MORPHOLOGIC AND TOPOGRAPHIC ANALYSES OF GEOLOGIC FEATURES IN THE COLUMBIA HILLS, GUSEV CRATER, MARS. J. W. Rice, F. C. Chuang, D. C. Berman, and D. A. Crown, Planetary Science Institute (1700 E. Fort Lowell Rd., Suite 106, Tucson, AZ 85719; rice@psi.edu).

Introduction: Exploration of the Columbia Hills in Gusev crater by the Spirit rover between 2004 and 2010 revealed a diversity of geologic materials and processes that are now recognized for their potential to satisfy the objectives of the Mars 2020 rover mission. However, many questions remain about the origin and evolution of the Columbia Hills despite the wealth of information obtained from both the rover and orbital data [1-25].

Mars 2020: The search for a suitable landing site for the 2020 rover mission is now a major focus of the Mars exploration community. At the recent Mars 2020 Rover Landing Site Workshop (August, 2015), 21 sites were evaluated by the science community, the rover project team, and instrument science teams. Discussion focused strongly on the science merits of all candidate landing sites with the goal of producing a ranking of the sites from most to least favorable. These results will serve as input to the Mars 2020 project and be considered with other factors (e.g., engineering, operations, planetary protection). The Mars science community determined that the *Columbia Hills site be ranked second highest for the Mars 2020 Rover Mission*.

Geology of Gusev crater and the Columbia Hills: The floor of Gusev crater is primarily composed of Early Hesperian (3.7-3.0 Ga) basaltic lava flows that form ridged plains [26-28]. These volcanic plains embay various older (Noachian) features on the floor including the Columbia Hills and numerous other mesas and buttes. The Columbia Hills are most likely upper remnants of a central peak or peak ring in Gusev crater and rise ~130 m above the volcanic plains. The hills are composed of sedimentary and altered rocks based on the analyses of various outcrops and samples from instruments onboard the Spirit rover [2, 6-12, 14, 16-19, 25, 29]. We next describe some of the key geologic features in and around Columbia Hills proper (Figure 1) along with new characterizations from HiRISE images and a new Digital Terrain Model (DTM) derived from images PSP_001777_1650 and PSP_001513_1655 (Figure 2).

Lava flows. The lava flows that embay the Columbia Hills on all sides have distinct flow margins along the west, south, and southeast portions of the hills. Preliminary analyses of HiRISE stereo DTM data along the two stepped margins to the southwest of Columbia Hills indicate they are each ~4 m in height. Future analyses of lava flow margins within the zone of HiRISE stereo coverage will concentrate on variations in flow thickness and the examination of lava flow units exposed in the walls of craters.

Landslides. Mass wasting in the form of landslides is an important geomorphic process that has shaped the Columbia Hills. We have used the HiRISE stereo DTM to conduct preliminary analyses of two landslides.

Landslide 1 occurs on the south-facing slope of Husband Hill. Recognizable features include the crown, toe, and main landslide body, as well as side margins along the upper parts of the landslide. The toe is curved, producing a lobate shape. The main landslide body deposited material on top of dunes in the adjacent El Dorado dune field to the east. Dune crests are still visible along the margins of landslide, which suggests the deposit is relatively thin. It's unclear if the inner portions of the landslide deposit were thick enough to completely bury dunes. One impact crater within the deposit contains dunes similar to those in the dune field, suggesting that the deposit went around or was thin enough to not bury it.

Landslide 2 occurs on a northwest-facing hill slope toward Home Plate. It is less distinct than landslide 1, but recognizable features include a curved lobate toe, crown, and striations on the surface of the main body. The area behind the toe appears to be eroded, with some exposed patches similar in tone to nearby Home Plate. Striations longitudinal to the slide direction may be analogous to the same types of features seen in terrestrial long runout landslides. However, there are striations covering the slopes outside of the inferred margins, suggesting that either a separate mass-wasting event deposited materials with the striations or that the main landslide event may be larger than our current mapping of it.

We have used HiRISE stereo DTM data to characterize landslide morphometry. The surface slopes of landslides 1 and 2 are ~10° and ~12°, respectively, with local slopes of over 15° in places on both features. Landslide 1 extends for ~330 m over an observed elevation range of ~60 m. Landslide 2 extends for ~235 m over an observed elevation range of ~50 m.

Volcanic Vents. Home Plate is a deposit attributed to hydrovolcanic eruptions due to the interaction of rising magma with either groundwater and/or subsurface ice. Five other Home Plate-like features have been identified in the Inner Basin and three more in the East Basin of the Columbia Hills. We used the stereo DTM to assess the morphometry of Home Plate and other potential volcanic vents in the Columbia

Hills. Preliminary results show that Home Plate is ~71 x 82 m across and ~5,600 m^2 in area, with exposed thicknesses of 1-2 m along its margins. The entire feature slopes to the northwest at ~5°, with local slopes of > 20° along the NW margin. These data will be used to examine potential mechanisms for their origins, degradational processes, and to calculate the volume of volcanic materials.

Crater Size-Frequency Distributions. As part of our analyses of morphologic and topographic characteristics, we are also measuring and analyzing crater size-frequency distributions to assess ages and interpret degradation history. The diameters of all craters were measured on the surface of the Columbia Hills as seen in HiRISE image PSP_001777_1650. The count area was loosely based on the -1930 m elevation contour (calculated from the DTM), avoiding the flatter areas around the margins of the hills that exhibit significant aeolian infill. Craters were categorized by morphology as fresh, degraded, or buried. Crater size-frequency distributions show a crater retention age of several hundred million years for craters between ~30 and ~75 m in diameter, with a depletion of craters at smaller diameters. These results are similar to counts on MOC image E03-00012 as counted by [30]. This age is unlikely to be the formation age of the Columbia Hills, given that the surrounding plains that embay the hills appear to contain a higher density of craters, but rather a stabilization age for the surface. Haldemann et al. [30] suggest this could be due to slope effects or different target properties.

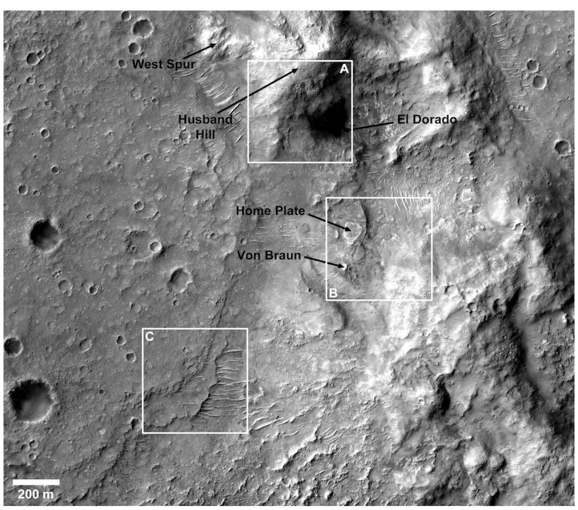

Figure 1. HiRISE (PSP_001513_1655) context view of the Columbia Hills with Husband Hill landslide (Box A), Home Plate and von Braun butte (Box B) and lava flows (Box C) indicated.

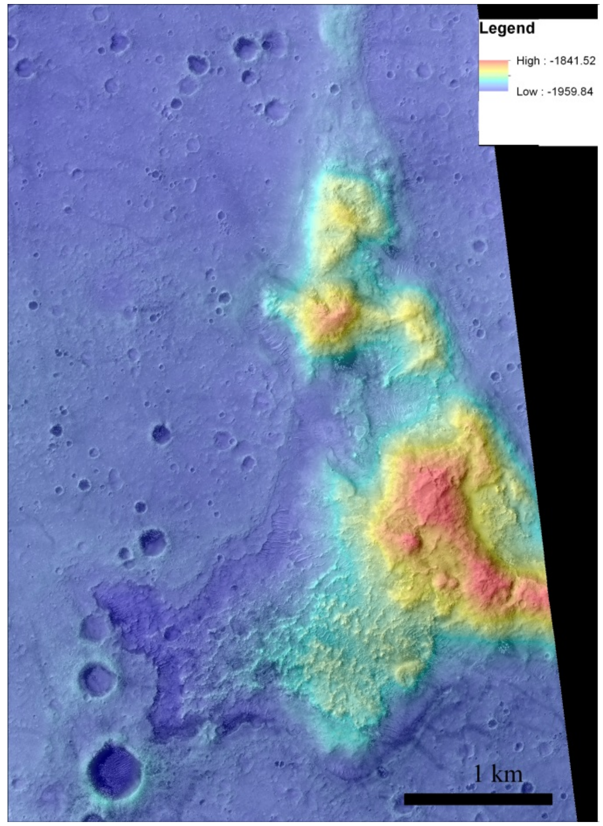

Figure 2. Portion of HiRISE DTM derived from images PSP_001777_1650 and PSP_001513_1655

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