LOCALIZED PYROCLASTIC DEPOSITS IN THE GRIMALDI REGION OF THE MOON. B. Ray Hawke[1], T.A. Giguere[1,2], L.R. Gaddis[3], O.Gustafson[4], S.J. Lawrence[5], J.D. Stopar[5], C.A. Peterson[1], J.F. Bell III[5], M.S. Robinson[5], and the LROC Science Team, [1]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI 96822 (hawke@higp.hawaii.edu), [2]Intergraph Corporation, Box 75330, Kapolei, HI 96707, [3]U.S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ 86001, [4]Dept. Earth & Atmospheric Sciences, Cornell University, Ithaca, NY 14853, [5]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85281.

Introduction: In recent years, increasing attention has been devoted to lunar dark mantle deposits of pyroclastic origin [e.g., 1-3]. These deposits provide important clues concerning the composition, distribution, and styles of emplacement of the products of explosive volcanism on the Moon. Sample studies of volcanic gasses thought to be representative of certain large pyroclastic deposits of regional extent have provided important insights into the composition of the lunar mantle as well as eruption mechanisms [e.g., 4,5]. In addition, it has been suggested that pyroclastic deposits might prove to be an important source of lunar resources as well as an excellent site for a lunar base [e.g., 6].

We have analyzed Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) and Narrow Angle Camera (NAC) images, as well as other spacecraft data, to conduct a survey of the Moon to search for previously unidentified lunar pyroclastic deposits [3]. This report extends our previous work to include the highlands terrain in and around Grimaldi basin on the west limb of the Moon. This region was selected for study because it exhibits large numbers of very small dark deposits of possible pyroclastic origin noted during the LROC target selection process. These low albedo deposits were targeted for observations by the LROC Narrow Angle Camera, and numerous high-resolution (0.5m/pixel) NAC images were obtained. The purposes of this study are as follows: (1) To identify and characterize previously unknown localized pyroclastic deposits, (2) To further investigate previously identified pyroclastic deposits, (3) To determine the composition of the pyroclastic units, and (4) To investigate the eruption mechanisms responsible for the emplacement of the various deposits.

Data and Methods: Previously mapped dark mantling deposits of pyroclastic origin on the western limb were initially identified on rectified Earth-based photographs and confirmed through detailed geologic analyses of Lunar Orbiter frames [7-10]. In general, lunar dark mantle deposits exhibit fine-textured surfaces with a smooth, velvety appearance. Characteristically, these deposits are low-albedo (0.079-0.096) units that appear to cover and subdue the features of the underlying terrain [e.g., 1,3,6,10,11]. The smaller, localized dark mantle deposits [LDMD] usually have areal extents <1000 km^2 and are typically associated with small endogenic craters that lack rays, are non-circular in shape, and are elongated along fractures. We used these characteristics to identify previously unknown dark mantle deposits of pyroclastic origin.

Both LROC WAC and NAC images were utilized in this investigation. The high resolution (0.5m/pixel) provided by the NAC images was critical for the study of the smallest (<1km) pyroclastic candidates. Clementine UVVIS images were used to produce FeO, TiO_2, and optical maturity maps of the Grimaldi region utilizing the algorithms of Lucey *et al.* [12,13]. Topographic data was provided by the LROC GLD100 [14].

Results and Discussion:

Riccioli Pyroclastic Deposit. Riccioli is a pre-Orientale crater that is 146 km in diameter and located just NW of Grimaldi. This floor-fractured crater is host to both mare and pyroclastic material. A prominent endogenic dark-halo crater complex just inside the west rim has previously been described [9,10]. Figure 1 shows a mosaic of LROC NAC images superposed on a WAC image centered on the LDMD. The dark mantle deposit is ~10 km in diameter and is centered on an elongate vent. On the vent exterior, the deposit exhibits a low albedo and a smooth, block-free surface texture. The FeO and TiO_2 images show an average FeO value of 15.1 wt.% and an average TiO_2 value of 2.3 wt.%. These values are consistent with the basaltic composition suggested by Coombs and Hawke [10] based on Earth-based spectral data. The elongated central vent is 3.8 km by 2.2 km and has a maximum depth of ~441 m. The NAC frames show some blocks (>1m) on the steep portions of the vent wall. However, the vent interior is quite dark. There is evidence for other localized pyroclastic deposits associated with the mare basalt units in Riccioli, but they do not appear to be as extensive as those mapped by [10].

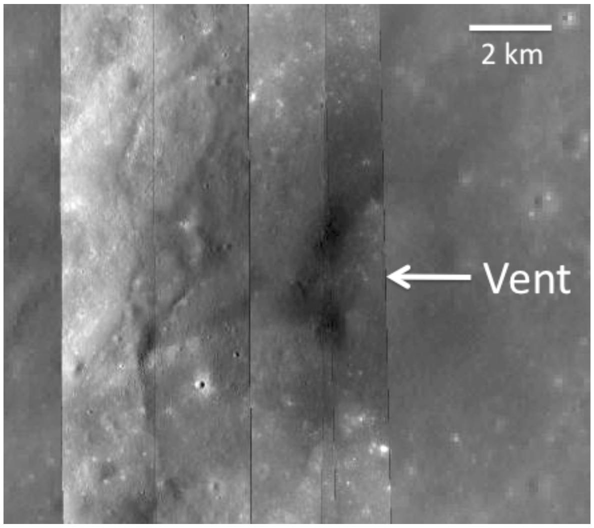

Figure 1. Mosaic of NAC frames superposed on WAC image showing the Riccioli pyroclastic deposit.

Grimaldi Pyroclastic Deposit. Grimaldi is a small two-ringed impact structure that is partly flooded with mare basalt. It is located in the highlands immediately west of Oceanus Procellarum. The Grimaldi pyroclastic deposit is located just northeast of the inner ring at ~1°S, 65°W. This pyroclastic unit was initially identified and mapped by McCauley [7] and has also been investigated by several workers [1,6,8,10]. The dark mantling unit is irregular in shape and is elongated in a NW-SE direction as are the source vents (Figure 2). The pyroclastic unit mapped by [7] covers an area of 450 km^2 [10]. LROC NAC images obtained for this unit show that it exhibits a low albedo and a smooth, block-free surface texture. The dark deposit has a maximum FeO abundance of 16.1 wt.% and a maximum TiO_2 value of 3.6 wt.%. These values are consistent with the basaltic composition suggested by near-IR spectra [6,10]. The pyroclastic debris was probably erupted from one or more of the three elongate depressions at the center of the deposit (Figure 2). The three vents are aligned along a NW-SE axis, and each is elongated along this axis. Several nearby structural features also trend NW-SE [7]. Structural control of the aligned and elongated vents is suggested. All of the vents have maximum widths of ~3.1 – 3.2 km but vary in length from 4.4 km (A) to 12.3 km (B). The longest vent (B) also has the greatest depth (1007 m). NAC images show that vent B has a very high density of >1 m blocks on its steep wall. Finally, vent A exhibits relatively low reflectance values and appears to be thickly mantled by dark pyroclastic debris.

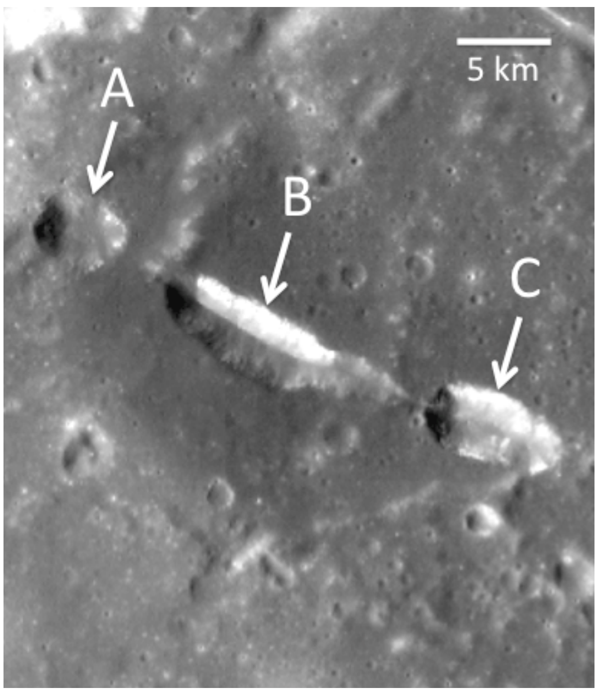

Figure 2. Portion of WAC frame showing the Grimaldi pyroclastic deposit. Vents A, B, and C are indicated.

Damoiseau Pyroclastic Deposits. Damoiseau (D = 37 km) is an Imbrian-aged, floor-fractured crater located just east of Grimaldi basin. At least six dark mantle deposits (diameters <8 km) were identified on the crater interior. NAC and WAC images show that these are not mare ponds. They are all associated with floor fractures and cover and subdue rough terrain. No well-defined source vents have yet been identified. All of these deposits exhibit enhanced FeO and TiO_2 values. The maximum values for these elements are 15.2 wt.% FeO and 5.5 wt.% TiO_2. Additional pyroclastic deposits are located on the eastern rim of Damoiseau crater and on the interior of Grimaldi F crater which is located just NW of Damoiseau.

Small Pyroclastic Deposits N-NE of Schlüter Crater. Twelve very small dark areas located N-NE of Schlüter crater and west of Riccioli were identified and targeted for LROC observations prior to the launch of the LRO mission. The low albedo units generally have irregular shapes and range from 1 km to 12 km in diameter. Both NAC and WAC images were used to investigate these 12 dark areas. No flat mare ponds were observed at these locations. In all instances, the dark material is draped over rough, irregular terrain. Most of the dark mantle deposits are associated with lineaments or fractures. No well-developed vents were seen, but several candidates were identified. All of the dark deposits exhibit maximum FeO values (10-15 wt.% FeO) that are much greater than those of the surrounding terrain (~4-6 wt.% FeO).

Summary: New evidence provided by LROC images strongly supports a pyroclastic origin for the dark deposits in the Grimaldi region of the Moon. Some of these units are among the smallest pyroclastic deposits yet identified on the lunar surface.

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