The unusual role of secondaries in the evolution of crater populations on Enceladus, and consequences for age estimation. E. B. Bierhaus[1] , L. Dones[2], and S. Robbins[2], [1]Lockheed Martin, [2]Southwest Research Institute.

Introduction: The ongoing (but sadly near final) Cassini image library of the icy Saturnian satellites provides many new pages of history in this rich, complex, and compelling system of satellites, rings, and giant planet. As with history in general, questions of timing are fundamental to our understanding of the evolution of these fascinating objects. A technique to constrain, and under optimum circumstances and knowledge even define, ages and sequences of events is to examine impact crater populations – cataloguing their sizes, locations and spatial densities is a chronometer that can mark relative and absolute ages.

We are in the process of measuring crater populations on the Saturnian satellites [1] and developing a high-fidelity model [2] of the accumulation of primary and secondary craters for the mid-sized Saturnian satellites, with the ultimate goal of using the crater populations to constrain timing and ages of events in the Saturnian system. Here we report on progress of this work, with attention to interesting consequences for Enceladus, including the young terrains.

Complex outcomes from simple inputs: Earlier [3] we demonstrated that the simple variation of impact speed (v_i), surface gravity (g), and escape velocities (v_{esc}) between the satellites can result in observably different crater populations, even if they all are exposed to the same impacting population. Another important parameter is v_{min}, the minimum speed necessary to form a secondary (see [3]), which dictates the presence and proximity of secondaries relative to their parent primary crater.

Enceladus lives in a special combination of these parameters compared with the mid-sized Saturnian satellites, and in contrast to the Galilean satellites. Enceladus has an effective escape velocity (velocity to reach the Hill Sphere) of ~209 m/s; if v_{min} for icy surfaces is ~150 m/s, then there is only a ~60 m/s window of ejection speeds that results in secondaries. This narrow window affects not only the total population of secondaries, it also affects the resulting imprint of the secondary size-frequency distribution (SFD), i.e. the secondary SFD is somewhat truncated at smaller sizes because the smaller ejecta fragments are typically ejected at higher velocities, and thus escape.

Adjacent secondaries depend on g and v_{min}. On the Moon, Mars, and on the Galilean satellites there is a classic progression of features beyond the rim of large impact craters: first there is the continuous ejecta blanket, which beyond roughly 1 crater radius transitions to a dense annulus, the adjacent secondary crater population.

In contrast, there are only a few possible examples of such "classic" behavior around large craters on the mid-sized Saturnian satellites, and none on Enceladus. While large craters have continuous ejecta blankets, and some (presumably young) craters have rays, the presence of a dense annulus of adjacent secondaries is subtle at best, or in many cases, simply absent.

This is likely due to the interplay between v_{min} and the distance that corresponds to that velocity. On high-g bodies v_{min} can get ejecta fragments only so far, meaning secondaries that form close to their parent primaries – i.e. adjacent secondaries – are possible. However, as g decreases, v_{min} results in greater distances. At some point, as g gets small enough, and because secondaries cannot form at velocities less than v_{min}, adjacent secondaries in the traditional sense will disappear altogether. (In the extreme case that the escape velocity becomes less than v_{min}, then secondaries may not form at all, which may be the case on Mimas.)

The fragments that form the adjacent secondaries on higher-g bodies are also the largest secondaries made by a primary impact. In the case of Enceladus, these large secondaries are globally distributed across the satellite.

Consequences for age estimates on Enceladus: Enceladus will have secondaries, but only secondaries from fragments moving in a narrow velocity range, and these fragments tend to be the largest. Because of the relatively low surface gravity, these large fragments, rather than making a dense, adjacent annulus of secondaries, will contribute to the global background of randomly distributed craters.

We are examining two consequences: (1) the evolution of the crater SFD over time could be uniquely diagnostic on Enceladus because of the narrow velocity range of secondaries that form, and (2) we can use the entire surface area of Enceladus to constrain the ages of lightly cratered terrains – this is because young terrains accumulate direct primaries, as well as secondaries from anywhere else on the satellite.

We will present the details of our calculations at the meeting.

References: [1] Robbins S.J. et al. (2015) *LPSC XXXXVI*, Abstract #1832. [2] Bierhaus E.B. et al. (2015), DPS #47, id 508.01. [3] Bierhaus E.B. et al. (2012) Icarus, v. 218, 602-621.