PRECISE TOPOGRAPHIC MEASUREMENTS OF APOLLINARIS AND TYRRHENA PATERAE, MARS.

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Introduction

Topographic measurements have been used to classify and interpret both terrestrial and martian volcanoes in previous studies [1-6]. However, the topography for most martian volcanos is not constrained to a high precision, making classification and interpretation difficult. To derive precise topography for martian volcanoes I have taken shadow measurements and photoclinometric profiles from Apollinaris and Tyrrhena Patera. Apollinaris Patera has been classified as a shield, while Tyrrhena Patera is classified as a highland patera [1]. Although the two volcanos have been classified differently (according to morphology) they share some gross morphologic and geographic features. Both occur in the southern hemisphere away from the two major martian volcanic provinces - Tharsis and Elysium, and both are roughly 200 km across. The major difference between the two is their relief, Apollinaris Patera is approximately 5 km high while Tyrrhena Patera is lower (~ 2 km). Based on its low relief and style of erosion previous workers have interpreted Tyrrhena Patera to be the result of dominantly pyroclastic activity [1], resulting in an ash shield, while Apollinaris Patera has been interpreted to be built from effusive activity [1], although others [7] have classified Apollinaris as a composite (pyroclastic + effusive).

Methods

Shadow measurements can provide very precise height determinations if the following conditions are met; 1) low sun angle above the horizon, 2) pixel size is much smaller than the size of the feature being measured and 3) relatively distortion free viewing geometry (low emission angle). Fortunately, Viking images exist of Apollinaris and Tyrrhena Paterae that meet these criteria. To determine accurate shadow lengths actual DN values from calibrated Viking images [8] were observed. Measuring shadows from photographic prints can be difficult due to contrast stretches that can make determination of the shadow edge inaccurate. Error reported on the shadow measurements is determined from the assumption that the top and bottom of the shadow can each be located to within 3/4 pixel accuracy (total error, 1 1/2 pixels).

Photoclinometry [8,9] was employed to measure flank slopes of Apollinaris Patera and Tyrrhena Patera. For the method to determine an accurate slope, all changes in brightness must be the result of a change in slope, not albedo. Inspection of Viking images from multiple passes (in multiple wavelengths) over Apollinaris Patera (8 orbits) and Tyrrhena Patera (5 orbits) revealed no gross change in brightness other than that due to change in slope (across the measured profile). Current work includes the reduction and analysis of Viking color data from 4 different orbits to determine any subtle albedo changes that may be affecting the photoclinometry. Estimation of a flat field (DN value of a flat surface) was done by examining the DN values of caldera floors and at breaks in slope (caldera rim, impact crater rim). Incorrect determination of the flat field introduces serious error to a given profile. However the validity of the flat field can be checked by taking a profile across a fresh bowl-shaped crater, or by comparing photoclinometricly derived heights with shadow measurements. If the profile across a fresh bowl shape crater determines that the two rims are of the same height and shadow measurements correspond to profile height, then a high confidence level can be put on the flat field value. These checking procedures were carried out whenever possible.

Results

Apollinaris Patera: Shadow measurements (635A57 INA=79.5^o , Res= 250 m/pix) indicate a minimum relief of 5100 ± 90 m for the west flank of the volcano (Fig. 1). The slope of the volcano under the shadow must be greater than the angle of the sun above the horizon, 10.5^o. Shadow measurements were also taken of the caldera wall, determining a height of 770 ± 90 m. Photoclinometric profiles show a distinct break in slope approximately 12 km from the summit plateau. The lower flanks have a minimum slope of $3.7^o \pm 0.4^o$ while the upper regions have a minimum slope of $5.7^o \pm 0.6^o$ (actual slopes are greater due to the oblique angle of the profile to the topographic slope). This change in slope may reflect a change in eruptive style (effusion rate, chemistry, volatile content). **Tyrrhena Patera:** Both high and moderate resolution low-sun angle images of the Tyrrhena Patera region were used to determine flank slopes and caldera scarp heights. Shadow measurements from orbit 445A (INA=68^o, res=60 m/pix) indicate that the caldera scarp (Fig. 1) is typically 400 m high, with the maximum relief being 470 ± 35 m. Photoclinometric profiles (image 087A14, res=230 m/pix) indicate that the maximum slope on the measured flank is $3.6^o \pm 0.5^o$. The accuracy of the photoclinometric profiles was checked using shadow measurements from the high resolution images.

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Conclusions

The lower slopes of Apollinaris Patera are comparable to the slopes measured for Tyrrhena Patera suggesting a similar evolution. The break in slope on Apollinaris may reflect a change in the style of eruption from an early stage activity similar to Tyrrhena Patera to a later stage, effusive episode. The basal scarp that skirts Apollinaris may reflect the interface between a relatively unconsolidated, and easily eroded, base (pyroclastic) and an overlying resistant cap (effusive). This model is similar to that proposed by Mouginis-Mark et al [10] for the evolution of Alba Patera. The measured depths of the caldera will be used as a constraint on the geometry of the magma chamber underlying each volcano. Future work will include similar measurements for other martian volcanos to allow for a global interpretation, at a greater precision than previously possible, of volcanic processes on Mars.

References

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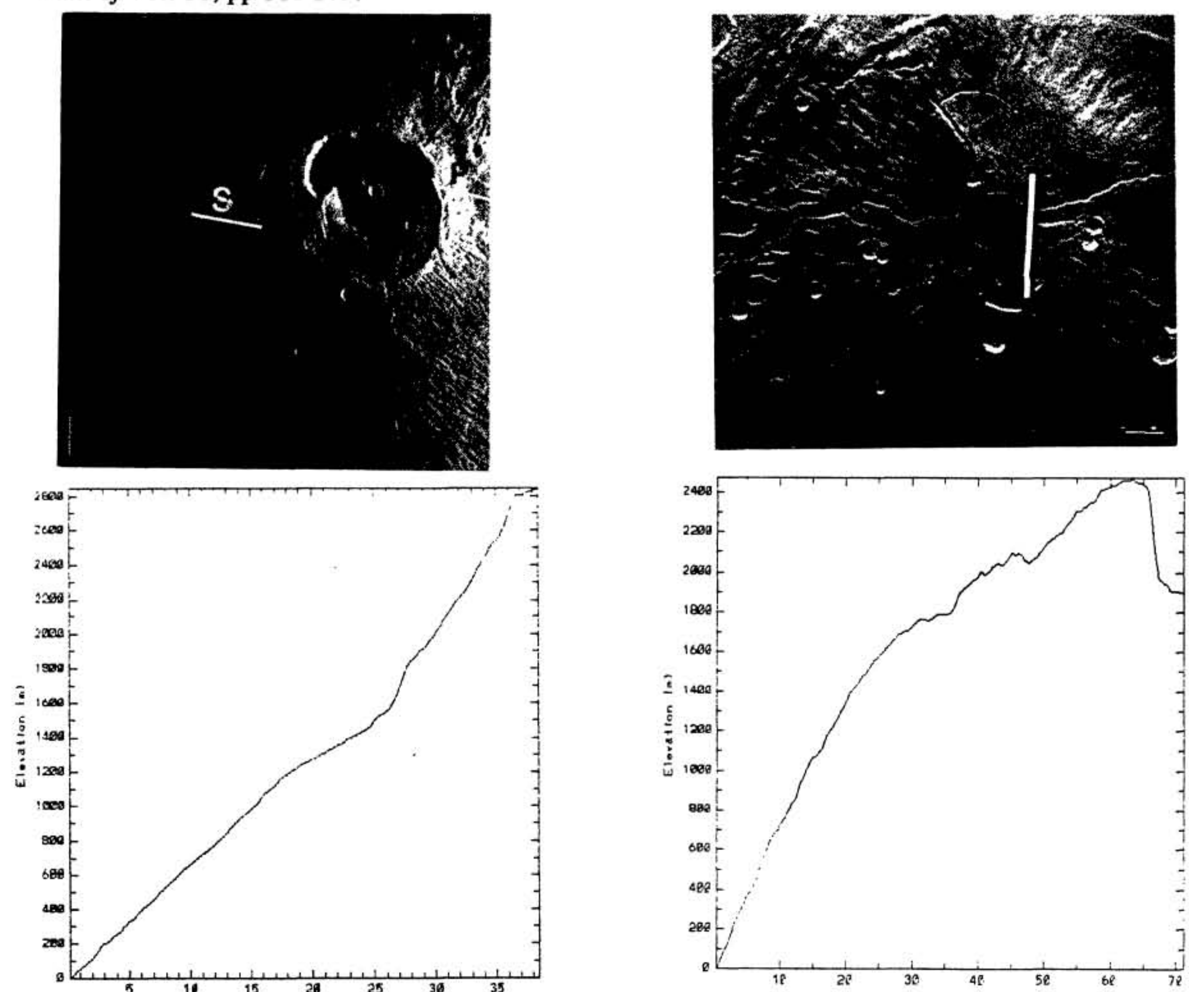

Figure 1. UL - Apollinaris Patera, Viking 635A57 INA=79.5 res=250 m/pix, P indicates photoclinometric profile plotted at LL, S indicates shadow measure of edifice height - 5100 m, scale bar = 50 km. UR - Tyrrhena Patera, Viking 087A14 INA=67°, res=230 m/pix, P indicates photoclinometric profile plotted at LR, scale bar = 46 km.