OLYMPUS MONS' PRISTINE RADIUS. F. V. De Blasio[1], [1]Dept. of Earth and Environmental Sciences, Università degli Studi di Milano Bicocca, Italy, e-mail: fabio.deblasio@unimib.it

Introduction: Totalizing a height of 23 kilometers measured from the plains of Amazonis Planitia on Mars, Olympus Mons (OM) is the tallest volcano in the whole solar system. Its approximately 550-600 km-wide shield is encircled by the aureole, a complex halo extending for nearly 1800 km made up of the merged deposits of least ten enormous sub-circular hummocky subunits (Fig. 1). Associated to the aureole is the up to 10 km high basal scarp, separating the edifice of OM from the proximal part of the aureole. The origin of the aureole has been variously interpreted (see e.g., discussion in [1,2]). Recent imagery and modellling favors an interpretation of the aureole as the compound deposit resulting from the superposition of repeated and probably independent collapses of the Olympus Mons border [2,3], even though uncertainty persists as to the geometry and timing of failures. The basal scarp would thus represent the scar of such ancient landslides. Thus, owing to the enormous aureole volume (>>10^6 km^3), the mass failures that created the deposit must have dramatically transformed the pristine size and shape of the volcanic edifice, causing a retreat of the OM border.

In a recent work [4], I have used topographic MOLA data for the collapsed material to reconstruct the original outline of Olympus Mons before the collapse of the aureole landslides, based on the hypothesis that the aureole resulted from few catastrophic events. Due to post-aureole lava and sedimentary deposition on the eastern and southern flanks, and to the uncertainty of the slippage level especially on the northern side, the topographic data for the reconstruction are precise only between the northern and western directions, comprising an angle of about 120°.

Recontructions of the pristine geometry of Olympus Mons: The calculation of the pristine outline of OM has been performed using MOLA data, restoring the volume contained in the aureole back to the flank of OM. In total, 18 sections were chosen. Figure 2 shows schematically the altimetric profile of the aureole along one representative section. To determine the pristine overhang, the volume shown in Fig. 2 as "aureole deposit" measured with MOLA data along the given three-dimensional section (i.e., all available data point are used for the given section) is made to coincide with the volume indicated as "collapsed section". The aureole volume must be calculated after inferring the flow reference level of the landslide. Accounting for geometrical factors r^2 in the volume calculations where r is the distance from the OM center, and considering the increase in void fraction from the original consolidated lava flow deposit to fragmented rock, allows calculating pre-aureole extension, i.e., overhang distance of OM prior to collapse shown in Fig. 2 as L_{EXT}.

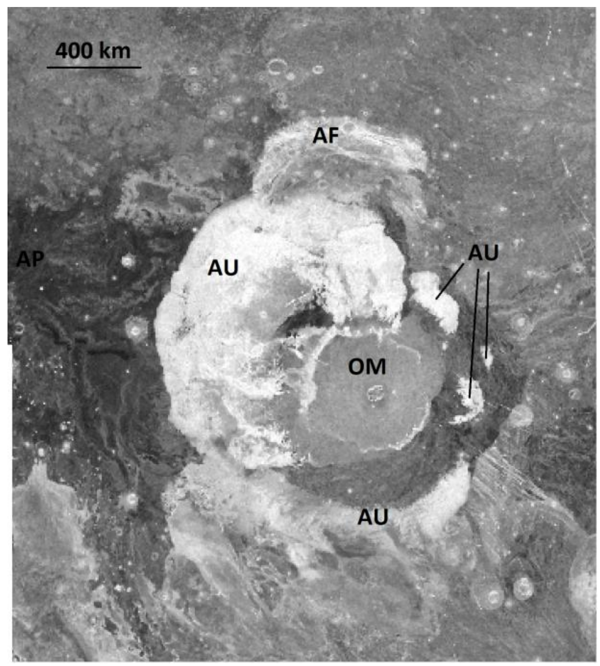

Figure 1. The composite aureole deposit (AU) is well visible in this MOLA 2.4-kilometer baseline ruggedness map as the whitish halo surrounding the volcanic Olympus Mons shield (OM). Rugged terrain is indicated by white tones. Note the small lobes surrounding Olympus Mons also from the eastern and southern sides. The extremely flat area west of the aureole is Amazonis Planitia (AP) and the ridge at the north is Acheron Fossae ridge (AF). For simplicity, the different aureole subunits are not identified in the figure.

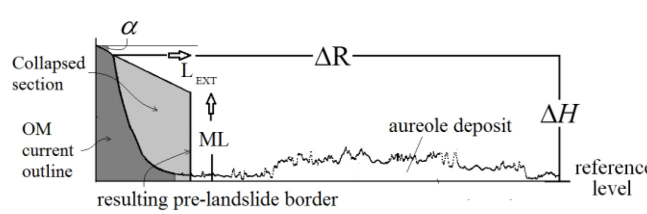

Figure 2. Example of geometrical relationships used for inferring the pristine overhang length of OM. L_{EXT} is the extension of the OM flank prior to failure.

Table I shows the average lengths extensions of OM calculated with this procedure. It appears that the radius along the western and north-western OM was between about 135 to 240 km longer (if the fragmentation of the landslide material has been moderate to null), or between 115 to 180 km (in the hypothesis of a 20% reduction of density owing to voids in the fragmented aureole). Considering the presence of intact blocks in the aureole, it does not seem that void fraction could be higher that this figure.

Thus, as a approximate and representative value for the pristine OM deriving from the reconstruction along different sections and different void ratios, it is possible to state that the volcanic shield radius was approximately 200 km longer along the northern to western directions before the collapse of the aureole landslides [4]. This makes the OM shield a volcanic construct correspondingly wider. Although it is is likely that the OM edifice was wider along the opposite S and E directions as well, the extra length along these sections is not knowable owing to the extreme lava flows volumes in these areas covering the aureole almost to the top [1].

Further analysis [4] shows that the volume of the aureoles, even if enormous, was not enough to fill the conical edifice which would be obtained extending ideally the Olympus Mons flanks with present slope angles. In other words, a significant overhang remains in the pre-aureole reconstructed Olympus Mons.

Notice that post-aureole basaltic lava flows have in some places covered the basal scarp, changing radically its slope from 30°- 40° to gently sloping <10° deposits (Fig. 3). This indicates that similar to the neighboring Alba Mons, lava flows from OM solidifies producing gentle topography. However, it is difficult to understand how such slopes may fail gravitationally producing the huge aureole landslides.

Portion	Quality of reconstruction (based on cleariness of sliding level, lack of lava flows)	Extra pristine length L_{EXT} (no change in fragmented rock density, km)	Extra pristine length L_{EXT} (20% change in fragmented rock density, km)
N	acceptable	200	168
N-NW	good	237	182
W	excellent	208	176
SW	good	135	115

Table I. Pristine length of the OM odifice along the indicated portion calculated with the MOLA data. Only average values are indicated. See ref. [4] for much more detailed data.

Conclusions: Overall, the reconstruction shows that the pre-aureole pristine OM volcano shield was wider than 800 km. This aspect as well as the extraordinary runout of the aureole landslides may, according to ref. [4], be better explained by a subaqueous rather than subaerial environment for the growth of the OM boundary and for some of the aureole landslides.

The aureole landslides collapsed in the area that some researchers consider as formerly (Hesperian times?) wetted by the Oceanus Borealis (see e.g., contributions in ref. [5]). Howerer, basic questions persist such as: how could a relatively shallow ocean have affected the much higher borders of OM? What is the timing of aureole collapses in relation to the demise of the ocean on Mars?

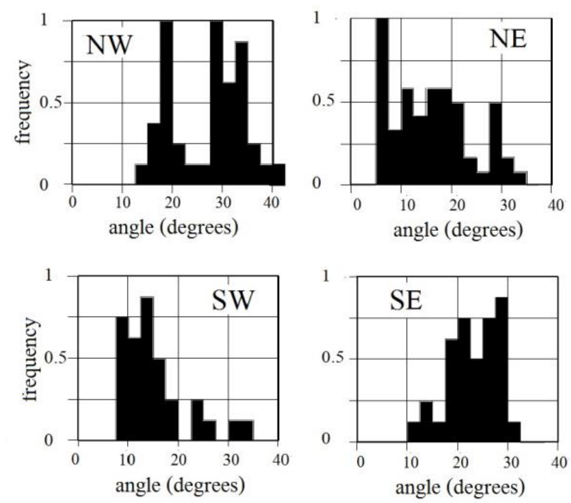

Figure 3. Histogram of the slope angles around the OM edifice. Note the commonness of small angles (around 10°) for the NE and SW portions, indicating the presence of lava flows which smooth out the otherwise steep (>30°) basal scarp.

References: [1] Mouginis-Mark P. (2017), *Chemie der Erde*, doi.org/10.1016/j.chemer.2017.11.006. [2] De Blasio, F.V. (2011), *EPSL 312*, 126-139. [3]. McGovern, P.J., et al.. (2004). *JGR 109*, E08008. [4]. De Blasio, F.V. (2018) *Icarus 302*, 44-61. [5]. Cabrol, N. and E. Grin (eds.). 2010. Lakes on Mars. Elsevier. NY