"NEW" VOLCANIC FEATURES IN LUNAR, FLOOR-FRACTURED OPPENHEIMER CRATER. Lisa R. Gaddis[1], Lynn Weller[1], Janet Barrett[1], Randy Kirk[1], Moses Milazzo[1], Jay Laura[1,2], B.R. Hawke[3], T. Giguere[3,4], Briony Horgan[5], and Kristen Bennett[5]. [1]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, AZ; [2]Department of Geography, Arizona State University, Tempe, AZ; [3]Univ. Hawaii, Honolulu, HI; [4]Intergraph Corp., P.O. Box 75330, Kapolei, HI; [5]School of Earth and Space Exploration, Arizona State University, Tempe, AZ. (lgaddis@usgs.gov).

Introduction: Recent observations of the lunar floor-fractured crater Oppenheimer (35.2°S, 166.3°W, 208 km dia.) by imaging instruments on the Lunar Reconnaissance Orbiter (LRO) and SELENE/Kaguya missions [1-3] allow us to conduct detailed examinations of pyroclastic volcanic deposits and vents in the crater floor. We used data from the Kaguya Terrain Camera (TC; ~10 m/pixel) and Multiband Imager (MI; 5 visible wavelength or VIS channels at 415 to 1000 nm, ~20 m/pixel), and from the LRO Narrow Angle (NAC; 0.5 to 2.0 m/pixel) and Wide Angle Cameras (WAC; ~100 m/pixel). We have identified "new" or previously unrecognized volcanic vents and characterized associated volcanic deposits in the floor of Oppenheimer crater.

Lunar pyroclastic deposits are often very dark, with smooth surface textures [e.g., 4-7]; smaller or localized deposits are <1000 km^2 and are associated with vents recognized as endogenic (non-impact) craters or irregular depressions. Such lunar pyroclastic deposits are of interest partly because they are volatile- and metallic-element (e.g., S, Fe, Ti) enriched remnants of ancient lunar volcanic eruptions [8, 9]. Their compositions and distributions provide information on the early lunar interior [10, 11] and the distribution of possible resource materials [12]. Studies of pyroclastic deposits with telescopic and Clementine color (ultraviolet, visible) data demonstrated their compositional heterogeneity and expanded our knowledge of deposit types [7, 13, 14].

Oppenheimer Pyroclastics: Seven small pyroclastic deposits were previously identified [15] in the floor of Pre-Nectarian-aged Oppenheimer crater (4.04 Ga; [16]), and these deposits are associated with vents located along fractures in the crater floor (***Figure 1***) and within three Imbrian-aged craters in the floor. The deposits vary in size from ~200 to 1500 km^2 [7], and are thought to have been emplaced by explosive, vulcanian-style eruptions [17]. Clementine color data for Oppenheimer pyroclastics were used to suggest that their compositions were dominated by mafic minerals (e.g., pyroxene) in fragmented basalts, with little or no glass [18].

Analyses: MI VIS and NAC data reveal several previously unrecognized pyroclastic vents and features in the floor of Oppenheimer crater. These vents were identified on the basis of deposit albedo and distribution, spatial association with floor-fractures (***Figures 2, 3***), and topography [GLD100, 19].

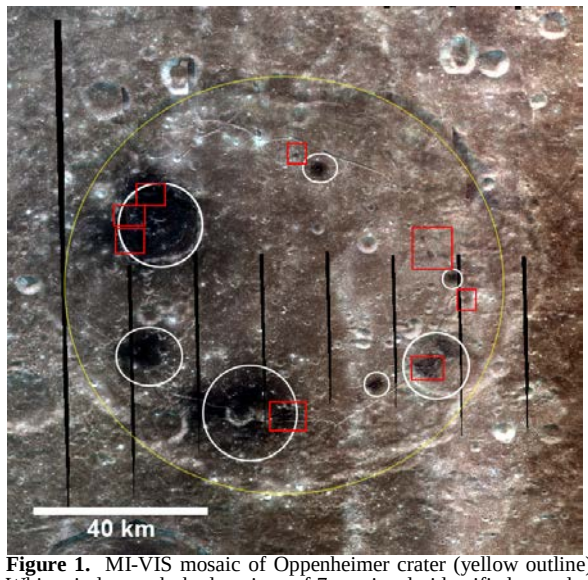

Figure 1. MI-VIS mosaic of Oppenheimer crater (yellow outline). White circles mark the locations of 7 previously identified pyroclastic deposits and vents [15]. Red rectangles mark the locations of the 8 "new" deposits and features discussed here.

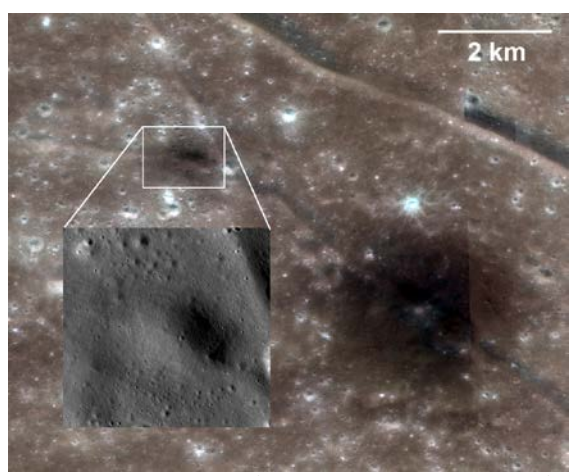

Figure 2. MI-VIS mosaic of northern Oppenheimer crater floor showing the larger known deposit and a "new" pyroclastic deposit located along floor fractures. Inset image is NAC frame M130381136R showing the non-circular vent and smooth mantle.

Starting in the north-central crater floor and searching clockwise along fractures, the MI-VIS color mosaic reveals at least 8 previously unrecognized volcanic deposits: (1) a small, ~1300-m-long, non-circular vent with low-relief, low-albedo, diffuse deposits located along a shallow floor fracture (***Figure 2***). (2) In the ENE portion of the floor, at least three small (<2000 m) dark deposits with elongate vents are located along narrow, shallow floor fractures less than 300 m across. In the low-sun TC mosaic, these features show low relief and resemble low-volume terrestrial fissure eruptions. (3) Adjacent to the known deposit and vent in the E crater floor are several irregular depressions that may be satellite vents, and to the SE is another possible low-relief fissure vent and deposit ~3500 m long. (4) In the ESE floor, a portion of the known deposit in Oppenheimer H crater (33 km dia.) is shown to be comprised of a complex set of overlapping non-circular depressions and associated dark deposits (~2500 m) aligned along fractures, resembling a terrestrial "chain of craters." (5) In the SSW floor, a small, satellite deposit ~2000 m across is observed around a non-circular vent along a fracture to the east of a known deposit. (6) In the NW floor, dark deposits associated with Oppenheimer U crater appear to originate from several depressions in the smaller crater floor. The dark deposits extend most prominently beyond the crater wall to the N and WSW (***Figure 3***), and they have very low albedo and appear to mantle even relatively steep slopes on the crater wall.

Summary: At least eight previously unrecognized features that appear to be associated with localized pyroclastic eruptions are observed in addition to the seven known sites of volcanism in the floor of Oppenheimer crater. In all cases, the pyroclastic deposits appear to represent low-volume eruptions of pyroclastic material from non-circular vents aligned along floor fractures. The deposits resemble those observed as "dark-halo craters" at Alphonsus crater, and likely formed similarly as a result of vulcanian-style eruptions [17]. The discovery of these "new" volcanic deposits suggests that volcanism played a larger role in the formation and evolution of Oppenheimer crater, and helps to provide a better understanding of the spatial and temporal distribution of volcanism on the lunar far side.

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References: [1] Robinson et al., 2010, Space Sci. Rev. 150, 81-124. [2] Haruyama et al., 2008, Adv. Sp. Res. 42, 310-316. [3] Ohtake et al., 2010, Space Sci. Rev. 154, 57-77. [4] Pieters et al., 1973, JGR 78, 5867. [5] Gaddis et al., 1985, Icarus 61, 461. [6] Hawke et al., 1990, PLPSC 20th, 249. [7] Gaddis et al., 2003, Icarus 161, 262. [8] Heiken et al. 1974, GCA 38, 1703. [9] Delano, 1986, JGR 91, D201. [10] Shearer et al., 2006, RMG 60, 365. [11] Duke et al., 2006, RMG 60, 597. [12] Hawke et al., 1989, PLPSC 19th, 255. [13] Lucey et al., 2006, RMG 60, 83. [14] Wilcox et al., 2006, JGR 111, E09001. [15] Rosanova et al., 1998, LPS XXIX, #1710. [16] Hiesinger et al., 2012, GSA #30953-212430. [17] Head et al., 2000, LPS XXXI, #1280. [18] Petro et al., 2001, LPS XXXII, #1953. [19] Scholten et al., 2011, LPS 42nd, abs. #2046.

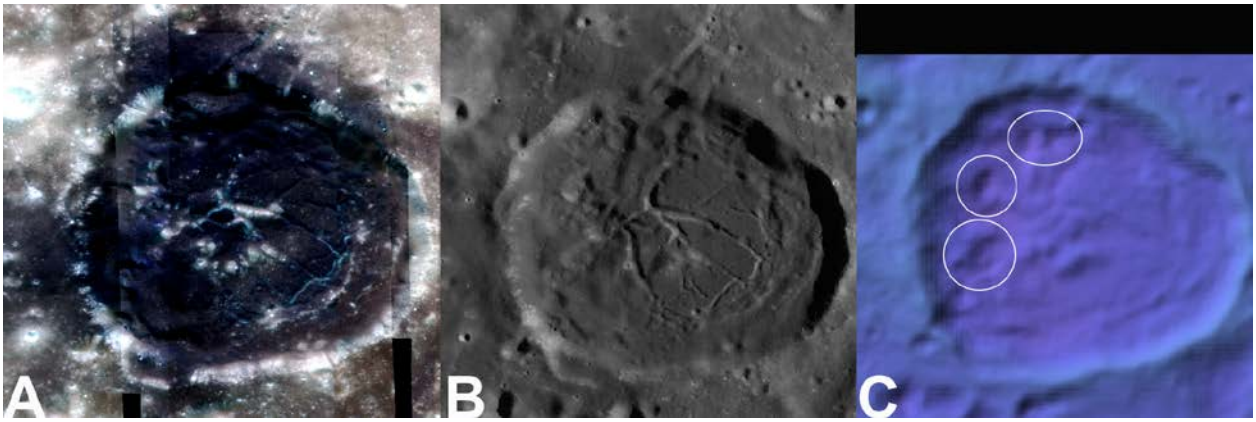

Figure 3. Views of Oppenheimer U crater (38 km dia.) in the NW floor of Oppenheimer crater. (A) MI-VIS mosaic showing very dark pyroclastic materials covering the fractured crater floor and portions of the area beyond the crater walls. (B) WAC mosaic showing several depressions in the western portion of the fractured floor. These may represent multiple source vents for pyroclastic material. (C) WAC DTM (elevation map) showing the locations of at least 3 irregular depressions that may be local vents.