The Lack of Secondary Craters Around Double Layered Ejecta Craters: Implications to the Volatile History of Mars, Joseph M. Boyce and Peter Mouginis-Mark, Hawaii Institute of Planetology and Geophysics, University of Hawaii, Honolulu Hawaii, 96822

As a general rule on planets, impact crater excavation produces large blocks of material ejected from the near-surface zone by stress wave/spall interaction [1] in ballistic arcs. These large blocks impact the surface beyond the continuous ejecta blanket to form secondary impact craters. Martian double-layered ejecta (DLE) craters appear to violate this general rule, and have no observed secondary craters. Other Martian impact craters, even other types of fluidized ejecta craters produce secondary craters [2-6] although Zunil, a SLE crater, produced secondary craters that begin outward of ~10 radii [7]. Consequently, it is possible that DLE craters produce secondary craters but that they have not been identified yet.

The lack of observed secondary craters around DLE craters does not rule out the existence of large ejecta blocks but that they are ineffective at producing craters. Most likely the reason DLE craters do not produce secondary craters is that blocks ejected by these craters are fragmented and weak as a result of 1) target materials composed of already fragmented materials (e.g., clastic sedimentary rocks), 2) volatiles in the target materials [8-9], or 3) crushing by the dynamic pressure in the high-velocity outflow of gas and particles during ejection. Such fragmented blocks would be ineffective at producing secondary craters. First we consider the target material. The observation that some areas of thick sequences of lava flows (e.g., Alba Patera) contain fresh DLE craters with no secondaries adjacent to fresh SLE and MLE craters with abundant secondaries (Figure 1) suggests that rock type alone is not an important factor in suppression of secondaries. This is because 1) all these craters have formed in the same target rock type, and 2) the target material in these areas is expected to be coherent rock. Second, water in target materials enhances fragmentation during impact, hence, subsurface water or ice present during crater formation would weaken or disaggregate ejecta blocks causing them to have little effect when they impact. Third, it is also possible that the absence of secondary craters around DLE craters is a result of the same high-velocity outflow of particles and gas that produced their radial texture. If this outflow overtook and entrained the blocks, then the dynamic pressure in the flow would fragment the blocks [10]. This mechanism could be the result of winds generated by an advance ejecta curtain [11], or by a base surge [12] although the ejecta-generated winds would have a better chance of catching up with the ejected blocks in flight.

These observations have important implications to Martian history and suggest that volatiles (i.e., subsurface water and/or ice, and/or atmospheric gas) are required to suppress secondary crater formation around DLE craters. Moreover, the inventory of volatiles available to participate in this suppression must have fluctuated repeatedly over Martian history for SLE, DLE and MLE craters to form close to each other on the same terrain.

References: [1] Melosh, H.J., 1989, Oxford Univ. Press, 245p; [2] Mouginis-Mark, P. J., 1979a, J. Geophys. Res., 84: 8011 – 8022; [3] Mouginis-Mark, P. J., 1979b, Proc. Lunar Planet. Sci. Conf. 10th, 1651 – 1668; [4] Schultz, P.H., and J. Singer, 1980, 11th Lunar Plant Sci. Conf., Geochemica Et Cosmochimica Acta, 2243-2259; [5] Barlow, N. G. and C. B. Perez, 2003, J. Geophys. Res., 108 (E8), 5085, doi: 10.1029/2002JE002036; [6] Mouginis-Mark, P. J., J. M. Boyce, V. E. Hamilton, and F. S. Anderson, 2003, *Proc. Sixth International Conference on Mars*. 3001 – 3003; [7] McEwen, A., and 8 others, 2005, Icarus, 176, 351-381; [8] Wohletz, K. H. and M. F. Sheridan, 1983, Icarus, 56, 15 – 37; [9] Kieffer, S. W. and C. H. Simonds, 1980, Rev. Geophys. Space Phys., 18, 143 – 181; [10] Vickery, A. M., 1989, J. Geophys. Res., 91, 14139-141160; [11] Schultz, P.H., 1992, J. Geophys. Res., 97, 11,623-11662; [12] Boyce at al., 2005, Submitted to J. Geophys. Res. Planets.

Figure 1. (A) THEMIS image showing a 17.66 km diameter, and 1138 m deep DLE crater (32.7ºN, 236.9ºE) (top) located ~ 130 km north of an 18.16 km diameter and 1179 m deep SLE crater (29.7ºN, 236.5ºE) (bottom) on the flank of Alba Patera at an elevation of ~ 0 m. The boxes outline locations of high-resolution images. (B), a high-resolution image of the DLE crater. No secondary craters are found around this crater, even though it appears morphologically fresh. (C), a high-resolution image of the SLE crater. This crater has abundant secondary craters (arrows).

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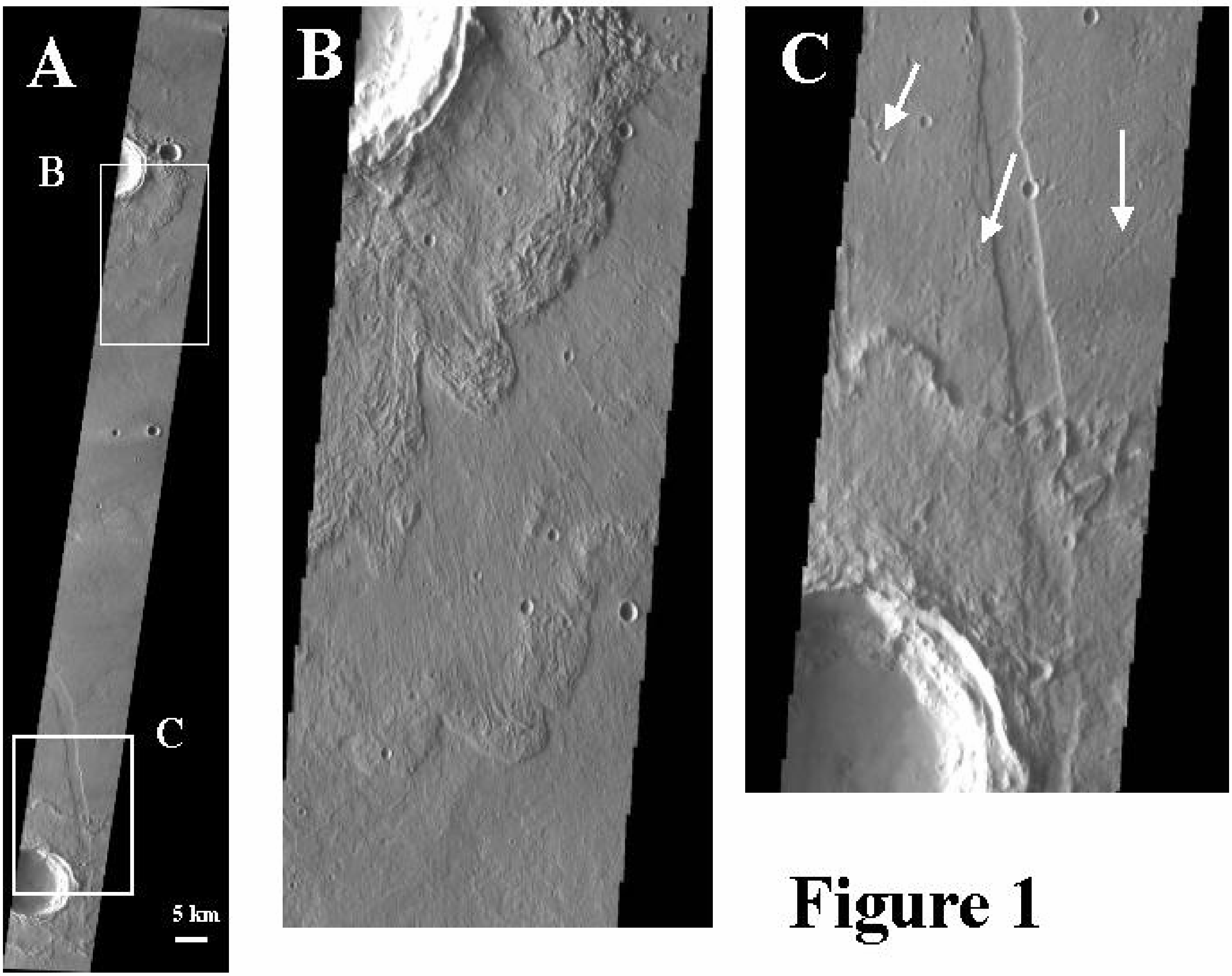

Figure 1