ICE FLOW IN DEBRIS APRONS AND CENTRAL PEAKS, AND THE APPLICATION OF CRATER COUNTS. W. K. Hartmann[1], C. Quantin[2], S. C. Werner[3], and O. Popova[4]. [1]Planetary Science Institute, 1700 E Ft Lowell Rd Ste 106, Tucson AZ 85719-2395 USA, hartmann@psi.edu; [2]Université Claude Bernard, Lyon 1, 2, rue Raphaël Dubois, 69622 Villeurbanne Cedex, Lyon, France; [3]Geological Survey of Norway, Leiv Eirkssons vei 39, 7491 Trondheim, Norway; [4]Russian Academy of Sciences, Leninsky Prospekt 38, Bldg 1, 119334 Moscow, Russia

We apply studies of decameter-scale craters to studies of probable ice-flow-related features on Mars, to interpret both chronometry and geological processes among the features.

The first issue is reliability of the crater chronometry systems at decameter scales. McEwen et al. developed a useful test of this [1]. They argued that fresh-looking, Zunil-style Martian ray craters are the youngest or near-youngest craters in their size ranges. Thus, crater-count ages from small craters (D ~ 10-25 m), superimposed on these “Zunils,” should be comparable to the expected formation intervals of the host “Zunils,” typically 1 to a few My. McEwen et al., however, found few or no small superposed craters in MOC images, and concluded that crater chronometry systems are in error by factors of 700 to 2000 at these scales.

In an ongoing project at the International Space Science Institute in Bern, we studied the 3 craters tested by McEwen et al. and 5 other young ray craters, using newer HiRISE imagery. In all eight cases we find populations of decameter-scale craters do exist, and that they give the expected order of magnitude ages (from a few 10^5 y to a few 10^6 y) for the youngest few craters in each size bin [2]. This statement is true for either the Hartmann or Neukum isochron systems [3, 4], and also for ages estimated directly from the observed formation rate of decameter craters on Mars, independent of the isochron systems [5,6,7].

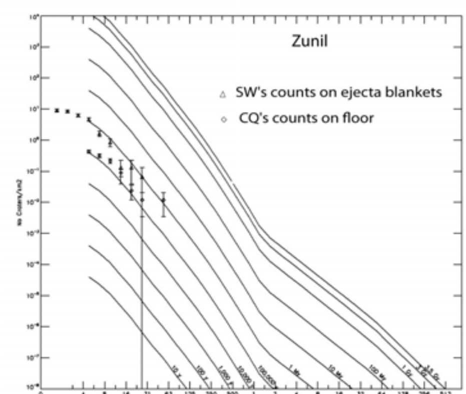
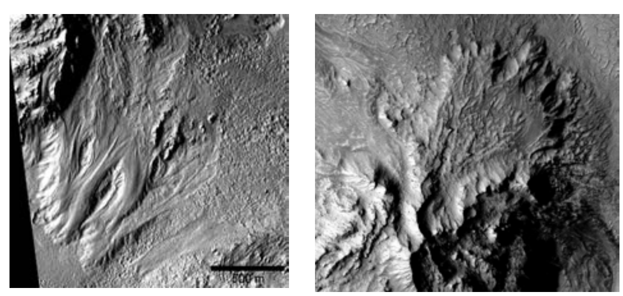


Fig. 1. Example of our application of the McEwen et al. [1] test. Decameter-scale craters inside the young ray crater Zunil and on its ejecta blanket show an age around 0.2-1 My, not inconsistent with it being one of the youngest craters in its size class.

This successful test of crater chronometry at decameter scale opens the door to application of small craters to order-of-magnitude chronometry of small-scale Martian formations and dramatic improvements of chronology of very young Martian features. Many refinements are still desirable, particularly in terms of effects of secondaries [1]. Nonetheless, the positive McEwen et al. test results allow interesting observations of flow features that may be related to mobility of water- or ice-rich material.

Figure 2 shows a first example. While studying the youngest young ray craters, we found lobate flow features on central peaks in three of our eight study craters: Zunil, Tooting, and Tomini. These are absent in lunar craters, and to our knowledge they are uncommon on central peaks of older Martian craters. Central peaks bring up deep material [8], and in view of the presence of rampart ejecta blankets around these craters, we suggest that these lobate features are flows not of lava, but of muddy slurries resulting from impact into ice-rich substrates, where the central peak brought up material rich in “molten ground ice.” Counts of decameter craters in these larger primary impact craters suggest ages of no more than a few My. Based on these observations the flow features appear to have short survival times. Sublimation of ice contained in the material may result in gradual collapse of the initial topography and wind-related removal of the remaining dust deposits, thus explaining why such flow features are less prominent in ancient central peaks.



(a) **(b)**

Fig. 2. Examples of lobate flows off the central peaks of young ray craters: **(a)** Zunil. **(b)** Tomini. We interpret these as possible mud slurry flows resulting from impacts into ice-rich terrains.

Figure 3 shows a second example, namely a debris apron discussed in [9], where we noted a large deficiency of decameter-scale craters on the debris apron, relative to the surrounding plains only a few kilometers away. Craters smaller than 90 m (depth 30 m) show this depletion in the aprons, but the larger craters don't. While the survival lifetime of these craters in the plains is of order 10^7 - 10^8 y, it is only a few 10^6 y on the aprons. We interpret this in terms of the long-proposed high ice content of debris aprons [10, 11]. We suggest that the loss of smallest craters is due either to sublimation or flow of ice-rich material in the upper 30 m of the aprons. Our results support the suggestions of [10] that bulk masses of aprons are much older than the 10^6 y ages, and support the results of [11] that surface layers of aprons have been affected by ice sublimation. Our result is also consistent with radar detection of high ice content in this and another debris apron east of Hellas [12].

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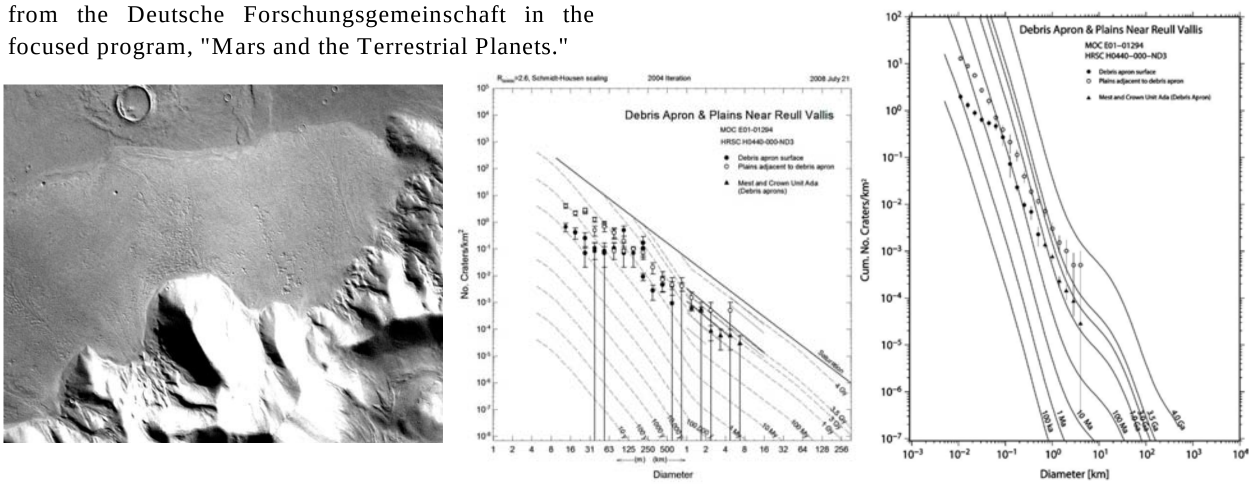

(a) **(b)** **(c)**

Fig. 3. Debris apron and crater counts showing strong losses of craters of diameter D ≲90 m and depth ≲30 m, relative to nearby plains. **(a)** Apron surface. **(b)** Crater counts in each D bin plotted in log-D increments against background of Hartmann isochrons. **(c)** Same counts in cumulative form plotted against Neukum cumulative isochrons.