EMPLACEMENT OF THE OUTER EJECTA LAYER OF LOW-ASPECT-RATIO LAYER EJECTA CRATERS. J. M. Boyce[1], N. G. Barlow[2], and L. Wilson[3], [1]Hawaii Institute of Geophysics and Planetology, University of Hawai'i, Honolulu, HI 96822, (jboyce@higp.hawaii.edu), [2]Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ. 86011, [3] Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, U.K.

Introduction: The unique physical characteristics of LARLE, or low-aspect ratio layered ejecta [1], suggest that they are emplaced by a flow mechanism that differs from those responsible for emplacement of other types of Martian ejecta layers. LARLE are characterized by 1) long run out distances (EM average ~ 10 [1]), 2) nearly uniform thinness (< ~5 m), 3) feathery shaped outer edges, with occasional long, narrow jet-like prominences, 4) curved, low-relief, sometimes overlapping, radial ridges within the layer (i.e., commonly have dune-like appearances), and 5) composed of fine-grain particulates (suggested by THEMIS IR and HiRISE images). Based on these characteristics, we proposed that the LARLE layer is emplaced by base-surge similar to those generated in explosion crater experiments and some explosive volcanic eruptions [1-3]. Here we propose a mechanism for the generation of the relatively large volume of fine-grain particles contained in these layers.

Background: The mechanism of emplacement of the LARLE ejecta layer is controversial. Wrobel et al., [4] proposing that this layer is not ejecta at all, but a “duricrust-like” erosion-resistant surface produced by extreme winds, lingering high temperatures, and water vapor generated by the impacts.They suggested that this blast moves outward to melt near-surface volatiles, causing them to migrate upward through the regolith. However, this model requires that LARLE craters < 5 km form in pure water ice or water, and that all of that material be transformed to vapor in order to produce the required blast.

In contrast, we have suggested [1-3] that the morphologic and thermal inertia characteristic of LARLE outer ejecta layers implies that they are fine-grain ejecta emplaced similar to base-surges associated with some explosive volcanic eruption and explosion-cratering events (Fig. 1). Such surges are radially spreading, suspension-driven, dilute, turbulent, gravity currents produced by either 1) collapse of an explosion column or eruption column of pyroclastic particles [5-7], and/or 2) secondary ejecta excavated by high-speed impact of primary ejecta [see 8-10]. While the study of base-surge has its roots in experimental explosion crater studies, the importance of base-surge in emplacement of some types of pyroclastic deposits also has been recognized and studied extensively. Of particular importance to this study are the ignimbrite deposits that have very low-aspect ratios (average deposit thickness to average run-out distance) as well as long run-out distances. These deposits have been termed low-aspect ratio ignimbrites (LARI) and have aspect ratios (*AR*) of 10^{-4} or less.

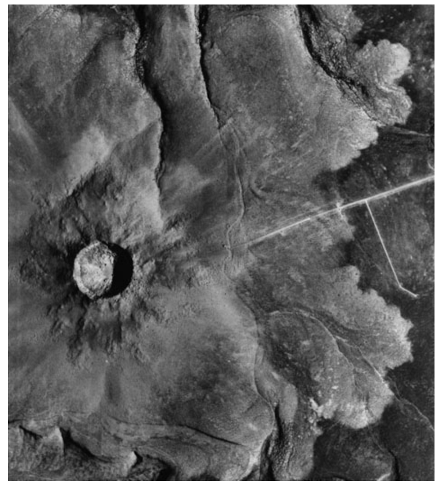

Fig. 1. Arial Photo of Schooner crater (375 m dia.) at the Nevada Test Site [11] taken shortly after formation showing light, thin (~ < 1 m), lobate, fine-grain ejecta extending outward for over 12 R. [AR ~2.23 x 10^{-4}]. This extensive ejecta layer of Schooner was deposited by sedimentation from a dust-laden, turbulent, gravity-driven base-surge [e.g., 8, 9]. Development of this thin deposit may have been enhanced by subsurface detonation in a target composed of alluvium that may have contained >10% water [9].

To test the reasonableness of our hypothesis, we [2] employed the numerical model of Dade and Huppert [12, 13] for the emplacement of LARI to predict the run-out distance of the outer ejecta layer of two Martian LARLE craters (Lonar, and an unnamed 4.2 km dia. crater at 44.3º S., 139.3º E). The results of this test showed remarkable correlation of nearly 99% between predicted values and actual run-out distances. We selected this particular flow model for our test because 1) it has been used to predict, with reasonable accuracy, the run-out distances of terrestrial LARI flows, 2) it employs the same mechanism that produced deposits around nucelear explosion craters, and 3) the physical characteristics of LARLE outer ejecta layers are consistent with those expected to be produced by deposition from a base-surge. There are other models that use a similar mechanism [e.g., see 5, 14] and we also plan to test these models against our observations.

Source of fine-grain particles: Of particular importance to our LARLE craters emplacement model is that relatively large volumes of fine-grain material be available for transport and deposition by this mechanism. While many observers suggest that base surge is

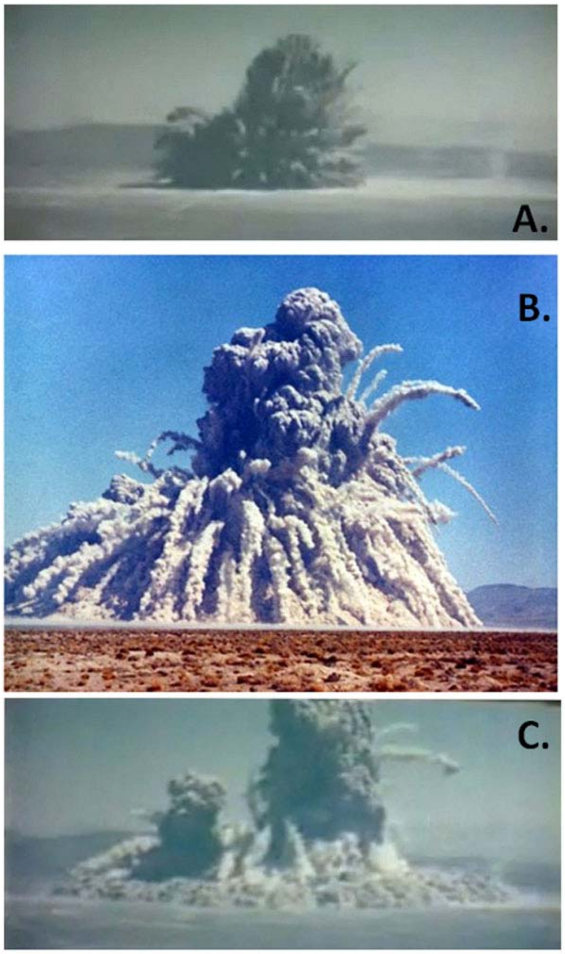

Fig. 2. Time sequence of images of Sedan crater ejecta . There is ~10 sec between each image, with earliest at the top.

fed mainly by material carried in the ejecta column as it collapses, others note that a substantial volume of that material in base-surges generated by most explosion crater experiments is actually secondary debris derived by excavation of the surface by impacting primary ejecta [i.e., 8]. This is suggested in the sequence of pictures of ejection of material from Sedan nuclear test crater and formation of its base surge shows in Fig. 2. Figure 2A shows an early phase of ejection, material move along ballistic pathways as an explosion column begins to rise. Figure 2B shows continued rising of the explosion column, as well as impact of some of the ballistic ejecta. Note that the billowy base surge is forming inward of the individual impacting ejecta blocks. In Fig. 2C, a well-developed base surge has formed and has expanded past the zone where most of the primary ballistic ejecta is landing. At this point, the explosion column still appears to be growing.

These experimental cratering events offer insight into how LARLE ejecta obtain relatively large volumes of fine-grain particulate materials, as well as the nature of their emplacement mechanism. For example, Fig. 2 shows that base-surges can be initiated by the impact of primary ejecta which excavates and sprays secondary ejecta outward. In the case of LARLE craters, most are found in areas surfaced by fine-grained deposits [1]. In these areas, impact of primary ejecta should excavate these fine-grained materials, resulting in their incorporation (added with the material from collapse of the ejecta column) into the base-surge. We also suggest that as crater size increases above a certain size in these areas, the relative proportion of material derived from the fine-grain surficial deposits will decrease in relationship to the volume of secondary ejecta produced by excavation of underlying consolidated rock. Hence, only craters smaller than a particular size will develop substantial base-surge deposits. In addition, craters must also be large enough to produce high enough velocity ejecta to excavate a sufficient volume of secondary material to produce the LARLE deposits.

Conclusions: We suggest that the emplacement of the long run-out outer ejecta layer of LARLE craters is by a mechanism (i.e., base-surge) that differs from those responsible for emplacement of the other types of ejecta layers. Furthermore, we suggest that while all impact craters produce thin, base-surge deposits, those that form LARLE deposits occur in regions where they excavate large volumes of fine-grain volatile-rich surface materials to incorporate into their base surges.

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