RIFT VALLEYS OF MARS AND EARTH: STRUCTURAL COMPARISONS AND IMPLICATIONS; Herbert Frey, Geophysics Branch, NASA/GSFC, Greenbelt, MD and Astronomy Program, University of MD, College Park, MD.

Despite its small size, Mars shows evidence of geologic activity closely related to the global plate tectonic style of the Earth. The large crustal uplift at Tharsis, and the associated giant shield volcanoes and rifts of the Valles Marineris (1,2) all suggest a level of crustal evolutionary development which is best characterized as "incipient plate tectonics." Knowledge of the nature and evolution of the martian tectonic structures may shed light on the early stages of plate tectonics of the Earth. In this paper comparisons are made between the martian rift canyons and the rift valleys of the Earth, especially those of East Africa.

Detailed comparisons are difficult because knowledge of the martian canyons is limited to Mariner 9 and Viking Orbiter imagery and related observations. These have shown that the martian canyons are severely eroded by fluvial activity as well as by scarp retreat and mass wasting (3,4). These same images have also revealed that portions of these walls are apparently more resistant to erosion; these "resistant points" occur as wedge-like projections or ridges and should provide a closer approximation to the original scarps that form the canyons (5). Linear trends of these resistant points may indicate, at least roughly, the major faults controlling these rift structures. Figure 1 shows one attempt at reconstructing the original scarps based on the locations of these less-eroded parts of the canyons. Individual canyons are better delineated in this way, and may now be compared with the well-known structures of Africa (6,7,8).

DIMENSIONAL COMPARISONS. Lengths: It is often said that the martian rifts are large (9), but as indicated by Figure 1, this is not true of their long dimensions. Individual canyons of the Valles Marineris range from 150-610 km in length. African rifts may be as short as 100 km or as long as 800 km. More meaningful than absolute dimensions are the rift lengths compared to planetary radius; described this way martian canyons and African rifts show very similar histograms (Figure 2A). This is true both for individual rifts and for compound systems, such as Coprates of Mars and the Western Rift of Africa. The lack of very small martian rifts, with L/R=0.01-0.05, is due in part to exclusion of martian cantera and pit chains, which have exactly these proportions. Widths: Martian canyons are wide compared with African rifts: typical values in the Valles Marineris average 85 km while on Earth the general width is 50 km. In terms of the planetary radius (Figure 2B), martian canyons are 3 times wider than African rifts of comparable L/R. This cannot be attributed entirely to erosion, as mapping canyon walls from resistant points compensates, to first order, for the effects of scarp retreat and mass wasting. Depths: Even when allowance is made for erosion and volcanic filling on the Earth, martian canyons are generally deeper. The Baikal Rift is an exception (9,10). Typical throws of the major faults in Africa are 2-3 km; the depth of the martian canyons in the central Valles Marineris is generally 6 km (11).

STRUCTURAL TRENDS. African rifts, while maintaining a general N-S trend, seldom follow this direction on a local basis (6). A complex pattern is revealed by the individual faults, although parallelism of bounding faults is generally preserved. There are fewer directional variations on Mars, both
within a given canyon and even within the rift system as a whole, which maintains a close E15S trend. Major trend-preserving faults, inferred from resistant points (Figure 1), are longer on Mars than in Africa (400-600 km on Mars, 100-200 on Earth).

**IMPLICATIONS.** The fact that both Mars and Africa show the same distribution of L/R suggests that the process responsible (if common) scales with planetary size. Temporal duration or lithospheric immobility are probably of little consequence in establishing the length of martian canyons. This is significantly different from the development of the uplift and shield volcanoes at Tharsis, whose size is due to lithosphere immobility (2,5). It has often been shown that terrestrial rifts have widths comparable to crustal thickness (8,9). Mechanically it may be the lithosphere thickness that is important, although directly below terrestrial rifts this may approach the crustal thickness. Martian canyons are significantly wider than terrestrial rifts. The depth of the martian crust is unknown, but it is generally inferred to be thicker than that of the Earth (12,13). Thermal history calculations show the martian lithosphere to have been significantly thicker than the Earth’s throughout the history of Mars (14). The wider extent of the martian rifts is consistent with the terrestrial situation, and may provide yet another indirect determination of the thickness of the crust in the region of the Valles Marineris.

The variation in trend within African rifts and rift systems reflects basement control (6,7); the faulting follows Precambrian structures. The complex trends in Africa are therefore indicative of the complex tectonic and orogenic history of the terrestrial lithosphere. The relatively simple trends in the Valles Marineris suggest a relatively simple basement structure; this would be expected on a planet without a complex tectonic history. The rifts on Mars represent the first major fractures of the lithosphere and are most likely due to two periods of crustal doming (5). But this fracturing occurred in a lithosphere already thicker than that of even the present-day Earth; to this extent the martian rift valley system cannot be considered a strict analog of first rifting on the Earth.

**REFERENCES**

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Figure 1. Sketch map of the Valles Marineris. Solid lines indicate reconstruction of canyon walls based on linear trends in most resistant points. Dotted lines indicate less certain reconstructions. Symbols marking individual canyons are same as in Figure 2.

Figure 2. Histograms of rift-canyon dimensions relative to planetary radius. (A) Length divided by radius for Africa (top) and for Mars (bottom). (B) Width divided by radius for Africa (top) and for Mars (bottom). Symbols refer to individual rifts or canyons; for Mars those are shown in Figure 1.