THE TECTONICS AND TOPOGRAPHY OF THE DICHOTOMY BOUNDARY IN THE EASTERN HEMISPHERE OF MARS.

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Introduction: One of most compelling and enduring questions about geologic evolution of Mars is the origin of the hemispheric dichotomy. In the eastern hemisphere the dichotomy boundary is marked by a steep scarp and a dramatic elevation change. Tectonic features in the eastern hemisphere suggest a deformational event involving both extension and compression was connected with the formation of the dichotomy boundary [1, 2].

Tectonics: In the highlands of Amenthes-northern Terra Cimmeria and northern Arabia Terra, lobate scarps are found between approximately 200 to 600 km south of the dichotomy boundary. These lobate scarps, interpreted to be the surface expression of thrust faults, are oriented roughly parallel to the dichotomy boundary (Figure 1). The proximity and parallel orientation of thrust faults to the dichotomy boundary suggests that compressional deformation was involved in its formation [2]. Extension along the boundary is thought to have occurred during the Late Noachian to Early Hesperian [3]. Thrust faulting of the highlands near the boundary appears to have occurred during roughly the same period [2, 4]. Thus the fractures and thrust faults may reflect a tectonic event that was associated with the dichotomy boundary (Figure 1). The deformation along the boundary suggests that the dichotomy formed in the Late Noachian to Early Hesperian [2, 3]. If the dichotomy formed earlier, this deformational event may have been responsible for shaping the present-day dichotomy boundary in the eastern hemisphere.

Topography: MOLA data [5, 6] has provided a detailed view of the morphology of the dichotomy boundary in the eastern hemisphere. In Amenthes, the dichotomy boundary is marked by a scarp with maximum slopes on the order of 15º (Figure 2). The extensional features are generally located on and adjacent to these relatively steep slopes and may extend into the northern plains. The highlands behind the scarp have very gently dipping slopes. The regional slope, however, is often away from the dichotomy boundary (Figure 2B, C). The area between the scarp and highland back slopes is often characterized by a broad rise (Figure 2). The thrust fault expressed by the lobate scarps are usually located on the back slopes. This is the case for the Amenthes Rupes, the largest thrust fault structure along the boundary (Figure 2C) [2, 4]. In this area, the boundary is marked by a more gently sloping, continuous surface (maximum slope of ~ 6º) (Figure 2C). In northern Arabia Terra, the morphology of the boundary is similar to that in Amenthes-northern Terra Cimmeria. The boundary is marked by a scarp, and the highland behind the scarp form a broad rise with gentle slopes (compare Figure 17 and 18). The fractures and faults are found along and adjacent to the boundary scarp, and the lobate scarps occur on the broad rise and on the back slopes. The spatial relationship of tectonic features, the time of their formation, and the morphology of the boundary suggest that lithospheric flexure may have played a role in the formation of the dichotomy boundary.

Age of Dichotomy: The available evidence suggests two possibilities for the age of the dichotomy: 1) the dichotomy formed in the Early Noachian, or 2) the dichotomy formed in the Late Noachian to Early Hesperian. Whether the dichotomy formed very early or later in Mars' geologic history, the implications are testable. If the crustal dichotomy formed in the Early Noachian from mantle convection and downwelling [3, 7, 8] or a very early episode of lithospheric recycling [9], the ancient boundary in the eastern hemisphere was tectonically altered during the Late Noachian to Early Hesperian. Models for an early origin have to explain how the northern lowlands have remained a topographic low over the history of the planet [10, 11]. If the dichotomy formed during the Late Noachian to Early Hesperian from mantle convection and downwelling, models have to account for the preservation of the ancient crust below the northern plains materials [12].

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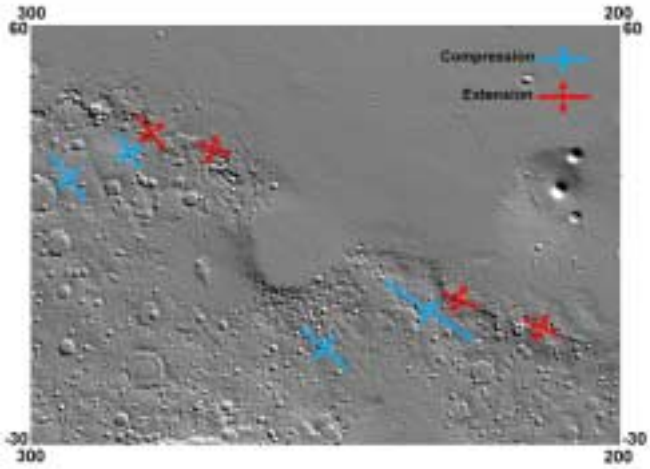

Figure 1. Inferred stresses based on the location of thrust faults (lobate scarps) and fractures and normal faults are overlaid on a shaded relief map derived from MOLA 1/16 degree/pixel resolution gridded data.

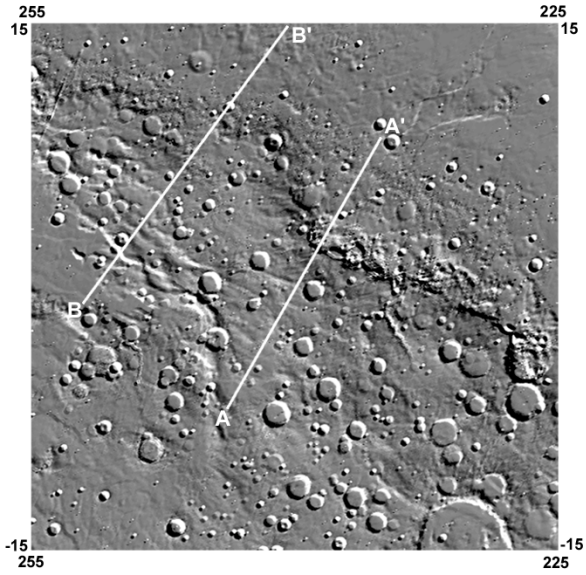

Figure 2A. Shaded relief map of the dichotomy boundary in the Amenthes-northern Terra Cimmeria region derived from MOLA 1/32 degree/pixel resolution gridded data.

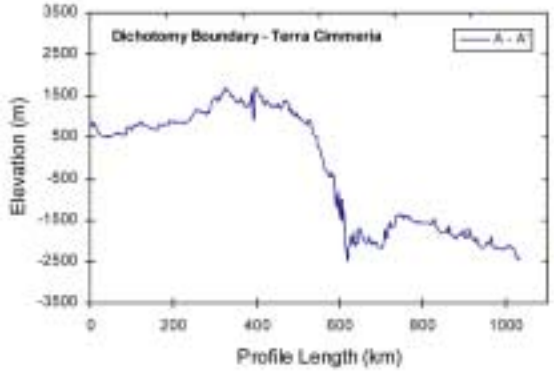

Figure 2B. MOLA profile across the dichotomy boundary in northern Terra Cimmeria. Profile location is shown in Figure 2A. Profile was derived from MOLA 1/32 degree/pixel resolution gridded data. Vertical exaggeration is ~100:1.

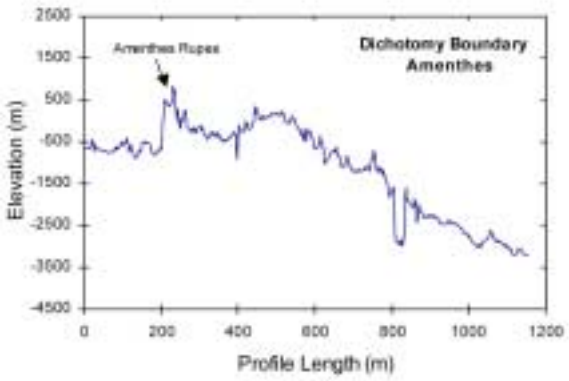

Figure 2C. MOLA profile across the dichotomy boundary in Amenthes. Profile location is shown in Figure 2A. Profile was derived from MOLA 1/32 degree/pixel resolution gridded data. Vertical exaggeration is ~110:1.

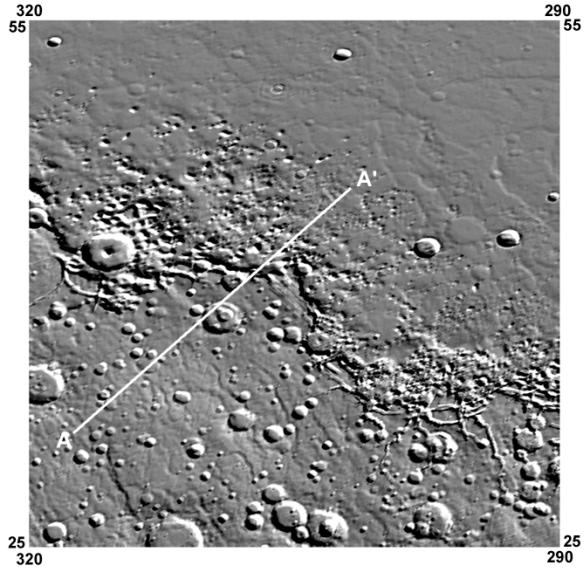

Figure 3A. Shaded relief map of the dichotomy boundary in the northern Arabia Terra region derived from MOLA 1/32 degree/pixel resolution gridded data.

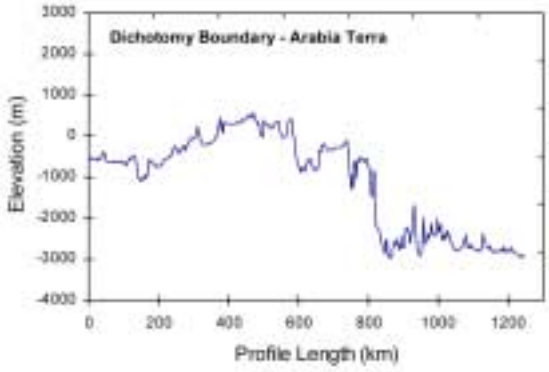

Figure 3B. MOLA profile across the dichotomy boundary in northern Arabia Terra. Profile location is shown in Figure 3A. Profile was derived from MOLA 1/32 degree/pixel resolution gridded data. Vertical exaggeration is ~120:1.