



National Aeronautics and
Space Administration

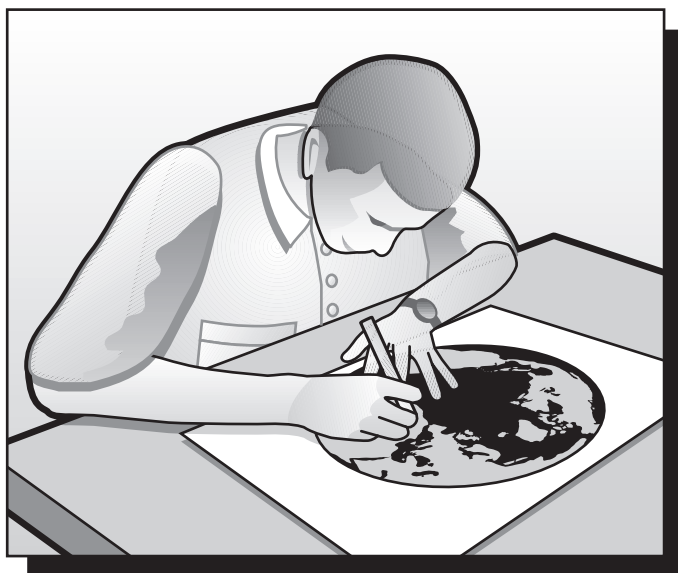
Educational Product

Teachers and
Students

Grades 5-college

Planetary Geology

**A Teacher's Guide with Activities
in Physical and Earth Sciences**





Planetary Geology—A Teacher's Guide with Activities in Physical and Earth Sciences is available in electronic format through NASA Spacelink—one of the Agency's electronic resources specifically developed for use by the educational community.

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Activities in Planetary Geology for the Physical and Earth Sciences

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Acknowledgments

This book is the second edition of NASA SP-179, first printed in 1982. It has been updated to take into account planetary missions that have flown throughout the solar system since the first edition. Both editions are outgrowths of various short courses in Planetary Geology that have been held over the last two decades, and from activities developed in the classroom. *Activities in Planetary Geology* was developed for the National Aeronautics and Space Administration with the guidance, support, and cooperation of many individuals and groups.

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Guide to Activity Level

	Unit 1			Unit 2			Unit 3			Unit 4				Unit 5																																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17																																		
	Geologic Events			Aerial Photos			Stereo Photos			Impact Cratering			Compar. Cratering			Rainy Day Craters			Coriolis Effect			Storm Systems			Landform Mapping			Wind Tunnel			Mars Mapping			Venus Geology			Outer Planet Sats.			Planets in Stereo			Intro. to Mapping			Moon Mapping			Mars Mapping		
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■ 9 - 12				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
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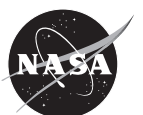
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Introduction

Many earth science courses include an introduction to the solar system. The challenge of earth science is to understand the natural processes that shape not only our planet, Earth, but all objects in the solar system. But there are more compelling arguments for including planetary science in the classroom. Those arguments, some of which are outlined below, inspired NASA to conduct short courses in planetology for earth science teachers at the secondary and college levels. This book is an outgrowth of these short courses.

The Planetary Perspective

Few processes can be understood in isolation from other natural phenomena. Planet Earth is no exception. The forces that drive Earth's evolution and shape its surface have most likely operated elsewhere in the solar system. Earth scientists attempt to recognize those forces on all planets and explain why they are manifested on our world in ways that seem familiar, and on other worlds in ways that may not.

Earth scientists are also concerned with earth materials, the building blocks of this planet. If there is one illuminating result of space exploration, it is the emergence of a unifying vision of the birth and growth of planets. Pictures of the planets sent back by spacecraft strongly suggest a close relationship among the inner planets. Rocks and soil brought back from the Moon bear remarkable similarity to Earth materials. Even spacecraft pictures of the outer planet satellites, many of which are planets themselves by virtue of their size, have astounded scientists with their exotic, but recognizable surfaces.

The American geologist T. C. Chamberlain (1843–1928) once wrote that when approaching a scientific problem, it is important to maintain several working hypotheses. Prior to manned and unmanned space travel there were only terrestrial examples of planet-making materials and processes. It is now possible to devise general theories from a collection of working hypotheses. The multiple working hypotheses come from the scenes of extraterrestrial environments.

A major goal of science is prediction. Once generalized theories are formulated, then experiments are designed to test the theories through their predictions. Some experiments that could address the questions of earth scientists simply cannot be performed on Earth because of their monumental proportions. What could be more illustrative, elegant, or challenging than to



Apollo 17 was launched December 7, 1972. Here astronaut Harrison Schmitt works with a lunar scoop in the Moon's Taurus-Littrow mountains.

consider the other planets as great experiments running under conditions different from those on Earth? The result is to gain insight into planetary scale problems and to escape the limited Earthbound view of nature.

Earth scientists are painfully aware that the processes active on Earth today have wiped clean much of the record of Earth's own history. However, relics and indirect evidence of our own past are often preserved on other planetary surfaces. A common tactic used by scientists to understand complex systems is to study simpler, analogous systems. While the Earth is a complex, turbulent, and delicately balanced system, the other planets may represent stages in the evolution of that system that have been arrested in their development or ventured down different pathways.

Finally, the study of the Earth and planets on a grand scale is not without practical benefits. Better analysis of the atmosphere, sea, and solid crust proves to be of technological, economic, and cultural value. But meteorologists have observed Earth's weather since Ben Franklin's day; what has been missing is another model, another atmosphere to study, where the variables are different, but the dynamics are as definitive. We may have found those requirements in the atmospheres of Venus, Mars, and the outer planets.



We are living in a time of revolutionary discoveries in earth science. It is possible that the fundamental work in earth and planetary sciences over the last three decades will someday be likened to Galileo turning the first telescope toward the heavens. From a scientific standpoint, earth science is a special case of the more general planetary or solar system sciences. This is the motivation to study other worlds—to learn more about that celestial neighborhood in which we occupy a small, but life-sustaining place.

About This Book

Science education is an integral part of scientific endeavors. When the National Aeronautics and Space Administration was created by an act of Congress in 1958, its charter required the agency to "...provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." Part of that responsibility includes introducing students to the scientific results of planetary exploration. This volume is designed to help meet this goal.

The activities are written either to supplement or to introduce topics usually encountered in earth science courses. Consistent with the rationale outlined above, most activities deal with new concepts in planetary geology, but, when generalized to include terrestrial processes, can illustrate broad problems in the earth sciences. The exercises are not keyed to any particular text; rather, each addresses concepts as independent units. The exercises are grouped into five units: 1) introduction to geologic processes, 2) impact cratering activities, 3) planetary atmospheres, 4) planetary surfaces, and 5) geologic mapping. Although each exercise is intended to "stand alone," students will benefit from having worked some of the prior exercises. For example, it would be difficult for students to work exercises in planetary geologic mapping without some knowledge of geologic processes and planetary surfaces. The suggested introductory exercises are noted at the beginning of each exercise. Depending on the level of the student and the context of the exercise, the sequence of the units is somewhat cumulative.

Depending on the instructor, activities can be adapted to most levels of instruction by modifying the questions and adjusting the expectations for answers. A list of suggested correlations of activities with topics commonly covered in earth science courses is included for the convenience of the instructor.

Special Note to the Instructor

Each activity includes an introduction with instructor's notes, a "blank" exercise sheet which can be copied for classroom use, and an answer key to the exercise.

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It is our hope that this book will be a valuable resource in teaching the physical, earth, and space sciences. Enclosed is an evaluation card. We would appreciate your returning this card with your comments.

A Note About Photographs

An essential part of Planetary Geology is the use of spacecraft photographs. Ideally each student-team should have access to glossy photographic prints for use during the laboratory exercises. Photocopies of the pictures in this book (such as Xerox copies) generally lack sufficient detail to be useful. Offset printing is slightly better, but again this process is at least three generations removed from the original product.

Glossy prints or copy negatives can be obtained for a nominal cost (in some cases for no charge) from various sources. Each spacecraft photograph caption in this book contains the necessary picture identification numbers to help you in obtaining the photos. Usually the mission name (Apollo, Viking, etc.) and frame number is sufficient identification.

Listed below are sources of space photography. Instructions for ordering photography will be provided upon written request. Be sure to include your name, title, the fact that the photographs will be used at a non-profit educational institution, and specific photograph numbers.

For planetary mission photography, contact:

National Space Science Data Center
Code 633
Goddard Space Flight Center
Greenbelt, MD 20771

For Earth photography, contact:

EROS Data Center
U.S. Geological Survey
Sioux Falls, SD 57198

For photographs indicating Arizona State University as their source, contact:

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Space Photography Laboratory
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