WIDESPREAD OCCURRENCE OF DIKES WITHIN THE OLYMPUS MONS AUREOLE MATERIALS.

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Introduction: Since their discovery by Mariner 9, the basal escarpment and aureole materials of Olympus Mons volcano have been recognized as enigmatic features on Mars [1, 2]. Various origins have been proposed for the aureole materials, including gravity sliding [3] and tectonic uplift [4, 5]. We present here a new interpretation for the aureole, based on our analysis of images from the Mars Orbiter Camera (MOC).

Fig. 1: Prominent ridge within the aureole to the west of Olympus Mons at 18°N, 143°. Note that the geometry of the ridge is similar on both sides, with no stratigraphy visible in either wall such as would be expected if this were a tilted block of material transported here by landslides [3]. The flat crest of the ridge, which may be the dike width, is ~35-45 m. Illumination from right. MOC image 53704.

We have identified numerous linear features within the northern and western parts of the aureole that we believe are exhumed dikes (Fig. 1). These features possess very narrow (~35 – 45 m) crestal axes, are more resistant to erosion than the adjacent terrain, show a lack of stratigraphy in their vertical faces, and have a "meandering" strike consistent with the characteristics of terrestrial dikes. Inspection of Viking Orbiter images suggests that some dike segments may be 100 – 150 km long, with maximum lengths >300 km. For dikes emplaced under elastic conditions, the ratio of the mean thickness W to the horizontal extent L is equal to $[(\pi/2)(1-\nu)(P/\mu)]$, where ν (~0.25) and μ (~3 GPa) are the Poisson's ratio and shear modulus of the host rocks, and P is the excess pressure in the magma source holding the dike open. Using W ~40 m and L ~200 km, P = ~0.5 MPa. Given that the outcrops probably expose the thinner parts of the dikes near their upper terminations, the true value of the mean thickness may be greater than 40 m by a factor of 2 or 3, implying P = 1-2 MPa. Such values are consistent with the excess pressures inferred for Martian magma reservoirs that are predicted from theoretical models and by analogy with terrestrial examples [4].

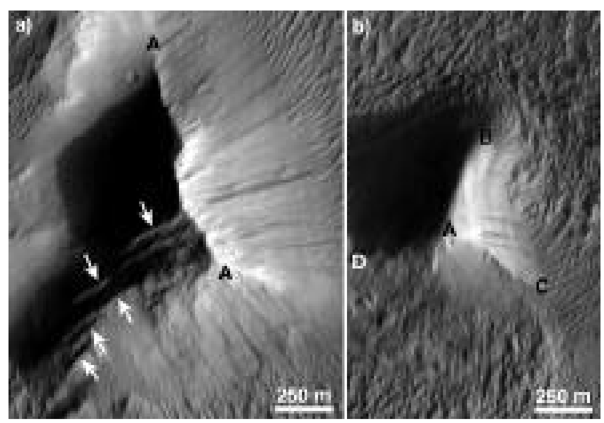

Fig. 2: Possible eroded vent complexes within the aureole materials at 30N, 134°. a) The most prominent trend of the dike is between points "A", but at least five separate, parallel, dikes that are each ~30 m wide (arrowed) can be seen to the west (left). b) Three prominent dike orientations exist within this remnant, between A-B, A-C and A-D. Illumination from right. MOC image 52004.

Eroded Vents? The degree of dike exposure implies that they have been exumed to a significant depth beneath the original surface. Shadow length measurements suggest that >120 m of overlying material must have been removed, even assuming that the dikes reached the original surface. If the dike never reached the original surface, then even more material must have been removed. This 3-dimensional view of the dike swarm enables local characteristics to be investigated. We have found good examples of radiating dikes that may indicate local centers of intrusion. Numerous parallel dikes intersect a dike that follows the regional trend (Fig. 2a), while Fig. 2b may illustrate an example of a partly preserved vent complex. These local centers might represent the "cores" of small volcanoes that once formed to the north of Olympus Mons and have subsequently been eroded. The diameter of these complexes is comparable to the small domes identified in Tempe Fossae [6].

Evidence for Young Age: Lobate lava flows can be seen to the north of the escarpment (Fig. 3). These flows are morphologically similar to many seen in the Tharsis [7] and Elysium Planitia [8] regions of Mars. However, within 10 km of the base of the Olympus Mons escarpment there is the first of several linear ridges aligned ESE – NNW. A striking attribute of this ridge is that it is clear that it is constructed on top of the young lava flows. Two prominent flow boundaries can be traced from the south side of the ridge and connected with flows north of the ridge (Fig. 3). None of the flows appear to have been diverted by the ridge as they flowed north, and so we infer that the ridge did not exist when the flows were emplaced. We suggest that the ridge is the product of phreato-magmatic activity where a shallow dike interacted with volatiles occupying pore spaces in the sequence of lava flows.

Implications and Future Studies: Few MOC images of the Olympus Mons aureole material are currently available to study the detailed morphology of the ridges. If these features are indeed dikes, then the following questions need to be investigated:

1) Is the majority of the Olympus Mons aureole composed of material formed by dike intrusion into volatile-rich substrates?
2) Where is the center of the igneous complex? The possibility that there was either a local center (i.e., a "failed" volcanic construct) or a regional dike complex [9] should be investigated.
3) How recently was the center active and was there a single center? Evidence for cross-cutting relationships between dike segments should also be sought in order to constrain temporal relationships.
4) How much over-lying material has been stripped from the area to expose the dikes? The exumed complexes shown in Fig. 2 suggest that >120 m has been removed from some areas. Is this a typical value?
5) How common was explosive activity due to dike intrusion? We describe elsewhere [10] the possibility that explosive volcanism may have been initiated on the northern Olympus Mons escarpment by dike intrusion into volatile rich layers. A search should be made of the MOC data to see if additional phreato-magmatic activity occurred within the aureole materials.

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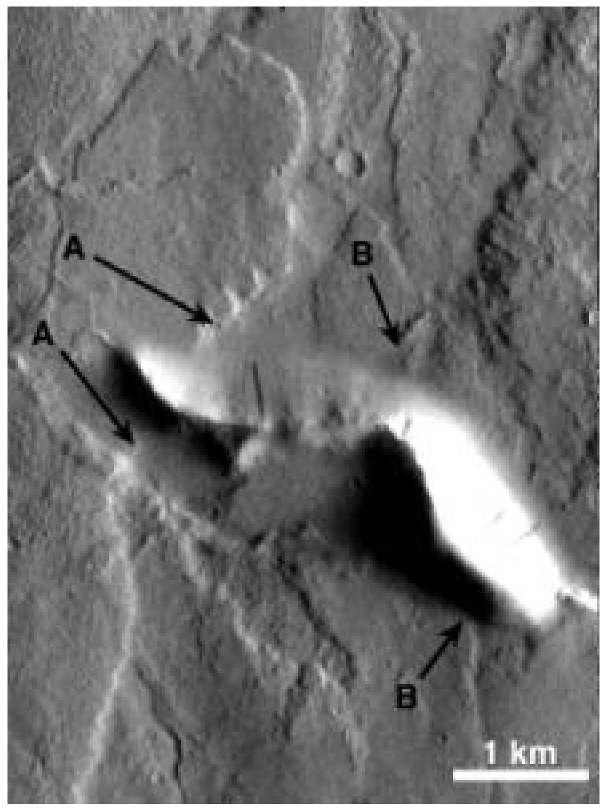

Fig. 3: Linear ridge located just to the north of the Olympus Mons escarpment at 24°N, 133°. Arrows "A" and "B" point to two lava flows that extend beneath the ridge, implying that the ridge has only recently been constructed. Illumination from right, north towards the top. MOC image 46605f.

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