EFFUSIVE LUNAR DOMES IN CAPUANUS CRATER: MORPHOMETRY AND MODE OF EMPLACEMENT. R. Lena[1], R. Evans[2], S. Lammel[3], J. Phillips[4], C. Wöhler[5] – Geologic Lunar Research (GLR) group. [1]Via Cartesio 144, sc. D, I-00137 Rome, Italy; r.lena@sanita.it; [2]114 Simonds St., Fitchburg, MA 01420, USA; revans_01420@yahoo.com; [3]26 Amberley Way, Uxbridge, Middlesex, England; slamm@blueyonder.co.uk; [4]101 Bull Street, Charleston, SC 29401, USA, thefamily90@hotmail.com; [5]Image Analysis Group, Dortmund University of Technology, Dortmund, Germany; christian.woehler@tu-dortmund.de

Introduction: Recent studies about lunar mare 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, 2]. In this contribution we provide an analysis of three domes located inside Capuanus, a ruined crater in Palus Epidemiarum, a small lava plain at the southwestern edge of Mare Nubium. In this region, tectonic features such as the complex rille systems of Rimae Ramsden and the long graben Rima Hesiodus can be found. The floor of Capuanus is a lava flooded plain similar to the surrounding mare surface.

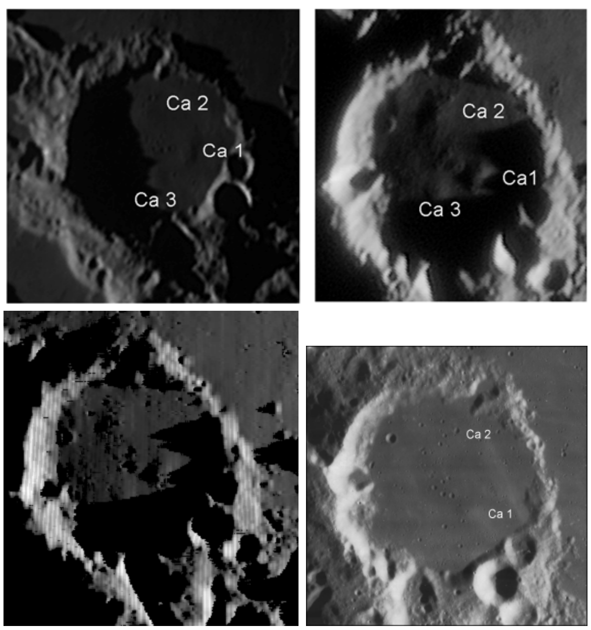

Fig. 1a-d: Domes inside Capuanus (north is to the top and west to the left). Upper row: Telescopic images acquired on August 04, 2010, at 09:15 UT (left) and on April 23, 2010, at 21:12 UT (right). Bottom row: Rendered image obtained based on the LOLA DEM (left), assuming the same illumination conditions as in the upper right image; Lunar Orbiter image IV-131-H3 (right).

Morphometric and rheologic properties: Based on the telescopic CCD images we obtained a DEM of the examined domes by applying the combined photoclinometry and shape from shading method described in [1]. The heights of the domes Ca1 and Ca2 were determined to 100 ± 10 m, resulting in flank slopes of 1.63° ± 0.16° and 1.27° ± 0.13°, while the edifice volumes amount to 1.90 km^3 and 3.17 km^3 for Ca1 and Ca2, respectively. The recently released global digital elevation map (DEM) obtained with the Lunar Orbiter Laser Altimeter (LOLA) on board the Lunar Reconnaissance Orbiter (LRO) spacecraft with its lateral resolution of 1/64 degrees or ~500 m in the equatorial regions of the Moon (http://pds-geosciences.wustl.edu/missions/lro/lola.htm) was used to render an image of the Capuanus domes using the LTVT software package [3] (cf. Fig. 1). In the LOLA DEM, the elevation differences between the dome centres and the surrounding surface correspond to 100 m for Ca1 and Ca2 and 50 m for Ca3, respectively, which is in good agreement with our image-based photoclinometry and shape from shading analysis (cf. Fig. 1). Accordingly, the rheologic model introduced in [4] yields effusion rates of 125 and 207 m^3 s^{-1} for the domes Ca1 and Ca2. They were formed from lavas of viscosities of 3.3 x 10^5 and 1.8 x 10^5 Pa s over similar periods of time of about 0.5 years. The dome Ca3 displays a lower flank slope, presumably due to the lower viscosity of 2.1 x 10^4 Pa s caused by a higher temperature and lower degree of crystallisation of the lava from which it formed.

dome	long.	lat.	flank slope [°]	D [km]	h [m]	V [km^3]
Ca1	-26.18°	-34.20°	1.63	7.0	100	1.90
Ca2	-26.72°	-33.75°	1.27	9.0	100	3.17
Ca3	-26.60°	-34.50°	1.04	5.5	50	0.59

Table 1: Morphometric properties of the domes on the floor of the crater Capuanus.

If we assume the minimum vertical magma pressure gradient of dp/dz = 328 Pa m^{-1} required to drive magma to the lunar surface [5], the magma that formed Ca1, Ca2, and Ca3 rose at speeds of 3.9 x 10^{-5}, 1.1 x 10^{-4}, and 4.7 x 10^{-4} m s^{-1} through dikes of 27, 21, and 9 m width and 120, 93, and 38 km length, respectively. When the value of dp/dz is doubled, the modelled magma rise speeds correspond to 1.6 x 10^{-4}, 4.2 x 10^{-4}, and 1.8 x 10^{-3} m s^{-1}, the dike widths to 13, 11, and 4 m, and the dike lengths to 60, 47, and 20 km. For the latter value of dp/dz, the dike lengths of Ca1 and Ca2 are comparable to the diameter of the crater Capuanus of 60 km.

The inferred rheologic properties of Ca1 and Ca3 are thus comparable to those of the class C_2 domes in the Cauchy region in Mare Tranquillitatis, such as Cauchy ω and τ and the dome Kepler 1 [1, 6]. Ca3 is a typical exemplar of class E_2 in the scheme introduced in [1, 2]. The inferred rheologic properties are comparable to those of the dome M7 in the Milichius region and to some of the aligned domes in northern Mare Tranquillitatis [2].

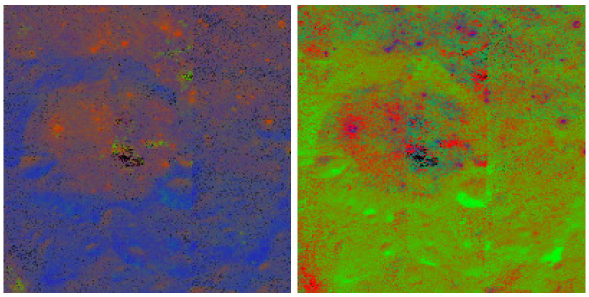

Fig. 2: Petrographic map (left) and petrographic basalt map (right) of Capuanus, covering the region from 24° to 28° W and from 32° to 36° S.

Elemental abundances and petrographic analysis: To estimate the abundances of six key elements in the Capuanus region, we rely on the regression-based approach described in [7], which involves the analysis of the mafic absorption trough around 1000 nm present in nearly all lunar spectra. The continuum slope, the trough width, and the centre wavelengths and relative depths of the individual absorption minima occurring in it are extracted from Clementine UVVIS+NIR multispectral image mosaics. These spectral features allow to estimate the abundances of the elements Ca, Al, Fe, Mg, Ti, and O based on a second-order polynomial regression approach, using the directly measured LP GRS abundance data as "ground truth" (Fig. 3).

We furthermore determined the petrographic map shown in Fig. 2, which indicates the relative fractions of the three endmembers mare basalt (red channel), Mg-rich rock (green channel), and ferroan anorthosite (FAN, blue channel). The petrographic map shows that the floor of Capuanus consists of mare basalt intermixed with highland material. In the eastern part, several small green spots are apparent, indicating Mg-rich rock (we found, however, that they are not confirmed by Chandrayaan-1 M^3 data of the region and may thus be due to local miscalibration effects). A second set of endmembers was inferred from the abundances of Al and Ti to distinguish the three main classes of lunar basalts (Fig. 2): low-Ti, moderate-Al basalt (red channel); low-Ti, high-Al highland material (green channel); high-Ti, low-Al basalt (blue channel). The petrographic basalt map indicates that most of the eastern part of the crater floor consists of Ti-rich basalt, like the surface of Palus Epidemiarum immediately north of Capuanus. Several craters exhibit a distinct "halo" of redder deposits, i.e. excavated mare basalt from below the veneer of ejecta deposits. These compositional contrasts suggest the occurrence of several volcanic episodes inside Capuanus.

Conclusion: We have described three lunar mare domes situated on the floor of the crater Capuanus. The morphometric properties of the domes are comparable to those of small and low mare domes in Mare Tranquillitatis. The modelled lenghts of the dome-forming dikes would become comparable to the diameter of Capuanus for a vertical magma pressure gradient of ~650 Pa m^{-1}. All three domes consist of typical mature mare basalt, where the composition of Ca2 and Ca3 corresponds to low-Ti basalt while Ca1 consists of basalt having a lower Al and a higher Ti content. The domes and the observed variety of basalt compositions suggest a complex volcanic history of Capuanus crater.

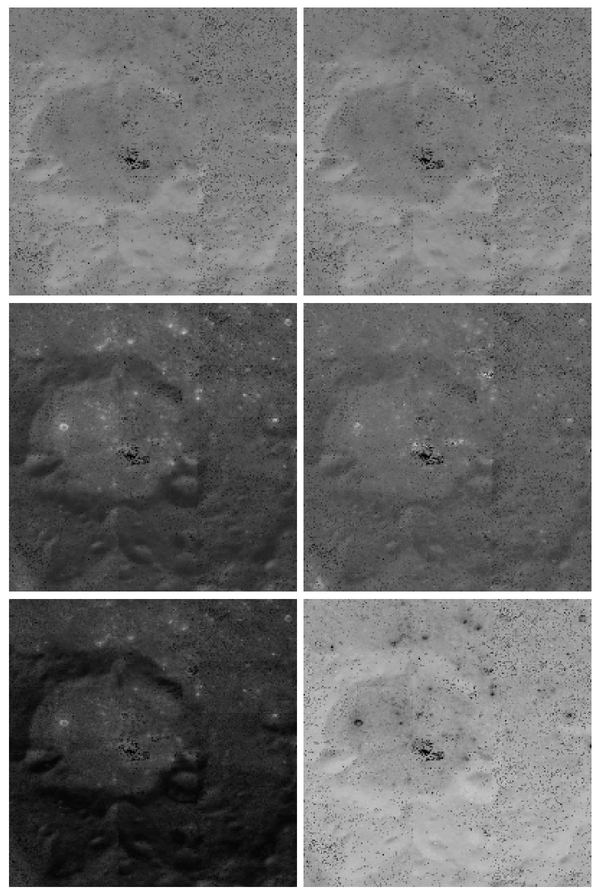

Fig. 3: Elemental abundance maps of (per row, top left to bottom right) of Ca (grey value range 2–18 wt %), Al (0–20 wt%), Fe (0–25 wt%), Mg (0–16 wt%), Ti (0–6 wt%), and O (40–47 wt%).

References: [1] Wöhler et al. (2006) *Icarus 183,* 237–264. [2] Wöhler et al. (2007) *Icarus 189,* 279–307. [3] Mosher and Bondo (2010) Lunar Terminator Visualization Tool (LTVT) http://ltvt.wikispaces.com/LTVT. [4] Wilson and Head (2003) *JGR 108(E2),* 5012–5018. [5] Wilson and Head (1996) *LPSC XXVII,* Abstract #1445. [6] Lena and Wöhler (2009) *LPSC XXXX,* Abstract #1092. [7] Wöhler et al. (2011) *Planet. Space Sci. 59,* 92–110.