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The role of water eruptions in the structure and history of Ascraeus Mons volcano, Mars

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We establish a time-stratigraphic sequence for the lava flows, sinuous rilles, flank vents and tectonic features of Ascraeus Mons volcano, situated on the Tharsis ridge of Mars. We have applied a numerical lava emplacement and erosion model to Digital Terrain Models of the sinuous rilles, constructed from Mars Express HRSC stereo imagery, and conclude that these rilles were formed by water erosion. The overall structure of the volcano is dissimilar to that of large terrestrial volcanoes in important respects, and we have performed laboratory analogue experiments of its deformation, which indicate that the tectonic features were formed by sinking of the volcano into a substratum that was much weaker than the volcanic edifice. An ice-rich substratum melted by a combination of pressure melting and magmatic heating seems the most likely mechanism. Analogous water-escape structures in a similar volcanic situation have been identified at Mt Haddington in the Antarctic, Réunion Island in the Indian Ocean, and other volcanoes. A possible Martian hydrological cycle and a hydrothermal system within the volcano may have contributed to prolonged subsurface water flow, and weakening of the volcano core. Based on field evidence, we propose that much of the broad aprons of lobate flows issuing from the NE and SSW foot of Ascraeus Mons are composed of mudflows rather than lava flows. These different strands of evidence can be linked into a coherent history of this volcano. The similarity of Ascraeus Mons to Pavonis Mons and Arsia Mons (though Ascraeus is younger) suggests that some of our conclusions may apply to these volcanoes too.