life interact in complex ways, yielding a planet that is unique in the Solar System.
2. Most geologic processes reflect the interactions of plates, which is a constant, but very slow movement.
3. The Earth is a planet, formed like other planets from dust and gas. But, in contrast to other planets, the Earth is a dynamic place where new geologic features continue to form and old ones continue to be destroyed.

4. The Earth is very old—about 4.57 billion years have passed since its birth. During this time, the map of the planet and its surface features have changed, and life has evolved.
5. Internal processes (driven by Earth’s internal heat) and external processes (driven by heat from the Sun) interact at the Earth’s surface to produce complex landscapes.
6. Natural hazards—earthquakes, volcanoes, landslides, floods—can be studied and understood. In some cases, geologic knowledge can help society avoid or reduce the danger of these hazards.
7. Energy and mineral resources come from the Earth and are formed by geologic phenomena. Geologic study can help locate these resources and mitigate the consequences of their use.
8. Physical features of the Earth are linked to life processes, and vice versa.
9. Science comes from observation; people make scientific discoveries.
10. Geology utilizes ideas from physics, chemistry, and biology, so the study of geology provides an excellent means to improve science literacy overall.

These narrative themes serve as the *take-home message* of the book, a message that students hopefully will remember long after they finish their introductory geology course. In effect, they provide a mental framework on which students can organize and connect ideas, and develop a modern, coherent image of our planet.

PEDAGOGICAL APPROACH

Educational research demonstrates that students learn best when they actively engage with a combination of narrative text and narrative art. Some students respond more to the words of a textbook, which help to organize information, to provide answers to questions, to fill in the essential steps that link ideas together, and to help a student develop a personal context for understanding information. Some students respond more to narrative art—art designed to tell a story—for visual

images help students comprehend and remember processes. And some respond to question-and-answer-based active learning, an approach where students can in effect “practice” their knowledge. *Earth: Portrait of a Planet*, Fourth Edition, provides all three of these learning tools. The text has been crafted to be engaging, the art has been configured to tell a story, the chapters are laid out to help students internalize key principles, and the on-line activities have been designed to both engage students and provide active feedback. For example, each chapter starts with a question—a Geopuzzle—that prompts students to think about what they already know, and prepares them to search for additional information as they read the chapter. *Take-Home Message* panels at the end of each section help students solidify key themes before proceeding to the next section. Questions at the end of each chapter not only test basic knowledge, but also stimulate critical thinking. New *SmartWork* online homework helps students prepare with automatic feedback, and visual drag and drop, labeling, and “hot spot” reviews. Finally, *See for Yourself* and *Geotour* features guide students on virtual field trips to spectacular geologic locales around the globe where they can apply their newly acquired knowledge to real-world sites and features.

ORGANIZATION

The topics covered in this book have been arranged so that students can build their knowledge of geology on a foundation of overarching principles. Thus, the book starts with cosmology and the formation of the Earth, and then introduces the architecture of our planet, from surface to center. With this basic background, students are prepared to delve into plate tectonics theory. Plate tectonics appears early in the book, so that students can relate the content of subsequent chapters to the theory. Knowledge of plate tectonics, for example, helps students understand the suite of chapters on minerals, rocks, and the rock cycle. Knowledge of plate tectonics and rocks together, in turn, provides a basis for studying volcanoes, earthquakes, and mountains. And with this background, students are prepared to see how the map of the Earth has changed through the vast expanse of geologic time, and how energy and mineral resources have developed. The book’s final chapters address processes and problems occurring at or near the Earth’s surface, from the unstable slopes of hills, down the course of rivers, to the shores of the sea and beyond. This section concludes with a topic of growing concern in society—global change, particularly climate change.

Although the sequence of chapters was chosen for a reason, this book is designed to be flexible enough for instructors

to choose their own strategies for teaching geology. Geology is a nonlinear subject, in that individual topics are so interrelated that there is not always a single best way to order them. Thus, each chapter is self-contained, reiterating relevant material where necessary.

SPECIAL FEATURES

Earth: Portrait of a Planet, Fourth Edition contains a number of features that distinguish it from competing texts. Several of which are new to this edition.

Narrative Art and “What a Geologist Sees”

It’s hard to understand features of the Earth System without being able to see them. To help students visualize topics, this book is lavishly illustrated, with figures that attempt to give a realistic context for a geologic feature without overwhelming students with extraneous detail. The talented artists who worked on the book have used the latest computer graphics software, resulting in the most sophisticated pedagogical art ever provided by a geoscience text. In addition to artist-produced drawings, the book provides abundant photographs from around the world, many of which were taken by the author. Where appropriate, photographs are accompanied by annotated sketches labeled “What a Geologist Sees,” which help students to be certain that they see the features that the photo was intended to show.

In this edition, drawings and photographs have been integrated into *narrative art* that has been laid out, labeled, and annotated to tell a story—the figures are drawn to teach! Subcaptions are positioned adjacent to the relevant parts of a figure, labels point out key features, and balloons provide important annotation. The arrangement of subparts has been designed to convey time progression, where relevant. Color schemes in drawings have been tied to those of relevant photos, so that students can easily visualize the relationships between drawings and photos.

Featured Paintings: *Geology at a Glance*

In addition to individual figures, British artist Gary Hincks has created spectacular two-page annotated paintings for each chapter, called *Geology at a Glance*. These paintings integrate key concepts introduced in the chapters and visually emphasize the relationships between components of the Earth System. They provide students a way to review a subject . . . at a glance.