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Structural characteristics of Pavonis Mons, Mars, and implications for its volcano-tectonic evolution

Klaus Gwinner (1,2), James W. Head (2), and Lionel Wilson (3)

(1) German Aerospace Center (DLR), Institute of Planetary Research, Berlin, Germany (klaus.gwinner@dlr.de), (2) Department of Geological Sciences, Brown University, Providence, USA, (3) Environmental Science Department, Lancaster University, Lancaster, United Kingdom

Pavonis Mons is the smallest of the three large Tharsis Montes volcanic edifices on Mars. While Viking-based studies have already revealed main structural features of these shields and have provided a framework on their evolution, detailed information on major aspects of their volcano-tectonic structure and evolution is still incomplete. In particular this is the case for the nature of asymmetries that develop along a NE direction, roughly coincident with the crest line of the Tharsis rise, as well as the evolution of the magma reservoir as the shields were built above the ground, and the related consequences for caldera formation and edifice stability. In addition, different morpho-structural features of the Martian shields have been discussed controversially, such as flank "terraces", rillelike channels, and evidence of flank instabilities. We have analyzed recently available high-resolution data, in particular DTMs with up to 50 m grid spacing derived from HRSC data, as well as high-resolution imagery (HRSC, CTX, HIRISE) and regional-scale MOLA DTMs for obtaining new constraints on the volcano-tectonic structure and evolution of Pavonis. We mapped tectonic elements (faults and fractures, wrinkle ridges, collapse pits), main volcanic elements (vent locations, limits of shield, apron and caldera floor units), and elements of flank morphology. Analysis of edifice morphometry is based on slope maps and slope statistics.

We were able to identify several major fault systems affecting flanks and base of the edifice. Widespread occurrence of normal faulting from 2-3 km below the summit plateau to the base shows that the middle and lower flanks are characterized by extension. While the summit plateau and uppermost flanks show evidence for compressional deformation, including wrinkle ridges and downslope-convex flank facets interpreted as surface expression of flank thrusts, the system of intersecting flank facets that have been denoted as compressional "terraces" instead shows different morphological characteristics on the middle and lower flanks and includes an increasing number of fan-shaped deposits towards the base of the shield. Close to the up-slope margin of these deposits, flank vents are observed in a number of locations.

While, unlike Arsia Mons, no well developed chain of small shields connects the embayments of the SW and NE flanks of Pavonis, our results further support the hypothesis that a zone of repeated intrusions by parallel dikes, crossing below the summit, is also present in the subsurface of Pavonis. In particular, the density map of pit crater chains shows maxima at both embayments and also preferential occurence in a 20-30 km wide zone connecting the embayments and trending NNE-SSW. The centers of both summit calderas are aligned with this zone as well as a cluster of fissure vents and small cones on the floor of the earlier caldera.

On the basis of increased density of fractures, presence of a wide flank graben system that locally has produced a concave-upward flank profile, depression of the summit plateau of as much as 1-1.5 km, and the highest number of flank facets of all flanks we suggest that the eastern flank of the shield is subject to sector instability that, from cross-cutting relationships, was initiated before the collapse of the two summit calderas. The instable sector is delimited to the north by the NE embayment, the collapse walls of which are bordered by a set of parallel normal faults. We will discuss further implications of our results for regional and edifice stresses, the physical conditions for magma ascent and storage, and the scenario for the more recent phases of the volcano-tectonic evolution of the edifice, and relationships with similar examples on Mars and Earth.