RIFT SYSTEM ARCHITECTURE ON VENUS.
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Introduction: Terrestrial rift systems are composed of structures with a variety of length scales. At the shortest length scale, individual faults form discrete rift basins. These basins link together to form more complex rift systems [e.g., 1]. For example, the East African Rift system can be subdivided into several distinct rift branches, the Ethiopian Rift, the Kenya Rift, and the Western Rift [1,2]. In turn, each of these rift branches is composed of numerous distinct rift basins. For example, the Western Rift has been subdivided into 23 distinct segments in its northern region and an additional 9 segments in the southern Malawi rift region on the basis of boundary fault geometry [3,4]. These individual rift segments frequently form distinct topographic basins, as manifested by the numerous rift valley lakes in eastern Africa.

Devana Chasma has long been recognized as one of the major examples of rifting on Venus [5-10]. In this work, we use topographic profiles across Devana Chasma to assess the basin scale structure of this rift system. We focus on a 2500 km long segment of Devana between 20° North and 4° South which lies in the plains between Beta Regio and Phoebe Regio. There is a 600 km offset in the trend of Devana Chasma near 8° North. Interpretation of the gravity anomaly along the rift, the decreased fault density in the offset region, and the virtual absence of rift flank topography within the offset suggest that Devana should actually be considered to be two distinct rifts. One of the rifts propagated southward from Beta Regio and the other propagated northward from Phoebe Regio [11,12]. Here, we consider examples from both the Beta and Phoebe branches of Devana Chasma.

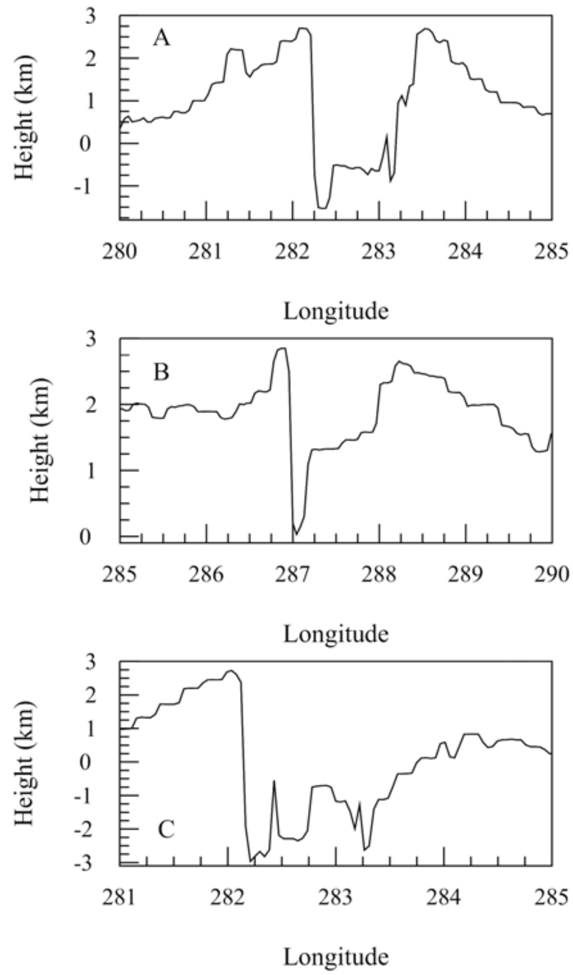

Figure 1: (a) Topographic profile across full graben in Devana Chasma, 16.5° North. (b) Topographic profile across asymmetric graben in Devana Chasma, 2° South. (c) Topographic profile across half-graben in Devana Chasma, 15.1° North.

Full Graben and Half-graben: Terrestrial rift basins are commonly half-graben, with a single dominant boundary fault and a highly asymmetric basin geometry [1]. This is apparent in topographic profiles [3,4] and in reflection seismology, gravity, and aeromagnetic profiles that reveal patterns of subsurface faulting [13,14]. One hypothesis is that these structures form with a single dominant normal fault. This becomes the boundary fault for the half-graben, and the topographic relief on the footwall side of the fault becomes the most prominent rift flank. The flexural response to the change in topography created by fault motion leads to uplift on the hanging wall side of the fault, producing the other rift flank [15,16]. An alternative model is that the rift initially forms as a pair of conjugate faults, producing an initially symmetric full graben. However, if one of the faults slips more rapidly than the other, it will eventually offset the second fault at depth, terminating slip on the second fault. The more rapidly growing fault becomes the boundary fault of an increasingly asymmetric half-graben system [17].

Figure 1 shows two examples of full graben along Devana Chasma. Figure 1a is a profile taken along 16.5° North latitude. The rift flank topography has a high degree of symmetry across the basin, with peak rift flank elevations being 2 km higher the surrounding terrain. Both sides of the rift basin are bounded by steep normal faults, with 4 km of offset on the west side and 3.5 km of offset on the east side. Radar imagery shows that the faulting in this area is confined to the topographic basin and is pervasive across the basin floor. Figure 1b shows a more asymmetric structure at 2° South. Lava flows on the rift flanks suggest that the rift in this region cuts through a preexisting volcano, so at least part of the rift flank topography is constructional. The western side of the basin is dominated by a single boundary fault system, with a vertical offset of 2.8 km. The topographic relief on the east side of the basin occurs dominantly on two structures with vertical offsets of 1.0 and 1.3 km. Faulting is strongly restricted to the vicinity of the basin walls, with little deformation on the basin floor, in contrast to the region shown in Figure 1a.

Half-graben do occur occasionally in Devana Chasma, but they are rare. Figure 1c is a profile taken along 15.1° North. The boundary fault is on the west side of the basin, with a vertical relief of 5.5 km. The gradual topographic rise on the east side of the basin is reminiscent of terrestrial half-graben topography profiles. However, considerable faulting has occurred off of the boundary fault, as shown by the topographic variations along the basin floor. Radar imagery shows that the faulting is most concentrated between 282° and 283.5° longitude. Faulting does occur east of 283.5°, in the region of the presumed flexural arch, but it is much less densely spaced.

Multiple Parallel Graben: Figure 2 shows a topographic profile across two closely spaced rift basins at 4.5° North. In both basins, the dominant fault appears to be on the western side of the basin. The western basin is 2.8 km deep and just 60 km wide. The eastern basin is shallower (2.6 km), wider (125 km), and more asymmetric. Between 4.5° and 5.5° North, these two basins parallel one another. Between 5.5° and 6.5° North, the basin at 288.7° East is paralleled on its western side by another rift basin located at 287.5° East. Thus, for a 200 km long section, Devana Chasma consists of two deep, closely spaced (basin centers < 150 km apart), parallel basins. Multiple basins are also seen in some other parts of Devana, although the example shown here is the longest set of parallel basins that we have documented so far.

Conclusions: Devana Chasma, like the East African Rift system on Earth, formed as a result of rifting due to stresses from upwelling mantle plumes. Nevertheless, we have shown here that there are some significant structural differences between Devana and the East African Rift. In Devana, individual rift basins are frequently full graben, rather than the half-graben that usually occur on Earth. Moreover, the closely spaced, parallel rift basins that occur in parts of Devana are unlike the usual terrestrial case, in which only a single rift basin usually occurs at any given point along the strike of the rift system. These structural differences may be due to differences in lithospheric structure between Venus and Earth [e.g., 18]. The quantitative implications of our observations for lithospheric structure in this part of Venus are currently being assessed.

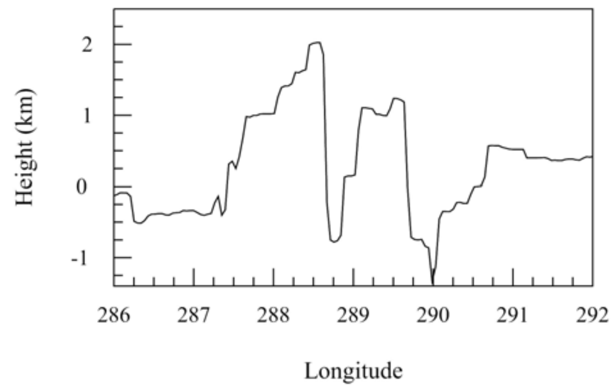

Figure 2: Topographic profile across two closely spaced rift basins in Devana Chasma, 4.5° North.

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