Geophysical Research Abstracts, Vol. 7, 04244, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04244

Acheron Fossae, Mars: A Martian rift observed by the High Resolution Stereo Camera (HRSC)

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The Acheron Fossae region is situated about 1000 km north of Olympus Mons in the northwestern Tharsis province. Topographic data show a curvilinear ridge, about 600 km long and 25-100 km wide and rising more than 2000 m above its surroundings. The name-giving extensional structures (Fossae), the topographic rise and its shape as well as its isolated position between the lowlands to the north, the Olympus Mons aureole deposits to the south, and Alba Patera lava flows to the east, have not been investigated in detail before. High-resolution colour orthoimages and a Digital Elevation Model (DEM) covering the northern and eastern parts of Acheron Fossae, both derived from data acquired by the High Resolution Stereo Camera (HRSC) on Mars Express, were used for a detailed photogeological survey and analysis of geomorphologic features and their structural setting. HRSC-data and crosscutting relationships reveal a rather complex tectonic history of the Acheron Fossae region, with three periods of magmatectonic activity. During a first period, crustal flexure lead to the formation of an early mountain range. Later on, a rift-like complex graben system (Acheron Fossae I), about 500 km in observable length, 30-155 km wide and trending SE-NW to E-W, was superimposed on the pre-existing montain range. In its eastern part, a topographic rise up to 3000 m in altitude with a small volcano on top indicates magmatic uprise and syntectonic volcanism. Along strike, magmatic uprise caused crustal upwarping, changes in rift elevation and local tilting of graben floors. Rift architecture changes westwards from a more spatially distributed extensional faulting over a width of 155 km (eastern segment of Acheron Fossae I) to focussed extensional deformation in its

western segment, documented by two deep and very extensive graben (rift width 65 km). Fault lengths of normal faults vary from 30 to 150 km. Fault scarps of master faults show 1200-2200 m of observable throw. Measured strain varies between 4 % and 9 %. Towards east, the rift-like graben system of Acheron Fossae I ends abruptly, for yet unknown reasons. In its western part, the E-W striking Acheron Fossae I system of subparallel graben is crossed and vertically displaced (1225 m of observable throw) by a younger SE-NW trending graben system, the Acheron Fossae II, which is about 300 km long and 20-50 km wide. Its major fault segments vary from 30-80 km. Where the Acheron Fossae II system meets the Acheron Fossae I system, the Acheron Fossae II graben bifurcates and a double graben system crosses westwards a topographical and structural high, which is related to local magmatic uprise. Graben floors are tilted and dipping away from this topographical rise. Observable throw varies from 800-1200 m. Towards the west, the Acheron Fossae II structures disappear at the border to the northern lowlands, which are composed of lava, as evidenced by very small and low volcanic shields. Formation and development of the Acheron Fossae mountain range on one hand (crustal flexure) and of the rift-like systems of Acheron Fossae I and II on the other hand (crustal extension) document quite different magmatectonic processes and fundamental changes in character and orientation of crustal stress fields operating near the dichotomy boundary. One should expect that the Acheron Fossae I and II graben systems did extend further westwards and eastwards, originally.