Geomorphology 240 (2015) 8–17

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Planetary geomorphology: Some historical/analytical perspectives

V.R. Baker *

Department of Planetary Sciences, University of Arizona, Tucson, AZ 85721, United States

ARTICLE INFO

Article history:
Received 2 December 2013
Received in revised form 5 July 2014
Accepted 7 July 2014
Available online 17 July 2014

Keywords:
Planetary geomorphology
Mars
Percival Lowell
History
Lunar craters
Scientific reasoning

ABSTRACT

Three broad themes from the history of planetary geomorphology provide lessons in regard to the logic (valid reasoning processes) for the doing of that science. The long controversy over the origin of lunar craters, which was dominated for three centuries by the volcanic hypothesis, provides examples of reasoning on the basis of authority and a priori presumptions. Percival Lowell's controversy with geologists over the nature of linear markings on the surface of Mars illustrates the role of tenacity in regard to the beliefs of some individual scientists. Finally, modern controversies over the role of water in shaping the surface of Mars illustrate how the a priori method, i.e., belief produced according to reason, can seductively cloud the scientific openness to the importance of brute facts that deviate from a prevailing paradigm.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Ever since scholarly historical writings began in ancient Greece controversy occurred as to the proper goal for historical scholarship. The first substantive historical account, Herodotus's *The Histories*, is meticulous in its detail. It documents the fifth-century B.C.E. conflicts between the Persian Empire and the Greek city states, and it also describes much of the world during that time period, including aspects of its geography and geomorphology. Herodotus was not a participant in the historical events that he documented. He merely recorded details, based on his extensive travels, interviews, and recordings of stories, many of which were probably exaggerated by their tellers. Herodotus's stated purpose was to prevent the fading from memory of the wondrous deeds and glories of the times that he recorded. His detachment from the history portrayed is a forerunner to the view of historiography that steps aside from philosophical commentary as to meaning. *The Histories* is exemplary for its great storytelling and for its celebration of great accomplishments.

In contrast to the approach of *The Histories*, the other great classic of early historical scholarship is the work of an "insider", that is, an active participant in regard to the events described. Thucydides, who lived from c. 460 to c. 395 B.C.E, had been an Athenian general during a long period of warfare between Sparta and Athens. His book, *The History of the Peloponnesian War*, is a marvel for its detailed coverage of a war that was tragic for all its participants, revealing of noble and cowardly human actions, and immensely complex for its political and military strategies. Thucydides' *History* emphasizes the analysis of past events, seeking meaning and explanation. A quotation attributed to Thucydides conveys his different view historiography from that of Herodotus: "History is philosophy teaching by example." It is more this view that guides the present study.

A complete and detailed history of planetary geomorphology cannot be condensed into a short journal article. Very great differences exist between the various periods of planetary surface studies, extending from the earliest telescopic observation, beginning 1608 or 1609, to the era of spacecraft exploration, extending from 1962 to present. The latter period, which began with a flyby of Venus by the Mariner 2 spacecraft on December 14, 1962, has involved about 80 successful missions from many nations (Carr, 2013). The accelerating pace of discoveries from these missions is a wonder and a challenge for the analytical approach to the topic. Nevertheless, it is possible to pursue a few major themes and perhaps to learn something from whatever lessons they might contain. The first of these themes, on the origin of lunar craters, traces back to the early 17th century, when telescopic observations were first made of extraterrestrial planetary surfaces. The second theme concerns the famous Mars canals controversy centered on the eccentric astronomer, Percival Lowell. The third and final theme is also concerned with Mars, but it emphasizes modern research during the present era of spacecraft exploration. As the most Earthlike of the presently known planets, Mars continues to be a source of scientific controversy, particularly in regard to the role of water as an agent for the shaping its surface.

* Tel.: +1 520 621 7875; fax: +1 520 621 1422.
E-mail address: baker@email.arizona.edu.

http://dx.doi.org/10.1016/j.geomorph.2014.07.016
0169-555X/© 2014 Elsevier B.V. All rights reserved.

2. Creating craters: lunacy or logic?

One of the great scientific controversies for astronomy and geology began in 1608–1609 when Galileo Galilei pointed a crude 3.8-cm diameter telescope at the moon to observe the peculiar circular "spots" on its surface. Galileo was even able to make geomorphological observations: that the "spots" were actually topographic depressions, that many of them had central mountains, and that some were floored with dark material. The controversy over the origin of these circular depressions raged over the next three and a half centuries. Though this is a controversy that has received considerable historical attention (Baldwin, 1949, 1963; Shoemaker, 1962; Green, 1965; Marvin, 1986; Hoyt, 1987; Schultz, 1998), it is worth recounting for some of its more salient episodes that illustrate important points about the nature of geomorphological reasoning.

What were, according to Davies (1969), perhaps the first geomorphological experiments took place in 1665. The experimenter was Robert Hooke, a scholar of immense breadth of interests, who made many fundamental discoveries (Drake, 1996). Hooke, who also seems to have delivered the first scientific lectures in Britain on geomorphology (Davies, 1969), had made telescopic observations of the moon, publishing excellent drawings of the cratered lunar landscape in his 1665 book *Microgarphia*. Using analogical reasoning from experimental observations, Hooke inferred two hypotheses for the origin of the circular lunar depressions. From his observations of pits forming on the cooled surface crust of boiled gypsum Hooke inferred that internal heat (volcanism) could cause similar-appearing pits on the moon. Hooke further observed that somewhat similar-appearing pits could also be produced by impact from the dropping of pellets of clay or musket balls on to a muddy target material.

To distinguish between the two hypothesized origins for lunar craters, Hooke invoked the prevailing theory held by the astronomers of his day: that interplanetary space was completely empty and, therefore, could not contain the impactors that would be necessary for the second hypothesis to be true. Thus, Hooke rejected his second hypothesis, that of impact, on the basis of logical inference from a theory that largely derived from a priori presumptions about the natural world. In the cosmology of the Middle Ages the heavens were presumed to be perfect. The planets and the sun, of course, existed but no other objects could interfere with the mathematical perfection that described the movement of various heavenly spheres. Moreover, the mathematical certainties that explained these movements, so famously derived by Hooke's great intellectual competitor, Sir Isaac Newton, seemed to require this perfection. The circularity of this argument continued to elude much of the scholarly world, leading to the dismissal of sightings of "rocks falling from the sky" as "peasants' fables".

For lunar studies after Hooke until the 20th century, nearly all astronomers, emphasized the volcanic origin for lunar craters. Such notable astronomers of the late 18th century as William Hershel and Johann Hieronymus Schröter strongly advocated this position, and it was also the conclusion of numerous astronomical observing campaigns, including the extensive and highly authoritative project of the Paris observatory at the end of the 19th century (Loewy and Puiseux, 1897). Some minority support for an impact origin of lunar craters was offered in the 19th century (e.g., Proctor, 1873), but the volcanic hypothesis continued to prevail. In retrospect, the emphasis on volcanism derived from inadequate understanding of the impacting process and from methodological issues. But progress was also severely imped-ed by the imposition of authority. W. Pickering, director of the Harvard Observatory and widely regarded as the authority on lunar astronomy, was strongly against the impact hypothesis for lunar craters (Pickering, 1903). Pickering's Harvard colleague and founder of that university's geology program, Nathanial Southgate Shaler, also argued strongly against the impact origin (Shaler, 1903), favoring instead a volcanic origin.

Although many of the important observations related to crater morphologies were made by advocates for both the impacting and volcanism origins (Schultz, 1998), there long remained a lack of appreciation for terrestrial examples of impact cratering. In contrast, the many available examples of volcanic phenomena had long been an inspiration for lunar hypotheses by geologists, such as Dana (1846). The other major impediment was the lack of physical understanding for high-velocity impact processes. Even when this began to be understood in the early 20th century (Ives, 1919; Gifford, 1924, 1930), however, those ideas continued to be held with suspicion by most astronomers until the modern era.

Many of the problems for understanding the geomorphology of impact cratering are encapsulated in the experience of Grove Karl Gilbert, arguably the greatest geomorphologist of his day. Gilbert's lunar observations were made in 1892, using the 67.31-cm refracting telescope of the U.S. Naval Observatory. He also repeated the experimental approach employed by Hooke by propelling balls of clay and mud into various target materials (El-Baz, 1980; Pyne, 1980), concluding that only an impacting process could produce the kinds of detailed morphological features that he had meticulously described from his telescopic observations (Gilbert, 1893). Similar results were obtained by other experiments around this same time period.

Even Alfred Wegner, more famous for his role in the continental drift controversy, was involved (Greene, 1998), concluding that impacting had to be the causative process for lunar craters.

Gilbert's lunar studies and those of several other prominent advocates for impacting failed to convince the astronomers who favored volcanic origins. It was a fact of observational astronomy that nearly all lunar craters are circular in outline. Circular craters were presumed by the currently prevailing theory to be only possible if all the impacting objects came from a vertical direction. This would seem to be highly unlikely for the moon, since the expected random approach directions of impacting objects would surely generate a great many oblique impacts. Moreover, even the experiments of Gilbert and others showed that oblique impacts produce elliptical craters, thereby confirming that the impact direction must be vertical to produce a circular crater. Gilbert tried to modify his impact hypothesis to account for this problem by postulating that the lunar-crater-generating objects derived from a temporary circular orbit around Earth. These objects were then subsequently perturbed to fall vertically to the surface of the moon. Of course, this had the appearance of modifying a hypothesis that had failed experimental testing. In hindsight, of course, the problem here was the presumption that the low-velocity impacting conditions that were assumed by the theory and demonstrated the testing were indeed the conditions actually applicable to nature. More modern studies of the high-energy, high-velocity nature of the impacting process have shown that oblique impacts also produce circular craters, but this discovery did not come until later in the 20th century.

In a subsequent study, Gilbert also addressed the important issue of terrestrial analogues for lunar craters. He did this with an investigation of Coon Butte in northern Arizona. In a paper that makes important statements about the role of analogical reasoning in geology, Gilbert (1896) came to the conclusion that Coon Butte, known today as Meteor Crater, was the product of a steam explosion. The latter seemed consistent with the proximity of the site to an area of extensive volcanic craters. Gilbert's analysis carefully considered an impact hypothesis for the feature, but rejected it, in part because of the lack of understanding of how relatively small hypervelocity projectiles are able to generate the phenomenal energies that drive the impacting process. Even despite his lack of access to this modern understanding, however, Gilbert was, nevertheless, critical of his own results. Toward the end of his paper he refers to some remaining anomalous phenomena, and notes that these illustrate what we now know as a principle of fallibilism that underlies all science, and especially planetary geomorphology (Gilbert, 1896, p. 12):

Download English Version:

https://daneshyari.com/en/article/6431872

Download Persian Version:

https://daneshyari.com/article/6431872

Daneshyari.com