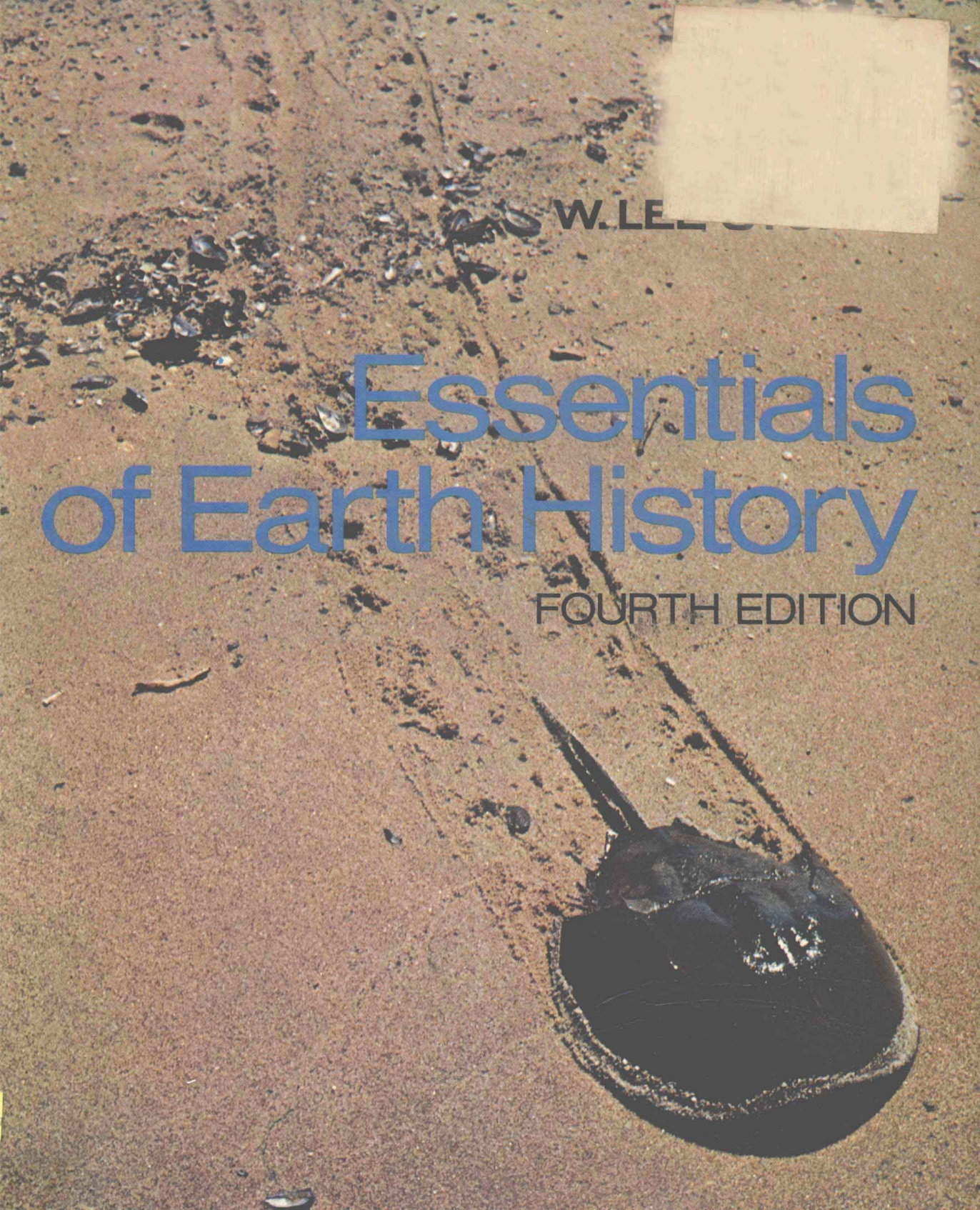
W. LEE
Essentials
of Earth History
FOURTH EDITION

Earth History

An Introduction to Historical Geology

FOURTH EDITION

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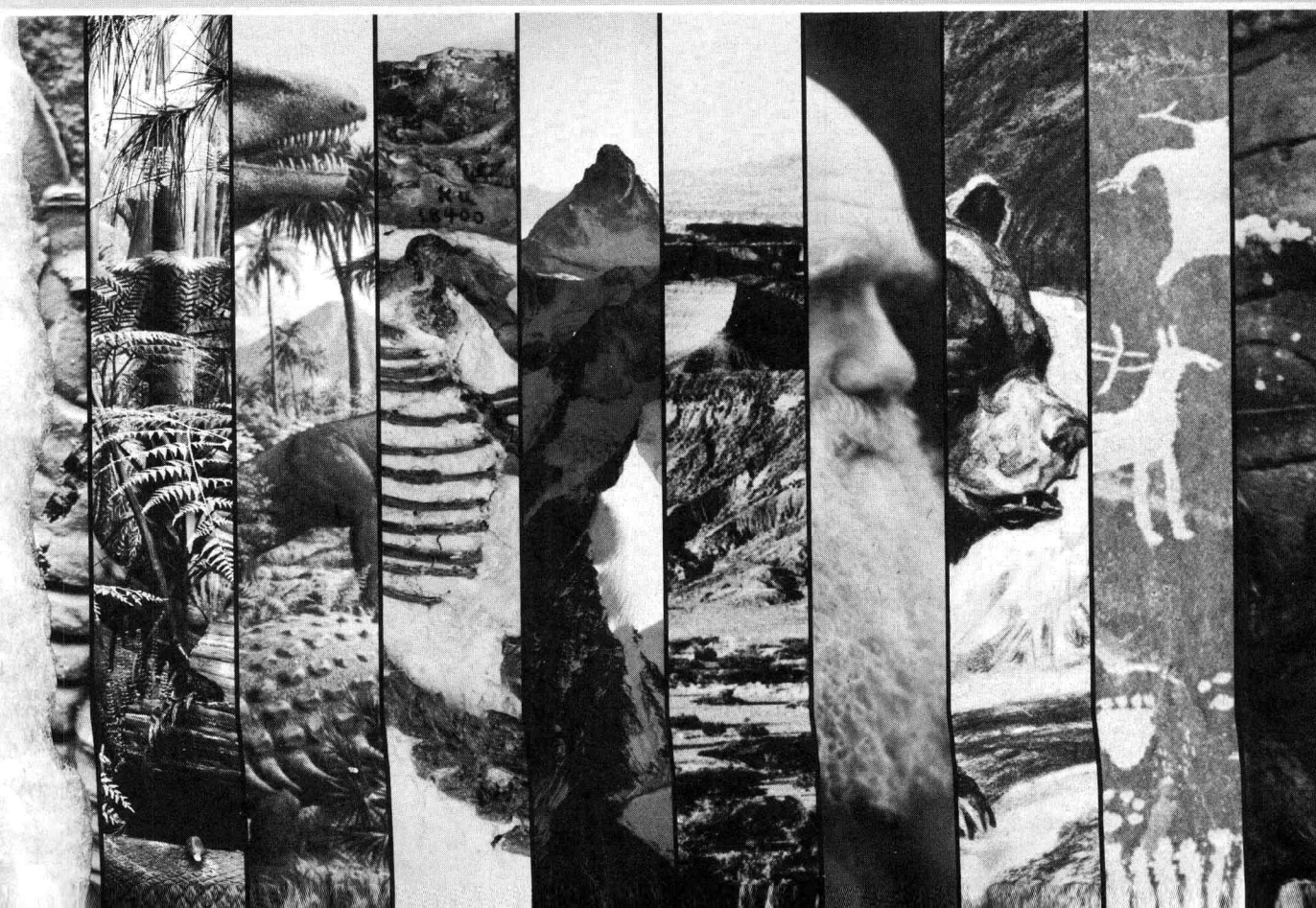

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Preface

The first edition of *Essentials of Earth History* was published in 1960. At that time there were a number of excellent books on the market, and I still have these on my shelves and acknowledge a debt of gratitude to their authors for my background in the subject of earth history. But I found myself constantly having to explain to my students things not in their textbooks, and I decided to write my own. My aim was to stress principles, to shorten the overly long and often boring recitation of inconsequential matters, and to present the history of the earth in an integrated narrative form. I felt that the cosmic beginnings of the earth should be introductory and not an appendix at the end of the book.

Before 1960 no introductory text went much beyond the confines of the United States or North America. I wanted my readers to have a broader background. If there is a truly cosmopolitan or international science, it is geology.

These original guidelines continued to shape my revisions of the 1966 and 1973 editions. My instincts about extraterrestrial matters were justified by space explorations that revealed the earth-like nature of neighboring planets and satellites. There is now an immense body of knowledge going under the heading of planetary geology. Our hard-won information about other members of the solar system is absolutely essential to an understanding of the origin and history of the earth and even of life upon it.

Geology literally has become quite suddenly a "one-world" science. As the words "global tectonics" imply, a revolutionary new theory has appeared to unify the jigsaw puzzle of the earth's crust. The oceans are literally splitting at the seams while the continents move, collide, and merge in surprising ways. Organic evolution is seen to have transpired in a setting even more dynamic and challenging than biologists had supposed. This newly discovered dimension in the history of the earth has cast new light on the meaning of fossils and the evolution of all forms of life including man.

Information continues to pour in from all sides as the implications of global tectonics are examined by geologists and biologists at all levels. In order to bring this edition up to date, I have rewritten at least 35 percent of the previous text and introduced almost 175

new illustrations to supplant or augment those of the previous edition. A new chapter on global tectonics is included, and information on the Precambrian interval has been expanded from one to two chapters. Information formerly included in a chapter entitled "Organizing and Correlating the Record" has been disseminated to other appropriate chapters, and the discussion of the beginnings of life is now in the chapters on the Precambrian where it logically belongs. As with previous editions, the explanations of local geology are left up to those who live with it and know it best. Certainly it is the explanation of what a student can see in his or her surroundings that means the most and will be remembered the longest.

It would be impossible to express my appreciation in print to the numerous persons who have helped with this book. To Logan Campbell, who offered me the opportunity to write this fourth edition and helped at all stages, I am most grateful. I have been extremely fortunate in having Rosalie Herion as my production editor; the book is a reflection of her meticulous, fair, and honest efforts, and I hope she will be pleased with the outcome. To those who have aided in composing and illustrating, I also extend many thanks. Finally, to the several hundred persons who have loaned me photos, I express appreciation.

W. Lee Stokes

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Essentials of Earth History

1

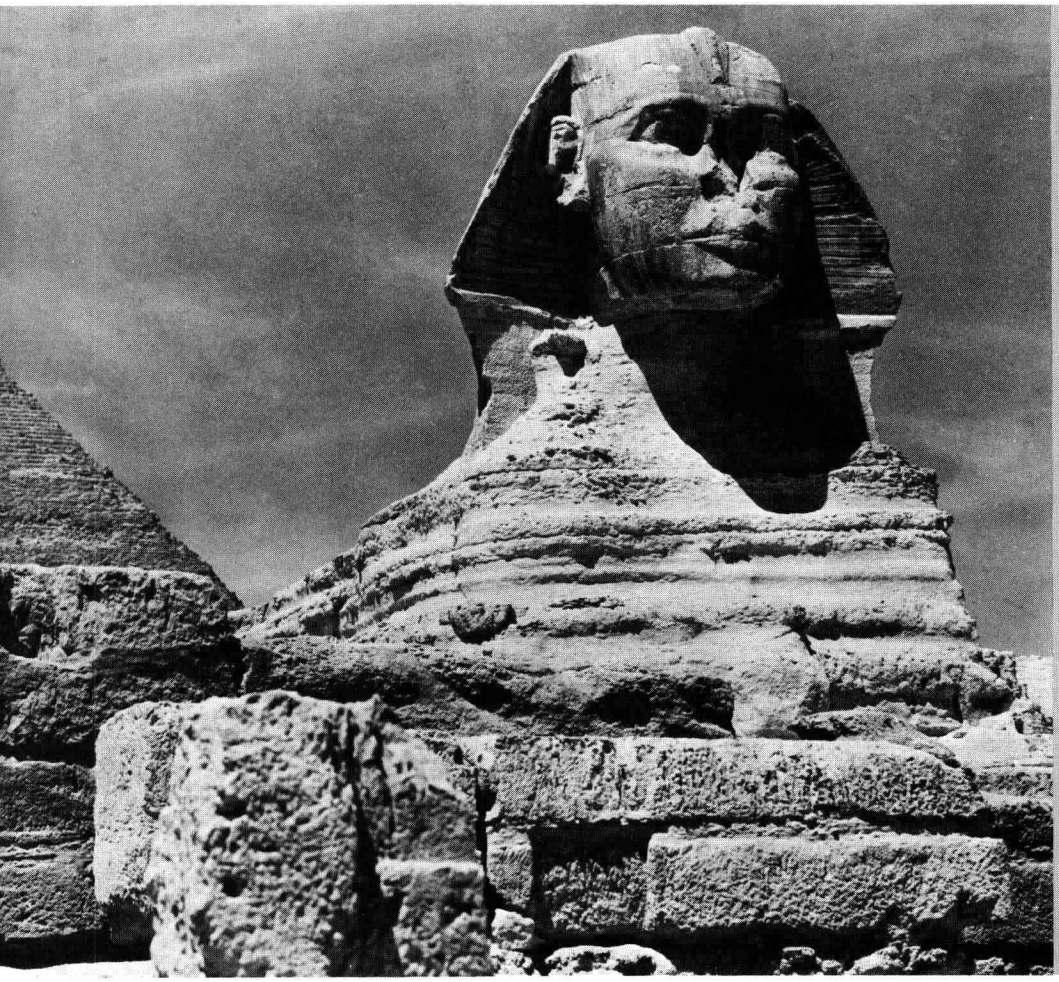
What Is Historical Geology?

Happy is he who knows the origin of things. Thus wrote the Roman poet, Virgil, many centuries ago. He may have said this as he puzzled over the many myths and legends that describe the beginnings of the earth and the human species. The urge to explain origins is strong, and the absence of facts did not deter ancient peoples from inventing myths to satisfy the need.

The beginnings of historical research came mostly by necessity as hereditary ruling dynasties felt a need to establish their rights to govern or own property. The Egyptian monarchs, for example, believed themselves to be descended from gods and needed proof of their lineages.

The court historians of the royal Brunswick-Luneburg line, when ordered to write a family history late in the seventeenth century, decided that "in order to show the remotest origin of our state, we must say something about the first configurations of the Earth, of the nature of the soil and what it contains." All land or title holders who traced their rights to royal grants or ancestral privileges were most anxious to keep their histories intact.

Another ancient incentive to historical



Symbolic of the interactions of man, stone, and time, the Great Sphynx at Giza, Egypt, gazes over the desert in company with the nearby Great Pyramid. The exact dating of this famous monument is unknown, but it is thought, on good evidence, to portray the features of Pharaoh Khafre or Chephres, who ruled about 2600 B.C. It is carved from a natural remnant left isolated by extensive quarrying in the vicinity. The horizontal lines that are visible throughout the monument, and well displayed in the foreground of this photo, are natural bedding planes of the native stone totally unlike the tiers of man-made masonry that are seen in the pyramid in the background. (Courtesy Arab Information Center.)

research was ecclesiastical in nature. Theologians, working from biblical data, tried to establish the sequence of events and personalities between great landmark events such as the Creation, Flood, and birth of Christ. Needless to say, the concept of a 6-day creation and the number of generations given from Adam to Christ placed severe restriction on human history and gave no prehistory at all.

Much of what was written in ancient times was a mixture of fact and fiction; a historian must be wary in accepting these writings as truth. Homer's Iliad and Odyssey contain both truth and fancy. That there was indeed a City of Troy has been verified, but no one seriously believes in a one-eyed Cyclops or in Circe, who could change humans into beasts and back again.

This is not the place to discuss the decipherment of human history. Our topic is prehistory. The thought that there could even be a prehistoric period was slow in coming and difficult for people to accept. Strict interpretations of the creation scripture seemed to require that the entire history of the earth be compressed into little more than 6,000 years. One could not fail to see, however, that great

events had taken place of which there were no records. Observations were made of the remains of dead plants and animals in associations that were hard to explain by common everyday experiences. For a while, ready explanations for these observations were found in the biblical Flood, but this too carries little weight today.

The Observer and the Observed

Many scientists believe that the only reliable basis for scientific thinking is observation. A thing that is observed many times by many people becomes virtually undeniable and generally accepted. A thing observed only rarely may be accepted or it may not; a thing observed not at all may not be accepted by anyone even though it is not impossible. The veracity or credibility of an observer must always be considered. The testimony of a great many eyewitnesses, if they agree, is generally acceptable, but credibility falls off as the number of observers decreases.

We frequently read that someone is a trained observer or a reliable observer. What does this mean? Generally it means that the person has a background in science and has done work in which true and accurate observations are an absolute necessity. A credible observer is one who has established credibility by past performance. Such an observer is known not to be governed by emotion or ulterior motives. That is what a scientist ought to be and usually is. Absolute honesty in scientific observation and reporting is one basic standard to which scientists on the whole adhere. Those who "fudge the facts" in science are severely dealt with, as numerous cases can testify.

Examples will be helpful. Herodotos, the Greek historian, was both an observer and a recorder. But he recorded what others told him, and his writings are known to be a mixture of facts, myths, and legends. He made some excellent observations on the geology of Egypt. When he visited that country in 450 B.C., he made reasonable comments on the origin of the Nile Delta and the cause of the annual flood.

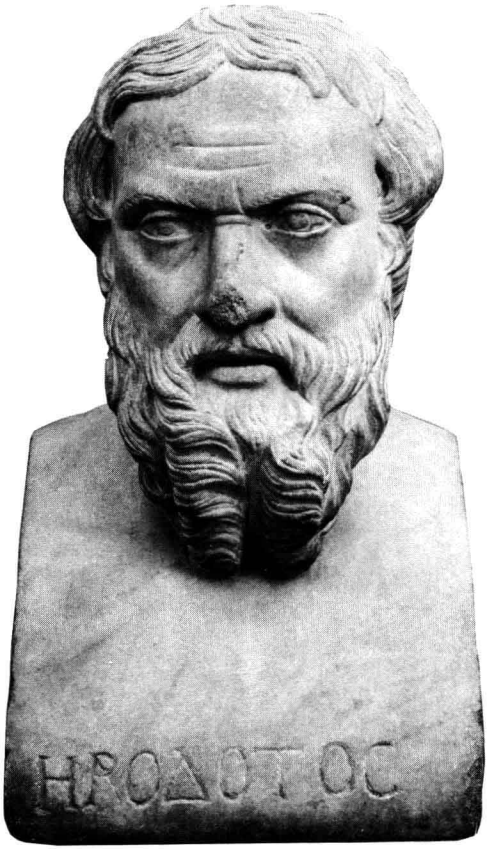


Figure 1.1 Portrait bust of the Greek historian Herodotus (c. 484–425 B.C.). He traveled widely and made intelligent observations and speculations about the geography and geology of places he visited. (Courtesy The Metropolitan Museum of Art, Gift of George F. Baker, 1891. All rights reserved, The Metropolitan Museum of Art.)

The effective beginning of geologic observation and reporting is Pliny the Younger's (A.D. 61–113) description of the eruption of Vesuvius in A.D. 79. His two letters are said to be the first records of reliable eyewitness descriptions of an important geologic event. He recounted in detail the burial of the city of

Figure 1.2 Drawing of Vesuvius made in 1751. Flows of lava and local landmarks are depicted.

Pompeii and the death of Pliny the Elder in the eruption. A fictional account of the same event is the novel "The Last Days of Pompeii," by Bulwer-Lytton.

The importance of correct observation is stressed in all sciences but with different aims and emphasis. Certain sciences, such as astronomy and geology, are largely observational. Biology is partly observational and partly experimental. Chemistry and physics are chiefly experimental. Thus geologists and astronomers observe what is going on and seek to relate causes and effects. From their observations of present effects, they seek to deduce past causes and future consequences. By a study of processes that have culminated in the past, they hope to learn something of both causes and effects. Chemists and physicists, by contrast, are able to control and repeat many of their experiments so as to duplicate given causes with the expectation of producing predictable effects.

Observational scientists have little control over either the causes or the effects of that which they study. Nature may or may not repeat a situation and if it does, the repetition is never at the convenience of a human being.

Needless to say, much of what a geologist observes is the inert, dead, and static result of events and processes that no longer operate. Nevertheless, a static arrangement or situation is observable. It may in fact be of utmost importance that it be observed and recorded with meticulous care and honesty. Here the geologist calls into use all the techniques of mathematics and record keeping.

Importance of Specimens

In everyday experience, some things are rare while others are abundant. A rare or unique thing may be unusually valuable, significant, or difficult to classify. The relative abundance