Rampart craters on Ganymede and Europa: implications for fluidized ejecta emplacement. Joseph Boyce[1] Nadine Barlow[2], Peter Mouginis-Mark[1], Sarah 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 Science, Harvard University, Cambridge, MA, 02138

Craters are found on the airless satellite Ganymede that have ejecta layers which terminate in ramparts similar to those of fluidized ejecta craters on Mars (Fig. 1). The ejecta of these craters also show other characteristics of ejecta fluidization such as lobate outer edges, uniformly thin continuous ejecta deposits, and evidence of flow around, instead of over pre-existing topography. The presence of these craters has implications to the leading models of ejecta fluidization that rely on either a planet's atmosphere or water in the ejecta for fluidization.

We have identified 26 Ganymede craters whose layered ejecta terminate in ramparts. These craters range in diameter from ~ 8 km to ~ 115 km, and are found exclusively on the grooved terrain. We have measured the average rampart width (used to calculate W_{av} ratio), average run-out distance of ejecta (use to calculate average EM ratio), and in a few cases, sinuosity (Γ) of the ejecta layers for these craters, as well as for 6 of the freshest Europa pedestal craters [1]. The Europa craters range in diameter from ~ 8 km to ~ 28 km, with 2 (i.e., Grainne and Diarmuid) appearing to have ramparts (Fig. 2). Each Europa crater appear to have only one ejecta layer, but they may have subtle outer layers not identifiable because of image resolution limitations. In addition, we have supplemented previous Mars data [2] with similar measurements for 97 (20 SLE, 41 DLE and 36 MLE) Martian layered ejecta craters. These craters range in diameter from 7.0 km to 55.2 km and are distributed throughout Mars on a variety of mid-latitude terrain types. These craters were chosen because they are fresh appearing craters with well-preserved ramparts, relatively symmetrical ejecta blankets, and are located in different geographic and geologic regions.

Considering the morphology and morphometry of the Ganymede rampart crater, they most resemble Martian double-layer ejecta having wide inner layer ramparts compared with ramparts of their outer layer, or for that matter, ejecta layers on any other type of craters (Fig. 3). The exception is the crater, Nergal, which appears to be a single-layer ejecta crater. This suggests that the progression of number of layers with crater diameter noted for Mars also applies to Ganymede. In addition, the average W_{av}, EM, and Γ of Europa craters are similar to Martian single-layer ejecta craters. We have also confirmed the observations of [3, 4] that the EM ratio of Ganymede craters and Mars craters remain nearly constant with crater size. The same also is true for Europa craters. We have also confirmed that the average EM ratio of the craters on Ganymede is less than the equivalent type crater on Mars of the same size [see 3, 4], and similar to that of Europa craters (Fig. 4). The most reasonable explanation for this difference is the increased ejection angle caused by ice in the targets that would reduce run-out distance [5].

Also, considering the areal distribution and geologic environment in which Ganymede, Europa and Martian rampart layered ejecta craters form (as well as such craters as Ries on Earth), we suggest that the interaction between ejecta and a body's atmosphere does not play a significant role in ejecta fluidization, nor can ejecta fluidization be explained by the flow of dry ejecta. Our data are consistent with ejecta fluidization models that rely on shock-induced melting and vaporization of ice to produce transient liquid water during impact crater formation, which can help facilitate the fluid-like movement of ejecta. However, our data do not account for why fluidized ejecta are absent on other icy bodies, even the most geologically active ones such as Enseladus, where substantial water should be produced by shock-induced melting and vaporization and entrained in the ejecta. This suggests that ice (or water) alone in the target materials is not the sole controlling factor in whether ejecta are fluidized, but must also involve other factors, such as a specific temperature regime, layering within the target, or unique mechanical properties. In addition, while the morphologic features of Ganymede, Europa, and Martian layered ejecta are generally similar, there are differences (i.e., Mars-like Multi-layered craters appear to be absent on Ganymede) that may be a result of differences in the content of ice and/or nature of layering in their respective near surface materials, or other factors not yet identified.

References: Moore, J. et al., 2001, *Icarus*, 151, 93-111; [2] Barlow, N., 2006, *Meteor. Planet. Sci.*, 41, 1425-1436; [3] Neal, J., and Barlow, N., 2003, *Large Meteorite Impact Conf.*, LPI, 4021; [4] Neal, J., and Barlow, N., 2004, *Lunar Planet Sci.*, *XXXV.* Abstract # 1337; [5] Boyce et al., 2009, *Meteor. Planet. Sci.*, in press.

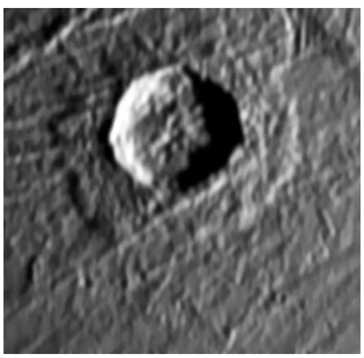

Fig. 1. The 37 km dia. double-layer ejecta Ganymede crater Achelious. Note V-shaped ramparts of the outer ejecta layer in the bottom portion of the of the image.

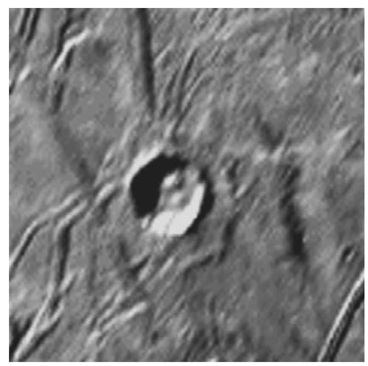

Fig. 2. The 8 km dia. Europa rampart crater Diarmuid.

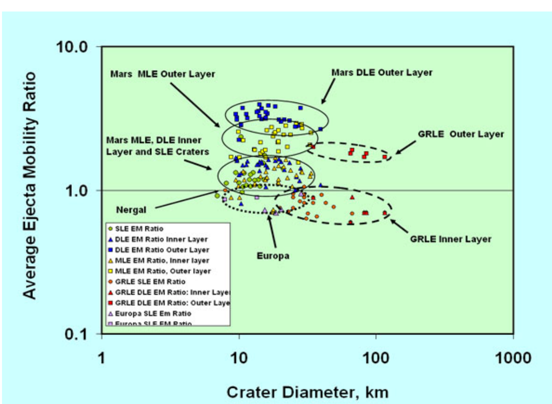

Fig. 3. W_{av} plotted against crater Dia.

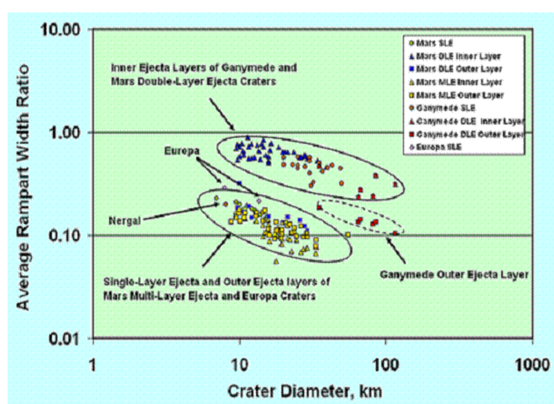

Fig. 4. Avg. EM Ratio plotted against Dia.