Unresolved characteristics of Europa's crater population. E. B. Bierhaus[1], K. Zahnle[2], and C. R. Chapman[3], [1]Lockheed Martin PO Box 179, MS S8110 Denver CO 80201), [2](NASA Ames), [3](SwRI).

Introduction: We address aspects of Europa's crater population that have been largely overlooked in favor of the high-profile, and critical, "How young is young?" question. The relative scarcity of large impact craters [1] on Europa is key evidence for ongoing geological activity, and the primary crater morphology [2] is key evidence for an ocean underneath the ice shell. Yet the youth implied by the sparse crater population is more complex than first seemed; in particular, we discuss the following two topics that we find are currently unresolved: (1) hemispherical differences in crater density, and (2) terrain differences in crater density.

Data: During orbits 15 and 17, Galileo obtained near pole-to-pole swaths of regional resolution (230-450 m/pix, resulting in ~ 1 km completeness limit for crater measurements) images of Europa's leading and trailing sides. These image data, hereafter referred to as "REGMAP", represent the best opportunity to measure and establish the primary crater SFD. These measurements do not include primaries specifically targeted for higher resolution imaging (e.g. Pwyll, Cilix, Rhiannon, and others), which could artificially inflate the crater density. We also provide a global measurement for craters > 30 km (derived from the combined Voyager/Galileo basemap), and a lower-limit estimate of small primaries near 1 km (derived from high-res image data, see [3]). Figure 1 is an R-plot for these data, which are consistent with the measurements in [2]; the consistency between two independent measurements lends significant confidence that this indeed is the trend for primaries on Europa (also, see Figure 4).

Hemispherical Differences: Two factors suggest that the leading side should express a higher crater density than the trailing side: (1) Zahnle et al. [4] estimate an enhanced impact rate on the leading side is a natural consequence of helio-centric impactors, mostly Jupiter family comets (JFCs); Zahnle et al. [5] estimate that ejecta (from a primary impact) that escapes Io and hits Europa will "avoid" the trailing side (most of these inter-moon secondaries, which Zahnle et al. call "sesquinaries", will form Europan craters < 1 km). Figure 2 compares the crater density on Europa's leading and trailing sides. The densities are similar; most points are within error bars of one another. But the trailing side is systematically lower, and in the range of a few km the leading side exhibits a clear density enhancement (a factor of ~ 3.5) over the trailing side.

The comparison is further complicated by the presence of large primaries that are just outside the image boundaries of the leading-side image data. The craters themselves are not visible, but their significant near-field secondary populations are visible, see Figure 3. Though we did not include the adjacent fields in our measurements, it's entirely possible that we included more distant secondaries. The secondary fields of these two craters may have undue influence on the density of craters near 1 km.

The presence of any hemispherical difference is perhaps somewhat puzzling, since the combined effects of youth and expected non-synchronous rotation of the ice shell should diminish density differences. While non-primary sources, secondary and/or sesquinary, may account for part of the difference, the suggestion of higher density deserves a more detailed explanation.

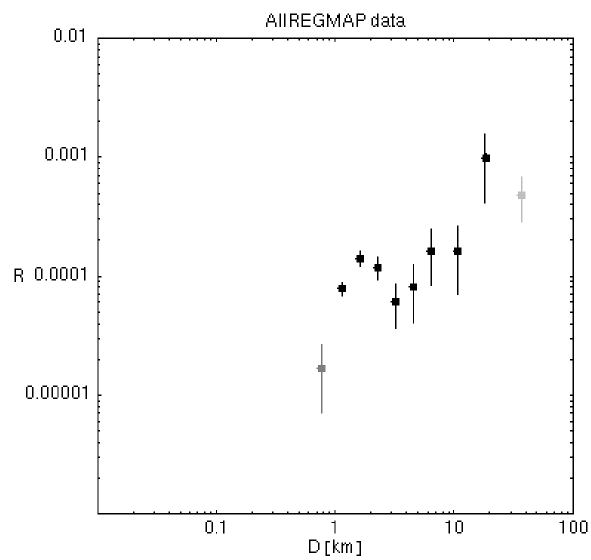

Figure 1: The black points are from REGMAP measurements (see text). The light grey point (far right) is a global measurement for craters > 30 km. The dark grey point (far left) is a lower-limit estimate of small (~ 1 km) primaries.

Terrain Differences: Perhaps the most perplexing discovery we've made is the paradoxical density contrast on ridged and chaos terrains. Stratigraphic relationships [6] unambiguously identify chaos terrains as the youngest features. It would seem imminently reasonable, then, that ridged terrains would possess a higher crater density, since they have had more exposure time to impactors. Figure 3 shows is an R-plot for the two terrains. Surprisingly, the chaos-terrain crater density is systematically higher. Since the density contrast occurs over most of the diameter range, we believe that observational effects (e.g. craters are more visible in chaos regions) are not responsible. Several researchers have observed that most primary craters, regardless of where they formed, are morphologically fresh. We are faced with the conundrum that while the crater record tells us Europa was very active in recent solar system history, the crater record, both in terms of spatial density and morphology, also tells us Europa has been relatively quiescent. This is a paradox we are straining to resolve.

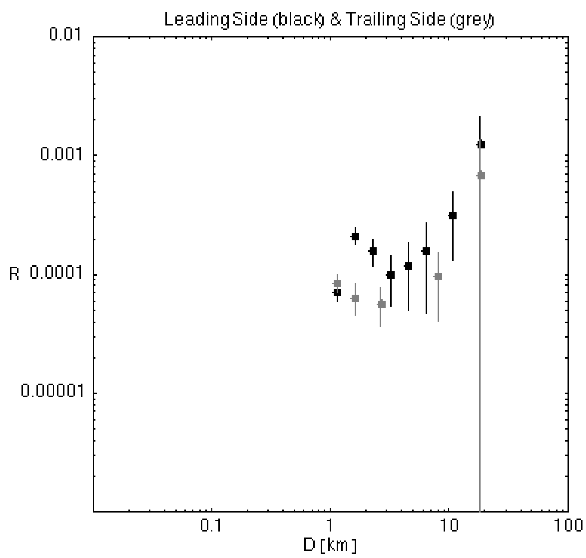

Figure 2: A comparison between crater densities on Europa's leading (black points) and trailing (grey points) sides. The two agree within error bars, with the exception of craters a few km diameter.

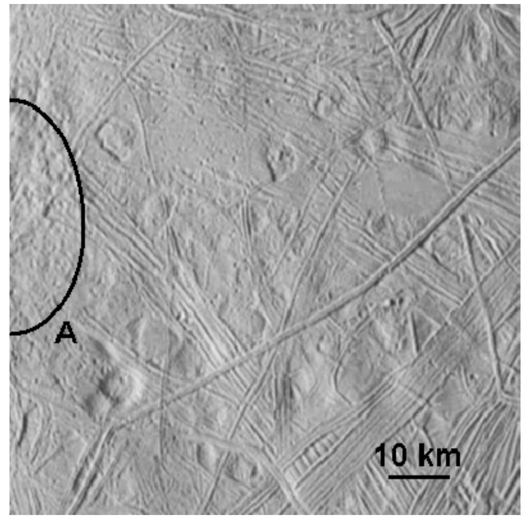

Figure 3: Portion of E15REGMAP02 frame 74265. The boundary marked by "A" is the possible edge of the continuous ejecta blanket for a primary crater just beyond the image edge; adjacent secondaries appear throughout the image.

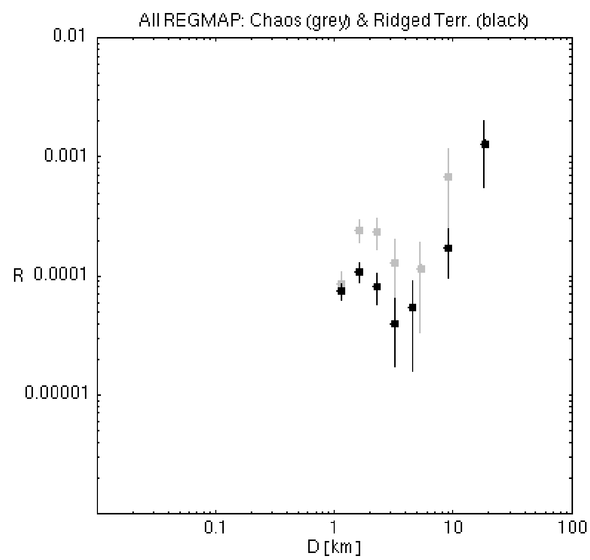

Figure 4: Comparison of crater densities on chaos (grey points) and ridged (black points) terrain types. Even though chaos terrains are among the youngest terrains (realized via stratigraphic relationships, [6]) on Europa, they exhibit a higher crater density, implying a greater age.

References: [1] Schenk et al. (2004) In *Jupiter: The planet, satellites, and magnetosphere*. Cambridge Univ. Press. [2] Schenk (2002) *Nature* **417**, 419-421. (1997) [3] Bierhaus et al. (2005) *Nature* **437**, 1125-1127. [4] Zahnle et al. (1998) *Icarus*, **136**, 202—222. [5] Zahnle et al. (2007) In press. [6] Figueredo and Greeley (2004) *Icarus*, **167**, 287-312.