RIDGES IN WESTERN COLUMBIA PLATEAU, WASHINGTON–ANALOGS TO MARE-TYPE RIDGES? Ronald Greeley and Paul D. Spudis, Dept. of Geology and Center for Meteorite Studies, Arizona State University, Tempe, Arizona 85282.

The origin and general geology of mare ridges have been the subject of debate since the beginning of lunar geologic study. Hypotheses of origin center on two main themes–tectonism and volcanism, as reviewed by Head (1) and Lucchitta (2). Good evidence to support both origins exists for a few individual ridges and the conclusion is reached that some ridges are tectonic, some result from volcanic processes (intrusive and/or extrusive activity), and others may involve a combination of both processes. The Mariner 10 mission to Mercury and Mariner and Viking missions to Mars have revealed ridges similar in size and morphology to mare ridges on the Moon. Because lunar mare ridges are formed on mare basalts, this relation has been taken as a tentative criterion for the identification of basalt-like, or at least volcanic units on Mercury and Mars. At the same time, because some mare ridges are also demonstrably tectonic, other mare ridges have been used in studies of the structural deformation of planetary surfaces. Thus, in order for the interpretations of the tectonic and volcanic histories to be valid, the geology of the mare ridges upon which the interpretations are based must be well known. This has prompted detailed studies of ridges, such as those of Lucchitta and others currently in progress.

Despite the near ubiquitous occurrence of mare-type ridges on the known terrestrial planets (Moon, Mars, Mercury), until now, satisfactory full-scale analogs have not been described on Earth, either because they have not formed on Earth, they have not been preserved in a readily recognizable state, or because they occur in the vast unexplored regions of the ocean floor or more remote continental areas. Some interesting small-scale features formed by crustal buckling on terrestrial lava lakes have been proposed as analogs (3, 4).

Recent surveys of LANDSAT images and the literature, together with limited field work, suggest that a series of ridges in the western Columbia Plateau may hold clues to the nature and origin of mare ridges on the terrestrial planets. The Columbia Plateau is one of the largest volcanic flood basalt provinces in the world, exceeding $5.2 \times 10^5 km^2$ in areal extent. Early regional geologic studies (5, 6, 7) noted the presence of long, linear to slightly sinuous ridges confined to Columbia basalts that provide most of the surface relief on the plateau. Individual ridges may be up to 130 km in length and range in width from 1 to 5.5 km. Typical surface relief is highly variable, ranging from 50 to 350 m. The regional strike of the ridges is generally in the WNW direction but local variations from that trend are common. These ridges were interpreted in early mapping efforts as anticlinal folds confined to Columbia River basalts (6, 7) and this interpretation has been verified by most subsequent studies (8, 9, 10).

Accepting the anticlinal fold interpretation for the Columbia Plateau ridges does not give immediate insight into their origin. Surficial compression of the lavas has been invoked by some (6, 8) and observations of locally interbedded sediments support ideas of considerable bedding-plane slip and mostly shallow level deformation. Others have argued that the ridges are drape-folds over rotated basement fault blocks (10) and attach little importance to surficial compression. The Columbia basalts lie within a large structural basin (11), but the ridges show no preferred orientation with basin trends. The ultimate explanation of the origin of these ridges remains a problem.

Ridges on the planets, primarily the Moon and Mars, may take many forms, but most are basically similar. In mare units on the Moon, ridges commonly consist of broad elevated arches with crenulated crests of narrow dimension (12). This morphology is distinct from ridges that occur in the lunar highlands which are typically simple scarps. This "wave-ridge" morphology is also seen on Mars where they are confined primarily to smooth plains units, such as Chryse Planitia (13). Table 1 is a compilation of some of the rather limited morphometric data available for ridges on the three planets. It should be noted that these ridges all occur on flood lavas and have similar geologic settings (structural basin location). It is seen that the ridges on all three planets are very similar in

RIDGES IN WESTERN COLUMBIA PLATEAU

Greeley, R. and Spudis, P. D.

size and shape. The main anomaly seems to be the relatively greater relief of the terrestrial (Columbia Plateau) ridges. This may be due in part to the location of the western Columbia Plateau adjacent to the High Cascade watershed; fluvial erosion has probably accentuated and exaggerated the relative relief of the ridges in this area. Rates of erosion on the Moon and Mars are orders of magnitude lower than the Earth and the original relief of the Columbia Plateau ridges may have been comparable to those on the other planets.

The geologic setting, morphometry, and morphology of the Columbia Plateau ridges and comparison with similar features on the other terrestrial planets are considered provocative, but the true significance of the structures to the planetary problem of mare ridges is not clear at this time. Future plans include detailed photogeologic and field investigation of the ridges as possible analogs to the planetary structures that have intrigued and perplexed planetary investigators for many years.

REFERENCES

(1) Head, J. W. (1976) Rev. Geophys. Space Phys. 14: 265-300. (2) Lucchitta, B. K. (1976) Proc. Lun. Sci. Conf. 7: 2761-2782. (3) Bryan, W. B. (1973) Proc. Lun. Sci. Conf. 4: 93-106. (4) Hodges, C. A. (1973) NASA SP 330: 31-12 to 31-21. (5) Smith, G. O. (1901) USGS Water Supply Paper 55. (6) Smith, G. O. (1903) J. Geol. 11: 166-177. (7) Calkins, F. C. (1905) USGS Water Supply Paper 118. (8) Waters, A. C. (1955) GSA Bull. 66: 663-684. (9) Swanson, D. A. (1967) GSA Bull. 78: 1077-1110. (10) Bentley, R. D. (1977) GSA Mtg. Guidebook, West. Wash. Univ., p. 339. (11) Swanson, D. A. (1977) pers. comm. (12) Strom, R. G. (1971) Mod. Geol. 2: 133-157. (13) Greeley, R. and others (1977) JGR 82: 4093-4109.

Table 1
Ridge Morphometry

Planet	Earth	Moon	Mars
N	5	4	4
L	76 km	68 km	64 km
W	3 km	4.3 km	3 km
r	300 m	170 m	110 m

N = number ridges measured (selected areas)
L = average length, km
W = average width, km
r = average relief relative to surrounding plain, m

Data Sources:	Earth	AMS 1:250,000 series - Yakima sheet, Walla Walla Sheet (Columbia Plateau)
	Moon	LTO 75 C1 Scheele (Herigonius)
	Mars	USGS I - 1059 Yorktown (Chryse Planitia)