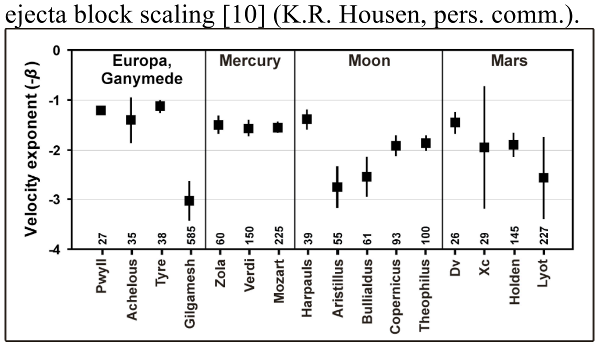
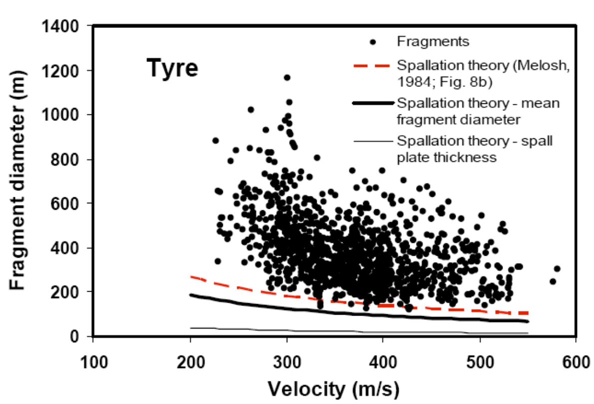
**SECONDARY CRATERS OF LARGE CRATERS AND BASINS ON EUROPA AND GANYMEDE: EJECTA SIZE-VELOCITY DISTRIBUTIONS ON ICY BODIES.** William B. McKinnon and Kelsi N. Singer, Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University in St. Louis, MO 63130 (mckinnon@wustl.edu).

**Introduction:** We have mapped fields of secondary craters around three large primary craters on Europa and Ganymede and estimated the size and velocity of the fragments that formed the secondaries using updated scaling equations for ice impacts [1]. We characterize the upper envelope of the fragment size-velocity distribution to obtain a power-law function for the largest fragments at a given ejection velocity. We compare our power-law velocity exponents to the exponents found by Vickery for similar studies of mercurian, lunar, and martian craters [2,3]; for all but basin-scale impacts, fragment size apparently decreases more slowly with increasing ejection velocity than on rocky bodies. Spallation theory provides estimates of the size of ejected spall plates at a given velocity [4], but this theory predicts fragments considerably smaller than are necessary to form most of our observed secondaries. In general, ejecta fragment sizes scale with primary crater diameter and decrease with increasing ejection velocity by $1/\upsilon_{ej}$ or greater.

**Secondary Craters on Icy Satellites:** The relationship between the size and velocity of fragments ejected during large cratering events on icy satellites is poorly known. Yet knowledge of the size-velocity distribution (SVD) of ejected fragments is critical to understanding the contribution of ejecta to the overall population of small craters and thus to the paramount issue of age dating by means of crater counts [e.g., 5]. Only one (preliminary) study has previously mapped and determined the SVD for such secondaries, from the crater Pwyll on Europa [6]. Here we consider three large primaries on Europa and Ganymede, including the largest preserved multiring impacts on Europa (Tyre, below) and Ganymede (Gilgamesh).

The size, depth and range from the primary of a given secondary crater allows us to calculate the size and velocity of a secondary-forming fragment via crater scaling [7]. Quantile regression fitting characterizes the decline in maximum fragment size with increasing ejection velocity $\upsilon_{ej}$ according to $d_{frag,max} = A\upsilon_{ej}^{-\beta}$. Based on ejection physics we expect to see trends when comparing the SVDs of different secondary fields with the size of the primary, surface gravity, tensile strength of the target, etc. For the two large icy satellites considered here, $\beta$ values (99th percentile) are near 1 for the three midsized craters (crater diameters in km are given in the figure below), while Gilgamesh has a much steeper $\beta \sim 3$; however, no trend for a steeper velocity dependence with increasing primary size is apparent for the Moon or Mercury (see figure and also [8,9]). While the velocity exponents for the icy midsized craters are consistently lower than those found for terrestrial craters of similar size, $\beta = 1$ is actually predicted by spallation theory [4]. Moreover, $\beta \approx$ 1+ can be shown to be consistent with maximum lunar ejecta block scaling [10] (K.R. Housen, pers. comm.).




Larger craters on the same body eject larger fragments (as described by the pre-exponential factor $A$). Spallation theory [4], however, underpredicts the largest ejecta fragment size at a given velocity by a factor of several, as illustrated by the figure at left. Curves illustrate predicted spall plate thickness, a larger average spall fragment size (by $\sqrt[3]{100}$), and a stress-wave estimate (dashed curve). We suspect fragments cluster.

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