THARSIS AUREOLE DEPOSITS: AN ALTERNATIVE ORIGIN, S. H. Williams, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058-4399

Aureole deposits are semi-circular zones of distinctively ridged and grooved terrain associated with the Tharsis volcanoes, particularly Olympus Mons. Numerous emplacement mechanisms have been proposed, including lava flows or the remnants of an ancient volcanic construct (1,2), subglacial volcanics (3), ignimbrite sheets (4), landslide deposits (5,6), thrust sheets extruded by the weight of the Tharsis constructs (7), thrust sheets emplaced by gravitational spreading (8,9), and the eroded remnants of plutons (10).

Any successful theory of aureole development must be able to adequately explain all of the following observations.

A) Aureole deposits are characterized by concentric and radial ridges and grooves. Along some are offsets; others show no relative horizontal motion.

B) The distribution of aureole lobes is not symmetric with respect to the Olympus construct. There is no correlation between the distribution of aureole deposits and the shape of the Olympus basal scarp.

C) The edges of the aureole deposits display complex morphologies. In some places, the aureole feathers out; in others, the aureole ends in a scarp. In some instances, the edge of the aureole is parallelled by striations. The edge of the aureole displays complex interactions with craters and tectonic features.

D) In high resolution images (Figure 1), the aureole appears to have been subjected to extensional tectonics and substantial aeolian erosion. The upper several hundred meters of the aureole is unstratified and relatively fine grained. The deposit is sufficiently indurated to allow some steep scarps along radial fractures. Other steeply-dipping layers parallel to the transverse ridges seem to be more indurated; perhaps they represent normal faults. Dunes are found in the lows between transverse ridges.

These observations are fatal to each of the mechanisms proposed for the origin of the aureole deposits. The objections to the lava flow, subglacial volcanics and ignimbrite models are presented in detail in (6). The lack of correlation between the aureole distribution and the Olympus basal scarp is fatal to the landslide hypothesis. If the transverse ridges and valleys are extensional tectonic features, then the aureole lobes cannot have formed by thrusting. Unroofed plutons would coalesce and not form individual lobes.

A hypothesis that fits all of the observed features of the aureole deposits is that each aureole lobe is a thick layer of aeolian material uplifted and exposed to aeolian erosion by the emplacement of large sills during the later stages of the development of the Tharsis volcanic constructs. Fracturing of a relatively brittle layer by uplift during sill emplacement would occur in the observed pattern. The Olympus basal scarp could be due to differential erosion at the base of the construct as the pile is uplifted during sill emplacement. Uplift at the edge of the sill could produce the observed details at the aureole edges. Perhaps sill injection may occur at a threshold construct size, accounting for the prevalence of aureole lobes associated with Olympus. The chief drawback of the sill hypothesis is that terrestrial sills of similar size typically occur in large sedimentary basins (11). This is not thought to be a fatal objection due to the significant differences in the tectonic stress field due to the presence of a large eruptive construct and the nature of the upper few kilometers of the terrestrial and martian surfaces.

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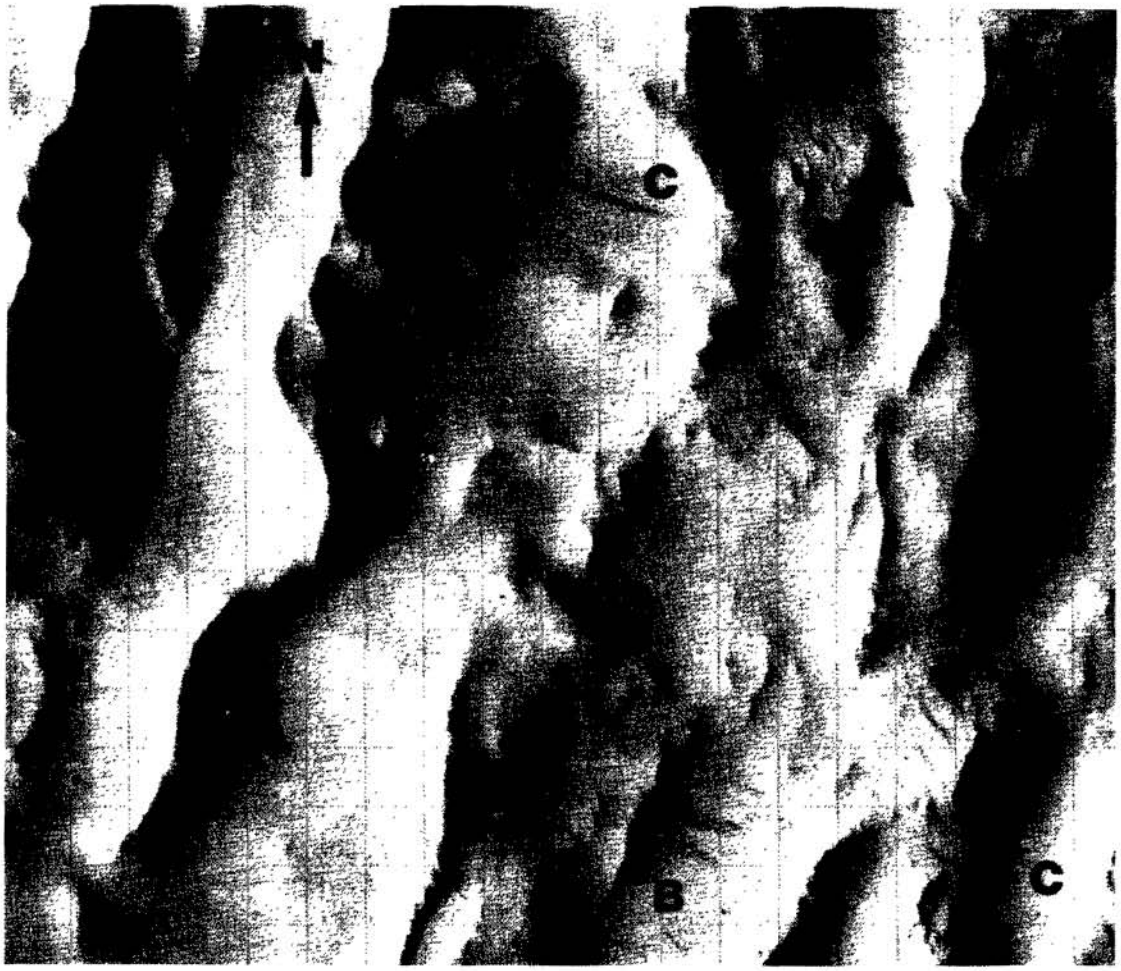


Figure 1. A portion of Viking frame 441B03 at 8.3 m/pixel resolution showing the nonstratified, fine-grained nature of the aureole deposit. Steeply dipping surfaces roughly parallel to the transverse ridges are marked (A) and dunes are at (B). Dark streaks in the talus (C) are eroded remnants of zones in the 50 m size range. It is not likely that they could be boulders that size in ignimbrites, as proposed in (4); perhaps they are eroded zones where alteration has occurred due to preferential volatile transport. Frame width is approximately 7 km.