LUNAR RING-MOAT DOME STRUCTURES AND THEIR RELATIONSHIPS WITH SMALL IMPACT CRATERS. A.T. Basilevsky[1, 2], F. Zhang[1], C. Wöhler[3], R. Bugiolacchi[1], J.W. Head[4], L. Wilson[5]. [1]State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology, Macau, China, fezhang@must.edu.mo, [2]Vernadsky Institute, RAS, Moscow, Russia, [3]Image Analysis Group, TU Dortmund University, Dortmund, Germany, [4] Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI, USA, [5]Lancaster Environment Centre, Lancaster University, Lancaster, UK.

Introduction: Here we consider the stratigraphic and morphologic relationships between ring-moat dome structures (RMDS) (diameters of 100s of m) and impact craters of about the same size. A few ringed structures were first recognized in the Flamsteed Ring region [1] but the catalogue was vastly expanded by [2, 3], and found to occur mostly in clusters and a range of mare settings. The origin and evolution of these geological structures remain unclear [2], specifically regarding their: 1) age (e.g., contemporaneous with the maria or much younger) and 2) physical properties (e.g., basaltic lavas, or vesicular magmatic foams [4]).

In this analysis we discuss the age relations to investigate two possible cases: 1) the RMDS is superposed on the crater (RMDS relatively younger) or the crater cuts the RMDS (relatively older). Based on LROC NAC DTMs [5,6], RMDS heights (h), height/diameter ratios (h/D) and maximum steepness of their slopes (β) as well as crater depths (d), depth/diameter ratios (d/D) and maximum steepness of inner slopes (α) were measured. For impact craters, these parameters allow us to estimate approximately their absolute age [7, 8] and thus evaluate if RMDSs formed during the time of basaltic plains formation or later. The morphology of craters impacting RMDSs may also reveal the physical nature of the basalts and the contribution of volatiles to their evolution.

RMDS – craters age relations: We are considering here two of several cases of age relations of RMDS with craters whose age can be estimated based on crater morphology and size relations [7, 8] (Fig. 1 and 2).

In Fig. 1 a 180 x 190-m dome appears superposed on the SW rim of a 300-m crater, whose d/D and α show that this crater belongs to morphologic class C (suggesting that its age is between 750 and 1500 Ma [7], or even less than 500 Ma [8]). If superposed, this RMDS should be less than this age value. The very subdued profile A-B leaves open the possibility that the crater might postdate the RMDS.

A RMDS ~150 m in diameter (Fig. 2) is apparently superposed on the northern part of the 115-m crater whose d/D and α show that this crater is also morphologic class C; this suggests that its age should be ~150-350 Ma; if superposed, this RMDS should be less than this age. The very subdued northern wall of the crater leaves open the possibility that the crater is younger than the RMDS. A further consideration is that some of the craters may not be impact craters, but rather pits caused by the extrusion of the dome-forming foam from below the rigid lava flow upper thermal boundary layer, and the partial collapse of the subsurface void [4].

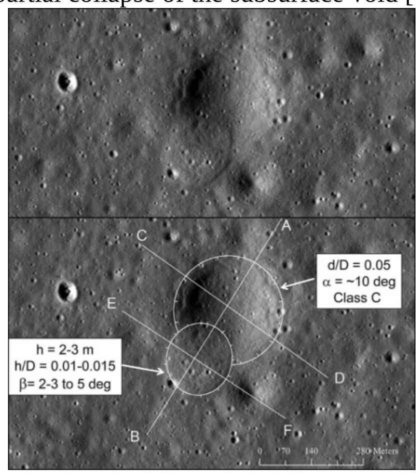

Fig. 1. The 180 x 195-m RMDS appears superposed on the 300-m crater of morphologic class C in Mare Fecunditatis (NAC frame M1126787189LE).

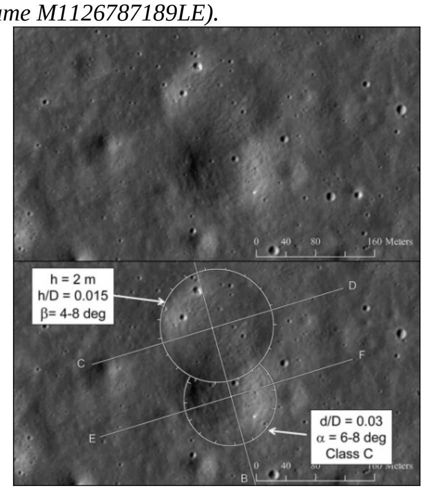

Fig. 2. The 150 m dome appears superposed on the 115-m crater of morphologic class C in Mare Humorum (NAC frame: M1142680981LE).

If RMDSs represent a specific facies of lunar mare basaltic volcanism it would be logical to expect that they were formed between 3.9 to 3.3 Ga [9]; this agrees with estimates [2] from counts of craters ≥300 m on a 60 km^2 area containing both RMDSs and adjacent mare surfaces. Absolute model age (AMA) of this “mixture” was found to be 3.2 + 0.2/-0.7 Ga, although this estimate was based on counts of only 12 craters, so counts of smaller craters were also involved [2]: they indicate AMAs of 25 ± 2 Ma for the RMDS and 36 ± 0.5 Ma for the adjacent mare. The difference was explained by [2] as being due to “a number of physical factors related to the target’s physical properties, such as porosity, the thickness of the regolith, the angle of slope, etc., affecting the rate of degradation”. The major riddle, however, remains the alleged very young age. One possibility considered was that they represent “geologically very recent small eruptions occurring several billion years after the emplacement of the mare lava flows” [2]). A second scenario considered was that RMDSs are formed from magmatic foams below a cooling lava flow surface and extruded to produce the domes above the solid basaltic flow top as the flow evolved [4]. Impacts into foamy materials should produce smaller and deeper craters [4] that may explain the unusually low AMA.

The RMDS – crater age relationships are shown in Fig. 1 and 2 where RMDSs are interpreted to be superposed on degraded craters (and observed in some other RMDS-crater pairs analyzed by us) suggest that the formation of RMDSs could have occurred several billion years after the emplacement of the mare lava flows.

Crater morphology as an indicator of target material characteristics: Here we consider two cases where impact craters 80 to 160 m in diameter are superposed on RMDSs (Figs 3 and 4).

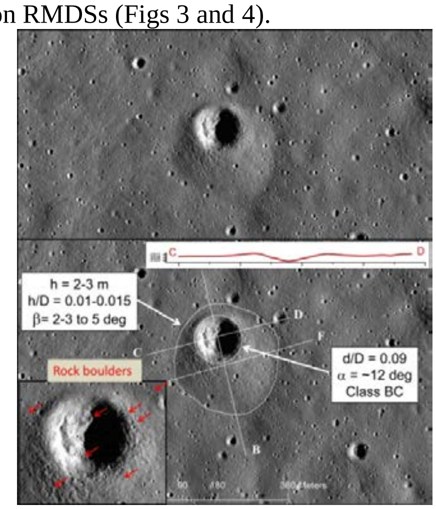

Fig. 3. The 120-m crater is superposed on the northern part of a 270 m RMDS in Mare Fecunditatis (NAC frame: M131284180LE).

In Fig. 3 a 120-m crater has a prominent but rounded rim, d/D = 0.09 and α ~12 deg. That implies it is of morphologic class BC [7] (60-150 Ma), so the RMDS should be older. Meter-sized rock boulders on the crater rim suggest a slightly younger age of the order of several tens of Ma [10]. The crater topographic profile (Fig. 3) looks regular, unlike typical impacts onto magmatic foam [4]. The distinctly rounded rim crest and the presence of meter-sized boulders on the rim and inside the crater suggest its formation on a stratified target, with fragmental material overlying a more massive rock target.

Fig. 4 shows a second case of three craters superposed on a 500-m RMDS; Crater 1 is 170 m in diameter, craters 2 and 3 are 80 m in diameter. For our analysis, the most informative craters are 2 and 3.

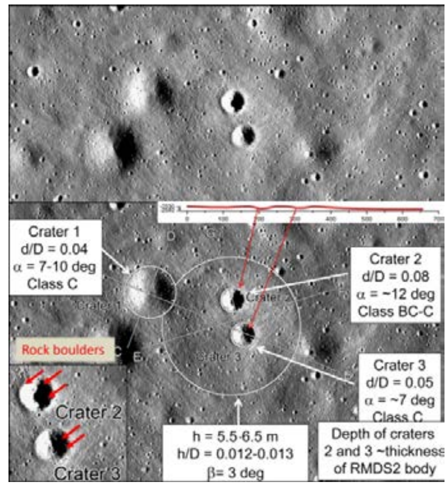

Fig. 4. Three craters, 170, 80 and 80 m in diameter are superposed on the 500-m RMDS in Mare Fecunditatis (NAC frame: M131284180RE).

The morphologic class (Fig. 4) of crater 1 is C (age ~300-600 Ma) and the 80-m craters 2 and 3 have prominent rims, d/D = 0.08 and 0.05 and α ~12 and 7 deg.; craters of morphologic class BC transitional to C (crater 2) and class C (crater 3). Their ages should be ~100-200 Ma [7], or less than 500 Ma [8]. Therefore, the RMDS in Fig. 4 should be older than a few hundred Ma. Meter-sized rock boulders are observed on the rim of craters 2 and 3, suggesting an age of the order of several tens of Ma [10]. Topographic profiles of the craters (Fig. 4) appear normal, in contrast to those in magmatic foam. The presence of meter-sized boulders on the rim and inside this crater also suggests its formation in a massive rock target, not in thick magmatic foam.

Conclusions: We continue to analyze similar examples to further test models of the ages and physical properties of RMDSs.

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