OBSERVATION OF STRATIFIED EJECTA BLOCKS AT ARISTARCHUS CRATER. M. Zanetti[1,2], H. Hiesinger[2], C. H. van der Bogert[2], B. L. Jolliff[1]. [1]Washington University in St. Louis, Earth and Planetary Science Dept. and the McDonnell Center for the Space Sciences, 1 Brookings Drive, Campus Box 1169, , St Louis, MO 63130. Michael.Zanetti@wustl.edu [2]Westfälische Wilhelms-Universität Münster, Institut für Planetologie, Wilhelm-Klemm Str. 10, 48149 Münster, Germany.

Introduction: The lunar crater Aristarchus is a complex impact crater 40 km in diameter and ~3.5 km deep [1,2], located in northern Oceanus Procellarum, on the edge of the Aristarchus Plateau. The crater impacted into both the plateau material and the surrounding mare deposits. This unusual impact location means that the impact excavated material from the pyroclastic-deposit-rich plateau and the adjacent flood-basalt plains [1]. It also excavated a very bright nonmare unit from beneath the volcanics. We are currently producing a detailed geologic map of Aristarchus Crater and its surrounding proximal ejecta blanket using high-resolution Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) images [3]. Because of the ~50 cm/pixel resolution, previously unseen features of the lunar surface can be examined. We report here on the observation of numerous large blocks of Aristarchus ejecta that display clear layering of alternating light and dark albedo material (Figs. 1,2). These stratified blocks occur primarily along the northeastern crater wall, but are also observed within the near-rim ejecta blanket. To date, only blocks of material have been identified, and no clear layering is observed within the crater walls of Aristarchus. If the observed layering is due to successive eruptions of lava, these blocks show that possibly hundreds of eruption cycles were necessary to create the observed lava thicknesses in Oceanus Procellarum.

Stratified Ejecta Blocks: Stratified ejecta blocks range in size from a few meters to more than 150 m in diameter. The strata alternate between dark and light layers, where bright layers are typically thicker than the dark layers. Bright layers vary in thickness but are most commonly 2–3 meters thick, with a few layers up to 10 meters thick. Dark layers are typically less than 1 meter thick. Figure 1 shows one of the best examples of the stratified blocks on the Aristarchus Crater wall. The block measures 95 m in length by 90 meters at its widest point, perpendicular to bedding, and is at least 35 meters thick, based on shadow measurements of its height. It contains 25–30 individual layers of bright material, separated by thinner bands of dark material. Bright layer thickness varies between 1 and 6 meters , and dark layers have a maximum thickness of ~ 1 m. In the upper right portion of the block, several bands appear to have a shallow angular relationship, and one or more layers appear to pinch out. The block appears to be mantled by dark, apparently dusty material in some places. Figure 2 shows a 65 m stratified block located within a large field of fragmented stratified material. This image illustrates the variability of stratified block sizes, and the importance of high resolution images in their identification.

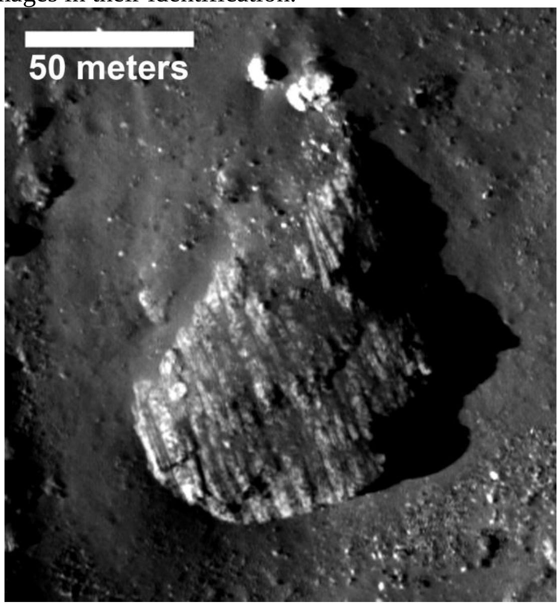

Figure 1: Large stratified block from Aristarchus.

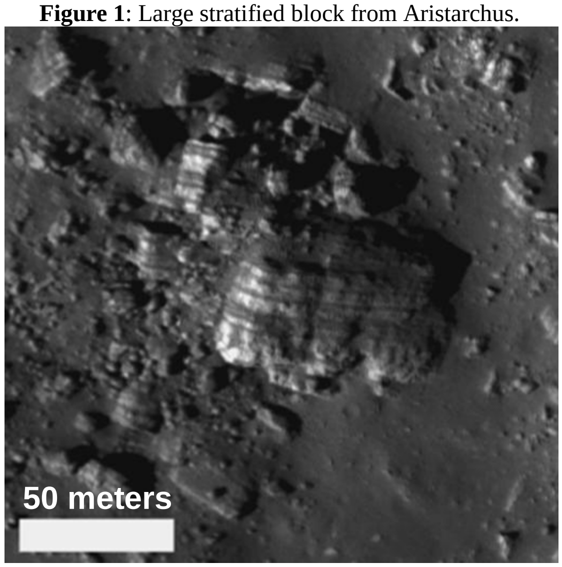

Figure 2: Stratified block in strewn field, most blocks in image show signs of layering.

Identification of Stratified Blocks: Two factors most significantly affect the identification of stratified blocks. The most important factor is the spatial resolution of images. Most strata within the blocks, unless the layers are very thick, are only visible in the highest resolution, 0.5 m/pixel, NAC images. The second factor is the illumination angle . High sun (low incidence) angles are, for the most part, not adequate for viewing strata. Even at moderate illumination angles, observation is sometimes difficult because the bright layers in the strata can saturate the pixels and wash out finer details. NAC frames that have both resolution high enough to discern strata and illumination angles adequate for identification currently only provide partial coverage of the crater.

Location within Aristarchus Crater: The locations of all observed stratified blocks within Aristarchus crater are shown in Figure 3. Owing to the observational constrains mentioned above, the distribution shown in the map is likely not representative of all of the stratified blocks within Aristarchus Crater. However, based on the investigation of images where illumination conditions are favorable, the overwhelming majority of stratified blocks are found along the northern and northeastern wall. The blocks are randomly oriented on the wall and appear to have tumbled downslope from areas closer to the crater rim; however, a few small stratified blocks are observed on the outer rim sloping away from the crater center. The blocks appear to both lie on top of and within impact melt on the crater wall, and in some cases they appear to have been transported downslope by the flow of melt. In-situ layering within the wall of the crater itself has not been observed. The location of the stratified block fields are all on the Oceanus Procellarum Mare side of the impact point, and no stratified blocks are yet observed on the plateau side wall material or ejecta blanket.

Origin of Stratified Material: We consider three possible explanations for the formation of stratified blocks, and their possible geographic distribution within Aristarchus Crater. A possible explanation for the layering is that the thicker, bright layers are flood basalt lavas and the thinner, dark layers are pyroclastic material. In this scenario, pyroclastic material erupted from areas on the Aristarchus Plateau would have been deposited as the lava plains were periodically flooding, building an alternating stratigraphic sequence of lava flows and pyroclastic deposits. A second possibility is that the dark layers are the result of the development of a thin layer of regolith on top of layers of flood lavas, with no pyroclastic deposition. Because the period of time between flows would be geologically short, only a thin < 1 m of regolith could develop. However, this scenario requires that regolith development happen rather quickly between the frequently occurring lava flows, at much greater rates than currently proposed [4]. Our preferred hypothesis is that the thick bright layers are flood basalt lava layers, which are capped by a darker vesiculated crust, caused by quenching during cooling in the vacuum of space. This cooling crust might explain the consistency of thickness of the dark layers. The variation in bright layer thickness would be explained by varying lava flow thickness. If these layers are indeed related to lava flows, this is consistent with the blocks preferred geographic relationship with the mare portion of the target.

Survey of Copernican Craters: We are currently surveying other large craters in order to locate other sources of stratified blocks. Due to the large volume of data returned by the LROC, we have limited our observations to Copernican-aged craters with diameters > than 15 km which are in potentially stratified mare targets. These constraints allow us to observe fresh craters large enough to produce blocks of ejecta where stratification could be clearly identified. Small stratified blocks have seen observed near Kepler Crater, in addition to spectacular horizontal bedding in the crater walls. However, the stratified blocks are not as large, nor contain as many layers as seen at Aristarchus Crater. At other surveyed craters, including Copernicus and Lichtenberg, stratified blocks have not yet been observed. The observation of stratified blocks at Kepler supports our preferred interpretation of successive lava flows, without the need for intervening pyroclastic deposition.

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References: [1] Guest, (1973) GSA Bulletin, 84, 2873- 2894. [2] Guest and Spudis, (1985) Geology Magazine, 4, 317-327. [3] Robinson et al., (2010) Space Sci Rev (2010) 150: 81–124 DOI 10.1007/s11214-010-9634-2. [4] Crawford et al., 2010, Earth Moon and Planets, doi:10.1007/s11038-010-9358-z.

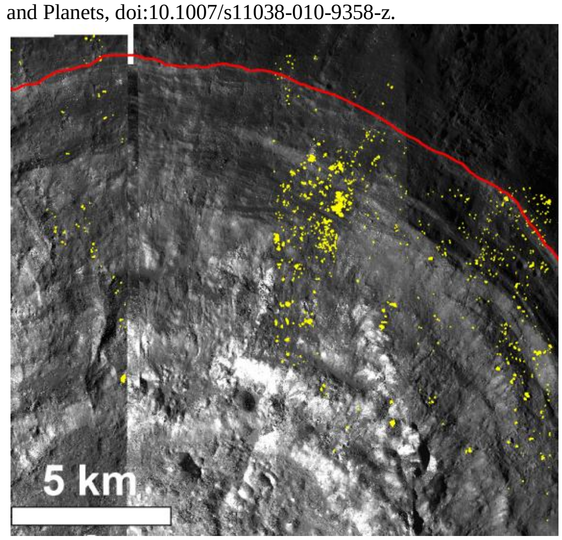

Figure 3: Location of observed stratified blocks (yellow dots) around Aristarchus Crater. Red line denotes the crater rim. North is up.