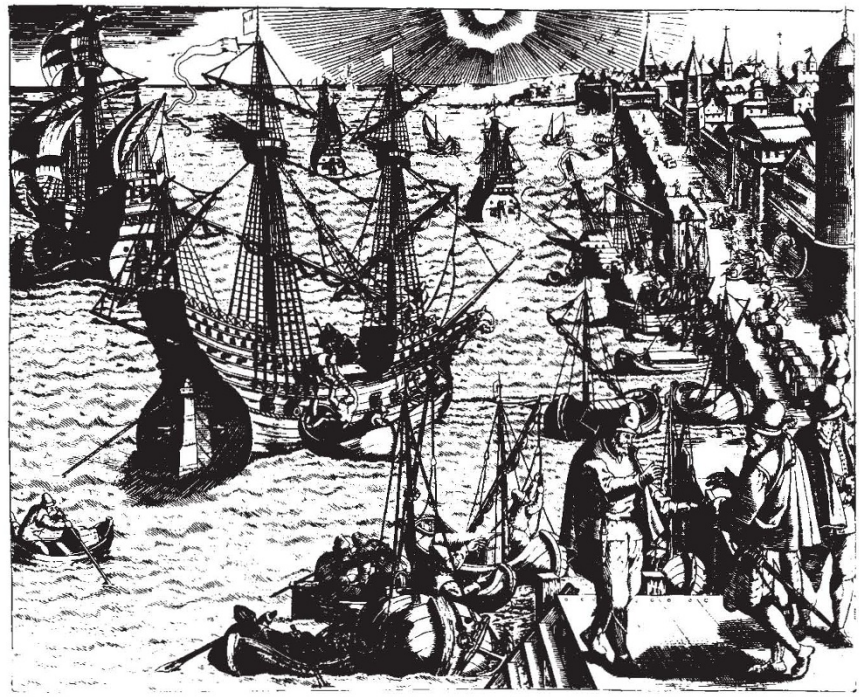
Missing rings

H. Jay Melosh

The Geology of Multi-Ring Impact Basins: The Moon and Other Planets. By Paul D. Spudis. *Cambridge University Press: 1993. Pp. 263. £37.50, $59.95.*



FOLLOWING their exploration of the Amazon, Portuguese traders, as shown here, gained considerable control of their new-found lands in the early seventeenth century. This engraving is taken from *Explorers of the Amazon* by Anthony Smith, now out in paperback (Chicago University Press, $15.95, £12.75). For a review, see *Nature* 344, 901 (1990).

MODERN studies of the Moon, culminating in the manned Apollo landings of the late 1960s and early 1970s, revealed that most lunar landforms were created by the impact of high-speed meteoroids. Even the broad volcanic plains fill depressions created by impacts. The lunar surface is covered with impact craters at all scales, from only a few microns in diameter up to vast structures that may occupy an entire hemisphere. Not surprisingly, the biggest impacts have had the most profound effect. The fundamental geological fabric of the Moon was established by several dozen huge impacts that deeply shattered its crust and spewed ejecta over millions of square kilometres of its surface. The circular scars of these impacts range in diameter from roughly 300 km up to the recently confirmed South Pole/Aitken basin with a diameter of 2,600 km, larger than the Moon's radius.

These great structures are not simply scaled-up versions of smaller craters, however, but show their own peculiarities and so are given the special name 'basins' by lunar geologists. The most obvious difference between a crater and a basin is the presence of two or more roughly circular rings around a low-lying central plain. The importance of the concentric structures was first recognized for the Orientale basin by W. K. Hartmann and G. P. Kuiper in 1962 and the feature has since become the defining characteristic of these large structures on the Moon. Impact basins are not, however, confined to the Moon, but have been recognized on all the terrestrial planets (including Earth) and are seen in modified form on the icy satellites Ganymede and Callisto.

Although multi-ring impact basins are a widespread and distinctive element of planetary crusts, the mechanism by which the rings themselves form is still highly controversial. Even the identification of which ring (if any) corresponds to the edge of the cavity excavated by the impact is still contentious: a few planetary scientists suppose that the outermost ring is the rim of this cavity, while most suppose that at least some of the rings formed outside the cavity during its collapse. Another unexplained aspect of multi-ring basins is that the diameters of adjacent rings often have ratios roughly approximating $\sqrt{2}$ or 2, which has led some planetary geologists to an almost mystical insistence that the rings are spaced by intervals of $\sqrt{2}$ (ring diameter ratios of 2 are therefore sometimes explained by a 'missing' ring spaced at the 'correct' interval).

The Geology of Multi-Ring Impact Basins is the first book-length treatment of this subject. The author attempts to bring together the wealth of geological, geophysical, geochemical and remote-sensing data that have been collected about basins and to address the major problems of basin formation. The emphasis is strongly lunar: basins on other planets and satellites are treated in a single chapter, whereas each of five lunar near-side basins is given its own chapter, with a sixth chapter devoted to the processes of their formation. Each of the chapters on the five lunar basins describes the structure and geology of the basin, presents the results of remote spectral reflectance studies and, where appropriate, discusses the implications of the Apollo or Luna lander samples for basin excavation. These chapters succeed in collecting a great deal of otherwise disparate data and give a valuable overview of the geology of the lunar nearside.

In other ways, however, the book is seriously flawed. The author cites the existence of up to six concentric rings around many basins, all perfectly circular and spaced at intervals of exactly $\sqrt{2}$. Most planetary mappers simply cannot see this many rings, a fact that is supported by the US Geological Survey series of planetary maps, which do not show most of the rings Spudis illustrates in his book. Furthermore, it is obvious that many of the rings are not perfectly circular (Spudis himself states this in describing the western portion of the Orientale system). Nevertheless, ring diameters listed in the book are presented without uncertainties or ranges. Spudis raises the rough $\sqrt{2}$ ring spacing to an apparent law of nature, although the reader must take his word for the 'correct' ring diameters to obtain the near-perfect fit that he describes. One has to suspect that Spudis searches for rings by looking for isolated topographical features along circles spaced at the expected intervals and, not surprisingly, usually finds them.

There are several other less important problems with the text. Jargon and acronyms are used too frequently (the term "KREEP" is not defined anywhere), and the book contains many implicit, undefended assumptions (for example, "more mafic" is equated to "deeper origin"). Conflicting views, such as the existence of a Procellarum basin, are often dismissed without substantial discussion. Too many citations refer to unpublished work, mainly by Spudis and colleagues.

Overall, the book does offer a valuable collection of data on multi-ring basins, but any reader should be aware that it is a highly idiosyncratic view of the subject that fails to reflect the mainstream ideas of planetary scientists. □

H. Jay Melosh is in the Department of Planetary Sciences, University of Arizona, Tucson, Arizona 85721, USA.