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Research resource review: Planetary Surface Processes

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Research resource review

H. Jay Melosh, *Planetary Surface Processes*. Cambridge: Cambridge University Press, 2011; 520 pp.: 9780521514187, £45 (hbk).

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Though investigations of solid extraterrestrial surfaces extend at least as far back as Galileo's telescopic examination of the Moon, detailed exploration of solar system landscapes had to await the advent of the space age. Over the past several decades, topographic and image databases have been generated with progressively higher levels of sophistication for all large bodies of the inner solar system, for dozens of moons of the outer solar system, and for numerous asteroids and cometary nuclei. Modern remote sensing technology increasingly allows for the conduct of meter-scale photogeological and morphological work and for the quantitative determination of ground thermal properties and surface mineralogy. The study of surfaces of solar system bodies has become an important part of the geosciences, allowing new light to be shed on other worlds and providing improved context for the study of our own.

Planetary Surface Processes, by Jay Melosh of Purdue University, was not written as a descriptive survey of landscapes in our solar system. Instead, the author has attempted the more challenging task of describing the processes that are most fundamental to the study of planetary surfaces. The author has succeeded admirably in this regard, using his more than 25 years of teaching and research experience to help guide compilation of the 11 chapters that comprise this attractive volume. Content is subdivided on the basis of process type and strongly emphasizes the quantitative treatment of physical concepts and processes.

Early chapters introduce elementary background information and cover the processes that most profoundly influence the morphologies of bodies at global scales. Chapter 1 ('The grand tour') presents a brief overview of the solid bodies of the inner solar system and several moons of the gas giants. Chapter 2 ('The shapes of planets and moons') focuses on processes that determine the forms of solar system bodies, and includes discussion of gravity, tidal forces, centrifugal acceleration related to rotation, and measures of hypsometry and topographic roughness.

The next several chapters discuss the flow of mass and energy inside solar system bodies and the operation of associated tectonic and volcanic processes. Chapter 3 ('Strength versus gravity') builds on earlier content by introducing numerical techniques for analysis of stresses and strains in geological materials, and by describing concepts such as isostasy, crustal flexure, and the geoid. Chapter 4 ('Tectonics') covers primordial and radiogenic sources of internal heat as well as related processes of heat dissipation and convection, diapirism, and folding and faulting. Chapter 5 ('Volcanism') describes the generation and ascent of magmas and explores elementary mechanisms of lava emplacement at the surface.

The remaining chapters focus on processes that predominantly act against the constructional effects of tectonic and volcanic mechanisms, including impact, slope, aeolian, fluvial,

glacial, and periglacial processes. Chapter 6 ('Impact cratering') considers the processes and landforms associated with impact events. This subject is the focus of Melosh's classic textbook, *Impact Cratering: A Geologic Process* (1989), and the author has expertly summarized and updated the most important concepts from that book in the compilation of this chapter. Surveyed topics include the morphological classification of impact craters and basins, processes of crater formation and degradation, mechanisms of emplacement of impact ejecta, and the dating of planetary surfaces using impact crater statistics. Chapter 7 ('Regoliths, weathering, and surface texture') focuses on such subjects as impact comminution and gardening, equilibrium in crater populations, regolith maturity, and ground thermal regimes. Chapter 8 ('Slopes and mass movement') concisely describes the elementary processes involved in soil creep, landslides, and other types of mass movement. Chapter 9 ('Wind') discusses topics including the processes of entrainment and transport by wind, and the classification of aeolian landforms. Chapter 10 ('Water') focuses on a very diverse range of subjects including groundwater flow, stream flow, and the operation of wave processes in standing water bodies. Chapter 11 ('Ice') presents an overview of glacial flow mechanisms, the thermal and morphological classification of glaciers, and the basic nature of selected periglacial processes.

Direct references to the literature are made in the main text, and each chapter ends with a brief annotated bibliography of selected additional resources. These bibliographies are accompanied by short sets of exercises that serve to highlight key ideas and to further illustrate practical problems. The text contains an abundance of well-chosen line drawings, and the magnitudes of physical parameters typical of geological materials are usefully summarized in numerous tables. Small black-and-white images, some of which are reproduced as color plates, are also scattered throughout the main body of the text. Given the extraordinary planetary vistas that have been revealed in recent decades, some readers may wish that more images had been included in this volume and that utilized images had been printed with larger sizes on the page.

A reader who makes the effort to carefully work through this text will achieve a quantitative understanding of many of the fundamental physical processes of greatest relevance to the study of planetary surfaces. This text will not only expose readers to the basic physical relations that have become the mainstay of modern geomorphology texts (e.g. Glen's flow law, the Manning and Chezy equations, and the power laws associated with Horton-Strahler stream ordering), but will also introduce readers to elementary physical concepts of equal importance to the study of planetary surfaces (e.g. physical constraints on the shapes of rotating bodies, the nature of heat and mass transfer within and near the surfaces of solid bodies, the basic physics of igneous plumbing systems and of volcanic eruptions, and essential concepts such as thermal inertia). Aspects of the historical development of ideas are described in places, illuminating the human side of past research efforts and providing improved context for associated concepts. Despite a page count of 500, the volume's broad scope does limit the depth with which individual topics can be explored (e.g. the periglacial section is only about eight pages long), but chapter bibliographies helpfully point interested readers toward more narrowly focused resources.

Presentation of images and empirical data is minimized in the text in favor of the documentation of physical concepts and processes. As a result, the text does not contain as much descriptive information as is typical for books that focus instead on terrestrial geomorphology. For example, though the morphological classes of glaciers are defined, readers are not shown photographs that depict what cirque, valley, or piedmont glaciers actually look like. Because this text is not meant to be a

comprehensive catalog of all classes of planetary landforms, readers not already familiar with recent discoveries will certainly need to consult with outside resources if the full diversity of solar system environments and landscapes is to be appreciated. However, by emphasizing physical principles, Melosh has assembled a useful text that is destined to remain relevant for a greater length of time than would a more descriptive and qualitative treatment of the subject.

Planetary Surface Processes is a wonderful text that would be ideal for use in a graduate or advanced undergraduate course in planetary science, particularly if used in conjunction with lecture or lab content that further exposes students to the richness of planetary landscapes as revealed by remotely sensed images and geophysical data sets. The broad scope of the book may also appeal to planetary and terrestrial researchers seeking to expand their understanding of basic processes of relevance to the study of surface environments. *Planetary Surface Processes* is a superb example of what the careful and enthusiastic distillation of a career's worth of teaching and research can produce, and is highly recommended.

Reference

Melosh HJ (1989) *Impact Cratering: A Geologic Process*. Oxford: Oxford University Press.