SMALL CRATERS FROM OBLIQUE IMPACTS AND THE ORIGIN OF AN UNUSUAL STREAK IN ELYSIUM PLANITIA, MARS. G. Komatsu[1], M.A. de Pablo[2], J. Ormö[3], L.L. Tornabene[4], [1]International Research School of Planetary Sciences, Università d'Annunzio, Viale Pindaro 42, 65127 Pescara, Italy (goro@irsps.unich.it), [2]Departamento de Geología, Universidad de Alcalá, 28871 Alcalá de Henares, Madrid, Spain, [3]Centro de Astrobiologia, Instituto Nacional de Tecnica Aeroespacial, Ctra de Torrejon a Ajalvir, Km 4, 28850 Torrejon de Ardoz, Madrid, Spain, [4]Lunar and Planetary Lab, University of Arizona, Tucson, Arizona, USA.

Introduction: An elongated, narrow fan-shaped (about 500 m wide, 2 km long), light-toned feature extending towards the west direction was first identified at 5.74º N, 169.6º E on probable lava plains of Elysium Planitia on Mars, in narrow- and wide-angle images (E23-00771, E23-00772, respectively) acquired by Mars Orbiter Camera (MOC) onboard Mars Global Surveyor in December of 2002 (**Fig. 1A**), and in other images more recently acquired by Thermal Emission Imaging System (THEMIS) and High Resolution Stereo Camera (HRSC) onboard Mars Odyssey and Mars Express [1]. The feature seems to originate from a small (~40 m wide) quasi-circular structure. The light-toned feature displays relatively sharp boundaries near the apex and shows a range of brightness variation. Based on the observations of [1], the light-toned feature was interpreted to be either an ephemeral phenomenon in the air or a deposit on the ground, which may have been produced from volcanic vents and transported by the prevailing wind.

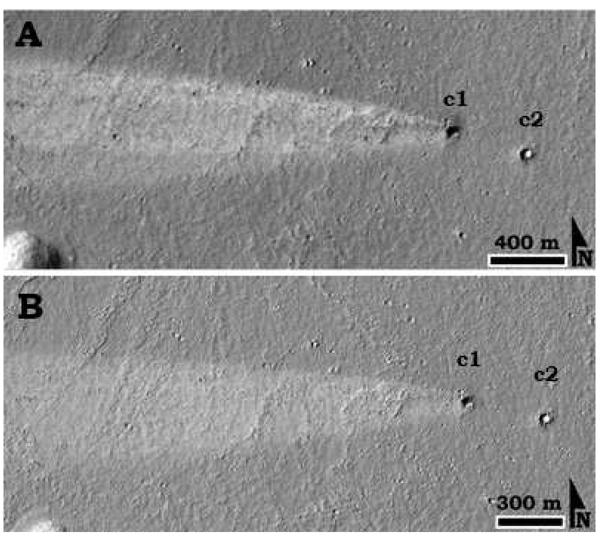

Fig. 1. *The light-toned feature (streak) in Elysium Planitia. A) MOC image, E23-00771. B) HiRISE image, PSP_008304_1860.*

Here we present results of an analysis of a newly available High Resolution Imaging Science Experiment (HiRISE) image (PSP_008304_1860) acquired by Mars Reconnaissance Orbiter on the light-toned feature and the quasi-circular structure that appears to be its source (**Fig. 2**).

Small crater morphology: With the new information provided by the HiRISE image it is now possible to determine that the relatively fresh ~40-m wide quasi-circular structure is most likely a small crater (c1 in **Figs. 1, 2**). A HiRISE stereo pair has not yet been acquired for the production of Digital Elevation Model (DEM), but it appears that the crater wall on the WNW side is steeper than the other sides. Multiple arrays of boulder strewn fields are distributed primarily to the ESE direction of the crater. Another crater (c2 in **Figs. 1, 2**), of similar size and preservation state as c1, occurs about 300 m to the ESE of c1. Like c1, this crater has arrays of boulder strewn fields distributed to the ESE although the presence of crater wall asymmetry is less certain (e.g., eolian infilling preferentially on the east side can give an impression of asymmetry). Low parallel ridges concentric to the rim are observed on the WNW periphery of the craters. These characteristics of the two craters, particularly the boulder strewn field distribution, are commonly observed with other similar-sized craters identified in the same HiRISE image.

The morphological characteristics of the craters in the HiRISE image are best interpreted to be impact craters formed by oblique impacts from the WNW direction. Thirty-eight craters in the image with the clearest indications of impact directions were examined. The trajectories of the impactors were inferred based on the known characteristics of small craters formed by oblique impacts, i.e., wider downrange ejecta distribution [2, 3]. The elliptical crater shape typical for very low impact angles (<12°, [4]) and "butterfly" distribution of the ejecta (e.g., [2, 5]) are not clearly observed at the studied craters, giving a minimum possible impact angle. The rather uniform direction of the reconstructed trajectories of the impactors that formed them makes it very unlikely the craters formed as primaries during separate events. Likewise their wide areal distribution excludes the formation from a single atmospheric breakup from a single event. The effect from impact angle on the final shape of the crater increases with decreased impact velocity [e.g., 6]. Secondaries are commonly formed at lower velocities than primaries. Thus, the impact angle of the studied craters, if secondaries, may be relatively higher with respect to their morphologies. The reconstructed trajectories seem to point towards an origin of the impactors from the 10.1-km diameter, rayed, geologically young Zunil crater (<10 Ma; [7] or <100 Ma; [8]) about 245 km to the WNW, or perhaps from the

13.5-km diameter, rayed, Corinto crater about 1800 km to the WNW. Therefore, we find that, most likely, these craters were formed as secondaries of Zunil or Cornito, although they were not previously mapped as such [8]. Typical Zunil secondaries mapped by [8] have dark inner ejecta and often bright outer ejecta, but these are characteristics not obvious for the small craters in our study.

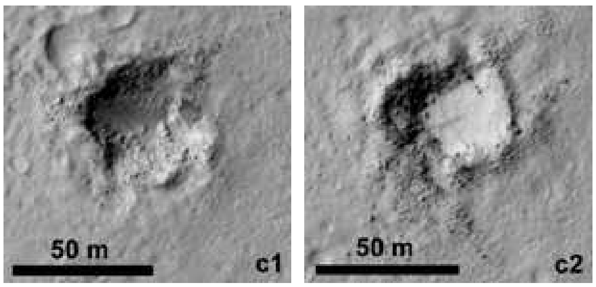

Fig. 2. *The source crater (c1) of the light-toned feature and the crater (c2) with the similar morphology (but without a light-toned feature). HiRISE image, PSP_008304_1860.*

The light-toned feature: The light-toned feature observed in the HiRISE image is interpreted to be a deposit on the ground based on its m-scale morphology. The feature emanates from c1 and extends to the west (**Fig. 1A, B**). This streak-like feature is about 5 km long based on a THEMIS visible image covering its entire length. It is shaped like a narrow fan with its apex positioned at c1. Its boundaries are relatively distinct in its eastern half but margins of the western half are somewhat ill-defined.

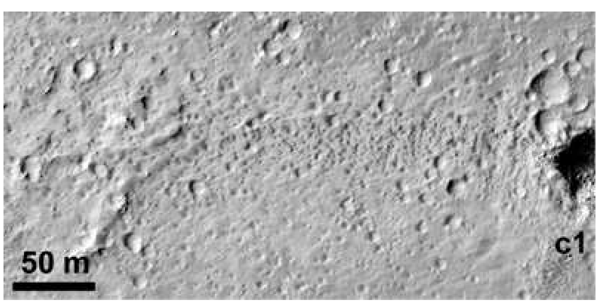

Fig. 3. *The source crater (c1) and the light-toned feature in the vicinity. HiRISE image, PSP_008304_1860.*

The surface texture is hummocky (possible dune forms) near its apex and in the vicinity of c1 (**Fig. 3**), but further away underlying topographic features are visible continuously from outside and across the feature (**Fig. 1**) implying that the feature consists of a thin deposit on the ground. A brightness variation is observed within the feature; in particular, it is darker along its center axis near the apex (corresponding to the hummocky zone), along its center further west, and also in the southern part (MOC image; **Fig. 1A**). This brightness variation is less apparent in the HiRISE image (**Fig. 1B**). The differences between various images of the feature may be due to their variable observation parameters and conditions, but the possibility that they could be real (i.e., time-dependent properties of the feature) cannot be excluded. The feature's west-trending direction is consistent with more obvious wind streaks visible in the HiRISE and other previously acquired images. This observation indicates that the distribution of the light-toned feature is most likely controlled by wind. However, this type of light-toned feature is associated practically only with c1 among craters of similar dimensions, morphology, and preservation state in the HiRISE image. Only another small crater exhibits a similar light-toned feature but at a much smaller size (less than 200 m long). Besides this, only c1 exhibits dark-toned materials on the crater floor (**Fig. 2**).

Assuming that the small craters including the one with the light-toned feature in the study area are secondaries from Zunil or Corinto, we hypothesize three formation mechanisms of the light-toned feature. The first two hypotheses are: (1) it was formed during the impact event by ejection of unconsolidated fine-grained materials from underneath a lava layer and immediately drifted with the wind in one direction; (2) unconsolidated fine-grained materials underneath a lava layer were ejected by the impact, deposited around the rim, and later transported by the wind. The near-total absence of similar light-toned features at nearby similar-sized craters implies that the unit of unconsolidated fine-grained materials is irregularly distributed beneath the lava layer. Alternatively, (3) it was formed by a fumarole activity taking advantage of the fractures produced by the impact. The material comprising the feature may have been precipitated from the gas emitted from a vent(s) or the gas may have ejected the unconsolidated fine-grained materials from underneath the lava layer.

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