EARTHLIKE PLANETS

SURFACES OF MERCURY, VENUS, EARTH, MOON, MARS

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Surfaces of Mercury, Venus, Earth, Moon, Mars

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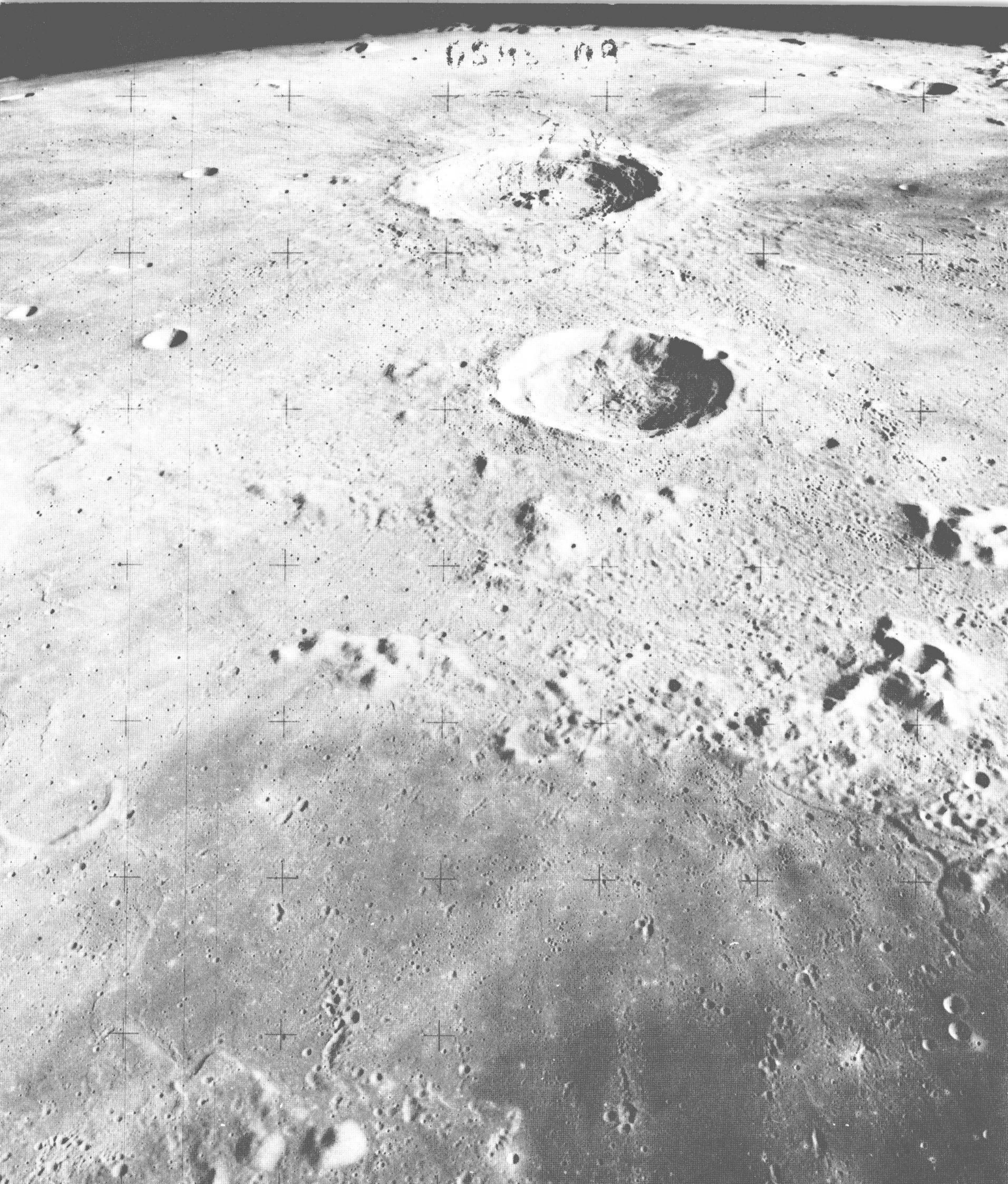

Apollo 15 photograph of the Moon, viewed northward over the crater Autolycus and the 50-kilometer-diameter crater Aristillus (near top of image).

PREFACE

We are all transitory inhabitants of the third planet orbiting the Sun—an average star in an average galaxy containing at least two billion similar stars and probably many billions of other planets. Together we are witness to an unprecedented episode in our species' development, when the capacities to explore Earth's physical surroundings and widely disseminate the results have expanded incredibly fast and effectively. As a result, we are immersed in a planetary information explosion.

Traditional explanations of the nature and history of Earth and the other rocky, Earthlike planets of the inner Solar System—Moon, Mars, Venus, and Mercury—are crumbling under the impact of close-up and direct observations of actual surface phenomena. New insights are developing that link Earth, including the very atoms that compose its sentient beings, with the origin and evolution of those other four planets of the inner Solar System.

A scientific Book of Genesis is emerging, no less dramatic than the literary one; a common planetary environmental history is unfolding that unites the surface histories of Earth and the other inner planets and probably places some conditions on our planetary future.

This book makes available to college undergraduates and to other serious nonspecialists the outlines of the intellectual revolution under way concerning Earth and its kindred planets, especially their surface features, processes, and histories. No equations are used, and reliance is placed on the reader's physical intuition rather than on any previously developed expertise in physical theory. As a consequence, the book should be suitable as a supplementary text in college geology and astronomy courses and also of use in specialized courses covering topics in physical geology, geomorphology, planetary astronomy, volcanology, and planetary science. In order to facilitate diverse potential uses of this book, individual chapters generally contain sufficient background to permit them to be read out of sequence if necessary. General references are included at the end of each chapter for those who wish to explore further.

It is our hope that this book contains a sufficiently accessible overview of the surfaces of the Earthlike planets so that many others who are curious about planetary exploration (for example, readers of *Scientific American, Sky and Telescope, Nature,* or *Science*) will find stimulation and edification from it. A major objective has been to bring the subject of the Earthlike planets into a broad intellectual framework, including past parallels and future possibilities.

Planetary exploration surely is one of the brightest accomplishments of the second half of the twentieth century; if college students and others find that this book serves as a window into some of the contemporaneous additions to the intellectual heritage of humankind, then our purposes will be superbly met.

June 1980

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No single scientist, or even three, can have all the expert knowledge, much less the balanced perspectives, needed to do justice to the present state of knowledge concerning the surfaces of the Earthlike planets. To the extent we have succeeded in producing a useful book, the helpful criticism and suggestions of many of our colleagues have been essential. We wish to acknowledge in particular reviewers of specific portions of the manuscript: Professor Arden Albee, Division of Geological and Planetary Sciences, and Jet Propulsion Laboratory, Caltech; Dr. Michael Carr and Dr. Newell Trask, United States Geological Survey; Dr. Clark R. Chapman and Dr. William K. Hartmann, Planetary Science Institute; Dr. Fraser P. Fanale, Jet Propulsion Laboratory, Caltech; Dr. Donald E. Gault, Murphys Center of Planetology; Professor John E. Guest, University of London, England; Professor William M. Kaula, Department of Earth and Space Sciences, and Institute of Geophysics and Planetary Physics, University of California, Los Angeles; Professor Robert B. Leighton, Division of Physics, Mathematics, and Astronomy, Caltech; Dr. Peter H. Schultz and the late Dr. Thomas R. McGetchin, Lunar and Planetary Institute; Professor Robert P. Sharp, Division of Geological and Planetary Sciences, Caltech; Professor Robert G. Strom, Lunar and Planetary Laboratory, University of Arizona; and Dr. George W. Wetherill, Department of Terrestrial Management, Carnegie Institution of Washington.

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AN INTELLECTUAL REVOLUTION

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Humankind has broken the chains of gravity and taken the first tentative flights from its ancestral home, beginning with orbital flights about the Earth and culminating in the first visit to the Moon. The extraordinary accomplishments that mark the age of space exploration have permanently altered our view of ourselves and our potential.

Paralleling the revolution in human perspective inspired by the grandeur and majesty of human space flight has been a revolution in our view of Earth (Fig. 1.1) and its kindred planets within the inner Solar System. The Moon, Mercury, Venus, and Mars have been surveyed by sophisticated robots. Related studies of all kinds—laboratory analyses, Earth-based telescopic observations, and theoretical analyses—have been enormously expanded to accompany close-up and direct observations by space probes.

Orbiting spacecraft have taken spectacular photographs, and entry probes and landers have made esoteric surface and atmospheric measurements on the inner planets—the *Earthlike* planets. The information so acquired is being combined and compared with the knowledge gained from intricate analysis of meteorites and lunar samples. The results truly challenge our intellectual limits as our place in the evolution of the Solar System—indeed, in the entire physical universe—is revealed in new and unimagined ways.

The exploration of our planetary neighbors has provided extraordinary fare for our insatiable curiosity about our own environment; it has provided specific findings of importance to understanding environmental problems on Earth. Surely it will

Figure 1.1
Earth as viewed by the last humans to visit the Moon (Apollo 17). When seen from space, Earth displays three prominent colors: the clouds of the atmosphere are white, the continents are brown or reddish-tan, and the oceans are blue-black.

provide the basis for future utilitarian activity, just as the expansion of terrestrial geology at the end of the nineteenth century from a continental scale to a global scale provided the basis for new views of the Earth. So, likewise, do planetary geology and exploration now represent an intellectual and societal challenge of what is truly the next frontier.