LONAR CRATER ON MARS: IMPLICATIONS OF ITS UNUSUAL MORPHOLOGY: J. M. Boyce[1], N. G. Barlow[2], ,and L. L. Tornabene[3] [1]Institute for Geophysics and Planet., Univ. Hawaii, Honolulu HI, 96822, [2]Dept. Physics and Astronomy, N. Ariz. Univ., Flagstaff, AZ 8600, [3]Lunar Planet. Lab., Univ. Ariz., Tucson, AZ, 85721: jboyce@higp.hawaii.edu

While there has been considerable previous work on Martian layered ejecta formation, our understanding of fluidized ejecta, especially the role of volatiles in their formation and emplacement, is still far from complete [1-13]. Toward advancing our understanding in this area, we have initiated a study of Lonar crater (Fig 1), the freshest of an enigmatic crater type found in the polar regions of Mars referred to as quasi- multi-layer ejecta (QMLE) craters [14]. Here, we have focused on its outer ejecta layer.

Figure 1. *Photomosaic of THEMIS VIS images of Lonar Crater showing its 3 ejecta layers.*

Lonar is a ~ 11.5 km diameter, ~ 1372 m deep QMLE crater located at 72.97°N, 38.32°E. It lies ~ 750 km from the north pole of Mars. The near-pristine nature of Lonar is indicated by its *1)* exceptional depth to diameter ratio, *2)* the preservation of small-scale features such as secondary craters, and *3)* the scarcity of erosional outliers of the thin outer ejecta layer. Like other QMLE craters [14], Lonar has the general morphologic attributes of double layer ejecta (DLE) craters. This includes a moderately lobate inner ejecta layer extending ~ 1-2 crater radii (R) from the rim with a moat near the base of the rim, and broad, low terminal rampart. The second thinner highly lobate ejecta layer extends~ 3-5 R from the rim ending in a narrow high rampart (Fig 2). However, the inner ejecta layer lacks prominent radial groves like DLE craters. But most notably, Lonar also has a third ejecta layer which extents outward to a remarkable 10-12 R. The feathery shape of the edge of the outer layers (Fig. 3a), its long, narrow jet or ray-like prominences of ejecta (Fig. 3b), and its nearly uniform thinness (< ~5 m) are unlike any other ejecta deposits on Mars. The feathery morphology is reminiscent of turbulent flow in a low density fluid.

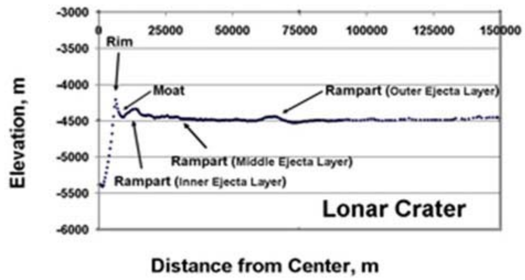

Figure 2: *Cross section from the center of Lonar Crater northwestward ~ 150 km (scale in m). This cross section shows the moat, and ramparts at the outer edges of the inner ejecta layer at ~ 1.3 R, the middle ejecta layer at ~ 3.5 R, and the outer ejecta layer at ~ 10R. .*

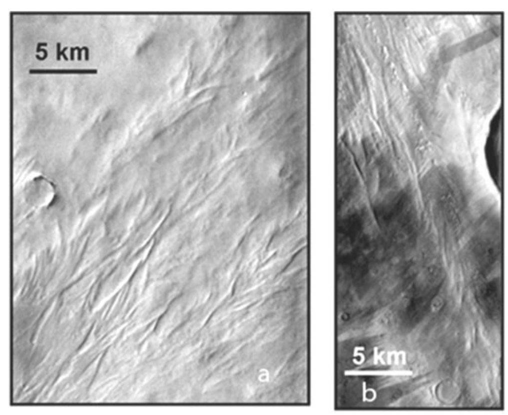

Figure 3: *Terminations of the outer ejecta layer of Lonar showing feathery edges (a – left, THEMIS VIS V20518001), including long prominences of ejecta (b – right, THEMIS VIS 20543001) that south ward from the crater. Also note the string of secondary crater-like pits in (b). These are found only in the prominence.*

Lonar has a large number of secondary craters within its outer ejecta layer (Fig. 4 a, and b). Their maximum diameter is < ~ 600-700 m. Many appear to be quite fresh with herringbone patterns comparable to that identified around fresh lunar craters [15]. The

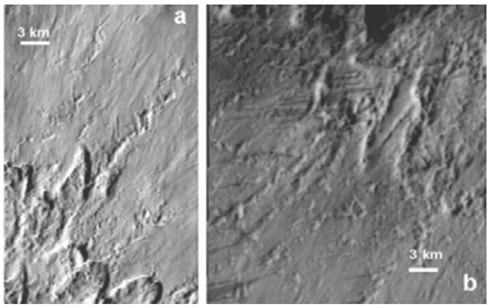

Figure 4. *Images of extensive secondary crater chains found in the continuous outer ejecta layer to the northeast (a – left, THEMIS V21167001) and southwest (b – right, THEMIS V2119200).*

distribution of the secondaries is strikingly different from that of the large rayed craters where secondaries can be found at large radial distances from the primary [16], and large near-in secondaries are outside or buried by the outer ejecta lobes [10], or from most DLE craters where secondary craters are not found at all [7]. Because Lonar secondaries appear to have formed within its outer layer this layer must have been emplaced before, or during secondary crater formation (unless deposition or later erosion of the layer was affected by the secondary pits in a way that allowed them to show through). This would require the outer layer ejecta to travel at a velocity of > 200-300 m/sec at its inner edge. This is 3 times that expected for most fluidized ejecta at that distance [1, 5].

We propose that the outer ejecta layer of Lonar is a fine-grain deposit, most likely cemented by ice, whose grains were transported and deposited as a dust laden density-driven flow. Such distant deposits of fine-grain materials are also found around some nuclear test craters (Fig 5) and are produced by base surge [e.g., 17]. This mechanism is suggested for the outer ejecta layer of Lonar because of it is too far from the crater for ballistic emplacement, its polar location where surface volatiles are readily available to cement the grains, the expected production of abundant fine grain materials by impacts [18] (especially if volatiles are present [19, 20]) coupled with evidence that abundant fine-grain materials are produced by impacts on Mars [21], and its feathery morphology suggesting turbulent flow similar to the edges of some types of flames.

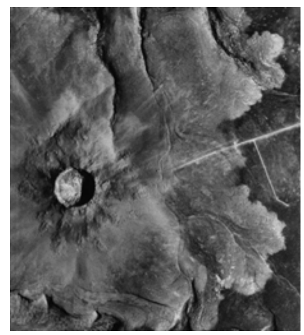

Figure 5. *Arial Photo of Schooner crater (275 m dia.) at the Nevada Test Site showing the light colored thin (from > m near the rim to a few cm near the outer edge), lobate, fine grain materials that extends outward over 12 R.* [from 22]. *The lobate (instead of feathery) nature of the edge may be due to the combination of the comparatively larger outflow of fine-grain materials from the much larger Martian craters and the thinner Martian atmosphere.*

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