CHRONOLOGY, ERUPTION DURATION, AND ATMOSPHERIC CONTRIBUTION OF APOLLINARIS PATERA, MARS. M.S. Robinson[1], P.J. Mouginis-Mark[1], J.R. Zimbelman[2], S.S.C. Wu[3]. [1]Planetary Geosciences, SOEST, University of Hawaii, Honolulu, HI, 96822. [2]CEPS National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560. [3]Astrogeology Branch, U. S. Geol. Survey, Flagstaff, AZ, 86001.

INTRODUCTION: Geologic mapping from Viking image data of the Martian volcano Apollinaris Patera has allowed identification of 6 major events that have shaped its current morphology. Derivation of new topographic data has allowed accurate estimates of the volume of erupted products from which estimates of an eruption duration are presented for the edifice and its corresponding atmospheric water contribution.

For this study topographic data were acquired using stereophotogrammetric (Viking picnos 603A42, 639A92) techniques [1] in both profiling and contouring modes (1 km contour). The profiling mode results in a more precise measurement than the contouring mode, but is limited in its areal coverage. The contour data are used in a more general sense to provide synoptic coverage for the volcano. These new stereophotogrammetric measurements constrain the topography to an accuracy of ~800 m vertically and ~1000 m horizontally. Conversion of the derived contour map to a raster-based digital elevation model (DEM) was done by a growing contours interpolation. An ambiguity arises in this volume calculation due to an uncertainty regarding the actual base of the volcano relative to the pre-existing topography. Thus, the volume estimate was bracketed by using the 100 m and the 750 m elevations, which generally correspond to the lower and upper portions of the circumferential basal scarp, respectively. The resulting volumes are 103,000 km^3 and 97,000 km^3; therefore the total volume of Apollinaris Patera is estimated to be ~100,000 km^3.

CHRONOLOGY: For this study the volcano is mapped into 4 distinct units (Fig. A); the main edifice (m), the outer caldera (cf1), the distinct fan (f) that occurs on the southern flank, and the inner caldera (cf2) [see also 2,3]. We propose the following 6 stage chronology for Apollinaris Patera (Fig. B): **1)** emplacement of the main edifice (m), largely by explosive activity, **2)** formation of the basal scarp, either by tectonic or erosive processes, **3)** erosion of valleys on the main flanks (f), **4)** formation of the outer caldera (cf1), with infilling, **5)** emplacement of the fan materials (f), dominantly by effusive activity, **6)** and finally, formation of the inner caldera (cf2), with lava flooding (cf2). These divisions are not temporally sharp, but may be gradational in some cases (see Fig. B). For instance, basal scarp formation may have commenced during the latter part of stage 1, while eruption of the materials comprising the fan may be related to intra-caldera activity of stage 4. Formation of the neighboring chaotic material occurred throughout much of the lifetime of the volcano.

ERUPTION DURATION: Typical effusion rates of terrestrial volcanic eruptions are in the range 10^{-3} to 10^{-2} km^3 yr^{-1} [4] from which a plausible range of activity for Apollinaris Patera is estimated, excluding periods of repose, from 10^7 to 10^8 yrs. To constrain further this estimate it is assumed that, to a first order, the rate of eruption at Apollinaris Patera is similar to that of the Hawaiian Hot Spot. The oldest seamount in the Hawaiian-Emperor chain has an age of 65 x 10^6 years and the total volume of the chain is estimated to be 10^6 km^3 [5]. Therefore, the average rate of eruption for the Hawaiian-Emperor Chain is 1.5 x 10^{-2} km^3 yr^{-1} (including periods of repose), which roughly corresponds with the upper rate from Crisp. This Hawaiian-Emperor rate must be considered a lower limit due to removal of an unknown amount of material by erosion. Therefore, our smaller duration estimate (10 x 10^6 years) seems more reasonable.

ATMOSPHERIC CONTRIBUTION: Assuming a density of 2000 kg m^{-3}, which is reasonable for analogous terrestrial deposits, the total mass of material erupted is 2 x 10^{17} kg. Thus a total mass of 2 x 10^{15} kg is predicted for the water vapor released into the atmosphere assuming a reasonable value of 1 wt % for the released water content of the parent magma [6]. This estimate may be substantially low due to the input of non-juvenile water resulting from the interaction of groundwater/ice during phreatomagmatic eruptions. From the volume calculation and our estimate of eruption duration, approximately 10^7- 10^8 kg yr^{-1} (assuming 1 wt %) of water vapor was added to the Martian atmosphere; for comparison the current total Martian atmospheric water budget is estimated to be about 10^{12} kg [7]. Along with water vapor, it is likely that other gases, such as CO_2 and SO_2, were also released in amounts similar to water, and they also would have an important control on climate [8,9]. Based on these estimates, outgassing from Apollinaris Patera must have had a significant effect on local climate, if not global climate.

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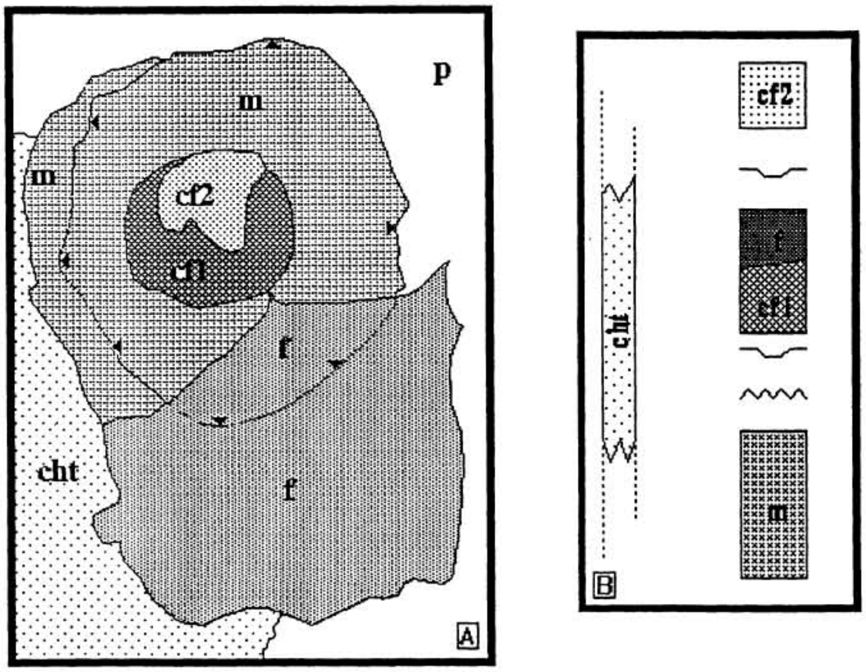

Fig. A. Sketch geologic map indicating the division of Apollinaris Patera into four units (m = main edifice, cf1 = outer caldera, f = fan deposit, cf2 = inner caldera). Unit cht is chaotic terrain and unit p is a simplification of plains units genetically unrelated to Apollinaris Patera. **Fig. B** shows the chronology of events that have resulted in the present morphology of the volcano. Initially unit m was emplaced, then basal scarp and valley formation (jagged line) occurred. Next, outer caldera formation (broken line) with subsequent infilling (cf1), fan (f) emplacement, possibly as a result of late stage overflow from cf1 deposits, and finally inner caldera formation (broken line) with infilling by ponded lava deposits (cf2). Triangles indicate basal scarp, dotted where inferred. Formation of the chaotic terrain adjacent to the volcano both preceded and followed emplacement of the fan materials. Unit cf1 is about 80 km E-W, north is to the top.

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