Lunar domes in the Caucasus Montes: Morphometry and mode of formation. J. Phillips[1], R. Lena[2] Geologic Lunar Research (GLR) Group. [1]101 Bull Street, Charleston, SC 29401, USA; thefamily90@hotmail.com; [2]Via Cartesio 144, sc. D, 00137 Rome, Italy; r.lena@sanita.it

Introduction: Lunar domes may form as effusive shield-like volcanoes, or the magma may remain subsurface as a laccolith, resulting in an up-doming of the surface. Laccoliths have recently been proposed to explain various geological features such as domes or floor-fractured craters on the surface of the Moon and also Mars and Mercury [1]. Under the assumption of an intrusive origin, we utilise the laccolith model introduced in [2] to estimate the corresponding geophysical parameters, especially the intrusion depth and magma pressure, already previously inferred for the domes termed V1 (unofficially designed as *Valentine dome*) and V2 in [3-5] (cf. Fig.1, South up and East on the left).

In this contribution we provide an analysis of two further candidate intrusive domes, based on GLD100 dataset [6]. The first dome, termed V3 is located at 29.33° E and 11.73° N and has an elongated base area of 29 x 23 km² (cf. Fig. 1). A straight rille can be distinguished on its surface, which is likely due to tensional stress consistent with laccolith formation. The second examined dome, termed V4, is located to the east of V1 dome, at 30.65° E and 11.23° N, and has an elongated base area of 36 x 24 km². These domes are clearly apparent in the low-sun telescopic CCD image shown in Fig. 1a.

Morphometric properties: Based on GLD100 dataset, the heights of the domes V3 and V4 are determined to 110 ± 10 m and 85 ± 10 m, resulting in average flank slopes of 0.5° and 0.3° respectively (Fig. 2). Furthermore, the dome V4 is limited by a fault, about 90 m high, which may indicate the beginning of the piston-like uplift of a laccolith [7]. Assuming a parabolic shape the estimated edifice volumes correspond to about 27.0 and 29.2 km^3 for the domes V3 and V4. According to our previous works [4-5], based on measurements made on terrestrial CCD imagery by applying the combined photoclinometry and shape from shading method, the heights of the domes V1 and V2 derived by GLD100 dataset correspond to 130 ± 10 m and 80 ± 10 m, resulting in average flank slopes of 0.55° and 0.80°, respectively.

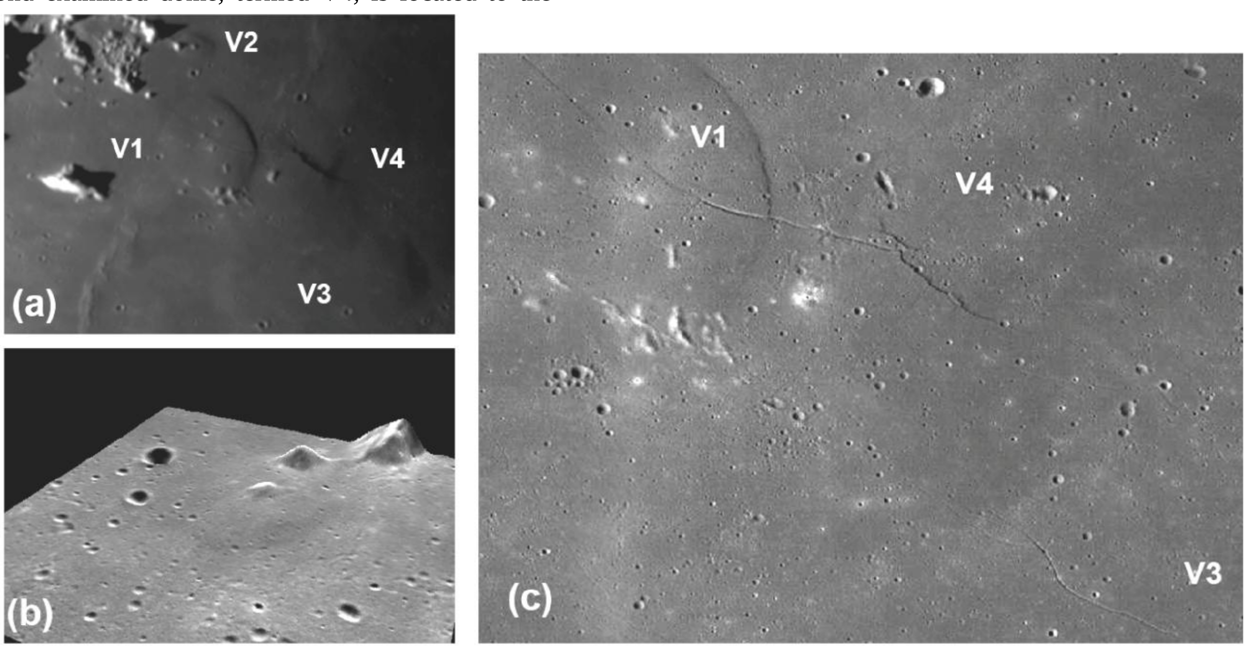

Fig. 1. (a) Telescopic image acquired on August 27, 2013 at 09:27 UT with a 400 mm aperture Starmaster driven Dobsonian (Phillips). The domes in the examined region are termed V1-V4; (b) WAC derived elevation model (GLD100) of the dome V2. View from northwestern direction. The vertical axis is 10 times exaggerated; (c) Crop of the LRO WAC image M117420283ME.

Laccolith modelling: If we assume that the linear rilles on the surfaces of V3 and V4 are the result of tensional stress, the curvature radii of the dome surfaces inferred from our 3D analysis, based on GLD100 dataset, yield thicknesses of the uppermost mare basalt layer of at least 0.3 and 0.5 km respectively, assuming a typical value of the critical stress of basalt of 13 MPa [8]. The laccolith model in [2] applied according to the numerical scheme suggested in [4] yields intrusion depths of 2.1 km and 3.3 km and maximum magma pressures in the laccolith of 16 MPa and 27 MPa, respectively (cf. Table 1). The inferred intrusion depth and magma pressure of V3 and V4 is thus comparable to values obtained for the Valentine dome V1 reported in [4-5]. The examined domes are positioned in the surroundings of Caucasus Montes and their characteristics could imply on origin due to a subsurface intrusion of a large magmatic body.

dome	D [km]	h [m]	slope	h_1 [km]	d [km]	p_0 [M Pa]
V3	29 x 23	110	0.5°	0.27	2.1	16.1
V4	36 x 24	85	0.3°	0.51	3.3	27.0

Table 1: Morphometric properties and modelling results for the examined domes.

Conclusion: Similar to previously examined lunar domes V1 and V2, the domes V3 and V4 are of strongly elongated shape. Both domes display straight rilles traversing their surfaces, which are likely of tensional origin associated with dikes that ascended to shallow depths below the surface [9-10]. The two low and large lunar domes V3 and V4 are interpreted as being formed by magmatic intrusion. It is unlikely that they are kipukas as no spectral contrast is apparent between them and the surrounding surface.

Regarding the morphometric properties and modelling results, the examined domes are typical representative of class In1, while the shape of the steeper and smaller dome V2 (class In2, as introduced in [5]) indicates that laccolith formation proceeded until the stage characterized by flexure of the overburden.

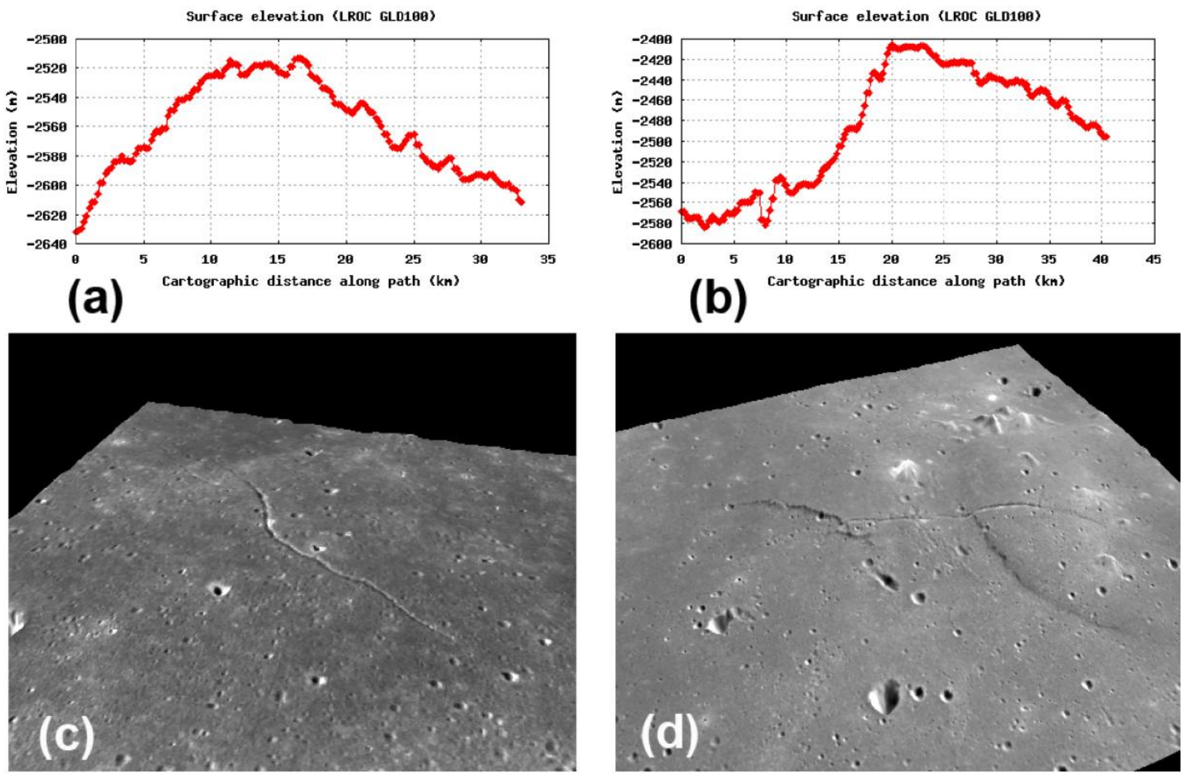

Fig. 2. Top: Cross-sectional profile in east-west direction derived with the ACT-REACT Quick Map tool of the domes (a) V3 and (b) V4, described in the text. Bottom: WAC derived elevation model (GLD100) of the domes (c) V3 (View from northwestern direction. The vertical axis is 10 times exaggerated) and (d) V4 and V1 (View from northwestern direction. The vertical axis is 10 times exaggerated).

References: [1] Head et al. (2009) *Earth and Planet. Sci. Letters 285*, 251–262 ; [2] Kerr and Pollard (1998), *J. Struct. Geol. 20* (12); [3] Wöhler et al. (2006) *Icarus 183*, 237-264; [4] Wöhler & Lena (2009) *Icarus 204*, 381-398; [5] Lena et al. (2013) *Lunar Domes: Properties and Fomation Processes.* Springer Praxis Books; [6] Scholten et al. (2012) *J. Geophys. Res.* 117 (E00H17), doi:10.1029/2011JE003926; [7] Wichman and Schultz (1996) *Icarus 122*, 193-199; [8] Pollard and Fletcher (2005), *Fundamentals of Structural Geology*, Cambridge University Press; [9] Wilson and Head (2002) *J. Geophys. Res.* 107 (E8), 5057; [10] Wilson and Head (1996) *LPSC XXVII*, abstract # 1445.