GEOLOGIC MAPPING OF URVARA CRATER, CERES: DISTRIBUTION AND CHARACTERISTICS OF BOULDER TRACKS ON CRATER HILLSLOPES. D. A. Crown[1], M. S. Crown[1,2], D. C. Berman[1], H. G. Sizemore[1], A. Neesemann[3], D. P. O'Brien[1], D. L. Buczkowski[4], and J. E. C. Scully[5]. [1]Planetary Science Institute (1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719; crown@psi.edu), [2]The Gregory School (Tucson, AZ), [3]Freie Universität Berlin (Berlin, Germany), [4]Johns-Hopkins University Applied Physics Laboratory (Laurel, MD), [5]Jet Propulsion Laboratory (Pasadena, CA).

Introduction: The geologic characteristics of dwarf planet Ceres are being revealed through analyses of Dawn mission datasets. Detailed analyses of impact features on Ceres provide important constraints on surface geology, geologic history, and crustal properties, including the abundance, distribution, and role(s) of ice. As part of 1:250,000-scale geologic mapping of Urvara crater using high resolution images from the Dawn extended mission (XM2; 3.5-20 m/pixel), we are documenting the geologic characteristics of hillslopes associated with Urvara's rim and central peak. The high-resolution XM2 images reveal small-scale details of surface morphology that allow characterization of mass-wasting processes on Ceres. Here we describe characteristics of boulder tracks and associated features that occur within hillslope talus deposits and extend into adjacent plains.

Background: Urvara is a 170-km diameter impact crater centered at 45.66°S, 249.24°E and is the third largest preserved impact feature on Ceres' surface after Kerwan (280 km) and Yalode (260 km). Urvara is immediately adjacent to Yalode and both serve as significant stratigraphic markers in Ceres' geologic record [1]. The geologic characteristics of Urvara and Yalode have been described in both global and quadrangle mapping studies [1-3]. Urvara's floor has been divided into a series of geologic units, with the potential for post-impact cryovolcanic resurfacing [1, 3]. Urvara has an absolute model age estimate of 244±9 Ma (using an evaluation range of 1-229.3 km and the lunar-derived chronology model of [4]) [1].

Urvara Crater Hillslopes and Boulder Tracks: Urvara has a well-defined crater rim with variable morphology. Urvara has a prominent, singular northern rim scarp, whereas its southern terraced rim consists of a series of smaller circumferential scarp segments that step in toward the crater floor over a ~30 km distance. The central peak is an elongate ridge with a NE-SW orientation. The upper parts of Urvara rim scarps are often prominent features defining the distinct topographic change from adjacent cratered surfaces to hillslope talus deposits. The upper and lower boundaries of hillslopes are not always clearly topographically defined but may also be discerned by changes in albedo, surface texture, and morphology.

Hillslopes associated with Urvara range from highly cratered surfaces with moderate albedo, similar to adjacent crater floor materials, to more pristine-appearing surfaces characterized by unconsolidated talus deposits that show bright and dark streaks, boulder tracks, scattered boulders, and slump blocks. Scarp crests and the upper parts of many hillslopes show massive blocky outcrops, sometimes with rocky spurs extending downslope; these are the source of hillslope mass-wasting deposits (e.g., talus, boulders). The distal margins of talus deposits sometimes show fan-shaped or lobate terminations suggesting multiple cycles of mass-wasting and discrete movement of masses or lobes of material. Small fields of boulders on Urvara floor materials are observed below some areas with multiple boulder tracks.

Boulder tracks were identified and mapped at 1:10K-1:20K scale on Urvara's rim scarps and central peak by systematically surveying XM2 mosaics; mapped track paths were revised and additional tracks added based on a review at 1:5K scale. Boulder tracks are typically defined by the presence of a series of shallow, elongate (downslope) depressions, with or without an associated boulder preserved at or near the track terminus; tracks also include sections delineated by albedo streaks and elongate troughs. Track location, length, azimuth, and the presence of associated boulders were recorded.

Our database currently contains 112 boulder tracks associated with Urvara crater rim hillslopes. Boulders were present in association with 57 tracks (53 with one boulder, and four with two boulders). Mapped boulder tracks ranged in length from 242 to 5092 m (mean = 1153 m). Boulder tracks exhibited up to 62 discrete along-track depressions (mean = 11.78). Boulder tracks were found in abundance on the northern rim scarp, resulting in a prominent trend in orientation (98 on south-facing slopes, eight on north-facing slopes, and six on east- or west-facing slopes).

From the mapped boulder tracks, we created a database that includes the locations of observed boulders and boulder track depressions. Image resolution allowed measurements of the widths (cross-track) and lengths (down-track) of these features at 1:3K-1:5K scale for 16 boulder tracks. For this subset of the population, boulder widths ranged from ~19 to 43 m and boulder lengths ranged from ~16 to 54 m; mean depression widths along individual tracks ranged from ~25 to 58 m and mean depression lengths ranged from ~32 to 100 m.

Lunar Comparisons: A series of recent studies have used high-resolution images (LRO NAC with resolutions of 0.49-1.53 m/pixel) and topographic datasets (118 m/pixel LOLA DEM) from the Lunar Reconnaissance Orbiter to study mass-wasting processes on lunar hillslopes, including rockfalls and boulder tracks [5-8]. Lunar rockfalls were typically associated with equator-facing slopes with typical boulder diameters of ~7-10 m. From an analysis of their global distribution, lunar rockfalls were attributed to a combination of small impact events and solar-induced thermal effects on fractured bedrock.

For a subset (N = 687) of the larger population (N = 136,610), morphometric measurements were made for lunar hillslopes, including boulder dimensions (long axis, short axis, and shadow length), track length, slope angle, and elevation drop [8]. Boulder deposition included rolling, bouncing, and sliding behavior in order of decreasing occurrence. Boulder sizes ranged from ~1.5-24 m with boulder track lengths of up to ~4 km (average values of between 270 and 1070 m for different geologic contexts).

The boulders and boulder tracks at Urvara crater on Ceres can be compared to those studied on the lunar surface. Similarities include boulder track morphology (including evidence for bouncing and other types of movement) and boulder track length. Lunar boulder tracks tend to occur on equator-facing slopes whereas those associated with Urvara are predominantly on pole-facing slopes. Differences in boulder sizes can be partly attributed to differences in image resolution that allow smaller lunar boulders to be identified.

Further analyses of boulder source regions, hillslope topography, and our measured morphometric parameters for Ceres are needed for more detailed comparisons to mass-wasting processes on the Moon and other planetary bodies.

Future Work: Continued geologic mapping investigations of Urvara crater [9] will include additional analyses of the types, distribution, and timing of mass-wasting processes on Ceres. Geologic mapping provides important spatial and temporal context for detailed studies of individual geologic features and the geomorphic evolution of hillslopes created by impact processes.

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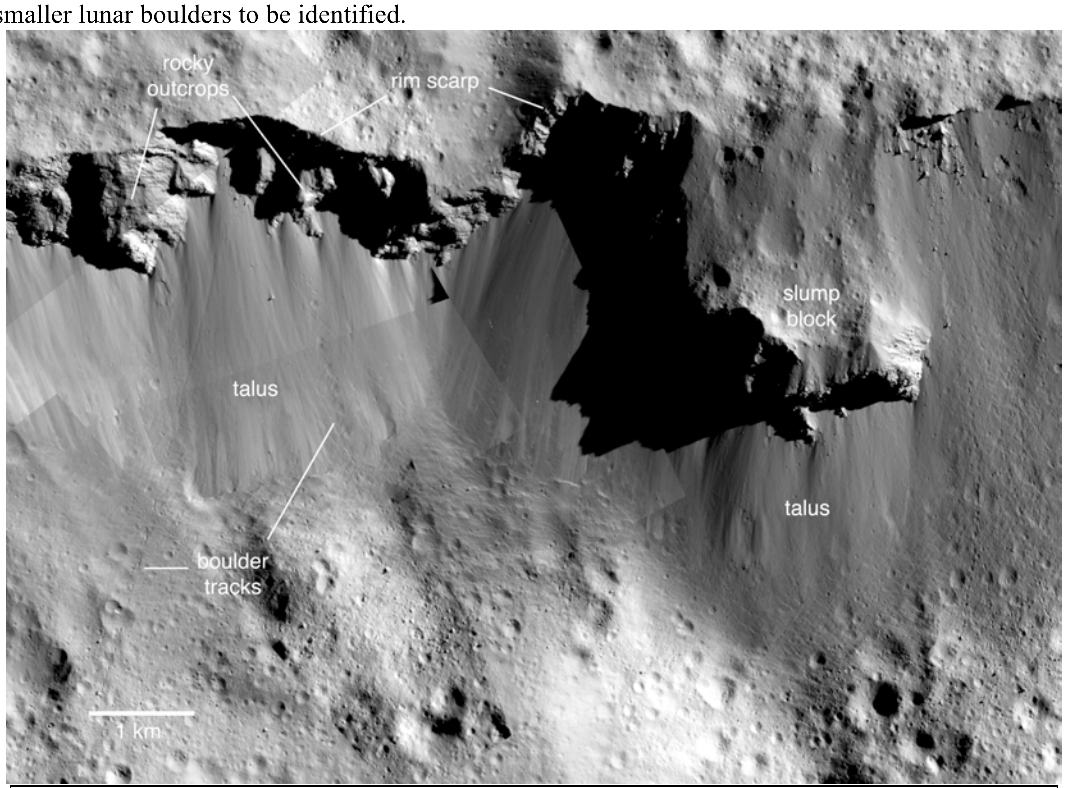

Figure 1. Mosaic of Dawn XM2 images of northern rim of Urvara crater, Ceres showing hillslope geomorphology.