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Types, morphology, and significance of vent structures on the summit and flanks of Pavonis Mons, Mars

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Small volcanic edifices in volcanic plains-type and rift-related settings of Mars were given much consideration recently, but only a few reports have addressed vent-related morphologies on the flanks and in the summit regions of the large Martian shields. Impact crater chronology has shown ages on the order of only few hundred million years for several of the shield calderas, despite the much higher ages of the entire edifices. Theoretical considerations suggest that the magma supply to the volcanoes must have been episodic, with pulses of increased magma supply from the mantle occurring on the order of every few hundred million years, which is compatible with the age differences of intersecting calderas. A key question for understanding the volcanic evolution concerns the age and structure of the flanks of the shields and their involvement in the volcanic activity through time.

Based on impact crater chronology using CTX data, we can demonstrate that Pavonis Mons showed 3-4 periods of emplacement of large volumes of volcanic deposits during the last ∼0.5 Myr. These were associated with caldera formation, but also with the formation of new rift apron deposits and with resurfacing of the flanks, most likely being due to volcanic deposition as well. We performed a systematic survey of vent structures and associated local deposits visible on the entire shield, and observe a great number of both on the flanks and inside the caldera complex. We have analyzed recently available high-resolution images (HRSC, CTX, HIRISE), as well as high-resolution DTMs with up to 50 m grid spacing derived from HRSC data and 463 m-resolution MOLA DTMs for morphometric characterization.

We mapped more than 300 vent features, the majority of which are rimless depressions at the head of rille-like channels which formed most likely by erosion by lava. Also a number of small shields characterized by a low crater/cone diameter ratio were formed by mainly effusive flank eruptions. From comparison with terrestrial analogs and taking into account Martian eruption conditions, the edifice heights and the diameters of the crater and cone suggest a significant contribution of fragmented products of explosive eruptions (scoriae or spatter) for a second class of cone-shaped edifices. Two further vent types comprising central vents with lava ramparts and fissure vent associations (linearly arranged narrow troughs and pits associated with small-scale ramparts) usually do not provide sufficient relief to be resolved in the DTM datasets. For all types of vents, emission of lava flows can be observed occasionally. Towards the base of the shield, deposition of volcanic material is indicated by the presence of an increasing number of fan-shaped deposits with terrace-like morphology. Close to the up-slope margin of these deposits, flank vents are locally observed, or the fan apex is linked to collapsed lava tubes or eroded lava channels. Some of these can be traced up-slope to an associated flank vent. We note that almost all mapped vents occur in the same area where the fan-shaped deposits occur, or inside the caldera complex. As with the caldera floor, these flank areas show a significantly younger base age than the remaining part of the summit plateau and the upper flanks, as well as more recent resurfacing. We also note that the occurrence of none of the vent structures and deposits considered is limited to the vicinity of the large rift apron deposits, although some types show a high concentration there. In summary, we suggest that the phases of high volcanic activity of Pavonis during the last ∼0.5 Myr were accompanied – in addition to the formation of rift aprons – by significant resurfacing due to effusive and explosive flank eruptions in other sectors.