MARE TRANQUILLITATIS: DISTRIBUTION OF MARE DOMES, RELATION TO BROAD MARE RISE, AND EVIDENCE OF A PREVIOUSLY UNRECOGNIZED BASIN FROM LOLA ALTIMETRIC DATA. A. R.Tye[1] and J. W.Head[1], [1]Department of Geological Sciences, Brown University, Providence, RI, 02912.

Introduction: The locations and styles of volcanic source vents provide important information on the nature of the ascent and eruption of magma and the mode of emplacement of lunar mare deposits [1]. Lunar mare domes, small volcanic edifices often with a central pit, mark the locations of lunar source vents representing effusive eruptions of low-flux, low volume flows [2]. Previous mapping of the global distribution of lunar mare domes [2] utilized visible wavelength images and near terminator photography, the latter enhancing the detectability of the low-sloped domes. New altimetry data from the Lunar Orbiter Laser Altimeter (LOLA) [3] onboard the Lunar Reconnaissance Orbiter can now be used to detect and map lunar mare domes in much more detail. In this analysis, following the guidelines of [1], we used new LOLA data to detect and map the spatial distribution and morphometric properties of lunar mare domes with unprecedented precision. We correlated these with new data on the topography of associated mare units and surfaces, and on the structure of the ancient basins containing the maria (Fig. 1).

We mapped a total of 115 mare domes and showed that they are distributed highly inhomogeneously in the study area (Mare Tranquillitatis and parts of Serenitatis, Nectaris, Fecunditatis, and Crisium) (Fig. 1), and are associated with a large broad rise in the maria, elevated up to 2.2 km above the surrounding mare regions. We also documented four deposits that appear to be elements of a previously unrecognized basin ring in Eastern Mare Tranquillitatis (Fig. 2). The area of this previously unrecognized basin is 1.5×10^5 km^2, and it contains 77 (67%) of the 115 domes in the study area.

Lunar mare domes: LOLA altimetry profiles permit precise geometric analyses and LOLA hillshade data allows examination of terrain under multiple optimal lighting geometries [3]. Together, these datasets take the study of morphological features such as lunar mare domes to unprecedented levels of detail and comprehensiveness. Of the 115 mare domes we mapped in the study area, 36 were previously identified [2] and are now confirmed and 79 were newly mapped.

A significant concentration of domes formed within the previously unrecognized basin. Within the basin, domes form linear clusters parallel to the northwestern ends of the Rima Cauchy features, indicating a possible genetic relationship. Shield fields often form in the latter half of fissure eruptions [4].

Broad Mare Topographic Rise: LOLA data reveal the presence of regional mare deposits that form a broad rise virtually co-extensive with a suspected basin ring (see below) and whose elevation is nearly as high as the basin ring remnants (Figs. 1, 2). Observations on the nature of this broad rise include: 1) the rise is composed of multiple summits (Fig. 1, 2), one of which shows concentrations of small shields and another coincides with a linear scarp; 2) the vast majority of the mare domes in the region are concentrated in the area of the rise or its flanks; 3) the rise contrasts extensively with the low, basin-like topography of adjacent western Tranquillitatis, Nectaris and Fecunditatis; 4) regional volcanism was episodic, high-volume, and of a lava-flood nature; Tranquillitatis mare units consist of four highly extensive, spectrally distinct units, based on differences in Ti-concentrations, which were emplaced in distinct episodes over >260 Myrs [5]; 5) recent gravity data from the GRAIL mission [6] indicate that there is no basin-wide positive Bouguer gravity anomaly, which sets this basin apart from most other known basins and indicates that mantle uplift is not likely to be a contributor to the elevation of the broad rise. This broad feature has recently been interpreted as a lunar "shield volcano" [7]. Our analysis and related data indicate that although the feature is shield-shaped and volcanically surfaced, it has not been constructed in the same way as a terrestrial shield. The feature lacks a caldera, either central or asymmetric to the rise, and the presence of large shallow magma reservoirs that form shield volcanoes is unlikely due to the extreme lunar crust-mantle density contrast [1,6,8]. Available evidence suggests this structure was built up by large, infrequent eruptions which flooded an area greater than the rise itself, a different process than the construction of a typical terrestrial shield. The broad rise may better be understood as a lava plateau (typically "the product of fissure eruption" [9]) that lacked the topographic constraints to take on a uniformly flat topography.

Evidence for Previously Unrecognized Basin Ring: Four specific features have been detected and analyzed that together appear to be elements of a previously unrecognized basin ring in Eastern Mare Tranquillitatis (Fig. 2). Each of these elements has been numbered (1-4); these features are not within close enough range of neighboring basins to have been formed entirely by them, though they may have been influenced by processes like secondary cratering. Feature (1) is a pronounced topographic high on the north side of the candidate basin ring. Feature (2) is a formation of kipukas and mare draped over an underlying curvilinear ridge outlining the curvature of the northwestern portion of the candidate basin ring. Feature (3)

is a compact, multiple-peaked highlands outcrop along the southern edge of the candidate basin ring with existing curvature on its northern edge that closely traces the candidate basin ring outline. Feature (4) is a broad collection of highland material along the eastern expanse of the candidate basin ring which is close to Crisium and appears to have been highly influenced by its secondary craters. The highland material outcropping within the candidate basin ring we also interpret as having been influenced by Crisium. Though modified by subsequent impacts, these features outline about half of the overall extent of the candidate ancient basin ring.

Unpreserved portions of the ring of the previously unrecognized basin are likely to have been affected by pre-existing topography due to neighboring basins, obliterated by the impacts that formed those basins, or buried by the mare lavas. The concentration of mare domes and the presence of the broad rise indicate that the previously unrecognized basin is a significant source region for mare volcanism.

Stratigraphy of Previously Unrecognized Basin: One long-accepted chronology orders area impact basins [10]: Fecunditatis, Tranquillitatis (the topographic low in Western Mare Tranquillitatis; it is also suggested that Mare Tranquillitatis is likely composed of multiple basins [10]), Nectaris, Crisium, Serenitatis. New LOLA-based crater counts and topographic observations have suggested that Serenitatis is older than Nectaris [11]. Fecunditatis and Western Tranquillitatis are both deeply buried and lack visible surviving ejecta deposits, so for this study the previously unrecognized basin is examined vis-à-vis Serenitatis, Nectaris, and Crisium. Thin, lineated ejecta deposits have mantled all four ring deposits of the previously unrecognized basin, which are lineated toward Imbrium, and likely originate there. Feature (4) shows a finger of highlands/ejecta material, which extends inward into the interior of the previously unrecognized basin and appears linear from the center of Crisium. We interpret this as a secondary crater chain from Crisium and evidence that Crisium post-dates the previously unrecognized basin. Feature (1) has been interpreted to show ejecta superposed from Nectaris [11], which would indicate Nectaris post-dates the previously unrecognized basin. There is no observed stratigraphic relationship between Serenitatis and the previously unrecognized basin, but based on its morphological freshness, it seems likely to be younger.

Summary and Conclusions: Using LOLA altimetry data, we identified and characterized 115 lunar mare domes and an ancient impact basin in Eastern Tranquillitatis. The basin pre-dates Nectaris and Crisium, and probably Serenitatis. We observe a broad rise feature co-extensive with the basin that, combined with the inhomogeneous concentration of domes within the basin, indicates that this basin was an important mare source region. Evidence suggests that the rise was formed by infrequent, high-volume episodes which flooded areas beyond the rise itself. These qualities distinguish its eruption style from that of a terrestrial shield volcano, and may make it better understood as a lava plateau.

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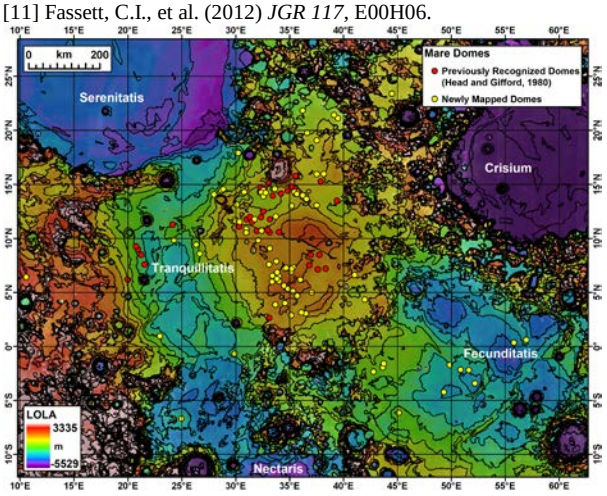

Fig. 1. Study area. Elevation shown in color with 250 m contours.

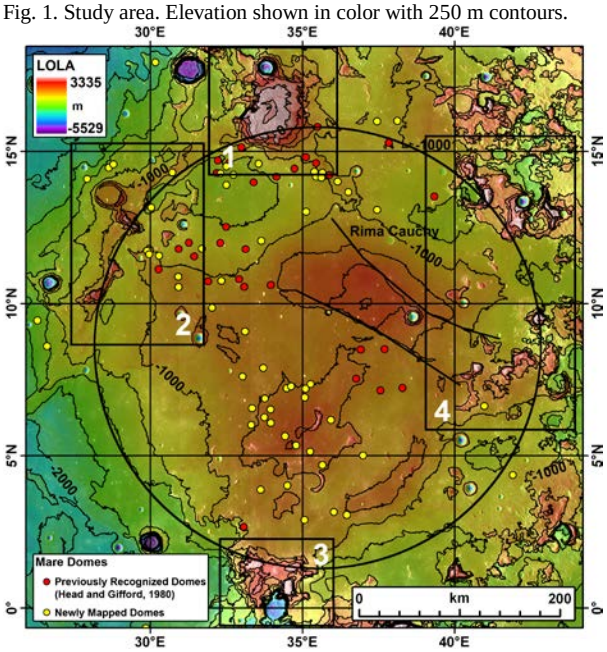

Fig. 2. Locations of four features that form the elements of a candidate previously unrecognized basin ring. Elevation shown in color with 250 m contours. Dome locations plotted in color based on whether they were previously identified [2] or newly identified. Black lines mark location of Rima Cauchy.