Impact Related Features Outside the Second Layer of Martian Double-Layer Ejecta Craters: What they tell us about the Parent Crater. Joseph Boyce and Peter Mouginis-Mark, Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI. 96826.

Unlike other types of fluidized ejecta impact craters, Martian double-layered ejecta (DLE) craters rarely have secondary impact craters [1]. In our continued effort to understand DLE and other types of Martian fluidized ejecta craters we have examined recently acquired THEMIS images, and found two exceptionally fresh DLE craters that include well-developed secondary crater fields. One of these craters (crater 1 in Figure 1) is a 12.0 km diameter, 1015 m deep crater located at 54.6º N, 190.7º E. The other crater (crater 2 in Figure 2) is a 13.0 km diameter, 1201 m deep crater located at 73.0º N, 38.3º E. Morphologically, crater 1 is a typical DLE crater, but crater 2 includes an additional thin (~ 5-10 m thick), relatively smooth and extensive outer ejecta deposit (note: technically, making this a MLE crater). It extends continuously to an average of ~ 6-8 R from the crater rim, but, in places, long narrow strands of ejecta extend to ~ 10-12 R.

Secondaries from crater 1 excavate the surrounding plains. The Vastitas Borealis Formation (VBF) blankets these plains. Our preliminary data suggest secondaries from crater 1 are absent in areas nearby where the VBF has been eroded away. In contrast, secondaries from crater 2 are found only in its thin outer ejecta layer. The depths of the secondaries from both craters appear to be approximately as deep as the thickness of these weak, easily excavated and eroded surface units compared with the material beneath [1, 2, 3], and as a result would be completely erased if these deposits were removed (or filled) by erosion. Therefore, the new data suggest that weak ejecta blocks are produced by DLE craters, but unless they impact weak materials they break apart upon impact like dirt clods, leaving little trace. There are three likely ways to produce weak ejecta blocks, (1) the target rock is composed of intrinsically of weak and/or fragmented material [4], or (2) the target rock is comminuted by the cratering process, such as when significant water is present in the target materials [5, 6], or (3) when airborne blocks are crushed by the dynamic pressure during the high-velocity outflow of gas-rich ejecta [7]. The latter two require abundant volatiles, with case (2) requiring volatiles in the subsurface, and 3 requiring them either in the subsurface and/or the atmosphere. Consequently, we suggest case (3) that DLE craters require the presence of significant amounts of volatiles in order to produce the observed relationships. The amount of volatiles must have varied considerably in space and/or time during Martian history.

The geologic setting and spatial relationship of DLE craters to other types of fluidized ejecta craters provide insight into which of the three cases may apply to Mars. For example, in the Alba Patera region, fresh DLE craters (with no secondaries) are found near other types of fresh fluidized ejecta craters (with abundant secondaries) of approximately the same size, and in the same geologic unit (Figure 3). This suggests that conditions that favor development of the different types of craters either rapidly fluctuate temporally or there are significant local heterogeneities in the thick sequence of volcanic deposits in this area (e.g., interbedded patches of highly friable, weak sedimentary or pyroclastic rock). However, while such local heterogeneities are possible, Alba Patera appears to be surfaced mainly by lava flows that should produce strong ejecta blocks and secondaries when excavated, even by the DLE craters. Since this is not the case, we suggests that the intrinsic physical properties of the target rock alone are not responsible for suppression of secondaries from DLE craters.

References: [1] Boyce, J.M., and P.J. Mouginis-Mark, 2006, JGR-Planets, in press; [2] Head J.W. et al., 1999, Science, 286, 2134-2137; [3] Tanaka, K., et al., 2003, JGR, 108(E4), 8043, doi: 10. 2003JE0011908; [4] Mouginis-Mark, P.J., 1981, Icarus, 45, 60-76; [5] Kieffer S., and Simonds C., 1980, Rev. Geophys. Space Phy., 18, 143-181; [6] Wohletz, K., and M. Sheridan, 1983,Icarus, 56, 15-37; [7] Vickery, A., 1989 JGR, 91, 14139-141160.

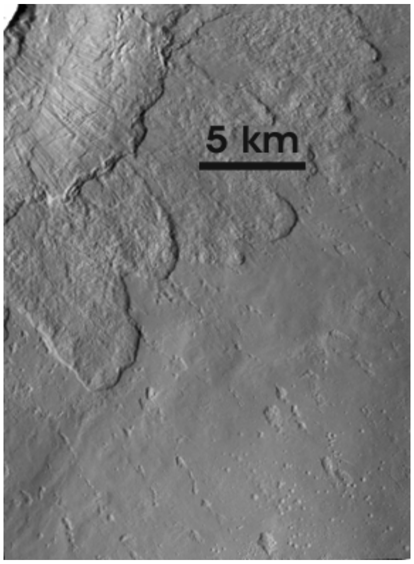

Figure 1. A fresh high-latitude DLE crater (crater 2) showing abundant secondary craters. Most of the secondaries are shallower than the thickness of the VBF that blankets the plains in this area. THEMIS V0837004

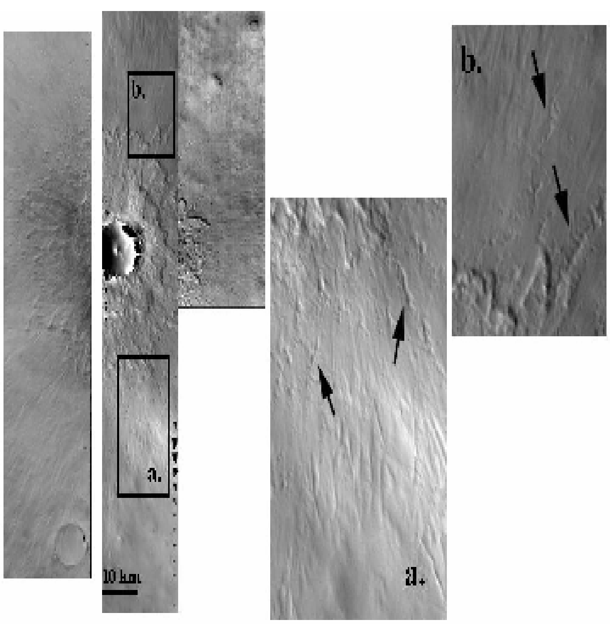

Figure 2: This fresh, high-latitude impact crater (crater 2) has the same general morphologic characteristics as all DLE craters, but includes a thin, highly irregular-shaped outer ejecta layer. Enlarged areas (a and b) show the secondary craters (arrows) in this layer. THEMIS VIS images V10709002, V11358008, V09798018, V10085009 and IR image I03669002.

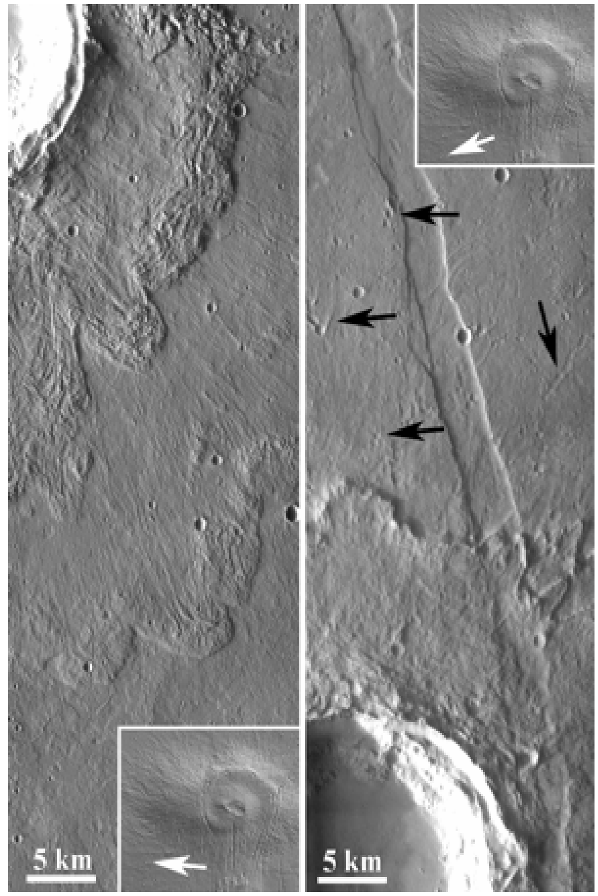

Figure 3: Two fresh fluidized ejecta craters (Right: DLE crater; Left: a typical SLE crater with abundant secondary craters) on the SW flank of Alba Patera illustrate strikingly different ejecta morphologies, despite the inference that the target rock in each case was a set of volcanic flows. THEMIS V14221014.

Noted: if the pits around crater 2 are secondaries, then their development on the outer ejecta deposit is inconsistent with current models for the timing of fluidized ejecta emplacement and secondary crater formation [e.g.,8, 9, 10]. In these models secondaries would be expected to have formed first and be overridden by the continuous ejecta deposits.

References for Note.

[8] Melosh, H. J. (1989), *Impact cratering: A geologic process*, 245p., Oxford U. Press.; [9] Mouginis-Mark, P.J., H. Garbeil, J.M. Boyce, C.S.E. Ui, and S.M. Baloga. (2004) The geometry of Martian impact craters: First results from an interactive software package. *J. Geophys.Res.–Planets*,109, E08006, doi: 10.1029/ 2003JE 002147.; [10] Mouginis-Mark, P.J., and S.M. Baloga (2006), Morphology and geometry of distal ramparts of Martian impact craters. In press, Meteoritics and Planetary Science.