MORPHOLOGY OF VENUS CALDERAS: SIF AND MAAT MONTES. P. J. Mouginis-Mark, Planetary Geosciences, SOEST, Univ. Hawaii, Honolulu, Hawaii, 96822.

Head and Wilson (1) reviewed the probable internal structure of volcanoes on Venus and the factors that should control the formation of their calderas. These factors include the presence or absence of mantle plumes, less gas exsolution (than on Earth), conditions more favorable to horizontal rather than vertical dike emplacement, and increased reservoir depths with higher elevation. All factors suggest that the morphology, structure and size of Venus calderas should be different from those on Earth. In order to search for morphological evidence for the influence of "neutral buoyancy zones" (1) on the structure of volcanoes of different heights, we have been studying the Magellan imaging radar and altimetric data for Sif Mons (22°N, 352°E) and Maat Mons (1°N, 194°E). Sif Mons rises to an elevation of ~2 km above the surrounding plain (max. elevation equals planetary radius of 6054.4 km), while Maat Mons has ~8 km of relief (max. elevation equals planetary radius of 6060.5 km).

Three types of pits and depressions can be identified on Sif Mons (ref. 2; Fig. 1): a large summit caldera, smaller nested calderas at the summit, and pit chains on the flanks. The largest collapse on Sif Mons is a 40 km diameter central caldera, with two smaller nested calderas each ~10 km across, and numerous pit chains comprised of depressions <1.5 km in diameter. Scalloping along the southern caldera rim indicates multiple episodes of collapse involving progressively smaller volume changes with time. These same types of features are also seen at the summit of Maat Mons (Fig. 2); the largest caldera is ~31 x 28 km in diameter and there are at least five smaller collapse craters at the summit between 5 to 10 km diameter. Extending down the SE flank to a distance of ~40 km is a series of smaller pits which are all >~3 km diameter. At full Magellan resolution (75 m/pixel), there is no sign of any constructional features around the rim of these small pits, indicating that they were all formed by collapse. There is also no sign of radial fractures which might indicate the top of dikes (1). At least two episodes of collapse can be seen on the flanks of Maat Mons, where chains of small pits cut across larger collapse features.

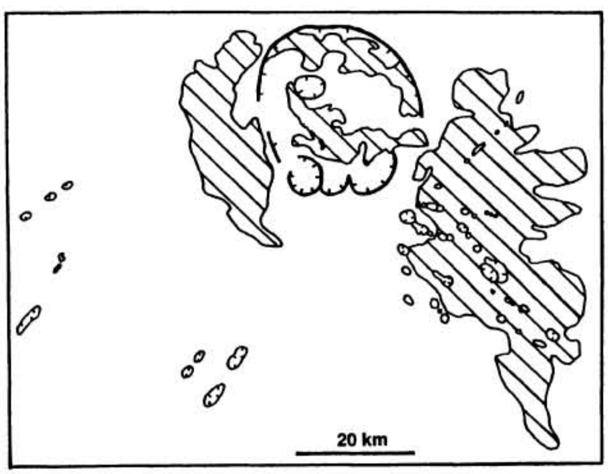

Fig. 1 (Left): Summit of Sif Mons. Fig 2. (Right): Summit of Maat Mons. Both sketch maps show the distribution of the nested calderas, pit craters and radar-dark lava flows (cross-hatch shading) in relation to the main summit caldera. North towards top for both maps.

Compared to calderas found on Mars and Earth (e.g., 3, 4), these two Venus calderas are relatively shallow. Although the Magellan altimetric data have insufficient spatial resolution to confidently determine their absolute depths, in a qualitative sense these calderas appear to be shallower based on the length of the radar shadows. No talus slopes are seen within the Venus calderas, nor are there any constructional features (e.g., cinder cones) apparent on either volcano. Somewhat surprisingly, given the radar's ability to detect subtle topographic relief, there is little evidence that sagging or subsidence of the summits took place following the formation of the calderas. In Martian calderas such as Olympus Mons, Alba Patera, and Pavonis Mons, wrinkle ridges are prominent features and have been used to infer that subsidence occurred over areas that are tens of kilometers across once a lava lake solidified (5). This absence of wrinkle ridges within Venus calderas could either be interpreted as a lack of extensive summit lava flows (i.e., only small-volume eruptions) or the absence of deformation and subsidence after the emplacement of the flows (i.e., no deformation, or the deformation took place prior to the solidification of the lava lake).

The distribution of near-summit lava flows at Sif Mons appears to be more uniform than at Maat Mons. At Sif Mons, the flows are generally radar-bright with uniform backscatter characteristics. Radar-dark flows are found on the west and southwest flanks at 12 and 70 km from the caldera rim and correspond to vent elevations above the 6051.84 km mean planetary radius of 2.5 and 0.9 km. Within the caldera of Maat Mons, the generally radar-dark floor appears to have been partially buried by small (~10 x 15 km) flows that originated from two of the smaller pits. The most prominent of these flows is cut by the sharp boundary of the pit crater, indicating that the floor of the pit subsided after the flow was erupted. Nor are there any flows that originate from the crater chains on the flanks. This could indicate that while radial dike systems might exist within the volcano, magma transport at the higher elevations has been sub-surface, promoting collapse over the overlying material. Numerous small "fans" of radar-bright flows are particularly prominent on the eastern flank of Sif Mons (1.9 to 2.0 km elevation) and the lower southern flank of Maat Mons (at ~5.1 km elevation).

CONCLUSIONS: The above observations permit some of the theoretical predictions (1) to be compared to geomorphic observations. Interestingly, although the summit of Maat Mons is 6 km higher than Sif Mons (8 km vs. 2 km above the mean planetary radius), the two summit areas are remarkably similar. The concept of neutral buoyancy zones on Venus is therefore not supported by the landforms found on these two volcanoes.

Assuming that the volatile contents of the parental magmas were similar, it is surprising that the area of the summit affected by the primary episode of collapse is about the same on both volcanoes. Pit craters have formed on the rim of Sif Mons and within 5 km of the rim of Maat Mons, which supports the idea that there were intrusives at high elevations on these volcanoes. The process of pit chain formation seems to have worked with equal efficiency at both locations. These pit chains are approximately radial to the summit, suggesting the presence of radial dikes. However, based on the uniform distribution of fresh (radar-bright) lava flows around the volcanoes, there is no strong evidence for well developed rift zones analogous to those found in Hawaii; these rift zones should constitute topographic obstacles that diverted subsequent flows if the rift zones exist. No strong evidence for circumferential fissures (such as those identified for certain terrestrial calderas such as Fernandina; ref. 6) can be seen on either of the Venusian volcanoes described here. Several broad areas of radar-dark material close to the western summit of Sif Mons may, however, be lava flows fed by circumferential fissures that are too small to be identified in the radar images. Together with the remnant patches of radar-dark material within the caldera of Maat Mons, this suggests that low effusion rate eruptions at a range of elevations may be fed by the magma reservoir.

Acknowledgment: Harold Garbeil is thanked for his assistance in data reduction. This work was support by NASA under the VDAP Program.

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