RAMPART CRATERS ON GANYMEDE, EUROPA, MARS AND EARTH: IMPLICATIONS FOR LAYERED (FLUIDIZED) EJECTA EMPLACEMENT. Joseph Boyce[1], Nadine Barlow[2], Peter Mouginis-Mark[1], Sarah T. Stewart[3], [1]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI, 96922, [2]Dept. of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ, 86001, [3]Dept. of Earth and Planetary Sciences, Harvard University, Cambridge, MA, 02138

We have identified layered ejecta craters on Ganymede and Europa whose layers terminate in ramparts similar to those of layered ejecta craters on Mars [1] (Fig. 1). The morphology of these craters suggests that their ejecta were fluidized during emplacement in a manner similar to Martian layered ejecta. These craters most resemble Martian double-layer ejecta (DLE) craters, with the exception of the small Ganymede crater, Nergal, that is most like a Martian single-layer ejecta (SLE) crater. Lonar, a terrestrial fluidized ejecta crater with a single ramaprt, appears to be most similar to Martian SLE craters.

In our Solar System, the radial extent (i.e., ejecta mobility or EM) of the ejecta of these craters appears to be self similar, but with those of Ganymede and Europa systematically less extensive than those on Mars (Fig 2). The radial extent of the ejecta (i.e., ejecta mobility or EM) scales with crater diameter; however the EM of layered ejecta on Ganymede and Europa are systematically smaller than found on Mars. We suggest that this may be due to increased ejection angles caused by the effects of the abundant ice in their crusts.

Independent of planet, there are two fundamental morphologic types of layered ejecta craters; DLE craters and multi-layered ejecta (MLE) craters, of which SLE craters are most likely just an end member. DLE craters have two morphologically different layers, while MLE craters have one (SLE craters) or more ejecta layers that are morphologically similar. Mars-like MLE craters appear to be absent on Ganymede and Europa, but this could be due to a difficulty in identifying them due to a lack of high-resolution images at low-sun angle.

Considering the morphology, areal distribution, and geologic environment in which Ganymede, Europa and Martian layered ejecta craters (and Lonar) formed, we suggest that none of the simple models for ejecta fluidization [e.g., 2 - 5] entirely fit the observed data. For example, the mere existence of fluidized craters on Ganymede and Europa suggests that an atmosphere is not required for ejecta fluidization. But, this does not rule out the possibility that a shock produced transient gas cloud could be important to ejecta fluidization.

In addition, the putative absence of fluidized ejecta on other bodies suggests that the presence of abundant volatiles in the target may also not be the sole cause of ejecta fluidization. The restriction of Ganymede fluidized ejecta craters to the grooved terrain and the concentration of DLE craters on Mars to the northern lowlands [e.g., 4, 5] suggests that these terrains may share key characteristics (e.g., near surface layering, elevated subsurface temperature) that control the development of the ejecta around these craters. The presence of layered ejecta craters on Europa, a remarkably active icy body, reenforces that suggestion.

While most models of ejecta fluidization require some form of volatiles as a fluidizing medium, it has been proposed that fluidization could be caused by dry granular flow [7]. However, Ganymede and Europa ejecta would contain substantial amounts of entrained shock-generated water and vapor [8 - 11], hence ruling out dry granular flow.

However, what role this water plays in fluidization of the ejecta of these craters can not be demonstrated conclusively.

References

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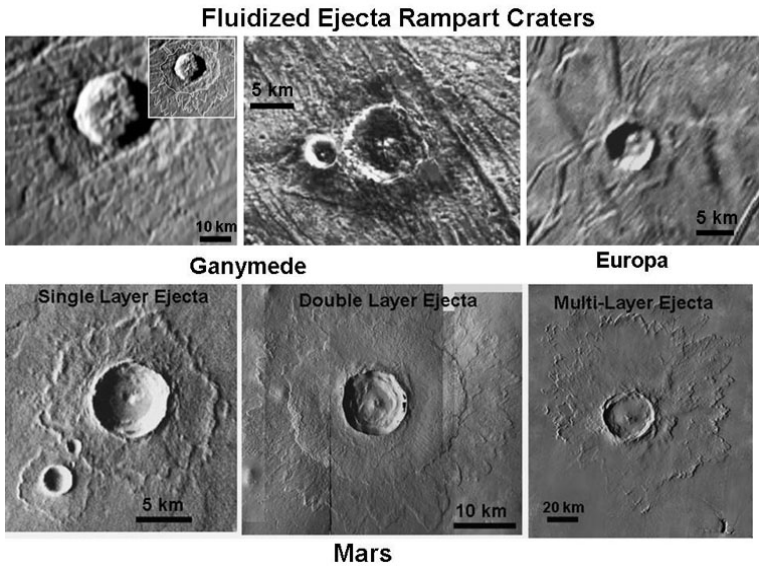

Fig. 1. Examples of fluidized ejecta craters with marginal rampart ridges. From top left across and down the craters shown are Achelious, Nergal (both Ganymede), Diarmuid (Europa) an Unnamed Mars crater, Steinheim (Mars), and Tooting (Mars).

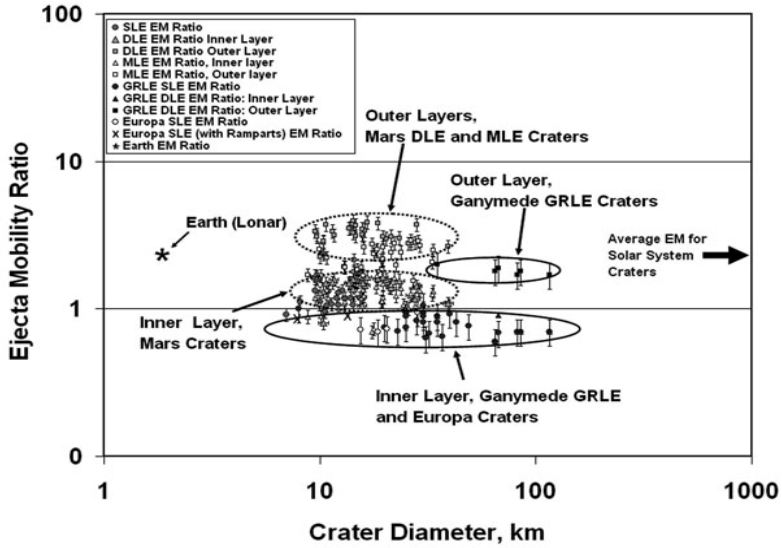

Fig. 2. Impact crater ejecta on Ganymede and Europa are not only self-similar with crater size, but have comparatively low average EM ratios.