Lunar domes to the east of Arago: Morphometry and mode of formation. J. Phillips[1] and R. Lena[2]. [1]101 Bull Street, Charleston, SC 29401, USA. thefamily90@hotmail.com [2] BAA lunar section, Via Cartesio 144, sc. D, 00137 Rome, Italy; gibbidomine@libero.it.

Introduction: Recent studies about lunar domes are based on the evaluation of their spectrophotometric and morphometric properties, rheologic parameters, and their classification based on the spectral properties and three dimensional shapes of the volcanic edifices [1-3]. In this contribution we provide an analysis of three domes located to the east of Arago crater, where seven well known domes [1, 3], including the domes Arago α (termed A2) and Arago β (termed A3), are located. A comprehensive map of the area under description was recently produced by the authors [4], and a classification of these domes was performed based on previous works [1-3]. We term the examined lunar domes, previously not described, as A8-10 (Fig.1 and Tables 1-2). The lavas of these mare domes are characterized by high R_{415}/R_{750} of about 0.67 indicating a high TiO_2 content (Table 3 and Fig. 2). Morphometric and spectral properties of the domes A1-A7 are reported in [3].

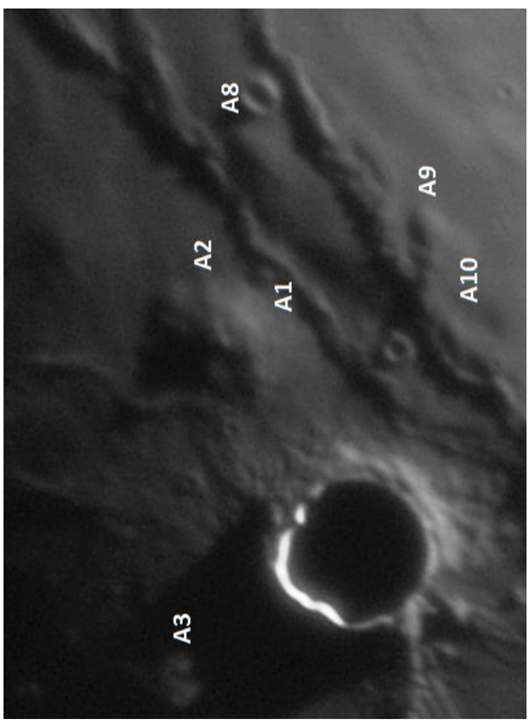

Fig. 1. Telescopic image acquired on on June 11, 2016 at 01:30 UT with a 254 mm aperture TMB refeactor (Phillips). Morphometric properties of the domes A1-A7 have been examined in previous studies [1, 3]. A2-A3 are Arago α and Arago β.

Morphometric dome properties: Based on GLD100 dataset [5] the heights of the domes A8-A10 are determined to 93 m, 100 m and 73 m, resulting in average flank slopes of 1.2° (A8) and 2.2° (A9-A10), respectively (Fig. 3). Assuming a parabolic shape the estimated edifice volumes correspond to 2.90, 1.10 and 0.43 km^3 for the domes A8-A10, respectively.

Dome	long. [°]	lat. [°]	D [km]	h [m]	slope [°]	V [km³]
A8	22.54	8.23	9.0	93	1.2	2.90
A9	23.01	7.34	5.2	100	2.2	1.10
A10	22.72	6.81	3.9	73	2.2	0.43

Table 1: Morphometric properties of the examined domes.

Dome	viscosity [Pa s]	E [$m^3 s^{-1}$]	T [years]	U [$m s^{-1}$]	W [m]	L [km]
A8	$1.1x10^5$	155	0.56	$1.2x10^{-4}$	16	75
A9	$2.7x10^5$	50	0.70	$1.8x10^{-5}$	25	100
A10	$2.5x10^5$	40	0.90	$1.7x10^{-5}$	24	100

Table 2: Modeling results for the viscosity, effusion rate (E), effusion time (T) and magma rise speed (U), dike width (W), dike length (L).

Dome	R_{415}	R_{750}	R_{415}/R_{750}	R_{950}/R_{750}
A8	0.0547	0.0806	0.6784	1.0567
A9	0.0586	0.0807	0.6767	1.0292
A10	0.0610	0.0912	0.6696	1.0222

Table 3: Spectral data of the examined domes.

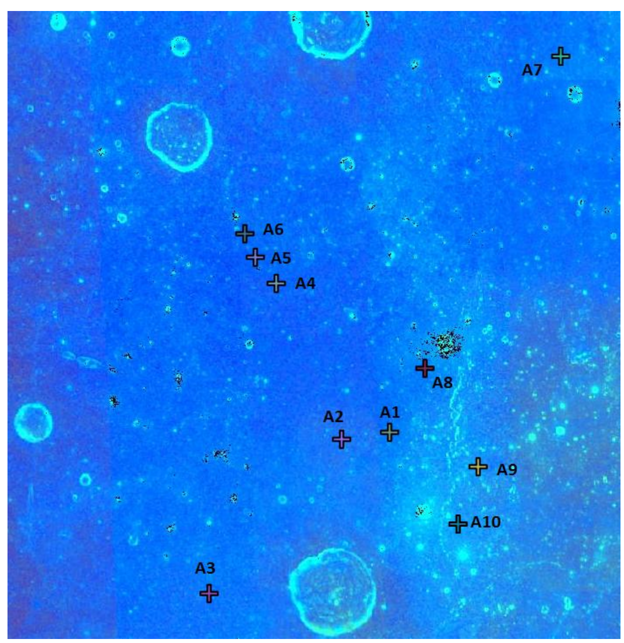

Fig. 2. Clementine color ratio imagery of the Arago region including lunar domes.

Rheologic properties: The rheologic model developed in [6], which relies on the morphometric dome properties, yields estimates of the lava viscosity η, the effusion rate E, and the duration T of the effusion process for a monogenetic lava dome.

Using the morphometric values listed in Table 1, we obtained rheologic properties for the examined domes (Table 2). Lava viscosity is computed based on a lava density of 2,800 kg m^{-3}.

According to the classification scheme for lunar domes introduced in [1, 3], and based on a principal component analysis (PCA), the domes A8 and A9 are situated between class C_2 and A (due higher R_{415}/R_{750} ratio), while the dome A10 is situated beween class A and E_1 (principally due its small diameter, moderate average slope and high R_{415}/R_{750} ratio).

The domes A8-10 formed over a period of time of about 0.56, 0.70 and 0.90 years, respectively and with effusion rates of 40-50 m^3 s^{-1} (A9 and A10) and 155 m^3 s^{-1} (A8). According to the model developed in [7], we estimated the magma rise speed U and the dike geometry (width W and length L).

For the three domes we found magma rise speeds of the order 10^{-4}-10^{-5} m s^{-1} and dike lengths of 75 km for A8 and of 100 km for A9 and A10. The inferred dike widths amount to 16 m for A8 and 25 m for A9-10, respectively.

With their rheologic properties and dike dimension, the examined domes are typical representative of the rheologic group R_1 introduced in [1, 3], characterized by lava viscosities of 10^4-10^6 Pa s, magma rise speeds U of 10^{-5}-10^{-3} m s^{-1}, dike widths W around 10-25 m, and dike lengths L between about 30 and 150 km. Thus, in this region a different style of volcanic activity occurred, comparing the examined domes with the morphometric properties of the domes Arago α (A2), Arago β (A3) of class D and low domes A1 and A4-A7 of class A, previously reported [1, 3].

Wieczorek et al. [8] determined a total crustal thickness of 55 km and an upper crustal thickness of 32 km for Mare Tranquillitatis. Hence, if it is assumed that the vertical extension of a lunar dike is comparable to its length L [9], the inferred dike lengths indicate that the magma that formed A8-A10 originated well below the lunar crust, regarding the thicknesses of the total and upper crust in northern Mare Tranquillitatis.

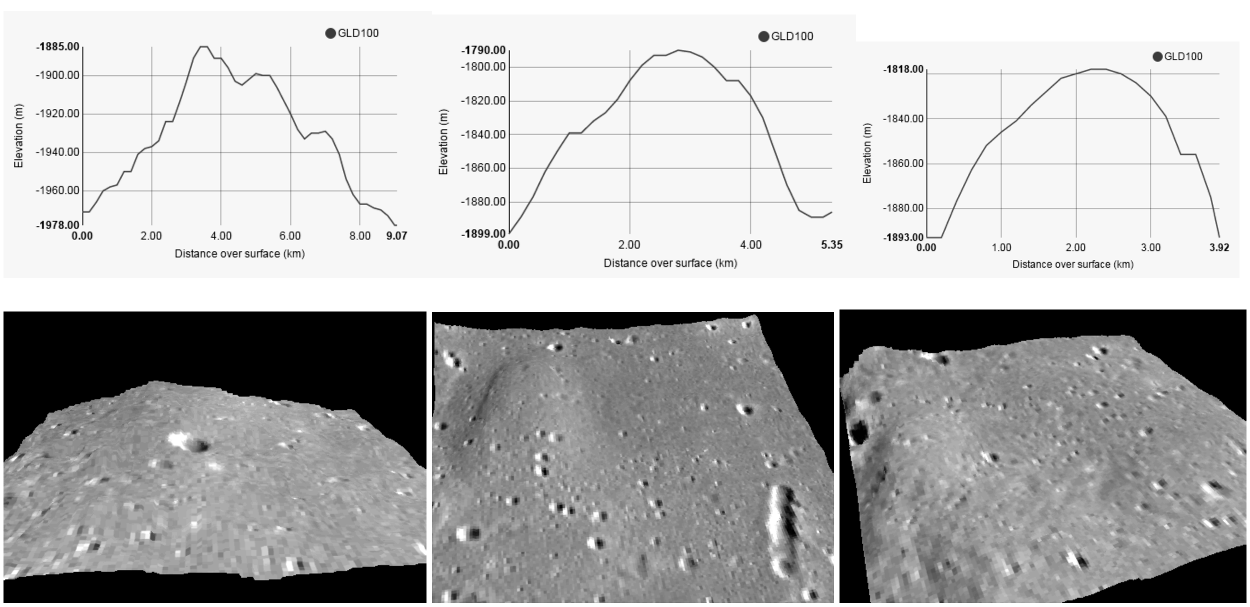

Fig. 3. (Top) Cross-sectional profile in east-west direction derived from GLD100 dataset for the domes A8 (left), A9 (middle) and A10 (rigth). (Bottom) WAC draped on top of the global LROC WAC-derived elevation model (GLD100), 3D reconstruction of the domes A8-A10, respectively. The vertical axis is 10 times exaggerated.

References: [1] Wöhler et al. (2006) *Icarus* 183, 237-264; [2] Wöhler & Lena (2009) *Icarus* 204, 381-398; [3] Lena et al. (2013) Lunar domes: Properties and Fomation Processes. Springer Praxis Books; [4] Lena et al. (2014) Lunar domes atlas, http://lunardomeatlas.blogspot.it/ and Arago Quadrant, http://aragodomes.blogspot.it/; [5] Scholten et al. (2012) *J. Geophys. Res.* 117 (E00H17), doi:10.1029/2011JE003926; [6] Wilson & Head (2003) *J. Geophys. Res.* 108(E2), 5012–5018; [7] Rubin (1993) *J. Geophys. Res.* 98, 15919-15935; [8] Wieczorek et al. (2006), Rev. Mineral. Geochem., 60, 221-364; [9] Jackson et al. (1997), Lunar Planet. Sci. XXVIII, abstract #1429.