CosmoQuest Surface Mapping: Cratered with a Chance of Rocks. J.A. Grier[1], M. Richardson[1], P. Gay[2], C. Lehan[2], R. Owens[2], S. Robbins[3], D. DellaGiustina[4], and C. Johnson[4]. [1]Planetary Science Institute (jgrier@psi.edu,), [2]Astronomical Society of the Pacific (starstryder@gmail.com), [3]Southwest Research Institute, [4]University of Arizona Lunar and Planetary Laboratory.

Introduction: The CosmoQuest virtual research facility employees citizen scientists to aid team-scientists in identifying craters and other scientifically interesting features on a variety of worlds. In this poster, we look at how effectively citizen scientists are able to mark craters in a variety of different scenarios, including under differing illumination angle, on varying terrains, and in images of differing quality. We also take a preliminary look at our ability to effectively mark boulders both when they appear <5 pixels across, and when they dominate an image.

Impact craters are one of the most common and most useful features found on planetary surfaces. The number and morphology of these features allows for studies of the age of and nature of the target surface, as well as investigations into the impactor population responsible for the craters. Performing statistical studies on the crater size-frequency distribution allows for the estimates of the age of impacted surface (assuming a given crater production function and using absolute ages from the Moon to calibrate results). Representation of such data was standardized beginning in 1979 with the Crater Analysis Techniques Working Group [1].

Boulder size and frequency statistics are also of key importance in understanding processes such as impact crater formation, ejectal emplacement, and regolith formation. Counts of boulders on the surfaces of airless bodies such as the asteroids Vesta and Itakowa can lend critical insight into these processes.

Validating Citizen Science counting models: Conversations about how to best collect and analyze crater data continue, [2,3] especially in light of new and innovative ways to annotate images, and to involve the general public ("Citizen Scientists") in authentic research endeavors. It is most common for studies of cratered surfaces to be conducted by a single expert analyst ("crater counter"). However, the CosmoQuest Virtual Research Facility allows for citizen scientists to assist in counting craters on planetary surfaces. Work by Robbins et al., 2014 [4] compared the results of groups of citizen analysts against those of professional researchers. The work of eight professionals was put side by side against that of the citizens, and found that the average spread in the population of craters by experts is greater than the difference between the average of the experts' data and the volunteers' consensus data. The work validates that a number of citizen scientists working on the same area and producing a consensus result can render robust counts, comparable with those produced by a professional crater counter.

In this ongoing work, we extend our initial calibration efforts to look at how software can be used to aggregate citizen science data into easy-to-check maps to perform spot validation of crater counts.

Factors Effecting Counting Data: There are a host of important factors that can effect the acquisition of crater count and boulder couont data. Light angle, terrain, number, morphology/freshnes, and potential psychological effects can all have an effect on how count data is acquired. These effects are measured in CosmoQuest's citizen science portals for mapping the Moon, Mars, Mercury, and Vesta.

<u>Moon Mappers</u> – Moon Mappers is CosmoQuest's original Citizen Science Project. This project gathers crater data from the Apollo 15 landing site using Lunar Reconnaissance Orbiter's (LRO) Narrow Angle Camera (NAC) images with sun angles from 27° (~noon) to 83° (~sunrise/set) to understand how detection varies with incidence angle. Since many bodies in the solar system are limited to flyby imaging, understanding how professionals may be biased in their analysis of these terrains due to non-optimal lighting conditions could help create a "correction factor" to better understand these bodies and the related impactor population.

<u>Mars Mappers</u> – Research by Edwin Kite examines small craters at proposed rover landing sites. The frequency of small craters (for certain landscapes) are inversely correlated with erosion rates. Rapid-erosion sites are preferred sites for rover investigation because near-surface rocks at these sites will have spent relatively little time undergoing irradiation by galactic cosmic rays. Because galactic cosmic rays destroy complex organic matter, rapid-erosion sites are favorable locations for the preservation of complex organic matter and thus for astrobiology-rover investigation. Planet Mappers: Work by Stuart Robbins will examine small craters in volcanic areas to model when both very large volcanoes and much smaller volcanoes (on their flanks, in surrounding fields, and even within the main caldera) last erupted, with implications for possible past life on Mars.

<u>Mercury Mappers</u> - Full-planet photographic coverage of Mercury from MESSENGER reveals that one of the basic assumptions of impact cratering is broken on that planet: Secondary craters – craters formed

when blocks of ejecta from an extraplanetary impactor are launched and create their own craters – dominate crater counts at diameters as large as 10 km. Secondary craters on the Moon and Mars only begin to dominate at diameters of ~1 km. This discrepancy is explained by impactors' velocities being more than twice as fast at Mercury than Earth, generating higher energy ejecta. Mercury's larger gravity further enhances the ejecta impact velocity. By mapping craters across Mercury, we can better understand the maximum diameter of secondaries relative to their parent primary.

Vesta Mappers - The Dawn Mission began getting up close and personal with asteroid Vesta in July 2011. Data gathered includes tens of thousands of images taken by the framing camera. Citizen Scientists will annotate images and assist in crater counting efforts. Accumulated findings can help the Dawn Science Team determine more about the age and composition of the surface. Vesta Mappers is a collaboration between the Dawn science and education/public outreach teams and CosmoQuest.

Additional Asteroids – In preparation for the OSIRIS-Rex encounter with Bennu, CosmoQuest is testing our ability to effectively map large boulders. As part of this work, we are replicating the study done by Robbins et al. for rocks in Itokowa images obtained by the Hayabusa spacecraft.

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